1. theory: temp $\dot{s}$ Equilibria.

g

$$\triangle$$

S ℓ

for all ΔH
ΔS

$\leftarrow$ evaporation
$\Delta H > 0$
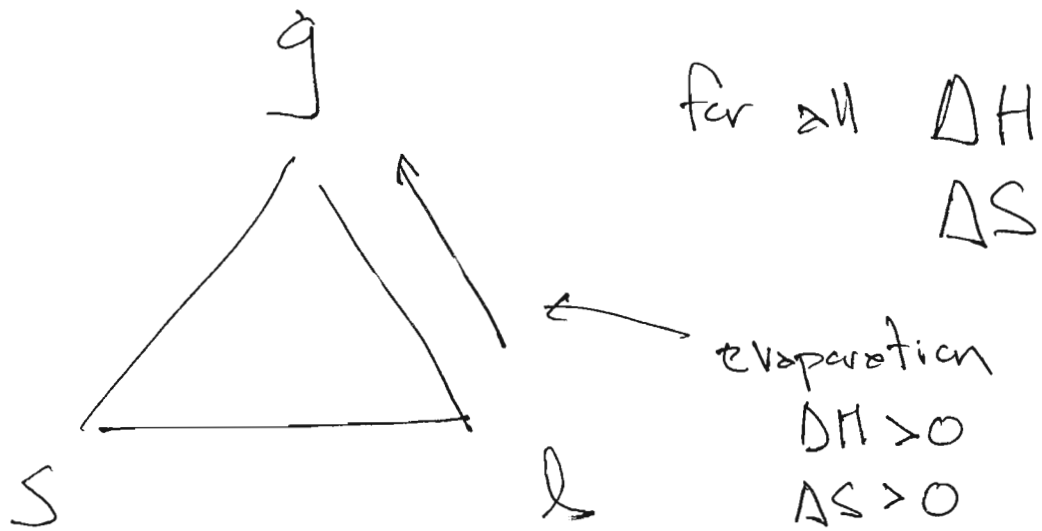$\Delta S > 0$

which phase favored at high or low
T.

2. Theory dissolving gases, solid, liq

if it dissolves $\longrightarrow$ spontaneous

$$\Delta G < 0$$

$$\Delta G = \Delta H - T\Delta S$$

$\uparrow$ $\uparrow$ $\uparrow$
want   neg   pos
neg

$\Delta S_{mix} > 0$
not true for
high charge
density ions.

water + salt $\longrightarrow$ aqueous sol'n

want $\longrightarrow \Delta H_{sol'n} = \Delta H_{lattice} + \Delta H_{Hydration}$
$+$ $-$

3. Theory - dissolving   Gases. $T\uparrow$ solubility $\downarrow$

See #2 $\Delta H_{sol'n} = \Delta H_{lat} + \Delta H_{Hydrat}$
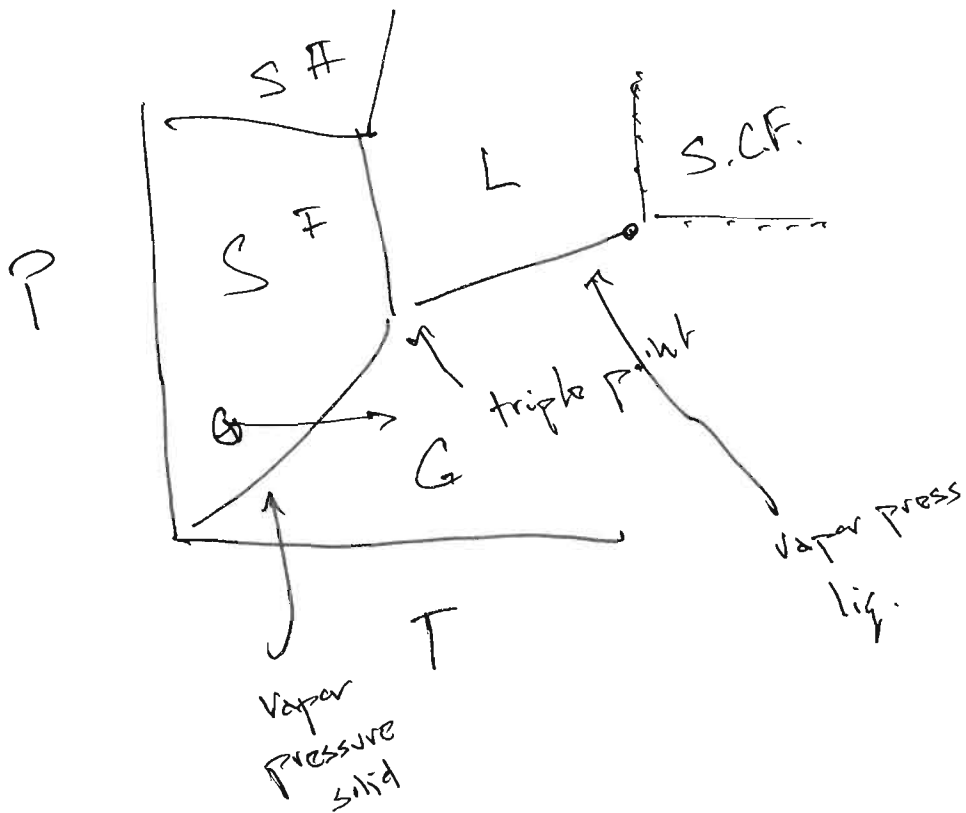   always exothermic.   NEG

4. Ranking Miscibility of Liq.

like dissolves (mixes) like.

Best   most similar IMF.

5. Phase Diagrams

S#

L   S.C.F.

P   S#

triple point

G

vapor press liq.

T

Vapor pressure solid

6. ΔH for phase change and/or ΔT

$$\text{heat} = \Delta H \qquad \text{phase change}$$

at the $\longrightarrow$ $\Delta H_{trans} \times n$

phase transition

temp.

heat for melting $36 g$ ice $\longrightarrow$ 2 mol H_2O

$$2 \times \Delta H_{fus, H_2O} =$$

_____

$$\text{heat} = C \times \Delta T = C \times m \times \Delta T$$

$\uparrow$ Energy Temp^{-1} $\uparrow$ $\uparrow$ $\uparrow$

$\qquad$ mass $\qquad$ change in T

Specific heat

7. Theory: Vapor Pressure

Equilibrium.

$$G_\ell = G_{gas}$$

INDEPENDENT OF VOLUME!

Depends on IMF of liq.

Strong IMF $\longrightarrow$ low V.P.

Weak IMF $\longrightarrow$ high V.P.

$\boxed{T \uparrow \qquad V.P. \uparrow}$

Dynamic Equil.

constant evap & condensation

8. Claussius - Clapeyron Calc.

plus in formula.

$$\ln\left(\frac{P_2}{P_1}\right) = -\frac{\Delta H_{vap}}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

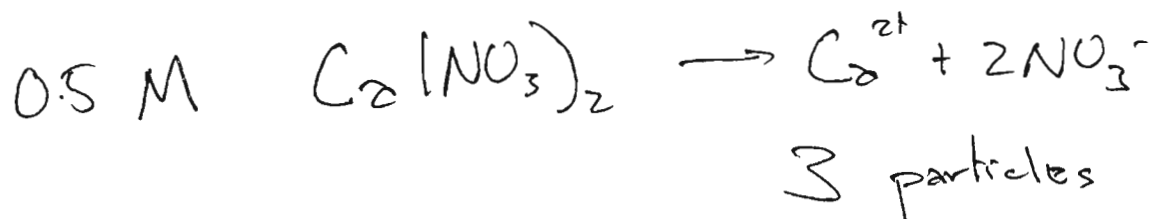$$P_1, T_1, P_2, T_2, \Delta H$$

9. Ranking Colligative Prop.

Qualitative.

Biggest change.
Smallest change.

conc $\dot{s}$ Van't Hoff #

\# of particles.

Need know common Ions.

$$0.5 \text{ M} \quad Ca(NO_3)_2 \longrightarrow Ca^{2+} + 2NO_3^-$$

3 particles

10. Calc. CollJigative

Easy. don't forget
Van't Hoff #.

$$\Delta T = i K_f \underline{\underline{M}}$$

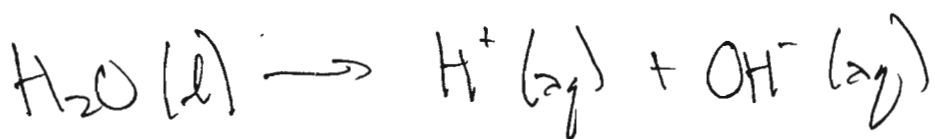Use correct formula.

B.P. ele., F.P. depress, Osmotic Press.

CHEMICAL EQUILIBRIA

11.

K & balanced Eq'n

Easy, easy.

Balanced Eq'n $\longrightarrow$ K.
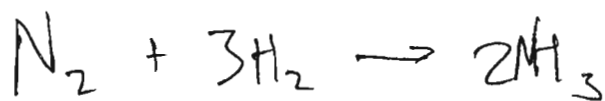
don't include solids & liquids.
Activity = 1.

$$H_2O (l) \longrightarrow H^+ (aq) + OH^- (aq)$$

$$K = \frac{[H^+][OH^-]}{1} = [H^+][OH^-]$$

12. Calculations using Conc. & K

Balanced eqn + data

$$\downarrow$$

Find value for K $\Big\{$ given

$$N_2 + 3H_2 \longrightarrow 2NH_3 \qquad K_p = \frac{P_{NH_3}^2 \Big\} \text{given}}{P_{H_2}^3 \, P_{N_2}} = \text{find.}$$

13. RXN direction Q & K

~~an~~ is the system at equilibrium?

$$H_2 + F_2 \longrightarrow 2HF$$

$$Q = \frac{P_{HF}^2}{P_{H_2} \, P_{F_2}}$$

$$\uparrow$$
NOW

Q > K
shift back to R
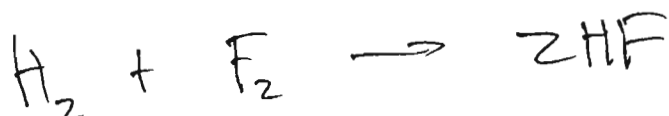
Q < K
rxn shift to P

14. Le Chatlier

changing   conc.
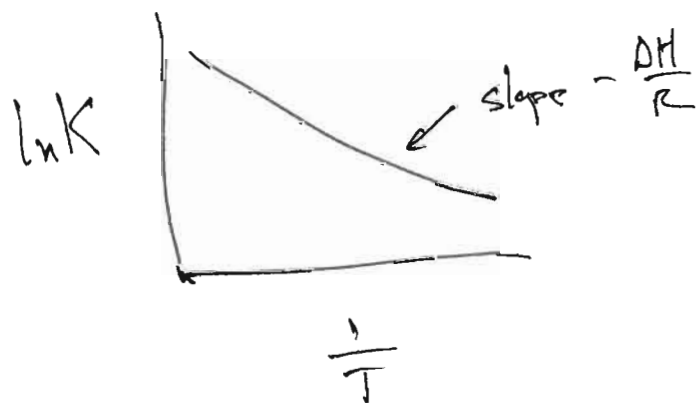
changing   temp (ΔH)

changing   P (or V) (Δn_{gas})

System "opposite" of stress.

15: Temp Dep of equilibria.

$$\ln\left(\frac{K_2}{K_1}\right) = -\frac{\Delta H}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

Qualitative.   Exothermic $\rightarrow$ T↑ K↓

Endo   T↑ K↑

$\ln K$ slope $-\frac{\Delta H}{R}$

$\frac{1}{T}$

16. Temp Dep of K_w

$H_2O \longrightarrow H^+ + OH^-$

$$K_w = [H^+][OH^-]$$

Endothermic. $T\uparrow \quad K\uparrow$

$T = 25°C \quad \underline{\underline{K_w = 10^{-14}}} \quad T = 80° \quad K_w \neq 10^{-14}$

17. Ranking A/B strength from K

EASY.

Larger K_a stronger Acid

Larger K_b stronger Base

$$K_a \times K_b = K_w$$

$F^-, CH_3COO^- \longleftarrow A^- \text{ (weak base)}$

$K_a \rightarrow HF \quad K_a = CH_3COOH \longrightarrow K_b$

18. Acid Assumptions   amphiprotic   well-separated
                                                  K's.

     Weak Acid $[H^+] \approx \sqrt{K_a C_a}$

  IGNORED K_w $[H^+]_o = 0$ trouble if K_a is

                                      close to K_w

  Final $C_A = C_{A_o}$ didn't dissociate.

                          weak acid. K_a to be

                                       small.

  concentration to be large. NO DILUTE SOL'N.

19. Simple A/B (strong, weak, buffer)

            use the right formula.

$$K_b, \; C_b \longrightarrow [OH^-] \; ?$$

$$[OH^-] = \sqrt{C_b \times K_b}$$

$$\boxed{[H^+], [OH^-], pH, pOH .}$$

20. See #19

21. Identify Buffer

   which is a buffer
   "   is n<u>ot</u> a buffer.

   Neutralize $\longrightarrow$ HA & A^- ?

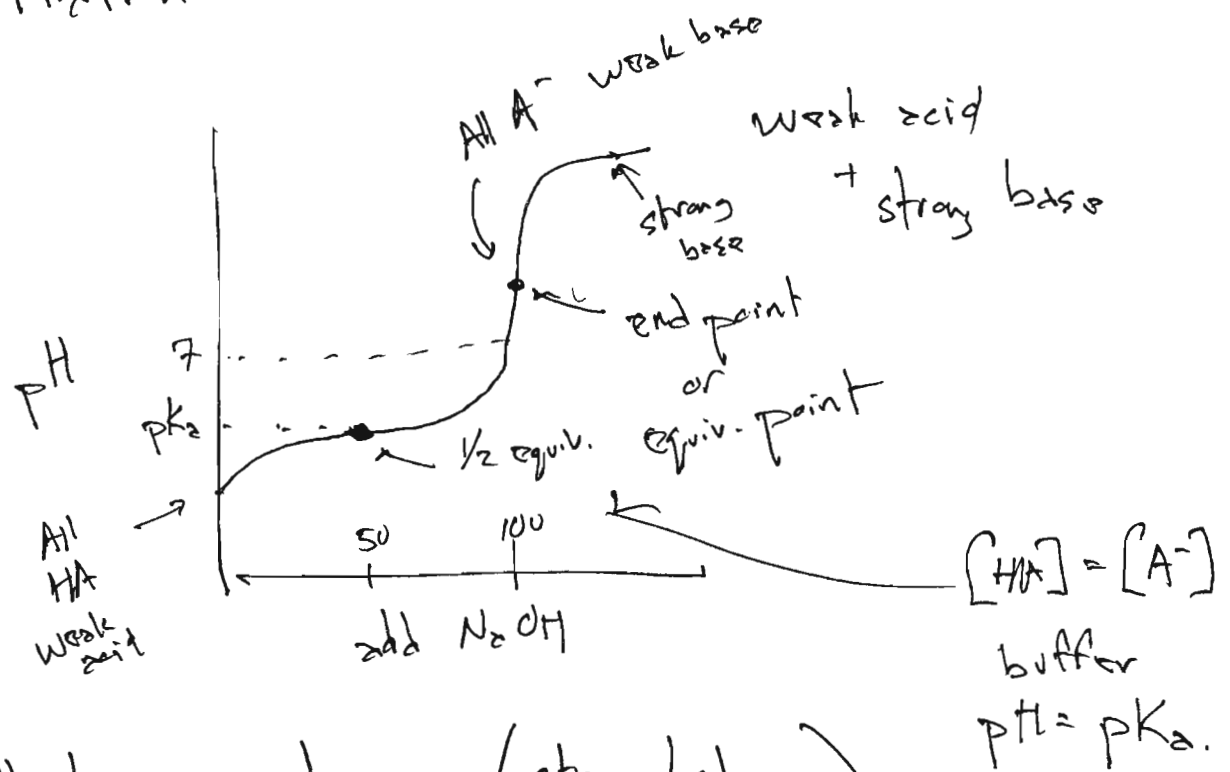   or
                        B & BH^+

22. Buffer Neutralization Calc.

   Calculation.

   Neutralize $\longrightarrow$ Buffer
                $\searrow$ weak A/B
                $\searrow$ Strong A/B

      HA & A^-
       ACID $\curvearrowright$ BASE

23. Titration Curve Features

All A^- weak base

weak acid
+ strong base

strong base

end point
or
equiv. point

½ equiv.

pH

7

pK_a

All HA
weak acid

50   100

add $NaOH$

$[HA] = [A^-]$
buffer
$pH = pK_a$.

24. Titration calc (strong / strong)

Strong acid (base)

↓

neutral   end point $pH = 7$

↓

Stong base (acid)

end   moles acid = moles base.

.1 mol = 100 mL of 1M HCl   titrate w/ 0.5 M NaOH.   200 mL

what volume is end point?
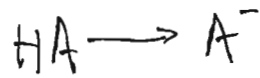added

25. Titration Calc (weak + strong)
    HARDER.

    Buffer Neutralization   EXCEPT.

    (Volume changing !)

    titrating   0.5 M HA & 1 M NaOH

    what a pH at endpoint? $HA \rightarrow A^-$
                                        $\uparrow$
                                     Weak base

26. Estimating solubility from K_{sp}

                                        volume = 1.5
                                               x
                                          original
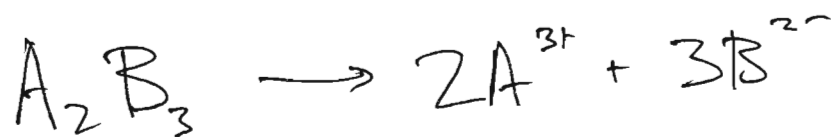   volume

    Many   compound.

    which is   most soluble
        ''   is   least   '' .

    How many ions?

                2 ions   molar sol $\sim \sqrt{K_{sp}}$

                5 ions   '' $\sim \sqrt[5]{K_{sp}}$

27. K_{sp} Calculation

Super easy!

$$A_2B_3 \longrightarrow 2A^{3+} + 3B^{2-}$$

$$K_{sp} = [A^{3+}]^2 [B^{2-}]^3$$

$$K_{sp} = [2x]^2 [3x]^3 = 108(x)^5$$

28. Common Ion K_{sp} calc.

Harder... Same but
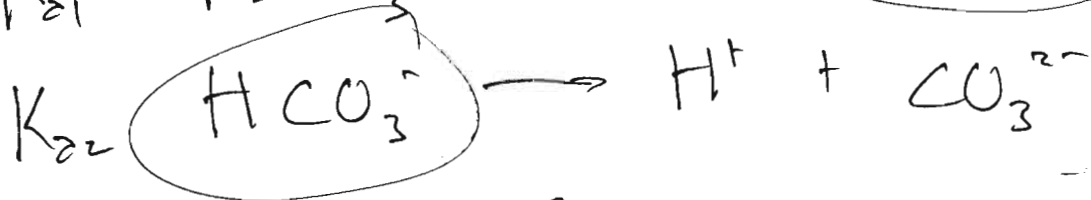
One conc. is GIVEN.

$AgCl$ in $1M$ $NaCl$ sol'n

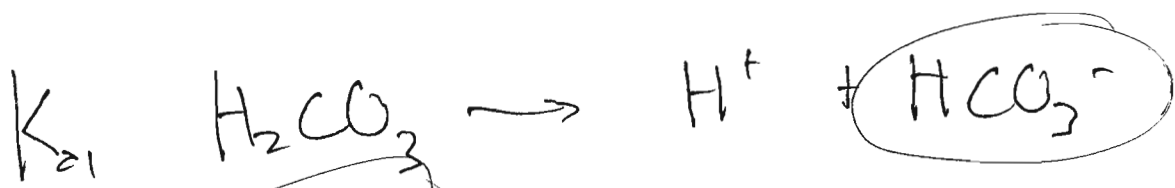$$\overset{?}{K_{sp}} = \boxed{[Ag^+]}[Cl^-] \quad \text{KNOWN}$$

$PbCl_2$

$$K_{sp} = [Pb^{2+}][Cl^-]^2$$

29. Equilibria Expression polyprotic

K_{a1} $H_2CO_3 \longrightarrow H^+ + \boxed{HCO_3^-}$
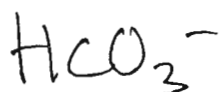
K_{a2} $\boxed{HCO_3^-} \longrightarrow H^+ + CO_3^{2-}$

$$K_{a2} = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]}$$

30. Amphiprotic calculation
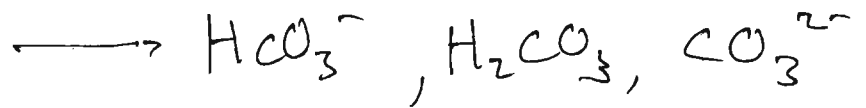
in multiple equilibria.

0.1M soln of ~~HCO_3^-~~

$Na HCO_3$

HCO_3^-

$$[H^+] = \sqrt{K_{a1} \times K_{a2}}$$

$$pH = \frac{pK_{a1} + pK_{a2}}{2}$$

31. Mass & charge balance.

know mass eq'n & charge

know all species

$NaHCO_3$ ⟶ H^+, OH^-
Na^+

⟶ HCO_3^-, H_2CO_3, CO_3^{2-}

MASS

$[NaHCO_3]_0 = [HCO_3^-]$
$+ [H_2CO_3]$
$+ [CO_3^{2-}]$

$[H^+] + [Na^+] =$
$(OH^-) + [HCO_3^-]$
$+ 2 [CO_3^{2-}]$

ECHEM
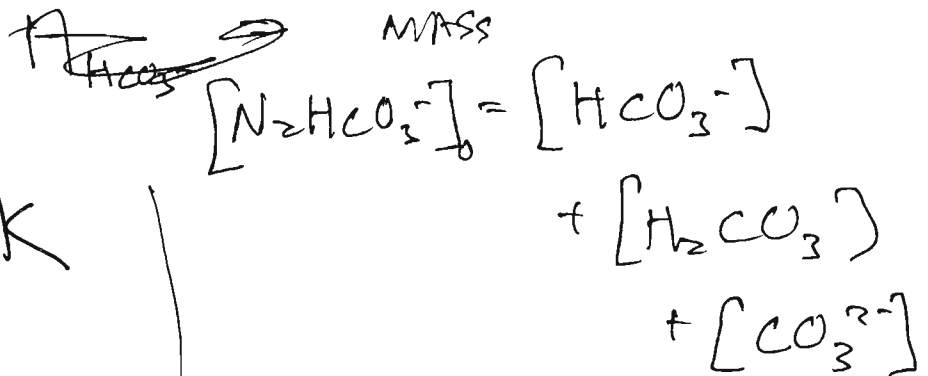
32. DE, DG, K

$\Delta G < 0$

spontaneous

$K > 1$

$E > 0$ voltaic

_____

$\Delta G > 0$ $K < 1$ $E < 0$
electrolytic.

33. Balance Redox

Practice.

34. Ranking oxidizing agents. Reducing Agents.

→ Std. Reduction Potentials.

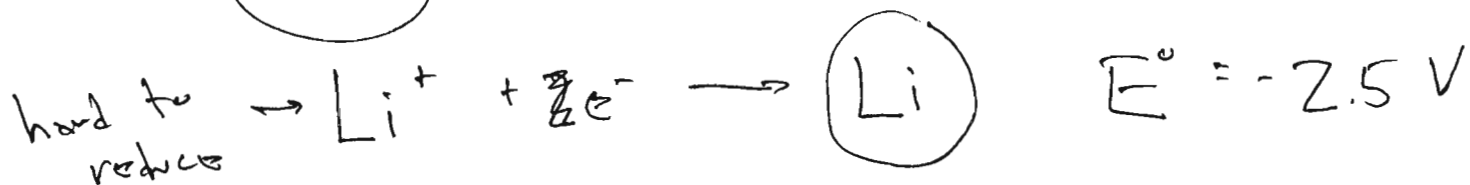easy to reduce ($\rightarrow$ F$_2$) + 2e$^-$ $\longrightarrow$ 2F$^-$ $\quad$ E$^\circ$ = 3 V

hard to reduce $\rightarrow$ Li$^+$ + $\frac{8}{2}$e$^-$ $\longrightarrow$ (Li) $\quad$ E$^\circ$ = -2.5 V

F$_2$ is best oxidizing agent

Li is best reducing agent

35. Stoichiometry / Current

$$q \text{ (charge)} \longrightarrow \# \text{ of } e^-$$

$$\downarrow$$
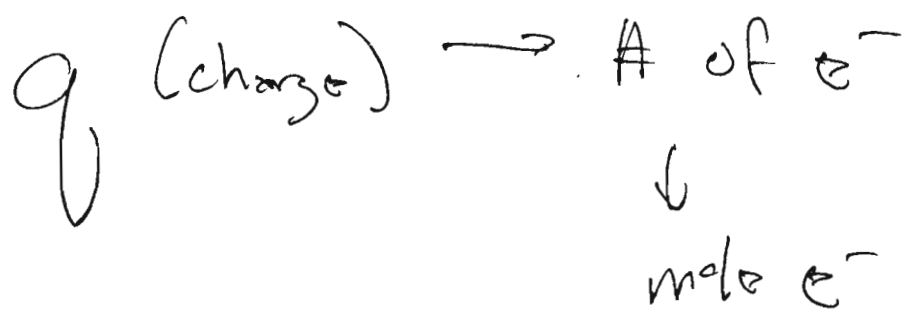
$$\text{mole } e^-$$

$$F = 1 \text{ mole } e^-$$

charge = current × time.

$\longrightarrow$ mole $e^- \longrightarrow$ moles **stuff**

36. Cell Diagrams

Given a cell.

which anode

" cathode.

~~Zn~~ ~~Cu²⁺~~

$$Zn^{2+} + Cu \longrightarrow Cu^{2+} + Zn$$

$$\underbrace{\qquad\qquad\qquad\qquad}$$

$$2 e^-$$

$$2 \text{ mole } e^-$$

$$\downarrow$$

$$1 \text{ mole } \underline{\underline{Zn}}.$$
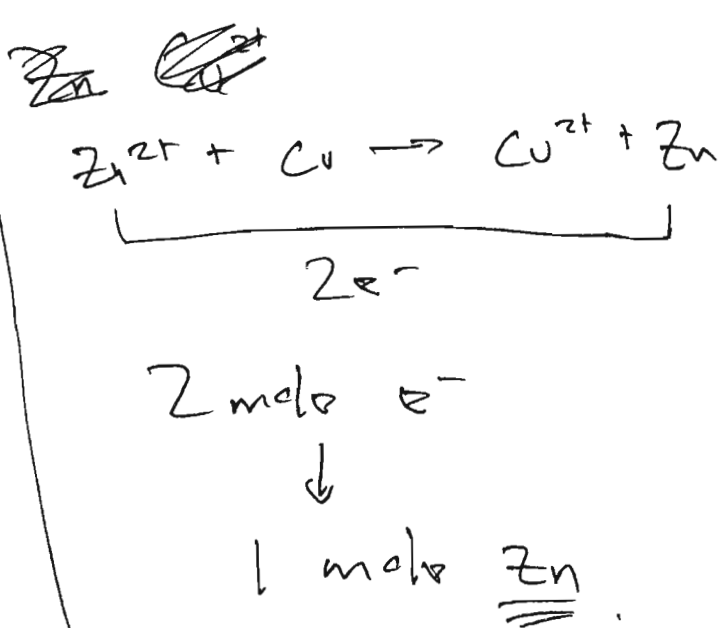
37. Cell conventions (Voltaic / Electrolytic)

	ΔG	E	cat	anod	e⁻ flow	cat	an
Spontaneous (volt)	−	+	red	ox	to cat	+	−
non-spontaneous (elect)	+	−	red	ox	to cat	−	+

38. Std. reduction potentials

compared to H_2. $E^\circ = 0 V$.

39. Cell potential (std)

EASY.

what are the two ½ reactions.

Find in the table. std. red. potentials

$$E^0_{cell} = E^0_{CAT} - E^0_{ANODE}$$

$E > 0$ voltaic (battery) $E < 0$ electrolytic.

40. Cell potential (Nernst)

"HARD"

$$E = E^0_{cell} - \frac{0.059}{n} \log Q$$

↑ # of e^- ↑ equil.

$$Q = \frac{\text{stuff on right}}{\text{stuff on left}}$$

$$Cu^{2+} + Zn \longrightarrow Zn^{2+} + Cu$$

$n = 2$

$$Q = \frac{[Zn^{2+}]}{[Cu^{2+}]}$$