EE 362 Electronic, Magnetic, & Opt. Prop. of Mat'ls Quiz 3 (Spring 2026)

Name **KEY A**

Instructions: Open book & notes. Place answers in indicated spaces. Show all work. Use 5-6 significant figures.

A semiconductor has a bandgap of 0.5 eV. At 325 K, assume the Fermi energy level is at E_v + 0.254 eV. We wish to determine the probability that a state at energy $E_A = E_c + 0.6k_BT$ is occupied by an **electron**. First, find $E_c - E_F$ (eV) and k_BT (eV). Then, calculate the energy difference $\Delta E = E_A - E_F$ (eV). Finally, determine the probability that a state at E_A is occupied by an electron (unitless).

We are given $E_F = E_v + 0.254$ eV $\Rightarrow E_v = E_F - 0.254$ eV.

By definition,

$$E_g = E_c - E_v = E_c - (E_F - 0.254 \text{ eV}) \Rightarrow E_c - E_F = E_g - 0.254 \text{ eV} = 0.5 - 0.254 \text{ eV}$$

$$\Rightarrow \underline{E_c - E_F = 0.246 \text{ eV}}.$$

Next, compute $k_BT = (8.617333\times10^{-5}$ eV/K) 325 K $\Rightarrow$ $\underline{k_BT = 0.028006332 \text{ eV}}$.

The energy difference $\Delta E = E_A - E_F$ where $E_A = E_c + 0.6k_BT$ is then

$$\Delta E = (E_c + 0.6k_BT) - E_F = E_c - E_F + 0.6k_BT = 0.246 + 0.6(0.0280063)$$

$$\Rightarrow \underline{\Delta E = 0.2628038 \text{ eV}}.$$

Use Fermi-Dirac probability function (3.79) to find the probability of an electron at $E = E_A$ as

$$f_F(E = E_A) = \frac{1}{1 + e^{\frac{E_A - E_F}{k_BT}}} = \frac{1}{1 + e^{\frac{0.2628038}{0.028006332}}} \Rightarrow \underline{f_F(E_A) = 8.40741 \times 10^{-5}}.$$

$E_c - E_F$ = **0.246 eV** k_BT = **0.0280063 eV** ΔE = **0.2628038 eV**

prob$_{e,EA}$ = **8.40741 × 10^{-5}**

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Name _KEY B_

Instructions: Open book & notes. Place answers in indicated spaces. Show all work. Use 5-6 significant figures.

A semiconductor has a bandgap of 0.6 eV. At 350 K, assume the Fermi energy level is at E_v + 0.305 eV. We wish to determine the probability that a state at energy $E_B = E_c + 0.4k_BT$ is occupied by an **electron**. First, find $E_c - E_F$ (eV) and k_BT (eV). Then, calculate the energy difference $\Delta E = E_B - E_F$ (eV). Finally, determine the probability that a state at E_B is occupied by an electron (unitless).

We are given $E_F = E_v + 0.305$ eV $\Rightarrow E_v = E_F - 0.305$ eV.

By definition,

$$E_g = E_c - E_v = E_c - (E_F - 0.305 \text{ eV}) \Rightarrow E_c - E_F = E_g - 0.305 \text{ eV} = 0.6 - 0.305 \text{ eV}$$

$$\Rightarrow \mathbf{E_c - E_F = 0.295\ eV}.$$

Next, compute $k_BT = (8.617333\times10^{-5}$ eV/K) 350 K $\Rightarrow$ $\mathbf{k_BT = 0.030160666\ eV}$.

The energy difference $\Delta E = E_B - E_F$ where $E_B = E_c + 0.4k_BT$ is then

$$\Delta E = (E_c + 0.4k_BT) - E_F = E_c - E_F + 0.4k_BT = 0.295 + 0.4(0.030160666)$$

$$\Rightarrow \mathbf{\Delta E = 0.307064266\ eV}.$$

Use Fermi-Dirac probability function (3.79) to find the probability of an electron at $E = E_B$ as

$$f_F(E = E_B) = \frac{1}{1 + e^{\frac{E_B - E_F}{k_BT}}} = \frac{1}{1 + e^{\frac{0.307064266}{0.030160666}}} \qquad \Rightarrow \mathbf{f_F(E_B) = 3.788372 \times 10^{-5}}.$$

$E_c - E_F$ = **0.295 eV** $\quad$ k_BT = **0.0301607 eV** $\quad$ ΔE = **0.307064 eV**

$\text{prob}_{e,EB}$ = **3.78837 × 10^{-5}**