19.16 (a) Equation 19.7 is not valid for ceramic and polymeric materials since, in the development of this expression, it is assumed that free electrons are responsible for both electrical and thermal conduction. Such is the case for most metals. For ceramics and polymers, free electrons are the primary contributors to the electrical conductivity. However, free electrons do not contribute significantly to the thermal conductivity. For ceramics, thermal conduction is primarily by means of phonons; for polymers, the energy transfer is made by chain vibrations, translations, and rotations.

(b) Estimated room-temperature values of L, in Ω-W/(K)^2, for the several materials are determined below. Electrical conductivity values were determined by taking reciprocals of the electrical resistivities given in Table B.9, Appendix B; thermal conductivities are taken from Table B.7 in the same appendix. (*Note:* when a range of values is given in these tables, an average value is used in the computation.)

For zirconia (3 mol% Y_2O_3)

$$L = \frac{k}{\sigma T} = \frac{2.65\ \text{W/m-K}}{\left[\dfrac{1}{10^{10}\ (\Omega-\text{m})}\right](293\ \text{K})} = 9.0 \times 10^{7}\ \ \Omega\text{-W/K}^2$$

For synthetic diamond

$$L = \frac{3150\ \text{W/m-K}}{\left[\dfrac{1}{1.5 \times 10^{-2}\ (\Omega-\text{m})}\right](293\ \text{K})} = 0.161\ \ \Omega\text{-W/K}^2$$

For intrinsic gallium arsenide

$$L = \frac{45.5\ \text{W/m-K}}{\left[\dfrac{1}{10^{6}\ (\Omega-\text{m})}\right](293\ \text{K})} = 1.55 \times 10^{5}\ \ \Omega\text{-W/K}^2$$

For poly(ethylene terephthalate) (PET)

$$L = \frac{0.15\ \text{W/m-K}}{\left[\dfrac{1}{10^{12}\ (\Omega-\text{m})}\right](293\ \text{K})} = 5.12 \times 10^{8}\ \ \Omega\text{-W/K}^2$$

For silicone