PROBLEM 3.129

KNOWN: Air and carbon monoxide are contained to opposite sides of a rigid, insulated container by a partition free to move.

FIND: Determine the final equilibrium temperature and pressure. Also, find the volume occupied by each gas finally.

SCHEMATIC & GIVEN DATA:

![Diagram of the container with the gases and partition]

Fig. P3.129

ANALYSIS: An energy balance reads \( \Delta U + \Delta KE + \Delta PE = \Delta Q \), or \( \Delta U = 0 \), where \( \Delta U = [\Delta U]_{\text{CO}} + [\Delta U]_{\text{Air}} + [\Delta U]_{\text{partition}} \). That is,

\[
[\Delta U]_{\text{CO}} + [\Delta U]_{\text{Air}} = 0
\]

With Eq. 350 the total becomes

\[
(mCv)_{\text{CO}} [(T - 450K)] + (mCv)_{\text{Air}} [(T - 350K)] = 0
\]

Using Eq. 247b

\[
Cv,\text{CO} = \frac{R}{K - 1} = \frac{(531/28=1)}{1.395 - 1} = 0.751 \frac{kJ}{K}
\]

\[
Cv,\text{Air} = \frac{R}{K - 1} = \frac{(314/28=1)}{1.395 - 1} = 0.927 \frac{kJ}{K}
\]

Solving Eq. 1,

\[
T = \frac{(mCv)_{\text{CO}}(450K) + (mCv)_{\text{Air}}(350K)}{(mCv)_{\text{CO}} + (mCv)_{\text{Air}}} = \frac{(450)(0.751 K)+450K)}{(0.751)(0.751 + 0.927)} = 474 K
\]

(b) The total volume remains constant, where \( V = V_{\text{CO}} + V_{\text{Air}} = 3.07 m^3 \), and

\[
V_{\text{Air}} = \frac{(mRT)}{P_{\text{Air}}} = \frac{(2.08)(314/28)}{(5 \times 10^5 N/m^2)} = 0.4 m^3
\]

\[
V_{\text{CO}} = \frac{(mRT)}{P_{\text{CO}}} = \frac{(4)(314/28)}{(2.08)} = 2.67 m^3
\]

At equilibrium, each gas will be at \( T = 474 K \) and pressure \( P \). With \( V = mRT/P \),

\[
3.07 m^3 = \frac{(mR)_{\text{Air}} T}{P} = \frac{(mR)_{\text{CO}} T}{P} \Rightarrow P = \frac{(mR)_{\text{Air}} + (mR)_{\text{CO}} T}{3.07 m^3}
\]

Calculating

\[
p = \frac{[2.08(314/28=1)] + 450(314/28=1)}{2.67 m^3} = 1 \text{ bar}
\]

\[
= 2.89 \text{ bar}
\]
PROBLEM 3.129 (Continued)

(c) The final volumes occupied by the air and CO₂ are, respectively

\[
\begin{align*}
\bar{V}_{\text{air}} &= \frac{m_{\text{air}}RT}{P} = \left(269 \frac{3314}{28.97 \text{ K}} \text{ m}^3 \text{ K} \right) (417.4 \text{ K}) = 1 \text{ m}^3 \\
\bar{V}_{\text{co}_2} &= \frac{m_{\text{co}_2}RT}{P} = \left(4 \text{ kg} \frac{314}{28.01 \text{ K}} \text{ m}^3 \text{ K} \right) (417.4 \text{ K}) = 2.07 \text{ m}^3
\end{align*}
\]

Note, \( \bar{V}_{\text{air}} + \bar{V}_{\text{co}_2} = 3.07 \text{ m}^3 \), the total volume occupied initially.