QUIZ #2 (3 PROBLEMS, 100 PTS)

APRIL 8, 2008

- *Write your name on each blue book.*
- *Clearly show your work, your reasoning, and state all assumptions.*
- *Include units for all numerical calculations.*

VALUES FOR R:
8.314 J K^{-1} mol^{-1}
83.14 cm^3 bar mol^{-1} K^{-1}
8314 cm^3 kPa mol^{-1} K^{-1}
1.987 cal K^{-1} mol^{-1}

1) SHORT ANSWER (30 Pts)

a) (10 pts): The intermolecular interaction potential between molecules that form hydrogen bonds is sometimes described by the following equation:

$$\Gamma(r) = \frac{6^6}{5^5}\varepsilon\left[\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^{10}\right]$$

In this equation, ε and σ have the same meaning as for potentials discussed in class. Describe briefly the origin of the two terms in this interaction potential. Would you expect ε to be larger or smaller in magnitude than for a similar fluid that interacts only through dispersion forces? Do fluids of this type have a Boyle temperature? Explain your answers.

b) (10 pts) Express the differential $(\partial u/\partial P)_s$ in terms of measurable properties, and then evaluate it for a fluid that obeys the ideal gas equation of state.

c) (10 pts) You are told that Gas A obeys the following equation of state:

$$P = \frac{RT}{v-b}$$

Can this gas be liquefied by Joule-Thompson expansion? Justify your answer.

QUESTION 2 (40 pts)

Helium enters a reversible compressor at 300 K and 1.2 MPa and is compressed adiabatically to 18 MPa.

a) Calculate the temperature of the gas exiting the compressor (in K) and the work per mole of helium (in J/mole) needed to run the compressor if helium behaves as an ideal gas

b) Calculate the work per mole of helium needed to run the compressor if helium exits the compressor at the temperature predicted by part (a) and but behaves instead according to the following equation of state:

$$Pv = RT - \frac{a}{T}P + bP$$

where a=0.0004 m^3 K/mol and b=1.5x10^{-5} m^3/mol

QUESTION 3 (30 pts)

Methanol and benzene are mixed together in a flow calorimeter at a constant pressure of 1 bar, and heat is supplied or removed so that the temperature of the methanol-benzene solution is 15°C, the same as that of the pure components entering the calorimeter. The enthalpies of the pure components at 1 bar, 15 °C are 2100 J/mol for methanol and 1400 J/mol for benzene. The table below shows the heat removed by the calorimeter for each of the mole fractions of methanol indicated in the final solution:

x MeOH	Q (J/mol)
0.00	0.0
0.21	-636.3
0.38	-578.0
0.51	-554.2
0.62	-470.5
0.71	-376.2
0.79	-278.5
0.85	-193.6
0.91	-121.5
0.96	-58.5
1.00	0.0

(a) Make of plot of the enthalpy of the methanol/benzene mixture, h_{mix}, versus the mole fraction of methanol, assuming methanol and benzene form an ideal solution.

(b) On the same plot as part (a) show the real enthalpy of the methanol/benzene mixture, h_{mix}, versus the mole fraction of methanol for the real solutions.

(c) Estimate the partial molar enthalpies of methanol $\bar{H}_{MeOH}$ and of benzene, $\bar{H}_{C6H6}$, in an equimolar solution methanol and benzene.

(d) Determine the magnitude of $\left(\partial\mu_{MeOH}/\partial T\right)_{P,n_{C6H6}}$, the partial derivative of the chemical potential of methanol with respect to temperature at constant pressure and moles of benzene, for an equimolar solution of methanol and benzene at 15°C.