(2.3) The translational energy of one mole of gas is given by \((3/2)RT\), which corresponds to an average thermal molecular velocity \(v\) (the root mean square velocity), while the most probable velocity \(v' = \sqrt{0.67}v\).

(a) What is the most probable velocity of a helium atom at 800 C?

First we must define the value of the gas constant, \(R\), as:

\[ R = \frac{8.31451}{\text{joule mole K}} \]

Then we should convert the temperature, \(T\), from deg. C to deg. K as follows:

\[ T = (800 + 273.15) \cdot K \]

The mass of one mole of helium is (data from Appendix I):

\[ m = \frac{4.003}{1000} \cdot \text{kg mole} \]

From eqn. (2.20) on p. 22 we can calculate the kinetic energy of one mole helium gas as:

\[ E = \frac{3}{2}RT \]

\[ E = 13384.0746 \cdot \text{kg m}^2 \cdot \text{sec}^{-2} \]

Eqn. (2.23) is then rewritten to compute the mean square velocity, \(v\):

\[ v = \sqrt{\frac{2E}{m}} \]

\[ v = 2585.9277 \cdot \text{m sec}^{-1} \]

and from the statement above about the most probable velocity, \(v'\), we have:

\[ v' = \sqrt{3}v \]

\[ v' = 2111.4011 \cdot \text{m sec}^{-1} \]

(b) What voltage would be required to accelerate an alpha particle to the same velocity?

The charge of an electron, \(q_e\) is:

\[ q_e = 1.6021773 \cdot 10^{-19} \cdot \text{coul} \]

However, the \(\alpha\)-particle has two elementary charges, hence:

\[ q_\alpha = 2 \cdot q_e \]

The mass of an \(\alpha\)-particle is \(M_w/N_A\):

\[ m_\alpha = \frac{4.003}{6.022137 \cdot 10^{23}} \cdot \text{gm} \]

We can now apply eqn. (2.5) on p.15 to calculate the necessary acceleration voltage:

\[ V_{acc} = \frac{m_\alpha \cdot v'_\alpha^2}{2q_\alpha} \]

\[ V_{acc} = 0.0462 \cdot \text{kg m}^2 \cdot \text{sec}^{-2} \cdot \text{coul}^{-1} \]

In the fundamental units, or

\[ V_{acc} = 0.0462 \cdot \text{volt} \]