Short circuit worksheet solutions

Q1ai $V_{PX} = 0.20 \times 0.050 = 0.010\,\text{V}$

Q1aii $V_{YQ} = 0.20 \times 0.050 = 0.010\,\text{V}$

Q1b Voltage drop due to internal resistance of the battery $= 0.20 \times 0.10 = 0.02\,\text{V}$

$\therefore V_{XY} = 12.0 - 0.010 - 0.010 - 0.02 = 11.96\,\text{V}$

Q1c $V_{XY} = 0\,\text{V}$

Q1d $I = \dfrac{emf}{R_T} = \dfrac{12.0}{0.050 + 0.050 + 0.10} = \dfrac{12.0}{0.20} = 60\,\text{A}$

Q1e Voltage drop due to internal resistance of the battery $= 60 \times 0.10 = 6.0\,\text{V}$

$\therefore V_{PQ} = 12.0 - 6.0 = 6.0\,\text{V}$

Q2a $V_P = V_Q = 240\,\text{V},\ V_A = V_B = V_C = V_D = V_E = V_X = V_Y = V_Z = 0\,\text{V}$

Q2b $V_{PA} = 240\,\text{V},\ V_{PQ} = 0\,\text{V},\ V_{QX} = 240\,\text{V},\ V_{PD} = 240\,\text{V},\ V_{AE} = 0\,\text{V}$

Q2c $V_P = V_Q = V_X = V_Y = V_Z = 240\,\text{V},\ V_A = V_B = V_C = V_D = V_E = 0\,\text{V}$

Q2d $V_{PA} = 240\,\text{V},\ V_{PQ} = 0\,\text{V},\ V_{QX} = 0\,\text{V},\ V_{PD} = 240\,\text{V},\ V_{AE} = 0\,\text{V}$

Q2e It means a 'zero'-resistance alternative path for current to flow between points *Y* and *D* instead of through light L_2. This can be caused by *Y* and *D* coming in contact, or a 'zero'-resistance wire connecting *Y* and *D*.

Q2f After the fuse is blown, $V_A = V_B = V_C = V_D = V_E = V_P = V_Q = V_X = V_Y = V_Z = 0$.

Q3a $R_1 = \dfrac{12^2}{40} = 3.6\Omega,\ R_2 = \dfrac{12^2}{20} = 7.2\Omega,\ R_3 = \dfrac{12^2}{10} = 14.4\Omega,\ R_4 = \dfrac{12^2}{5} = 28.8\Omega$

Q3b $I_1 = I_3 = \dfrac{V_{AC}}{R_1 + R_3} = \dfrac{18 - 3}{3.6 + 14.4} = \dfrac{5}{6}\,\text{A},\ \therefore V_1 = I_1 R_1 = \dfrac{5}{6} \times 3.6 = 3.0\,\text{V},\ V_3 = I_3 R_3 = \dfrac{5}{6} \times 14.4 = 12\,\text{V}$

$I_2 = I_4 = \dfrac{V_{XZ}}{R_2 + R_4} = \dfrac{18 - 3}{7.2 + 28.8} = \dfrac{5}{12}\,\text{A},\ \therefore V_2 = I_2 R_2 = \dfrac{5}{12} \times 7.2 = 3.0\,\text{V},\ V_4 = I_4 R_4 = \dfrac{5}{12} \times 28.8 = 12\,\text{V}$

$\therefore$ both L_3 and L_4 operate at maximum power, $P_3 = 10\,\text{W},\ P_4 = 5W$

For L_1, $P_1 = V_1 I_1 = 3.0 \times \dfrac{5}{6} = 2.5\,\text{W}$, for L_2, $P_2 = V_2 I_2 = 3.0 \times \dfrac{5}{12} = 1.25\,\text{W}$

$\therefore$ L_3 is the brightest.

Q3c $V_B = 18 - 12 = 6\,\text{V},\ V_Y = 18 - 12 = 6\,\text{V},\ \therefore$ points *B* and *Y* are at the same potential, and a short between *B* and *Y* does not affect the circuit. Hence L_1, L_2, L_3 and L_4 remain alight.

Q3d $V_{BC} = 0\,\text{V}$ and L_3 goes off. $\therefore V_{AB} = 18 - 3 = 15\,\text{V}$, which is higher than the 12V-rating of L_1. This causes the filament to blow and L_1 goes off. L_2 and L_4 are not affected by the short.

Q3e $V_{AY} = V_{XY} = 0\,\text{V}$ and L_2 goes off. $\therefore V_{YZ} = 18 - 3 = 15\,\text{V}$, which is higher than the 12V-rating of L_4. This causes the filament to blow and L_4 goes off. L_1 and L_3 are not affected by the short.

