A material has a Fermi energy of 0.5 eV. *a*) At 80°F, determine the energy $E = E_F + 3k_BT$ and the probability that a state at this energy is occupied by an electron (unitless and %). *b*) At 80°F, determine the energy $E = E_F - 2.7k_BT$ and the probability that a state at this energy is occupied by a hole (unitless and %).

In Kelvin, $(80-32)\frac{5}{9} + 273.15 = 299.81667\ K$

a) $E_a = E_F + 3k_BT = 0.5 + 3(8.617333 \times 10^{-5})(299.81667)$

$\hookrightarrow \underline{\underline{E_a = 0.57751\ eV}}$

Per (3.79), $f_F(E) = \dfrac{1}{1 + e^{(E-E_F)/k_BT}}$

$f_F(0.57751\,eV) = \dfrac{1}{1 + e^{(0.57751-0.5)/(8.617333 \times 10^{-5} \cdot 299.817)}}$

$\underline{\underline{f_F(0.57751\,eV) = 0.047426 = 4.7426\ \%}}$

b) $E_b = E_F - 2.7k_BT = 0.5 - 2.7(8.617333 \times 10^{-5}(299.81667)$

$\hookrightarrow \underline{\underline{E_b = 0.430242\ eV}}$

Per Example 3.7, $f_{hole}(E) = 1 - f_F(E)$

$f_{hole}(0.43024\,eV) = 1 - \dfrac{1}{1 + e^{(0.43024-0.5)/(8.617333 \times 10^{-5} \cdot 299.817)}}$

$\underline{\underline{f_{hole}(0.43024\,eV) = 0.062973 = 6.2973\ \%}}$