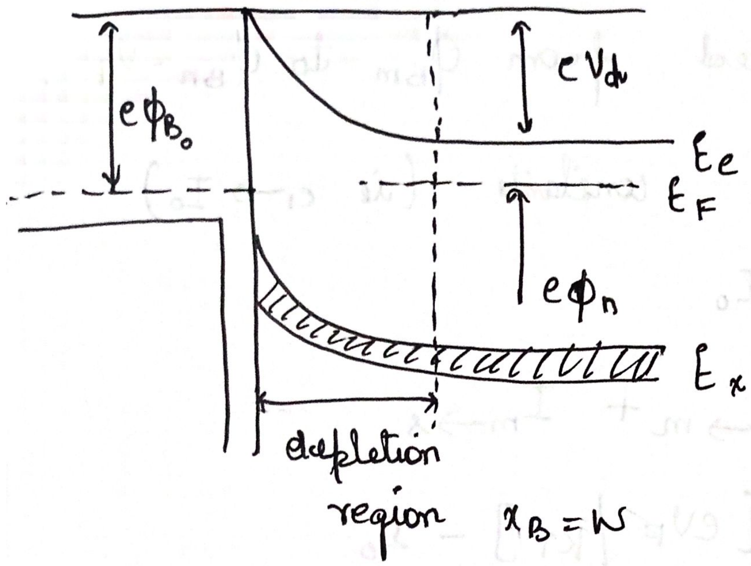
Q3

a) Zero biased

Let $I_{s \to m}$ be the current from semiconductor to metal and, $I_{m \to s}$ be the current from metal to semiconductor



At zero biased,

$$I_{s \to m} = I_{m \to s}$$

$$n = N_c e^{[-(E_c - E_F)/kT]},$$

where $N_c = 2\left[\frac{2\pi m_n^* kT}{h^2}\right]^{3/2}$

At MS junction,

$$E_c - E_F = e\phi_{Bn}$$

$$n = N_c \cdot \exp\left[-e\phi_{Bn}/kT\right]$$

We k/w $I_{s \to m} = -neAV_T$ — ①

Avg. thermal velocity of $\bar{e}$ is

$$V_T = -\sqrt{(2kT/\pi m_n^*)} \quad \text{— ②}$$

using ② in ①

$$I_{s \to m} = neA\sqrt{2kT/\pi m_n^*}$$

$\Rightarrow I_{s \to m} = \frac{1}{2} neA\sqrt{2kT/\pi m_n^*}$ [$\bar{e}$ movements have equal prob. from right to left and left to right]

$\Rightarrow I_{s \to m} = A[4\pi e m_n k^2/h^3] \cdot T^2 \cdot \exp\left[-e\phi_{Bn}/kT\right]$

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2) Forward biased IV

$$I_{s\to m} = ART^2 \cdot \exp\left[-e(\phi_{Bm} - V_F)/kT\right]$$

$$I_{s\to m} = I_e \exp\left[eV_F/kT\right]$$

V_F is applied to metal side.

→ barrier height is reduced from ϕ_{Bm} to $\phi_{Bn} - V_F$

But $I_{m\to s}$ remains constant (ie $e_1 \to I_0$)

$$I_{m\to s} = -I_0$$

So, $I_{total} = I_{s\to m} + I_{m\to s}$

$$= I_0 \exp\left[eV_F/kT\right] - I_0$$

3) Reversed Biased IV.

Barrier height ↑ to $\phi_{Bn} + V_R$, so.

$$I_{s\to m} = ART^2 \exp\left[-e(\phi_{Bn} + V_R)/RT\right]$$

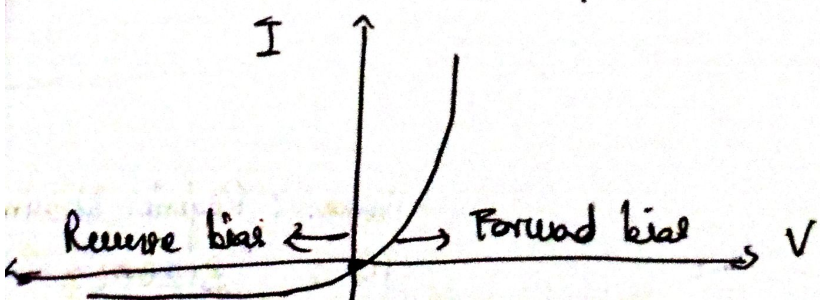
$$= I_0' \exp\left[-eV_R/RT\right]$$

$\therefore$ $V_R = -V_R$.

So, $I_{s\to m} = I_0 \exp(eV_R/kT)$

But $I_{m\to s} = -I_0$ (reman cond)

$$I_{Total} = I_0\left[\exp(eV_R(kT) - 1\right]$$



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b)

Features	Schottky diode	P-N diode
① Forward current	It occurs due to the thermionic emission (majority carrier transport)	It occurs due to diffusion currents. (minority carrier transport).
② Reverse Current	It is generated only due to majority carriers which overcome the barrier (It depends less on temperature).	It is generated due to minority carriers diffusing to the depletion layer and drifting to other side (depends more on temp.
③ Speed	It has high switching speed due to majority carrier transport. No recombination time needed.	It is limited by recombination time of injection minority carriers
④ Cut-in voltage.	It is small about 0.3V.	It is large about 0.7V.
⑤ Ideality factor	It is about 1 due to no recombination in depletion layer.	It is about 1.2 to 2.0 due to recombination in depletion layer.

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