CHEMISTRY 127 **EXAM II** **October 20, 2006**

NAME (PRINT) KEY SECTION _____

SIGNATURE _____ TA _____

PLEASE READ THE FOLLOWING INSTRUCTIONS

Do NOT begin the exam until asked to do so.

There are 8 numbered pages, 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. Use a **pen** with blue or black ink for the entire exam.

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 and the BONUS, 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

			Grader
I	**(50)**	_____	_____
II	**(28)**	_____	_____
III	**(47)**	_____	_____
IV	**(25)**	_____	_____
BONUS		_____	_____
TOTAL		_____	_____

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I. (50 points)

A. (10 points) Write your answers to the following questions on the blanks provided.

2 pts each

No 1. The number of moles of HCℓ in 10 mL of 12 M HCℓ is equal to that in 1000 mL of 0.012 M. **(Yes** or **No)**

$BaSO_4$, AgCl 2. Solutions of silver sulfate and barium chloride are mixed. Write the formula of the precipitate(s) that form(s). If no precipitate forms, write NR. (1pt 1pt)

weak acid 3. Classify $HClO_3$ as strong acid, weak acid, strong base or weak base

No 4. $C_6H_5NH_2$ is an Arrhenius acid when added to water? **(Yes** or **No)**

Na^+ 5. Acetic acid and sodium hydroxide are combined. What are the spectator ion(s)?

B. (9 points) Write the ***net ionic*** equations for the reactions between aqueous solutions of the following compounds. (Do not forget to indicate the physical states of the compounds) −1 for not showing physical states (one time) −1 for not having (s) for $Ba_3(PO_4)_2$

3 pts each

1. HCN(aq) and KOH(aq): $HCN(aq) + OH^-(aq) \rightarrow H_2O + CN^-(aq)$

2. Na_3PO_4(aq) and $Ba(OH)_2$(aq): $PO_4^{3-}(aq) + Ba^{2+}(aq) \rightarrow Ba_3(PO_4)_2(s)$

−1 for each mistake

3. NH_3(aq) and HCℓ(aq): $NH_3(aq) + H^+(aq) \rightarrow NH_4^+(aq)$

C. (11 points) Ten milliliters of a 0.250 M solution of $Al_2(CO_3)_3$ is mixed with 25.0 mL of a 0.012 M solution of K_2CO_3.

1. **(6 points)** How many moles of CO_3^{2-} ions are present in the final mixture?

3 pts (not having mole ratio −2)

$$10mL \times \frac{0.250\,mol\,Al_2(CO_3)_3}{1000mL} \times \frac{3\,mol\,CO_3^{2-}}{1\,mol\,Al_2(CO_3)_3} = 7.50\times10^{-3}\,mol$$

$$25.0mL \times \frac{0.012\,mol\,K_2CO_3}{1000mL} \times \frac{1\,mol\,CO_3^{2-}}{1\,mol\,K_2CO_3} = 3.0\times10^{-4}\,mol$$ 2 pts

7.8×10^{-3} mol CO_3^{2-} total = 7.8×10^{-3} mol (1 pt for addn)

2. **(5 points)** What is the molarity of CO_3^{2-} ions in the final solution? (Assume the volumes are additive)

5 pts

$$M_{CO_3^{2-}} = \frac{7.8\times10^{-3}}{0.0350} = 0.22\,M$$

$$M_{CO_3^{2-}} = \frac{\text{answer in \#1}}{0.0350}$$

0.22 M

30 pts

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D. (10 points) A sample of limestone weighing 1.005 g is dissolved in 75.00 mL of 0.2500 M hydrochloric acid. The following reaction occurs:

$$CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$$

It is found that 18.50 mL of 0.150 M NaOH is required to titrate the excess HCℓ left after reaction with the limestone.

1. **(4 points)** How many moles of hydrochloric acid are used ?

4pts

$n_{HCl} = 75.00\text{mL HCl} \times \frac{0.2500\text{ mol HCl}}{1000\text{ mL}} - 18.50\text{mL NaOH} \frac{0.150\text{ mol NaOH}}{1000\text{mL}}$

$= 0.01875 - 0.002775$

0.01598 mol HCl

2. **(4 points)** How many grams of $CaCO_3$ (MM = 100.09 g/mol) are there in the sample?

4pts

$\text{mass of } CaCO_3 = 0.01598\text{ mol HCl} \times \frac{1\text{mol H}^+}{1\text{mol HCl}} \times \frac{1\text{mol CaCO}_3}{2\text{mol H}^+} \times \frac{100.09\text{g}}{1\text{mol CaCO}_3}$

OR $= \frac{\text{answer in \#1}}{2} \times 100.09$

2 pts for using right mole ratio
2 pts for the mass

0.7997 g

3. **(2 points)** What is the mass percent of $CaCO_3$ in the limestone?

2 pts all or nothing

$\frac{0.7997}{1.005} \times 100 = 79.57\%$ -OR- $\frac{\text{answer in \#2}}{1.005} \times 100$

79.57%

E. (10 points) What is the volume of 0.2500 M cobalt (III) sulfate, $Co_2(SO_4)_3$, required to react completely with 11.20 mL of 1.45 M sodium carbonate to form cobalt (III) carbonate?

$Na_2CO_3(s) \rightarrow 2Na^+(aq) + CO_3^{2-}(aq)$

$2Co^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow Co_2(CO_3)_3(s)$

10pts

$11.20\text{mL } Na_2CO_3 \times \frac{1.45\text{mol } Na_2CO_3}{1000\text{mL}} \times \frac{1\text{mol } CO_3^{2-}}{1\text{mol } Na_2CO_3} \times \frac{2\text{mol } Co^{3+}}{3\text{mol } CO_3^{2-}} \times \frac{1\text{mol } Co_2(SO_4)_3}{2\text{mol } Co^{3+}}$

2pts 2pts 2pts

$n_{Co_2(SO_4)_3} = 0.00541\text{mol}$

$V = \frac{0.00541}{0.2500} = 0.0217\text{L}$

2pts for # of moles of Na_2CO_3

2pts for volume

21.7L or 0.0217L

20 pts

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II. (28 points)

A. (10 points) Three experiments are performed:

(A) $Ca(OH)_2$ is mixed with HF.

(B) NaOH is mixed with $Mg(NO_3)_2$

(C) Cu reacts to form Cu^{2+}.

2 pts each

Write the letter of the experiment(s) that answers each of the following questions. If none of the experiments applies, write NONE.

None **1.** Which experiment involves a strong acid?

B **2.** Which experiment produces a precipitate?

A, B **3.** Which experiment involves a strong base?

1 pt each

None **4.** Which experiment involves Cu as an oxidizing agent?

A **5.** Which experiment produces water as a product?

B. (8 points) Iodine reacts with thiosulfate ion, $S_2O_3^{2-}$, to give iodide ion and the tetrathionate ion, $S_4O_6^{2-}$. The balanced equation for the reaction that takes place is

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

If 25.0 g of iodine is dissolved in enough water to make 1.50 L of solution, what volume of 0.244 M sodium thiosulfate will be needed for complete reaction?

$$n_{I_2} = 25.0\,g\,I_2 \times \frac{1\,mol\,I_2}{253.8\,g} = 0.0985\,mol\,I_2$$

↑ 2 pts

8 pts

$$0.0985\,mol\,I_2 \times \frac{2\,mol\,S_2O_3^{2-}}{1\,mol\,I_2} = 0.197\,mol$$

↑ 3 pts

$$V_{Na_2S_2O_3} = 0.197\,mol\,S_2O_3^{2-} \times \frac{1\,mol\,Na_2S_2O_3}{1\,mol\,S_2O_3^{2-}} \times \frac{1\,L}{0.244\,mol}$$

$$= 0.807\,L$$

↑ 3 pts

0.807 L or 807 mL

18 pts

C. (10 points) Consider the ***unbalanced*** equation for a redox reaction in ***acidic medium***:

$$C_2H_5OH(\ell) + Cr_2O_7^{2-}(aq) \rightarrow Cr^{3+}(aq) + CO_2(aq)$$

Write a balanced equation for this reaction using smallest whole number coefficients. The equation itself will not be graded but you will need to balance it to answer the following questions. Write your answers in the blanks provided.

2 pts each

C — **1.** Which element is being oxidized?

C_2H_5OH — **2.** What species is the reducing agent?

6 — **3.** How many electrons are being gained in the balanced **reduction half equation** (use smallest whole numbers)?

14 — **4.** In the balanced **reduction half equation** (using the smallest whole number coefficients), what is the coefficient of H^+?

4 — **5.** What is the coefficient of Cr^{3+} in the balanced **redox reaction**? (use the smallest whole numbers)

oxidation half equation:

$$3H_2O + C_2H_5OH(\ell) \rightarrow 2CO_2(g) + 12e^- + 12H^+(aq)$$

reduction half reaction:

$$14H^+(aq) + 6e^- + Cr_2O_7^{2-}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O$$

overall:

$$16H^+(aq) + 2Cr_2O_7^{2-}(aq) + C_2H_5OH(\ell) \rightarrow 4Cr^{3+}(aq) + 11H_2O + 2CO_2(g)$$

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III. (47 points)

A. (15 points) Answer Y for **Yes** or N for **No**.

3 pts each

NO **1.** After the pressure of one mole of gas is tripled (at constant temperature), its volume is three times greater than its original value.

No **2.** The partial pressure of water vapor in a gas collected over water is independent of the temperature.

No **3.** A molecule of He at 100 °C and 1 atm pressure will have exactly the same speed as a molecule of N_2 at the same temperature and pressure.

Yes **4.** At a constant temperature and pressure, CH_4 gas will effuse twice as fast as SO_2 gas.

No **5.** You are given two tanks of equal volume, each at the same temperature and pressure. One contains H_2 and the other He. The tank containing the hydrogen has a larger number of molecules than the one containing helium.

B. (6 points) What increase in the Celsius temperature will produce a 5.0% increase in the volume of a sample of gas originally at 25.0°C if the gas pressure held constant?

6 pts

$V_1 = V$ $\quad V_2 = V_1 + 0.05V_1$

$= 1.05V$

$\frac{V_1}{V_2} = \frac{T_1}{T_2}$ $\quad \frac{V}{1.05V} = \frac{298}{T_2}$ ⇐ -2 if the temp. is in °C

$T_2 = 313$ -3 for wrong set up

15 °C ⇐ -1 for not having T in °C

C. (5 points) A compound has the simplest formula $C_2H_2X_2$. A 256.0 mL flask, at 373 K and 740.0 mm Hg, contains 0.789 g of the gaseous compound. What is the atomic mass of the unknown element, X?

5 pts

$\frac{740.0}{760.0} \times 0.2560 = \frac{0.789}{MM} \times 0.0821 \times 373$

$MM = 96.93$ g/mol

If the # of moles found first 2 pts MM 2 pts

$96.93 = 2 \times 12.01 + 2 \times 1.008 + 2X$

$X = 35.45$ g/mol

35.45 g/mol

for finding MM 4 pts for dividing by 2 to obtain atomic mass 1 pt

26 pts

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D. (9 points) A metal hydride, MH_2 reacts with water according to the following equation:

$$MH_2(s) + H_2O(\ell) \rightarrow M(OH)_2(s) + 2H_2(g)$$

When 0.1232 g of $MH_2(s)$ reacts with water, 225.0 mL of dry $H_2(g)$ are produced at 16°C and 0.9870 atm pressure. Calculate the molar mass of MH_2 and identify the metal M.

9 pts

$0.9870 \times 0.225 = n_{H_2} \times 0.0821 \times 289$ 2 pts

$n_{H_2} = 0.009360$ mol

4 pts (each mistake -2)

$n_{MH_2} = \frac{0.009360}{2} = 0.004680$ mol

$MM = \frac{0.1232}{0.004680} = 26.32$ g/mol ↑ 2 pts

26.32 g/mol; Mg ← 1 pt

E. (6 points) Consider two different containers separated from each other by a valve. Both containers are at the same temperature. Calculate the final pressure inside the system after the valve connecting the two containers is opened. Ignore the volume of the tube connecting the two containers.

	Container A	Container B
Gas	Ar	O_2
V	2.0 L	3.0 L
P	1.0 atm	2.0 atm
T	25°C	25°C

If they find the partial pressure of one of the gases 3 pts

6 pts

$\frac{P_1 V_1}{P_2 V_2} = \frac{n R T_1}{n R T_2}$

$1.0\text{atm} \times 2.0\text{L} = 5.0\text{L} \times P_2$

$P_{Ar} = 0.40\text{atm}$ ↑ 3 pts

$2.0\text{atm} \times 3.0\text{L} = 5.0\text{L} P_2$

$P_2 = 1.2\text{atm}$ ↑ 1 pt

$P_{Ar} + P_{O_2} = 0.40 + 1.20 = 1.60\text{atm}$ ↑ 2 pts

1.60 atm

F. (6 points) If a 0.0250 mol of NO effuses through a pinhole in a certain amount of time, how much N_2O_4 would effuse in that same amount of time under the same conditions?

6 pts

$\frac{n_{N_2O_4}}{n_{NO}} = \sqrt{\frac{MM_{NO}}{MM_{N_2O_4}}}$ $\frac{n_{N_2O_4}}{0.0250} = \sqrt{\frac{30.01}{92.02}}$

for inverse -4
for not taking square root -2

0.0143 mol N_2O_4

21 pts

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IV. (25 points)

A. (15 points) A student weighs out 0.1965 grams of an unknown chloride into an Erlenmeyer flask and titrates it with $AgNO_3$ using K_2CrO_4 as indicator. To reach the endpoint, 17.24 mL of 0.1529 M $AgNO_3$ is required.

1. What is the number of moles of chloride ion in the sample?

5pts

$$17.24\,mL\,AgNO_3 \times \frac{0.1529\,mol\,AgNO_3}{1000\,mL\,AgNO_3} \times \frac{1\,mol\,Ag^+}{1\,mol\,AgNO_3} \times \frac{1\,mol\,Cl^-}{1\,mol\,Ag^+}$$

3 pts for 1 mistake

$0.002636\ mol\ Cl^-$

2. What is the mass of chloride in the sample?

3pts

$$Mass = 0.002636\,mol \times \frac{35.45\,g}{1\,mol\,Cl}$$

-OR- answer in #1 x 35.45

$0.09345\ g$

3. Calculate the mass percent Cl^- ion in the sample.

3pts

$$\frac{0.09345}{0.1965} \times 100$$

-OR- $\frac{\text{answer in \#2}}{0.1965} \times 100$

$47.56\ \%$

4. If the student read the molarity of the $AgNO_3$ as 0.1259 M instead of the correct value, would the calculated mass percent Cl^- be LESS than or GREATER than or the SAME as (CIRCLE ONE) the actual value.

5. If the student was past the endpoint of the titration when he took the final buret reading, would the calculated mass percent Cl^- be LESS than or GREATER than or the SAME as (CIRCLE ONE) the actual value.

B. (10 points) A 0.100 g sample of an unknown acid requires 12.95 mL of 0.0857 M NaOH for neutralization to a phenolphthalein end point. What is the molar mass of the unknown acid?

$HA(aq) + OH^-(aq) \rightarrow 2H_2O + A^-(aq)$

10pts

$$12.95\,mL\ OH^- \times \frac{0.0857\,mol}{1000\,mL} = 0.00111\,mol$$

5 pts

$$MM = \frac{0.100}{0.00111} = 90.1\,g/mol$$

5pts

$90.1\ g/mol$

25 pts

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BONUS (15 points) ALL or NOTHING

The bonus should be done only after you have completed the main part of this exam and checked your work for errors. The time allotted for this exam does not include time for the bonus. (SHOW ALL WORK! Lucky guesses will not be considered. Method of solution should be reasonable and must get all answers correct for any credit)

A chemist weighed out 5.14 g of a mixture containing unknown amounts of BaO(s) and CaO(s) and placed the sample in a 1.50 L flask containing CO_2(g) at 30.0°C and 750.0 mm Hg. After the reaction to form $BaCO_3$(s) and $CaCO_3$(s) was completed, the pressure of CO_2(s) remaining was 230.0 mm Hg. Calculate the mass percentage of CaO(s) in the mixture.

$m_{BaO} + m_{CaO} = 5.14\ g$

$BaO(s) + CO_2(g) \rightarrow BaCO_3(s)$

$CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

$$n_{CO_2\ reacted} = \frac{1.50 \times 750/760}{303K \times 0.0821} - \frac{1.50 \times 230.0/760}{303 \times 0.0821} = 0.0413\ mol$$

$n_{BaO} + n_{CaO} = 0.0413\ mol$

$n_{BaO} = 0.0413 - n_{CaO}$

$$n_{BaO} \times \frac{153.3\ g}{1\ mol} + n_{CaO} \times \frac{56.08\ g}{1\ mol} = 5.14\ g$$

$(0.0413 - n_{CaO})\ 153.3 + n_{CaO} \times 56.08 = 5.14$

$6.32 - 153.3\ n_{CaO} + 56.08\ n_{CaO} = 5.14$

$-97.22\ n_{CaO} = -1.18$

$n_{CaO} = 0.0122\ mol$

mass of $CaO = 0.0122 \times 56.08$

$= 0.684\ g$

$$\text{mass \%} = \frac{0.684}{5.14} \times 100$$

13.3 %