Chemistry 236 -- Quiz 3

Lab Day ____

February 26, 2012 — Experiments 3 and 4

Pledge and signature:

Note: <u>If you want your paper returned folded (*i.e.*, score concealed), please print your name on the back.</u>

A. (13) Bomb Calorimetry.

1. (3) A 0.3508 g tablet of glucose ($C_6H_{12}O_6$, $M = 180.16$) is completely burned in a bomb calorimeter having $C_K = 7.222$ kJ K^{-1}, producting a temperature increase of 1.972°C. Calculate (a) the combustion heat, and (b) the specific and molar heats of combustion of glucose.

2. (3) Consider the reaction, $A(s) + 3B(g) \rightarrow 2C(s) + D(g)$. ΔE° is estimated for this reaction at 25°C using bomb calorimetry. Calculate $\Delta H^\circ - \Delta E^\circ$ for this reaction at 25°C [$R = 8.3145$ J mol^{-1} K^{-1}.]

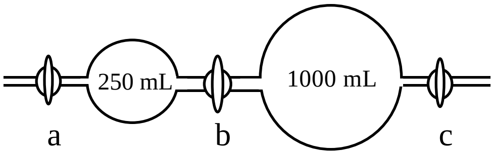
3. (3) Suppose that a mass *m* of A raises the temperature of 1.00 kg of water by 2.00 K. A mass 1.35 *m* of B raises the temperature of 2.20 kg of water by 1.40 K. Calculate the ratio of specific combustion heats q_{specific} for B and A (*i.e.*, $q_{\text{specific},\mathbf{B}}/q_{\text{specific},\mathbf{A}}$).

4. (4) In calibrating the bomb calorimeter, you will (a) weigh a benzoic acid pellet on an analytical balance (~ 1 gram), (b) measure out 2.00 L of water in a volumetric flask and then pour this into the calorimeter bucket containing the loaded bomb, and (c) measure the temperature change (~2 K) produced by the reaction. Give reasonable uncertainties for these three operations and use these to estimate the % uncertainty for a single determination of the calorimeter constant.

B. (13) Phase Equilibria and the Triple Point.

1. (2) Equal amounts (10 g) of *n*-propyl alcohol are placed in two bulbs, and the air is pumped out of both. One is 250 mL in volume, the other 500 mL. Both are held at the same constant temperature until the liquid-vapor equilibrium is established. If the measured P for the 250-mL vessel is 20.0 Torr, calculate P for the 500-mL bulb.

2. (3) Consider the apparatus pictured to the right. The 0.250-L chamber is filled with $N_2(g)$ at 30°C to a pressure of 919 Torr. 10.0 g of liquid water is then placed in the 1.000-L chamber, after which the air is pumped out via valve **c**, with little loss of water. Valve **c** is shut, valve **b** is opened, and the system is allowed to come to equilibrium at 30°C, where the vapor pressure of water is 32 Torr. Calculate the final pressure in the apparatus.



3. (3) The vapor pressure of solid arsenic is 1.00 Torr at 372°C and 10.0 Torr at 437°C. Calculate the average $\Delta H_{\mathrm{m,sub}}$ for As(s) in this temperature region. (R on p. 1)

4. (5) In analyzing our vapor pressure data for water, we assumed that $\Delta H_{\mathrm{m,vap}}$ was independent of temperature. Over an extended T range, this becomes a poor approximation. Suppose the T-dependence of $\Delta H_{\mathrm{m,vap}}$ near T_0 can be expressed as $\Delta H_{\mathrm{m,vap}} = a + b\,(T^2 - T_0^2)$, T in K.

   (a) From this expression, what are $\Delta H_{\mathrm{m,vap}}$ and ΔC_P (i) at the triple point (T_0); and (ii) 5.00 K above the triple point. [Hint: $(\partial H/\partial T)_P = C_P$; give answers in terms of a and b.]

   (b) Use this expression to obtain a version of the integrated Claussius-Clapeyron equation that could be used to analyze vapor pressure data near T_0 to obtain a and b. [Hint: You may want to start here with the differential equation, $d \ln P/dT = \Delta H_{\mathrm{m,vap}}/(RT^2)$.]