[redacted]

(2) Consider energy fluctuations in a canonical ensemble. The relative magnitude of these energy fluctuations is given by the expression:

$$\frac{\sigma_E}{\overline{E}} = \frac{\left(kT^2 C_v\right)^{1/2}}{\overline{E}}$$

where $\overline{E}$ is the average energy, k is the Boltzmann constant, T is the temperature and C_v is the constant volume molar heat capacity.

(a) Derive an expression to estimate the relative magnitude of the energy fluctuations in an ideal gas system.

$\Rightarrow$ In Ideal Gas System $\Rightarrow$ $\overline{E} \simeq N \cdot k \cdot T$

$$\left.\frac{\partial \overline{E}}{\partial T}\right|_{N,P} = C_V \simeq N \cdot k$$

$$\frac{\sigma_E}{\overline{E}} \simeq \frac{\left[k \cdot T^2 \cdot (N \cdot k)\right]^{1/2}}{N \cdot k \cdot T}$$

$$\frac{\sigma_E}{\overline{E}} \simeq \frac{k \cdot T \cdot N^{1/2}}{N \cdot k \cdot T} \simeq \frac{1}{\sqrt{N}} \longrightarrow *$$

(b) Use the expression derived in part **(a)** to estimate the relative magnitude of the energy fluctuations in a macroscopic sample of an ideal gas.

	Number of Molecules	$\frac{\sigma_E}{\overline{E}}$
Microscopic $\rightarrow$	25	$\frac{1}{\sqrt{25}} = 0.2$
	2,500	$\frac{1}{\sqrt{2500}} = 0.02$
	250,000	$\frac{1}{\sqrt{250000}} = 0.002$
Macroscopic $\rightarrow$	25,000,000	$\frac{1}{\sqrt{25,000,000}} = 0.0002$