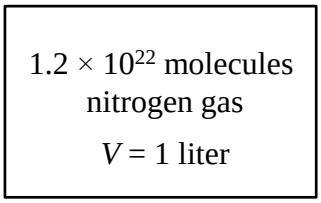
1.19 A closed vessel having a volume of 1 liter holds 1.2×10^{22} molecules of nitrogen gas. For the nitrogen, determine (a) the amounts present, in kmol and kg, and (b) the specific volumes, in m^3/kmol and m^3/kg.

KNOWN: A vessel of known volume holds a specified number of molecules of nitrogen gas.

FIND: Determine (a) the mass and number of moles present, and (b) the specific volumes on molar and mass bases.

SCHEMATIC AND GIVEN DATA:

$g = 9.81$ m/s^2
$M_{\text{nitrogen}} = 28.01$ kg/kmol (Table A-1)



ENGINEERING MODEL:
1. Nitrogen is a closed system.

ANALYSIS:
(a) From Section 1.5, the number of molecules in a gram mole (mol) is 6.022×10^{23} (Avogadro's number). Thus

$$n = \frac{1.2 \times 10^{22} \text{ molecules}}{6.022 \times 10^{23} \dfrac{\text{molecules}}{\text{mol}}} = 0.0199 \text{ mol}$$

Converting to kmol

$$n = (0.0199 \text{ mol}) \left| \frac{1 \text{ kmol}}{10^3 \text{ mol}} \right| = \underline{\mathbf{1.99 \times 10^{-5} \text{ kmol}}}$$

Using Eq. 1.8 to determine the mass of the nitrogen

$$m = nM = (1.99 \times 10^{-5} \text{ kmol}) \left(28.01 \frac{\text{kg}}{\text{kmol}} \right) = \underline{\mathbf{5.57 \times 10^{-4} \text{ kg}}}$$

(b) Specific volume on a molar basis is

$$\overline{v} = \frac{V}{n} = \frac{1 \text{ liter}}{1.99 \times 10^{-5} \text{ kmol}} \left| \frac{10^{-3} \text{ m}^3}{1 \text{ liter}} \right| = \underline{\mathbf{50.25 \text{ m}^3/\text{kmol}}}$$

Specific volume on a mass basis is

$$v = \frac{V}{m} = \frac{1\,\text{liter}}{5.57\times10^{-4}\ \text{kg}}\left|\frac{10^{-3}\ \text{m}}{1\,\text{liter}}\right| = \underline{\mathbf{1.80\ m^3/kg}}$$