ENGINEERING CHEMISTRY

Department of Science and Humanities

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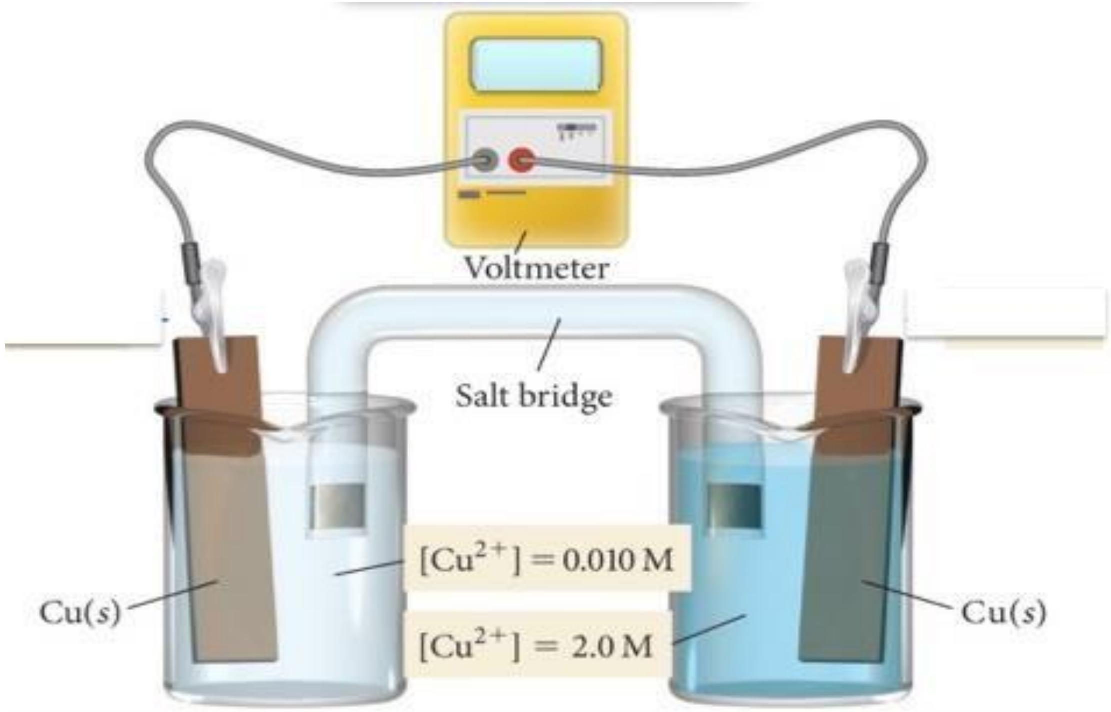
Class content:

- ***Concentration cells***
  - ***Types of concentration cells***
    - ***Electrolyte concentration cells***
    - ***Electrode concentration cells***

Concentration cells:

- An electrochemical cell in which identical electrodes are in contact with a solution of identical species but of different concentration



https://chemdemos.uoregon.edu/demos/Voltaic-Cell-CuCu-concentration-cell-Demonstration

- In this cell 2 copper electrodes are immersed in copper sulphate solutions of concentration c_1 & c_2 , such that $c_2 > c_1$
- An electrolyte has spontaneous tendency to diffuse from a solution of higher concentration to a solution of lower concentration which is the **driving force** for development of potential
- Oxidation takes place at anode and reduction takes place at cathode
- e.g.,**$Cu/Cu^{2+}(c_1)//Cu^{2+}(c_2)/Cu$**

Reactions :

At anode: $Cu \rightarrow Cu^{2+} (c_1) + 2e^-$

At cathode: $Cu^{2+} (c_2) + 2e^- \rightarrow Cu$

Expression for cell potential:

The emf of the cell = $E_{cathode} - E_{anode}$

$$E_{cathode} = E^o + \frac{2.303RT}{nF} \log c_2$$

$$E_{anode} = E^o + \frac{2.303RT}{nF} \log c_1$$

$$E_{cell} = \left(E^o + \frac{2.303RT}{nF} \log c_2 \right) - \left(E^o + \frac{2.303RT}{nF} \log c_1 \right)$$

$$E_{cell} = \frac{2.303RT}{nF} \log\left(\frac{c_2}{c_1}\right)$$

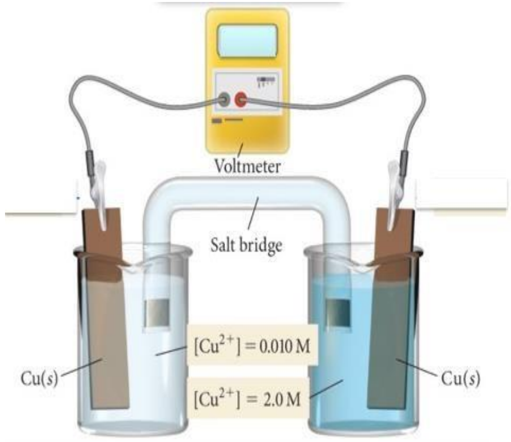
$$\text{At 298K,} \quad E_{cell} = \frac{0.0591}{n} \log\left(\frac{c_2}{c_1}\right)$$

Electrochemical equilibria

- The emf of the cell is positive only if $c_2 > c_1$

  i.e., conc of metal ion at cathode > conc. of metal ion at anode

- The emf of the cell depends upon the ratio c_2/c_1
- When $c_2 = c_1$, the emf of the cell becomes zero
- During working of the cell, concentration of ions increases at anode decreases at cathode
- When current is drawn from the cell c_1 increases and c_2 decreases
- The cell can operate only as long as the concentration terms are different



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Types of concentration cells:

- Electrolyte concentration cell
- Electrode concentration cell

Electrolyte concentration cell:

- Electrolyte concentration cell consists of two same electrodes that are dipped in the same electrolyte but with different concentrations of electrolytes
- $Cu/Cu^{2+}(c_1)//Cu^{2+}(c_2)/Cu$
- Cell potential is given by

$$E_{cell} = \frac{2.303RT}{nF} \log\left(\frac{c_2}{c_1}\right)$$

Electrode concentration cell

- Electrode concentration cell consists of two identical electrodes of different activity which are dipped in the same solution of electrolyte
- $Na\text{-}Hg(c_1)/Na^{+}/Na\text{-}Hg(c_2)$
- Cell potential is given by

$$E_{cell} = \frac{2.303RT}{nF} \log \frac{Na\text{-}Hg(c_1)}{Na\text{-}Hg(c_2)}$$

- **Na-Hg(c_1)/Na^+/Na-Hg(c_2) :**

  Reactions are :

  At anode: Na-Hg(c_1) $\rightarrow Na^+ + e^-$

  At cathode: $Na^+ + e^- \rightarrow$ Na-Hg(c_2)

Cell potential = $E_{cathode} - E_{anode}$

$$E_{cathode} = E^o - \frac{2.303RT}{nF}\log\frac{\text{Na–Hg}(c_2)}{\text{Na}^+}$$

$$E_{anode} = E^o - \frac{2.303RT}{nF}\log\frac{\text{Na–Hg}(c_1)}{\text{Na}^+}$$

$$E_{cell} = \frac{2.303RT}{nF}\log\frac{\text{Na–Hg}(c_1)}{\text{Na–Hg}(c_2)}$$

- **$Pt/H_2(p_1\ atm)/H^+/H_2(p_2\ atm)/Pt$:**
  Nernst Equation:

$$E_{cell} = \frac{2.303RT}{nF}\log\frac{p_1}{p_2}$$

- **$Pt/Cl_2(p_1\ atm)/Cl^-/Cl_2(p_2\ atm)/Pt$:**
  Nernst Equation:

$$E_{cell} = \frac{2.303RT}{nF}\log\frac{p_2}{p_1}$$

THANK YOU

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