Statistical Mechanics 219   SQ 2018

Prof. Sergey Syzranov   **Homework 2**
Solve by 23 April 2018

1. Compute the momentum distribution of particles for a relativistic ideal gas.

   Hint: use the dispersion of one particle in the form $\varepsilon(\mathbf{p}) = \sqrt{p^2 + (mc)^2}$.

2. Consider a two-dimensional ideal gas of molecules with the quadratic dispersion $\xi_{\mathbf{k}} = \frac{k^2}{2m}$ which occupies area S.

   (a) Derive the density of states for one molecule.

   (b) Compute the average energy of a molecule.

   (c) Compute the average $\langle \varepsilon^2 \rangle$ of the square of the energy of a molecule.

3. Spin-1 is placed in the magnetic field $\mathbf{B}$ and weakly coupled to a thermostat at temperature T. Compute the average value of the spin projection on the field.

4. Compute the average energy $\langle \varepsilon \rangle$ of a quantum harmonic oscillator with frequency ω at temperature T.

5. Compute the average potential energy $\langle U \rangle$ of a molecule in the Earth's atmosphere assuming that the temperature does not change with altitude. Using that the Earth's surface is S and the pressure near the surface is P, compute the heat capacitance of the atmosphere.

   Reminder: the Earth is flat.