Quiz Answers: Week 1
ECE 656: Electronic Transport in Semiconductors:
A Modern Approach

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1) Which band structure below best describes graphene?

a) $E = E_C + \hbar^2 k^2 / \left(2m_n^*\right)$

b) $E = E_V - \hbar^2 k^2 / \left(2m_p^*\right)$

c) $E = \hbar \upsilon_F k$

d) $E = \pm \hbar \upsilon_F k$

e) $E = \pm \hbar \upsilon_F k^2$

2) What is the "crystal momentum" of an electron?

a) $\vec{p} = m_0 \vec{\upsilon}$

b) $\vec{p} = m_n^* \vec{\upsilon}$

c) $\vec{p} = \left(m_n^* + m_p^*\right) \vec{\upsilon}$

d) $\vec{p} = \hbar \vec{k}$

e) $\vec{p} = \hbar^2 k^2 \vec{k}$

3) What is the quantity, $\psi\left(\vec{r}\right) = u\left(\vec{r}\right) e^{i\vec{k}\bullet\vec{r}}$, called?

a) a plane wave electron wavefunction
b) the envelope function
c) an atomic orbital
d) a Wannier function
e) a Bloch wave

4) Consider a 2D semiconductor sheet in the x-y plane. The top surface is at $z = 0$ and the bottom at $z = t$. What is the wavefunction of the **second** subband? (Assume infinite confining potentials on the top and bottom).

a) $\psi\left(\vec{r}\right) = \sin\left(\pi z / t\right) e^{i2k_x x} \times e^{i2k_y y}$

b) $\psi\left(\vec{r}\right) = \cos\left(2\pi z / t\right) e^{ik_x x} \times e^{ik_y y}$

c) $\psi\left(\vec{r}\right) = \sin\left(2\pi z / t\right) e^{ik_x x} \times e^{ik_y y}$

d) $\psi\left(\vec{r}\right) = \cos\left(\pi z / t\right) e^{ik_x x} \times e^{ik_y y}$

e) $\psi\left(\vec{r}\right) = \cos\left(2\pi z / t\right) e^{ik_x x} \times e^{ik_y y}$

5) What is a "quasi-electric field" for electrons?

a) A quantity that exerts a force on electrons due to variations in electron affinity

b) A quantity that exerts a force on electrons due to variations in bandgap

c) A quantity that exerts a force on electrons due to variations in effective mass

d) A quantity that exerts a force on electrons due to variations in the density of states

e) A quantity that exerts a force on electrons and that is obtained by solving the Poisson equation.

6) Which of the following is true about the density of states in *k*-space?

a) It depends on the dimensionality of the semiconductor.

b) States are spaced uniformly in k-space.

c) It is independent of the semiconductor's band structure.

d) All of the above.

e) None of the above.

7) Which of the following is true about the density of states in energy space?

a) It depends on the dimensionality of the semiconductor.

b) States are spaced uniformly in energy space.

c) It is independent of the semiconductor's band structure.

d) All of the above.

e) None of the above.

8) What is the quantity, $\dfrac{\sum_{k_x>0,k_y,k_z} \upsilon_x f_0\left(E_k\right)}{\sum_{k_x>0,k_y,k_z} f_0\left(E_k\right)}$?

a) Zero.

b) The average, thermal equilibrium electron velocity

c) The average, thermal equilibrium velocity of electrons with a +x-directed velocity

d) The rms thermal velocity

e) The Richardson thermal velocity

9) What is the difference between a "script F" Fermi-Dirac integral, $\mathcal{F}_j(\eta_F)$ and a "roman F" Fermi-Dirac integral, $F_j(\eta_F)$?

a) There is no difference – they are the same quantity.
b) $\mathcal{F}_j(\eta_F) = dF_j/d\eta_F$
c) $F_j(\eta_F) = d\mathcal{F}_j/d\eta_F$
d) $F_j(\eta_F) = \Gamma(j+1)\mathcal{F}_j(\eta_F)$
e) $F_j(\eta_F) = \mathcal{F}_j(\eta_F)$ for $\eta_F << 0$

10) Which of the following is true when $\eta_F >> 0$?

a) $\mathcal{F}_j(\eta_F) \rightarrow \exp(\eta_F)$
b) $\mathcal{F}_j(\eta_F) > \exp(\eta_F)$
c) $\mathcal{F}_j(\eta_F) < \exp(\eta_F)$
d) $\mathcal{F}_j(\eta_F) \rightarrow \exp(\eta_F^j)$
e) $\mathcal{F}_j(\eta_F) \rightarrow 1$.

11) How do the bandwidths (BW) of typical electron and phonon dispersions compare?

a) The electron and phonon BWs are similar
b) The electron BW is a little bigger than the phonon BW
c) The electron BW is somewhat less than the phonon BW
d) The electron BW is much greater than the phonon BW
e) The electron BW is much less than the phonon BW

12) What is the Einstein approximation?

a) A relation between the mobility and diffusion coefficient
b) A simple approximation for the acoustic phonon dispersion
c) A simple approximation for the optical phonon dispersion
d) An approximation for the electron dispersion in graphene
e) An approximation for nonparabolic energy bands