Quiz 5.

1. If the pn junction is highly doped, then Zener breakdown occurs.

In a highly doped junction, the conduction and valence bands on ~~g~~opposite sides of the junction are sufficiently close during reverse bias that electrons may tunnel directly from the valence band on the p side into the conduction band on n side. 2'

For the avalanche breakdown, it happens when electrons or holes, moving across the space charge region, acquire sufficient energy from the electric field to create electron-hole pairs by colliding with atomic electrons ~~at~~ within the depletion region. The newly created electron and holes move in opposite directions due to the electric field and thereby create a reverse-biased current. In addition, the newly generated electron or holes may acquire sufficient energy to ionize other atoms, leading to the avalanche process. 2'

GaAs: $n_i = 1.8\times10^{6}\ \text{cm}^{-3}$ $\quad \varepsilon = 13.1\times 8.85\times10^{-14}\ \text{F/cm}$

2.

(a) $$J_s = \frac{eD_p p_{no}}{L_p} + \frac{eD_n n_{po}}{L_n} = \frac{e\cdot D_p\cdot\frac{n_i^2}{N_d}}{\sqrt{D_p\cdot\tau_{po}}} + \frac{eD_n\cdot\frac{n_i^2}{N_a}}{\sqrt{D_n\cdot\tau_{no}}} = 1.68\times10^{-17}\ \text{A/cm}^2$$ 2'

(b) $$V_{bi} = \frac{kT}{q}\cdot\ln\frac{N_a\cdot N_d}{n_i^2} = 1.17\ \text{V}$$

$$W = \sqrt{\frac{2\varepsilon(V_{bi}+R)}{e}\cdot\frac{N_a+N_d}{N_aN_d}} = 2.14\times10^{-4}\ \text{cm}$$ 2'

$$\therefore J_{gen} = \frac{en_iW}{2\tau_0} = 6.17\times10^{-6}\ \text{A/cm}^2.$$

$$\therefore J = J_s + J_{gen} = 6.17\times10^{-10}\ \text{A/cm}^2$$ 1'

(c). $$\frac{J_{gen}}{J_s} = 3.67\times10^{7}$$ 1'