Phys-C0220 Thermodynamics and Statistical Physics
Spring 2014

Exam 11.4.2014

1. Define or explain the following as accurately and concisely as you can:

   (a) Maxwell's demon
   (b) Carnot cycle
   (c) entropy
   (d) thermodynamic limit
   (e) statistical ensembles
   (f) Bose condensation

2. Laws of thermodynamics:
   a) Formulate the laws of thermodynamics.
   b) Use the first and the second law to show that when two isolated bodies at different temperatures are thermally connected, heat flows from the hotter to the colder.
   c) Using the second and the third law, show that the heat capacity of any system is zero at $T = 0$.

3. Show that for an ideal gas, pV^γ =const. for an adiabatic process. What is the numerical value of γ?

4. Use the canonical formalism to derive the heat capacity of a set of $3N$ quantum harmonic oscillators. Show that it reduces to the classical result $C_N = 3Nk_B$ in the limit $T \to \infty$. Follow these steps:
   a) Hamiltonian of a single oscillator is given by $\hat{H}_i = \hbar\omega\left(\hat{n} + \frac{1}{2}\right)$. Calculate the canonical partition function. *Hint: make use of the geometric sum.*
   b) Derive a general expression for the heat capacity from the definition of the partition function.
   c) Calculate the heat capacity by plugging the result of part a) into the formula derived in part b).

TURN!