NAME:_____   PUID: _____

Week 4 Quiz ANSWERS Equilibrium Carrier Concentrations
ECE 305: Semiconductor Devices
Mark Lundstrom, Purdue University, Spring 2015

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

1) Velocity, mobility, and electric field are related by $v = \mu \mathcal{E}$. What are the units of mobility?
   a) cm/s
   b) cm^2/s
   c) cm^2-V/s
   d) cm^2/(V-s)
   e) cm^2-V-s

2) Electric field and current density are related by $\mathcal{E} = \rho J$. What are the units of resistivity?
   a) Siemens/m.
   b) Siemens-m.
   c) Ohms/m.
   d) Ohm-m.
   e) Ohms/Siemens

3) How do we determine the electric field vs. position, x, from an energy band diagram?
   a) The electric field is $E_C(x)$.
   b) The electric field is $E_V(x)$.
   c) The electric field is $E_i(x)$.
   d) The electric field is obtained by flipping $E_C(x)$ upside down.
   e) The electric field is the slope of $E_C(x)$.

4) The quantity, $-\mu_n \mathcal{E}$ represents:
   a) The instantaneous velocity at which electron drift in an electric field.
   b) The average velocity at which electron drift in an electric field.
   c) The average power dissipated in a semiconductor under bias.
   d) The average velocity at which electrons diffuse.
   e) The thermal velocity of electrons.

ECE-305 Week 4 Quiz continued:

5) As the doping density of a semiconductor increases, the mobility generally:
   a) Stays the same
   b) Increases.
   c) Decreases.
   d) First increases, then decreases.
   e) First decreases, then increases.

6) At high temperatures, the mobility decreases because:
   a) Lattice vibrations scatter the electrons.
   b) The intrinsic carrier concentration increases.
   c) The semiconductor crystal begins to melt.
   d) The Einstein relation begins to break down
   e) Because of Mathiesson's rule

7) To decrease the resistivity of a semiconductor, we can:
   a) Increase the carrier density
   b) Decrease the mobility
   c) Increase the electric field
   d) Increase the cross-sectional area of the resistor
   e) Decrease the length of the resistor

8) The Einstein relation relates what two quantities?
   a) The diffusion coefficient and the minority carrier lifetime.
   b) The diffusion length and the minority carrier lifetime.
   c) The hole and electron mobilities.
   d) The hole and electron diffusion coefficients.
   e) The mobility and the diffusion coefficient.

9) Under what conditions is the Fermi level constant?
   a) For an intrinsic semiconductor.
   b) For an extrinsic semiconductor.
   c) In the freezeout regime.
   d) In equilibrium for any semiconductor.
   e) Where there is a temperature gradient.

ECE-305 Week 4 Quiz continued:

10) Which of the following is NOT a recombination mechanism?
    a) Shockley-Read-Hall (SRH).
    b) Auger.
    c) Radiative.
    c) Band-to-band.
    d) Impact ionization.
    e) R-G center.

Note: "Shockley-Read-Hall" is what semiconductor people call R-G center recombination – after the three people who first figured it out.

11) In the equation, $R = \Delta n_p / \tau_n$, what is the meaning of the parameter, τ_n?

    a) It is the <u>majority</u> electron lifetime.
    b) **It is the <u>minority</u> electron lifetime.**
    c) It is the <u>majority</u> electron diffusion length.
    d) It is the <u>minority</u> electron diffusion length.
    e) It is the transit time of a <u>minority</u> electron across a p-type region.