Eq. 1.8 is used in both parts: \( n = \frac{m}{M} \), where \( M \) is from Tables A-1.

(a) \( m = M \, n \), where \( n = 20 \text{ kmol} \).

\[
\begin{align*}
\text{Air:} & \quad m = (28.97 \text{ kg/kmol})(20 \text{ kmol}) = 579.4 \text{ kg} \\
\text{C:} & \quad m = (12.01 \text{ kg/kmol})(20 \text{ kmol}) = 240.2 \text{ kg} \\
\text{H}_2\text{O:} & \quad m = (18.02 \text{ kg/kmol})(20 \text{ kmol}) = 360.4 \text{ kg} \\
\text{CO}_2: & \quad m = (44.01 \text{ kg/kmol})(20 \text{ kmol}) = 880.2 \text{ kg}
\end{align*}
\]

(b) \( n = \frac{m}{M} \), where \( m = 50 \text{ lb} \).

\[
\begin{align*}
\text{H}_2: & \quad n = \frac{50 \text{ lb}}{2.016 \text{ lb/lbmol}} = 24.802 \text{ lbmol} \\
\text{N}_2: & \quad n = \frac{50 \text{ lb}}{28.01 \text{ lb/lbmol}} = 1.785 \text{ lbmol} \\
\text{NH}_3: & \quad n = \frac{50 \text{ lb}}{17.03 \text{ lb/lbmol}} = 2.934 \text{ lbmol} \\
\text{C}_3\text{H}_8: & \quad n = \frac{50 \text{ lb}}{44.09 \text{ lb/lbmol}} = 1.134 \text{ lbmol}
\end{align*}
\]
The actual forces developed when birds and aircraft collide are difficult to determine precisely, but estimates can be calculated using average values of acceleration and force magnitudes, as follows:

The goose is accelerated from a very low velocity to 150 miles/h in 10^-5 s. Thus the average acceleration magnitude is

\[ |a| = \left( \frac{150 \text{ miles/h} - 0}{10^{-5}} \right) \frac{1 \text{h}}{3600 \text{s}} \frac{5280 \text{ft}}{1 \text{mile}} = 2.2 \times 10^5 \text{ ft/s}^2 \]

The magnitude of the average force applied is

\[ |F| = m |a| = \left( \frac{12 \text{ lb}}{32.2 \text{ lb-ft/s}^2} \right) \frac{1 \text{ lb-ft}}{2.2 \text{ lb-ft/s}^2} = 82,000 \text{ lb} \quad \text{(rounded)} \]
1.23 The specific volume of 5 kg of water vapor at 1.5 MPa, 440°C is 0.2160 m³/kg. Determine (a) the volume, in m³, occupied by the water vapor, (b) the amount of water vapor present, in gram moles, and (c) the number of molecules.

**KNOWN:** Mass, pressure, temperature, and specific volume of water vapor.

**FIND:** Determine (a) the volume, in m³, occupied by the water vapor, (b) the amount of water vapor present, in gram moles, and (c) the number of molecules.

**SCHEMATIC AND GIVEN DATA:**

\[ m = 5 \text{ kg} \]
\[ p = 1.5 \text{ MPa} \]
\[ T = 440^\circ C \]
\[ v = 0.2160 \text{ m}^3/\text{kg} \]

**ENGINEERING MODEL:**

1. The water vapor is a closed system.

**ANALYSIS:**

(a) The specific volume is volume per unit mass. Thus, the volume occupied by the water vapor can be determined by multiplying its mass by its specific volume.

\[ V = mv = (5 \text{ kg}) \left(0.2160 \frac{\text{m}^3}{\text{kg}}\right) = 1.08 \text{ m}^3 \]

(b) Using molecular weight of water from Table A-1 and applying the appropriate relation to convert the water vapor mass to gram moles gives

\[ n = \frac{m}{M} = \left(\frac{5 \text{ kg}}{18.02 \frac{\text{kg}}{\text{kmol}}}\right) \left(\frac{1000 \text{ moles}}{1 \text{ kmol}}\right) = 277.5 \text{ moles} \]

(c) Using Avogadro’s number to determine the number of molecules yields

\[ \# \text{Molecules} = \text{Avogadro's Number} \times \# \text{moles} = \left(6.022 \times 10^{23} \frac{\text{molecules}}{\text{mole}}\right)(277.5 \text{ moles}) \]

\[ \# \text{Molecules} = 1.671 \times 10^{26} \text{ molecules} \]
PROBLEM 1.29

\[ P_2 = 200 \text{ lbf/in.}^2 \]
\[ V_2 = 2.0 \text{ ft}^3 \]

\[ P_1 = 40 \text{ lbf/in.}^2 \]
\[ V_1 = 3.5 \text{ ft}^3 \]

The pressure-volume relation is linear during the process. Therefore,

\[ \frac{P - P_1}{V - V_1} = \frac{P_2 - P_1}{V_2 - V_1} \quad \text{and} \quad V = \frac{P - P_1}{P_2 - P_1} (V_2 - V_1) + V_1 \]

Using given data where \( P = 150 \text{ lbf/in.}^2 \)

\[ V = \frac{(150 - 200) \text{ lb} \text{f in.}^2}{(40 - 200) \text{ lb f in.}^2} (3.5 - 2.0) \text{ft}^3 + 2.0 \text{ ft}^3 = \frac{-50}{-160} (1.5) \text{ft}^3 + 2.0 \text{ ft}^3 = 2.5 \text{ ft}^3 \]
1.37 Figure P1.37 shows a tank within a tank, each containing air. Pressure gage A, which indicates pressure inside tank A, is located inside tank B and reads 5 psig (vacuum). The U-tube manometer connected to tank B contains water with a column length of 10 in. Using data on the diagram, determine the absolute pressure of the air inside tank B and inside tank A, both in psia. The atmospheric pressure surrounding tank B is 14.7 psia. The acceleration of gravity is \( g = 32.2 \text{ ft/s}^2 \).

**KNOWN:** A tank within a tank, each containing air.

**FIND:** Absolute pressure of air in tank B and in tank A, both in psia.

**SCHEMATIC AND GIVEN DATA:**

**ENGINEERING MODEL:**
1. The gas is a closed system.
2. Atmospheric pressure is exerted at the open end of the manometer.
3. The manometer fluid is water with a density of 62.4 lb/ft\(^3\).

**ANALYSIS:**
(a) Applying Eq. 1.11

\[
 p_{gas,B} = p_{atm} + \rho g L
\]

where \( p_{atm} \) is the local atmospheric pressure to tank B, \( \rho \) is the density of the manometer fluid (water), \( g \) is the acceleration due to gravity, and \( L \) is the column length of the manometer fluid. Substituting values

\[
 p_{gas,B} = 14.7 \frac{\text{lbf}}{\text{in.}^2} + \left( 62.4 \frac{\text{lb}}{\text{ft}^3} \right) \left( 32.2 \frac{\text{ft}}{\text{s}^2} \right) (10 \text{ in.}) = 15.1 \frac{\text{lbf}}{\text{in.}^2}
\]
Since the gage pressure of the air in tank A is a vacuum, Eq. 1.15 applies.

\[ p(\text{vacuum}) = p_{\text{atm}}(\text{absolute}) - p(\text{absolute}) \]

The pressure of the gas in tank B is the local atmospheric pressure to tank A. Solving for \( p(\text{absolute}) \) and substituting values yield

\[ p(\text{absolute}) = p_{\text{atm}}(\text{absolute}) - p(\text{vacuum}) = 15.1 \text{ psia} - 5 \text{ psig} = \textbf{10.1 psia} \]