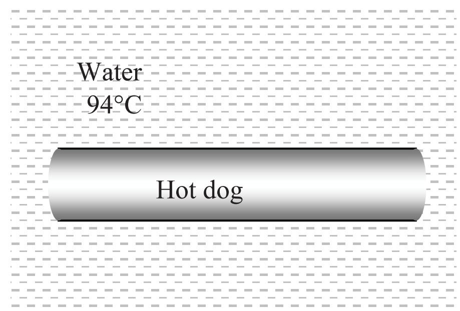
11-50 A hot dog is dropped into boiling water, and temperature measurements are taken at certain time intervals. The thermal diffusivity and thermal conductivity of the hot dog and the convection heat transfer coefficient are to be determined.

Assumptions **1** Heat conduction in the hot dog is one-dimensional since it is long and it has thermal symmetry about the centerline. **2** The thermal properties of the hot dog are constant. **3** The heat transfer coefficient is constant and uniform over the entire surface. **4** The Fourier number is $\tau > 0.2$ so that the one-term approximate solutions (or the transient temperature charts) are applicable (this assumption will be verified).

Properties The properties of hot dog available are given to be $\rho = 980$ kg/m^3 and $c_p = 3900$ J/kg.°C.

Analysis (*a*) From Fig. 11-16b we have

$$\left.\begin{array}{l} \dfrac{T-T_\infty}{T_0-T_\infty} = \dfrac{88-94}{59-94} = 0.17 \\ \dfrac{r}{r_o} = \dfrac{r_o}{r_o} = 1 \end{array}\right\} \dfrac{1}{Bi} = \dfrac{k}{hr_o} = 0.15$$



The Fourier number is determined from Fig. 11-16a to be

$$\left.\begin{array}{l} \dfrac{1}{Bi} = \dfrac{k}{hr_o} = 0.15 \\ \dfrac{T_0-T_\infty}{T_i-T_\infty} = \dfrac{59-94}{20-94} = 0.47 \end{array}\right\} \tau = \dfrac{\alpha t}{r_o^{\ 2}} = 0.20$$

The thermal diffusivity of the hot dog is determined to be

$$\frac{\alpha t}{r_o^2} = 0.20 \longrightarrow \alpha = \frac{0.2 r_o^2}{t} = \frac{(0.2)(0.011\,\text{m})^2}{120\,\text{s}} = \mathbf{2.017 \times 10^{-7}\ m^2/s}$$

(*b*) The thermal conductivity of the hot dog is determined from

$$k = \alpha \rho c_p = (2.017 \times 10^{-7}\ \text{m}^2/\text{s})(980\,\text{kg/m}^3)(3900\,\text{J/kg.°C}) = \mathbf{0.771\,W/m.°C}$$

(*c*) From part (*a*) we have $\dfrac{1}{Bi} = \dfrac{k}{hr_o} = 0.15$. Then,

$$\frac{k}{h} = 0.15 r_o = (0.15)(0.011\,\text{m}) = 0.00165\,\text{m}$$

Therefore, the heat transfer coefficient is

$$\frac{k}{h} = 0.00165 \longrightarrow h = \frac{0.771\,\text{W/m.°C}}{0.00165\,\text{m}} = \mathbf{467\ W/m^2.°C}$$