

Show work to get credit. In probs 1, 4, 6, your answer should have number and units.

- (1) (5 pts) 2 moles of CO_2 goes to ??? moles of CO and ??? moles of O_2 at constant pressure.
(a) How many moles of CO and O_2 are produced? (b) What is the change in internal energy?

- (2) (5 pts) You measure the current, I , through an inductor with inductance L . It has probability distribution $\mathcal{P}(I) = Ae^{-LI^2/(2k_B T)}$. (a) Determine A . (b) Determine the average of I and the average of I^2 .

(3) (5 pts) In atomic experiments, it is possible to confine the atoms so that they can only move in 1D (the other two dimensions are frozen out). Give the entropy for neon atoms confined to 1D. There are N atoms confined to a length, L , with internal energy U where $k_B T$ is much larger than the spacing of quantum levels.

(4) (5 pts) System a has 2 harmonic oscillators and system b has 3 harmonic oscillators. There are a total of 7 excitations. (a) Determine the most likely and the least likely macrostates. (b) Determine the probability to be in each of these states.

(5) (10 pts) You have an ideal gas in thermal equilibrium at a temperature T . Each atom is confined to a box in y, z with area A and experiences an external force $F(x) = -\partial PE(x)/\partial x$ which depends on x where $PE(x)$ is the potential energy. The density and pressure depend on x but not on y, z, t . (a) Determine the differential equation for the pressure as a function of x . (Hint: the force on the gas from the changing pressure must balance the external force or the gas will flow.) (b) Solve the differential equation for the pressure as a function of x if the pressure at $x = 0$ is $P(0)$. (c) Give the number density as a function of x in terms of the number density at $x = 0$. (d) For a harmonic potential, $PE(x) = (1/2)M\omega^2 x^2$, determine the number density versus x if there are N atoms. (e) From the result of (d), determine the average potential energy of a single atom.

(6) (10 pts) When gas 1 has volume V_1 , N_1 atoms, and total internal energy U_1 , the multiplicity is $f_1(N_1)V_1^{N_1}U_1^{3N_1/2}$. When gas 2 has volume V_2 , N_2 molecules, and total energy U_2 , the multiplicity is $f_2(N_2)V_2^{N_2}U_2^{7N_2/2}$. Gas 1 and 2 are in thermal equilibrium, the total volume of this system is V , and the total internal energy of this system is U . (a) What is the average value of U_1 and what is its spread for *any* large N_1 and N_2 ? (Hint: the average value of $U_1 \neq U/2$.) (b) If $N_1 = N_2$, $V_1 = V_2 = 4 \text{ m}^3$, $P = 1.5 \text{ atm}$, and T is room temperature, what is the relative uncertainty in U_1 ? This should be an actual number (for example 1.8×10^{-3}).