

Assignment 3 - Solutions.

①(a) Determine the thermal voltage ( $V_T$ ) at  $25^\circ\text{C}$ .

$$T_K = T_C + 273 = 25 + 273 = 298\text{K}$$

$$V_T = \frac{kT}{q} \quad (k = 1.38 \times 10^{-23} \text{ J/K}, q = 1.6 \times 10^{-19} \text{ C})$$

$$V_T = \frac{(1.38 \times 10^{-23} \text{ J/K})(298\text{K})}{(1.6 \times 10^{-19} \text{ C})} \approx 25.69 \text{ mV} //$$

(b).  $I_D$ . ?

$$I_S = 40\text{nA} , n = 2 , V_D = 0.5\text{V} , V_T = 25.69\text{mV}$$

$$I_D = I_S (e^{V_D/nV_T} - 1)$$

$$I_D = 40\text{nA} (e^{0.5/2(25.69)} - 1) = 40\text{nA} (e^{0.73} - 1) \approx 40\text{nA} (16813)$$

$$I_D = 0.673\text{mA} //$$

②(a).  $E = 30\text{V}$

$$R = 1.5\text{k}\Omega$$

$$V_D = 0.7\text{V}$$

$$V_R = E - V_D$$

$$V_R = 30\text{V} - 0.7\text{V}$$

$$V_R = 29.3\text{V}$$

$$I_D = \frac{V_R}{R} = \frac{29.3\text{V}}{1.5\text{k}\Omega}$$

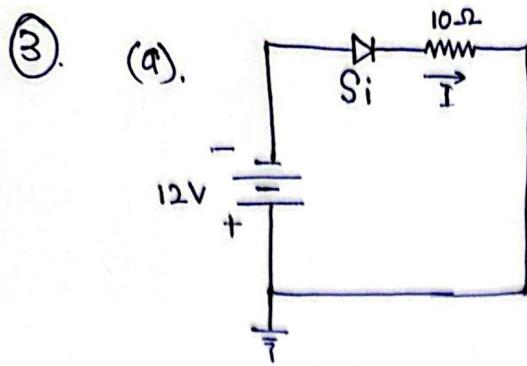
$$I_D = 19.53\text{mA} //$$

(b).  $V_D = 0\text{V}$

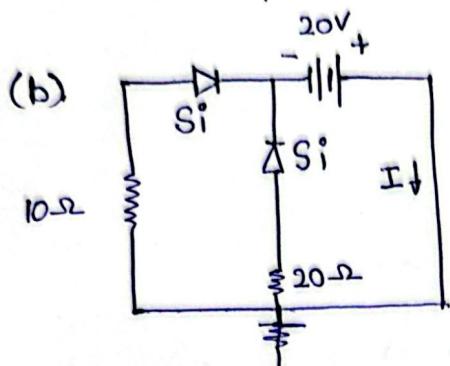
$$V_R = E = 30\text{V}$$

$$I_D = \frac{30\text{V}}{1.5\text{k}\Omega} = 20\text{mA} //$$

(c). Yes, the ideal model is a good approximation here because the source voltage (30V) is much larger than the diode drop (0.7V), leading to only a 2.35% difference in current.



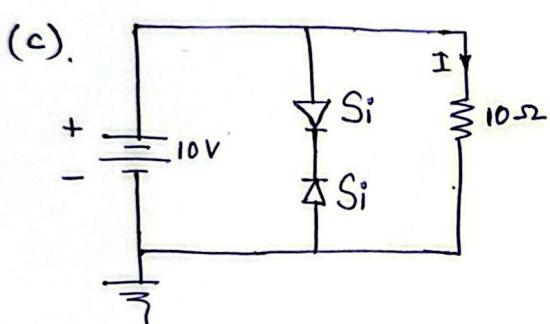
In here positive terminal of 12V source connected to n-side, so the diode is reverse biased.  $\therefore I = 0 \text{ A} //.$



Both diodes are forward-biased, the 20V source is the primary driver.

the path through the Si diode to the right has a total voltage of  $20V - 0.7V = 19.3V$

$$I = \frac{19.3V}{20\Omega} = 0.965 \text{ A} //.$$



Top diode is reverse biased,  $I = \frac{10V}{10\Omega} = 1 \text{ A} //.$

- ④ (a). The Si diode and GaAs diode are parallel. The Si diode will turn on first and 'Clamp' the voltage, preventing the GaAs diode from conducting.

$$V_o = 1V - 0.7V = 0.3V$$

$$I = \frac{V_o}{R} = \frac{0.3V}{1k\Omega} = 0.3 \text{ mA}.$$

- (b). Total diode drop =  $0.7V + 0.7V = 1.4V$ .

Total voltage across the circuit =  $16V - (-4V) = 20V$ .

$$V_o = 16V - 1.4V = 14.6V$$

$$I = \frac{V_o - (-4V)}{4.7k\Omega} = \frac{14.6V + 4V}{4.7k\Omega} = \frac{18.6V}{4.7k\Omega} = 3.96mA //.$$