

*Chemistry 1A, Fall 2008*

## Midterm Exam #2

October 14, 2008

(90 min, closed book)

Name: \_\_\_\_\_

SID: \_\_\_\_\_

GSI Name: \_\_\_\_\_

- The test consists of 4 short answer questions and 11 multiple choice questions.
- Put your written answers in the boxes provided. Answers outside the boxes may not be considered in grading.
- Show your work to receive the maximum credit possible.
- Write your name on every page of the exam.

	Page	Points	Score
Question A	2	15	
Question B(i-vii)	3	17	
Question B (viii-ix) Question C (bonus)	4	6	
Question D	5	27	
Question E	6	13	
Question F and G (multiple choice)	7-8	24	
Total		100	

**Useful Equations and Constants:**

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

$$\text{pX} = -\log X$$

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

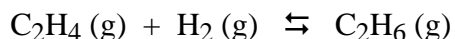
$$N_0 = 6.02 \times 10^{23} \text{ 1/mol}$$

**Strong acids and bases:**

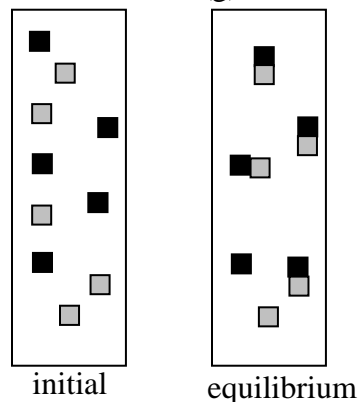
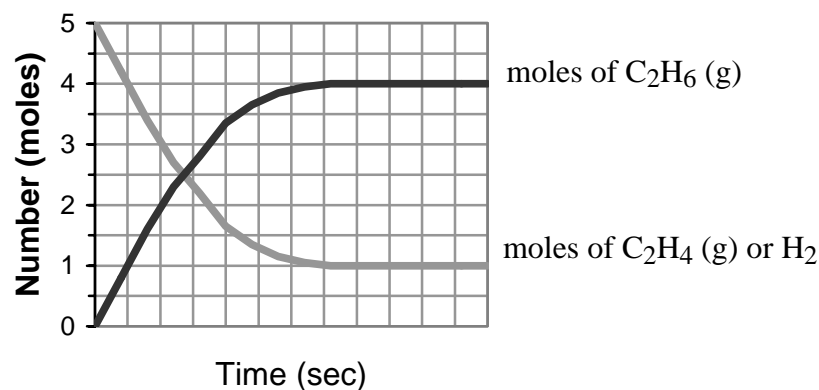
HCl	LiOH
HNO <sub>3</sub>	NaOH
H <sub>2</sub> SO <sub>4</sub>	KOH
HClO <sub>4</sub>	
HBr	
HI	

**A) Gas Phase Equilibria**

Consider the reaction between ethylene,  $\text{C}_2\text{H}_4$ , and hydrogen,  $\text{H}_2$  to form ethane,  $\text{C}_2\text{H}_6$ .



The progress of a reaction between 5.0 moles of  $\text{C}_2\text{H}_4(\text{g})$  and 5.0 moles of  $\text{H}_2(\text{g})$  is shown in the graph below.



- i. What is the equilibrium constant for the reaction? Assume the reaction container is 1.0 liter. Show your work.

Imagine that the same reaction starts with the ethylene,  $\text{C}_2\text{H}_4(\text{g})$ , and hydrogen,  $\text{H}_2(\text{g})$  reactants only. This reaction mixture results in the moles listed below at equilibrium.

moles ethylene,  $\text{C}_2\text{H}_4(\text{g})$  at equilibrium = 1.0 moles  
 moles hydrogen,  $\text{H}_2(\text{g})$  at equilibrium = 0.50 moles  
 moles ethane,  $\text{C}_2\text{H}_6(\text{g})$  at equilibrium = 2.0 moles

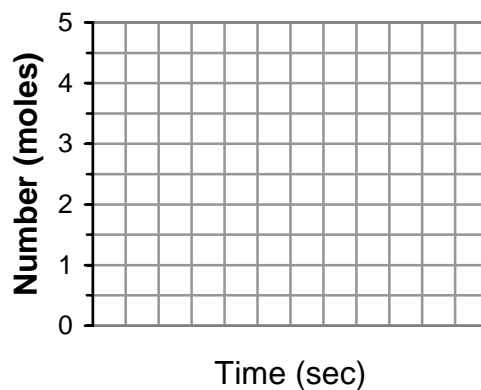
- ii. How many moles of ethylene,  $\text{C}_2\text{H}_4(\text{g})$ , and hydrogen,  $\text{H}_2(\text{g})$  were present at the start of the reaction?

Imagine that the same reaction begins with 5.0 moles of ethane,  $\text{C}_2\text{H}_6(\text{g})$  and no reactants.

iii. moles  $\text{C}_2\text{H}_6$  + moles  $\text{C}_2\text{H}_4$  = \_\_\_\_\_

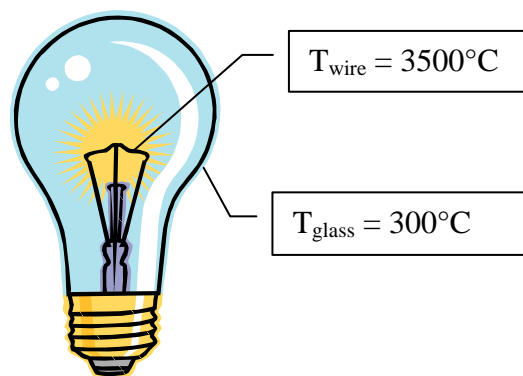
iv. moles  $\text{C}_2\text{H}_6$  + moles  $\text{H}_2$  = \_\_\_\_\_

- v. Draw a graph showing the progress of the reaction. Label the curves showing all 3 molecules.



**B) Heterogeneous Equilibria**

The common light bulb has a thin wire made of tungsten, W, in a glass bulb with all the air removed. The tungsten wire glows when it is heated with an electric current. If the tungsten wire breaks, the light bulb no longer lights.



i. Write the chemical equation for the sublimation of tungsten.

ii. Write the equilibrium expression for the sublimation of tungsten.

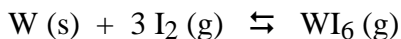
iii. For the sublimation reaction,  $K(300^{\circ}\text{C}) < K(3500^{\circ}\text{C})$ . Explain why.

After the light bulb is in use for a long time, you can observe a black substance coating the glass. Eventually, the light bulb no longer lights.

iv. What is the black substance? \_\_\_\_\_

v. Why does it deposit on the inside of the glass bulb?

Light bulbs with a small amount of iodine gas,  $\text{I}_2$ , are called tungsten-halogen light bulbs. Iodine reacts with tungsten according to the chemical equation given on the left below.



For this reaction,  $K(300^{\circ}\text{C}) > K(3500^{\circ}\text{C})$

vi. What happens when you raise the temperature?

favors reactants more

favors products more

no preference

vii. Explain why the addition of iodine makes the light bulbs last longer.

**B) Heterogeneous Equilibria (continued)**

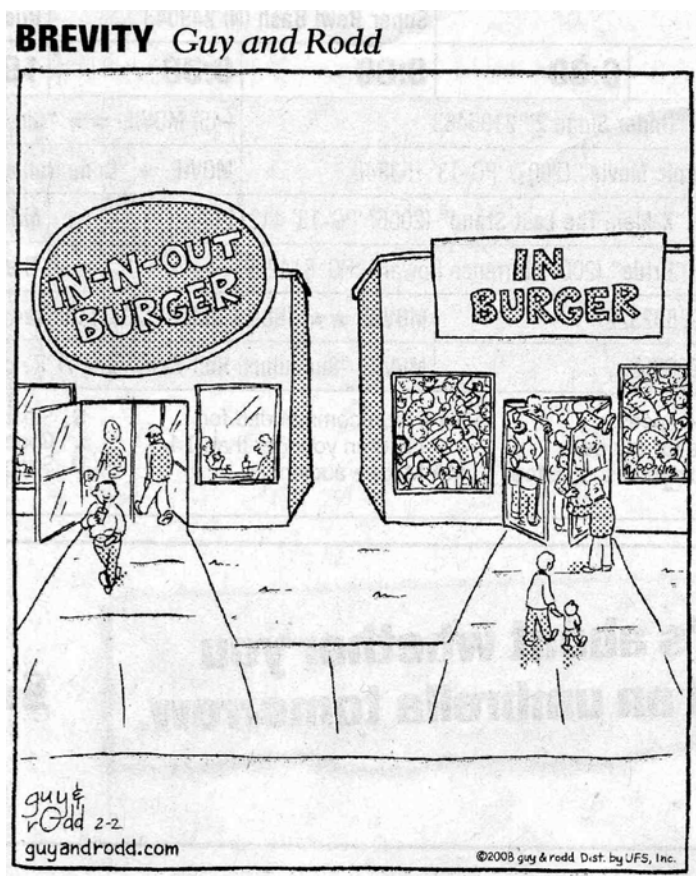
All of the air has been removed from inside the glass bulb, but there is always a small amount of water. The water reacts with the tungsten according to the chemical equation given below.



**viii.** Balance the reaction.

**ix.** How would you classify this reaction?

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**C) Bonus Point**

What is the chemical analogy to this cartoon?

**D) Lakes and K<sub>sp</sub>**

A lake is surrounded by rocks containing gypsum, a mineral with the chemical formula  $\text{CaSO}_4(\text{s})$  ( $K_{\text{sp}}=1.9 \times 10^{-4}$ ) and magnesite, a mineral with the chemical formula  $\text{MgCO}_3(\text{s})$  ( $K_{\text{sp}}=6.8 \times 10^{-6}$ ).

i. List at least three ions you would expect to find in the lake as a result of the dissolution of the minerals near the lake. *Be sure to include the correct charge on each ion.*

i. \_\_\_\_\_ ii. \_\_\_\_\_ iii. \_\_\_\_\_

ii. If gypsum,  $\text{CaSO}_4(\text{s})$ , is dissolved in pure water, what would the equilibrium concentration of calcium ions be? Show your work.

concentration of calcium ions = \_\_\_\_\_

The water in this lake is found to have a  $\text{Ni}^{2+}$  concentration of  $1.0 \times 10^{-5} \text{ M}$ . A river that feeds the lake brings the  $\text{OH}^-$  concentration to  $1.0 \times 10^{-6} \text{ M}$  where the lake and river water meet. The  $K_{\text{sp}} = 6.5 \times 10^{-18}$  for  $\text{Ni}(\text{OH})_2$ .

iii. Write the chemical equation.

iv. Write the equilibrium expression.

v. What is the value of Q when the river meets the lake?

vi. Will  $\text{Ni}(\text{OH})_2(\text{s})$  precipitate? \_\_\_\_\_

vii. Suppose that a lake is saturated with dissolved  $\text{MgCO}_3(\text{s})$ . If more  $\text{MgCO}_3(\text{s})$  is added to the water, the concentration of aqueous magnesium ions will (circle the correct answer):

increase

stay the same

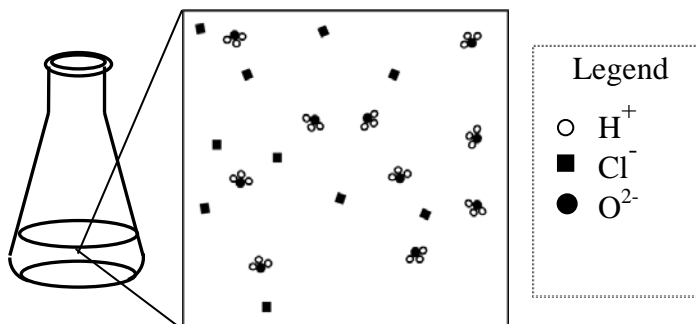
decrease

viii. Explain your reasoning.

**E) Lab and Lecture Linked**

In the laboratory experiment, *Determination of the Molarity of a Strong Acid*, you determined the concentration of a concentrated stock solution of HCl.

- i. From the molecular picture shown below, calculate the concentration of the HCl solution. The volume of the solution shown is  $1.52 \times 10^{-23}$  L. Show your work.



\_\_\_\_\_ M HCl

To make a solution that is easier to use for a titration, it is necessary to dilute the solution. You pipet 10.00 mL of the concentrated solution above into a 50.00 mL volumetric flask and dilute to the mark with distilled water.

- ii. After mixing thoroughly, what is the concentration of this solution?

\_\_\_\_\_ M HCl

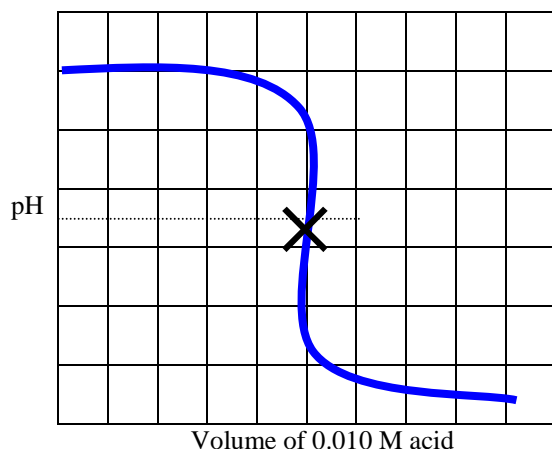
- iii. For the same volume of solution shown in the picture above, how many  $\text{H}_3\text{O}^+$  molecules would be in a picture of the diluted solution?

\_\_\_\_\_  $\text{H}_3\text{O}^+$  molecules

- iv. Explain your answer in words or equations.

**F) Titration Curves**

The titration of 20 mL of 0.010 M NaOH with 0.10 M HCl is shown for your reference in the graph below. The dotted line indicates pH of 7.

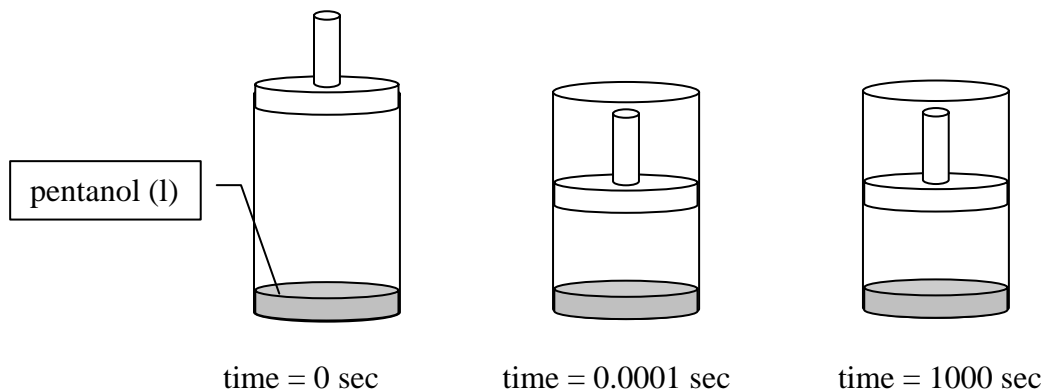


For the following questions mark all that apply. Mark your exam and your scantron form. The scantron machine can read multiple marks.

- 
- |  |   |
|--|---|
| <b>1)</b> If the concentration of HCl was doubled, which of the following would be true? | A) the initial pH would be lower<br>B) the initial pH would be higher<br>C) the pH at the equivalence point would be lower<br>D) the volume at the equivalence point would be smaller |
|--|---|
- 
- |   |   |
|---|---|
| <b>2)</b> If the concentration of NaOH was doubled, which of the following would be true? | A) the initial pH would be lower<br>B) the initial pH would be higher<br>C) the pH at the equivalence point would be lower<br>D) the volume at the equivalence point would be smaller |
|---|---|
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|---|---|
| <b>3)</b> If the NaOH was replaced with 0.020 M $\text{NH}_3$ , which of the following would be true?<br>( $K_b = 1.8 \times 10^{-5}$ ) | A) the initial pH would be lower<br>B) the pH at the equivalence point would be lower<br>C) the volume at equivalence would be smaller<br>D) the pH at $\frac{1}{2}$ equivalence would be lower |
|---|---|
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- |  |  |
|--|--|
| <b>4)</b> Examine the data past the equivalence point in the reference graph. The pH is low and keeps getting lower. This is because ... | A) the hydronium ion ( $\text{H}_3\text{O}^+$ ) concentration is decreasing<br>B) there is excess strong acid in solution<br>C) the solution is getting more dilute as the titration proceeds<br>D) the conjugate base makes the pH drop |
|--|--|
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**G) Vapor Pressure**

Shown below is a sample of liquid pentanol placed in a cylinder by a moveable piston and allowed to reach equilibrium. The piston is then pushed down so the volume of the cylinder is half of what it was originally. Assume the temperature is constant at 25°C for the process.



5) At time = 0 sec, what is the pressure inside the cylinder?	A) 0 atm	B) $2.1 \times 10^{-3}$ atm	C) $4.2 \times 10^{-3}$ atm
6) At time = 0 sec, which is true?	A) $Q < K$	B) $Q > K$	C) $Q = K$ D) $K = 1$
7) In the instant that the piston is lowered ( $t = 0.0001$ sec) which is true?	A) $Q < K$	B) $Q > K$	C) $Q = K$ D) $K = 1$
8) Compare the system at 0 sec and 1000 sec, Which is true for the process?	A) $P_{\text{pentanol}}$ increases	B) $P_{\text{pentanol}}$ decreases	C) $P_{\text{pentanol}}$ stays the same
9) Compare the system at 0 sec and 1000 sec, Which is true for the process?	A) moles vapor increases	B) moles of vapor decreases	C) moles of vapor stay the same
10) If the liquid in the container was hexane ( $\text{C}_6\text{H}_{14}$ ) instead of pentanol ( $\text{C}_5\text{H}_{12}\text{O}$ ) which is true?	A) $K < 2.1 \times 10^{-3}$	B) $K > 2.1 \times 10^{-3}$	C) $K = 2.1 \times 10^{-3}$
11) The best explanation for my previous answer is...?	A) the molar mass of the compounds is about the same B) both have van der Waals attractions (London forces) of about the same magnitude C) pentanol can form hydrogen bonds D) OH bonds are stronger than CH bonds E) K should be the same at the same temperature		