*. Applications — Nernst Equation —

(1) Calculation of emf of the cell.

$$Zn \,|\, Zn^{++} \,||\, Cu^{++} \,|\, Cu.$$

By applying Nernst eq^{n} —

$$E = E^{\circ} - \frac{0.0591}{2} \log \frac{[Cu]\,[Zn^{++}]}{[Zn]\,[Cu^{++}]}$$

In the Standard state, the activity of a solid is taken as unity.

$$\therefore E = E^\circ - \frac{0.0591}{2} \log \frac{[Zn^{++}]}{[Cu^{++}]}$$

(2) Calculation of Equilibrium Constant

Consider a equilibrium reaction—

$$aA + bB \rightleftharpoons cC + dD$$

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

The Nernst eqn may be represented as—

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{n} \log \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

At equilibrium—

$$E_{cell} = 0$$

$$0 = E^\circ_{cell} - \frac{0.0591}{n} \log K_c$$

$$\log K_c = \frac{E^\circ_{cell} \times n}{0.0591}$$

$$\therefore \boxed{E^\circ_{cell} = \frac{0.0591}{n} \log K_c}$$

(3) Calculation of the single electrode potential. –

$$Zn^{++} + 2e^- \rightarrow Zn$$

$$E = E^\circ - \frac{RT}{nF} \ln \frac{[Zn]}{[Zn^{++}]}$$

$$= E^\circ - \frac{RT}{nF} \ln \frac{1}{[Zn^{++}]}$$

$$E = E^\circ + \frac{RT}{nF} \ln [Zn^{++}]$$

If concentration of 'Zn' is unity.

$$E = E^\circ + \frac{RT}{nF} \ln [Zn^{++}]$$

$$\boxed{E = E^\circ + \frac{0.0591}{n} \log [Zn^{++}].}$$

In general –

$$M^{n+} + ne^- \rightarrow M$$

$$\boxed{E = E^\circ + \frac{0.0591}{n} \log [M^{n+}].}$$

Notes

(4) To Find out the pH of a Solution :-

Nernst equation is also used to find out the pH of a solution.

$$Pt(s) \,|\, H_2(g) \,|\, H^+ \,||\, Ag^+(aq) \,|\, Ag(s)$$

(1 atm) (1 M)

Given, $E = 0.900\ V$ (at 298 K)

$E^\circ_{Ag^+/Ag} = 0.80V$, $E^\circ_{2H^+/H_2} = 0$.

The cell reaction is —

$$H_2(g) \longrightarrow 2H^+(aq) + 2e^-$$

$$Ag^+_{(aq)} + 1e^- \longrightarrow Ag(s) \quad] \times 2$$

$$H_2 + 2Ag^+ \longrightarrow 2H^+ + 2Ag$$

$n = 2$

$$E^\circ_{cell} = 0.80V - 0 = 0.80V$$

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{n} \log \frac{[H^+]^2}{p_{H_2} + [Ag^+]^2}$$

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{2} \log \frac{(H^+)^2}{1\,atm + 1\,M^2}$$

Notes

$$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{2} \log [H^+]^2$$

$$\log [H^+]^2 = (E^{\circ}_{cell} - E_{cell}) \times \frac{2}{0.0591}$$

$$= (0.80V - 0.900V) \times \frac{2}{0.0591}$$

$$= -0.10V \times \frac{2}{0.0591}$$

$$\log [H^+]^2 = -3.381$$

$$2 \log [H^+] = -3.381$$

$$\log [H^+] = \frac{-3.381}{2} = -1.6905$$

taking -ve sign both sides

$$-\log [H^+] = -(-1.6905)$$

$$pH = 1.6905$$

$$pH \simeq 1.7$$