1. One mole of an ideal monatomic gas undergoes an isothermal expansion from a volume of 2 Liters to a volume of 20 Liters. If the initial pressure is 30 atm calculate the:
a, work performed.
b, heat exchanged with the environment.
c, and change in entropy of the gas.

2. A cylindrical column of gas of given temperature rotates about a fixed axis with constant angular velocity. Find the equilibrium distribution function.

3. A rod-like pollen grain floats in the air at a constant temperature. On average, is the angular momentum vector nearly parallel to or perpendicular to the long axis of the grain?

4. A system of two energy levels Eo and E1 is populated by N particles at temperature T. The particles populate the energy levels according to the classical distribution law.
a, Derive an expression for the average energy per particle.
b, Compute the average energy per particle vs the temperature as $T \to 0$ and $T \to \infty$.
c, Derive an expression fro the specific heat of the system of N particles.

5. a, Derive a formula for the maximum kinetic energy of an electron in a non-interacting Fermi gas consisting of N electrons in a volume V at zero absolute temperature?
b, Calculate the energy gap between the ground state and the first excited state for such a Fermi gas consisting of the valence electrons in a 100 A cube of copper.
c, Compare the energy gap with kT at 1K.
The density for copper is 8.93 g/cm$^3$ and its atomic weight is 63.6.

6. Consider a classical system of $N$ noninteracting diatomic molecules enclosed in a box of volume $V$ at temperature $T$. The Hamiltonian for a single molecule is

$$H(\vec{r}_1, \vec{r}_2, \vec{p}_1, \vec{p}_2) = \frac{1}{2m}(p_1^2 + p_2^2) + \frac{K}{2}|r_1 - r_2|^2$$

a. Find the Helmholtz free energy of the system.
b. Find U/N, and compare your result to what the equipartition theorem suggests.
c. Show that the mean-square molecular diameter $\left\langle |r_1 - r_2|^2 \right\rangle = \frac{3kT}{K}$

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