PROBLEM 11.1

KNOWN: 100 lb of CO₂ is at 212°F in a 19.8 ft³ cylinder.

FIND: Determine the pressure using (a) the van der Waals equation, (b) the compressibility chart, (c) the ideal gas model.

ANALYSIS: Using the given data, \( v = 0.193 \text{ ft}³/\text{lb}. \)

(a) The van der Waals equation is given by Eq. 11.2,

\[
p = \frac{RT}{V-b} - \frac{a}{V^2}
\]

From Table A-24E,

\[
a = 926 \text{ atm} \left( \frac{\text{ft}³}{\text{mol}} \right)^2 \quad b = 0.686 \frac{\text{ft}³}{\text{mol}}
\]

\[
p = \frac{(1545 \text{ ft}³/\text{mol})(678 \text{ atm}) \left( \frac{\text{ft}³}{\text{mol}} \right)^2}{(0.193 \text{ ft}³/\text{mol})(4401 \text{ lb}) - 0.686 \text{ ft}³/\text{mol}} = 50 \text{ atm}
\]

(b) Compressibility Chart

From Table A-1E, \( T_e = 548 \text{ °F}, \ P_e = 72.9 \text{ atm}. \) Thus, \( T = \frac{672}{548} = 1.226 \) and

\[
V_e = \frac{72.9}{RT_e} = \frac{(0.193)(4401)}{(1545)(72.9)} \left( \frac{\text{ft}³}{\text{mol}} \right)^2 = 1.548
\]

Then Fig. 3-1 gives \( P_e \approx 49.94 \text{ atm}. \)

(c) With the ideal gas equation of state,

\[
p = \frac{RT}{V} = \frac{(1545)(212)(\text{mil})}{(0.193)(4401)} = 57.76 \text{ atm}
\]

Discussion: Methods (a), (b) suggest that the pressure level would be safe, but at the high end of the allowed range. The ideal gas model suggests that the pressure would not be satisfactory.

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