Instructions:
1. You may not consult with any other student about the problems in this exam.
2. You may use any notes and/or the textbook for this course during the exam.
3. You must show your work to get full credit.

1. Calculating Work and Enthalpy Change for a Real Gas

At $T = 100$ K, the equation of state of a certain gas is well approximated by the virial equation up to the second term:

$$Z = 1 + B'_2 P,$$

where $B'_2 = 0.0500$ bar$^{-1}$ at 100 K. And in the temperature range from 100 K to 500 K, its constant-pressure molar heat capacity at any pressure below 10 bar is given approximately by:

$$\overline{C}_p(T) = 2.5R \times \left[ 1 - \frac{10}{T} \right],$$

where $R$ is the gas constant and $T$ is the temperature in Kelvins.

Questions:
(a) One mole of this gas, initially at $T = 100$ K, $P = 1.00$ bar, is compressed isothermally and reversibly to a final pressure of $P = 2.00$ bar. Calculate the work involved. (If you are stuck, complete this part as if the gas is ideal and you will receive partial credit.)
(b) After the process in (a), the gas is heated at constant pressure to $T = 500$ K. Calculate $\Delta H$ for this process. (If you are stuck, complete this part as if the gas is ideal and you will receive partial credit.)

2. Entropy of Mixing

In a thermally insulated container with a fixed volume $V$, 2 mole of an ideal monatomic gas A at pressure 1 bar occupying $2/3$ of the total volume is separated from 1 mole of another ideal monatomic gas B at pressure 2 bar occupying the rest of the volume. When the partition is removed, the system is allowed to reach equilibrium. $C_P$ of a monatomic ideal gas = $5R/2$.

Questions:
(a) Calculate the final temperature and pressure of the mixture in terms of the volume $V$.
(b) Calculate $\Delta S$ of this process.
(c) If the two gases A and B were the same, what is $\Delta S$ of the same process?

3. Absolute Entropy of a Mixed Crystal

Sodium chloride has a cubic crystal structure. The lattice structure of NaCl is shown in the figure below. The small black circles represent Na$^+$ ions and the large white circles Cl$^-$. 
Chlorine has several naturally occurring isotopes. The two most abundant are Cl-35, about 75% of all Cl atoms, and Cl-37, about 25%. Assuming that these are the only two isotopes of Cl, calculate the entropy of one mole of NaCl crystal at 0 K by counting microstates. (At 0 K, you can ignore any translational motions. You can also assume that Na has only one significant isotope. The answer is NOT zero.)