Physics 301 Fall 2020

Test #1

1. Consider the the *adiabatic* expansion of N molecules with mass m of an ideal, monatomic gas of volume V at temperature T.

   (a) How are T,V related?

   (b) *Ask for dU/dV in these relations.* From (a) and the equipartition of energy, show that $\Delta U/U = -(2/3)\Delta V/V$

   (c) Calculate the change in entropy from the multiplicity of states Ω and show that you get the same answer as in (b).

$$\Omega = f(N)\left[\frac{V}{h^3}\left(2\pi m U\right)^{3/2}\right]^N$$

2. Consider a two-state paramagnet in a magnetic field with N elementary dipoles with magnetic moment μ in magnetic field B. Let N_1 be the number of dipoles aligned with the field. Define $\epsilon = \mu B$ and $\beta = 1/(kT)$.

   (a) What is the probability of finding a single paramagnet in the aligned state at a given value of β?

   (b) Find the explicit function for $\beta(U)$. Sketch $\beta(U)$.

   (c) How is β defined from the entropy S?

   (d) For $\epsilon\beta \ll 1$, find $\partial S/\partial\beta$ and then find the dependence of the multiplicity of states on β, that is the function $\Omega(\beta)$ valid for $\epsilon\beta \ll 1$.

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