(3.3) The translational energy of one mole of gas is given by (3/2)$\boldsymbol{R}T$, 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:

$$R := 8.31451 \cdot \frac{joule}{mole \cdot K}$$

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):

$$m := \frac{4.003}{1000} \cdot kg$$

From eqn. (3.30) we can calculate the kinetic energy of one mole helium gas as:

$$E := \frac{3}{2} \cdot R \cdot T \qquad E = 13384.0746 \cdot \mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{sec}^{-2} \qquad E = 13384.0746 \cdot \frac{joule}{mole}$$

Eqn. (3.33) is then rewritten to compute the mean square velocity, v:

$$v := \sqrt{2 \cdot \frac{E}{m}} \qquad v = 2585.9277 \cdot \mathrm{m} \cdot \mathrm{sec}^{-1}$$

and from the statement above about the most probable velocity, v_{prim}, we have:

$$v_{prim} := \sqrt{\frac{2}{3}} \cdot v \qquad v_{prim} = 2111.4011 \cdot \mathrm{m} \cdot \mathrm{sec}^{-1}$$

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

The charge of an electron, q_e is:

$$q_e := 1.6021773 \cdot 10^{-19} \cdot coul$$

However, the α-particle has two elementary charges, hence:

$$q_\alpha := 2 \cdot q_e$$

The mass of an α-particle is M_w/N_A:

$$m_\alpha := \frac{4.003}{6.022137 \cdot 10^{23}} \cdot gm$$

We can now apply eqn. (3.6) to calculate the necessary acceleration voltage:

$$V_{acc} := \frac{\frac{m_\alpha \cdot v_{prim}^2}{2}}{q_\alpha} \qquad V_{acc} = 0.0462 \cdot \mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{sec}^{-2} \cdot \mathrm{coul}^{-1}$$ In the fundamentral units, or

$$V_{acc} = 0.0462 \cdot volt$$