## 13-5 ~~~~. $E^\circ$ and the Equilibrium Constant:

A galvanic cell produces electricity because the cell reaction is not at equilibrium.

At equilibrium, $E$ (not $E^\circ$) $= 0$

When a battery (which is a galvanic cell) runs down to 0 V, the chemicals inside have reached equilibrium and the battery is "dead."

Now let us relate $E$ for a whole cell to the reaction quotient, $Q$, for the net cell reaction.

For the two half-reactions.

Right electrode: $aA + ne^- \rightleftharpoons cC \quad E^\circ_+$

Left electrode: $dD + ne^- \rightleftharpoons bB \quad E^\circ_-$

the Nernst Equation looks like this:

$$E = E_{+} - E_{-}$$

$$= \left(E_{+}^{o} - \frac{0.05916}{n} \log \frac{[C]^{c}}{[A]^{a}}\right) -$$

$$\left(E_{-}^{o} - \frac{0.05916}{n} \log \frac{[B]^{b}}{[D]^{d}}\right)$$

$$\therefore E = \underbrace{\left(E_{+}^{o} - E_{-}^{o}\right)}_{E^{o}} - \frac{0.05916}{n} \log \underbrace{\frac{[C]^{c}[D]^{d}}{[A]^{a}[B]^{b}}}_{Q}$$

$\because \log a + \log b = \log ab$

$$\boxed{E = E^{o} - \frac{0.05916}{n} \log Q}$$

The above equation is true at any time.

In the special case when the cell is at equilibrium, $E = 0$ and $Q = k$, the equilibrium constant.

$\therefore$ the above equation is transformed to these most important forms at equilibrium

$$\boxed{E^\circ = \frac{0.05916}{n} \log k}$$

(at 25°C)

(Finding $E^\circ$ from k)

$\because$ $E = 0$
$Q = k$

Finding $k$ from $E^\circ$

$$\boxed{k = 10^{nE^\circ/0.05916}}$$

(at 25°C)

$\because E^\circ = \frac{0.05916}{n} \log k$

$\therefore \log k = \frac{nE^\circ}{0.05916}$

$10^{\log k} = 10^{nE^\circ/0.05916}$

$\therefore k = 10^{nE^\circ/0.05916}$