

Quiz Answers: Week 8
ECE 656: Electronic Conduction In Semiconductors
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Lecture 18 Quiz :

- 1) What is the proper, near-equilibrium current equation when the temperature varies slowly with position?

- a) $J_{nx} = \sigma_n \frac{d(F_n/q)}{dx}$
- b) $J_{nx} = \sigma_n \frac{d(F_n/q)}{dx} - S_n \frac{dT}{dx}$
- c) $J_{nx} = \sigma_n \frac{d(F_n/q)}{dx} - S_n \sigma_n \frac{dT}{dx}.$
- d) $J_{nx} = \sigma_n \frac{d(F_n/q)}{dx} - \pi_n \frac{dT}{dx}.$
- e) $J_{nx} = \sigma_n \frac{d(F_n/q)}{dx} - \kappa_n \sigma_n \frac{dT}{dx}.$

- 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.

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- 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 ?
- Much less than $k_B T$.
 - Much greater than $k_B T$.
 - On the order of $k_B T$.**
 - Approximately $E_F - E_C$.
 - Approximately $E_C - E_F$
- 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 ?
- Much less than $k_B T$.
 - Much greater than $k_B T$.
 - On the order of $k_B T$.
 - Approximately $E_F - E_C$.**
 - Approximately $E_C - E_F$

Lecture 19 Quiz:

- 1) What is the relation between the Peltier coefficient and the Seebeck coefficient called?
- The Wiedemann-Franz law
 - The Lorenz relation
 - Mathiessen's rule
 - The Kelvin relation**
 - Dulong and Petit law
- 2) What are the coefficients, κ_0 and κ_e ?
- κ_0 is the thermal conductivity due to phonons and κ_e is the same quantity due to electrons.
 - κ_0 is the thermal conductivity due to electrons and κ_e is the same quantity due to phonons.
 - κ_0 is the open-circuit thermal conductivity due to electrons and κ_e is the short-circuit thermal conductivity due to electrons.
 - κ_0 is the short-circuit thermal conductivity due to electrons and κ_e is the open-circuit thermal conductivity due to electrons.**
 - κ_0 and κ_e two names for the same quantity, the thermal conductivity due to electrons.

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

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 .

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

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 .

5) 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.

Lecture 20 Quiz:

1) 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

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- 2) Where should the Fermi level be placed to maximize the power factor in an n-type semiconductor?
- Well below the conduction band edge, E_c
 - Well below the conduction band edge, E_c
 - Very close to the conduction band edge, E_c**
 - Very close to the valence band edge, E_v
 - Well below the valence band edge, E_v
- 3) Which of the following is true about the location of the Fermi level to maximize the power factor in an n-type semiconductor?
- It is higher in 1D than in 2D and higher in 2D than in 3D.
 - It is lower in 1D than in 2D and lower in 2D than in 3D.**
 - It is the same in 1D, 2D, and 3D.
 - It is the same in 1D and 2D, but higher in 3D.
 - It is the same in 2D and 3D, but lower in 1D.
- 4) The best thermoelectric materials all have one thing in common. What is it?
- A very high mobility.
 - A very high conductivity.
 - A very high Seebeck coefficient.
 - A very low lattice thermal conductivity.**
 - A very low Peltier coefficient.
- 5) 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 ?

- $\mathcal{E}_y = \rho_{yy} J_x$
- $\mathcal{E}_y = \rho_{xy} J_x$.
- $\mathcal{E}_y = \rho_{yx} J_x$.**
- $\mathcal{E}_y = \rho_{yy} J_y$.
- $\mathcal{E}_y = \rho_{yx} J_y$.