Quiz 1:

1) Trap-assisted recombination is most efficient for traps located where in the bandgap?
   a) In the upper half of the bandgap.
   b) In the lower half of the bandgap.
   c) Near the middle of the bandgap.
   d) Very close to the conduction band.
   e) Very close to the valence band.

2) The inverse process of Auger recombination is what process?
   a) Trap assisted recombination.
   b) Radiative recombination.
   c) Impact ionization.
   d) Photo generation.
   e) Surface recombination.

3) Which of the following is a property of equilibrium?
   a) Detailed balance holds.
   b) Steady-state conditions hold, but not detailed balance.
   c) Total recombination = 0.
   d) Total generation = 0.
   e) Recombination = generation.

4) The probability that a defect will capture an electron is proportional to what?
   a) The emission rate.
   b) The capture cross-section.
   c) The minority carrier lifetime
   d) The trap energy.
   e) The density of free holes.

Quiz 2:

1) In low-level injection, the SRH recombination rate is:
   a) $\Delta n/\tau_p$
   b) $\Delta n/\tau_n$
   c) $\Delta n/(\tau_n + \tau_p)$
   d) $\Delta n^2/\tau_n$
e) \( \Delta n^2/(\tau_n + \tau_p) \)

Continued

2) **In high-level injection**, the SRH recombination rate is:
   a) \( \Delta n/\tau_p \)
   b) \( \Delta n/\tau_n \)
   c) \( \Delta n/(\tau_n + \tau_p) \)
   d) \( \Delta n^2/\tau_n \)
   e) \( \Delta n^2/(\tau_n + \tau_p) \)

3) If we remove all the electrons and holes from a semiconductor, what happens to the SRH recombination rate?
   a) It becomes zero.
   b) It becomes less than zero.
   c) It becomes greater than zero.
   d) Detailed balance holds.
   e) It is undefined.

4) When there are multiple recombination mechanisms present, how do we determine the effective minority carrier lifetime for all processes combined?
   a) Add the lifetimes for the individual processes.
   b) Multiply the lifetimes for the individual processes.
   c) Add the inverse lifetimes for the individual processes.
   d) Multiply the inverse lifetimes for the individual processes.
   e) Take the maximum of the individual lifetimes.

**Quiz 3:**

1) How are surface states distributed in energy across the bandgap?
   a) They are sharply peaked near the Fermi energy.
   b) They are sharply peaked near the middle of the bandgap.
   c) There is typically a single, discrete energy for surface states.
   d) There are typically two, discrete energies located symmetrically above and below mid-gap.
   e) Surface states are broadly distributed across the entire bandgap.
2) The low-injection surface recombination rate is typically written as the excess minority carrier concentration at the surface times what?
   a) The minority carrier surface lifetime.
   b) The minority carrier surface capture cross section.
   c) The minority carrier surface capture coefficient.
   d) The minority carrier surface emission coefficient.
   e) The minority carrier surface recombination velocity.

3) What semiconductor pioneer figured out how to fix the surface state problem for bipolar transistors?
   a) William Shockley
   b) Gordon Moore
   c) Jene Hoerni
   d) Robert Noyce
   e) Jack Kilby

4) Where do the different energy levels of the surface states come from?
   a) From different types of defects on the surface.
   b) From different types of impurities adsorbed on the surface.
   c) From the uneven height of the surface.
   d) From the amphoteric nature of surface states.
   e) No one understands the answer to the question.