FIRST LETTER OF YOUR LAST NAME [ ]

Average = 68%

CHEMISTRY 1128 **EXAM I** **February 19, 2016**

NAME (PRINT) ECE SECTION KEY

SIGNATURE _____ TA _____

PLEASE READ THE FOLLOWING INSTRUCTIONS

Do NOT begin the exam until asked to do so.

There are 8 numbered pages, a page of useful information, and a periodic table in this exam. Check to see that they are all here before you begin the exam. Return all these papers when you are finished. Write your name on every page.

On the multiple choice section of the test, fill out all answers in #2 pencil on the answer sheet. Label the answer sheet with your name, Peoplesoft # (Column A-G) and the last two digits of your section # (column L-M). Make sure to erase completely; there will be no regrades on the multiple choice portion of the test.

The long answer portion of the exam should be done in pen with blue or black ink. Exams done in pencil, erasable ink, or where white-out, liquid paper, etc. have been used are *ineligible for regrades*.

Be sure to follow the directions in answering all questions. Write your final answers in the blanks provided. In working problems, you must **SHOW ALL WORK**. No credit will be given unless all work is clearly shown and the method of solution is logically correct. Use correct units and significant figures.

Do not write below this line

Page	Total	Grader
4	_____ / 8	
5	_____ / 8	
6	_____ / 18	
7	_____ / 12	
8	_____ / 19	

MC Grade _____ LA Grade _____ Total Grade _____ /150 Checked by _____

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I. **(100 points) On the multiple choice section of the test fill out all answers in #2 pencil on the answer sheet. Label the answer sheet with your name, Peoplesoft # (Column A-G) and the last two digits of your section # (column L-M). Make sure to erase completely there will be no regrades on the multiple choice portion of the test.**

1. Consider having an aqueous solution that is 10.0% by mass NH_4NO_3. What is the molality of this solution?

   a. 1.90 m **b.** 1.39 m **c.** 0.0019 m

   d. 110 m **e.** 0.190 m

2. A desalination plant produces 6.45 atm of pressure in order to produce pure water. What is the maximum molarity of NaCl that can be in the water before this plant stops working? Assume that the only salt in the salt water is NaCl and the temperature is 25°C. (Assume complete dissociation).

   a. 0.264 M **b.** 1.57 M **c.** 0.132 M **d.** 0.00130 M **e.** 0.528 M

3. You have two ice cubes made of slightly salty water. Ice cube B melts at a higher temperature than Ice cube A. Which of the following statements is **TRUE** assuming that the same type of salt is dissolved in both cubes.
   a. Both ice cubes are made of pure water.
   b. Cube A has a higher salt content than B.
   c. Cube B has a higher salt content than A.
   d. We cannot determine the answer without more information.

4. Which of the following solutions will have the highest vapor pressure?

   a. 0.10 m $CaCl_2$ **b.** 0.200 m NaBr **c.** 0.050 m K_2SO_4

   d. 0.050 m $Al_2(SO_4)_3$ **e.** Pure water

5. If 5.58 grams of naphthalene, $C_{10}H_8$ (molar mass = 128.2 g/mol) is dissolved in 152 grams of benzene, what will be the boiling point of the resulting solution? K_b for benzene = 2.53°C/m and the boiling point of pure benzene is 80.10°C

   a. 80.48 °C **b.** 80.82 °C **c.** 100.82 °C

   d. 79.37 °C **e.** 80.06 °C

6. Which of the following will be the most soluble in benzene (C_6H_6)?

   a. Water

   b. Ammonia (NH_3)

   c. Methanol (CH_3OH)

   d. Butanol ($CH_3\ CH_2CH_2CH_2OH$)

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7. For $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, in the first 20.0 seconds for the concentration of NH_3 to increase to 0.75 M. What is the average rate of the reaction in this given time interval?

a. 0.019 M/s **b.** 0.038 M/s **c.** 0.0042 M/s **d.** 0.0063 M/s

8. For the generic reaction $A(g) + 2B(g) \rightarrow 3C(g)$, it takes 30.0 seconds for the concentration of B to drop from 1.0 to 0.6 M. Predict the increase in concentration of C in the same time interval.

a. 0.2 M **b.** 0.3 M **c.** 0.4 M **d.** 0.6 M

9. The generic aA + bB → products reaction displays a rate expression of: rate = k [B]. Which of the following statements is **FALSE** about the reaction described.

a. The reaction is first order in B.
b. The reaction is first order in A.
c. The reaction is zero order in A.
d. The reaction is first order overall.

10. The generic aA + bB → products reaction displays a rate expression of: rate = k [B]. Which of the following statements is **FALSE** about the reaction described.

a. The reaction rate will double if the concentration of B is doubled.
b. The reaction rate will be halved if the concentration of B is halved.
c. The reaction rate will stay unchanged if the concentration of A is doubled.
d. The reaction rate will double if the concentration of A doubled.

11. Consider the data for the following hypothetical reaction

A → products,

Rate (mol/L·s)	0.68	0.79
[A], M	0.30	0.40

What is the order of the reaction with respect to A, considering the rate expression is rate =k $[A]^m$?

a. m = 0 **b.** m = 1 **c.** m = 1/2 **d.** m = 3

12. In the transition-state model, which of the following statements is a **FALSE** statement for the following reaction?

$CO + NO_2 \rightarrow CO_2 + NO$

a. The activated complex is $O \equiv C \cdots O \cdots N = O$
b. The activated complex is in equilibrium with the reactants.
c. The activated complex may either decompose into products or revert back to the reactants.
d. The activated complex is energetically lower than the reactants.

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13. At 300°C, the equilibrium constant for the following reaction is 155.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

What is K for the following reaction?

$$2/3\ NH_3(g) \rightleftharpoons 1/3\ N_2(s) + H_2(g)$$

a. 6.45×10^{-3} **b.** 5.37 **c.** 3.72×10^{6} **d.** 0.186 **e.** 2.3×10^{-10}

14. Consider the following reaction

$Sb_2S_3(s) + 3H_2(g) \rightleftharpoons 2Sb(s) + 3H_2S(g)$

where the equilibrium constant, K, is 0.429 at a certain temperature. If the equilibrium partial pressure of H_2 is 0.200 atm, what is the partial pressure of $H_2S(g)$?

a. 0.466 atm **b.** 0.151 atm **c.** 0.265 atm **d.** 0.200 atm **e.** 0.429 atm

15. All of the following statements are false for a chemical system at equilibrium **EXCEPT**

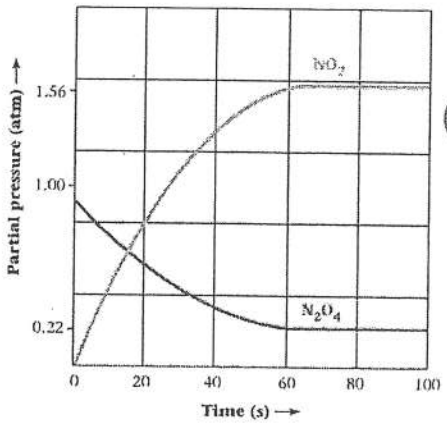
a. The pressure of reactants and products must be equal.
b. The forward reaction is exothermic.
c. The partial pressures of the reactants and products remain constant unless the equilibrium is disturbed.
d. The chemical reaction proceeds in the forward direction until all the limiting reactant is consumed.

16. Which of the following statements is/are **CORRECT?**

i. Product pressures appear in the numerator of an equilibrium constant expression.
ii. Equilibrium constant changes when the temperature changes.
iii. Equilibrium can be established starting with only reactants, with only products or with any mixture of reactants and products.

a. i only **b.** ii only **c.** i and ii **d.** i and iii **e.** i, ii, and iii

17. Consider the following graph for the decomposition of N_2O_4 to NO_2. Which of the following statements is **FALSE** about the graph?



a. The equilibrium is initially established after 60 seconds.
b. The equilibrium is initially established after 100 seconds.
c. Initially the partial pressure of N_2O_4 is high, and the rate of the reaction is high.
d. As the reaction proceeds the partial pressure of N_2O_4 falls and the rate of forward reaction decreases.

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II. Show all of your work for this section of the exam and place your final answer on the lines provided.

A. (8 points) You have a solution of $FeCl_3$ with a concentration of 1000 ppm. How cold would it need to be in order for the water solution to freeze? Assume that for the only species dissolved in the water is the $FeCl_3$ and it ionizes completely. Report your answer in °C for the freezing point of the solution and please pay attention to the sign (i.e. positive or negative). Molal freezing point constant, k_f, of water is 1.86°C/m.

Assume 1000 ppm has 1×10^6 g soln 1000 g $FeCl_3$

$$\#\text{ of mol of } FeCl_3 = 1000\text{g } FeCl_3 \times \frac{1\text{mol } FeCl_3}{162.2} = 6.165\text{mol}$$

2 pts

$$m = \frac{6.165\text{mol}}{(1\times10^6 - 1000)\times10^{-3}} = 0.00617\text{m}$$

2 pts

2 pts for i

$$\Delta T_f = 4 \times 0.00617 \times 1.86\,\frac{°C}{m}$$

$$= 0.0459$$

2 pts

$$T_f = -0.0459°C$$

-1 for not having (-) sign

$-0.0459°C$

8

B. (8 points) A bottle of phosphoric acid solution is 75% H_3PO_4 by mass and the density of the phosphoric acid solution is 1.57 g/mL.

1. What is the molarity of H_3PO_4 in the solution?

Assume 100g of soln 75g H_3PO_4

$$\#\text{ of mol of } H_3PO_4 = 75\text{ g } H_3PO_4 \times \frac{1\text{ mol}}{97.994\text{ g}}$$

$$= 0.765\text{ mol}$$ (2pts)

(5pts) $$V_{soln} = 100\text{g soln} \times \frac{1\text{ mL soln}}{1.57\text{ g}} = 63.7\text{ mL}$$ (1)

$$M = \frac{0.765}{0.0637} = 12.0$$

12 M (2pts)

2. What is the molality of H_3PO_4 in the solution?

mass of solvent = 100 - 75 = 25 g (1pt)

(3pts) $\frac{0.765\text{ mol}}{0.0250}$ ⇝ # of mol from 1

30.6 m (2pts)

8

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C. (8 points) The half-life for a first order reaction is 1.50 sec at temperature 25°C. What is the half-life of the same reaction at 35°C, knowing that the activation energy, E_a = 100.0 kJ/mol? Please remember to report half life at 35°C and not the reaction rate at 35 °C.

$$\ln \frac{1.5}{(t_{1/2})_2} = \frac{-100.0\ kJ/mol}{8.31 \times 10^{-3}} \left(\frac{1}{308} - \frac{1}{298} \right)$$

$$\frac{1.5}{(t_{1/2})_2} = e^{1.31}$$

$$\frac{1.5}{(t_{1/2})} = 3.71$$

0.405

8 pts

1 mist. 5

2 mist. 3

3 mist. 0

D. (10 points) The decomposition of 4.25 grams of N_2O_5 to NO_2 and O_2 is a first order reaction. Knowing that at 67.0°C the starting amount of N_2O_5 is reduced to half at 1.98 min, calculate how many minutes it will take to produce 0.500 g of O_2?

$$N_2O_5(g) \rightarrow 2NO_2(g) + \tfrac{1}{2}O_2(g)$$

0.500g O_2

# of mol of N_2O_5 decomposed $= 0.500\,g\,O_2 \times \frac{1\,mol\,O_2}{32.00\,g} \times \frac{1\,mol\,N_2O_5}{1/2\,mol\,O_2}$

$= 0.03125\,mol$

All or nothing (3 pts)

10 pts

mass of N_2O_5 left $= 4.25 - 0.03125 \times 108.2$

$= 4.25 - 3.376 = 0.874$

2

$\frac{\ln 2}{1.98} = 0.35\,min^{-1} = k$ (2 pts)

$\ln 4.25/0.874 = 0.35 \times t \quad \frac{1.5}{0.35} = t$

$t = 4.5$ min

4.5 min.

3 pts All or nothing

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E. **(8 points)** Given the following reactions and their equilibrium constants at 298 K, what is the equilibrium constant for the formation of 1 mol of NOCℓ from its elements, N_2, $Cℓ_2$ and O_2?

$1/2\ N_2(g) + O_2(g) \rightleftharpoons NO_2(g)$ $\quad K = 1.0 \times 10^{-9}$

$NOCℓ(g) + 1/2\ O_2(g) \rightleftharpoons NO_2Cℓ(g)$ $\quad K = 1.1 \times 10^{2}$

$2NO_2Cℓ(g) \rightleftharpoons 2NO_2(g) + Cℓ_2(g)$ $\quad K = 11.1$

$\frac{1}{2}\ N_2(g) + \frac{1}{2} O_2(g) + \frac{1}{2} Cℓ_2(g) \rightleftharpoons NOCℓ(g)$

$\frac{1}{2} N_2(g) + O_2(g) \rightleftharpoons NO_2(g) \quad K = 1.0 \times 10^{-9}$

$NO_2Cℓ(g) \rightleftharpoons NOCℓ(g) + \frac{1}{2} O_2(g) \quad K' = \frac{1}{1.1 \times 10^{2}}$

$NO_2(g) + \frac{1}{2} Cℓ_2(g) \rightleftharpoons NO_2Cℓ(g) \quad \left(\frac{1}{11.1}\right)^{1/2}$

$K = 1.0 \times 10^{-9} \times \frac{1}{1.1 \times 10^{2}} \times \left(\frac{1}{11.1}\right)^{1/2}$

(2) (2) (2+2)

2.7×10^{-12}

F. **(4 points)** For the following reaction

$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$ $\quad K = 1.52$ at 973 K

At equilibrium, a 1.0L container has 3.8 g of carbon, and CO with a partial pressure of 1.96 atm.

1. What is the equilibrium partial pressure of CO_2?

2pts

$1.52 = \frac{(P_{CO})^2}{P_{CO_2}} = \frac{(1.96)^2}{P_{CO_2}}$

2.53 atm

All or nothing

2. What is the total gas pressure at equilibrium?

3pts

$2.53 + 1.96 = 4.49$

from part 1

4.49 atm

All or nothing

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G. (9 points) Consider the decomposition of hydrogen cyanide to cyanogen and hydrogen gases.

$$2HCN(g) \rightleftharpoons C_2N_2(g) + H_2(g)$$

At a certain temperature, K for this decomposition is 0.17. What are the partial pressures of all gases at equilibrium if initially the partial pressures are $P_{C_2N_2} = P_{H_2} = 0.32$ atm and $P_{HCN} = 0.45$atm?

$$\frac{(0.32)^2}{(0.45)^2} = 0.51 > 0.17$$

3 pts

$$\sqrt{\frac{(0.32 - x)^2}{(0.45 + 2x)^2}} = \sqrt{0.17}$$

4 pts

$$\frac{0.32 - x}{0.45 + 2x} = 0.4123$$

$$0.32 - x = 0.1855 + 0.8246x$$

$$0.1345 = 1.8246x$$

$$x = 0.074 atm$$

$P_{C_2N_2} = P_{H_2} = 0.32 - 0.074 =$

2 pts 2 pts 2 pts

$P_{C_2N_2} =$ 0.25 $P_{H_2} =$ 0.25 $P_{HCN} =$ 0.598 / 0.60

H. (10 points) Consider the following system which is at equilibrium.

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g) \qquad \Delta H = 197 \text{ kJ}$$

9

How will the amount of SO_3 at equilibrium be affected by

10 pts

2 pts each

1. adding oxygen?
   Increase decrease no change
2. increasing the pressure by decreasing the volume of the reaction container?
   Increase decrease no change → decrease is acceptable since it said SO_2 (s)
3. increasing the pressure by adding argon gas?
   Increase decrease no change
4. decreasing the temperature?
   Increase decrease no change
5. removing gaseous sulfur dioxide?

decrase

(1) Assume 100g of solution 10.0g will be NH_4NO_3

# of mol of NH_4NO_3: $10.0\,g\ NH_4NO_3 \times \frac{1\,mol\ NH_4NO_3}{80.052\,g}$

$= 0.125\,mol$

$m = \frac{0.125}{0.090} = 1.39\,m$

(2) $\Pi = i \times M \times R \times T$

$6.45\,atm = 2 \times M \times 0.0821 \times 298$

$M = 0.132\,M$

(5) $5.58\,g\ napht \times \frac{1\,mol\ napht}{128.2\,g} = 0.0435\,mol$

$\Delta T_b = \frac{0.0453}{0.152} \times 2.53$

$= 0.72^\circ C$

$T_b = 80.82$

(8) average rate $= \frac{0.75 - 0}{2 \times 20.0} = 0.019\,M$

(8) average rate $= -\frac{\Delta[B]}{2\Delta t} = \frac{\Delta[C]}{3\Delta t}$

$= \frac{-0.6-1.0}{2\times 30.0} = \frac{\Delta[C]}{3\times 30.0}$

$= 0.20\,M \times 3 = 0.60$

(11) $\frac{0.79}{0.68} = \left(\frac{0.40}{0.30}\right)^m$

$\log 1.16 = m \log\left(\frac{0.40}{0.30}\right)$

$m = 0.5$

(13) $\left(\frac{1}{155}\right)^{1/3} = 0.186$

14. $0.429 = \frac{(P_{H_2S})^3}{(0.200)^3}$

$P_{H_2S} = 0.151$