Thermodynamics

Do two out the following three problems, each on a separate sheet.

Problem 1

Consider a solid crystal of N atoms. Treat each atom as an independent 3-dimensional isotropic harmonic oscillator of frequency ω. Calculate the constant-volume heat capacity, $C_V = \left(\frac{\partial U}{\partial T}\right)_V$.

Problem 2

Consider a gas of N particles, in volume V at absolute temperature T. The parameter b is the volume of one particle, and k is the Boltzmann constant. Here are two differentials of pressure, possibly derived from the equation of state of this substance:

$$dp = [-NkT2/(V - Nb)2]dV + [-2Nk/(V - Nb)]dT$$

$$dp = [-NkT/(V - Nb)2]dV + [Nk/(V - Nb)]dT$$

One of these is correct; the other one is impossible. Explain which one is correct, then derive the original equation of state from which the correct differential was derived.

Problem 3

If the temperature in this room increases by 1° C, what is the change in the total energy of the air inside the room, assuming it can be considered an ideal gas? You can make any reasonable assumptions about the room; note that the room is not sealed.