

Final Test Prep

- 1) List the 3 factors that affect solubility.

Solute-solvent interactions ("like dissolves like"), pressure (solubility of a gas in liquid) & temperature (aqueous)

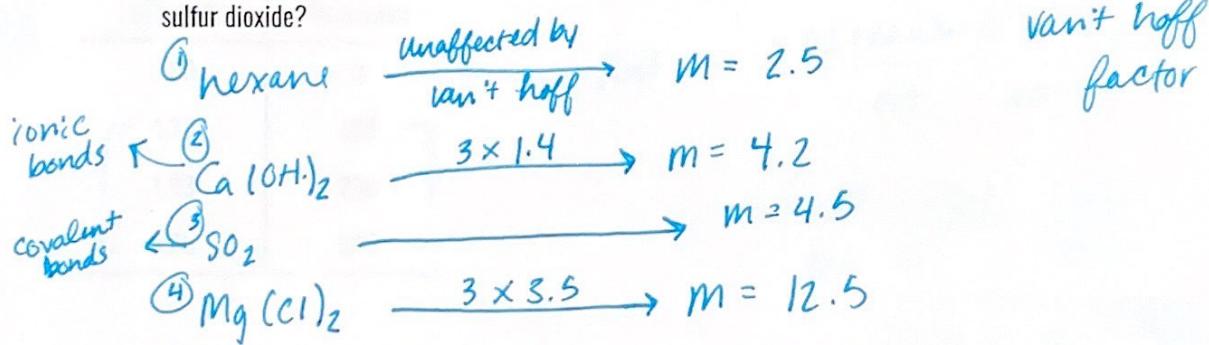
- 2) List the 5 factors that affect the rate of reactions.

Nature of reacting species, state of reactants, temperature, concentration & catalysts

- 3) How do catalysts work?

They either lower activation energy or increase the frequency of collisions, which speeds up the reaction

- 4) Rank the following solutions from lowest to highest boiling point: a 2.5 m solution of hexane, a 3.5 m solution of magnesium chloride, a 1.4 m solution of calcium hydroxide, and a 4.5 m solution of sulfur dioxide?



- 5) Find the new freezing point of a solution that has 58.44 g of NaCl in 1.00 kg of H₂O ($K_f = 1.86^\circ\text{C}/\text{m}$).

3 SF

$$m = \frac{\text{moles solute}}{\text{kg solvent}} = i = 2$$

$$= \frac{1.00 \text{ mol}}{1.00 \text{ kg}} = 1 \text{ mol}$$

Na: 22.99

Cl: 35.45

58.44 g/mol

$$\Delta T_f = i K_f m$$

$$(2)(1.86^\circ\text{C}/\text{mol})(1.86^\circ\text{C}/\text{mol}) = \frac{58.44 \text{ g}}{58.44 \text{ g/mol}} = 1 \text{ mol}$$

$$\Delta T_f = 3.72^\circ\text{C}$$

<https://haleyschulze.wixsite.com/chem2schultz>

$$\text{Freezing point of H}_2\text{O} = 0.00^\circ\text{C} - 3.72^\circ\text{C} \rightarrow \boxed{-3.72^\circ\text{C}}$$

3 SF

- 6) Find the new vapor pressure of a solution when 10.0 mL of glycerol is added to 500 mL of water at 50°C. At this temperature, the vapor pressure of pure water is 92.5 torr.

$$P_{\text{soln}} = i \chi_{\text{solvent}} \cdot P_{\text{solvent}}^{\circ}$$

$$(1)(0.980)(92.5 \text{ torr})$$

$$\chi_{\text{solvent}} = \frac{\text{moles solvent}}{\text{total moles}}$$

$$P_{\text{soln}} = 90.7 \text{ torr}$$

$$\frac{506 \text{ moles}}{510 \text{ moles}} = 0.980$$

- 7) What is the osmotic pressure at 22°C of a 1.4 L solution of 37.3 g of KCl?

2SF

$$\Pi = i MRT$$

$$(298K)(2)(0.36 \frac{\text{mol}}{\text{L}})(0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}) \left(\frac{74.55 \text{ g/mol}}{37.3 \text{ g}} \right) \cdot \text{mol} = 0.500 \text{ mol}$$

$$M = \frac{\text{moles solute}}{\text{L solution}} = 0.36$$

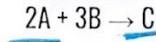
$$\left. \begin{array}{l} i = 2 \\ T = 22^\circ\text{C} + 273 = 298 \text{ K} \\ R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \end{array} \right\}$$

$$\Pi = 17 \text{ atm}$$

- 8) Determine the average reaction rate between 100 s and 300 s.

2SF

[A] (mol/L)	Time (sec)
2.50	0
1.76	100
1.03	200
0.89	300



$$\text{Rate} = -\frac{\Delta [\text{reactants}](M)}{\Delta t \cdot (\text{s})}$$

$$= -\frac{(0.89 - 1.76)}{300 - 100} = \frac{0.87}{200}$$

$$14.4 \times 10^{-3} \text{ M/s}$$

- a) What would the rate of appearance of C be over the same time frame?

$$4.4 \times 10^{-3} \left(\frac{\text{mol A/L}}{\text{s}} \right) \left(\frac{1 \text{ mol C}}{2 \text{ mol A}} \right) = 2.2 \times 10^{-3} \text{ M/s}$$

9) Given the following data, determine the rate law expression of the reaction.



Experiment	[C] (M)	[D] (M)	[E] (M)	Rate (M/s)
1	0.400	0.300	0.560	7.14×10^{-4}
2	0.100	0.500	0.200	4.55×10^{-5}
3	0.100	0.200	0.200	4.55×10^{-5}
4	0.400	0.300	0.750	1.28×10^{-5}
5	0.100	0.300	0.560	3.57×10^{-4}

$$C: \frac{\exp 1}{\exp 5} : \left(\frac{0.200}{0.100} \right)^x = \frac{5.69 \times 10^{-6}}{2.85 \times 10^{-6}}$$

$$2^x = 2 \rightarrow x = 1$$

$$\text{Rate} = k [C]^x [D]^y [E]^z$$

$$\text{rate} = k [C] [E]^2$$

$$D: \frac{\exp 2}{\exp 3} : \left(\frac{0.500}{0.200} \right)^y = \frac{4.55 \times 10^{-5}}{4.55 \times 10^{-5}}$$

$$2.5^y = 1 \rightarrow y = 0$$

$$K = \frac{\text{rate}}{[C][E]^2}$$

$$\exp 1: \frac{5.69 \times 10^{-6}}{[0.200][0.500]^2}$$

$$E: \frac{\exp 4}{\exp 1} : \left(\frac{0.750}{0.560} \right)^z = \left(\frac{1.28 \times 10^{-5}}{5.69 \times 10^{-6}} \right)$$

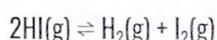
$$1.5^z = 2.25 \rightarrow z = 2$$

$$K = 1.14 \times 10^{-4}$$

$$\boxed{\text{Rate} = 1.14 \times 10^{-4} [C][E]^2}$$

- 10) What is the equilibrium constant for the following reaction if, at equilibrium, $[HI] = 1.2 \text{ M}$, $[H_2] = 0.75 \text{ M}$, and $[I_2] = 0.56 \text{ M}$.

ZSF



$$K_{\text{eq}} = \frac{[\text{products}]}{[\text{reactants}]} = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2} = \frac{(0.75)(0.56)}{(1.2)^2}$$

$$\boxed{K_{\text{eq}} = 0.29}$$

- 11) For the following gaseous reaction, $[A] = 3.5 \text{ M}$, $[B] = 2.0 \text{ M}$, $[C] = 1.4 \text{ M}$, and $[D] = 0.3 \text{ M}$. What is the Q value for this equation? Which direction will the reaction shift if $K_{\text{eq}} = 1.2 \times 10^{-3}$?

2 SF

$$Q = \frac{[C]^4}{[A]^2[B]^3} = \frac{(1.4)^4}{(3.5)^2(2.0)^3} = \boxed{10.040}$$

$K < Q$
 $\text{React.} \rightarrow \text{prod.}$

Reaction will shift left,
 towards reactants

- 12) At equilibrium in the following reaction at room temperature, the partial pressures of the gases are found to be $P_{N_2} = 0.086 \text{ atm}$, $P_{H_2} = 0.029 \text{ atm}$, and $P_{NH_3} = 0.058 \text{ atm}$. What is the K_p for this reaction?

2 SF

$$K_p = \frac{[NH_3]^2}{[N_2][H_2]} = \frac{(0.058)^2}{(0.086)(0.029)} = \boxed{1.6 \times 10^{-3}}$$

- 13) What is the pH of $Be(OH)_2$ if $[H^+] = 0.28 \text{ M}$?

2 SF

Strong base

$$pOH = -\log(0.28) \rightarrow pOH = 0.55$$

$$pH = 13.45$$

- 14) Find the $[OH^-]$ of a solution of NaOH with a pH of 12.847?

3 SF

$$[OH^-] = 10^{-pOH} \rightarrow [OH^-] = 0.0703$$

- 15) A 0.175 M weak acid solution has a pH of 3.25. Find K_a for the acid.

$$[HA] = 0.175 \text{ M}$$

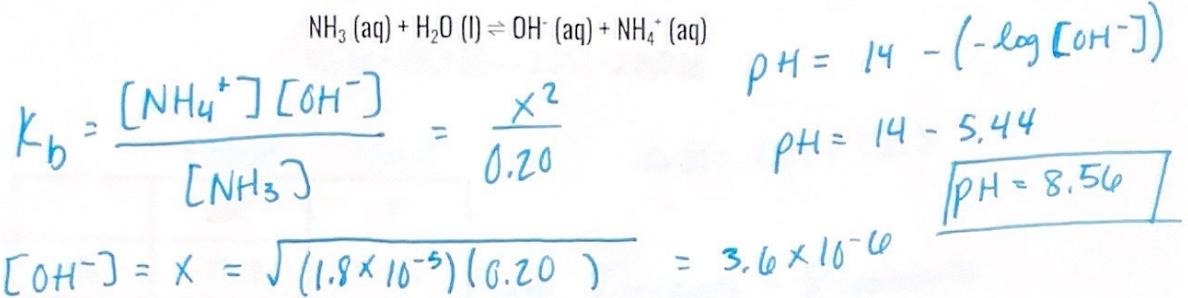
$$\downarrow [H^+] = 10^{-3.25} = 5.62 \times 10^{-4}$$

$\downarrow x$

$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{x^2}{0.175} = \frac{(5.62 \times 10^{-4})^2}{0.175} = \boxed{1.8 \times 10^{-6}}$$

16) Calculate the pH of a 0.20 M solution of ammonia. K_b of NH_3 is 1.8×10^{-5} .

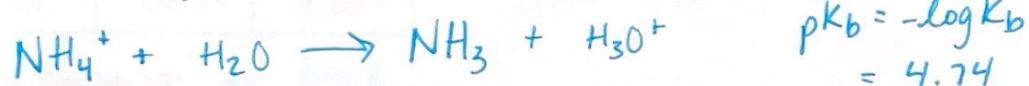
2SF



17) What is the pH of a buffer system prepared by dissolving 1.7 M NH_4Cl and 2.0 M NH_3 ?

 $K_b = 1.80 \times 10^{-5}$ for NH_3

2SF



$$p\text{OH} = pK_b + \log \left(\frac{1.7\text{M}}{2.0\text{M}} \right) = 4.70$$

$$\boxed{\text{pH} = 9.30}$$

18) Calculate the molar solubility of $\text{Al}(\text{OH})_3$ in pure water. K_{sp} of $\text{Al}(\text{OH})_3$ = 3.0×10^{-34}

$$K_{sp} = [\text{Al}^{3+}][\text{OH}^-]^3$$

$$K_{sp} = (x)(3x)^3$$

$$K_{sp} = 27x^4$$

$$x = \sqrt[4]{\frac{3.0 \times 10^{-34}}{27}}$$

$$\boxed{1.8 \times 10^{-9} \text{ mol/L}}$$

19) Estimate the molar solubility of CaF_2 at 25°C in 0.010 M $\text{Ca}(\text{NO}_3)_2$ solution.

$$K_{sp} = [\text{Ca}^{2+}][\text{F}^-]^2$$

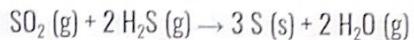
$$K_{sp} = (0.010)(2x)^2$$

$$K_{sp} = 0.040x^2$$

$$x = \sqrt{\frac{3.9 \times 10^{-11}}{0.040}} = \boxed{3.1 \times 10^{-5} \text{ mol/L}}$$

common ion
effect

20) For the reaction



	KJ/mol ΔH°	J/mol ΔS°
react		
SO_2	-296.8 ←	0.2481
H_2S	-20.6 ←	0.2057
S	0.0 ←	0.0318 ←
prod		
H_2O	-241.8 ←	0.1887 ←

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

ΔH° : $\sum \text{products} - \sum \text{reactants}$

$$= [3(0.0) + 2(-241.8)] - [-296.8 + 2(-20.6)]$$

$$\Delta H^\circ = -145.6 \text{ KJ/mol}$$

a) Calculate ΔG° . at 298 K.

$$\Delta S^\circ: [3(0.0318) + 2(0.1887)] - [0.2481 + 2(0.2057)] = -0.1867 \text{ J/mol}$$

$$\Delta S^\circ = -1.867 \times 10^{-4} \text{ KJ/mol}$$

$$\begin{aligned} \Delta G^\circ &= -145.6 \text{ KJ/mol} - (298 \text{ K})(-1.867 \times 10^{-4} \text{ KJ/mol}) \\ &= \boxed{-145.5 \text{ KJ/mol}} \end{aligned}$$

b) Is this reaction spontaneous?

yes, ΔG° is (-)

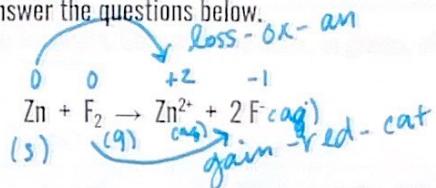
c) Is it favorable?

No, ΔS° is (-)

d) Is it endothermic or exothermic?

Exothermic, ΔH° is (-)

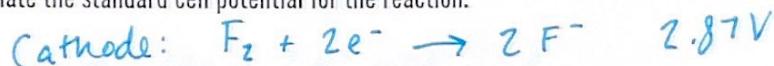
21) Use the following reaction to answer the questions below.



- a) Which is the oxidizing agent? F_2
- b) How many electrons are transferred? 2 electrons
- c) What is the anode reaction?



d) Calculate the standard cell potential for the reaction.



3 SF

$$\mathcal{E}_{\text{cell}}^{\circ} = \text{cathode} - \text{anode} \rightarrow \frac{2.87 - (-0.76)}{13.63 \text{ V}}$$

e) Is this reaction spontaneous? Yes, $\mathcal{E}_{\text{cell}}^{\circ}$ is (+)

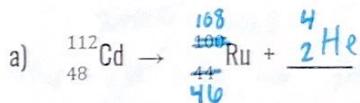
f) Use the Nernst equation to calculate the cell potential for the reaction when $[\text{F}_2] = 0.543$ [Zn²⁺] = 0.345 M and [F⁻] = 0.724 M.

$$\mathcal{E}_{\text{cell}} = \mathcal{E}_{\text{cell}}^{\circ} - \left(\frac{0.0592}{n} \cdot \log Q \right)$$

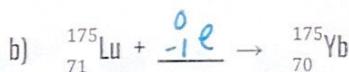
$$3.63 \text{ V} - \left(\frac{0.0592}{2} \cdot \log 0.333 \right) \quad Q = \frac{(0.345)(0.724)^2}{(0.543)}$$

$$\boxed{\mathcal{E}_{\text{cell}} = 3.64 \text{ V}} \quad \leftarrow 3.63 \text{ V} - (-0.014)$$

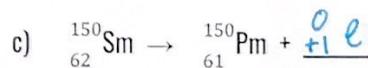
22) Complete and identify the following reactions.



Alpha Decay



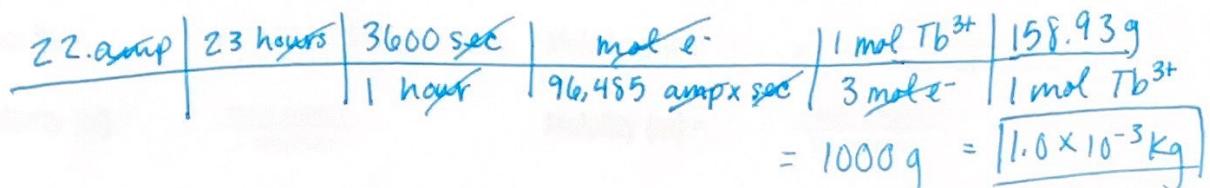
Electron Capture



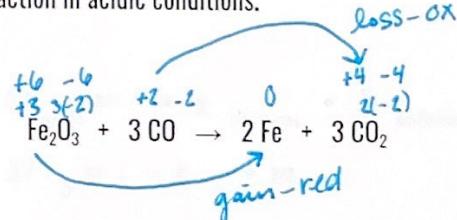
Position Emission

23) A current of 22.0 A was used for 23 hours. Calculate the mass, in grams, of Tb^{3+} produced.

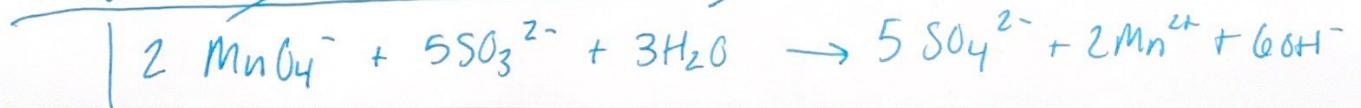
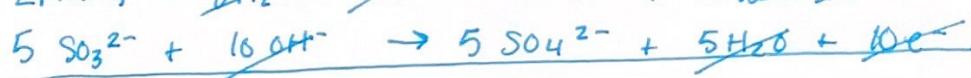
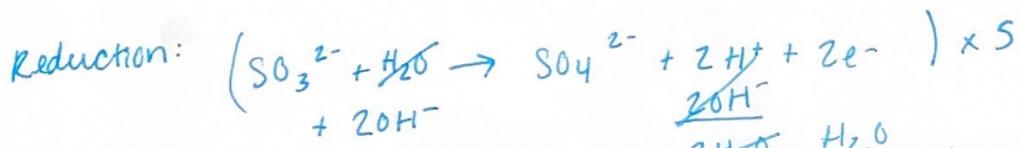
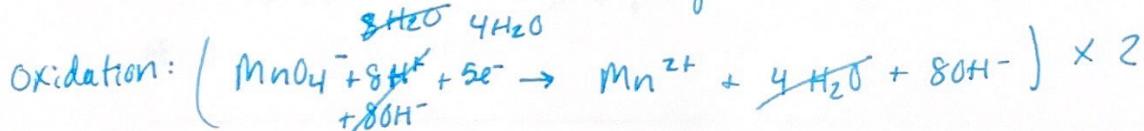
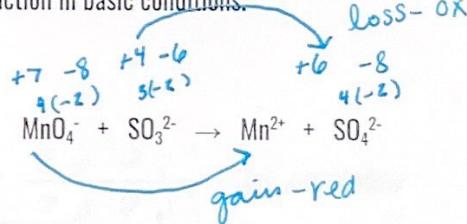
$$F = 96,485 \text{ amp} \times \text{sec} / \text{mol e}$$



24) Balance the following reaction in acidic conditions.



25) Balance the following reaction in basic conditions.



Equations

Units of Concentration:

$$\text{Mass \%} = \left(\frac{\text{mass solute}}{\text{mass solution}} \right) \times 100\% \quad \text{Mole fraction: } \chi_i = \frac{\text{moles}_i}{\text{total moles}}$$

$$\text{Molarity (M)} = \frac{\text{mass solute}}{\text{L solution}} \quad \text{Molality (m)} = \frac{\text{moles solute}}{\text{kg solvent}}$$

Colligative Properties:

$$\text{Vapor Pressure Lowering: } P_{\text{soln}} = i \cdot \chi_{\text{solvent}} \cdot P_{\text{solvent}}$$

i = van't Hoff factor

$$\text{Boiling Point Elevation: } \Delta T_b = i \cdot k_b \cdot m$$

$$\text{Freezing Point Depression: } \Delta T_f = i \cdot k_f \cdot m$$

$$\text{Osmotic Pressure: } \Pi = i \cdot MRT \quad R = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mol}}$$

Rate Laws:

$$\text{Rate} = \frac{-\Delta [\text{reactants}]}{\Delta t}$$

$$\text{Rate} = k [\text{reactants}]^n$$

Equilibrium Constants:

$$K_{eq} = \frac{[\text{products}]}{[\text{reactants}]}$$

$$Q = \frac{[D]^d [E]^e}{[A]^a [B]^b} \quad K_p = \frac{(P_D)^d (P_E)^e}{(P_A)^a (P_B)^b} \quad \text{for a reaction: } aA + bB \rightleftharpoons dD + eE$$

pH:

$$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$$

$$K_w = K_a K_b$$

$$pH = -\log[H^+]$$

$$pOH = -\log[OH^-]$$

$$[H^+] = 10^{-pH} [OH^-] = 10^{-pOH}$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$K_b = \frac{[HB^+][OH^-]}{[B]}$$

→ buffers

Henderson-Hasselbalch:

$$\text{Acidic: } pH = pK_a + \log \frac{[A^-]}{[HA]}$$

$$\text{Basic: } pH = pK_b + \log \frac{[HB^+]}{[B]}$$

$$\text{Buffer: } pK_a = -\log K_a \quad pK_b = -\log K_b$$

Solubility:

$$\text{Solubility Product Constant: } K_{sp}$$

$$\text{Molar solubility (in mol/L): } x$$

Gibbs Free Energy:

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

Oxidation-Reduction:

Gain

OIL RIG: Oxidation is Loss & Reduction is Gain

Red Cats: Reduction — Cathode

Electrolysis:

Standard Cell Potential: $E_{cell}^{\circ} = \text{cathode} - \text{anode}$

Nernst Equation: $E_{cell} = E_{cell}^{\circ} - \left(\frac{0.0592}{n} \cdot \log Q \right)$

Faraday's Constant $F = 96,485 \frac{C}{mole^-}$ $C = 1 \text{ amp} \times 1 \text{ sec}$

reaction quotient

Organic:

1 carbon: Methane

2 carbons: Ethane

3 carbons: Propane

4 carbons: Butane

5 carbons: Pentane

6 carbons: Hexane

7 carbons: Heptane

8 carbons: Octane

9 carbons: Nonane

10 carbons: Decane

Alkyl halide: R-X

Alcohol: R-OH

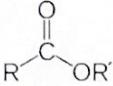
Ether: R-O-R

Aldehyde:


Ketone:


Carboxylic

Acid:


Ester:


Amine: R-NH₂

Amide:
