Consider a rigid, nonlinear molecule, such as methane, whose moment of inertia tensor is isotropic, i.e. $I_{xx} = I_{yy} = I_{zz} = I$, with all other components being zero. The rotational energy eigenvalues are $J(J+1)h^2/2I$ for integer values of J. Since this is <u>not</u> a linear diatomic molecule, the degeneracy of the J^{th} level in this case can be taken to be $(2J+1)^2$. The molecule is in thermal equilibrium at temperature T. Throughout this problem, consider only rotational degrees of freedom, ignoring translations and vibrations.

(a) State the equipartition theorem, and give an inequality for it to apply to this problem.

When the equipartition theorem is applicable, you may use it rather than doing an explicit calculation in the remainder of this problem.

Parts (b)-(d) concern *the high T limiting behavior*, with $k_B T$ *large* compared to any characteristic energies of the system.

Give the dominant contribution to:

(b) the average rotational energy of the molecule, $E_R(T)$.

(c) the heat capacity C(T).

(d) the entropy σ (T).

In parts (e)-(g), assume that $k_B T$ *is small* compared to any characteristic energies of the system.

Give the dominant contribution to:

(e) $E_R(T)$.

(f) C(T).

(g) σ (T).