NAME: ANSWERS **PUID: _____**

ECE 656 Quiz 1 ANSWERS: Fall 2017
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This is a closed book quiz.

Be sure to fill in your name and Purdue student ID at the top of the page.

DO NOT open the quiz until told to do so, and stop working immediately when time is called.

25 points possible – 2.5 points per question.

---------- Course policy ----------

I understand that if I am caught cheating in this quiz, I will earn an F for the course and be reported to the Dean of Students.

Read and understood: _____
signature

Answer the **ten multiple choice questions** below by choosing the **one, best answer**.

1) What is the physical meaning of the quantity, $\left(1/\hbar\right)\partial E\left(\vec{k}\right)/\partial k_x$?
   a) The effective mass of an electron.
   b) The phase velocity of an electron.
   c) The phase velocity of a hole.
   d) The group velocity of an electron.
   e) The group velocity of a hole.

2) What happens when the time between scattering events is short?
   a) Momentum is conserved.
   b) Momentum is NOT conserved.
   c) Energy is conserved.
   d) Energy is NOT conserved.
   e) Electrons are NOT conserved.

3) Consider electrons in the conduction band of silicon. If these electrons are confined in a quantum well with the confinement direction being [010]. Which of the following statements is true about the confinement mass (which determines the subband energy) and the valley degeneracy of the lowest subband(s)?
   a) Confinement mass = m_ℓ^* and valley degeneracy = 2.
   b) Confinement mass = m_ℓ^* and valley degeneracy = 4.
   c) Confinement mass = m_t^* and valley degeneracy = 2.
   d) Confinement mass = m_t^* and valley degeneracy = 4.
   e) Confinement mass = $\sqrt{m_\ell^* m_t^*}$ and valley degeneracy = 4.

4) How does conduction band nonparabolicity typically affect the density of states (DOS) **in energy space**?
   a) It increases the DOS.
   b) It decreases the DOS.
   c) It has no effect on the DOS.
   d) It causes the DOS to become non-uniform in k-space.
   e) It causes extended states to become localized states.

5) Which of the following is generally true of the characteristic times? (Scattering time, τ, momentum relaxation time, τ_m, and energy relaxation time, τ_E.)

a) $\tau > \tau_m > \tau_E$.

b) $\tau > \tau_m < \tau_E$.

c) $\tau < \tau_m > \tau_E$.

d) $\tau < \tau_m < \tau_E$.

e) $\tau \approx \tau_m \approx \tau_E$.

6) Which of the following is a reasonable estimate of the velocity for zone-center optical phonons in a typical semiconductor?

a) 0 cm/sec.

b) 10^3 cm/sec.

c) 10^5 cm/sec.

d) 10^7 cm/sec.

e) 10^9 cm/sec.

7) For moderately doped CdSe (a II-VI semiconductor) at room temperature, which of the follow scattering mechanisms will dominate?

a) Acoustic deformation potential scattering.

b) Optical deformation potential scattering.

c) Polar optical phonon scattering.

d) Ionized impurity scattering.

e) Electron-plasmon scattering.

8) The transition rate for electron-phonon scattering contains a term, $\left(N_\omega + 1/2 \mp 1/2\right)$. Which of the following statements is true?

a) The phonon emission rate goes as $\left(N_\omega\right)$ and the absorption rate as $\left(N_\omega + 1\right)$

b) The phonon emission rate goes as $\left(N_\omega\right)$ and the absorption rate as $\left(N_\omega - 1\right)$

c) The phonon emission rate goes as $\left(N_\omega + 1\right)$ and the absorption rate as $\left(N_\omega\right)$

d) The phonon emission rate goes as $\left(N_\omega - 1\right)$ and the absorption rate as $\left(N_\omega\right)$

e) The phonon emission rate goes as $\left(N_\omega + 1/2\right)$ and the absorption rate as $\left(N_\omega - 1/2\right)$

9) We generally assume that II scattering is not involved in intervalley scattering. Why?
   a) Because it is elastic, and intervalley scattering requires a large change in energy.
   b) Because it is inelastic and intervalley scattering requires no change in energy.
   c) Because polar materials have only a single conduction band valley.
   d) Because intervalley scattering requires a large change in momentum, and II scattering favors small changes in momentum.
   e) Because intervalley scattering requires a small change in momentum, and II scattering favors large changes in momentum.

10) For which of the following scattering mechanisms are the scattering rate and momentum relaxation rate the same **and** which of those has the largest energy relaxation rate?
   a) Ionized impurity scattering.
   b) POP scattering.
   c) Intervalley scattering.
   d) Alloy scattering.
   e) Acoustic deformation potential scattering.