Section 1. True/False: Write T(rue)/F(alse) in the space provided (5×2 pts.)

<u>True</u> An isolated system in equilibrium will be found with equal probability in each of its accessible microstates.

<u>True</u> It is possible for a higher energy state to have a greater population of molecules than a lower energy state.

<u>False</u> From the second law of thermodynamics it can be proved that for a closed system entropy can never decrease.

<u>False</u> If a closed system at rest in the absence of external fields undergoes an adiabatic process that has $w = 0$, then the system's temperature remains constant.

<u>True</u> The reversible work done results from an infinitesimal change in the allowed energies of a system without changing the probability distribution of its states.

Section 2. Fill in the blanks (5 pts. per blank)

Consider a system having two states with energies 0 and ϵ respectively.

1. The expression for the average energy at a temperature T is $\underline{\frac{\epsilon \exp(-\epsilon/kT)}{1+\exp(-\epsilon/kT)}}$.
2. If ϵ is small relative to kT the population difference between the two states is <u>almost zero</u>.

A system is composed of two subsystems A and B with 300 and 200 oscillators respectively sharing 100 units of energy (ϵ). For the macrostate with $q_A = 11$ the number of microstates of A, W_A, and B, W_B, are 5.3×10^{19} and 1.1×10^{75} respectively, while when $q_A = 13$ they are respectively 3.3×10^{22} and 1.0×10^{75}.

3. The entropy (in units of k) of the combined system in the macrostate with $q_A = 11$ is $\underline{\ln W_A W_B = \ln W_A + \ln W_B = 45.4 + 175.1 = 220.5}$.
4. When $q_A = 12$ the temperature of A (in units of ϵ/k) is $\underline{\frac{(13-11)\epsilon}{(51.9-45.4)k} = 0.31}$.

Section 3. Write the answer beside the question. (4×5 pts.)

The molar enthalpy of N_2 (in J) at 1 and 100 bar and some temperatures (in K) are given.

	100	200	300	400	500	600
1 bar	2856	5800	8717		14,573	17,554
100 bar	−1946	4328	8174	11,392	14,492	17,575

1. What is the average C_P at 1 bar for N_2 between 300 and 500 K?

   Answer: $\frac{(14573-8717)}{(500-300)} = 29.28 \text{ J mol}^{-1}\text{K}^{-1}$

2. What is the enthalpy of N_2 at 400 K and 1 bar?

   Answer: $8717 + 29.28 \times 100 = 11645$ J

3. What is the highest temperature at which N_2 cools on Joule-Thomson expansion from 100 bar to 1 bar?

   Answer: $14573 + \frac{(17554-14573)}{100}(T-500) = 14492 + \frac{(17575-14492)}{100}(T-500)$ or $T = 580$K

4. If the initial temperature is 200 K, what is the temperature after Joule-Thomson expansion from 100 bar to 1 bar?

   Answer: $4328 = \frac{(5800-2856)}{(200-100)}(T-100) + 2856 = 29.44(T-100) + 2856 = 150$ K