Chemistry 2740 Spring 2009 Test 1

Time: 50 minutes
Questions: 6
Marks: 41
Aids allowed: calculator, 8.5×11-inch formula sheet
Useful data is given at the end of this exam paper.

1. Name the thermodynamic quantity corresponding to each of these symbols: [1 mark each]
   (a) $\Delta_c U_m$
   (b) C_V
   (c) $\Delta_r h$

2. Explain why $\Delta U \approx \Delta H$ for reactions occurring entirely in solution. [2 marks]

3. Give a qualitative example (no calculations) which shows that the work is path-dependent. [4 marks]

4. Starting from first principles, prove that $\Delta U = q_V$. [4 marks]

5. Calculate the enthalpy of formation of sodium hydride at $-20°C$. [10 marks]

6. A classic demonstration involves putting some liquid nitrogen in a balloon, getting rid of as much air as possible, sealing it (usually with a clip), and then watching the balloon expand as the liquid nitrogen evaporates. Typically, we put in a lot of liquid nitrogen and let the balloon explode. However, suppose that we have put just 5 mL of liquid nitrogen (density 0.8086 g/mL) in a balloon of sufficient capacity that it doesn't explode.

   (a) The boiling point of liquid nitrogen (i.e. the initial temperature) is 77.34 K. If we let the nitrogen evaporate completely and return to room temperature (20°C) at a constant external pressure of 1 atm, what is the work done during this process? Is work done on or by the system? The molar mass of nitrogen is 28.013 48 g/mol. [8 marks]

   (b) The enthalpy of vaporization of liquid nitrogen at its boiling point is 5.586 kJ/mol. The molar heat capacity of nitrogen gas (in $\mathrm{J\,K^{-1}mol^{-1}}$) is given by the equation

   $$C_{p,m} = A + BT + CT^2,$$

   where $A = 28.3$, $B = 2.54 \times 10^{-3}$, $C = 5.4 \times 10^{-5}$, and T is in Kelvin. Calculate the heat gained by the nitrogen during this process. [8 marks]

   (c) Calculate the change in internal energy of the nitrogen during this process. [2 marks]

Useful data

$R = 8.314\,472\,\mathrm{J\,K^{-1}mol^{-1}}$
$1\,\mathrm{m^3} = 1000\,\mathrm{L}$
$1\,\mathrm{atm} = 101\,325\,\mathrm{Pa}$

To convert degrees Celsius to Kelvin, add 273.15.

Standard thermodynamic data at 1 bar and 298.15 K

Species	$\frac{\Delta_f H^\circ}{\mathrm{kJ\,mol^{-1}}}$	$\frac{C_{p,m}}{\mathrm{J\,K^{-1}mol^{-1}}}$
$H_{2(g)}$	0	28.82
$Na_{(s)}$	0	28.2
$NaH_{(s)}$	−56.44	36.37