19.22 This problem asks that we treat a porous material as a composite wherein one of the phases is a pore phase, and that we estimate upper and lower limits for the room-temperature thermal conductivity of an aluminum oxide material having a 0.25 volume fraction of pores. The upper limit of k (k_{upper}) may be determined using Equation 16.1 with thermal conductivity substituted for the elastic modulus, E. From Table 19.1, the value of k for Al_2O_3 is 39 W/m-K, while for still air in the pore phase, k = 0.02 W/m-K (Section 19.4). Thus

$$k_{upper} = V_p k_{air} + V_{Al_2O_3} k_{Al_2O_3}$$

$$= (0.25)(0.02 \text{ W/m-K}) + (0.75)(39 \text{ W/m-K}) = 29.3 \text{ W/m-K}$$

For the lower limit we employ a modification of Equation 16.2 as

$$k_{lower} = \frac{k_{air} k_{Al_2O_3}}{V_p k_{Al_2O_3} + V_{Al_2O_3} k_{air}}$$

$$= \frac{(0.02 \text{ W/m-K})(39 \text{ W/m-K})}{(0.25)(39 \text{ W/m-K}) + (0.75)(0.02 \text{ W/m-K})} = 0.080 \text{ W/m-K}$$