Quiz ANSWERS Week 9
ECE 656: Electronic Conduction In Semiconductors

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1) What is the proper, near-equilibrium current equation when the temperature varies slowly with position?
   a) $J_{nx} = \sigma_n \dfrac{d(F_n/q)}{dx}$
   b) $J_{nx} = \sigma_n \dfrac{d(F_n/q)}{dx} - S_n \dfrac{dT}{dx}$
   c) $J_{nx} = \sigma_n \dfrac{d(F_n/q)}{dx} - S_n \sigma_n \dfrac{dT}{dx}$**.**
   d) $J_{nx} = \sigma_n \dfrac{d(F_n/q)}{dx} - \pi_n \dfrac{dT}{dx}$.
   e) $J_{nx} = \sigma_n \dfrac{d(F_n/q)}{dx} - \kappa_n \sigma_n \dfrac{dT}{dx}$.

2) What is the strongest factor that determines the magnitude of the Seebeck coefficient?
   a) The location of the Fermi level with respect to the band edge.
   b) The shape of the density of states.
   c) The energy dependence of the mean-free-path for backscattering.
   d) The dimensionality of the semiconductor.
   e) All of the above-listed factors are equally important.

3) What are the two, most general driving forces for current?
   a) Gradients in the electrostatic potential and temperature.
   b) Gradients in the carrier concentration and temperature.
   c) Gradients in the electrochemical potential and temperature.
   d) Gradients in the electrostatic potential and carrier concentration.
   e) Gradients in the electron density and electrostatic potential.

4) For a non-degenerate, n-type semiconductor, the current typically flows at an energy, Δ_n, above the bottom of the conduction band. What is a typical value for Δ_n?
   a) Much less than $k_B T$.
   b) Much greater than $k_B T$.
   c) On the order of $k_B T$.
   d) Approximately $E_F - E_C$.
   e) Approximately $E_C - E_F$.

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5) For a degenerate, n-type semiconductor, the current typically flows at an energy, Δ_n, above the bottom of the conduction band. What is a typical value for Δ_n?
   a) Much less than $k_B T$.
   b) Much greater than $k_B T$.
   c) On the order of $k_B T$.
   d) **Approximately $E_F - E_C$**.
   e) Approximately $E_C - E_F$

6) What is the relation between the Peltier coefficient and the Seebeck coefficient called?
   a) The Wiedemann-Franz law
   b) The Lorenz relation
   c) Mathiessen's rule
   d) The Kelvin relation
   e) Dulong and Petit law

7) What are the coefficients, κ_0 and κ_e?
   a) κ_0 is the thermal conductivity due to phonons and κ_e is the same quantity due to electrons.
   b) κ_0 is the thermal conductivity due to electrons and κ_e is the same quantity due to phonons.
   c) κ_0 is the open-circuit thermal conductivity due to electrons and κ_e is the short-circuit thermal conductivity due to electrons.
   d) κ_0 is the short-circuit thermal conductivity due to electrons and κ_e is the open-circuit thermal conductivity due to electrons.
   e) κ_0 and κ_e two names for the same quantity, the thermal conductivity due to electrons.

8) When we write the current equation in this form: $J_{nx} = L_{11}\dfrac{d\left(F_n/q\right)}{dx} + L_{12}\dfrac{dT_L}{dx}$

   what is the coefficient L_{12} called?
   a) The Seebeck coefficient.
   b) The Soret coefficient.
   c) The Peltier coefficient.
   d) The electronic thermal conductivity, κ_0.
   e) The electronic thermal conductivity, κ_e.

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9) When we write the current equation in this form: $\dfrac{d(F_n/q)}{dx} = L_{11}J_{nx} + L_{12}\dfrac{dT_L}{dx}$

what is the coefficient L_{12} called?

a) The Seebeck coefficient.
b) The Soret coefficient.
c) The Peltier coefficient.
d) The electronic thermal conductivity, κ_0.
e) The electronic thermal conductivity, κ_e.

10) The current in an n-type conductor flows at an energy, Δ_n, above the bottom of the conduction band. What determines the value of Δ_n?

a) The location of the Fermi level .
b) The shape of the bandstructure.
c) The energy dependence of the mean-free-path.
d) All of the above.
e) None of the above.

11) What is the "power factor"
a) $S\sigma$
b) $S^2\sigma$
c) $S^2\sigma T$
d) $\kappa_L + \kappa_e$
e) κ_0/κ_L

12) Where should the Fermi level be placed to maximize the power factor in an n-type semiconductor?
a) Well below the conduction band edge, E_C
b) Well above the conduction band edge, E_C
c) Very close to the conduction band edge, E_C
d) Very close to the valence band edge, E_V
e) Well below the valence band edge, E_V

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13) Which of the following is true about the location of the Fermi level to maximize the power factor in an n-type semiconductor?

a) It is higher in 1D than in 2D and higher in 2D than in 3D.
b) It is lower in 1D than in 2D and lower in 2D than in 3D.
c) It is the same in 1D, 2D, and 3D.
d) It is the same in 1D and 2D, but higher in 3D.
e) It is the same in 2D and 3D, but lower in 1D.

14) The best thermoelectric materials all have one thing in common. What is it?

a) A very high mobility.
b) A very high conductivity.
c) A very high Seebeck coefficient.
d) A very low lattice thermal conductivity.
e) A very low Peltier coefficient.

15) For a general (possibly anisotropic) material, we write:

$$\mathcal{E}_i = \rho_{ij} J_j + S_{ij} \partial_j T$$

Assume that J_x is non-zero and all other components are zero and that the temperature is uniform. What is $\mathcal{E}_y$?

a) $\mathcal{E}_y = \rho_{yy} J_x$
b) $\mathcal{E}_y = \rho_{xy} J_x$.
c) $\mathcal{E}_y = \rho_{yx} J_x$**.**
d) $\mathcal{E}_y = \rho_{yy} J_y$.
e) $\mathcal{E}_y = \rho_{yx} J_y$.