Consider two resistors R_1 and R_2 in series. The charge which leaves R_1 must be entering R_2. Since current measures the rate of flow of charge, this means that the same current I flows through R_1 and R_2. By Ohm's law:

Potential difference across $R_1 = V_1 = I R_1$, and

Potential difference across $R_2 = V_2 = I R_2$.

The potential difference V across the combination is V_1+V_2. Hence,

$$V = V_1 + V_2 = I (R_1 + R_2) \tag{3.36}$$

This is as if the combination had an equivalent resistance R_{eq}, which by Ohm's law is

$$R_{eq} \equiv \frac{V}{I} = (R_1 + R_2) \tag{3.37}$$

If we had three resistors connected in series, then similarly

$$V = I R_1 + I R_2 + I R_3 = I (R_1 + R_2 + R_3). \tag{3.38}$$

This obviously can be extended to a series combination of any number n of resistors R_1, R_2 ....., R_n. The equivalent resistance R_{eq} is

$$R_{eq} = R_1 + R_2 + \ldots + R_n \tag{3.39}$$

Consider now the parallel combination of two resistors (Fig. 3.15). The charge that flows in at A from the left flows out partly through R_1 and partly through R_2. The currents I, I_1, I_2 shown in the figure are the rates of flow of charge at the points indicated. Hence,

$$I = I_1 + I_2 \tag{3.40}$$

The potential difference between A and B is given by the Ohm's law applied to R_1

$$V = I_1 R_1 \tag{3.41}$$

Also, Ohm's law applied to R_2 gives

$$V = I_2 R_2 \tag{3.42}$$

$$\therefore\ I = I_1 + I_2 = \frac{V}{R_1} + \frac{V}{R_2} = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right) \tag{3.43}$$

If the combination was replaced by an equivalent resistance R_{eq}, we would have, by Ohm's law

$$I = \frac{V}{R_{eq}} \tag{3.44}$$

Hence,

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \tag{3.45}$$

We can easily see how this extends to three resistors in parallel (Fig. 3.16).

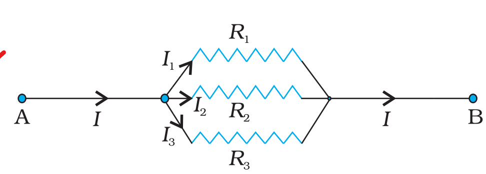

FIGURE 3.16 Parallel combination of three resistors R_1, R_2 and R_3.