Quiz Answers: Week 10
ECE 656: Electronic Conduction In Semiconductors
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Lecture 23 Quiz:

1) The equation of motion for an electron in k-space is $\frac{d(hk)}{dt} = \vec{F}_e$. What assumptions are necessary for this equation to be valid?
   
   a) Parabolic energy bands.
   b) Non-degenerate conditions.
   c) **No quantum mechanical reflections.**
   d) No B-field.
   e) No temperature gradients.

2) Under what conditions is this equation valid? $\frac{\partial f}{\partial t} + \vec{v} \cdot \nabla \rho, f + \vec{F_e} \cdot \nabla \rho, f = 0$
   
   a) No recombination-generation.
   b) Equilibrium.
   c) No scattering.
   d) Position independent effective mass.
   e) **All of the above**

3) What is the quantity, $\sum_{\vec{p}'} S(\vec{p}' \rightarrow \vec{p}) f(\vec{p}') [1 - f(\vec{p})]$?
   
   a) The collision integral.
   b) **The in-scattering rate.**
   c) The out-scattering rate.
   d) The relaxation time approximation.
   e) The collision operator.

4) What is the quantity, $-\left(\frac{f(\vec{p}) - f_0(\vec{p})}{\tau_m}\right)$?
   
   a) The collision operator.
   b) **The collision operator in the relaxation time approximation.**
   c) The solution to the steady-state Boltzmann equation.
   d) The in-scattering term of the collision operator.
   e) The out-scattering terms of the collision operator.

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5) In the solution to the steady-state Boltzmann equation, \[ \delta f = \tau_m \left( -\frac{\partial f_0}{\partial E} \right) \bar{v} \cdot \vec{F}, \] what is the term \( \vec{F} \) called?

a) The electrochemical potential.
b) The chemical potential.
c) The statistical force.
d) **The generalized force.**
e) The electric field.

Lecture 24 Quiz:

1) What is the quantity. \[ \frac{1}{A} \sum_k (E - F_{e_k}) \bar{v}(\vec{k}) f(\vec{r}, \vec{k})? \] (\( E \) is the total energy.)

a) The energy density.
b) The energy flux.
c) The heat density.
d) **The heat flux.**
e) The kinetic energy flux.

2) In this equation, \[ \hat{C}f = -\left( \frac{f(\vec{p}) - f_s(\vec{p})}{\tau_m} \right) \] what is \( f_s(\vec{p})? \)

a) The distribution function.
b) The equilibrium distribution function.
c) A distribution with the shape of the equilibrium distribution function.
d) The Bose-Einstein distribution.
e) The anti-symmetric part of the distribution function.

3) How do we interpret the quantity, \( \langle \bar{v} \bar{v} \rangle? \)

a) As a scalar.
b) As a vector.
c) **As a second rank tensor.**
d) As a third rank tensor.
e) None of the above.

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4) For spherical bands, how is the average scattering time, \( \langle \tau_m \rangle \) defined?
a) \( \langle v_x^2 \tau_m \rangle / \langle v_x^2 \rangle \).
b) \( \langle v_x^2 \rangle / \langle v_x \rangle \).
c) \( \langle (E - E_C) \tau_m \rangle / \langle (E - E_C) \rangle \).
d) All of the above.
e) None of the above.

5) What is \( \frac{1}{\mu_{\text{tot}}} = \frac{1}{\mu_1} + \frac{1}{\mu_2} \) called?

a) The Thompson relation.
b) The Kelvin relation.
c) The Wiedemann-Franz law.
d) The Lorenz number.
e) Mathiessen’s rule.

Lecture 25 Quiz:

3) Why is the BTE harder to solve in the presence of a B-field?
   a) Because we are no longer near equilibrium.
   b) Because non-degenerate statistics must be used.
   c) Because the cross product makes the math more difficult.
   d) Because the gradient in momentum space cannot be approximated by the gradient of \( f_S \).
   e) Because the gradient in position space cannot be approximated by the gradient of \( f_S \).

4) In this equation, \( \bar{J}_n = \sigma_S \bar{E} - \sigma_S \mu_H (\bar{E} \times \bar{B}) \), what is \( \mu_H \) ?
   a) The mobility.
   b) The effective mobility.
   c) The conductivity mobility.
   d) The chemical potential.
   e) The Hall mobility.

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3) What is the quantity, \( \frac{\langle \tau_m^2 \rangle}{\langle \tau_m \rangle^2} \), called?
   a) The Hall mobility.
   b) The Hall coefficient.
   c) **The Hall factor.**
   d) The Hall concentration.
   e) The Hall parameter.

4) What quantity does a Hall effect measurement find?
   a) The Hall mobility.
   b) The mobility.
   c) **The Hall concentration.**
   d) The carrier concentration.
   e) The Hall resistivity.

6) What does the criterion \( \omega_c \tau_m \ll 1 \) imply?
   a) Electrons scattering many times before completing a cyclotron orbit.
   b) The magnetic field low.
   c) Shubnikov-deHaas oscillations will not be observed.
   d) **All of the above.**
   e) None of the above.