

Quiz Answers: Week 15
ECE 656: Electronic Conduction In Semiconductors
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Lecture 37 Quiz :

- 1) For high-field transport in a bulk semiconductor, we write the Einstein relation as $D_n/\mu_n = 2u_{xx}/q$. What is u_{xx} for a non-degenerate semiconductor with parabolic energy bands? (Assume that the drift energy is negligible).
 - a) $u_{xx} = nk_B T_e / 2$, where T_e is the electron temperature.
 - b) $u_{xx} = nk_B T_e$, where T_e is the electron temperature.
 - c) $u_{xx} = 3nk_B T_e / 2$, where T_e is the electron temperature
 - d) $u_{xx} = k_B T_e / 2$, where T_e is the electron temperature.**
 - e) $u_{xx} = 3k_B T_e / 2$, where T_e is the electron temperature.

- 2) In practice, one commonly extends the near-equilibrium drift-diffusion equation to high-fields by replacing the mobility and diffusion coefficients by electric field dependent quantities, as in $J_{nx} = nq\mu_n(\mathcal{E})\mathcal{E}_x + qD_n(\mathcal{E})dn/dx$. What assumption is necessary to write the DD equation in this form?
 - a) Parabolic energy bands.
 - b) Non-degenerate carrier statistics.
 - c) The microscopic relaxation time approximation.
 - d) That the energy relaxation time is shorter than the momentum relaxation time.
 - e) That the shape of the distribution, whatever it is, does not vary with position.**

- 3) Assume that there is a dominant optical (or intervalley) phonon scattering process that dominates under high electric fields. How does the saturated velocity depend on the optical phonon energy, $\hbar\omega_0$?
 - a) $v_{SAT} \propto \hbar\omega_0$.
 - b) $v_{SAT} \propto (\hbar\omega_0)^2$.
 - c) $v_{SAT} \propto \sqrt{\hbar\omega_0}$.**
 - d) $v_{SAT} \propto 1/\hbar\omega_0$.
 - e) $v_{SAT} \propto 1/\sqrt{\hbar\omega_0}$.

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4) Which of the following statements is true when the drift energy is small compared to the thermal energy?

- a) $\langle \tau_m \rangle \approx \langle \tau_E \rangle$.
- b) $\langle \tau_m \rangle \gg \langle \tau_E \rangle$.
- c) $\langle \tau_m \rangle \ll \langle \tau_E \rangle$.**
- d) $\langle \tau_m \rangle$ and $\langle \tau_E \rangle$ both increase with increasing energy.
- e) $\langle \tau_m \rangle$ and $\langle \tau_E \rangle$ are independent of energy.

5) In the classic description of the velocity vs. electric field characteristic in bulk Si,

$$v_d = \mu_{n0} E / \sqrt{1 + (E/E_c)^2}$$
, approximately what is the magnitude of the critical electric field, E_c ?

- a) $\approx 0.1 \text{ kV/cm}$.
- b) $\approx 1 \text{ kV/cm}$.
- c) $\approx 10 \text{ kV/cm}$.**
- d) $\approx 100 \text{ kV/cm}$.
- e) $\approx 1000 \text{ kV/cm}$.

Lecture 38 Quiz:

1) What is meant by the term, “non-local” semiclassical transport.

- a) Transport that cannot be described by a DD equation with a field-dependent mobility and diffusion coefficient.
- b) Transport in an electric field that varies more rapidly in space than the energy relaxation length, where T_e is the electron temperature.
- c) Transport in an electric field that varies more rapidly in time than the energy relaxation time.
- d) All of the above.
- e) None of the above.

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- 2) Under what conditions does velocity overshoot occur for a rapidly varying electric field?
- a) When transport is ballistic .
 - b) When transport is quasi-ballistic.
 - c) When the momentum relaxation time is much shorter than the energy relaxation time.**
 - d) When the momentum relaxation time is much longer than the energy relaxation time.
 - e) When the momentum relaxation time is nearly equal to the energy relaxation time.
- 3) Assume that a strong electric field is switched on at $t = 0$. Which of the following statements is true about the velocity vs. time transient?
- a) The drift velocity overshoots its steady-state value.**
 - b) The carrier energy overshoots its steady-state value.
 - c) The drift velocity and carrier energy overshoot their steady-state values.
 - d) The drift velocity overshoots its steady-state value and the carrier energy undershoots its steady-state value.
 - e) The drift velocity undershoots its steady-state value and the carrier energy overshoots its steady-state value.
- 4) Which of the following statements is true about the drift and thermal energies during a velocity vs. time transient like that in question 3)?
- a) The drift energy overshoots its steady-state value.**
 - b) The thermal energy overshoots its steady-state value.
 - c) The drift energy and thermal energy overshoot their steady-state values.
 - d) The drift energy overshoots its steady-state value and the thermal energy undershoots its steady-state value.
 - e) The drift energy undershoots its steady-state value and the thermal energy overshoots its steady-state value.
- 5) When comparing velocity vs. time transient to a steady-state velocity vs. position transient, which of the following is true?
- a) Temporal velocity overshoot is stronger than s.s. spatial velocity overshoot.
 - b) Diffusion effects are much stronger in steady-state than in transient situations.
 - c) Ensemble effects are much stronger in steady-state than in transient situations.
 - d) All of the above.**
 - e) None of the above.