## Federal University of Santa Catarina (UFSC) Joinville Technological Center (CTJ) Graduate Program in Engineering and Mechanical Sciences (Pós-ECM)

Course: Plasmas and Electrical Discharges in Gases (ECM410054) Professor: Diego A. Duarte

## Kinetic theory of gases (List 1)

1. The Maxwell-Boltzmann distribution function for a monatomic gas is given by:

$$f(v) = \frac{4}{\sqrt{\pi}} \left(\frac{m}{2k_B T}\right)^{3/2} v^2 e^{-\left(\frac{mv^2}{2k_B T}\right)}$$

where *m* is particle mass, *T* the macroscopic gas temperature e  $k_{\rm B}$  the Boltzmann constant. Demonstrate the most probable speed ( $v_{mp}$ ), average speed ( $v_{av}$ ) and the root mean square speed ( $v_{rms}$ ):

a.  $v_{mp} = \sqrt{\frac{2k_BT}{m}}$ 

b. 
$$v_{av} = \sqrt{\frac{8k_BT}{\pi m}}$$
  
c.  $v_{rms} = \sqrt{\frac{3k_BT}{\pi m}}$ 

- At normal atmospheric pressure (760 torr), the density of helium is 178.5 g/m<sup>3</sup>. Find the (a) most probable, (b) average and (c) root mean square speed of the helium atoms.
- 3. In a discharge tube there are 0.4 g of helium and 1.4 g of nitrogen ( $N_2$ ). The volume of a tube is  $10^4$  cm<sup>3</sup>. At a temperature of 27°C determine (a) the partial pressure of He and  $N_2$ , (b) the total pressure exerted by the mixture.
- 4. The electron beam of an electron gun should hit a target by passing through 3 cm of gas contained in a tube. To ensure an adequate number of electrons, the electron mean free path must be at least 5.0 m. Find the highest permissible pressure of the gas in the tube, assuming it is nitrogen, N<sub>2</sub>, with a mean free path of 5.96  $\times 10^{-8}$  m at NTP.
- 5. Find the kinetic energy of a free electron in eV at room temperature in (a) atmospheric air and (b) in a discharge tube of pressure equal to  $10^{-3}$  torr.

6. An electron gun must be designed so that 95% of the emitted electrons hit the target 10 cm away without colliding with the gas molecules in the tube. If the mean free path of the gas is  $6.4 \times 10^{-8}$  m at NTP, determine how high a vacuum is needed in the tube.