CHEMISTRY 210 ✈ FALL 2005
LABTEST #2

Name: Key - run (1)

Directions: Answer the following questions in the spaces provided. Show all work and include units on your final answers to receive full credit. Pay attention to significant digits!

1. (15 points) You wish to determine the heat capacity of a coffee cup calorimeter. You may do so by mixing hot and cold water in a polystyrene coffee-cup, measuring the temperature changes, and then applying the principles of calorimetry. The following data were collected:

Determination of the heat capacity of a calorimeter

Volume of cold water	50.8 mL	$= 50.8\,g$
Temperature of cold water *The cold water is initially in the calorimeter.*	23.7°C	$\Delta T_{cw} = 14.4\,C^\circ$
Volume of hot water	49.6 mL	$= 49.6\,g$
Temperature of hot water	56.9°C	$\Delta T_{HW} = -18.8\,C^\circ$
Final temperature of the mixture	38.1°C	

The density of the water is 1.00 g/mL, and the specific heat of water is 4.18 $^{J}/_{g\cdot C^\circ}$

What is the heat capacity of the calorimeter?

$$-q_{lost} = q_{gained}$$

$$-m_{HW} C_W \Delta T_{HW} = m_{CW} C_W \Delta T_W + (hc)_{cal} \Delta T_{cw}$$

$$-(49.6\,g)\left(4.18\,\frac{J}{J\,C^\circ}\right)(-18.8\,C^\circ) = (50.8\,g)\left(4.18\,\frac{J}{g\,C^\circ}\right)(14.4\,C^\circ) + (hc)(14.4\,C^\circ)$$

$$3898\ J = 3058\ J + (hc)(14.4\,C^\circ)$$

$$hc = 58.3\ ^{J}/_{C^\circ}$$

2. (18 points) You mix a bleach sample (NaOCl is the active ingredient) with potassium iodide and acid to completely form triiodide (I_3^-) ions by the following reaction:

$$NaOCl + 3\,I^- + 2H^+ \rightarrow I_3^- + H_2O + Cl^- + Na^+$$

You then titrate the I_3^- ions with a sodium thiosulfate ($Na_2S_2O_3$) solution you have previously determined the concentration of. The triiodide and the sodium thiosulfate react by the following equation:

$$I_3^- + 2\,Na_2S_2O_3 \rightarrow 3\,I^- + S_4O_6^{2-} + 4\,Na^+$$

The following data were collected:

Titration of Bleach sample

$[Na_2S_2O_3]$ (determined previously)	0.0990 *M*
Volume of Bleach sample	2.00 mL
Final Volume of $Na_2S_2O_3$	32.62 mL
Initial Volume of $Na_2S_2O_3$	1.35 mL
Volume of $Na_2S_2O_3$ added	31.27 mL

A) What is the molarity of NaOCl in this bleach sample?

$$\text{Mol NaOCl} = \frac{31.27\,\text{mL}\ Na_2S_2O_3 \mid 0.0990\,\text{mol}\ Na_2S_2O_3 \mid 1\,\text{mol}\ I_3^- \mid 1\,\text{mol NaOCl}}{1000\,\text{mL} \mid 2\,\text{mol}\ Na_2S_2O_3 \mid 1\,\text{mol}\ I_3^-}$$

$$= 1.5479 \times 10^{-3}\,\text{mol}$$

$$[NaOCl] = \frac{1.5479 \times 10^{-3}\,\text{mol}}{0.002000\,\text{L}} = \boxed{0.774\,M}$$

B) The density of the bleach solution is 1.10 g/mL. Determine the mass % of NaOCl in the bleach solution.

$M_m = 74.44$

$$\frac{0.774\,\text{mol NaOCl}}{1\,\text{L bleach}} \mid \frac{74.44\,\text{g NaOCl}}{1\,\text{mol NaOCl}} \mid \frac{1\,\text{L bleach}}{1000\,\text{mL bleach}} \mid \frac{1\,\text{mol bleach}}{1.10\,\text{g bleach}}$$

$$= 0.0524\,\frac{\text{g NaOCl}}{\text{g bleach}} \times 100\% = \boxed{5.24\%}$$

C) The manufacturer reports that the bleach is 6.00 % by mass NaOCl. What is the % difference with the manufacturer's claim?

$$\%\,\text{diff} = \frac{6.00 - 5.24}{6.00} \times 100 = 13\%$$

3. (15 points) A series of iron-salicylate solutions were prepared (as we did in the lab) with varying concentrations, and their absorbances measured at 530 nm. The [Fe-SA] (in *M*) vs. ABS data were plotted using MS Excel and the equation for the line was determined by linear regression. The formula returned by Excel was:

$$y = 1247.5\ x \qquad ABS = 1247.5\ [Fe\cdot SA]$$

A commercial aspirin tablet was then prepared for analysis (as in the experiment that we performed). The tablet was first crushed. The powder was then washed into a 250-mL volumetric flask and excess NaOH solution was added to hydrolyze the acetylsalicylic acid (ASA) to salicylic acid (SA). The volumetric flask was then filled to the mark with DI water. This was called the "stock" solution.

Then, 5.00 mL of the stock solution was pipetted into a 100-mL volumetric flask, and the flask was filled to the mark with an iron (III) chloride solution, converting the SA to the iron-salicylate complex (Fe-SA). This was called the "sample" solution.

The absorbance of the sample solution was then measured at 530 nm, and found to be

$$ABS = 0.739$$

A) What is the [Fe-SA] (in *M*) in the sample solution?

$$0.739 = (1247.5\ M^{-1})\,[Fe\cdot SA]$$

$$[Fe\cdot SA] = \boxed{5.92\times10^{-4}\ M}$$

B) What is the experimental mass of ASA (in mg) in the commercial tablet? The molar mass of ASA ($C_9H_8O_4$) is 180.16 g/mol.

$$M_{ST}V_{ST} = M_{sample}V_{sample}$$

$$M_{ST}(5.00\ mL) = (5.9238\times10^{-4}\ M)(100.0\ mL)$$

$$M_{ST} = [SA] = 0.011848\ M$$

$$\frac{0.2500\ L}{1\ L}\left|\frac{0.011848\ mol}{1}\right|\frac{180.16\ g}{1\ mol} = \boxed{534\ mg}$$

4. (15 points) The following ΔH values were collected in the lab for various acid-base reactions. All species (except water) are aqueous. HCl is a strong acid. CH_3COOH is a weak acid. NaOH is a strong base.

A) Write the net ionic equation for reactions 1 & 2.

B) Calculate the ΔH for reaction 3.

C) In terms of bonds breaking and forming, briefly explain the sign (+ or –) and the magnitude (size) of the three Δ H values.

Explanation:

Reaction 1 & 2 both release (-) energy. However, Rxn 2 releases less energy because the bond for the proton in the weak acid must first be broken (endothermic) before the H^+ & OH^- can form H_2O (very exothermic). In Rxn 1, the H^+ & OH^- ions are already dissociated.

		ΔH (in kJ)
Reaction 1:	$HCl + NaOH \rightarrow H_2O_{(l)} + NaCl$	– 62.5

Net ionic equation:

$$H^+ + OH^- \longrightarrow H_2O_{(l)}$$

for Hess's law $H_2O_{(l)} \longrightarrow H^+ + OH^-$ $\Delta H = +62.5$

Reaction 2:	$CH_3COOH + NaOH \rightarrow H_2O_{(l)} + NaCH_3COO$	– 58.2

Net ionic equation:

$$CH_3COOH + OH^- \longrightarrow H_2O_{(l)} + CH_3COO^-$$

Reaction 3: $CH_3COOH \rightarrow H^+ + CH_3COO^-$ $\Delta H =$ 4.3 kJ

Sum of reverse of Rxn 1 & Rxn 2 (as written)

$\Delta H = (-58.2) + 62.5 =$ 4.3 kJ

5. (8 points) You must mix 10 mL of concentrated sulfuric acid (12 *M*) and water to form 0.50 L of a dilute solution.

A) Explain how to do this SAFELY (consider the appropriate lab safety rules in your explanation.)

Fill a 500-mL flask ~ ½ full with water, then add the concentrated acid slowly, with mixing. Fill to the 500-mL mark w/ water. (ALWAYS add acid to water, NOT the reverse!)

B) What would be the concentration of the dilute solution?

$$(10\,mL)(12\,M) = (500\,mL)(M_2)$$

$$\boxed{M_2 = 0.24\,M} \quad \text{(accept } 0.2\,M\text{)}$$

6. (15 points) In order to determine the molar mass of an unknown volatile liquid, 5.0 mL of the liquid is placed in a pre-massed 125-mL flask capped with aluminum foil with a few small holes punched in it. The system was heated inside a water bath that reached the constant boiling temperature recorded below. The flask with the volatile liquid was removed shortly after it appeared that all of the liquid had vaporized. It was cooled and the flask massed again. The flask was then emptied and its volume determined. Atmospheric pressure in the room was recorded. Based on the data below, calculate the molar mass of the compound.

Mass of flask + aluminum foil	87.323 g
Mass of flask + aluminum foil + condensed vapor	87.588 g
Temperature of boiling water bath	99.2 °C
Volume of the flask	152 mL
Atmospheric pressure	745.7 mmHg

> $m = 0.265\,g$
> $= 372.35\,K$
> $= 0.152\,L$

$$n = \frac{PV}{RT} = \frac{(745.7\ mmHg)(0.152\,L)}{\left(62.37\ \frac{L \cdot mmHg}{K \cdot mol}\right)(372.35\,K)}$$

$$n = 4.881 \times 10^{-3}\ mol$$

$$M_m = \frac{0.265\,g}{4.881 \times 10^{-3}\ mol} = \boxed{54.3\,g/mol}$$

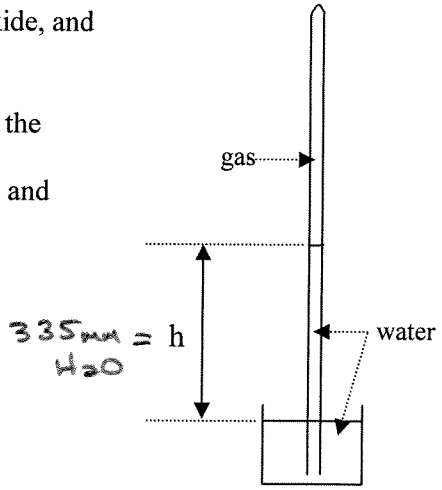
7. (2 points) Name several reasons why you move your backpack and belongings away from the work space to the cubbyholes in the back of the labs?

- Prevent spills onto materials
- Keep aisles clear to allow easy movement w/o tripping / spilling
- Allow for easy evacuation

8. (12 points) Oxygen gas is generated by the decomposition of hydrogen peroxide, and collected in a eudiometer tube over water.

The volume of gas inside the tube is 29.8 mL. The height difference between the water in the beaker and in the eudiometer is 33.5 cm (h in the diagram). Atmospheric pressure when this experiment was performed was 735.8 mmHg and the temperature was 22.0°C.

Note: Water vapor pressures at various temperatures are summarized on the constants sheet.



A) Calculate the total gas pressure inside the tube.

$$D_{mmHg} \cdot h_{mmHg} = D_{H_2O} h_{H_2O}$$

$$h_{mmHg} = \frac{(1.00\ g/mol)(335\ mm)}{13.55\ g/mol} = 24.7\ mm\ Hg$$

$$P_{gas} = 735.8\ mm\ Hg - 24.7 = 711.1\ mm\ Hg$$

B) Calculate the pressure of oxygen gas in the tube.

$$P_{Tot} = P_{O_2} + P_{H_2O}$$

$$711.1\ mmHg = P_{O_2} + 19.827$$

$$\boxed{P_{O_2} = 691.2\ mm\ Hg}$$