CHEM351 Final (Dec 10 2009).
$33\frac{1}{3}$ points / problem with maximum of 100 points.

1. 0.568 g of acetone (molecular weight 58.08 g mol^{-1}) is burned in an adiabatic bomb calorimeter (constant volume and constant temperature of 298 K) and heat release of 7.84 kJ was observed. Assume that the combustion reaction proceeds completely according to the following reaction:

$$(CH_3)_2\,CO(l) + 4O_2(g) \rightarrow 3CO_2(g) + 3H_2O(l)$$

Calculate a) the change in internal energy per mole and b) the change in enthalpy per mole (i.e., the reaction enthalpy). In part b) you may assume that the gas products behave according to the ideal gas law and that the vapor pressure of liquid compounds is negligible.

2. Br_2 is being formed from HBr and H_2O through the following chemical reactions under standard conditions:

$$(1)\ HBr \overset{K_1}{\rightleftharpoons} \frac{1}{2}H_2 + \frac{1}{2}Br_2 \text{ and } (2)\ H_2O \overset{K_2}{\rightleftharpoons} H_2 + \frac{1}{2}O_2$$

The equilibrium constants at 1200 K for these reactions are given as $K_1 = 2.24 \times 10^{-3}$ and $K_2 = 12.9 \times 10^{-9}$. After reaching the equilibrium, the total pressure is 1 bar.
a) What is the value for the equilibrium constant ($K = K_P$) at 1200 K for the reaction: $2HBr + \frac{1}{2}O_2 \rightleftharpoons Br_2 + H_2O$.
b) What is the value of $\Delta_r G^\circ$ at 1200 K temperature for the reaction in a)?
c) Derive the equation for the partial pressure of Br_2 in the equilibrium mixture for the reaction given in part a) at 1200 K when the reaction was initiated with the stoichiometric ratio of HBr and O_2 (e.g., 2 moles of HBr and $\frac{1}{2}$ mole of O_2). Note: you are not required to solve the equation for $[Br_2]$.

3. What is the value of the mean ionic activity coefficient for $Ce_2(SO_4)_3$ when the electromotive force (EMF) for the cell:

$$Ce(s) \mid Ce_2(SO_4)_3(aq) \mid Hg_2SO_4(s) \mid Hg(l)$$

is 3.208 V at 25 °C and constant pressure of 1 bar. The molality of $Ce_2(SO_4)_3$ is 0.0170 mol kg^{-1}. Use the following standard EMF values: for $Ce^{3+} \mid Ce$

$E^0 = -2.483$ V and for SO_4^{2-} | Hg_2SO_4 | Hg $E^0 = 0.6125$ V.