

your name _____

Physics 831 Quiz #5 - Friday, Oct. 11

1. A molecule, which lives in a **one-dimensional** world, has mass m and two internal states: a ground state and a single excited state which is at energy X above the ground state. Initially, a low-density gas of such molecules is at temperature T_i before expanding and cooling isentropically to a temperature T_f .

- (a) (5 pts) What is the initial energy per particle? Give answer in terms of m , T_i , X and the initial density per unit length ρ_i .
- (b) (10 pts) Derive an expression for the initial entropy per particle in terms of the same variables. Begin with the expression,

$$S = \ln Z + \beta E,$$

where

$$Z = \frac{z^N}{N!},$$
$$z = z_{\text{int}} \frac{L}{2\pi\hbar} \int dp e^{-p^2/2mT}.$$

- (c) (5 pts) After isentropically cooling to T_f , find the density ρ_f . Give answer in terms of ρ_i , T_i , T_f and X .

Fun facts to know and tell: $\lim_{N \rightarrow \infty} \ln(N!) = N \ln N - N$