Midterm Exam 2
(Closed Book, 90 minutes, 90 points)

October 18, 1995

CHEM 1A Prof A. Pines

NAME _____ **Discussion TA:** _____

Lab TA _____

Exam Version

(1) (2) (3) (4)

Identification Sticker

Possibly Useful Information:

Ideal Gas: $PV = nRT$

$V_m = 22.414$ L·mol^{-1} at STP

For $aA + bB = cC + dD$:

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

At equilibrium, $Q = K$

Sparingly soluble salt:

$MX_n(s) = M^{n+} + nX^-$

$K_{sp} = [M^{n+}][X^-]^n$

$N_0 = 6.0221 \times 10^{23}$ mol^{-1}

R= 0.08206 L atm mol^{-1} K^{-1}= 8.31451 J mol^{-1}K^{-1}

Weak Acid: $HA + H_2O = H_3O^+ + A^-$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

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

$K_w = [H_3O^+][OH^-]$

Conjugate Acid-Base: $K_aK_b = K_w$

$\Delta H^\circ = \Sigma \Delta H_f^\circ(products) - \Sigma \Delta H_f^\circ(reactants)$

Absolute T(K) = T(°C) + 273.15

$$u_{rms} = \sqrt{\overline{u^2}} = \sqrt{\frac{3RT}{M}}$$

Weak Base: $B + H_2O = HB^+ + OH^-$

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

$$pOH = pK_b - \log\frac{[B]}{[BH^+]}$$

$K_w = 1.00 \times 10^{-14}$ (25°C)

$pH = -\log[H_3O^+]$

Cp_{H2O}=1 cal g^{-1} °C^{-1}

Test-taking strategy: PLEASE READ THIS FIRST

Write your name on all 6 pages. This test consists of two parts: multiple choice and problems requiring a longer answer. **For the multiple choice section, mark one correct answer on your exam AND use a #2 pencil to bubble in one correct answer on your Scantron™ form for each question.** In order to maximize your score on the exam:

- Do the questions you know how to do first.
- Then, go back and spend more time on the questions you find more challenging.
- Budget your time carefully---don't spend too much time on one problem. Anticipate spending about 45 minutes on each section.
- Don't forget to include units in your calculations!
- **Be sure to leave sufficient time to transfer your multiple choice answers to the Scantron™ form**

(for Administrative use only)

Multiple Choice		2		Total E2	
1		3		Total E1	

NAME :_____

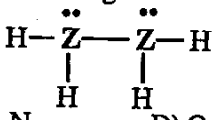
PART I: Multiple Choice, 3 points each, 48 points total
MARK THE CORRECT ANSWER ON YOUR EXAM AND SHADE IN THE BUBBLE OF THE CORRECT ANSWER FOR EACH QUESTION WITH A #2 PENCIL ON YOUR SCANTRON™ FORM

1.) The answer to #1 is B, fill in bubble B on your Scantron™ form.

2.) Which of the following has the largest molecular dipole moment?

A) BF_3 B) CO_2 C) CF_4 D) CCl_4 E) HCN

3.) Given the molecule below, which of the following elements could be Z?

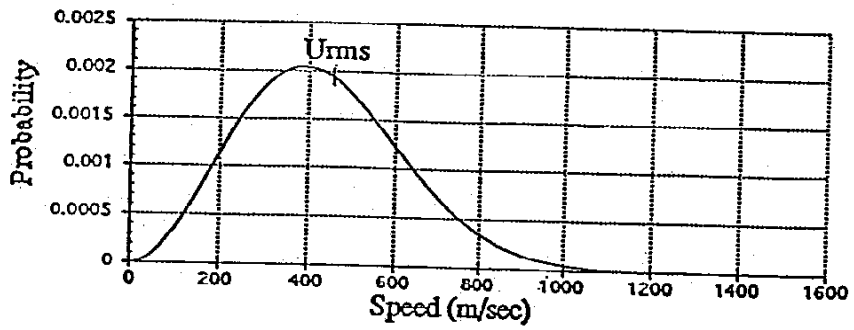


A) B B) C C) N D) O E) F

4.) In the following reaction, the Cl-P-Cl bond angles: $PCl_5 \longrightarrow PCl_4^+ + Cl^-$

A) All increase B)All stay the same C) All decrease
D) Some increase and some decrease E) Can't determine

5.) The speed distribution curve below is for O_2 at 300 K. The same distribution curve applies to ^4He at what temperature?



A) 37.5 K
B) 106K
C) 300K
D) 849K
E) 2400K

6.) If you fill a balloon with helium in Denver Colorado (P = 0.8 atm, t = 0° C) and drive to Death Valley California (P=1.05 atm, t = 40° C), the balloon will?

A) Shrink B) Stay the same C) Expand D) Sublime E) Can't determine

7.) Helium gas taken from a nuclear experiment contains the isotopes ^3He and ^4He. One mole of the gas weighs 3.25 g and has a pressure of 1.00 atm. What is the partial pressure of ^3He?

A) 0.0125 atm B) 0.25 atm C) 0.50 atm D) 0.75 atm E) 1.25 atm

8.) When you add the moderately weak acid, acetic acid (CH_3COOH) $K_a = 1.76 \times 10^{-5}$, to the moderately weak base, ammonia (NH_3) $K_b = 1.79 \times 10^{-5}$, a neutral conducting solution is created. Which of the following are the conducting species in this solution?

A) $Na^+ + Cl^-$ B) $H_3O^+ + OH^-$ C) $CH_3COOH + NH_3$ D) $CH_3COO^- + NH_4^+$ E) $H_2O + H_2O$

9.) The pH of a solution made by mixing 9.0 L of 0.010 M HCl and 1.0 L of 0.10 M NaOH is:

A) 13.0 B) 11.0 C) 7.0 D)3.0 E)1.0

NAME _____

10.) When 0.69 atm of SO_2Cl_2 (g) is placed in a flask at 100° C it dissociates,

$$SO_2Cl_2\ (g) \rightleftharpoons SO_2\ (g) + Cl_2\ (g),$$

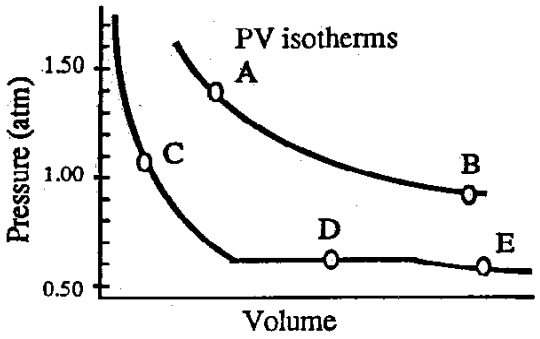
until the partial pressure of SO_2Cl_2 (g) is 0.13 atm. What is the equilibrium constant, K, for the dissociation reaction at 100°C?

A) 0.13 B) 0.60 C) 2.4 D) 4.3 E) 5.7

Use the PV isotherms below to answer the following two questions (11-12).

11.) At what point do liquid and vapor co-exist?

12.) At what point is the fluid (gas or liquid) the least compressible?



13.) Given the following reactions,

$$C(\text{graphite}) + 2H_2(g) \longrightarrow CH_4(g) \qquad \Delta H° = -75\ \text{kJ·mol}^{-1}$$

$$C(\text{graphite}) + 2F_2\ (g) \longrightarrow CF_4\ (g) \qquad \Delta H° = -925\ \text{kJ·mol}^{-1}$$

and knowing that the standard state of H is H_2 (g), F is F_2 (g) & C is graphite, calculate the standard enthalpy change $\Delta H°$ (in kJ·mol^{-1}) for the process:

$$CF_4(g) + 2\ H_2(g) \longrightarrow CH_4(g) + 2F_2(g)$$

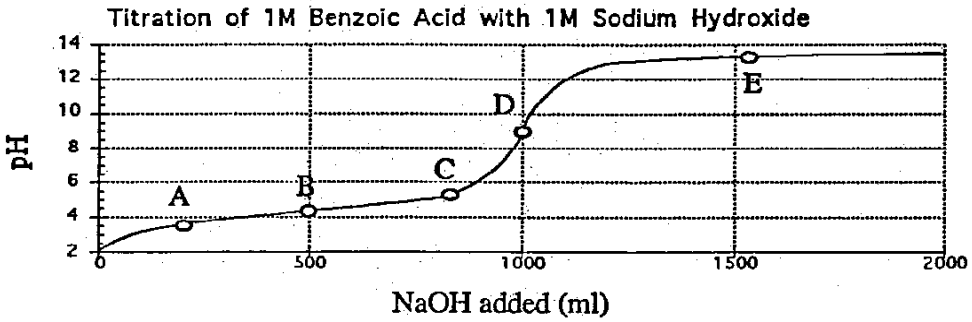
A) -1000 kJ·mol^{-1} B) -950 kJ·mol^{-1} C) -825 kJ·mol^{-1} D) 825 kJ·mol^{-1} E)1000 kJ·mol^{-1}

14.) 2.0 moles of NH_4Cl are dissolved in 1.0 L of water at 25.0 °C. Given the reaction below, calculate the final temperature of the water.

$$NH_4Cl\ (s) \rightleftharpoons NH_4^+(aq) + Cl^-(aq) \qquad \Delta H = 3.5\ \text{kcal mol}^{-1}$$

A) 32.0 °C B) 28.5 °C C) 25.0 °C D) 21.5 °C E) 18.0 °C

Use the titration curve below to answer the following three questions (15-17).



15.) Which point on the titration curve corresponds to adding 1.0 mol. sodium hydroxide (NaOH) and 1.0 mol. of benzoic acid (C_6H_5COOH) to 2.0 L of water?

16.) Which point corresponds to the pH of 1.0 L of 1.0 M sodium benzoate ($C_6H_5COO^-Na^+$) added to 500 ml of 1.0 M HCl?

17.) Which point corresponds to a buffer with a pH=pKa?

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Part II: Problems, 42 points total
SHOW ALL OF YOUR WORK AND USE UNITS IN YOUR CALCULATIONS
(12 pts)

1.) Glyoxalic acid ($H_2C_2O_3$) and Propionic acid ($H_6C_3O_2$) are two white solids that can be combusted in the presence of excess oxygen to form water (H_2O) and carbon dioxide (CO_2)

a.) Write a balanced reaction equation for the combustion of each acid.

Suppose you have **ONLY** the following equipment and supplies available:

- an apparatus that will allow you to combust either species
- a device to measure the number of moles of CO_2 produced in the combustion
- a device to measure the number of moles of H_2O produced in the combustion
- an unknown mass of one of the acids

b.) Given the unidentified sample of one of the two acids and **ONLY** the above equipment, write a procedure to determine which compound it is. Show your reasoning below. Write your procedure in the box.

Final Procedure

NAME_____

(15pts)

2.) In the Rocky Mountains in Colorado, tailings piles, remaining from the mining of galena (PbS), are polluting local water. Often water collects in puddles near the tailings pile and the following equilibrium is established

$$K_{sp} = 9.00 \times 10^{-29}$$
$$\Delta H^{o} = 131.8 \text{ kJ/mol}$$

$$PbS\ (s) \rightleftharpoons Pb^{2+}(aq) + S^{2-}(aq)$$

a.) Write an equilibrium expression (K_{sp}) for the above reaction.

b.) Assuming that the ore is dissolving to the maximum allowed by the K_{sp}, calculate the concentration of Pb^{2+} in a large puddle at the bottom of a tailings pile in moles per liter.

c.) What happens to the reaction quotient (Q) immediately after a heavy rainfall? Explain.

d.) How would you expect the concentration of Pb^{2+} to differ in the puddle on a hot afternoon (30° C) compared to a cool morning (5° C)? Explain in the context of Le Chatelier's principle.

e.) Given solutions of $Pb(NO_3)_2$, $NaNO_3$ and Na_2S suggest a way to decrease Pb^{2+} pollution. Explain your reasoning.

NAME_____

(15 pts)

3.) A pickle factory is discharging vinegar (1.0 M acetic acid, pKa = 4.75 and Ka = 1.76×10^{-5}) into a local creek. The EPA-allowable pH range for the receiving water is 4.5 to 8.5. The volume of the receiving area is 1000 liters. Show your work, include a balanced equation and equilibrium expression where needed.

a.) If 10.0 L of vinegar are dumped into the receiving water, will the pH of the receiving water still be within the EPA's acceptable limits? Explain and justify.

b.) The pickle factory engineer decides to add 20.0 kg of solid NaOH into the receiving area, to counteract the 10.0 L of vinegar. Is the receiving water now within the EPA allowable pH range? Explain and justify.

c.) The engineer now realizes that he should have added only 200 g of solid NaOH to partially neutralize the 10.0 L of vinegar in the receiving area. Had he done so what would the pH of the receiving area be?