

CHM 1301
CHM 1311 B

GENERAL CHEMISTRY: QUIZ 2

STUDENT NAME _____

STUDENT ID. No. _____

CIRCLE ONE: CHM 1301 CHM 1311B

CONSTANTS

$$R = 8.314 \text{ J/molK} = 0.08206 \text{ L atm/molK} = 0.08314 \text{ bar L/molK}$$

$$1 \text{ atm} = 760 \text{ Torr} = 760 \text{ mm Hg} = 101.325 \text{ kPa} = 1.01325 \times 10^5 \text{ Pa} = 1.01325 \text{ bar}$$

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$d_{\text{water}} = 1.00 \text{ g/cm}^3 ; g = 9.81 \text{ m/s}^2$$

There are 8 pages in this quiz including the cover page, equations and the periodic table.

Check and ensure you have answered each question before handing in the quiz.

PLEASE use a pen!! Box, underline or highlight your FINAL answer.

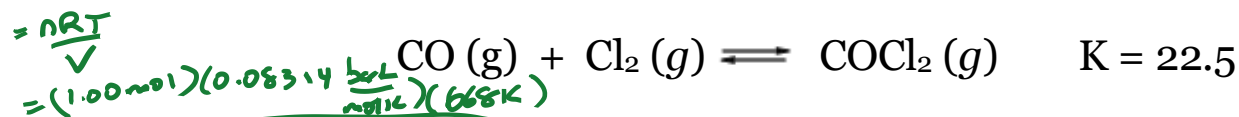
The quiz is out of 25 points with a maximum of 28 points possible

CLEARLY explain your thinking...

USE UNITS!

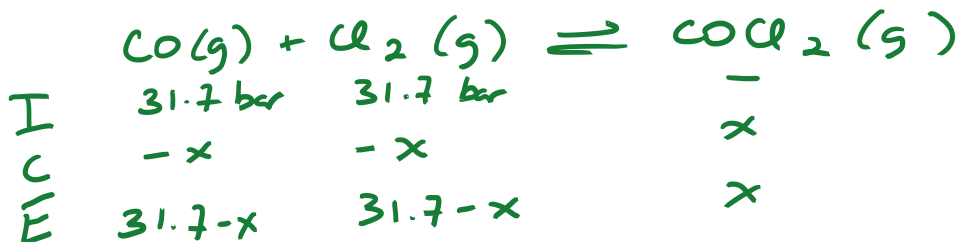
- (6) 1.00 mol each of CO and Cl₂ are introduced into an evacuated 1.75 L flask, and the following equilibrium is established at 668 K: for the reaction

$$P_{CO} = P_{Cl_2}$$



- a) Determine the equilibrium partial pressures of all the gases.

$$= 31.7 \text{ bar}$$



$$K = \frac{P_{\text{COCl}_2}}{P_{\text{CO}}P_{\text{Cl}_2}} = \frac{x}{(31.7 - x)^2} = 22.5$$

$$x = 22.5 (1.01 \times 10^3 - 63.5x + x^2)$$

$$22.5x^2 - 1.43 \times 10^3 x + 2.27 \times 10^4 = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{1.43 \times 10^3 \pm \sqrt{(-1.43 \times 10^3)^2 - 4(22.5)(2.27 \times 10^4)}}{2(22.5)}$$

$$\text{use } \ominus \text{ root} = 30.1 \text{ bar}$$

$$\therefore P_{\text{COCl}_2} = 30.1 \text{ bar} \quad P_{\text{CO}} = P_{\text{Cl}_2} = 1.6 \text{ bar}$$

- b) What is the total pressure at equilibrium?

$$P_{\text{TOT}} = P_{\text{CO}} + P_{\text{Cl}_2} + P_{\text{COCl}_2} = ((1.6 \times 2) + 30.1) \text{ bar}$$

$$= 33.2 \text{ bar}$$

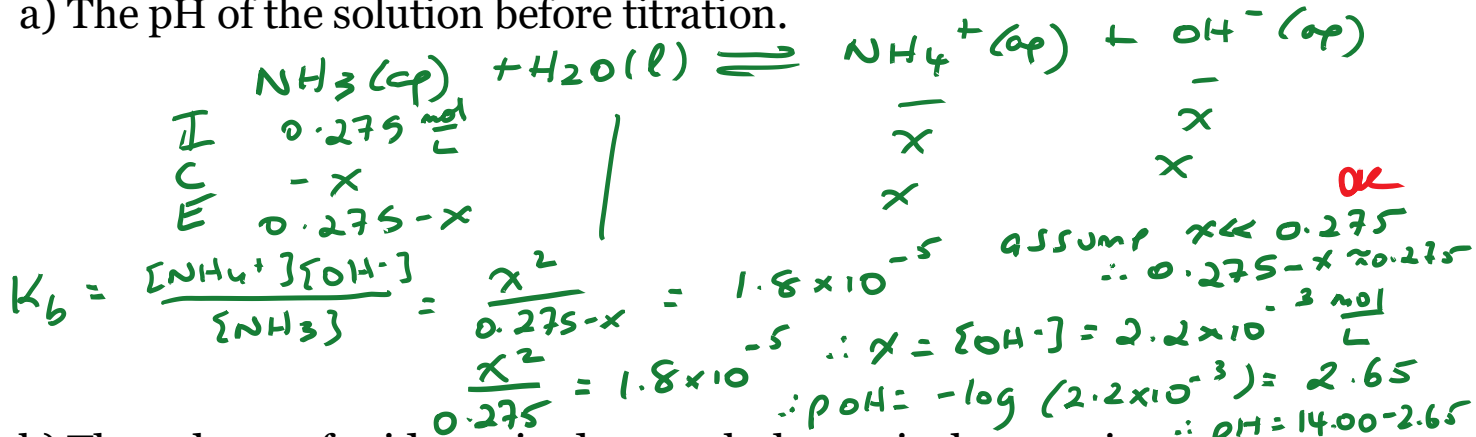
- c) Once the reaction reaches equilibrium, if the pressure is gradually increased, which way will the reaction shift? Explain your answer.

To the RIGHT (towards products)

1 mol of gas as product; 2 mol reactants
higher P means rxn shifts to form fewer moles

(8) 20.0 mL of 0.275 mol/L NH₃, (K_b = 1.8 × 10⁻⁵), are titrated with 0.325 mol/L HI solution. Calculate:

a) The pH of the solution before titration.



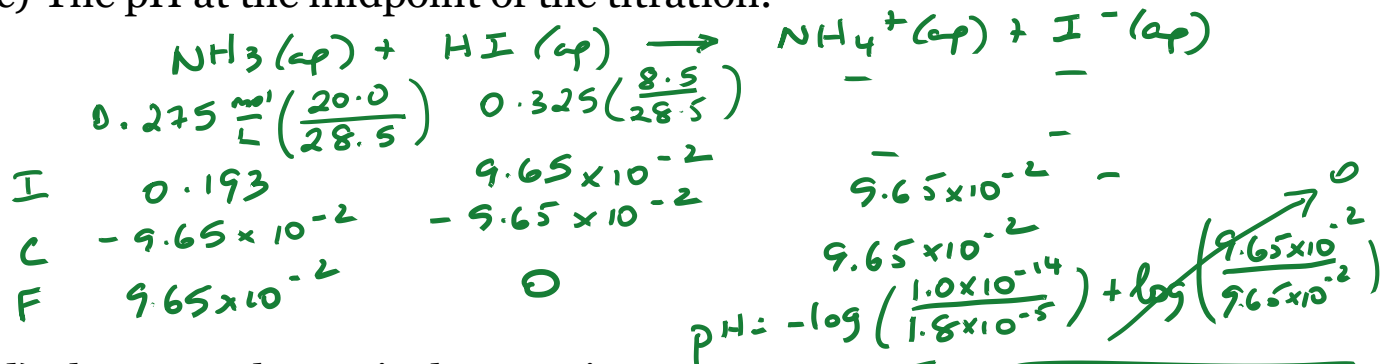
b) The volume of acid required to reach the equivalence point.

$$C_A V_A = C_B V_B$$

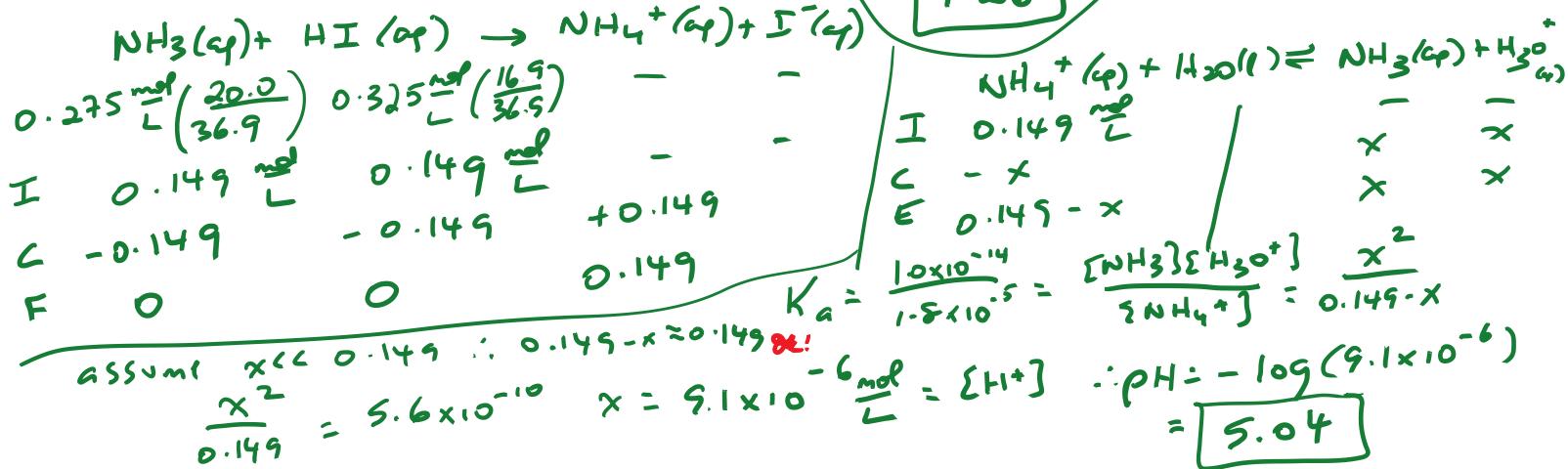
$$(0.325 \frac{\text{mol}}{\text{L}}) V_A = (0.275 \frac{\text{mol}}{\text{L}})(20.0 \text{ mL})$$

$$V_A = 16.9 \text{ mL}$$

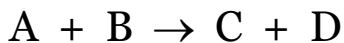
c) The pH at the midpoint of the titration.



d) The pH at the equivalence point.



(5) The initial rate of the reaction:



Is determined for different initial conditions. The rate data obtained at 25°C are listed in the table below:

$$\text{Rate} = k[A]^m[B]^n$$

Experiment	[A] ₀ (mol/L)	[B] ₀ (mol/L)	Initial Rate (mol/Ls)
1	0.185	0.133	3.35 × 10 ⁻⁴
2	0.185	0.266	1.35 × 10 ⁻³
3	0.370	0.133	6.75 × 10 ⁻⁴
4	0.370	0.266	2.70 × 10 ⁻³

a) What is the rate law for the reaction?

$$\frac{\text{Rate 2}}{\text{Rate 1}} = \frac{k(0.185)^m(0.266)^n}{k(0.185)^m(0.133)^n} = 2^n = \frac{1.35 \times 10^{-3}}{3.35 \times 10^{-4}} = 4$$

$$2^n = 2^2 \quad \boxed{n = 2}$$

$$\frac{\text{Rate 3}}{\text{Rate 1}} = \frac{k(0.370)^m(0.133)^n}{k(0.185)^m(0.133)^n} = 2^m = \frac{6.75 \times 10^{-4}}{3.35 \times 10^{-4}} = 2$$

$$2^m = 2^1 \quad \boxed{m = 1}$$

$$\text{Rate} = k[A][B]^2$$

b) What is the value WITH THE PROPER UNITS for the rate constant?

$$\text{Rate} = k[A][B]^2$$

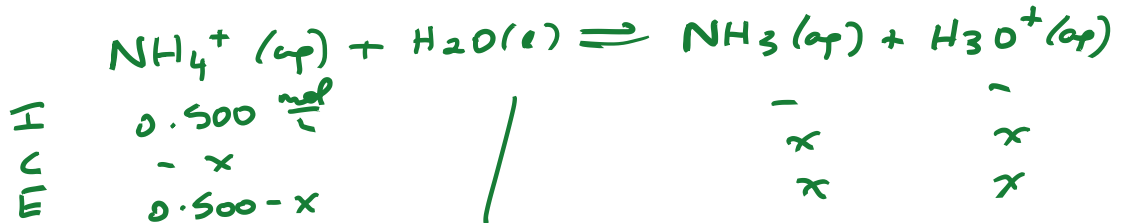
$$3.35 \times 10^{-4} \frac{\text{mol}}{\text{Ls}} = k \left(0.185 \frac{\text{mol}}{\text{L}}\right) \left(0.133 \frac{\text{mol}}{\text{L}}\right)^2$$

c) $k = 0.102 \frac{\text{L}^2}{\text{mol}^2\text{s}}$

BONUS QUESTION: To be answered ONLY if ALL previous questions have been answered!



(3) You are asked to bring the pH of 0.500 L of 0.500 mol/L NH_4Cl to 7.00. What volume, in drops, (1 drop = 0.05 mL) of which of the following solutions would you use: 10.0 mol/L HCl or 10.0 mol/L NH_3 ?



$$K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10} = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]} = \frac{x^2}{0.500 \cdot x}$$

assume $x \ll 0.500 \therefore 0.500 - x \approx 0.500$

$$\frac{x^2}{0.500} = 5.6 \times 10^{-10}$$

$$x = 1.7 \times 10^{-5} \frac{\text{mol}}{\text{L}} = [\text{H}_3\text{O}^+]$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log (1.7 \times 10^{-5}) = \boxed{4.78} \therefore \text{acidic}$$

ADD 10.0 $\frac{\text{mol}}{\text{L}}$ NH_3 to bring pH to 7.00

$$\text{pH} = \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

$$7.00 = -\log (5.6 \times 10^{-10}) + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

$$\log \frac{[\text{A}^-]}{[\text{HA}]} = -2.26$$

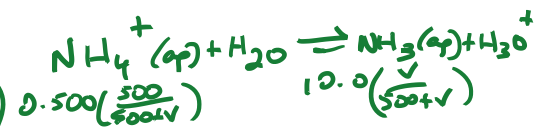
$$\frac{[\text{A}^-]}{[\text{HA}]} = 5.6 \times 10^{-3}$$

$$\frac{10.0V}{500+V} = 5.6 \times 10^{-3}$$

$$\frac{250}{500+V} = 5.6 \times 10^{-3}$$

$$\frac{10.0V}{250} = 5.6 \times 10^{-3}$$

$$V = 0.14 \text{ mL} = \frac{0.14 \text{ mL}}{0.05 \frac{\text{mL}}{\text{drop}}} = \boxed{3 \text{ drops}}$$



Equations and Constants

Gas Laws

$$pV = nRT$$

$$P_{\text{Total}} = p_1 + p_2 + p_3 + \dots$$

$$d = \frac{m}{V} = \frac{p(\text{MM})}{RT}$$

$$KE = (1/2)mv_{\text{av}}^2$$

$$u_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$\frac{\text{Rate}_A}{\text{Rate}_B} = \sqrt{\frac{M_b}{M_a}}$$

$$p + \frac{n^2 a}{V^2} (V - nb) = nRT$$

$$1 \text{ atm} = 760 \text{ Torr} = 760 \text{ mm Hg} = 1.01325 \times 10^5 \text{ Pa} = 1.01325 \text{ bar} = 101.325 \text{ kPa}$$

Equilibrium

$$K_p = K(RT)^{\Delta n}$$

$$K = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

$$K_{\text{sp}} = [C]^c [D]^d$$

Acid/Base

$$pOH = -\log [\text{OH}^-]$$

$$pH = -\log [\text{H}^+]$$

$$pH + pOH = 14$$

$$K_a \cdot K_b = K_w$$

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

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

$$C_1 V_1 = C_2 V_2$$

Electrochemistry

$$\Delta G^\circ = -nFE^\circ$$

$$E = E^\circ - \frac{RT}{nF} \ln(Q)$$

$$\text{Or } E = E^\circ - \frac{0.059}{n} \log(Q) \text{ at } 25^\circ\text{C}$$

$$Q = I \cdot t$$

Quantum Mechanics

$$\lambda \cdot \nu = c$$

$$E = h \cdot \nu$$

$$m = \frac{h}{\lambda c}$$

$$E = \frac{1}{2} m u^2$$

$$\lambda = h/mu$$

$$\text{Energy of state} = -2.178 \times 10^{-18} \text{ J} / n^2$$

$$\Delta x \cdot \Delta p \geq h / 4\pi$$

$$E = -C(1/n^2)$$

Liquids and Colligative Properties

$$\ln(p_1/p_2) = \Delta H^\circ / R (1/T_2 - 1/T_1)$$

$$p_{\text{solution}} = X_{\text{solvent}} \cdot p_{\text{solvent}}^\circ$$

$$\Delta T_{\text{BP}} = K_{\text{BP}} \cdot m$$

$$\Delta T_{\text{FP}} = K_{\text{FP}} \cdot m$$

$$\Delta T = K \cdot m \cdot i$$

$$\Pi = cRT$$

$$\text{molality} = \text{mol solute} / \text{mass solvent (kg)}$$

General

$$n = \frac{m}{\text{MM}} \quad d = \frac{m}{V} \quad c = \frac{n}{V}$$

Thermodynamics

$$\Delta U = q$$

$$w_{\text{system}} = -p\Delta V$$

$$\Delta E = q + w$$

$$\Delta H = \Delta E + p\Delta V$$

$$q_p = \Delta E + p\Delta V$$

$$\Delta E = nC_v\Delta T$$

$$\Delta H = q_p = m C_p \Delta T$$

$$C_p = C_v + R$$

$$\Delta_r H^\circ = \sum \nu_p \Delta_f H_p^\circ - \sum \nu_r \Delta_f H_r^\circ$$

$$\Delta H^\circ = \frac{q}{n}$$

$$q_{\text{rev}} = -w_{\text{max}} = nRT \ln(V_2/V_1)$$

$$\Delta S = q_{\text{rev}} / T$$

$$\Delta S_{T_1-T_2} = nC_p \ln(T_2/T_1)$$

$$\Delta S_{T_1-T_2} = nC_v \ln(T_2/T_1)$$

$$\Delta S^0_{\text{surroundings}} = \frac{q_{\text{surroundings}}}{T} = \frac{-\Delta H_{\text{sys}}}{T}$$

$$\Delta G^0 = \Delta H^0 - T\Delta S^0$$

$$\Delta G = \Delta G^0 + RT \ln(Q)$$

$$\Delta G^0 = -RT \ln(K)$$

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

Kinetics

$$\text{Rate} = k [A]^x [B]^y [C]^z$$

$$\text{Rate} = k$$

$$\text{Rate} = k[A]$$

$$\text{Rate} = k[A]^2$$

$$[A] = -kt + [A]_0$$

$$\ln[A] = -kt + \ln[A]_0$$

$$1/[A] = kt + 1/[A]_0$$

$$t = [A]_0 / 2k$$

$$\ln 2 = kt$$

$$k = Ae^{-E_a/RT}$$

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Bonding

$$DE = k(Q_1 Q_2 / r)$$

$$DH_{\text{rxn}} = \sum \nu_p D(\text{reactants}) -$$

$$\sum \nu_r D(\text{products})$$

Formal Charge = #valence e⁻ in free atom - #lone pair e⁻ - 1/2(# bonding e⁻)

Data For Water and Other Constants

Density d = 1.00 g/mL (25°C)

C = 4.184 J g⁻¹ °C⁻¹ (liquid)

Avogadro's Number	<i>N</i>	6.022x10 ²³	mol ⁻¹
Boltzmann's constant	<i>k</i>	1.30866x10 ⁻²³	J·K ⁻¹
Faraday's constant	<i>F</i>	96,485	C·mol ⁻¹
Gas constant	<i>R</i>	8.31451	J·K ⁻¹ ·mol ⁻¹
	<i>R</i>	0.08206	L·atm·K ⁻¹ ·mol ⁻¹
Mass of Electron	<i>m_e</i>	9.10938188 x 10 ⁻³¹	kg
Planck's constant	<i>h</i>	6.62608x10 ⁻³⁴	J·s
Speed of Light	<i>c</i>	2.99792458x10 ⁸	m·s ⁻¹

K_w = 1.00 x 10⁻¹⁴ General Information:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

