PROBLEM 3.176

KNOWN: Knudsen number, specific heat ratio and thermal accommodation coefficient for an ideal gas and solid surface.

FIND: Expression for the the ratio of the thermal resistance due to molecule-surface collisions to the thermal resistance associated with molecule-molecule collisions, $R_{t,m\text{-}s}/R_{t,m\text{-}m}$.

ASSUMPTIONS: (1) Ideal gas behavior.

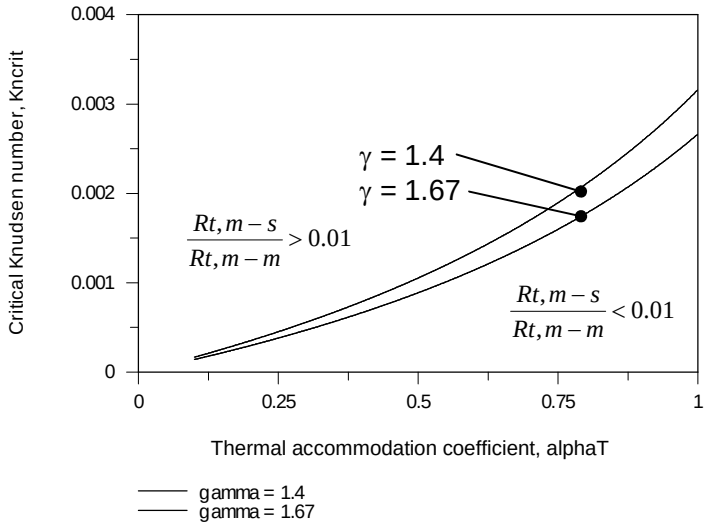
ANALYSIS: The expressions for $R_{t,m\text{-}m}$ and $R_{t,m\text{-}s}$ are

$$R_{t,m-m} = \frac{L}{kA} \quad \text{and} \quad R_{t,m-s} = \frac{\lambda_{\text{mfp}}}{kA}\left[\frac{2-\alpha_t}{\alpha_t}\right]\left[\frac{9\gamma-5}{\gamma+1}\right]$$

therefore,

$$\frac{R_{t,m-s}}{R_{t,m-m}} = \frac{\lambda_{\text{mfp}}}{L}\left[\frac{2-\alpha_t}{\alpha_t}\right]\left[\frac{9\gamma-5}{\gamma+1}\right] = Kn\left[\frac{2-\alpha_t}{\alpha_t}\right]\left[\frac{9\gamma-5}{\gamma+1}\right] \qquad <$$

Associating the critical Knudsen number, Kn_{crit}, with $R_{t,m\text{-}s}/R_{t,m\text{-}m} = 0.01$, we may plot the value of the critical Knudsen number for $\gamma = 1.4$ and 1.67 over the range $0.01 \le \alpha_t \le 1$ as shown below.



COMMENTS: (1) Relatively large Knudsen numbers are associated with more significant surface-molecule collisions. (2) The critical Knudsen number is relatively insensitive to the specific heat ratio, γ.