EC - IA: 2

★ Module 1

Q.1

1. Determine the hardness of water sample prepared by dissolving 1.02 g of $CaCl_2$ in 750 ml distilled water.

Solⁿ: Molecular weight of $CaCl_2$ = 111 g

Molecular weight of $CaCO_3$ = 100 g

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

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

$111 \frac{mg}{L}$ of $CaCl_2$ = $100 \frac{mg}{L}$ of $CaCO_3$

$\frac{1.02\ g}{750\ mL}$ of $CaCl_2$ = ? $\frac{mg}{L}$ of $CaCO_3$

$\frac{1020\ mg}{0.75\ L}$ of $CaCl_2$ = Hardness of water sample required ($x \frac{mg}{L}$ of $CaCO_3$)

$1360 \frac{mg}{L}$ of $CaCl_2$ = $x \frac{mg}{L}$ of $CaCO_3$

$x \frac{mg}{L}$ of $CaCO_3$ = $\left(\frac{1360 \times 100}{111}\right) \frac{mg}{L}$ of $CaCO_3$

= $1225.2252252523 \frac{mg}{L}$ of $CaCO_3$

Hardness of water sample = 1225.2252 ppm

2. Convert 80° French of hardness in mg/L and °Clarke

Solⁿ: Given hardness = 80° Fr

1 mg/L = 0.1 °Fr

1 °Fr = $\frac{1}{0.1}$ mg/L = 10 mg/L

∴ 80 °Fr = (80 × 10) mg/L = 800 mg/L

0.1 °Fr = 0.07 °Clarke

1 °Fr = $\frac{0.07}{0.1}$ °Cl = 0.7 °Clarke

∴ 80 °Fr = (80 × 0.7) °Cl = 56 °Clarke

Q.3 Calculate the temporary hardness of water sample if it contains $MgSO_4$ = 60 ppm, $Ca(HCO_3)_2$ = 11.1 ppm, $Mg(NO_3)_2$ = 14.8 ppm, $NaHCO_3$ = 13 ppm

Soln:

Sr. No.	Constituent	ppm ≡ mg/L	Multiplication Factor	$CaCO_3$ equivalent	Hardness
1.	$MgSO_4$ 24+32+4(16) = 120	60	$\frac{50}{60}$	1	perm.
2.	$Ca(HCO_3)_2$ 40+2[1+12+3(16)] = 162	11.1	$\frac{50}{81}$	6.85	Temp.
3.	$Mg(NO_3)_2$ 24+2[14+3(16)] = 148	14.8	$\frac{50}{74}$	10	perm.
4.	$NaHCO_3$ 23+1+12+3(16) = 84	13	$\frac{50}{84}$	7.74	–

Temporary Hardness = Hardness caused by $Ca(HCO_3)_2$
= 6.85 ppm or 6.85 mg/L

Q.4 Calculate the total hardness of water sample if 50 mL water sample required 20 mL of $\frac{M}{10}$ EDTA solution for titration using EBT.

Soln: Concentration of EDTA = $\frac{M}{10}$ = 0.1 M

1000 mL of 1 M EDTA soln = 100 g of $CaCO_3$ [Due to Avogadro's number of molecules]

1 mL of 1 M EDTA soln = 100 mg of $CaCO_3$

1 mL of 0.1 M EDTA soln = (100 × 0.1) mg of $CaCO_3$
= 10 mg of $CaCO_3$

50 mL of sample hard water = 20 mL of 0.1 EDTA soln
= (20 × 10) mg of $CaCO_3$ eq.

1000 mL of sample hard water = (20 × 10 × 20) mg of $CaCO_3$ eq.
= 4000 mg of $CaCO_3$ eq.

Hence, Total hardness = 4000 ppm

Q.5 Calculate the amount of lime required for the softening of 50,000 liter of water sample having following impurities: $CaCl_2$ = 2.22 ppm, $MgSO_4$ = 6.0 ppm, $Ca(HCO_3)_2$ = 8.1 ppm, $NaCHCO_3)_2$ = 4.2 ppm

Soln:

Sr. No.	Impurities	(in ppm)	Multiplication Factor	$CaCO_3$ equivalent	Req.
1.	$CaCl_2$ 40+2(35.5) = 111	2.22	$\frac{50}{55.5}$	2	S
2.	$MgSO_4$ 24+32+4(16) = 120	6.00	$\frac{50}{60}$	5	L+S
3.	$CaCHCO_3)_2$ 40+2[1+12+3(16)] = 162	8.10	$\frac{50}{81}$	5	L
4.	$NaCHCO_3)_2$ = 145	4.20	-	-	-

$$\text{Lime required} = \frac{74\,[CaCO_3 \text{ eq. of } MgSO_4 + Ca(HCO_3)_2] \times \text{volume}}{100 \times 1000 \times 1}$$

$$= \frac{74\,(5+5) \times 50000}{100 \times 1000}$$

Lime required = 370 g

Q.6 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, $NaCHCO_3)_2$ = 7.3 ppm, $CaCHCO_3)_2$ = 4.05 ppm, CO_2 = 2.2 ppm, HCl = 7.3 ppm

Soln:

Sr. No.	Impurities	(in ppm)	Multiplication factor	$CaCO_3$ equivalent	Req.
1.	$CaCl_2$ 40+2(35.5) = 111	1.11	$\frac{50}{55.5}$	1	S

Sr. No.	Impurities	(in ppm)	Multiplication Factor	$CaCO_3$ equivalent	Req.
2.	$MgSO_4$ $24+32+4(16)$ $=120$	6	$\frac{50}{60}$	5	L+S
3.	$Na(HCO_3)_2$ $23+2[1+12+3(16)]$ $=145$	7.3	–	–	–
4.	$Ca(HCO_3)_2$ $40+2[1+12+3(16)]$ $=162$	4.05	$\frac{50}{81}$	2.5	L
5.	CO_2 $12+2(16)$ $=44$	22	$\frac{50}{22}$	50	L
6.	HCl $1+35.5$ $=36.5$	7.3	$\frac{50}{36.5}$	10	L+S

$$\text{soda required} = \frac{106 \times [CaCO_3 \text{ eq. of } MgSO_4 + CaCl_2 + HCl] \times \text{vol.}}{100 \times 1000 \times 1}$$

$$= \frac{106 \times [5 + 1 + 10] \times 25\cancel{000}}{100 \times 1\cancel{000} \times 1}$$

$$= \frac{106 \times 16 \times 25}{100}$$

soda required $= 424g$

Q.7 calculate the COD of effluent water sample if 50 mL of water sample on refluxing with 30 mL 0.05 N $K_2Cr_2O_7$ solutions required 12 mL of 0.05 N FAS solution while blank titration reading is 33 mL.

Sol^n: volume of water sample = 50 mL

Blank titration reading = 33 mL = V_1

Back titration reading = 12 mL = V_2

N(FAS) = 0.051 N

$$COD = \frac{(V_1 - V_2) \times N_{(FAS)} \times 8000}{\text{volume of sample}}$$

$$= \frac{(33-12) \times 0.05 \times 8000}{50}$$

COD = 168 ppm

Q.8 calculate the equivalence of $CaCO_3$ hardness in degree clarke for following: (a) 7.4 mg of $Mg(NO_3)_2$ in 750 mL distilled water

Sol^n: Molecular weight of $CaCO_3$ = 100 g

Molecular weight of $Mg(NO_3)_2$ = 148 g

100 g of $CaCO_3$ = 148 g of $Mg(NO_3)_2$

100 ppm of $CaCO_3$ = 148 ppm of $Mg(NO_3)_2$

$100 \frac{mg}{L}$ of $CaCO_3$ = $148 \frac{mg}{L}$ of $Mg(NO_3)_2$

$x \frac{mg}{L}$ of $CaCO_3$ = $\frac{7.4 \text{ mg}}{750 \text{ mL}}$ of $Mg(NO_3)_2$

= $9.87 \frac{mg}{L}$ of $Mg(NO_3)_2$

$x \frac{mg}{L}$ of $CaCO_3$ = $\left(\frac{100 \times 9.87}{148}\right) \frac{mg}{L}$ of $CaCO_3$

= $6.67 \frac{mg}{L}$ of $CaCO_3$

= $(6.67 \times 0.07)^\circ Cl$ ...[$\because$ 1 mg/L = $0.07^\circ Cl$]

Eq. of $CaCO_3$ hardness = $0.4669^\circ Cl$

Q.9 calculate the equivalence of $CaCO_3$ hardness if 200 lit of 0.1 N HCl used in regeneration of cation exchange column.

Sol^n: Hardness of water = 200L of 0.1 N HCl

= 20L of 1 N HCl

1 L of 1N $CaCO_3$ = 50g of $CaCO_3$

20L of 1 N HCl = x g of $CaCO_3$

x g of $CaCO_3$ = 20 × 50 = 1000 g/L of $CaCO_3$ eq.

= $10^3 \times 10^3$ mg/L of $CaCO_3$ eq.

Hardness = 10^6 ppm of $CaCO_3$ eq

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

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

58.5g of NaCl = 50g of $CaCO_3$ eq.

58.5 $\frac{mg}{L}$ of NaCl = 50 $\frac{mg}{L}$ of $CaCO_3$ eq.

15000 mg of NaCl = $\frac{15000 \times 50}{58.5}$ = 12820.51282 $\frac{mg}{L}$ of $CaCO_3$ eq.

Hardness = 12820.513 ppm

Q.11 calculate the equivalence of $CaCO_3$ hardness for EDTA solution i- 50mL of standard hardwater solution (1.11g of $CaCl_2$ in 1000 mL) required 21 mL of EDTA solution for titration.

Sol^n: 1000 mL of SHW sol^n = 1.11g of $CaCl_2$

1000 mL of SHW sol^n = 1g of $CaCO_3$ eq. [∵ 100 g of $CaCO_3$ = 111 g of $CaCl_2$]

1 mL of SHW sol^n = 1mg of $CaCO_3$ eq.

50 mL of SHW sol^n = 50 mg of $CaCO_3$ eq.

50 mL of SHW sol^n = 21 mL of EDTA sol^n

21 mL of EDTA = 50 mg of $CaCO_3$ eq.

1 mL of EDTA = $\frac{50}{21}$ = 2.3810 mg of $CaCO_3$ eq.

Hardness of EDTA = 2.381 × 1000 = 2381 ppm

Q.2

1. Calculate the GCV of coal if its composition is as follows:

$C = 78\%$, $H = 5\%$, $S = 3\%$, $N = 5\%$, Ash = Remaining

Sol^n: $O = 0\%$ → [as concluded from the given data]

By Dulong's formula,

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

$$= \frac{1}{100}[8080 \times 78 + 34500[5 - 0/8] + 2240 \times 3]$$

$GCV = 8094.60$ kcal/kg

2. Calculate the NCV of coal if its composition is as follows:

$C = 89\%$, $H = 6\%$, $S = 2\%$, $N = 1\%$, Ash = Remaining

Sol^n: $O = 0\%$ [as concluded from the given data]

By Dulong's formula,

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

$$= \frac{1}{100}[8080 \times 89 + 34500(6 - 0/8) + 2240 \times 2]$$

$GCV = 9306$ kcal/kg

$NCV = GCV - (0.09 \times H \times 587)$

$= 9306 - (0.09 \times 6 \times 587)$

$NCV = 8989.02$ kcal/kg

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

Sol^n: wt. of coal = w = 1.2g

wt. after heating = w_1 = 0.88g

$$\%\ \text{moisture} = \frac{w - w_1}{w} \times 100 = \frac{1.2 - 0.88}{1.2} \times 100$$

moisture % = 26.67 %

4. calculate the % VM of coal having 10% moisture content if 1.8g of coal is heated at 920°C for 7 minutes gives residue of 1.09g

soln: % moisture = 10%

wt of coal = $w = 1.8g$

wt. after heating at 920°C = 1.09 g = w_2

wt. after removing moisture = $-\frac{\text{\% moisture} \times w}{100} + w$

$= \frac{-(10 \times 1.8) + 1.8 \times 100}{100}$

$w_1 = 1.62g$

% volatile matter $= \frac{w_1 - w_2}{w} \times 100$

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

% volatile matter = 29.44%

5. 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.

soln: wt of coal = $w = 1.8g$

% moisture = 10%

wt of residue = w_3 = 0.63g ⟶ wt. of ash

% ash = $\frac{w_3}{w} \times 100 = \frac{0.63}{1.8} \times 100 = 35\%$

% ash = 35%

6. calculate % C of coal if 1.56g of coal in combustion experiment gave increase in mass of KOH tube 4.8g.

soln: % C = $\frac{\text{increase in mass of KOH} \times 12 \times 100}{\text{wt. of coal sample} \times 44}$

$= \frac{4.8 \times 12 \times 100}{1.56 \times 44}$

$\% C = 83.92\%$

7. calculate % H of coal if 1.56g of coal in combustion experiment gave increase in mass of $CaCl_2$ tube 1.2g

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

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

$\% H = 8.55\%$

8. calculate the % N if 2.8g of coal in Kjeldahl's experiment required 15mL of 0.05 N KOH solution for neutralization while blank titration is 28mL of 0.05N KOH solution.

soln: vol. of acid used = blank titration − vol. of KOH required

$= 28 - 15$

$= 13 \text{ mL}$

$\% N = \frac{\text{vol. of acid used} \times N \times 1.4}{\text{wt. of coal sample}}$

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

$\% N = 0.325\%$

9. calculate % S in coal if 1.75g of coal in Bomb calorimeter experiment gave mass of 0.66g of $BaSO_4$ residue.

soln: $\% S = \frac{\text{wt. of } BaSO_4 \text{ residue} \times 32 \times 100}{\text{wt. of coal sample} \times 233}$

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

$\% S = 5.18\%$

10. calculate amount of oxygen required for combustion of 5 kg coal if it contains C = 85%, H = 4%, S = 2%, N = 1%, Ash = 4%

Sol^n: wt of coal = 5kg

$C = 85\% = 0.85$ kg

$H = 4\% = 0.04$ kg

$S = 2\% = 0.02$ kg

$N = 1\% = 0.01$ kg

Ash = $4\% = 0.04$ kg

$O = 100 - [85+4+2+1+4] = 4\% = 0.04$ kg

oxygen required = $\frac{32}{12} C + 8\left(H - \frac{O}{8}\right) + S$

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

$= 2.57$ kg

oxygen required for 5 kg coal = $2.57 \times 5 = 12.85$ kg

11. Calculate the mass and 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.

Sol^n: wt. of coal = 2kg

Qty of oxygen = 4.85 kg

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

$= \frac{4.85 \times 100}{23}$

$= 21.09$ kg

Qty of air req. for combustion = $21.09 + \frac{10}{100} \times 21.09 = 23.20$ kg

Mass of air req. = 23.20 kg

Volume of air req. = $\frac{\text{qty. of air} \times 22.4}{28.94} = \frac{23.20 \times 22.4}{28.94}$

Volume of air req. = $17.9572\ m^3$

Q.3

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

Soln: $\% T = 60\%$

$$\text{Absorbance} = -\log\left(\frac{\% T}{100}\right)$$

$$= -\log\left(\frac{6\cancel{0}}{10\cancel{0}}\right)$$

Absorbance = 0.2218

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

Soln: $\% A = 50\%$

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

$$A = -\log\left(\frac{\% T}{100}\right)$$

$$= -\log\left(\frac{5\cancel{0}}{10\cancel{0}}\right)$$

$A = 0.3010$

Absorbance = 0.3010

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

Soln: $A = 0.56$

$l = 0.75$ cm

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

$A = \varepsilon c l$

$$c = \frac{A}{\varepsilon l} = \frac{0.56}{6.4 \times 10^3 \times 0.75} \quad \frac{mol\ \cancel{cm}}{L \cdot \cancel{cm}}$$

$c = 1.1667 \times 10^{-4}$ mol/L

concentration = 1.1667×10^{-4} mol/L

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

Soln: wavelength → constant = 230 nm

	①	②
Path length = l	$l_1 = 2$cm	$l_2 = 1$cm
Transmittance = T	$T_1 = 0.45$	$T_2 = ?$
Absorbance = A	$A_1 = ?$	$A_2 = ?$ (to find)

we know, $A = \varepsilon c l = -\log_{10}[T]$

$A_1 = -\log_{10}[T_1]$

$= -\log_{10}(0.45)$

$A_1 = 0.3468$

$A_1 = \varepsilon c_1 l_1 \rightarrow$ ①

$A_2 = \varepsilon c_2 l_2 \rightarrow$ ②

Dividing ① by ② we get, $\frac{A_1}{A_2} = \frac{\cancel{\varepsilon} \cancel{c_1} l_1}{\cancel{\varepsilon} \cancel{c_2} l_2}$ [Assuming $c_1 = c_2 = c$]
↓
soln is same

$\therefore \frac{0.3468}{A_2} = \frac{2}{1}$

$\therefore A_2 = 0.1734$

Absorbance = 0.1734

5. Calculate molar absorptivity of 10^{-3} M solution having 0.334 absorbance measured in cuvette of length 1.2cm.

Soln: $c = 10^{-3}$ M

$A = 0.334$

$l = 1.2$ cm

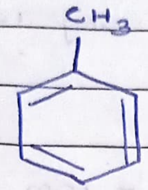
ε = Molar absorptivity $= \frac{A}{cl} = \frac{0.334}{10^{-3} \times 1.2}$

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

Molar absorptivity = $2.7833 \times 10^{2}\ L\ mol^{-1}\ cm^{-1}$

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

Sol^n: (a) Toluene : C_7H_8



Toluene is a non-linear molecule

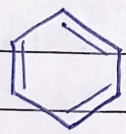
No. of atoms = 7C + 8H = 15

No. of theoretical fundamental modes of vibration = $3n - 6$

$= 3(15) - 6$

$= 39$

(b) Benzene : C_6H_6



Benzene is a non-linear molecule

No. of atoms = 6C + 6H = 12

No. of theoretical fundamental modes of vibration = $3n - 6$

$= 3(12) - 6$

$= 30$

Q. 4

1. A polymer sample consists of 10% by weight macromolecule with mass 10000 and 90% by weight of macromolecule with mass 100000. Calculate M_n, M_w and PDI

Sol^n: 10% weight macromolecule with mass 10000

$w_1 = 10g$

90% weight macromolecule with mas 100000

$w_2 = 90g$

$M_1 = 10000$

$M_2 = 100000$

$$N_1 = \frac{w_1}{M_1} = \frac{10}{10000}$$

$$N_2 = \frac{w_2}{M_2} = \frac{90}{100000}$$

$$\overline{M}_n = \frac{\Sigma w_i}{\Sigma N_i} = \frac{10 + 90}{\frac{10}{10000} + \frac{90}{100000}}$$

$$\overline{M}_n = 10000\left(\frac{100}{10 + 9}\right)$$

$$\overline{M}_n = 5.2632 \times 10^4$$

(No. avg. mol. wt)

$$\overline{M}_w = \frac{\Sigma N_i M_i^2}{\Sigma N_i M_i} = \frac{\Sigma N_i M_i^2}{\Sigma w_i} = \frac{N_1 M_1^2 + N_2 M_2^2}{w_1 + w_2}$$

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

$$\overline{M}_w = 9.1 \times 10^4$$

(Wt. avg. mol. wt)

$$PDI = \frac{\overline{M}_w}{\overline{M}_n} = \frac{9.1 \times \cancel{10^4}}{5.2632 \times \cancel{10^4}} = 1.7290$$

As PDI is greater than 1, the polymer is a polydisperse - polymer

2. A polymeric mixture is prepared by mixing three polymers A, B and C having following composition.

Polymer	No. of molecules	Mass of macro-molecules
A	200	5000
B	500	10000
C	800	15000

Solⁿ: $N_1 = 200$, $M_1 = 5000$

$N_2 = 500$, $M_2 = 10000$

$N_3 = 800$, $M_3 = 15000$

$$\overline{M_n} = \frac{\Sigma N_i M_i}{\Sigma N_i}$$

$$= \frac{N_1 M_1 + N_2 M_2 + N_3 M_3}{N_1 + N_2 + N_3}$$

$$= \frac{200 \times 5000 + 500 \times 10000 + 800 \times 15000}{200 + 500 + 800}$$

$\overline{M_n} = 12000$ (no. avg. mol. wt)

$$\overline{M_w} = \frac{\Sigma N_i M_i^2}{\Sigma N_i M_i}$$

$$= \frac{N_1 M_1^2 + N_2 M_2^2 + N_3 M_3^2}{N_1 M_1 + N_2 M_2 + N_3 M_3}$$

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

$\overline{M_w} = 13055.56$ (wt. avg. mol. wt)

$$\overline{M_z} = \frac{\Sigma N_i M_i^3}{\Sigma N_i M_i^2}$$

$$= \frac{N_1 M_1^3 + N_2 M_2^3 + N_3 M_3^3}{N_1 M_1^2 + N_2 M_2^2 + N_3 M_3^2}$$

$$= \frac{200 \times 5000^3 + 500 \times 10000^3 + 800 \times 15000^3}{200 \times 5000^2 + 500 \times 10000^2 + 800 \times 15000^2}$$

$\overline{M_z} = 13723.40$ (z avg. mol. wt)

$$PDI = \frac{\overline{M_w}}{\overline{M_n}}$$

$$= \frac{13055.56}{12000}$$

$PDI = 1.09 > 1$ [$\therefore$ Polydisperse - polymer]

3. In a polymer, there are 100 molecules of molecular weight of 100, 200 molecules of molecular weight 1000 and 300 molecules of 10000. Find Mn, Mw and PDI

$N_1 = 100,\ M_1 = 100$

$N_2 = 200,\ M_2 = 1000$

$N_3 = 300,\ M_3 = 10000$

$$\overline{M_n} = \frac{\Sigma N_i M_i}{\Sigma N_i}$$

$$= \frac{N_1 M_1 + N_2 M_2 + N_3 M_3}{N_1 + N_2 + N_3}$$

$$= \frac{100 \times 100 + 200 \times 1000 + 300 \times 10000}{100 + 200 + 300}$$

$\overline{M_n} = 5350$ (no. avg mol. wt)

$$\overline{M_w} = \frac{\Sigma N_i M_i^2}{\Sigma N_i M_i}$$

$$= \frac{100 \times 100^2 + 200 \times 1000^2 + 300 \times 10000^2}{100 \times 100 + 200 \times 1000 + 300 \times 10000}$$

$\overline{M_w} = 9408.41 = 9.4084 \times 10^3$ (wt. avg mol. wt)

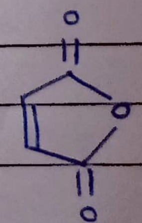
$$PDI = \frac{\overline{M_w}}{\overline{M_n}} = \frac{9408.41}{5350}$$

$PDI = 1.76 > 1$ [Polymer is polydisper]

Q.5

1. calculate the atom economy for the preparation of maleic anhydride from the following reactants: (balance the reaction if required)

(A) $2C_4H_{10} + 5O_2 \longrightarrow 2C_4H_2O_3 + 4H_2O$



(58)	(32)	(98)
× 2	× 5	× 2
= 116	= 160.	= 196

$$\% \text{ Atom economy} = \frac{196}{116+160} \times 100$$

$$= 71.01\%$$

(B) $C_4H_8 + 3O_2 \longrightarrow C_4H_2O_3 + 3H_2O$

(56) (32) $\times 3$ $= 96$ (98)

$$\% \text{ Atom economy} = \frac{98}{56+96} \times 100$$

$$= 64.47\%$$

(C) $C_6H_6 + 4.5O_2 \longrightarrow C_4H_2O_3 + 2H_2O + 2CO_2$

(78) (32) $\times 4.5$ $= 144$ (98)

$$\% \text{ Atom economy} = \frac{98}{78+144} \times 100$$

$$= 44.14\%$$

—x—