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Somaiya TRUST

Batch: P1-2 Roll No.: 16014022050
Experiment / assignment / ~~tutorial No.~~ IA-2
Grade: AA/ AB / BB / BC / CC / CD / DD

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→ Module 1 :

1. Given, mass of $CaCl_2$ = 1.02g
volume of distilled water = 750 ml

$\therefore$ $CaCl_2$ equivalent = $\frac{1.36g}{750ml}$ = 1.36 g/L = 1360 mg/L

mol. wt of $CaCO_3$ = 100 and mol. wt of $CaCl_2$ = 111
100g of $CaCO_3$ = 111g of $CaCl_2$
100 ppm of $CaCO_3$ = 111 ppm of $CaCl_2$

$\therefore$ 1ppm of $CaCl_2$ = $\frac{100}{111}$ ppm of $CaCO_3$

1360 ppm of $CaCl_2$ = $\frac{100}{111} \times 1360$ = 1225.23 ppm

Hence, hardness of water = 1225.23 ppm.

2. Given, hardness = 80°Fr
We know that,
1mg/L = 0.07°Cl = 0.1°Fr

$\therefore$ 80°Fr = $\frac{80}{0.1}$ = 800 mg/L and 80°Fr = $\frac{80 \times 0.07}{0.1}$ = 56°Cl

Hence, 80°Fr = 800 mg/L = 56°Cl.

3.

Constituent	multiplication Factor	$CaCO_3$ equivalent	Hardness
$MgSO_4$ = 60	100/120	100/120 × 60 = 50	P
$Ca(HCO_3)_2$ = 11.1	100/162	100/162 × 11.1 = 6.852	T
$Mg(NO_3)_2$ = 14.8	100/148	100/148 × 14.8 = 10	P
$Na(HCO_3)$ = 13	–	–	–

As temporary hardness is caused by bicarbonates of calcium and magnesium,

temporary hardness = 6.852 mg/L = 6.852 ppm.

4\. Given, $V_{EDTA} = 20\,ml$,

Volume of water sample = 50 ml

concentration of EDTA = 0.1M

We know,

$$\text{total hardness} = \frac{1000 \times V_{EDTA}}{\text{Volume of water}} \text{ ppm}$$

$$\therefore \text{ total hardness} = \frac{1000 \times 20}{50} = 400$$

But, molarity of EDTA solution is $M_{EDTA} = 0.1M$,

$\therefore$ hardness = 400×0.1 = 40ppm

Hence, hardness is 40 ppm.

5\.

constituents	amount (ppm)	Multiplication Factor	$CaCO_3$ equivalent
$CaCl_2$	2.22	100/111	2
$Ca(HCO_3)_2$	6	100/~~[illegible]~~ 162	5
$Na(HCO_3)$	1.1	100/~~[illegible]~~ 2×84	5
$MgSO_4$	4.2	100/~~[illegible]~~ 120	2.5

$$\text{lime requirements} = \frac{74}{100}\left[Ca(HCO_3)_2 + MgSO_4 + NaHCO_3\right] \text{ (in terms of } CaCO_3 \text{ eq.)}$$

$$= \frac{74}{100}(5+5+2.5) = 9.25 \text{ mg/L}$$

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5. Quantity of lime required for softening 50000L of water,
= 9.25 × 50 000
= 462500 mg
= 462.5 grams

Hence, amount of lime required = 462.5 grams

6.

constituents	amount (ppm)	multiplication Factor	$CaCO_3$ equivalent
$MgSO_4$	1.11	100/120	1
$CaCl_2$	6	100/~~120~~ 111	5
$NaHCO_3$	7.3	100/2×84	4.345
$Ca(HCO_3)_2$	4.05	100/162	2.5
CO_2	22	100/44	50
HCl	7.3	100/36.5×2	10

Soda requirement $= \frac{106}{100}\left[CaCl_2 + MgSO_4 + HCl - NaHCO_3\right]$ (in terms of $CaCO_3$ eq.)

$= \frac{106}{100}(1+5+10-4.345) = 12.3543$ mg/L

Quantity of soda required for softening of 25000L water,
= 12.343 × 25 000
= 308875.5 mg
= 308.876 grams

Hence, amount of soda required = 308.876 grams.

7. Given, Volume of water sample = 50ml
Volume of FAS in blank titration (V1) = 33ml
Volume of FAS in back titration (V2) = 12ml
Normality of FAS = 0.05

$$COD = \frac{(V_1 - V_2) \times N_{FAS} \times 1000}{\text{volume of sample}} = \frac{(31-10) \times 0.05 \times 1000}{50}$$

$= 168$ ppm

Hence, $\underline{\underline{COD = 168 \text{ ppm}}}$.

8. Given, mass of $Mg(NO_3)_2$ = 7.4mg
volume of water = 750 ml

$Mg(NO_3)_2$ equivalent $= \frac{7.4mg}{750ml} = 9.87 mg/L$

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

Hardness $= \frac{9.87}{148} \times 100 = 6.667$ mg/L

1 mg/L = 0.07 °Cl
6.669 mg/L = Hardness in °Cl

∴ Hardness = 6.669 × 0.07 = 0.467 °Cl

Hence hardness = ~~66~~ $\underline{\underline{0.467 \text{ °Cl}}}$

9. Hardness of water = 200L of 0.1 N HCl
1 equivalent of HCl = 1 equivalent of $CaCO_3$
0.1N of HCl = 0.1N of $CaCO_3$

∴ Hardness of water = 200 × 0.1 N $CaCO_3$ = 20L of 1N $CaCO_3$
1 L of 1N $CaCO_3$ = 50 g of $CaCO_3$
Hardness = 20 × 50 = 1000 g/L $CaCO_3$.

Hence, hardness = 10^6 mg/L $CaCO_3$ = $\underline{10^6 \text{ ppm}}$.

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10. 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 in $CaCO_3$

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

Hence, hardness = 128 2051 mg $CaCO_3$ eq.

11. 1000 ml of SHW solution = 1.11 g $CaCl_2$

1000 ml of SHW solution = 1g $CaCO_3$

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

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

∴ 50 ml of SHW solution = 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 EDTA = 2381 ppm

∴ $CaCO_3$ equivalent hardness of EDTA solution = 2381 ppm

Hence, hardness = 2381 ppm

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→ Module 2:

1. Given, $C = 78\%$, $H = 5\%$, $S = 3\%$, $N = 5\%$, Ash = remaining

By Dulong's formula,

$$GCV = \frac{1}{100}\left[8080C + 34500(H - O/8) + 2240S\right]$$

$$= \frac{1}{100}\left[8080 \times 78 + 34500(5 - 0) + 2240 \times 3\right]$$

$$= \underline{8094.6 \text{ kcal/kg}}$$

2. Given, $C = 89\%$, $H = 6\%$, $S = 2\%$, $N = 1\%$, N = remaining

By Dulong's formula,

$$GCV = \frac{1}{100}\left[8080C + 34500(H - O/8) + 2240S\right]$$

$$= \frac{1}{100}\left[8080 \times 89 + 34500(6 - 0) + 2240 \times 2\right]$$

$$= 9306 \text{ Kcal/Kg}$$

$$NCV = GCV - \left[\frac{9}{100} \times H \times 587\right] = 9306 - \left[\frac{9}{100} \times 6 \times 587\right]$$

$$= 9306 - 316.98$$

$$= \underline{8989.02 \text{ Kcal/Kg}}$$

3. Given, wt of coal sample $= w = 1.2g$
wt of sample after heating $= w_1 = 0.88g$

$$\% \text{ moisture} = \frac{\text{loss in wt}}{\text{wt of coal}} \times 100 = \frac{w - w_1}{w} \times 100$$

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

Hence, % moisture $= \underline{26.67\%}$

4. Given, % moisture = 10%
   wt of coal sample = 1.8 g (w)
   wt of sample after heating = w_2 = 1.09 g

weight of coal which is moisture,

$$\frac{10}{100} = \frac{x}{1.8}$$

$\therefore x = 0.18$ g of moisture present in sample

$\therefore$ wt of coal after removal of moisture, $w_1 = 1.8 - 0.18 = 1.62$ g

$$\% \text{ Volatile matter} = \frac{\text{volatile matter}}{\text{wt of sample}} \times 100 = \frac{w_1 - w_2}{w} \times 100$$

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

$$= 29.44\%$$

Hence, % Volatile matter = 29.44%

5. Given, weight of coal sample = w = 1.8g
   % moisture = 10%
   Weight of residue = w_1 = 0.63g

$$\% \text{ ash} = \frac{W_{ash}}{W_{coal}} \times 100 = \frac{w_1}{w} \times 100 = \frac{0.63}{1.80} \times 100 = 35\%$$

Hence, % ash = 35%

6. Given, wt of coal sample = 1.56g
   increase in mass of KOH tube = 4.8g

$$\% C = \frac{\text{increase in mass of KOH} \times 12 \times 100}{\text{wt of coal} \times 44} = \frac{4.8 \times 12 \times 100}{1.56 \times 44} = 13.92\%$$

Hence, % carbon = 83.92%

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7. Given, wt of coal sample = 1.5g
increase in mass of $CaCl_2$ tube = 1.2g

$$\% H = \frac{\text{increase in mass of } CaCl_2 \times 2 \times 100}{\text{wt of coal} \times 18}$$

$$= \frac{1.2 \times 2 \times 100}{1.56 \times 18} = 8.55\%$$

Hence, % hydrogen = 8.55%

8. Given, wt of sample = 2.8 g
Blank titration = ~~0.05N~~ 28ml
N_{KOH} = 0.05N
Volume of KOH = 15 ml

Volume of KOH used = 28-15 = 13 ml

$$\% N = \frac{V_{used} \times N_{KOH} \times 100}{W_{coal}} = \frac{13}{2.8} \times 100 \times 0.05 = 23.214\%$$

Hence, % Nitrogen = 23.214 %

9. Given, wt. of coal sample = 1.75 g
wt. of $BaSO_4$ residue used = 0.66g

$$\% S = \frac{\text{weight of } BaSO_4 \text{ residue} \times 32 \times 100}{\text{wt. of coal} \times 233} = \frac{0.66 \times 32 \times 100}{1.75 \times 233}$$

$$= 5.18\%$$

Hence, % sulfur = 5.18%

10. Given, weight of coal = 5kg

O_2 / kg $= \frac{32}{12} \times C + 8\left[H - \frac{O}{8}\right] + S$

$= \frac{32}{12} \times 0.85 + 8\left[0.04 - \frac{0.04}{8}\right] + 0.02$

$= 2.567$

$\therefore$ 5 kg $= 5 \times 2.567 = 12.83$ kg

Hence, 5kg requires 12.83kg of oxygen.

11. Given, weight of coal = 2kg
quantity of oxygen = 4.85kg

Quantity of air $= \frac{\text{oxygen quantity}}{23} \times 100 = \frac{4.85 \times 100}{23} = 21.087$ kg

Mass of air $= 21.087 + \frac{10}{100} \times 21.087 = 23.20$ kg

Volume of air $= \frac{\text{quantity of air} \times 22.4}{28.94} = \frac{23.20 \times 22.4}{28.94}$

$= 17.96\ m^3$

Mass of air = 23.20kg and volume of air = 17.96 m^3.

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→ Module 3:

1. Given, $\% T = 60\%$
$\lambda = 650$ nm
path length $(l) = 1.5$ cm

Absorbance, $A = 2 - \log[\% T] = 2 - \log 60 = 0.2218$

Hence, absorbance $= 0.2218$.

2. Given, $\% A = 50\%$, $\% T = 100 - 50 = 50\%$, $\lambda = 380$ nm, $l = 1.2$ cm

Absorbance, $A = 2 - \log[\% T] = 2 - \log 50 = 0.3010$

Hence, absorbance $= 0.3010$.

3. Given, $A = 0.56$, $l = 0.75$ cm, $\varepsilon = 6.4 \times 10^{3}$ $L\,mol^{-1}\,cm^{-1}$

$A = \varepsilon c l$

$c = \frac{A}{\varepsilon l} = \frac{0.56}{6.4 \times 10^{3} \times 0.75} = 1.167 \times 10^{-4}$ mol/L

Hence, concentration is 1.167×10^{-4} mol/L

4. Given, $\lambda = 230$ nm, $l_1 = 2$ cm, $l_2 = 1$ cm, transmittance $= 0.45$

$A = \varepsilon l c$

$$\left.\begin{array}{l} A_1 = \varepsilon l_1 c_1 \\ A_2 = \varepsilon l_2 c_2 \end{array}\right\} \therefore \frac{A_1}{A_2} = \frac{l_1}{l_2} \quad \text{—— (i)}$$

$A_1 = -\log[T_1] = -\log(0.45) = 0.3469$

substituting in eq (i), $\frac{0.3469}{A_2} = \frac{2}{1} \Rightarrow A_2 = 0.1734$

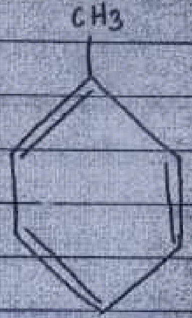
Hence, absorbance is 0.1734.

5. Given, concentration, $c = 10^{-3}$ M
absorbance, $A = 0.334$
cuvette length = path length = l = 1.2 cm

$A = \varepsilon c l$

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

6. Toluene -

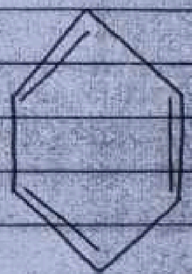


C_7H_8

Toluene is non-linear molecule.
no. of atoms, n = 7C + 8H = 15
no. of vibrational nodes = 3n - 6
= 3(15) - 6
= 39

Hence, no. of nodes = 39

Benzene -



C_6H_6

Benzene is non-linear molecule.
no. of atoms, n = 6C + 6H = 12
no. of vibrational nodes = 3n - 6
= 3(12) - 6
= 30

Hence, no. of nodes = 30.

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→ Module 4:

1. $M_N = \frac{(10 \times 10000) + (90 \times 100000)}{10+90}$

$\therefore M_N = \frac{9100000}{100} = \underline{\underline{91000}}$

$M_W = \frac{10(10000)^2 + 90(100000)^2}{10 \times 10000 + 90 \times 100000}$

$\therefore M_W = \underline{\underline{99010.989}}$

Now, $PDI = \frac{M_W}{M_N} = \frac{99010.989}{91000} = 1.088$

$\therefore \underline{\underline{PDI = 1.088}}$.

2. $M_N = \frac{(200 \times 5000) + (500 \times 10000) + (800 \times 15000)}{200+500+800}$

$\therefore M_N = \frac{18000000}{1500} = \underline{\underline{12 \times 10^3}}$

$M_W = \frac{(200 \times (5000)^2) + (500 \times (10000)^2) + (800 \times (15000)^2)}{(200 \times 5000) + (500 \times 10000) + (800 \times 15000)}$

$= \frac{235000000000}{18000000}$

$\therefore M_W = \underline{\underline{13.056 \times 10^3}}$

Now, $PDI = \frac{M_W}{M_N} = \frac{13.056 \times 10^3}{12 \times 10^3} = 1.088$

$\therefore \underline{\underline{PDI = 1.088}}$

3. $Mn = \dfrac{(100 \times 100) + (200 \times 1000) + (300 \times 10000)}{100+200+300}$

$\therefore MN = \dfrac{3210000}{600} = \underline{\underline{5350}}$

$Mw = \dfrac{(100(100)^2) + (200(1000)^2) + (300(100000)^2)}{100 \times 100 + 200 \times 1000 + 300 \times 10000}$

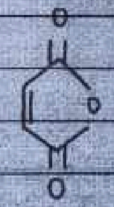
$\therefore MW = \dfrac{30201000000}{3210000} = \underline{\underline{9408.411}}$

Now, $PDI = \dfrac{MW}{MN} = \dfrac{9408.411}{5350} = 1.7586$

$\therefore$ $\underline{\underline{PDI = 1.7586}}$.

→ Module 5:

1. (i).

$C_4H_{10} + 3.5\,O_2 \longrightarrow$  $+ 4H_2O$

$C_4H_2O_3$

here,

$\%$ atoms economy $= \dfrac{\text{mol. wt of atoms utilised}}{\text{mol. wt of all the atoms}} \times 100$

$= \dfrac{4M_C + 2M_H + 3M_O}{M_{C_4H_{10}} + 3.5M_{O_2}}$

$= \dfrac{48 + 2 + 48}{58 + 112} \times 100$

$= 57.64\%$

Hence, atom economy $= 57.64\%$

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1. (ii).

$CH_3 - CH = CH - CH_2 + 3O_2 \longrightarrow$  $+ 3H_2O$

$C_4H_2O_3$

Here,

$$\% \text{ atom economy} = \frac{4M_C + 2M_H + 3M_O}{M_{C_4H_8} + 3M_{O_2}} \times 180$$

$$= \frac{48 + 2 + 48}{56 + 96} \times 100 = 64.47\%$$

Hence, atoms economy = $\underline{\underline{64.47\%}}$

(iii).

$C_6H_6 + 4.5O_2 \longrightarrow C_4H_2O_3 + 2H_2O$

Here,

$$\% \text{ atom economy} = \frac{4M_C + 2M_H + 3M_O}{M_{C_6H_6} + 4.5M_{O_2}} \times 100$$

$$= \frac{48 + 2 + 48}{78 + 144} \times 100 = 44.144\%$$

Hence, % atoms economy = $\underline{\underline{44.14\%}}$