Chemistry 1A　　　　　　　　**Midterm Exam 2**　　　　　　　**October 15, 1996**
Page 1 of 9.　　　　　**(Closed Book, 90 minutes, 150 points)**　　　**Professor Pines**

Version C

Name:_____　　　　TA:_____

SID:_____　　　　Section:_____

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│　　　　　　　Identification Sticker　　　　　　　│
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Whose picture is this (circle one), and what is his connection to Chemistry 1A?

Garcia　　　　Gallogly　　　　Le Châtelier　　　　Lewis　　　　Brønsted

Test-taking strategy: PLEASE READ THIS FIRST!
Write your name on all 9 pages. This test consists of two parts: multiple choice (**answers to be circled** *and* **entered on the Scantron sheet**) and short answer. In order to maximize your score on the exam:

- Do the questions you know how to do first, then, go back and answer the questions you skipped.
- Budget your time carefully -- don't spend too much time on any one problem.
- Show all work for which you want credit and don't forget to include units.
- **The tear-out back page has some data and useful equations.**

Page	Points
Multiple Choice	
4	
5	
6	
7	
8	
Total:	
Retro MC:	
Retro SA:	
Retro Total:	

Name: _____

Section 1: Multiple Choice. 16 questions, 4 points each.

Instructions: For the following questions, circle the answer on the exam sheet **and bubble** in the correct answer on your Scantron sheet. There is **only one** correct answer per problem, so for each question **fill in one bubble on your Scantron form.**

1.) You are taking test version **C**. Please fill in bubble "**C**" on your Scantron sheet.

2-5. In the next four problems, consider the **exothermic** reaction:

$$2\,ZnS(s)\ +\ 3\,O_2(g)\ \rightleftharpoons\ 2\,ZnO(s)\ +\ 2\,SO_2(g)$$

Which of the following five choices best describes how the given changes will affect the equilibrium state of this reaction?

> **A)** More ZnS is produced.
> **B)** More SO_2 is produced.
> **C)** Less SO_2 and ZnS are produced.
> **D)** More SO_2 and ZnS are produced.
> **E)** No change occurs.

2.) The partial pressure of $O_2(g)$ is increased.

3.) ZnO(s) is added to the system.

4.) The temperature is decreased.

5.) The volume of the reaction vessel is doubled.

6.) Which of the following conjugate acid-base pairs (see page 9 for K_a's) would buffer a solution **most effectively** at a pH of 7.0?

   A) NH_4^+, NH_3 **B)** HF, F⁻   **C)** H_2S, HS⁻   **D)** H_3O^+, H_2O **E)** HAc, Ac⁻
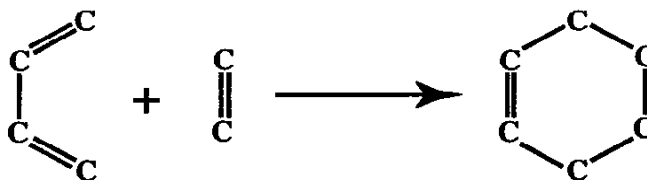
7.) Which of the following pH's might be found at the equivalence point of a titration of 0.1 M NH_3 (weak base) with 0.1 M HCl (strong acid)?

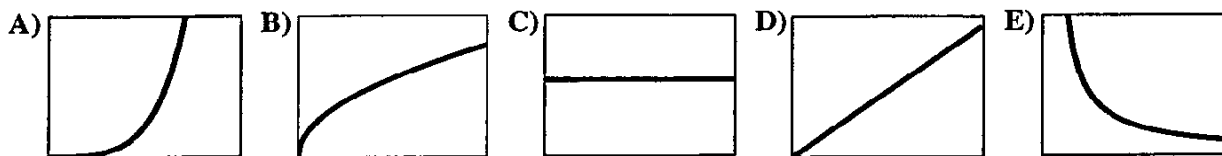   **A)** 1   **B)** 4   **C)** 7   **D)** 10   **E)** 13

8.) Using bond enthalpies (see page 9), estimate $\Delta H°$ for the following reaction (in $kJ \cdot mol^{-1}$). Ignore the C-H bonds (which are not shown).

A) -800   B) -550   C) -200   D) 200   E) 550

9-12. In the next four problems, choose which of the following five graphs best describes the behaviors listed below. Assume ideal gases for the last two problems (11 and 12).

9.) Energy in the **surroundings** as a function of time for an endothermic reaction.

10.) $[H_3O^+]$ as a function of $[OH^-]$ in an aqueous solution.

11.) PV as a function of T.

12.) u_{rms} as a function of the total kinetic energy, E_k.

13.) One mole of a hydrocarbon is combusted with oxygen to form 88 grams of CO_2 and 36 grams of H_2O. What is the *molecular* formula of the hydrocarbon?

   A) CH_2 B) C_2H_2 C) C_2H_4 D) C_2H_6 E) C_4H_{12}

14.) f(u)

Pictured on the left is the distribution of molecular speeds for Ar at 300 K. At what temperature will N_2 have the same distribution curve?

A) 150 K   B) 210 K   C) 300 K   D) 420 K   E) 600 K

15.) A sample of CO_2 is isotopically enriched with ^{18}O such that the ratio of ^{16}O to ^{18}O is 1 to 1. What will the mass spectrum of this CO_2 sample look like?

A)   **B)**   **C)**   **D)**   **E)**

16.) The reaction described by the following equation is carried out in a balloon:

$$Ge(CO_3)_2(s) \ + \ 4\,HI(\ell) \ \text{-------}> \ GeI_4(s) \ + \ 2\,CO_2(g) \ + \ 2\,H_2O(\ell)$$

If initially the balloon contains only 1 mole of $Ge(CO_3)_2$ and 1 mole of HI, what will be the approximate final volume of the balloon at STP?

    A) 5 L   **B)** 10 L   **C)** 20 L   **D)** 30 L   **E)** 40 L

17.) Professor Pines inhaled 0.25 moles of N_2O (laughing gas) from a cylinder which originally contained 2.00 moles of N_2O at a pressure of 8.00 atm. Assuming an ideal gas at constant temperature, what is the new pressure inside the cylinder?

    A) 1.00 atm   **B)** 2.50 atm   **C)** 4.00 atm   **D)** 7.00 atm   **E)** 9.15 atm

Section 2: Short Answer. 5 questions, 56 points total.

Answer the following five short answer questions. Partial credit will be given, so show your work whenever possible. Your final answers **must** be written in the boxes provided.

1.) (8 points) Circle the chromatogram below which best resolves the Zn and Fe spots. Then, **in 20 words or less**, explain your reasoning.

◎ Zn

○ Fe

● Cu
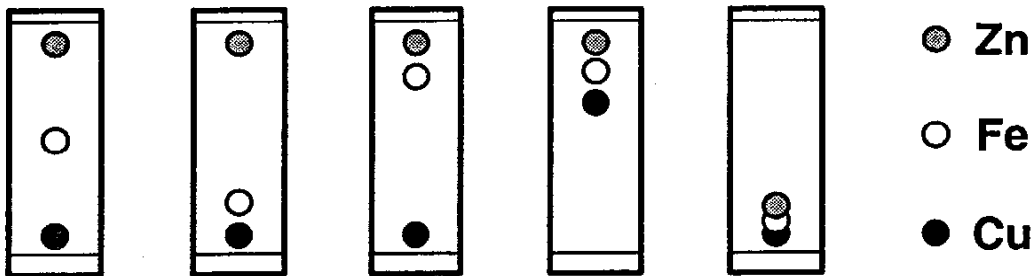
Explanation:

Name: _____

2.) (7 points) Draw the Lewis electron dot structure for ICl_2^-.

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Lewis Dot Structure:

</div>

Name **or** describe the *molecular* structure for ICl_2^-.

<div style="border:1px solid black">

Molecular Structure:

</div>

Consider the reaction of ICl_2^- with Cl_2 to form ICl_4^-. Explain **in 20 words or less** what happens to the Cl-I-Cl bond angles during the course of the reaction?

<div style="border:1px solid black">

Answer:

</div>

Name: _____

3.) (13 points) Vitamin C is ascorbic acid ($HC_6H_7O_6$), for which K_a is 8.0×10^{-5}. Calculate the pH of a solution made by dissolving a 50 mg tablet of pure vitamin C in water and diluting to a total volume of 10.0 mL.

> pH =

Calculate the pH of a solution made by dissolving a 50 mg tablet of pure vitamin C in water and diluting to a total volume of 1 billion (10^9) liters.

> pH =

4.) (15 points) Instead of using glucose as a source of nutritional energy, some individuals use ethanol (CH_3CH_2OH) instead.

a.) Write a balanced equation for the combustion of ethanol with oxygen to form carbon dioxide and water.

>

b.) What is the $\Delta H°$ of combustion for 1.00 mole of ethanol?
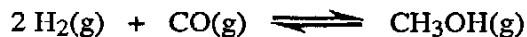
> $\Delta H°$ =

c.) A bottle of 80 proof vodka contains 4.0 moles of ethanol. How many bottles of vodka must an individual drink in one day to provide 1.00×10^7 J of energy?

> Ans:

5.) (13 points) Consider the following reaction of hydrogen and carbon monoxide to form methanol:

$$2\,H_2(g) \;+\; CO(g) \;\rightleftharpoons\; CH_3OH(g)$$

a.) Write the equilibrium expression for this reaction.

$$K_p =$$

b.) At 25° C, the partial equilibrium pressures of H_2, CO, and CH_3OH are 1.2 atm, 2.8 atm, and 2.3 atm, respectively. What is the value of K_p?

$$K_p =$$

c.) If, at 25° C, the partial pressures of the three gases are instantaneously adjusted such that the partial pressures of H_2 and CO are both 2.0 atm and the partial pressure of CH_3OH is 2.2 atm, in which direction will the reaction proceed?

Answer:

Section 3: *What's Wrong.* 5 questions, 6 points each.

For this section, in no more than twenty words per response, state what is wrong with the following pictures. **Note: only the first 20 words of each answer will be read!**

1.) For the titration of a weak acid with a strong base (1 eq = 1 molar equivalent):
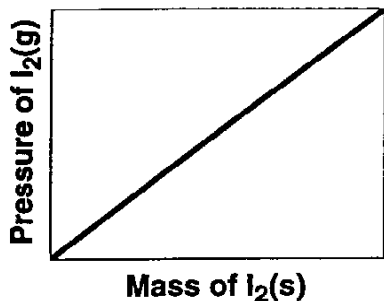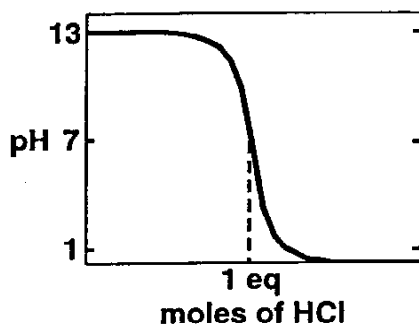
Answer:

pH axis: 13, 7, 1
1 eq
moles of NaOH
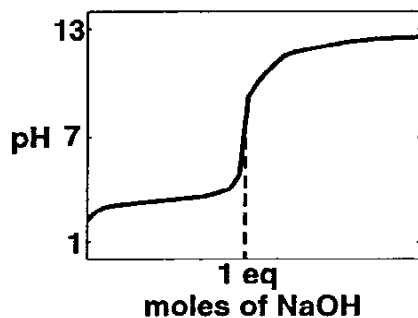
Page 8 of 9.   **Name:** _____

For this section, in no more than twenty words per response, state what is wrong with the following pictures. **Note: only the first 20 words of each answer will be read!**

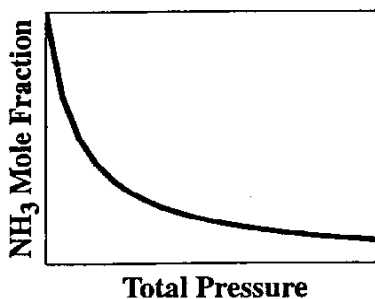**2.)** For the process $I_2(s) \rightleftharpoons I_2(g)$ at equilibrium in a 1.0 L flask:

Pressure of $I_2(g)$ (vertical axis) vs. Mass of $I_2(s)$ (horizontal axis)

Answer:

3.) For the titration of 0.1 M NaOH with 0.1 M HCl (1 eq = 1 molar equivalent):

pH (13, 7, 1) vs. moles of HCl (1 eq)

Answer:

4.) For the reaction: $N_2(g) + 3 H_2(g) \rightleftharpoons 2 NH_3(g)$

NH_3 Mole Fraction (vertical axis) vs. Total Pressure (horizontal axis)

Answer:

5.) A model which explains the smell of $C_6H_{12}O_2$ observed in the laboratory:

- C
- H
- O
- $C_6H_{12}O_2$

Answer:

8
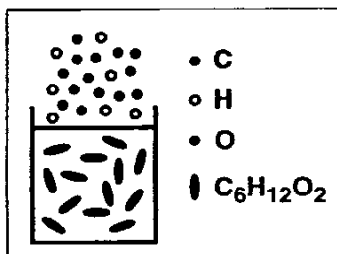
Standard Enthalpies of Formation (in kJ • mol⁻¹)

$CH_3CH_2OH(\ell)$	-278	$H_2O(g)$	-242
$CO_2(g)$	-394	$O(g)$	249

Average Bond Enthalpies (in kJ • mol⁻¹)

C - C	350	C - H	400
C = C	600	O = O	500

Ionization Constants of Acids (K_a) at 25°C

Hydrofluoric	HF	6.6×10^{-4}
Ascorbic	$HC_6H_7O_6$	8.0×10^{-5}
Acetic	HAc	1.8×10^{-5}
Hydrosulfuric	H_2S	9.1×10^{-8}
Ammonium	NH_4^+	5.6×10^{-10}

Possibly Useful Information

Absolute $T(K) = T(°C) + 273.15$

Ideal Gas: $PV = nRT$

$$\Delta H^o_{form} = \Delta H^o_{products} - \Delta H^o_{reac\,tan\,ts}$$

$$V = 22.414 \text{ L} \bullet \text{mol}^{-1} \text{ at STP}$$

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

$$E_k = \frac{nN_0 m\overline{u^2}}{2} = \frac{3}{2}nRT$$

$$K_b = \frac{[OH^-][HA]}{[A^-]}$$

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

$$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14} @ 25° C$$

$$\overline{\epsilon_k} = \frac{1}{2}m\overline{u^2} = \frac{E_k}{nN_0}$$

$$pH = pK_a - \log\left(\frac{[HA]}{[A^-]}\right)$$

$R = 8.31 \text{ J} \bullet \text{mol}^{-1} \bullet \text{K}^{-1}$

$R = 0.0821 \text{ L} \bullet \text{atm} \bullet \text{mol}^{-1} \bullet \text{K}^{-1}$

For the reaction: $a A + b B \rightleftharpoons c C + d D$

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