CYL110 II Semester 2008 - 2009
MINOR Exam I

Date: Feb. 13, 2009 Time: 1 hour

1. (a) Determine the molar volume of copper at 500 ℃ if the molar volume v at (20 ℃, 1.0 $\times 10^5$ Pa) is 7.11 cm^3/mol and the thermal expansion coefficient, β, is 0.0486 $\times 10^{-3}$ K^{-1}. [10]

   (b) Explain using intermolecular forces the observation that at 300 K and 30 bar the compressibility factor, Z, of isopropanol is less than n-pentane, but at 500 K and 30 bar, Z of isopropanol is greater than that of n-pentane. [10]

   (c) What would be the change in the internal energy when a van der Waals' gas undergoes isothermal expansion from V_1 to V_2? Given that $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_V - P$. [10]

2. The table below gives the experimental values of the molar enthalpy (in Joules) of nitrogen at various termperatures (in K) at two different pressures, 1 bar and 100 bars. Use this data to answer the questions that follow it.

	100	200	300	400	500	600
1 bar	2856	5800	8717	11635	14573	17554
100 bar	−1946	4442	8174	11392	14492	17575

   (a) What is the average molar C_P of nitrogen at 1 bar between 200 and 300 K? [5]

   (b) Above what initial temperature would nitrogen heat up when it undergoes a Joule-Thomson expansion from 100 bar to 1 bar? Explain. [10]

   (c) How would you determine (a flowchart or an outline of the procedure is all that is required) the final temperature if nitrogen, say at 300 K, undergoes an expansion as in part b. [10]

3. In his book "Treatise on Thermodynamics" Planck introduced a function $Y = S - \frac{H}{T}$ which is nowadays called the Planck function. In this question we will investigate some of its properties.

   (a) Starting from the Clausius inequality, $dS \geq \frac{dq}{T}$, derive the thermodynamic spontaneity criterion in terms of Y. [10]

   (b) The Gibbs-Helmholtz equation gives the temperature dependence of the Gibbs energy. Determine the analogous equation satisfied by the Planck function. [10]

4. (a) Richard Mollier devised a chart to display thermodynamic properties in which enthalpy (on the y-axis) is plotted against entropy. Represent (i) reversible isobaric heating and (ii) free expansion of an ideal gas on such a chart. [10]

   (b) When you open a bottle of your favorite carbonated softdrink (CocaCola, Pepsi, or any other), compressed CO_2 expands against the constant external atmospheric pressure (take it to be 1 bar = 10^5 Pa) as it bubbles up through the drink. If the process is adiabatic, CO_2 behaves ideally, the initial pressure is 3 bar, the initial temperature is 15 ℃, and the C_P is 37 J/(mol K) determine for 1 mole of CO_2 ($R = 8.314$ J /(mol K))

      i. the final temperature after the expansion, [5]

      ii. the entropy change of the gas. [10]