$$\star\ \boxed{\Delta G^\circ = -RT\ln K} \qquad K = e^{-\frac{\Delta G^\circ}{RT}}$$

if $K \gg 1$, $\Delta G^\circ = -ve$

$K \sim \frac{P}{R}$

if $K \ll 1$, $\Delta G^\circ = +ve$

$K \sim \frac{P}{R}$

if $K \approx 1$, $\Delta G^\circ \approx 0$

$$\Delta G = \Delta G^\circ + RT\ln Q$$

ΔG: what you've got.

ΔG°: STD conditions
1 M
1 atm
sld - pure

Q: Q_c, Q_p ?

Mix + match approach ...

Use P for gases
Use [ ] for solutes
} Q, K

ex: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$$Q = \frac{P_{NH_3}^2}{P_{N_2} \cdot P_{H_2}^3}$$

↑ thermodynamic reaction quotient.

ex: $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

$$Q = [Ag^+][Cl^-]$$

$2HCl(aq) + CaCO_3(s) \rightleftharpoons H_2O(l) + CO_2(g) + CaCl_2(aq)$

$$Q = \frac{P_{CO_2} \cdot [CaCl_2]}{[HCl]^2}$$

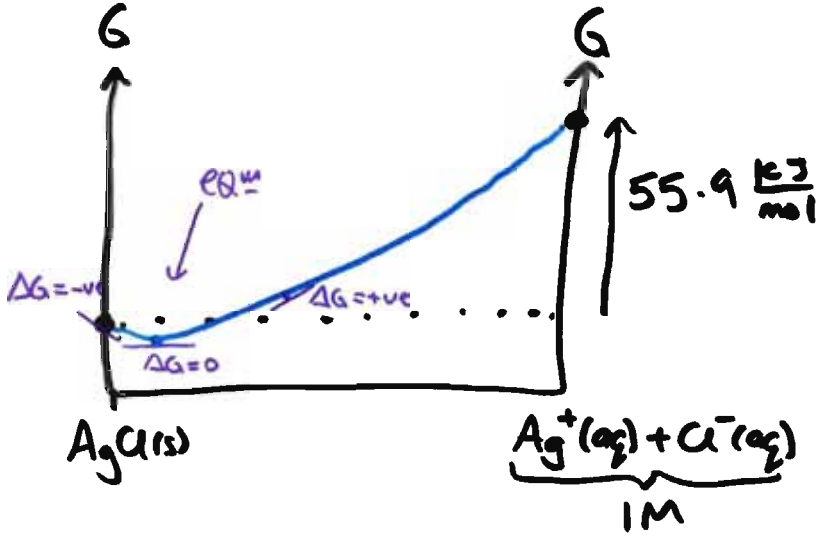
if $K_{sp}(AgCl) = 1.6 \times 10^{-10}$ @ 25°C

what's ΔG°?

$$\Delta G^\circ = -RT \ln K$$

$$= -8.3145 \frac{J}{mol \cdot K} \times 298K \times \ln(1.6 \times 10^{-10})$$

$$= +55.9 \text{ kJ/mol}$$



if $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta G^\circ = +5.40 \frac{kJ}{mol}$ (25°C)

let's say $P_{NO_2} = 0.150$ atm

$P_{N_2O_4} = 0.500$ atm.

what's dirx of rxn?

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$$Q = \frac{P_{NO_2}^2}{P_{N_2O_4}} = \frac{0.150^2}{0.500} = 0.0450$$

$$\Delta G = 5{,}400 \frac{J}{mol} + 8.3145 \frac{J}{mol \cdot K} \times 298K \ln$$

$$= -2280 \text{ J/mol}$$

$$= -2.28 \text{ kJ/mol}$$ spontaneous! fwd.

$\Rightarrow$ free energy

↳ 2280 J of useful work

Just like ΔH, ΔG's can be added.

Hess's Law

ex: ① $Ala + Gly \longrightarrow Ala\text{-}Gly \quad \Delta G^\circ = +29 \frac{KJ}{mol}$

but: $ATP + H_2O \longrightarrow ADP + P_i \quad \Delta G^\circ = -31 \frac{KJ}{mol}$

(+)

$Ala + Gly + ATP + H_2O \longrightarrow Ala\text{-}Gly + ADP + P_i$

② coupled

$\Delta G^\circ = +29 - 31$

$= -2 \frac{KJ}{mol}$

$\Delta G^\circ = -RT \ln K$

$K = e^{-\Delta G^\circ / RT}$

① $K = e^{\frac{-29{,}000\ J/mol}{8.3145 \frac{J}{mol \cdot K} \times 298K}} = 8.26 \times 10^{-6}$

② $K = e^{\frac{--2000\ J/mol}{8.3145 \frac{J}{mol \cdot K} \times 298K}} = 2.24$

Ch 19: Redox Rxns + Electrochemistry

Reduction gain of e^-s

Oxidation loss of e^-s

Ⓐ produce elec from chem rxns.

Ⓑ drive non-spont. chem rxns using elec.

ex: $Al^{3+} \longrightarrow Al$

Redox

ox #'s (see Ch. 3) ± # charge: #↑

oxidized reduced

ex: $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

(0) (+1)(-1) (+2)(-1) (0)

ox #↓ reduced

ox #↑, oxidized

Balancing Redox eqs is HARD!

- Use the ½-rxn method.
- split the overall rxn into two ½-rxns.
  - i) ox ii) red

for example: let's say that Fe^{2+} ions are oxidized into Fe^{3+} by dichromate ions ($Cr_2O_7^{2-}$), which are converted into Cr^{3+}.

$$Fe^{2+} + Cr_2O_7^{2-} \longrightarrow Fe^{3+} + Cr^{3+}$$

skeleton rxn.

- often carried out under v. high / low pH
  OH^- H^+

let's balance above rxn under acidic conditions.