Question

Electron-Energy Distribution: The Fermi energy in silver is 5.51 eV. (a) What is the average energy of free electrons in silver at 0 K? (b) What temperature is necessary for the average molecular energy in an ideal gas to have this value? (c) What is the speed of an electron with this energy?

Solution

a) For silver $\epsilon_F = 5.51\,eV$ hence

$$\bar{\epsilon}_0 = \frac{3}{5}\epsilon_F = \frac{3}{5}\,5.51 = 3.31 \quad eV \text{ at } 0\,K$$

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b) The average molecular energy in an ideal gas is $\frac{3}{2}\,kT$ hence the necessary temperature is given by

$$\begin{aligned}\frac{3}{2}\,kT &= 3.31 \\ T &= \frac{2 \times 3.31}{3(8.617 \times 10^{-5})} \\ &= 2.55 \times 10^4\,K\end{aligned}$$

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c) The (non-relativistic) speed of an electron at this energy is given by

$$\begin{aligned}v &= \sqrt{\frac{2\bar{\epsilon}_0}{m_e}} \\ &= \sqrt{\frac{3.31}{0.511 \times 10^6}}\;c \\ &= (3.6 \times 10^{-3})\,c \\ &= 1.08 \times 10^6\,m/s\end{aligned}$$
