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Week 5 Quiz ANSWERS: Equilibrium Carrier Concentrations
ECE 305: Semiconductor Devices

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

1) Which of the following is a statement of “low-level injection” in an n-type semiconductor?

- a) $N_D \ll N_A$.
- b) $N_A \ll N_D$.
- c) $n_0 \ll N_D$.
- d) $\Delta p \ll n_0$.**
- e) $\Delta p \approx \Delta n$.

2) Which of the following is true about $\nabla \cdot \vec{J}_N$?

- a) $\nabla \cdot \vec{J}_N = (\partial J_{Nx} / \partial x) \hat{x} + (\partial J_{Ny} / \partial y) \hat{y} + (\partial J_{Nz} / \partial z) \hat{z}$.
- b) $\nabla \cdot \vec{J}_N = (\partial^2 J_{Nx} / \partial x^2) \hat{x} + (\partial^2 J_{Ny} / \partial y^2) \hat{y} + (\partial^2 J_{Nz} / \partial z^2) \hat{z}$.
- c) $\nabla \cdot \vec{J}_N = (\partial J_{Nx} / \partial x) + (\partial J_{Ny} / \partial y) + (\partial J_{Nz} / \partial z)$.**
- d) $\nabla \cdot \vec{J}_N = (\partial^2 J_{Nx} / \partial x^2) + (\partial^2 J_{Ny} / \partial y^2) + (\partial^2 J_{Nz} / \partial z^2)$.
- e) $\nabla \cdot \vec{J}_N = \sqrt{J_{Nx}^2 + J_{Ny}^2 + J_{Nz}^2}$.

3) What is the name of this equation: $\frac{\partial n}{\partial t} = \frac{1}{q} \nabla \cdot \vec{J}_N + \frac{\partial n}{\partial t} \Big|_{\text{thermal R-G}} + \frac{\partial n}{\partial t} \Big|_{\text{other processes}}$?

- a) The Poisson equation.
- b) The minority carrier electron diffusion equation.
- c) The electron continuity equation.**
- d) The Shockley-Read-Hall equation.
- e) The electron current equation.

4) Which of the following is the minority carrier electron diffusion length?

- a) $L_N = \sqrt{\mu_n / \tau_n}$.
- b) $L_N = \sqrt{D_n / \tau_n}$.
- c) $L_N = \sqrt{\mu_n \tau_n}$.
- d) $L_N = \sqrt{D_n \tau_n}$.**
- e) $L_N = \sqrt{\mu_n \mathcal{E} \tau_n}$.

ECE-305 Week 5 Quiz continued:

- 5) The minority carrier diffusion equation (MDE) makes which of the following assumptions?
- a) Low-level injection.
 - b) Electric field is zero.
 - c) Steady-state conditions.
 - d) a) and b) above.**
 - e) a) and c) above.
- 6) Which one of the following describes the parameter τ_n in a p-type semiconductor?
- a) It is the average time it takes for an electron to diffuse across the region.
 - b) It is the average time between scattering events.
 - c) It is the average time before a minority carrier electron recombines with a hole.**
 - d) It is the average time for an electron to drift across the region.
 - e) None of the above.
- 7) How many boundary conditions are required for the 1D MDE?
- a) 0.
 - b) 1.
 - c) 2.**
 - d) 3.
 - e) 4.
- 8) What approximations are required to write the MDE as $d^2\Delta n_p/dx^2 = 0$?
- a) Steady-state.
 - b) No thermal R-G.
 - c) No "other processes" such as photogeneration.
 - d) All of the above.**
 - e) None of the above.
- 9) If the quasi-Fermi levels are split, what does it mean?
- a) That current is flowing.
 - b) That there are excess carriers.**
 - c) That the semiconductor is degenerate.
 - d) All of the above.
 - e) None of the above.

ECE-305 Week 5 Quiz continued:

10) When is $np = n_i^2$?

- a) Under steady-state conditions.
- b) Under low-level injection.
- c) When an electric field is absent.
- d) Only for a nondegenerate semiconductor in equilibrium.**
- e) When the diffusion constant is spatially uniform.

11) If there is a slope to the quasi-Fermi level, what does it mean?

- a) That current is flowing.**
- b) That there are excess carriers.
- c) That the semiconductor is degenerate.
- d) All of the above.
- e) None of the above.

12) For an n-type semiconductor with excess holes and electrons, which of the following is true ?

- a) $F_n = F_p$.
- b) $F_n > F_p$.**
- c) $F_n < F_p$.
- d) $F_n * F_p = E_F^2$.
- e) None of the above.