Name ______________________ **AP Chemistry** **October 29, 2013**

AP Chemistry Exam II

Part II: Essays. Show ALL work below. Work should be done in a clear and orderly fashion.

Free Response #1

(a) Write a balanced equation for the complete combustion of butane(C_4H_{10}) gas, which yields CO_2(g) and H_2O(l)

$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

(b) Calculate the volume of air at 29°C (probably the temp currently in the classroom: 84°F) and 1.01 atmosphere (current pressure at my house) that is needed to burn completely 227 grams of butane (one full can). Assume that air is 21.0 percent O_2 by volume. **2970 L**

(c) The heat of combustion of butane is -2,877 kJ/mol. Calculate the heat of formation, $\Delta H°_f$, of butane given that $\Delta H°_f$ of H_2O(l) = -285.3 kJ/mol and $\Delta H°_f$ of CO_2(g) = -393.5 kJ/mol.

-123.5 kJ/mol

(d) If the combustion of one mole of butane produces 2877 kJ/mol of heat. How much heat will be produced by 40.0 grams of butane.

1984 kJ

(e) Assuming that all of the heat evolved in burning 40.0 grams of butane is transferred to 18.00 kilograms of water (specific heat = 4.184 J/g × K), calculate the increase in temperature of the water.

26.3°C

(f) In a separate experiment 40.0 grams of butane was combusted and the gas was collected over water in a 19.0 liter metal canister at 88.0°C. Calculate the total pressure if the vapor pressure of water at 88.0°C is 487 torr.

4.89 atm

Free Response #2

A student was assigned the task of determining the molar mass of an unknown gas. The student measured the mass of a sealed 803 mL rigid flask that contained dry air. The student then flushed the flask with the unknown gas, resealed it, and measured the mass again. Both the air and the unknown gas were at 20.0°C and 767. torr.

The data for the experiment are shown in the table below.

Volume of sealed flask	803 mL
Mass of sealed flask and dry air	156.70 g
Mass of sealed flask and unknown gas	158.08 g

(a) Calculate the mass, in grams, of the dry air that was in the sealed flask. (The density of dry air is 1.2152 $g\ L^{-1}$ at 20.0°C and 767. torr.) **0.976 g**

(b) Calculate the mass, in grams, of the sealed flask itself (i.e., if it had no air in it). **155.72 g**

(c) Calculate the mass, in grams, of the unknown gas that was added to the sealed flask. **2.356 g**

(d) Using the information above, calculate the value of the molar mass of the unknown gas. **69.9 g/mol**

After the experiment was completed, the instructor informed the student that the unknown gas was sulfur dioxide.

(e) Calculate the percent error in the value of the molar mass calculated in part (d). **9.05%**

(f) For each of the following two possible occurrences, indicate whether it by itself could have been responsible for the error in the student's experimental result. You need not include any calculations with your answer. For each of the possible occurrences, justify your answer.

> Occurrence 1: The temperature of the air was 20.0°C, but the temperature of the SO_2(*g*) was lower than the reported 20.0°C. **Yes - higher molar mass.**
>
> Occurrence 2: The flask was incompletely flushed with SO_2(*g*), resulting in some dry air remaining in the flask. **No - smaller molar mass.**

Free Response #3

An 5.560 mol sample of methanol, CH_3OH , is placed in a 6.00 L evacuated rigid tank and heated to 369°C. At that temperature all of the methanol is vaporized and some of the methanol decomposes to form carbon monoxide gas and hydrogen gas, as represented in the equation: $CH_3OH(g) \rightleftharpoons CO(g) + 2\ H_2(g)$

(a) The reaction mixture contains 3.968 mol of $CO(g)$ at equilibrium at 369°C.

(i) Calculate the number of moles of $H_2(g)$ in the tank.**7.936 moles**

(ii) Calculate the number of grams of $CH_3OH(g)$ remaining in the tank. **50.94 g**

(iii) Calculate the mole fraction of $H_2(g)$ in the tank. **0.588**

(iv) Calculate the total pressure, in atm, in the tank at 369°C. **119 atm**

(b) Consider the three gases in the tank at 369°C: $CH_3OH(g)$, $CO(g)$, and $H_2(g)$.

(i) Calculate the average root mean square velocity of the molecules of each gas. **$CH_3OH(g)$: 707 m/s, $CO(g)$: 756 m/s, $H_2(g)$: 2830 m/s**

(ii) If the temperature was raised from 369°C to 693°C determine the new velocity of $CH_3OH(g)$ gas.

(c) Write the equilibrium expression for the expression and calculate K_c at 369°C. **$[CO(g)][H_2]^2 / [CH_3OH]$ 4.41**

(d) Calculate K_p based on K_c at 369°C. **1.22×10^4**

Free Response #4

At elevated temperatures, NH_3 gas decomposes into N_2 gas and H_2 gas.

(a) Write the balanced reversible equation for this reaction. **$2NH_3 \rightleftharpoons N_2 + 3H_2$**

(b) A 27.0 gram sample of NH_3 is placed in an evacuated 20.0-liter container at 381.6°C.

(i) What is the concentration in moles per liter of NH_3 in the container before any decomposition occurs? **0.0794 M**

(ii) What is the pressure in atmospheres of NH_3 in the container before any decomposition occurs? **4.27 atm**

(c) If the NH_3 is 25.80 percent decomposed when equilibrium is established at 381.6°C, calculate the value for the concentration equilibrium constant, K_c, for this decomposition reaction. **8.53×10^{-5}**

(d) Calculate the pressures equilibrium constant, K_p. **0.246**

(e) In order to produce some NH_3, a 3.75-mole sample of N_2 is first placed in an empty 3.00-liter container maintained at a temperature different from 381.6°C. At this temperature K_c equals 0.220. How many moles of H_2 must be added to this container to reduce the number of moles of N_2 to 0.700 mole at equilibrium? **13.9 moles**