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Week 5 Quiz: 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) $N_D << N_A$.
   b) $N_A << N_D$.
   c) $n_0 << N_D$.
   d) $\Delta p << n_0$.
   e) $\Delta p \approx \Delta n$.

2) Which of the following is true about $\nabla \bullet \vec{J}_N$?
   a) $\nabla \bullet \vec{J}_N = \left(\partial J_{Nx}/\partial x\right)\hat{x} + \left(\partial J_{Ny}/\partial y\right)\hat{y} + \left(\partial J_{Nz}/\partial z\right)\hat{z}$.
   b) $\nabla \bullet \vec{J}_N = \left(\partial^2 J_{Nx}/\partial x^2\right)\hat{x} + \left(\partial^2 J_{Ny}/\partial y^2\right)\hat{y} + \left(\partial^2 J_{Nz}/\partial z^2\right)\hat{z}$.
   c) $\nabla \bullet \vec{J}_N = \left(\partial J_{Nx}/\partial x\right) + \left(\partial J_{Ny}/\partial y\right) + \left(\partial J_{Nz}/\partial z\right)$.
   d) $\nabla \bullet \vec{J}_N = \left(\partial^2 J_{Nx}/\partial x^2\right) + \left(\partial^2 J_{Ny}/\partial y^2\right) + \left(\partial^2 J_{Nz}/\partial z^2\right)$.
   e) $\nabla \bullet \vec{J}_N = \sqrt{J_{Nx}^2 + J_{Ny}^2 + J_{Nz}^2}$.

3) What is the name of this equation: $\dfrac{\partial n}{\partial t} = \dfrac{1}{q}\nabla \bullet \vec{J}_N + \left.\dfrac{\partial n}{\partial t}\right|_{\substack{thermal \\ R-G}} + \left.\dfrac{\partial n}{\partial t}\right|_{\substack{other \\ processes}}$?
   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 requited to write the MDE as $d^2\Delta n_p \big/ dx^2 = 0$?

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.