In the name of God

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ADVANCED STATISTICAL MECHANICS I

Exercise Set 2

(Due Date: 1402/08/03)

1. Ideal Gas state equation: In order to derive the equation of state for Ideal Gas whose Hamiltonian is given by $\mathcal{H} = \mathcal{H}_0 + \mathcal{H}_{int}$, where $\mathcal{H}_{int} = 0$, there are at least three approaches. An approach is based on the first law of Thermodynamics and using Maxwell relations for thermodynamics. Based on the mentioned approach and pointing out on the Joule expansion of ideal gas, show that the internal energy depends on only temperature and particle number, namely $U(T, N) \sim NT$. (Hint: show that $\partial U/\partial P = 0$ and $\partial U/\partial V = 0$.)

2. Zero law of thermodynamics: suppose that A, B and C are in thermal equilibrium. For A and C, we have:

$$P_A V_A - n_A r_A P_A - P_C V_C = 0$$

and for B and C, we have:

$$P_B V_B - P_C V_C + \frac{n_B r_B P_C V_C}{V_B} = 0$$

Find 3 state equations of this system which are in thermal equilibrium.

3. Show that the violation of Kelvin-Planck's statement yields the violation of Clausius's statement and vise versa.

4. Show that it is impossible to have an engine possessing efficiency higher than Carnot engine.

5. Suppose that a system with T_s is contacted thermally with a reservoir with T_R.

A : Compute $\Delta S_{total} = \Delta S_{reservoir} + \Delta S_{system}$ if at the initial point $T_R > T_s$.
B : Compute $\Delta S_{total} = \Delta S_{reservoir} + \Delta S_{system}$ if at the initial point $T_R < T_s$.
C : For each cases, plot the ΔS_{total}, $\Delta S_{reservoir}$ and ΔS_{system} as a function of T_R/T_s

6. Producing a piece of ice during a night at desert. Is it possible to freeze water in a plate in the naked sky in desert? (Hint; suppose that the temperature of water is $T = 6°$C and the temperature of naked dark sky is $T = -23°$C. The time for doing experiment would be sunset till sunrise.)

7. We have a refrigerator which its power equates to 100W and a heater with 100W are working in the room temperature. Which system makes more heat in the room. Explain your answer.

8. We have a box isolated from the environment with volume V. We divided it into two parts with xV and $(1-x)V$. Pressures and temperatures in both partition are equal. There are xn and $(1-x)n$ particle in left and right parts, respectively. Now we remove the partition, how much changes will be occurred in Entropy?

Good luck, Movahed