Exam One CHM 205 (Dr. Mattson) 26 January 2007	***Academic Integrity Pledge:*** *In keeping with Creighton University's ideals and with the Academic Integrity Code adopted by the College of Arts and Sciences, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.* **Signature:**

Instructions: Show all work whenever a calculation is required. You will receive credit for <u>how</u> you worked each problem as well as for the correct answer. This exam is worth 100 points. <u>Box your answers.</u>

A solution contains 18.16 g ammonium sulfate, $(NH_4)_2SO_4$ (132 g/mol), in 200.0 mL water. Answer Questions 1 – 8 about this solution. [Given: d_{H2O} = 1.00 g/mL]

1. (5 pts) What is the mole fraction of solute in the solution? Hint: With this and many of the subsequent problems, start by writing the equation you plan to use.

2. (5 pts) What is the mass percent of the solute?

3. (5 pts) What is the molality of the solute?

4. (6 pts) Given that the density of the solution is 1.085 g/mL, what is the molarity of the solute?

5. (5 pts) Estimate the freezing point of the solution. [Given: K_f = 1.86 deg/molal for water; T_f^o = 0 °C]

6. (5 pts) Estimate the boiling point of the solution. [K_b = 0.51 deg/molal for water; T_b^o = 100 °C.]

7. (5 pts) Estimate the vapor pressure of the solution at 40 °C, given that the normal vapor pressure of water is 55.3 mmHg at this temperature.

8. (5 pts) Estimate the osmotic pressure of the solution at 298 K. [Given: R = 0.0821 L atm/mol K.]

9. (5 pts) Suppose we wished to identify an unknown salt, known to be LiBr, NaBr, KBr or RbBr. Using freezing point lowering to estimate the molar mass, we dissolved 4.936 g of the unknown salt in 75.0 g water and noted that the solution froze at -1.48 °C. Given that water normally freezes at 0 °C, what is the MM of the unknown salt? See Question 5 for K_f

Conclusion: The salt is LiBr, NaBr, KBr or RbBr.

10. (4 pts) Which of these solutes is soluble in water? Briefly explain or show work in support of your answer (e.g. solubility rule or Lewis/ABE.)

$Mg(NO_3)_2$	Sol	Not sol	C_7H_{16}	Sol	Not sol
CCl_4	Sol	Not sol	CH_3OH	Sol	Not sol

11. Nitrosyl bromide, decomposes at 10 ^{o}C:

$$2\ NOBr(g) \rightarrow 2\ NO(g) + Br_2(g)$$

(a) (5 pts) Use these data to determine the order of the reaction. Must show work!

time	[NOBr]
0 s	0.0700
30 s	0.0351
60 s	0.0234
90 s	0.0176
120 s	0.0141

(b) (3 pts) What is the value of the rate constant, including units?

12. Azomethane produces ethane and nitrogen:

$$C_2H_6N_2(g) \rightarrow C_2H_6(g) + N_2(g)$$

(a) (5 pts) Use the following initial rate kinetic data to determine the order of the reaction.

Expt	time	$[C_2H_6N_2]_0$	$rate_0 = \Delta[C_2H_6N_2]/\ \Delta t$
1	0 s	1.40×10^{-2}	3.10×10^{-6} mol/L s
2	0 s	3.29×10^{-2}	7.26×10^{-6} mol/L s

(b) (3 pts) What is the value of the rate constant (units).

13. (5 pts) Consider the reaction:

$$4\ NH_3(g) + 7\ O_2(g) \rightarrow 4\ NO_2(g) + 6\ H_2O(g)$$

If the rate of the reaction in terms of oxyen were known to be rate = $-\ \Delta[O_2]/\ \Delta t = 6.1 \times 10^{-2}$ mol/L s, what is the rate of the reaction expressed in terms of nitrogen dioxide, rate = $\Delta[NO_2]/\ \Delta t$?

14. (6 pts) Ammonia is converted to its elements in the presence of a Pt catalyst in a reaction that follows zero-order kinetics:

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

If $[NH_3]$ drops from 0.150 mol/L to 0.062 mol/L in 25.0 s, what is $[NH_3]$ after 32 s?

15. (6 pts) For a hypothetical reaction A $\rightarrow$ P that follows first order kinetics, how long does it take for [A] to drop from 0.250 M to 0.100 M if the rate constant is $1.7 \times 10^{-2}\ s^{-1}$?

16. Consider the following mechanism for which the first step is the rate-determining step:

Step 1: $HBr + HBrO_3 \rightarrow HBrO + HBrO_2$

Step 2: $HBr + HBrO_2 \rightarrow 2\ HBrO$

Step 3: $HBrO + HBr \rightarrow Br_2 + H_2O$

16(a) (5 pts) What is the overall reaction?

16(b) (5 pts) What is the rate law for the reaction?

16(c) (6 pts) Sketch the reaction profile given that the overall reaction is exothermic. Label each E_{act} and the overall ΔH.

(1 pt) Sign the Academic Integrity pledge (on the front) *and* print your name here:

Your exam score (100 possible): ________

Determine your grade:

A+ ≥ 95; A ≥ 90; B+ ≥ 85; B ≥ 80; C+ ≥ 75; C ≥ 70; D ≥ 60

Answers:

1. 0.0122

2. 8.32%

3. 0.688 molal

4. 0.684 molar

5. –3.84 ^oC

6. 101.1 ^oC

7. 53.32 mmHg

8. 50.2 atm

9. 165 g/mol, therefore RbBr.

10.

$Mg(NO_3)_2$ Sol (solubility rule)	C_7H_{16} Not sol (hydro-carbons are nonpolar)
CCl_4 Not sol (ABE has no E groups)	CH_3OH Sol (OH group has 2 E groups)

11. (a)

time	[NOBr]	$\Delta[A]/\Delta t$	$\Delta \ln[A]/\Delta t$	$\Delta 1/[A]/\Delta t$
0 s	0.0700			
30 s	0.0351	-0.00116	-0.0230	0.473
60 s	0.0234	-0.00039	-0.0135	0.475
90 s	0.0176	-0.00019	-0.00095	0.470
120 s	0.0141	Not 0th	Not 1st	Yes 2nd!

(b) 0.473 L/mol s

12. (a) rate = $k[C_2H_6N_2]^1$ (b) (3 pts) $2.21 \times 10^{-4}\ s^{-1}$

13. rate = $-\Delta[NO_2]/\Delta t = 3.5 \times 10^{-2}$ mol/L

14. $[NH_3] = 0.0374$ M

15. 53.9 s

16(a). $3\ HBr + HBrO_3 \rightarrow 2\ HBrO + Br_2 + H_2O$

16(b) rate = $k[HBr][HBrO_3]$

16(c) There should be three humps each labeled with an E_{act} the leftmost valley (starting materials) should be higher in energy than the rightmost valley, the final products because it is exothermic. ΔH is the energy difference between the rightmost and leftmost valleys.