UNIT - 22 SOLID STATE ELECTRONICS

1. **A Ge diode has a voltage drop of 0.4 V when 12 mA flows through it. If the same 470 Ohm is used, what battery voltage is needed?**

Data:

$V_D = 0.4\ V$

$I = 12\ mA = 12 \times 10^{-3}$

$R = 470\ \Omega$

$V_{Battery} = ?$

SOLUTION:

P.d across the resistor

$V_R = I\ R$

$V_R = (12 \times 10^{-3})(470)$

$V_R = 5.64\ V$

P.d across the battery

$V_{Battery} = V_R + V_D$

$V_{Battery} = (5.64) + (0.4)$

$V_{Battery} = 6.04\ V$

2. **A semiconductor diode laser has a peak emission wavelength of 1.55 µm. Find its band gap in eV. (0.8 eV)**

Data:

$\lambda = 1.55\ \mu m$

$\lambda = 1.55 \times 10^{-6}\ m$

$C = 3 \times 10^{8}\ m/s$

$h = 6.629 \times 10^{-34}\ J\ s$

$E_{Bandgap} = ?$

SOLUTION:

Band gap energy is given by

$$E_B = \frac{h\ C}{\lambda}$$

$$E_B = \frac{(6.629 \times 10^{-34})\ (3 \times 10^{8})}{(1.55 \times 10^{-6})}$$

$$E_B = \frac{1.9887 \times 10^{-25}}{1.55 \times 10^{-6}}$$

$$E_B = 1.283 \times 10^{-19}$$

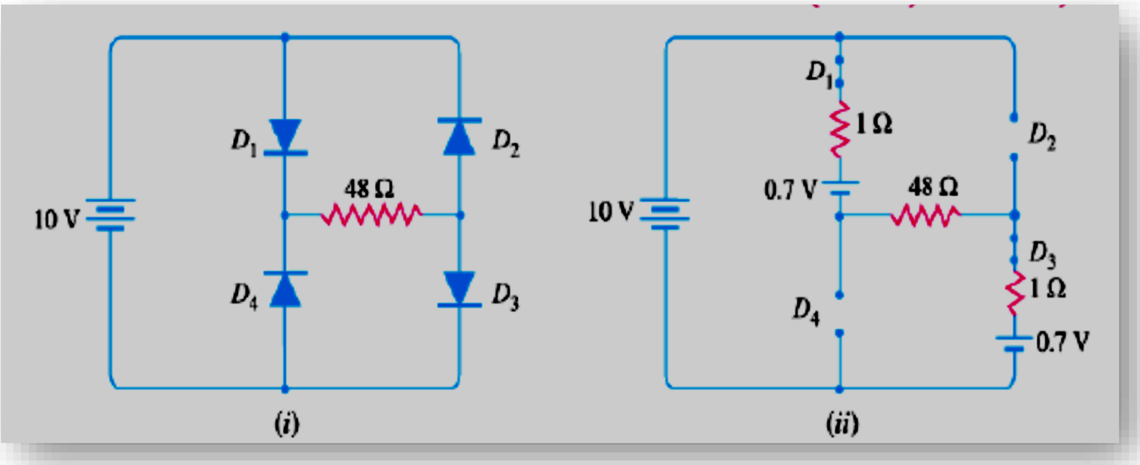
Band gap energy in eV

$1\ eV = 1.6 \times 10^{-19}$

$$E_B = \frac{1.283 \times 10^{-19}}{1.6 \times 10^{-19}}$$

$$E_B = 0.801\ eV$$

3. Calculate the current through 48 Ω resistor in the circuit shown in Fig. (i). Assume the diodes to be of silicon and the forward resistance of each diode is 1 Ω.



SOLUTION:

For a diode D_1 and D_3 in forward bias and D_2 and D_4 in reverse bias:

The voltage drops across D_1 and D_3 is 0.7*V*.

Thus, across D_1 and D_3 combined, the drop is 0.7 + 0.7 = 1.4 V.

The total resistance of D_1 and D_3, due to forward resistance, is *1 Ω+1 Ω=2 Ω*

Using Kirchhoff's voltage rule

$$10 - V_{D_1} - V_{48\Omega} - V_{D_3} = 0$$

$$10 - 0.7 - V_{48\Omega} - 0.7 = 0$$

$$10 - 1.4 - V_{48\Omega} = 0$$

$$8.6 - V_{48\Omega} = 0$$

$$V_{48\Omega} = 8.6\ V$$

The total resistance in the circuit includes the series resistance from the diodes

The total resistance is

$$R_{total} = R_{D_1} + R_{48\Omega} + R_{D_3}$$

$$R_{total} = 1 + 48 + 1$$

$$R_{total} = 50\ \Omega$$

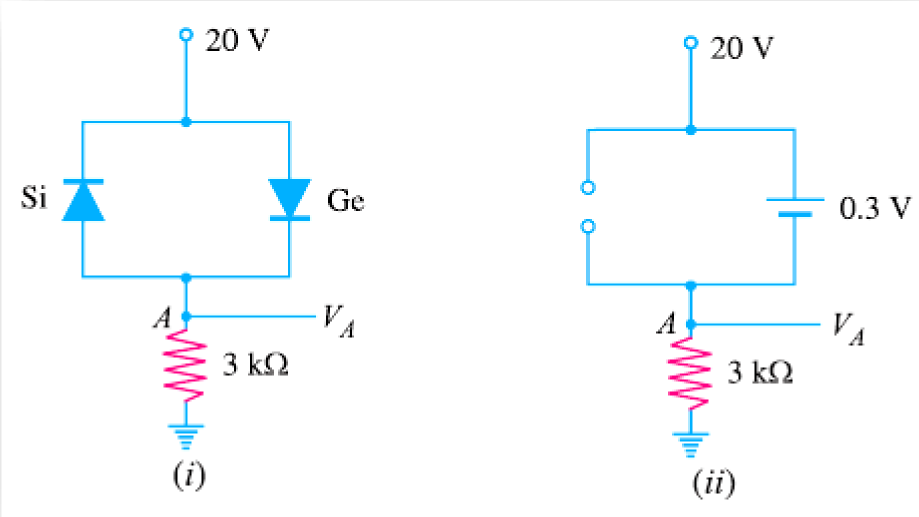
We calculate the current **I** through the circuit

$$I = \frac{V_{48\Omega}}{R_{total}}$$

$$I = \frac{8.6}{50}$$

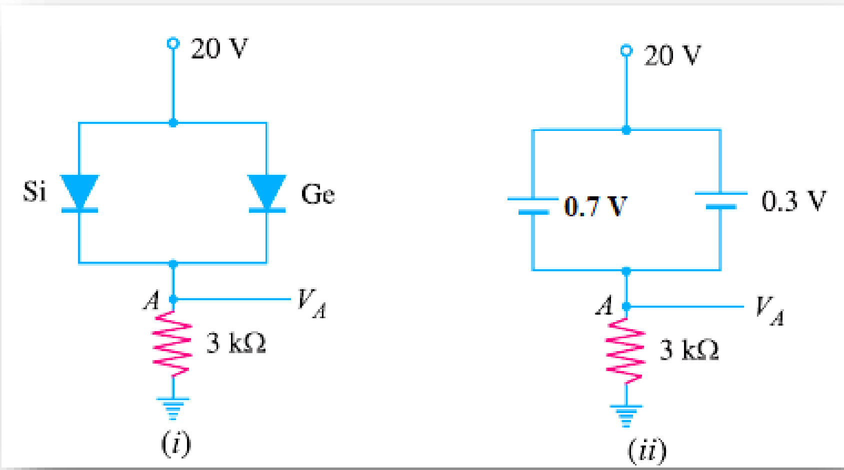
$$I = 0.172\ A$$

4. Find the voltage VA in the circuit shown in Fig.(i). Use a simplified model.



Data: The voltage V_{source}=20 V Silicon (Si) Diode: reverse voltage drop approximately 0.7V . when non-conducting Germanium (Ge) Diode: Forward voltage drop is approximately 0.3 V when conducting.	**Using Kirchhoff's voltage rule** $20 - V_{Ge} - V_A = 0$ $20 - 0.3 - V_A = 0$ $19.7 - V_A = 0$ $V_A = 19.7\ V$

4(a). Find the voltage VA in the circuit shown in Fig.(i). Use a simplified model.



Data: The voltage V_{source}=20 V Silicon (Si) Diode: Forward voltage drop is approximately 0.7 V when conducting. Germanium (Ge) Diode: Forward voltage drop is approximately 0.3 V when conducting.	**Using Kirchhoff's voltage rule** $20 - V_{Ge} - V_{Ge} - V_A = 0$ $20 - 0.3 - 0.7 - V_A = 0$ $20 - 1.0 - V_A = 0$ $19.0 - V_A = 0$ $V_A = 19.0\,V$

5. In a common base connection, I_E = 1 mA, I_C = 0.95 mA. Calculate the value of I_B.

Data: $I_E = 1\,mA = 1\times 10^{-3}A$ $I_C = 0.95\,mA = 0.95\times 10^{-3}A$ $I_B = ?$	**SOLUTIONS** The total emitter current I_E is the sum of the collector current I_C and base current I_B $I_E = I_C + I_B$ $1\times 10^{-3} = 0.95\times 10^{-3} + I_B$ $1\times 10^{-3} - 0.95\times 10^{-3} = I_B$ $0.05\times 10^{-3} = I_B$ $0.05\,m\,A = I_B$

6. Find the value of β if (i) $\alpha = 0.90$ (ii)) $\alpha = 0.98$ (iii)) $\alpha = 0.99$.

β is given by the following formula: $\beta = \frac{\alpha}{1-\alpha} \ldots\ldots(i)$ We can substitute the value of $\alpha = 0.90$ In equation (i) $\beta = \frac{0.90}{1-0.90}$ $\beta = \frac{0.90}{0.10}$ $\beta = 9$	We can substitute the value of $\alpha = 0.98$ In equation (i) $\beta = \frac{0.98}{1-0.98}$ $\beta = \frac{0.98}{0.02} = 49$ We can substitute the value of $\alpha = 0.99$ In equation (i) $\beta = \frac{0.99}{1-0.99}$ $\beta = \frac{0.98}{0.01} = 98$

7. Calculate I_E in a transistor for which β = 50 and I_B = 20 μA.

DATA

$\beta = 50$

$I_B = 20\ \mu A = 20 \times 10^{-6}\ A$

$I_E = ?$

The collector current I_C is given by:

$I_C = \beta \times I_B$

$I_C = 50 \times 20 \times 10^{-6}$

$I_C = 1000 \times 10^{-6} = 1\ mA$

The emitter current I_E is given by:

$I_E = I_C + I_B$

$I_E = 1000 \times 10^{-6} + 20 \times 10^{-6}$

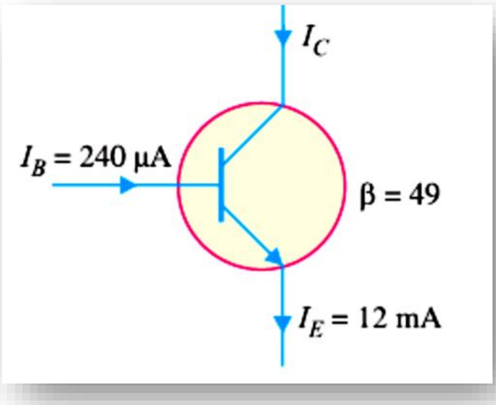
$I_E = 1020 \times 10^{-6}$

$I_E = 1.020 \times 10^{3} \times 10^{-6}$

$I_E = 1.020 \times 10^{-3}$

$I_E = 1.020\ mA$

8. Find the rating of α The transistor shown in Fig. Hence, determine the value of I_C using both α and the β rating of the transistor.



DATA

$\beta = 49$

$I_B = 240\ \mu A = 20 \times 10^{-6}\ A$

$I_E = 12\ mA$

Using the relationship between α and β

$$\alpha = \frac{\beta}{\beta + 1}$$

$$\alpha = \frac{49}{49 + 1}$$

$$\alpha = \frac{49}{50} = 0.98$$

The emitter current I_C is given by:

$I_C = \beta \times I_B$

$I_C = 49 \times 240 \times 10^{-6}$

$I_C = 11760 \times 10^{-6}$

$I_C = 11.76 \times 10^{3} \times 10^{-6}$

$I_C = 11.76 \times 10^{-3}$

$I_C = 11.76 \times m\ A$