10.213 Fall 1999 **Quiz I (100 pts total)**

USE TWO BLUE BOOKS, ONE FOR EACH QUESTION.
WRITE YOUR NAME ON EACH BLUE BOOK.
SHOW YOUR SOLUTION METHOD CLEARLY.

Problem 1 of 2 (45 pts total)

One mole of tetrafluoromethane (CF_4) is compressed in piston. The path followed during the compression is reversible and is given by:

$$PV^{1.5} = \text{constant.}$$

The initial and final properties of the gas are summarized in the table below. For CF_4 over the temperature range of interest, the ideal gas state heat capacity follows the relationship

$$C_p^{ig}/R = A + BT, \text{ with } A = 4.5, \; B = 0.005, \text{ and where T is in Kelvin.}$$

Property(units)	**initial**	**final**
T(K)	300	600
P(bar)	1	8
V(cm^3/mol)	24,900	6225
Z	1	1
$PV^{1.5}$ (bar $cm^{4.5}$/ $mol^{1.5}$)	3.93×10^6	3.93×10^6

For the process described above determine:

a) (15 pts) the change in enthalpy of the gas.
b) (15 pts) the reversible work required.
c) (15 pts) the reversible heat transferred.

TURN PAGE OVER

Problem 2 of 2 (55 pts total)

A tank a having a volume of 20 liters is filled to a pressure of 20 bar with pure N_2 Saturated liquid occupies 50% of the tank's volume. Saturated vapor occupies the other 50% of the space. At this high pressure, the vapor phase SHOULD NOT be considered an ideal gas. Use the thermodynamic data at the bottom of the page to address the following:

a) (10 pts) What is the temperature, in Kelvin, of the nitrogen in the tank?

b) (15 pts) What is the intensive volume, in units of cm^3/mol, of the gas in the tank?

c) (15 pts) What is the intensive volume, in units of cm^3/mol, of the liquid in the tank?

d) (5 pts) Calculate the number of moles present in the vapor phase, n_v, and the number of moles present in the liquid phase, n_l, and the average intensive volume for the nitrogen in the tank, $[V^t / (n_v+n_l)]$.

e) (10 pts) Qualitatively sketch a PV diagram for nitrogen showing the
- i) saturated liquid-vapor dome
- ii) critical point
- iiii) points representing the liquid and vapor phases in the tank and the isotherm passing through these points
- iv) point representing the overall state of the N_2 in the tank

Where ever possible, add numerical values to the P axis and V axis.

Thermodynamic Data for N_2:

Critical temperature	126.2 K	Normal boiling point:	77.2 K
Critical pressure:	34 bar	V_g^{sat} (77.2 K):	6136 cm^3/mol
Critical volume:	89.2 cm^3/mol	V_l^{sat} (77.2 K):	34.7 cm^3/mol
Z_c	0.289	Acentric factor:	0.038

Antoine Equation (from NIST web site) $\log_{10}(P^{sat})=A-[B/(T+C)]$

where P^{sat} has units of bar and T is given in Kelvin.

A= 3.74

B= 265

C= -6.79