Exam #1 **NAME________________________**

Chemistry 342, (01:160:342), Spring 2012
Physical Chemistry of Biochemical Systems

1. Explain (define in words) each of the symbols in the following expressions

   (a) $\Delta_r G = \Delta_r G^{\circ} + RT \ln Q$

   (b) $dG = Vdp - SdT + \mu_A n_A + \mu_B n_B + \ldots$

   (c) $S = -k \sum p_i \ln p_i$

2. (a) Starting from $dU = dq + dw$, show that $dU = TdS - pdV$; then derive a similar formula for dH.

   (b) Using the results of problem 2a, derive expressions for $(\partial H/\partial S)_p$ and $(\partial U/\partial V)_S$.

3. Write an equation describing how the reaction enthalpy depends on temperature. Define in words each of the symbols that you use.

4. The isothermal compressibility is defined as $\kappa = -(1/V)(\partial V/\partial p)_T$. What is κ for an ideal gas?

5. Draw a sketch of an osmometer, identifying all the parts. What does this measure?

6. For each of the following expressions, is the value *(a)* always positive; *(b)* always zero; *(c)* always negative; *(d)* none of the above? Justify your answers.

   (a) $\left(\frac{\partial G}{\partial T}\right)_{p,composition}$

   (b) $\left(\frac{\partial G}{\partial n_1}\right)_{T,p,n_2,n_3,\ldots}$ (ideal solution)

   (c) $\Delta_r G$ (at equilibrium)

   (d) $\Delta_r G^{\circ}$(at equilibrium)

   (e) $\Delta_{vap} H(T_{vap})$

   (f) $\Delta_{vap} G(T_{vap})$

7. For a binary mixture of components "A" and "B": write an equation for the mole fraction x_A and for the molality b_A. Derive an equation giving x_A in terms of b_A, assuming $x_A \ll 1$. Show your work, and define any symbols you are using.

8. At 25 C, the vapor pressure of pure water is 0.031 atmospheres. What is $\Delta_{vap} G^{\circ}$ at this temperature? Note that R = 8.31 J $K^{-1}mol^{-1}$, and that $\Delta_{vap} G^{\circ} \equiv \mu^{\circ}(\text{gas}) - \mu^{\circ}(\text{liquid})$. Show your work.

9. Phenol, C_6H_5OH, is a very weak acid, with a p$K_a$of 9.89. What is the pH of a 1 M solution of phenol in water?

10. The Clausius-Clapeyron equation states that, for a liquid–vapor phase boundary, $d\ln p/dT = \Delta_{vap} H/(RT^2)$. Assuming that the heat of vaporization is constant over some range of temperature and pressure, show that:

$$\ln p_2 = \ln p_1 + \frac{\Delta_{vap} H}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

where p_1 is the vapor pressure at temperature T_1, same for p_2, T_2.