M01T.1

1). Since we can measure frequency, temperature, energy, we can measure the energy density with respect to frequency, $E(v)$, which contains the information of the value of h and A.

As to photo gas, the particle number is not conserved, so the chemical potential is zero. Photo satisfies Bose-Einstein statistics, $a_v = \frac{2}{e^{\beta hv}-1}$, where a_v is the averaged occupy number and energy level degeneracy; 2 comes from two polarizations. The energy density is $E(v)dv = a_v hvg(v)dv$, where $g(v)$ is the density of states. $g(v)dv = \frac{4\pi v^2 dv}{(2\pi)^3/V(c/2\pi)^3} = V4\pi v^2 dv/c^3$. So, we can get

$$E(v) = \frac{8\pi V}{c^3}\frac{hv^3}{e^{hv\beta}-1} \tag{1}$$

After measuring the curve $E(v)$, we are able to know the value of h and β, then we should know the value of h and k_B. The Avogadro number is R/k_B.

2). The grand partition function Z.

$$\ln Z = -\int_0^\infty \ln[1-e^{-\beta hv}]g(v)dv = \frac{8\pi^5 V}{45}(\frac{k_B T}{hc})^3 \tag{2}$$

The entropy is $S = \frac{1}{\beta}(\frac{\partial \ln Z}{\partial T})_V$, the heat capacity is $c_V = T(\frac{\partial S}{\partial T})_V = 4aVT^3$, where $a = \frac{8\pi^5 k_B^4}{15(hc)^3}$. So, by measuring the heat capacity, we are able to know h.

One thought on “M01T.1”

December 17, 2013 at 1:15 am

Okay, looks correct.
Why was the third law of thermodynamics mentioned in part (b) of the statement of the problem?