Chemistry 2850 Practice Test 2

Time: 50 min

Marks: 49

Aids permitted: calculator, one 8.5×11-inch formula sheet

1. Give one statement of the third law of thermodynamics. [2 marks]
2. What is wrong with the following statement? [2 marks]

   ΔG gives the maximum work which a system can perform at constant temperature and pressure.

3. (a) Write down an expression for $d(\Delta G^\circ)$ in terms of dP and dT. [1 mark]
   (b) Suppose that we increase the pressure on a system at equilibrium holding the temperature constant. What determines the sign of the change in ΔG°? [2 marks]
   (c) Suppose that, for a given system, an increase in pressure causes an increase in ΔG°. What effect does this have on the equilibrium constant? Is your answer consistent with Le Chatelier's principle? Explain briefly. [6 marks]
4. Derive an equation for the cubic expansion coefficient of an ideal gas. Write your answer in terms of P, T and n. [4 marks]
5. Haemoglobin Howick (HH) is a naturally occurring mutant form of haemoglobin. It normally exists in solution as a dimer (two copies of the protein associated together) but can also form a tetramer:

   $$2\,\text{dimer} \rightleftharpoons \text{tetramer}.$$

   The equilibrium constant for this reaction is 3.3×10^5 (standard state = 1 mol/L) for deoxygenated HH. If a solution of 100 μmol/L of HH monomers is made, what are the equilibrium concentrations of dimer and tetramer? [8 marks]
6. What emf (voltage) would be generated by the cell

   $$\text{Pt}, \text{H}_2(1\,\text{bar}) | \text{H}^+(0.03\,\text{mol/kg}) \| \text{Cl}^-(0.004\,\text{mol/kg}) | \text{Ag}, \text{AgCl}$$

   at 25°C assuming ideal behavior? [8 marks]
7. The standard enthalpy of formation of carbon dioxide is -393.51 kJ/mol. Calculate the standard free energy of formation of carbon dioxide. [6 marks]
8. 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.

Useful data

$F = 96\,485.3383\,\mathrm{C/mol}$

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

$1\,\mathrm{bar} = 750\,\mathrm{mmHg}$

To convert degrees Celsius to Kelvin, add 273.15.

Standard Entropies at 25°C and 1 bar	
Species	$\bar{S}^\circ/\mathrm{J\,K^{-1}mol^{-1}}$
$C_{(s)}$ (graphite)	5.74
$CO_{2(g)}$	213.785
$O_{2(g)}$	205.152

Reduction process	$\mathcal{E}^\circ/\mathrm{V}$
$2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$	0
$AgCl_{(s)} + e^- \rightarrow Ag_{(s)} + Cl^-_{(aq)}$	0.222 33