

Problem 2-7

If n moles of an ideal gas at the temperature 4 K can be pumped through a tube of diameter d , what must be the diameter of the tube to pump the same number of moles of gas at the temperature 300 K?

Solution

We should assume that the pressure and the length of the tube is the same in two case, then from $PV = nRT$ we get

$$\frac{V_1}{V_2} = \frac{d_1^2}{d_2^2} = \frac{T_2}{T_1} \Rightarrow d_2 = d_1 \sqrt{\frac{T_2}{T_1}} \simeq 8.66d_1$$

Problem 2-14

A vessel contains CO_2 at the temperature of 137 C. The specific volume is $0.07 \text{ m}^3\text{kmol}^{-1}$.

1. Compute the pressure in Nm^{-2} (a) from the ideal gas equation, (b) from the van der Waals equation.
2. Calculate the ratio $\frac{Pv}{T}$ (in $\text{J kmol}^{-1}\text{K}^{-1}$), for the two pressures found above, and compare with experimental value as read from Fig. 2-1 (p. 12 of the lecture notes) assuming that $T_2=137 \text{ C}$.

Solution

$$(a): P = \frac{RT}{v} = 4.87 \times 10^7 \frac{N}{m^2}$$

$$(b): P = \frac{RT}{v-b} - \frac{a}{v^2} = 5.1 \times 10^7 \frac{N}{m^2}$$

$$(c): \left(\frac{PV}{T}\right)_{\text{ideal}} = 8.31 \times 10^3 \frac{J}{\text{kmolK}}, \quad \left(\frac{PV}{T}\right)_{\text{vdW}} = 8.7 \times 10^3 \frac{J}{\text{kmolK}}$$

Problem 2-25

A substance has compressibility $\kappa = \frac{aT^3}{P^2}$ and expansivity $\beta = \frac{bT^2}{P}$ where a and b are constants. Find the equation of state of the substance and the ratio $\frac{a}{b}$.

Solution

$$\begin{aligned} \kappa &= -\frac{1}{V} \left(\frac{dV}{dP}\right)_T = \frac{aT^3}{P^2} \Rightarrow \ln V(T, P) = \frac{aT^3}{P} + C_1(T) \\ \beta &= \frac{1}{V} \left(\frac{dV}{dT}\right)_P = \frac{bT^2}{P} \Rightarrow \ln V(T, P) = \frac{bT^3}{3P} + C_2(P) \end{aligned}$$

For both of these formulas to be correct, one needs $\frac{a}{b} = \frac{1}{3}$ (and $C_1 = C_2 = \text{const}$)