Chemistry 2740 Spring 2008 Practice Test 2

Time: 50 min **Questions:** 7 **Marks:** 47
Aids permitted: calculator, one 8.5 × 11-inch formula sheet
See reverse for useful data.

1. Many reactions involve water as a reactant or product. When treating such reactions, we generally ignore the activity of the water, i.e. set its value to unity. Why is it often reasonable to do this? [2 marks]

2. What is a fuel cell? [2 marks]

3. Why are mean activity coefficients used for ions in solution thermodynamics? [4 marks]

4. Explain how vapor pressure measurements of solutions can be used to determine the activity coefficient of the solvent. [8 marks]

5. Uric acid is a diprotic organic acid formed by the oxidation of purines. Gout is a medical condition in which crystals of uric acid or of sodium hydrogen urate (the sodium salt of the conjugate base of uric acid, also known as monosodium urate) are deposited in a joint, causing pain when the joint is flexed. Under physiological conditions, uric acid mostly exists as its conjugate base, the hydrogen urate ion.

   At 25°C and a physiological ionic strength of 0.15 mol/L, the (first) acid dissociation constant of uric acid is 5.50×10^{-6}.[1] Calculate the standard free energy of formation of the hydrogen urate ion, given that the standard free energy of formation of aqueous uric acid is −356.6 kJ/mol. [7 marks]

6. Consider the following equilibrium vapor pressure data for benzene:

T/°C	3.0	35.3	72.6	80.1
p/mmHg	30	150	600	760

   Determine the enthalpy of vaporization of benzene from these data. [10 marks]

   Hint: Start by writing a chemical reaction representing the process.

7. What equilibrium electric potential would be generated by the cell

$$\mathrm{Pt, H_2(1\,bar)|HCl}(p\mathrm{H} = 1.5)\|\mathrm{NaCl}(0.004\,\mathrm{mol/L})|\mathrm{Ag, AgCl}$$

   at 25°C? Use Debye-Hückel theory to calculate the potential. The half-reaction in the right half-cell is

$$\mathrm{AgCl_{(s)} + e^- \rightarrow Ag_{(s)} + Cl^-_{(aq)}}, \quad \mathcal{E}^\circ = 0.222\,33\,\mathrm{V}.$$

   For water at 25°C, $\varepsilon = 6.957 \times 10^{-10}\,\mathrm{C^2N^{-1}m^{-2}}$. [14 marks]

[1] Wang and Königsberger, *Thermochim. Acta* **310**, 237 (1998).

Useful data

$\mathcal{F} = 96\,485.342\,\mathrm{C/mol}$

$R = 8.314\,472\,\mathrm{J\,K^{-1}mol^{-1}}$

To convert degrees Celsius to Kelvin, add 273.15.

In the Debye-Hückel equation, $A = 1.107 \times 10^{-10}$.