PH2202: Thermal Physics

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1 Introduction

The course introduces us to the fundamentals of thermal physics and will end with statistical physics. The instructor for this course is Dr. Koushik Datta. The recommended reading for this course is "Heat and Thermodynamics" by Zemansky and Dittman.

2 Internal energy of Ideal Gas

We use some elementary equations already taught in CH1201. We will be using the ideal gas equation and the 1^{st} Law of Thermodynamics.

$$\begin{aligned} PV &= NRT \\ dU &= TdS - pdV + \mu dN \end{aligned}$$

We assume the fact that the internal energy of the system, something we will define later, depends on the variables entropy(S), volume(V) and no of moles(N). The first term of equation 2 above change in heat energy $dQ = TdS$ and work done on the system $dW = -PdV$ and chemical potential μdN.

$$\begin{aligned} dU &= \frac{\partial U}{\partial S}dS - \frac{\partial U}{\partial V}dV + \frac{\partial U}{\partial N}dN \\ T &= \frac{\partial U}{\partial S}dS && \text{(Comparing this to the first law)} \\ P &= -\frac{\partial U}{\partial V}dV \\ \mu &= \frac{\partial U}{\partial N}dN \end{aligned}$$

The chemical potential is a new term added in this course. So chemical potential essentially refers to the change in internal energy on adding or subtracting a molecule. Essentially when we add an infinitesimally small number of molecules say dN, we have the chemical potential term to be μdN.

Problem. We need to find a closed form expression of the internal energy of an ideal gas in terms of its state variables

We introduce one more equation into solving for the closed form expression i.e. the equipartition of energy.

$$\begin{aligned} U &= \frac{3}{2}NRT \\ \Rightarrow T &= \frac{2U}{3NR} \end{aligned}$$

$$\begin{aligned} \frac{\partial U}{\partial S} &= T = \frac{2U}{3NR} \\ \Rightarrow \ln(U) &= \frac{2S}{3NR} + f(V,N) && \text{(Integrating the equation gives us.)} \\ & && \text{(Putting this in the ideal gas equation)} \end{aligned}$$

So we now need to obtain the function f