

**Note: it is NOT OK to use the homework solutions from the previous years.
Working in groups is fine.**

Homework 1

SM 2012

1. Pathria 1.7 25 points
2. Consider the system of N localized (=distinguishable) spin $\frac{1}{2}$ particles in magnetic field (Pathria paragraph 3.10). Treat it in the **microcanonical** ensemble: Find $\Omega(E) \Rightarrow S(E) \Rightarrow T(E) \Rightarrow E(T)$. Discuss the case $E > 0$. Compare to the answers obtained in the canonical ensemble (Pathria 3.10). 25 points
3. Pathria 2.7 (distinguishable oscillators) 25 points
4. Pathria 3.41 25 points

Homework 2

1. Consider the system of N localized (=distinguishable) spin $\frac{1}{2}$ particles in magnetic field (same as problem 2 last time). Treat it in the **canonical** ensemble: Find $Z(T) \Rightarrow F(T) \Rightarrow S(T) \Rightarrow E(T)$. Compare to the previous answers. 20 points
2. Pathria 3.15 20 points
3. Find the Grand Partition Function for the gas in the previous problem. Find $P(n, T)$ and $\mu(n, T)$. 20 points
4. Pathria 4.4 20 points
5. Pathria 4.8 20 points
6. Pathria 4.6 20 points (extra credit).

Homework 3

1. Find the electric polarization of an ideal gas of molecules each having a dipole moment p in an external field E (neglect the mutual influence of the molecules). 15 points
2. Pathria 5.1 15 points
3. Find the density matrix of a harmonic oscillator in the coordinate representation. Discuss $\rho(x, x)$ at different T ($\ll \hbar\omega/k, \gg \hbar\omega/k$) 20 points
4. Find the Wigner function of a harmonic oscillator. 20 points
5. Pathria 6.7 15 points
6. Pathria 6.8 15 points

Homework 4

1. Pathria 6.10 20 points
2. Pathria 6.19 20 points
3. Pathria 6.21 20 points
4. Pathria 6.24 20 points
5. Pathria 6.26 20 points

Midterm

Homeworks 5

1. Pathria 7.11
2. Pathria 7.12
3. Pathria 7.13
4. Pathria 7.15
5. Pathria 7.27

Each problem is worth 20 points.

Homeworks 6

1. Pathria 7.28
2. Pathria 8.2
3. Pathria 8.9
4. Pathria 8.12
5. Pathria 8.19

Each problem is worth 20 points.

Homework 7

1. Pathria 9.1 10 points
2. Pathria 9.3 10 points
3. Pathria 11.6 15 points
4. Pathria 11.7 15 points
5. Pathria 11.9 20 points
6. From the exact expression of the free energy for the 1D (one-dimensional) Ising model derived in the class, find magnetization M and susceptibility χ as a function of T and H . Discuss the behavior of $\chi(H=0, T)$ at high and low temperatures. Is there a phase transition at finite T ? 20 points

Homework 8

1. Estimate the coefficient of viscosity η of a dilute gas. η describes the shear stress P_{xy} in the presence of a velocity gradient $\partial v_x / \partial y$: $P_{xy} = -\eta \partial v_x / \partial y$.
2. Pathria 14.11
3. Johnson–Nyquist noise of a resistor at temperature T is measured by an ideal voltmeter, having an input capacitance C and no internal noise. Find the RMS of voltage fluctuations: $\langle V^2 \rangle^{1/2}$. Hint: RC sets the bandwidth of the setup.