Physics 831 Quiz #5 - Friday, Oct. 5

Three gases of diatomic oxygen, A, B and C are prepared at the same density and temperature, except that:

In A the oxygen atoms are all ^{16}O and the molecules all have a mass of 32 amu.

In B each molecule has one ^{16}O and one ^{18}O, and all the molecules have a mass of 34 amu.

In C the oxygen atoms are all ^{18}O and the molecules all have a mass of 36 amu.

This means that the moments of inertia of the molecules are ordered $I_A < I_B < I_C$. For diatomic molecules made of identical atoms, remember that only even values of the orbital angular momentum ℓ are allowed. Also, the nuclei are all spin zero, so the ground state of each molecule in not degenerate. For each of the questions below, ignore all internal excitations other than those arising from the rotation of the molecules, and assume the densities are so low that the kinetic motion is always that of an ideal gas (even for the $T \to 0$ case).

For each problem 1-3, choose from the following list for the ordering of the excitation energy per particle:

(a) $\langle U/N \rangle^{(A)} = \langle U/N \rangle^{(B)} = \langle U/N \rangle^{(C)}$

(b) $\langle U/N \rangle^{(A)} > \langle U/N \rangle^{(B)} > \langle U/N \rangle^{(C)}$

(c) $\langle U/N \rangle^{(A)} < \langle U/N \rangle^{(B)} < \langle U/N \rangle^{(C)}$

(d) $\langle U/N \rangle^{(A)} > \langle U/N \rangle^{(C)} > \langle U/N \rangle^{(B)}$

(e) $\langle U/N \rangle^{(A)} < \langle U/N \rangle^{(C)} < \langle U/N \rangle^{(B)}$

(f) $\langle U/N \rangle^{(C)} < \langle U/N \rangle^{(A)} < \langle U/N \rangle^{(B)}$

(g) $\langle U/N \rangle^{(C)} > \langle U/N \rangle^{(A)} > \langle U/N \rangle^{(B)}$

(h) $\langle U/N \rangle^{(A)} = \langle U/N \rangle^{(C)} < \langle U/N \rangle^{(B)}$

(i) $\langle U/N \rangle^{(A)} = \langle U/N \rangle^{(C)} > \langle U/N \rangle^{(B)}$

(j) $\langle U/N \rangle^{(A)} = \langle U/N \rangle^{(B)} > \langle U/N \rangle^{(C)}$

(k) $\langle U/N \rangle^{(A)} = \langle U/N \rangle^{(B)} < \langle U/N \rangle^{(C)}$

(l) $\langle U/N \rangle^{(B)} = \langle U/N \rangle^{(C)} > \langle U/N \rangle^{(A)}$

(m) $\langle U/N \rangle^{(B)} = \langle U/N \rangle^{(C)} < \langle U/N \rangle^{(A)}$

1. Choose the ordering for $T \to 0$. _____
2. Choose the ordering for $T \sim \hbar^2/2I$. _____
3. Choose the ordering for $T >> \hbar^2/2I$. _____