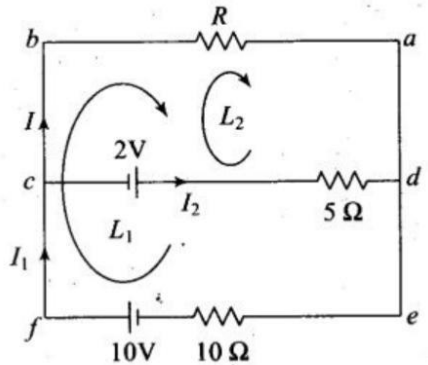
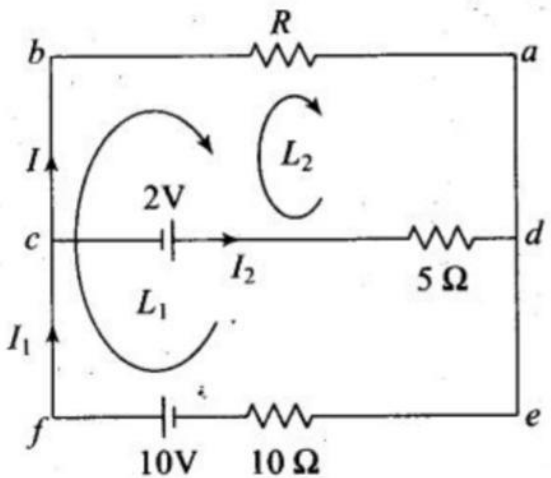
Q. 04 Two cells of voltage 10 V and 2 V, and internal resistances 10 Ω and 5 Ω respectively, are connected in parallel with the positive end of 10 V battery connected to negative pole of 2 V battery (figure). Find the effective voltage and effective resistance of the combination.



Solution:

In this problem first we are applying Kirchhoff's junction rule at c, $I_1 = I + I_2$



Applying Kirchhoff's voltage law in loop (e-f -b-a-e) loop L_1 outer loop, then we get

$$10 - IR - 10I_1 = 0$$

$$10 = IR + 10I_1 \qquad \ldots(i)$$

Applying Kirchhoff voltage law in loop (c-b-a-d-c) loop L_2,we get

$$-2 - IR + 5I_2 = 0$$

$$2 = 5I_2 - RI$$

As we know, $I_1 = I + I_2$ then

$$I_2 = I_1 - I$$

So the above equation can be written as

$$2 = 5(I_1 - I) - RI$$

or $4 = 10I_1 - 10I - 2RI$ ...(ii)

Subtracting Eqs. (ii) from (i), we get

$\Rightarrow$ $6 = 3RI + 10I$

$$2 = I\left(R + \frac{10}{3}\right)$$

Also, the external resistance is R. The Ohm's law states that

$$V = I(R + R_{\text{eff}})$$

On comparing, we have $V = 2$ V and effective internal resistance

$$(R_{\text{eff}}) = \left(\frac{10}{3}\right)\Omega$$

Since, the equivalent internal resistance (R_{eff}) of two cells is $\left(\frac{10}{3}\right)\Omega$, being the parallel combination of 5Ω and 10 Ω. *The equivalent circuit is given below:*