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→ Problems

1. A concentration cell was constructed by immersing two silver electrodes in 0.05 M and 0.1 M $AgNO_3$ solution. Write the cell reactions and calculate the EMF of the concentration cell at 298K.

$$E_{cell} = \frac{0.0591}{n} \log\left[\frac{C_2}{C_1}\right], \quad C_2 > C_1$$

Cell reaction :

Anode : $Ag(s) \rightarrow Ag^+_{(0.05M)} + e^-$

Cathode $Ag^+ (0.1M) + e^- \rightarrow Ag(s)$

Cell reaction : $Ag^+(0.1M) \rightarrow Ag^+(0.05M)$

$$E_{cell} = \frac{0.0591}{1} \log\left[\frac{0.1}{0.05}\right]$$

$$= 0.0177\ V$$

2. A concentration cell was constructed by immersing two copper electrodes in 0.01M and 10M $CuSO_4$ solution. Write the cell reactions, cell representation and calculate the EMF of the concentration cell at 298 K

Cell reactions:

Anode: $Cu(s) \rightarrow Cu^{2+}_{(0.01M)} + 2e^-$

Cathode: $Cu^{2+}_{(10M)} + 2e^- \rightarrow Cu(s)$

Cell reaction: $Cu^{2+}_{(10M)} \rightarrow Cu^{2+}_{(0.01M)}$

EMF

$$E_{cell} = \frac{0.0591}{n} \log\left[\frac{C_2}{C_1}\right]$$

$$= \frac{0.0591}{2} \log\left[\frac{10}{0.01}\right]$$

$$= 0.0295 \log 1000$$

$$= 0.0295 \times 3$$

$$= \underline{0.0885 V}$$

Cell representation:

$Cu \mid CuSO_{4(0.01M)} \parallel CuSO_{4(10M)} \mid Cu$

3. The spontaneous galvanic cell $Sn \mid SnSO_4(0.024M) \parallel SnSO_4(0.064M) \mid Sn$, develops an emf of 0.0126 V at 25°C. Calculate the value of Tin.

Given:- $Sn \mid SnSO_{4}(0.024M) \parallel SnSO_{4}(0.064M) \mid Sn$

$$E_{cell} = \frac{0.0591}{n} \log\left[\frac{C_2}{C_1}\right]$$

$$0.0126 = \frac{0.0591}{n} \log\left[\frac{0.064}{0.024}\right]$$

$$n = \frac{0.0591}{0.0126} \log\left[2.6666\right]$$

$$= 4.6904 \times 0.4259$$

$$= 1.9976 \approx \underline{\underline{2}}$$

$\therefore n$ (Valency) $= 2$

4. The emf of concentration cell at 25°C is ~~A~~ 0.024 V. Calculate x.

$$Au \mid Au^{3+}(0.03M) \parallel Au^{3+}(xM) \mid Au$$

$$E_{cell} = \frac{0.0591}{n} \log\frac{[C_2]}{[C_1]}$$

$$0.024 = \frac{0.0591}{3} \log\frac{[xM]}{[0.03M]}$$

$$0.024 = 0.0197 \log\frac{[xM]}{[0.03M]}$$

$$1.2182 = \log\frac{[xM]}{[0.03M]}$$

$$\text{antilog}(1.2182) = \frac{x\,M}{0.03\,M}$$

$10^{\square}$

$(10^{1.2182})$

$$16.527 = \left[\frac{x}{0.03}\right]$$

$$x = 0.4958\ M$$

5. write the cell representation and calculate the EMF of the concentration cell at 25°C consisting of two Zn electrodes immersed in solution of 0.1M and 0.01M $ZnSO_4$ solution connected internally by salt bridge.

Cell representation:

$Zn \mid ZnSO_4(0.01M) \parallel ZnSO_4(0.1M) \mid Zn$

$$E_{cell} = \frac{0.0591}{n} \log\left[\frac{C_2}{C_1}\right]$$

$$= \frac{0.0591}{2} \log\left[\frac{0.1}{0.01}\right]$$

$$= 0.0295 \times 1$$

$$= 0.0295\ V$$

6. Calculate the EMF of the given concentration cell at 298K

$Ag \mid AgNO_3(0.018M) \parallel AgNO_3(1.2M) \mid Ag$

Given: $Ag \mid AgNO_3(0.018M) \parallel AgNO_3(1.2M) \mid Ag$

$$E_{cell} = \frac{0.0591}{n} \log\left[\frac{C_2}{C_1}\right]$$

$$E_{cell} = \frac{0.0591}{1} \log \frac{[1.2]}{[0.018]}$$

$$= 0.0591 \log (66.66)$$

$$= 0.0591 \times 1.8238$$

$$= \underline{0.1077 V}$$

7. A cell is obtained by combining two cadmium electrodes immersed in cadmium sulphate solution of 0.1M and 0.5M at 298 K. Give the cell representation, cell reactions and calculate EMF of the cell.

<u>Cell Representation</u>: $Cd \mid CdSO_4 (0.1 M) \parallel CdSO_4 (0.5M) \mid Cd$

<u>Cell Reaction</u>: Anode : $Cd_{(s)} \rightarrow Cd^{2+}_{(0.1M)} + 2e^-$

Cathode : $Cd^{2+}_{(0.5M)} + 2e^- \rightarrow Cd (s)$

Net Reaction : $Cd^{2+} (0.5M) \rightarrow Cd^{2+} (0.1 M)$

$$E_{cell} = \frac{0.0591}{n} \log \left[\frac{C_2}{C_1}\right]$$

$$= \frac{0.0591}{2} \log \frac{[0.5]}{[0.1]}$$

$$= 0.0295 \times \log (5)$$

$$= 0.0295 \times 0.6989$$

$$= \underline{0.0206 V}$$

Eg: Suppose there are 50 polymers molecules of molecular weight 10^2, 200 polymer molecules of molecular weight 10^3, And then 100 molecules of molecular weight 10^4 Then $\overline{M_n}$ and $\overline{M_w}$?

Given $n_1 = 50 \quad M_1 = 10^2$

$n_2 = 200 \quad M_2 = 10^3$

$n_3 = 100 \quad M_3 = 10^4$

$$\overline{M_n} = \frac{\sum n_i M_i}{\sum n_i} = \frac{\overset{5000}{(50 \times 10^2)} + \overset{2,00,000}{(200 \times 10^3)} + \overset{10,00,000}{(100 \times 10^4)}}{\underset{350}{(50 + 200 + 100)}}$$

$$= \underline{3443} \text{ approx} = \underline{3442.8}$$

g/mol

$$\overline{M_w} = \frac{\sum n_i M_i^2}{\sum n_i M_i}$$

$$= \frac{50 \times (10^2)^2 + 200 \times (10^3)^2 + 100 \times (10^4)^4}{50 \times 10^2 + 200 \times 10^3 + 100 \times 10^4}$$

$$= \frac{50000 + 20,00,00,000 + 10^{18}}{5000 + 2,00,000 + 10,00,000}$$

$$= \underline{8465.14 \text{ g/mol}}$$

1) A polymer sample contains 5 molecules having a molecular weight of 2000, 4 molecules having molecular weight of 3000 and 3 molecules of 4000 m wt. Calculate $\overline{M}_n$ and $\overline{M}_w$?

Given : $n_1 = 5$ $M_1 = 2000$

$n_2 = 4$ $M_2 = 3000$

$n_3 = 3$ $M_3 = 4000$

$$\overline{M}_n = \frac{\Sigma n_i M_i}{\Sigma n_i} = \frac{5 \times 2000 + 4 \times 3000 + 3 \times 4000}{5 + 4 + 3}$$

$$= 2833.33 \text{ g/mol}$$

$$\overline{M}_w = \frac{\Sigma n_i M_i^2}{\Sigma n_i M_i} = \frac{5 \times (2000)^2 + 4 \times (3000)^2 + 3 \times (4000)^2}{5 \times 2000 + 4 \times 3000 + 3 \times 4000}$$

$$\cancel{= 5 \times 4000 + 4 \times}$$

$$= 3058.82$$

2. A polymer has the following composition 100 molecules of molecular ~~(wt)~~ mass 1000 g/mol, 200 molecules of molecular mass 2000 g/mol and 500 molecules of molecular mass 5000 g/mol. Calculate the number and weight average molecular weight.

Ans: $n_1 = 100$, $n_2 = 200$, $n_3 = 500$

$M_1 = 1000\ g/mol$ $M_2 = 2000\ g/mol$ $M_3 = 5000\ g/mol$

$$\cancel{\bar{M}_n = \frac{\sum n_i M_i}{\sum n_i} = \frac{1000+2000+5000}{100+200+500} = \frac{8000}{800}}$$

$$\cancel{\bar{M}_n = 10\ g/mol}$$

$$\bar{M}_n = \frac{\sum n_i M_i}{\sum n_i} = \frac{100 \times 1000 + 200 \times 2000 + 500 \times 5000}{100 + 200 + 500}$$

$$= \underline{3750\ g/mol}$$

$$\bar{M}_w = \frac{\sum n_i M_i^2}{\sum n_i M_i} = \frac{100 \times (1000)^2 + 200 \times (2000)^2 + 500 \times (5000)^2}{\cancel{100+200+500} \quad 100 \times 1000 + 200 \times 2000 + 500 \times 5000}$$

$$\cancel{10^5 + 4 \times 10^6 + 625}$$

$$\bar{M}_w = \frac{10^8 + 8 \times 10^8 + 125 \times 10^8}{10^5 + 4 \times 10^5 + 25 \times 10^5} \quad \cancel{= 44.6}$$

$$= \underline{4466.66\ g/mol}$$

3. Calculate the number average and weight average molecular mass of a polymer sample in which a 30% molecules have a molecular mass 20,000, 40% molecules haves 30,000 and rest have 60,0000.

$$\overline{M}_n = \frac{\Sigma n_i M_i}{\Sigma n_i} = \frac{30 \times 20000 + 40 \times 30000 + 30 \times 60000}{30 + 40 + 30}$$

$$= \underline{36000 \text{ g/mol}}$$

$$\overline{M}_w = \frac{\Sigma n_i (M_i)^2}{\Sigma n_i M_i} = \frac{30 \times (20000)^2 + 40 \times (30000)^2 + 30 \times (60000)^2}{30 \times 20000 + 40 \times 30000 + 30 \times 60000}$$

$$= \frac{12 \times 10^9 + 36 \times 10^9 + 108 \times 10^9}{6 \times 10^5 + 12 \times 10^5 + 18 \times 10^5}$$

$$= \underline{43333.33 \text{ g/mol}}$$