

Phys 741

Statistical Mechanics

Problem Set # 1

Dr. Gassem Alzoubi

The Hashemite University Department of Physics, Zarqa, Jordan

1. Starting from $dE = dQ - PdV$ and for an adiabatic process show that

$$C_P \left(\frac{\partial T}{\partial V} \right)_P dV + C_V \left(\frac{\partial T}{\partial P} \right)_V dP = 0$$

and verify that for an ideal gas this reduces to $PV^\gamma = \text{const}$, where $\gamma = \frac{C_P}{C_V}$

2. Show that

$$\left(\frac{\partial C_P}{\partial P} \right)_T = -T \left(\frac{\partial^2 V}{\partial T^2} \right)_P$$

and

$$\left(\frac{\partial T}{\partial P} \right)_S = (T/C_P) \left(\frac{\partial V}{\partial T} \right)_P$$

3. Pathria 1.2

4. (a) Starting from $dE = TdS - PdV$, show that for an ideal gas, the internal energy depends only on T , i.e. $E = E(T)$
(b) Write down a general expression for the equation of state that is consistent with $E = E(T)$
(c) Show that for a van der Waals gas C_V is a function of temperature alone
5. Three distinguishable particles can each occupy energy levels $0, \varepsilon,$ and 3ε . Calculate the entropy of the system if the total energy is a) $E = 2\varepsilon,$ b) $E = 3\varepsilon,$ c) $E = 9\varepsilon$
6. Consider a particle of mass m moving freely in a 1D box of size L . Find the eigenvalues and the normalized eigenvectors $\phi_n(x)$. Now consider a system of 3 non-interacting particles of mass m placed in such 1D box. If the energy of the system equals to $E = 38\varepsilon_0$, where $\varepsilon_0 = \frac{\hbar^2 \pi^2}{2mL^2}$ is the lowest eigenvalue, find the entropy of the following three cases where the system is composed of:
- (a) 3 distinguishable spinless particles
(b) 3 indistinguishable spinless bosons
(c) 3 indistinguishable spin-1/2 fermions

Good Luck