

Midterm#2 (40 points)

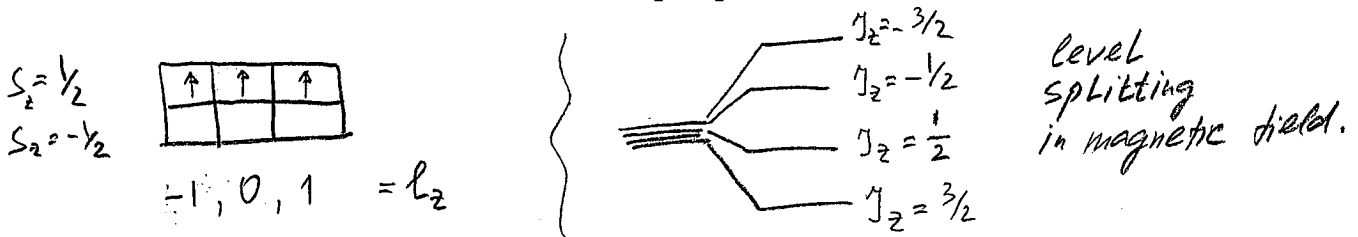
Problem #1 (15 points total)

What is the most probable kinetic energy $\bar{\epsilon}$ of molecules having Maxwell velocity distribution (12 points)? Is it equal to $\frac{1}{2}m(\tilde{v})^2$, where \tilde{v} is the most probable speed of the molecules (3 points)? ("The most probable" is not the same as "the average". \tilde{v} was computed in the lecture notes)

Problem #2 (15 points, 12 points for the correct algebraic answers, 3 more for the correct numeric results)

The electronic configuration of a phosphorus atom is described as $1s^2 2s^2 2p^6 3s^2 3p^3$. The magnetic moment of a phosphorus atom is determined by its $3p^3$ outer shell. According to the Hund rules three p-electrons in this shell make up the total momentum of the atom in such a way that $J=S=3/2$ and $L=0$ (see figure below). The atom is in thermal equilibrium at temperature $T=10$ K, external magnetic field of $B=1$ Tesla is applied. In magnetic field the energy level of phosphorus splits into four levels with different z-components of J , $J_z = -3/2, -1/2, +1/2, +3/2$. The energy of the level with specific J_z is given by $E = -g\mu_B J_z B$ and its magnetic moment $m = g\mu_B J_z$, where $g=2$ is g-factor and $\mu_B = 9.27 \cdot 10^{-24}$ J/T is the Bohr magneton.

- a) What is an average magnetic moment of phosphorus atom at these conditions?
- b) What is magnetic moment of 1 mole of phosphorus atoms at these conditions?



Problem #3 (10 points)

Heat engine works along the cycle shown in the figure. It uses n moles of monoatomic ideal gas. Find the efficiency of the engine.

