April 12, 2005

Name:_____

PHY 3513/Kumar
Mid-term Exam III: Solutions

You are allowed a formula sheet, a calculator and pencil and paper. The formula sheet must not contain anything other than the formulae.

The exam has to be finished within the allotted time of 50 minutes.

1. According to Debye's theory of heat capacities, the specific heat capacity of an insulating solid at very low temperatures is given by

$$c_v = \frac{12}{5}\pi^4 R\left(\frac{T}{\theta}\right)^3$$

where c_v is in J/Kilomole-K. If θ = 300K, what is entropy of this solid at T = 0.1K and T= 10 K.

$$S(T) = \int_0^T c_v \frac{dT}{T} = \frac{1}{3}c_v = .024T^3 = 2.4\times10^{-5}\,J/kmole\text{-}K \qquad for\ T = 0.1K$$

$$= 24\ J/kmole\text{-}K \qquad for\ T = 10K$$

2. (a) What are the speeds v_m, $\bar{v}$, and v_{rms} of N_2 molecules in air at 300K? (Take 29Kg/kmole for the molecular weight of Nitrogen gas).
(b) The experimental value of the viscosity of Argon gas is found to be 22×10^{-6} Pa-s at 15° and atmospheric pressure. The atomic weight of Argon is 40 kg/kmole. Estimate the size of the Argon atom.

(a) The scale velocity at T = 300K, is $\sqrt{(RT/M)} = \sqrt{(8.314\times10^3\times300/29)} = 293.27$ *m/s*

$v_m = \sqrt{2}\times293.27 = 414.75$ *m/s*
$\bar{v} = \sqrt{8/\pi}\times293.27 = 467.99$ *m/s*
$v_{rms} = \sqrt{3}\times293.27 = 507.96$ *m/s*

(b) $\eta = \frac{1}{6}\sqrt{\frac{\pi}{2}}\frac{m\bar{v}}{\pi d^2}$ *where* $\bar{v}$ *is the average velocity. The answer is* 2.8×10^{-10} *m*