Chemistry 2850 Spring 2007 Test 1

Time: 50 min

Marks: 47

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

Useful data is given on the reverse of this page.

Write all answers in the booklets provided.

1. Would you expect the entropy to increase or decrease in the gas-phase reaction A+B $\rightarrow$ C? Explain briefly. [2 marks]

2. (a) What is a state function? [2 marks]

   (b) Which of the quantities P, q, S and U are state functions? [4 marks]

3. Explain how an ideal gas can be used to make a thermometer. What would you measure? How would you go from your measurements to a temperature in Kelvin? [6 marks]

4. In the gas phase, it is easiest to measure the bond energy, but we normally want bond enthalpies. The gas-phase bond energy of HCl at 25°C is 410.0 kJ/mol. What is the bond enthalpy? [5 marks]

5. For nitrogen, $C_{P,m} = 29.12\,\mathrm{J\,K^{-1}mol^{-1}}$. 3.4 mol of nitrogen initially at a pressure of 2.4 bar and a temperature of 300 K is expanded reversibly and adiabatically until the temperature has dropped to 250 K. In this pressure and temperature range, nitrogen behaves like an ideal gas.

   (a) What are w, q, ΔU, ΔH and ΔS in this process? [8 marks]

   (b) What is the final pressure? [10 marks]

6. The standard enthalpy of combustion of ethene ($C_2H_{4(g)}$) is -1411.20 kJ/mol. Suppose that we want to know the enthalpy of combustion at 400°C. There are two problems: (a) at the required temperature, water is a vapor, and (b) we of course have to deal with the temperature change itself. Assume that the heat capacities of all compounds involved in this process are constant, and carry out both of these adjustments to obtain the enthalpy of combustion at 400°C. [10 marks]

   Hint: It is easiest to make the adjustments in the order listed above.

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

$1\,\mathrm{bar} = 100\,000\,\mathrm{Pa}$

To convert degrees Celsius to Kelvin, add 273.15.

Standard thermodynamic data at 1 bar and $25^\circ\mathrm{C}$

Species	$\Delta\bar{H}_f^\circ$ (kJ/mol)	$\bar{C}_P$ ($\mathrm{J\,K^{-1}mol^{-1}}$)
$C_2H_{4(g)}$		43.6
$CO_{2(g)}$	-393.51	37.1
$H_2O_{(l)}$	-285.830	75.40
$H_2O_{(g)}$	-241.826	33.58
$O_{2(g)}$	0	29.35