

Problem 1.6

[Difficulty: 1]

1.6 A spherical tank of inside diameter 16 ft contains compressed oxygen at 1000 psia and 77°F. What is the mass of the oxygen?

Given: Data on oxygen tank.

Find: Mass of oxygen.

Solution: Compute tank volume, and then use oxygen density (Table A.6) to find the mass.

The given or available data is: $D = 16 \cdot \text{ft}$ $p = 1000 \cdot \text{psi}$ $T = (77 + 460) \cdot \text{R}$ $T = 537 \cdot \text{R}$

$$R_{\text{O}_2} = 48.29 \cdot \frac{\text{ft} \cdot \text{lbf}}{\text{lbm} \cdot \text{R}} \quad (\text{Table A.6})$$

For oxygen the critical temperature and pressure are: $T_c = 279 \cdot \text{R}$ $p_c = 725.2 \cdot \text{psi}$ (data from NIST WebBook)

so the reduced temperature and pressure are: $T_R = \frac{T}{T_c} = 1.925$ $p_R = \frac{p}{p_c} = 1.379$

Using a compressibility factor chart: $Z = 0.948$ Since this number is close to 1, we can assume ideal gas behavior.

Therefore, the governing equation is the ideal gas equation $p = \rho \cdot R_{\text{O}_2} \cdot T$ and $\rho = \frac{M}{V}$

where V is the tank volume $V = \frac{\pi \cdot D^3}{6}$ $V = \frac{\pi}{6} \times (16 \cdot \text{ft})^3$ $V = 2144.7 \cdot \text{ft}^3$

Hence $M = V \cdot \rho = \frac{p \cdot V}{R_{\text{O}_2} \cdot T}$ $M = 1000 \cdot \frac{\text{lbf}}{\text{in}^2} \times 2144.7 \cdot \text{ft}^3 \times \frac{1}{48.29} \cdot \frac{\text{lbm} \cdot \text{R}}{\text{ft} \cdot \text{lbf}} \times \frac{1}{537} \cdot \frac{1}{\text{R}} \times \left(\frac{12 \cdot \text{in}}{\text{ft}} \right)^3$

$$M = 11910 \cdot \text{lbm}$$