Physics

Tutorial-6

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1) $\bar{v} = \frac{1}{N}\int_0^\infty v\,n(v)\,dv = \frac{1}{N} 4\pi N \left(\frac{m}{2\pi kT}\right)^{3/2} \int_0^\infty v^3 e^{-mv^2/2kT} dv$

If, $a = m/2kT$, then integral will be

$$\int_0^\infty x^3 e^{-ax^2} dv = \frac{1}{2a^2}$$

$$\bar{v} = \left[4\pi\left(\frac{m}{2\pi kT}\right)^{3/2}\right]\left[\frac{1}{2}\left(\frac{2kT}{m}\right)^2\right] = \sqrt{\frac{8kT}{\pi m}}$$

$$v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3\pi}{8}}\,\bar{v} \simeq 1.09\,\bar{v}$$

2) Molecular mass of N_2 is $28u$, $m = 28u \times (1.66 \times 10^{-27})\frac{kg}{u}$

$= 4.65 \times 10^{-26}$ kg.

At an absolute temperature of 273 K, the rms speed of N_2 molecule is $V_{rms} = \sqrt{\frac{3kT}{m}} = 493$ m/s

3) Particles which are regulated by Maxwell-Boltz statistics have to be distengereable each other and one energy state can be occupied by 2 or more particles means if we have two particles, A and B also two states 1 and 2 and we put A to state 1 and also B to state 2 its difference from A to 2 and B to 1

Particles regulated by Bose - Einstein statistics have to be indistinguishable eachother and 1 energy state can be occupied by 2 or more particle so instead of saying it as particle A or B they are same thing

Fermi-Dirac - Particles regulated by this have to be indistinguishable eachother and one energy state can be occupied by only one particle so we have to fill it to another state where a state has first been occupied by one particle

4) $g(\mathcal{E}_2) = 8, \; g(\mathcal{E}_1) = 2.$

$$\therefore \frac{n(\mathcal{E}_2)}{n(\mathcal{E}_1)} = \frac{1}{1000} = 4e^{-(\mathcal{E}_2 - \mathcal{E}_1)/kT} = 4e^{3\mathcal{E}_1/4kT}$$

as $\mathcal{E}_2 = \mathcal{E}_1/4$ and $\mathcal{E}_1 = -13.6\,eV$

$$\therefore T = \frac{\left(\frac{3}{4}\right)(13.6\,eV)}{(8.62 \times 10^{-5}\,eV/K)(\ln 4000)}$$

$$\boxed{T = 1.43 \times 10^4\,K}$$

5) 1) Maxwell Boltzmann possible ways $= 2^2 = 4$
$=$ [a][b], [b][a], [ab][ ], [ ][ab]

2) Bose Einstein possible ways $= 3 =$ [a][a], [aa][ ], [ ][aa]

3) Fermi Dirac possible ways $= 1 =$ [a][a]

6) The electronic configuration of Zn is $[Ar] 3d^{10} 4s^2$. Zinc in its ground state has two electrons in 4s subshell and completely filled K, L and M shells. Thus there are two free electrons per atom. The number of atoms per unit volume is the ratio of the mass density ρ_{Zn} to the mass per atom m_{Zn}. Then

7) As $n(v)\,dv = 4\pi N\left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-mv^2/2kT}\,dv$

At $v = v_p$, $\frac{d}{dv} n(v) = 0$

$$\therefore v_p = \sqrt{\frac{2kT}{m}}$$

8) $$f_{FD}(\varepsilon) = \frac{1}{e^{(\varepsilon-\varepsilon_F)/k_BT}+1} = 0.05$$

$$\therefore \varepsilon = \varepsilon_F + kT \ln 19 = \varepsilon_F + 2.94kT$$

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