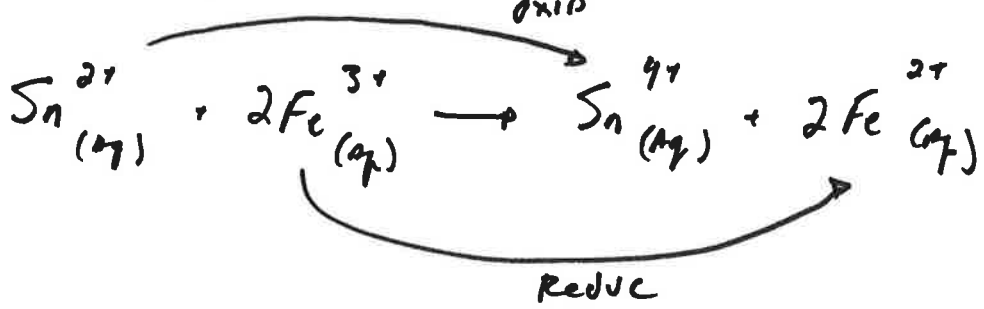
CH 20 Electrochemistry

20.1 Oxidation Reduction



20.2 Balancing Redox Reaction

Half Reaction

$$Sn^{2+}_{(aq)} + 2Fe^{3+}_{(aq)} \longrightarrow Sn^{4+}_{(aq)} + 2Fe^{2+}_{(aq)}$$

Oxidation $Sn^{2+}_{(aq)} \longrightarrow Sn^{4+}_{(aq)} + 2e^-$

Reduction $2Fe^{3+}_{(aq)} + 2e^- \longrightarrow 2Fe^{2+}_{(aq)}$

Rules

1) Divide equation in ½ oxidat - Reduct

2) Balance

A) other atoms

B) O $\longrightarrow$ H_2O

C) H $\longrightarrow$ H^+

D) Charge $\longrightarrow$ e^-

3) Multiply to cancel out electrons From Both sides - make them Equal

4) ADD Half Reactions Simplify By Cancelling

5) Check Atoms + Charge Balance

$$Sn^{2+} + 2Fe^{3+} \longrightarrow Sn^{4+} + 2Fe^{2+}$$

$$Sn^{2+} \longrightarrow Sn^{4+} \qquad 2Fe^{3+} \longrightarrow 2Fe^{2+}$$

$$Sn^{2+} \longrightarrow Sn^{4+} + 2e^- \qquad 2e^- + 2Fe^{3+} \longrightarrow 2Fe^{2+}$$

$$Sn^{2+} + \cancel{2e^-} + 2Fe^{3+} \longrightarrow 2Fe^{2+} + Sn^{4+} + \cancel{2e^-}$$

$$Sn^{2+} + 2Fe^{3+} \longrightarrow 2Fe^{2+} + Sn^{4+}$$

Balancing in Basic Solutions

1) Use OH^- and H_2O instead of H^+ and H_2O

$CN^- + MnO_4^- \longrightarrow CNO^- + MnO_2$ (Basic)

$\overset{+4\ -5}{CN^-} \longrightarrow \overset{+4\ -3}{CNO^-}$ (O: −2) oxidized

$\overset{+7}{MnO_4^-} \longrightarrow \overset{+4}{MnO_2}$ Reduced

Step 2 $CN^- + H_2O \longrightarrow CNO^-$

Step 3 $CN^- + H_2O \longrightarrow CNO^- + 2H^+$

Step 4 $CN^- + H_2O \rightarrow CNO^- + 2H^+ + 2e^-$

Step 2 $MnO_4^- \longrightarrow MnO_2 + 2H_2O$

Step 3 $4H^+ + MnO_4^- \longrightarrow MnO_2 + 2H_2O$

Step 4 $3e^- + 4H^+ + MnO_4^- \longrightarrow MnO_2 + 2H_2O$

Balance H^+ By adding OH^- to (4)

Both Sides

Step 5 $2OH^- + CN^- + H_2O \longrightarrow CNO^- + \cancel{2H^+} + 2e^- + \cancel{2OH^-}$

cancel $\longrightarrow 2H_2O$

Step 6 $2OH^- + CN^- \longrightarrow CNO^- + H_2O + 2e^-$

Step 5 $\cancel{4OH^-} + 3e^- + \cancel{4H^+} + MnO_4^- \longrightarrow MnO_2 + 2H_2O + 4OH^-$

$4H_2O$ ← cancel

Step 6

$3e^- + 2H_2O + MnO_4^- \longrightarrow MnO_2 + 4OH^-$

Multiply to Have Both equations Match electrons

Step 7 ~~$6OH^-$~~ + $3CN^-$ → $3CNO^-$ + ~~$3H_2O$~~ + ~~$6e^-$~~

$6e^-$ + ~~4~~ H_2O + $2MnO_4^-$ → $2MnO_2$ + ~~8~~ $2OH^-$

ADD

$H_2O + 3CN^- + 2MnO_4^- \longrightarrow 2MnO_2 + 2OH^- + 3CNO^-$

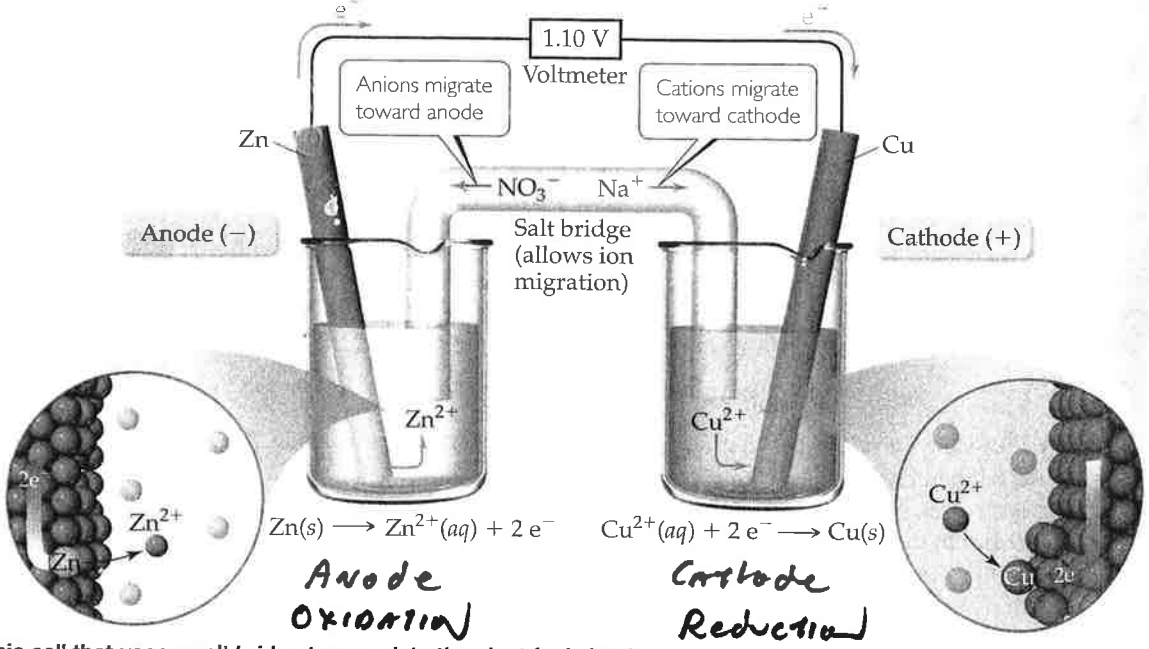
½ Reaction

Charge −5 Charge −5

20.3 Voltaic cells

GO FIGURE

How is electrical balance maintained in the left beaker as Zn^{2+} ions are formed at the anode?



▲ FIGURE 20.5 **A voltaic cell that uses a salt bridge to complete the electrical circuit.**

*To help remember these definitions, note that *anode* and *oxidation* both begin with a vowel, and *cathode* and *reduction* both begin with a consonant.

Zinc is liberating electrons which move through metal wire to the copper.

Salt Bridge Balances out the charge difference

$$1\ \text{Volt} = \frac{1\ \text{Joule}}{\text{Coulomb}} \qquad \text{Charge / electron} = 1.60 \times 10^{-19}\ \text{C}$$

E°_{cell} = Standard cell potential (emf. Electro motive force)

E° — std conditions Cell potential always positive

E°_{red} = Standard Reduction potentials

$$E^{\circ}_{cell} = E^{\circ}_{red} - E^{\circ}_{red}$$

Cathode — Anode

Reduction — Oxidation

$Zn^{2+} + 2e^{-} \rightarrow Zn_{(s)}$ = -0.76

$Cu^{2+} + 2e^{-} \rightarrow Cu_{(s)}$: +0.34

$$E^{\circ}_{cell} = E^{\circ}_{Red} - E^{\circ}_{red}$$

Cathode — Anode

Cathode : $Cu^{2+} + 2e^{-} \rightarrow Cu$ = 0.34

Anode = $Zn_{(s)} \rightarrow Zn^{2+} + 2e$ = -0.76

* Sign change is built into equation

$$E^{\circ}_{cell} = 0.34V - -0.76V$$

$$E^{\circ}_{cell} = +1.10V$$

$2H^+ + 2e^- \rightarrow H_2 = 0V$

SHE - Standard Hydrogen electrode

Although ½ Reactions may be multiplied By factors they are NOT multiplied in Determing E°_{cell}

(Standard Reduction Potential is an Intensive property. <u>independent</u> of Stoichiometric coefficients)

$Cd^{2+} + 2e^- \rightarrow Cd(s)$ $\quad E^\circ_{red} = -0.403V$

$Sn^{2+} + 2e^- \rightarrow Sn(s)$ $\quad E^\circ_{red} = -0.136V$

Tin more positive = Cathode

$$E^\circ_{cell} = E^\circ_{red} - E^\circ_{red}$$

Cathode Anode

$$E^\circ_{cell} = (-0.136\,V) - (-0.403\,V) = 0.267\,V$$