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a. Calculate the resistance of E and H for the circuit's configuration. [3]

$$V = IR \text{ so } R = V / I$$

$$6V - 0.6V \text{ potential barrier for diode E} = 5.4V$$

$$6V - 0.7V \text{ potential barrier for diode H} = 5.3V$$

$$\text{Circuit current} = 1 \text{ Amp so } 1A / 2 = 0.5 \text{ Amps for each diode}$$

$$\text{Resistance of E} = 5.4V / 0.5A = 10.8 \Omega$$

$$\text{Resistance of H} = 5.3V / 0.5A = 10.6 \Omega$$

b. B and C are identical and the current passing through A is 0.5A, calculate the current passing through B and C. [2]

$$I_1 + I_2 + I_3 + I_4 = 0$$

$$I_1 = +1A$$

$$I_2 = -0.5A \text{ due to leaving junction}$$

$$I_3 \text{ and } I_4 = \text{identical resistors}$$

$$1A - 0.5A + I_3 + I_4 = 0$$

$$\text{So, } 0.5 = I_3 + I_4$$

$$I_3 = 0.5A / 2 = 0.25A \text{ is the current passing through B.}$$

$$I_4 = 0.5A / 2 = 0.25A \text{ is the current passing through C.}$$

c (i) The Resistance of A. [2]

$$P = I^2 * R$$

$$R = P / I^2$$

The energy of resistor A = 1.25 J per second which is equal to 1.25 Watt of power.

Current of resistor A = 0.5 A

$$R = 1.25 \text{ W} / 0.5 \text{ A}^2 = 5 \Omega$$

c (ii) The Resistance of B and C [3]

$$V = IR$$

$$R = V / I$$

$$\text{Resistance of B} = 6\text{V} / 0.25 \text{ A} = 24 \Omega$$

$$\text{Resistance of C} = 6\text{V} / 0.25 \text{ A} = 24 \Omega$$

c (iii) The potential difference across A, B and C [1]

Resistor A = 6 V

Resistor B = 6 V

Resistor C = 6 V

The voltage of all resistors in parallel are the same.

c (iv) Since the total potential difference across L to M is 6V, calculate the potential difference across D and find its Resistance. [2]

$$V_{\text{series}} = \text{Voltage of B} + \text{Voltage of D}$$

$$\text{Voltage of D} = V_{\text{series}} - \text{Voltage B}$$

$$\text{Voltage of D} = 6\text{V} - 6\text{V} = 0 \text{ V so has no voltage drop so voltage of D} = 6\text{V}$$

$$\text{Resistance of parallel configuration of A, B and C} = 1 / (1/A + 1/B + 1/C)$$

$$\text{Resistance of parallel} = 1/6\Omega + 1/24\Omega + 1/24\Omega = 1/0.283\Omega = 3.53\Omega$$

$$\text{Resistance of series} = \text{Voltage total} / \text{Current total}$$

$$R_{\text{series}} = 6\text{V} / 1\text{ A} = 6\ \Omega$$

$$\text{Resistance of D} = R_{\text{series}} - R_{\text{parallel}}$$

$$\text{Resistance of D} = 6\ \Omega - 3.53\ \Omega = 2.47\ \Omega$$

d. The 'lost volts across one of the cells in the parallel arrangement is 2 V. Calculate r and hence the total resistance of the parallel combination of cells. [3]

$$\text{Voltage lost over one cell} = 2\text{ V}$$

$$\text{Circuit current} = 2\text{ A}$$

$$\text{Current of one cell} = 2\text{ A} / 4 = 0.25\text{ A}$$

$$V_{\text{drop}} = IR$$

$$R = V_{\text{drop}} / I$$

$$\text{Resistance } r = (6\text{V} - 2\text{V}) / 0.25\text{ A} = 16\ \Omega \text{ of each cell}$$

$$\text{Total resistance of parallel combination} = 1 / (1/16\Omega + 1/16\Omega + 1/16\Omega + 1/16\Omega) = 4\ \Omega$$

e. Given that the resistance F is 6Ω , calculate the voltage drop across it. [2]

Resistor F has a resistance of $6\ \Omega$ and current of 1 A due to reverse bias diode in parallel not impacting current.

$$V = IR = 6\Omega * 1\text{ A} = 6\text{ V}$$

f. Calculate the total resistance of the circuit; this includes total internal and the resistance cause by the reverse polarity battery and the open diodes in given scenario (ignore any “non-open diodes”). [2]

Combination of four identical cells = 2Ω

Resistor f = 6Ω

Diodes E and H total resistance = $1 / (1/5.3\Omega + 1/5.4\Omega) = 2.7\Omega$

Resistor D = 2.47Ω

Resistors A, B and C total resistance = $1 / (1/5\Omega + 1/24\Omega + 1/24\Omega) = 3.53\Omega$

Total resistance of 4 reversed batteries:

= $6V / 0.25 A = 24\Omega$ each

= $1 / (1/24 + 1/24 + 1/24 + 1/24) = 6\Omega$

Total circuit resistance = $4\Omega + 6\Omega + 2.7\Omega + 2.47\Omega + 3.53\Omega + 6\Omega = 24.7\Omega$

g. Calculate the emf of each of the cells in the parallel combination. [3]

Emf = $R * I + V$

Resistance of each cell = 16Ω

Current of cell = $0.25 A$

Voltage of cell = $6V$

Emf of each cell = $16\Omega * 0.25 A + 6V = 10 V$

Emf of each cell with voltage drop = $10V - 2 V = 8 V$