

1. (a) The kinetic energy of a particle is $E = \frac{1}{2}mv^2$. Evaluate $\frac{dE}{dv}$.

- (b) A particle has velocity $v(t) = Ae^{-bt}$ and kinetic energy $E(t) = \frac{1}{2}mv(t)^2$. Evaluate $\frac{dE}{dt}$.

- (c) The partition function for a system is $q(T) = T^2 e^{-\epsilon/k_B T}$. Evaluate $\frac{dq}{dT}$.

- (d) Evaluate $\int_0^\infty v e^{-mv^2/2k_B T} dv$. You may use the following integral: $\int_0^\infty e^{-x} dx = 1$

- (e) The ideal gas law is $PV = nRT$. Solve for P in terms of V and T , then evaluate $\left(\frac{\partial P}{\partial V}\right)_{T,n}$.

- (f) The energy of ideal gas is $U = \frac{3}{2}nRT$. Without substituting, calculate $\left(\frac{\partial U}{\partial T}\right)_V$ and $\left(\frac{\partial U}{\partial V}\right)_T$.

- (g) For the ideal gas $P = nRT/V$, compute $\left(\frac{\partial P}{\partial V}\right)_{n,T}$ and $\left(\frac{\partial P}{\partial T}\right)_{n,V}$.

2. The internal energy U is defined as $U = k_B T^2 \left(\frac{\partial \ln Q}{\partial T} \right)_{N,V}$ where k_B is the Boltzmann constant, and the partition function Q is defined as $Q(N, V, T) = \frac{1}{N!} \left(\frac{2\pi m k_B T}{h^2} \right)^{3N/2} V^N$, where m is the mass of the particle. Determine U as a function of T .

3. Starting from the ideal gas law, prove that $\left(\frac{\partial P}{\partial V} \right)_{n,T} = \frac{1}{\left(\frac{\partial V}{\partial P} \right)_{n,T}}$ by evaluating both sides.

Homework Problem 1

1. Consider an ideal gas ($PV = nRT$), where the internal energy is given by $U = \frac{3}{2}nRT$.

(a) Express T in terms of U and n .

(b) Write P as a function of U and V .

(c) Compute the following partial derivatives:

$$\left(\frac{\partial P}{\partial U}\right)_V \quad \left(\frac{\partial U}{\partial V}\right)_P \quad \left(\frac{\partial U}{\partial P}\right)_V$$

(d) What do you notice about $\left(\frac{\partial P}{\partial U}\right)_V$ and $\left(\frac{\partial U}{\partial P}\right)_V$?