799.

Problem 53.17 (RHK)

We have to show that the probability p_h *that a hole exists at a state of energy E is given by*

$$p_h = \frac{1}{\exp\left(-\left(E - E_F\right)/kT\right)+1} \ .$$

Solution:

In a sea of electrons the existence of a hole in an energy state means that the state is unoccupied. The probability of occupation of a state of energy E in a gas of conduction electrons of Fermi energy E_F is given by

$$p\left(E\right) = \frac{1}{\exp\left(\left(E - E_F\right)/kT\right)+1} \ .$$

Therefore, the probability that this state is unoccupied is $\left(1 - p\left(E\right)\right)$. We note that

$$\left(1-p\left(E\right)\right)=1-\frac{1}{\exp\left(\left(E-E_F\right)/kT\right)+1}$$

$$=\frac{\exp\left(\left(E-E_F\right)/kT\right)}{\exp\left(\left(E-E_F\right)/kT\right)+1}$$

$$=\frac{1}{\exp\left(-\left(E-E_F\right)/kT\right)+1}\ .$$

Or

$$p_h=\frac{1}{\exp\left(-\left(E-E_F\right)/kT\right)+1}\ .$$