Numericals:

1. A concentration cell was constructed using two iron electrodes in 0.01 M & 0.1 M Ferrous sulphate solution. Write the cell representation and calculate the emf of the cell.

Ans: E_{cell} = 0.02955 V

Given : $[Fe^{2+}]$= 0.01 M

$[Fe^{2+}]$ = 0.1 M

E_{cell} = ?

Cell representation: Fe/ Fe^{2+} (0.01M) // Fe^{2+} (0.1M) / Fe

E_{cell} = 0.0591/n log [0.1]/[0.01]

= 0.0591/2 (1)

= 0.02955 V

2. Represent the concentration cell formed by coupling two Cd electrodes immersed in two Cadmium sulphate solutions. Such that the concentration of Cd^{2+} ions in one electrode system is 0.05 M & that in the other system is 1.0 M, Calculate cell potential.

Ans: E_{cell} = 0.03844 V

Given : $[Cd^{2+}{}_{anode}]$= 0.05 M,

$[Cd^{2+}{}_{cathode}]$ = 1.0 M

E_{cell} = ?

Cell = Cd/ Cd^{2+} (0.05 M) // Cd^{2+} (1.0 M) / Cd

n=2

E_{cell} = 0.0591/n log [1.0]/[0.05]

= 0.02955 log 20

= 0.02955 (1.3010)

= 0.03844 V

3. The spontaneous galvanic cell Tin/Tin ion (0.024 M)//Tin ion (0.064 M)/Tin develops an emf of 0.0216 V at 25° C. Calculate the valency of tin.

Ans: n = 1

Given: E_{cell} = 0.0216 V

Cell : Tin/Tin ion (0.024 M)//Tin ion (0.064 M)/Tin

n =?

E_{cell} = 0.0591/n log [0.064 M]/[0.024 M]

0.0216 = 0.0591/n log 2.6

$n = 0.0591/0.0216 \log 2.6$

$= 2.736\ (0.414)$

$= 1.13 \sim 1$

4. In a spontaneous galvanic cell M/M^{n+} (0.03 N) // M^{n+} (0.064 N)/M develops an emf of 0.013 V at 25^0 C. Calculate the valency of metal.

Ans: n = 1.5

Given: $E_{cell} = 0.013$ V

Cell: M/M^{n+} (0.03 N) // M^{n+} (0.064 N)/M

n =?

$E_{cell} = 0.0591/n \log [0.064\ N]/[0.03\ N]$

$0.013 = 0.0591/n \log 2.133$

$n = 0.0591/0.013 \log 2.133$

$= 4.546\ (0.3289)$

$= 1.49 \sim 1.5$

5. Calculate the $E_{Zn}2+_{/Zn}$ for the reaction Zn^{2+} +2e ---> Zn, Given: $E^o_{Zn}2+_{/Zn}$ = - 0.76 V, $[Zn^{2+}]$ = 0.1 M

Ans: $E_{zn}2+_{/Zn}$ = -0.7895 V

Given: Zn^{2+} +2e ---> Zn

$E^o_{Zn}2+_{/Zn} = -0.76$ V,

$[Zn^{2+}] = 0.1$ M

$E_{Zn}2+_{/Zn} = ?$

$E_{Zn}2+_{/Zn} = E^o_{Zn}2+_{/Zn} + 0.0591/n \log [Zn^{2+}]$

$= -0.76 + 0.0591/2 \log [Zn^{2+}]$

$= -0.76 + 0.0295 \log [0.1]$

$= -0.76 + 0.0295 \log [-1]$

$= -0.7895$ V

6. If two Zn electrodes were in contact with Zn ions, emf of the cell was found to be 0.065 V. If concentration of solution at cathode is 0.1 M, Calculate concentration of other solution.

Ans: $[Zn^{2+}] = 6.32 \times 10^{-04}$ M

Given: E_{cell} =0.065 V,

$[Zn^{2+}{}_{cathode}]$ = 0.1 M

$[Zn^{2+}{}_{anode}]$ =?

Cell : Zn/Zn^{2+} (C_1 M) // Zn^{2+} (0.1 M)/Zn

E_{cell} = 0.0591/n log $[0.1]/[Zn^{2+}]$

0.065 = 0.0591/2 log $[0.1]/[Zn^{2+}]$

0.065 = 0.02955 log $[0.1]/[Zn^{2+}]$

0.065/0.02955 = log $[0.1]/[Zn^{2+}]$

Antilog (2.199) = log $[0.1]/[Zn^{2+}]$

158.12 = log $[0.1]/[Zn^{2+}]$

$[Zn^{2+}]$ = 0.1/158.12

= $6.32X10\text{-}^{04}$ M

7. When a Cu electrode is kept in contact with its solution at 25^0 C, electrode potential is found to be 0.34 V. Calculate concentration of solution. Given $E^0{}_{Cell}$ = 0.33 V.

Ans: $[Cu^{2+}]$ = 3.21 M

Given: E_{Cell} = 0.34 V

$E^o{}_{Cell}$ = 0.33 V

$[Cu^{2+}]$ =?

Ecell = E^oCell + 0.0591/n log $[Cu^{2+}]$

0.345 = 0.33 +0.0591/2 log $[Cu^{2+}]$

0.345 -0.33 = 0.0591/2 log $[Cu^{2+}]$

0.015 = 0.02955 log $[Cu^{2+}]$

0.015/0.02955 = log $[Cu^{2+}]$

Antilog (0.5076) = log $[Cu^{2+}]$

$[Cu^{2+}]$ = 3.21 M

8. 25 cm3 of the hard water sample consumed 10.6 cm3 of 0.01 M EDTA. Calculate the total hardness.

Ans: TH = 424 ppm

Given: V= 10.6 ml, Molarity of EDTA = 0.01 M

1000ml of 1 M EDTA= 100 g. of $CaCO_3$

Hence, 10.6 ml of 0.01 M EDTA = (10.6 X 0.01 X100/1000)

= 0.0106 g. of $CaCO_3$

Hence, Total hardness = [0.0106 /25] 10^6 = 424 ppm

9. 25 cm3 of the hard water sample consumed 12.6 cm3 of 0.01 M EDTA. 25 cm3 of the same water sample after boiling and filtering required 9.2 cm3 of same EDTA for titration. Calculate the total hardness, temporary hardness and permanent hardness.

Ans: TH = 504 ppm, PH = 368 ppm and TempH = 136 ppm

Given: V_1= 12.6 ml, Molarity of EDTA = 0.01 M

After boiling & filtering V_2= 9.2 ml

12.6 ml of 0.01 M EDTA = (12.6 X 0.01 X100/1000)

= 0.012 g. of $CaCO_3$

Hence, Total hardness = [0.012/25] 10^6 ppm = 504 ppm

9.2 ml of 0.01 M EDTA =(9.2 X 0.01 X 100/1000)

= 9.2 X 10^{-03} g. of $CaCO_3$.

Hence, Permanent hardness = (9.2 X 10^{-03} /25)10^6 ppm =368 ppm

Temporary hardness = Total hardness - Permanent hardness

= 504-368

= 136 ppm

10. Calculate the total & permanent hardness of the water sample. If 50 cm^3 of industrial hard water sample was required 20 cm^3 of M/50 (0.02M) EDTA salt solution. The same water sample after boiling & filtering required 13.7 cm^3 of the same EDTA salt solution with the same indicator.

Ans: TH = 800 ppm, PH = 548 ppm and TempH = 252 ppm

Given: V_1= 20 ml, Molarity of EDTA = 0.02 M

After boiling & filtering V_2= 13.7 ml

20 ml of 0.02 M EDTA = (20 X 0.02 X100/1000)

= 0.04 g. of $CaCO_3$

Hence, Total hardness = [0.04/50] 10^6 = 800 ppm

13.7 ml of 0.02 M EDTA =(13.7 X 0.02 X 100/1000)

= 0.0274 g. of $CaCO_3$

Hence, Permanent hardness = $(0.0274/50)10^6$ =548 ppm

Temporary hardness = Total hardness - Permanent hardness

= 800-548 = 252 ppm

11. 100 ml of water sample on titrating 0.01 M EDTA consumed 8.1 ml solution. Another 100 ml of sample after boiling for 20 minutes and filtering, the filtrate consumed 6.1 ml of same EDTA. Calculate total hardness and temporary hardness.

Ans: TH = 81 ppm, PH = 61 ppm and TemH = 20 ppm

Given: V_1= 8.1 ml, Molarity of EDTA = 0.01 M

After boiling & filtering V_2= 6.1 ml, Water sample = 100 ml

8.1 ml of 0.01 M EDTA = (8.1 X 0.01 X100/1000)

= 8.1×10^{-3} g. of $CaCO_3$

Hence, Total hardness = $[8.1 \times 10^{-3}/100]\ 10^6$ ppm = 81 ppm

6.1 ml of 0.01 M EDTA =(6.1 X 0.01 X 100/1000)

= 6.1×10^{-3} g. of $CaCO_3$ in 25 ml water boiled.

Hence, Permanent hardness = $(6.1 \times 10^{-3}/100)10^6$ = 61 ppm

Temporary hardness = Total hardness - Permanent hardness

= 81-61 = 20 ppm

12. 20 ml of sewage sample is reacted with 25 ml of $K_2Cr_2O_7$ solution and the unreacted $K_2Cr_2O_7$ required 9.0 ml of 0.25 N FAS Solution. Under similar conditions in blank titration 15.0 ml of FAS is used up. Calculate the COD of the sample.

Ans: COD = 600 mg/dm3

Given : B-A (15.0-9.0) = 6.0 ml , Normality of FAS = 0.25 N , Sewage sample = 20 ml

Hence , normality of oxygen in waste water N_1 = [(15.0- 9.0)/20] x 0.25

= 0.075 N_1

Hence, C.O.D of the sample = 0.075 x 8 x 1000

= 600 mg dm^{-3}

13. Solve for COD of 25 ml of water sample if 29.5 ml and 20 ml of 0.025 N FAS was required for blank and sample titration repectevely.

Ans: COD = 76 mg/dm3

Given : B-A (29.5-20.0) = 9.5 ml , Normality of FAS = 0.025 N , Sewage sample = 25 ml

Hence , normality of oxygen in waste water N_1 = [(29.5-20.0)/25] x 0.025

= 9.5 x 10^{-03} N_1

Hence, C.O.D of the sample = 9.5 x 10^{-03} x 8 x 1000

= 76 mg dm^{-3}

14. Calculate the BOD value of a sewage sample containing 10.2 mg/ 200 ml of organic mater with the formula $C_6H_{12}O_6$ (C = 12, H = 1, O = 16)

Ans: COD = 54.4 ppm

Given: Sewage sample = 10.2 mg/ 200ml

$C_6H_{12}O_6$ = 180

$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$

180 192

180 mg of $C_6H_{12}O_6$ required 192 mg of O_2 for Complete Oxidation

BOD of sample = 192 x 10.2/ 180

= 10.88 mg

= 10.88 x 1000/ 200

= 54.4 ppm

15. 1 dm^3 of water containing 200 mg of glucose (C_6 $H_{12}O_6$) completely oxidized to CO_2 and H_2O. Calculate the BOD of the waste water. (Given: C = 12, H = 1, O = 16)

Ans: BOD = 213.3 ppm

Given: 1 dm^3 water sample = 200 mg of glucose (C_6 $H_{12}O_6$)

$C_6H_{12}O_6$ = 180

$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$

180 192

180 mg of $C_6H_{12}O_6$ required 192 mg of O_2 for Complete Oxidation

BOD of sample = 200 x 192/ 180

= 213.3 ppm