Solutions to Tutorial Sheet-9

1. $I_D = I_s\left[\exp\left(\frac{V_D}{V_T}\right)-1\right] = 200\times10^{-9}\left[\exp\left(\frac{0.1}{0.026}\right)-1\right] = \mathbf{9.1625\ \mu A}$

2. (a) V_{DD} = 5 V, I = 5 mA, V_T = 0.7 V; $V_R = V_{DD} - V_T$ = 5 – 0.7 = 4.3 V

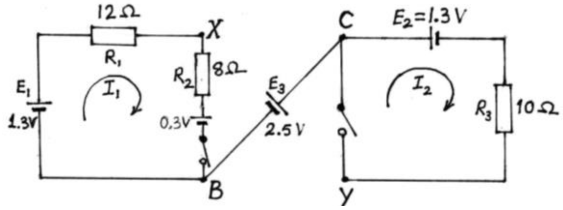
$\therefore\quad R = \frac{V_R}{I} = \frac{4.3}{5\times10^{-3}} = \mathbf{860\Omega}$

(b) $V_R = V_{DD} - V_T$ = 6 – 0.7 = 5.3 V; $\therefore\ R = \frac{5.3}{5\times10^{-3}} = 1060\,\Omega$

Power dissipated in resistance $R = I^2R = \left(5\times10^{-3}\right)^2\times1060$ = **26.5 mW**

Power dissipated in the diode $= IV_T = 5\times10^{-3}\times0.7 = \mathbf{3.5\ mW}$

3. Equivalent circuit is shown in figure.



Since diode D1 is forward biased (0.3 V < 1.3 V), it is replaced by a closed switch and a battery of 0.3 V. Diode D2 is reverse-biased, it is replaced by an open switch. Therefore, $I_2 = 0$. Now,

$I_1 = \frac{1.3-0.3}{8+12} = 0.05\,\text{A}$; $V_{XB} = V_{XA} + V_{AB} = I_1R_2 + V_{AB} = 0.05\times8 + 0.3 = 0.4 + 0.3 = 0.7\,\text{V}$

Now, $V_{CY} = I_2R_3 + E_2 = 0\times10 + 1.3 = 1.3$ V; $\therefore\quad V_{XY} = V_{XB} + V_{BC} + V_{CY} = 0.7 - 2.5 + 1.3 = -\mathbf{0.5V}$

4. Diodes are forward biased and hence each diode can be replaced by a resistance of 10 **Ω** and a battery of 0.6 V.

$I_D = \frac{5-0.6-0.6}{100+10+10} = \frac{5-1.2}{120} = \mathbf{31.667\,mA}$;

$V_D = I_D\left(r_f + r_f\right) + V_T + V_T = 31.667\times10^{-3}(10+10) + 0.6 + 0.6 = \mathbf{1.833V}$; $V_o = I_D\times100 = \mathbf{3.167V}$

5. Diode is reverse-biased, and hence it is an open-circuit. Hence,

Net resistance $= \left[8 + \left(\frac{6\times3}{6+3}\right)\right] = 10\ \Omega$; $\therefore\ I = \frac{15}{10} = 1.5$ A; $\therefore\ I_1 = 1.5\left(\frac{6}{6+3}\right) = \mathbf{1\ A}$

6. The diode is now forward-biased and therefore it behaves as a short-circuit. Hence, the current through 3 **Ω** resistor is **zero**.

7. $I = \frac{1-0.3}{20+8} = \frac{0.7}{28} = \mathbf{25\ mA}$

8. Diode D2 is reversed biased, hence it will not conduct. Assume that the diode D1 is removed.

$\therefore\ V_B = \left(\frac{100}{100+50}\right)7.5\text{ V} = 7.5\left(\frac{2}{3}\right)$ V and $V_D = \left(\frac{300}{300+150}\right)7.5\text{ V} = 7.5\left(\frac{2}{3}\right)$ V

Since $V_B \approx V_D$, the diode D_1 also does not conduct. $\therefore\ I_2 = \frac{7.5}{150+300} = \frac{7.5}{450} = \mathbf{16.66\,mA}$

9. (a) When V_i = 0 V, all diodes are likely to be forward-biased. Conduction through diode D1 brings the point A to 0.6 V. For the diodes D2, D3 and D4 to conduct, the minimum voltage required at point A is 0.6 V + 0.6 V + 0.6 V = 1.8 V. Since V_A = 0.6 V, these diodes do not conduct. So, these can be treated as open-circuit. Therefore, V_o = **0.6 V.**

$\therefore\ I = \frac{10-0.6}{2\times10^3} = \mathbf{4.7\,mA}$

(b) When V_i = 2 V, the diodes D2, D3 and D4 conduct. This makes the voltage at point A as V_A = 0.6 + 0.6 + 0.6 = 1.8 V. This makes the diode D1 reverse-biased and hence it cannot conduct.

$\therefore\quad V_o$ = **1.8 V** and $I = \frac{10-1.8}{2\times10^3} = \frac{8.2}{2} = \mathbf{4.1\,mA}$