23. Let i_1 be the current in R_1 and take it to be positive if it is to the right. Let i_2 be the current in R_2 and take it to be positive if it is upward.

(a) When the loop rule is applied to the lower loop, the result is

$$\varepsilon_2 - i_1 R_1 = 0 .$$

The equation yields

$$i_1 = \frac{\varepsilon_2}{R_1} = \frac{5.0 \text{ V}}{100 \Omega} = 0.050 \text{ A}.$$

(b) When it is applied to the upper loop, the result is

$$\varepsilon_1 - \varepsilon_2 - \varepsilon_3 - i_2 R_2 = 0 .$$

The equation gives

$$i_2 = \frac{\varepsilon_1 - \varepsilon_2 - \varepsilon_3}{R_2} = \frac{6.0 \text{ V} - 5.0 \text{ V} - 4.0 \text{ V}}{50 \Omega} = -0.060 \text{ A} ,$$

or $|i_2| = 0.060$ A. The negative sign indicates that the current in R_2 is actually downward.

(c) If V_b is the potential at point b, then the potential at point a is $V_a = V_b + \varepsilon_3 + \varepsilon_2$, so

$$V_a - V_b = \varepsilon_3 + \varepsilon_2 = 4.0 \text{ V} + 5.0 \text{ V} = 9.0 \text{ V}.$$

27. Since the potential differences across the two paths are the same, $V_1 = V_2$ (V_1 for the left path, and V_2 for the right path), we have $i_1 R_1 = i_2 R_2$, where $i = i_1 + i_2 = 5000$ A. With $R = \rho L / A$ (see Eq. 26-16), the above equation can be rewritten as

$$i_1 d = i_2 h \quad \Rightarrow \quad i_2 = i_1 (d / h) .$$

With $d / h = 0.400$, we get $i_1 = 3571$ A and $i_2 = 1429$ A. Thus, the current through the person is $i_1 = 3571$ A, or approximately 3.6 kA.

29. (a) The parallel set of three identical $R_2 = 18\ \Omega$ resistors reduce to $R = 6.0\ \Omega$, which is now in series with the $R_1 = 6.0\ \Omega$ resistor at the top right, so that the total resistive load across the battery is $R' = R_1 + R = 12\ \Omega$. Thus, the current through R' is (12V)/R' = 1.0 A, which is the current through R. By symmetry, we see one-third of that passes through any one of those 18 Ω resistors; therefore, $i_1 = 0.333$ A.

(b) The direction of i_1 is clearly rightward.

(c) We use Eq. 26-27: $P = i^2R' = (1.0 \text{ A})^2(12\ \Omega) = 12$ W. Thus, in 60 s, the energy dissipated is (12 J/s)(60 s) = 720 J.

30. Using the junction rule ($i_3 = i_1 + i_2$) we write two loop rule equations:

$$10.0 \text{ V} - i_1R_1 - (i_1 + i_2)\, R_3 = 0$$

$$5.00 \text{ V} - i_2R_2 - (i_1 + i_2)\, R_3 = 0.$$

(a) Solving, we find $i_2 = 0$, and

(b) $i_3 = i_1 + i_2 = 1.25$ A (downward, as was assumed in writing the equations as we did).

33. First, we note in V_4, that the voltage across R_4 is equal to the sum of the voltages across R_5 and R_6:

$$V_4 = i_6(R_5 + R_6) = (1.40 \text{ A})(8.00\ \Omega + 4.00\ \Omega) = 16.8 \text{ V}.$$

The current through R_4 is then equal to $i_4 = V_4/R_4 = 16.8 \text{ V}/(16.0\ \Omega) = 1.05$ A.

By the junction rule, the current in R_2 is

$$i_2 = i_4 + i_6 = 1.05 \text{ A} + 1.40 \text{ A} = 2.45 \text{ A},$$

so its voltage is $V_2 = (2.00\ \Omega)(2.45 \text{ A}) = 4.90$ V.

The loop rule tells us the voltage across R_3 is $V_3 = V_2 + V_4 = 21.7$ V (implying that the current through it is $i_3 = V_3/(2.00\ \Omega) = 10.85$ A).

The junction rule now gives the current in R_1 as $i_1 = i_2 + i_3 = 2.45 \text{ A} + 10.85 \text{ A} = 13.3$ A, implying that the voltage across it is $V_1 = (13.3 \text{ A})(2.00\ \Omega) = 26.6$ V. Therefore, by the loop rule,

$$\varepsilon = V_1 + V_3 = 26.6 \text{ V} + 21.7 \text{ V} = 48.3 \text{ V}.$$

36. (a) Using the junction rule ($i_1 = i_2 + i_3$) we write two loop rule equations:

$$\varepsilon_1 - i_2R_2 - (i_2 + i_3)\, R_1 = 0$$
$$\varepsilon_2 - i_3R_3 - (i_2 + i_3)\, R_1 = 0.$$

Solving, we find $i_2 = 0.0109$ A (rightward, as was assumed in writing the equations as we did), $i_3 = 0.0273$ A (leftward), and $i_1 = i_2 + i_3 = 0.0382$ A (downward).

(b) The direction is downward. See the results in part (a).

(c) i_2 = 0.0109 A . See the results in part (a).

(d) The direction is rightward. See the results in part (a).

(e) i_3 = 0.0273 A. See the results in part (a).

(f) The direction is leftward. See the results in part (a).

(g) The voltage across R_1 equals V_A: (0.0382 A)(100 Ω) = +3.82 V.