Chapter 28 Problems

2,6,8,9,15,20,21,36,40

2.(a) What is the current in a 5.60-**Ω** resistor connected to a battery that has a 0.200-**Ω** internal resistance if the terminal voltage of the battery is 10.0 V? (b) What is the emf of the battery?

(a) $\Delta V_{\text{term}} = IR$

becomes $10.0\text{ V} = I(5.60\ \Omega)$

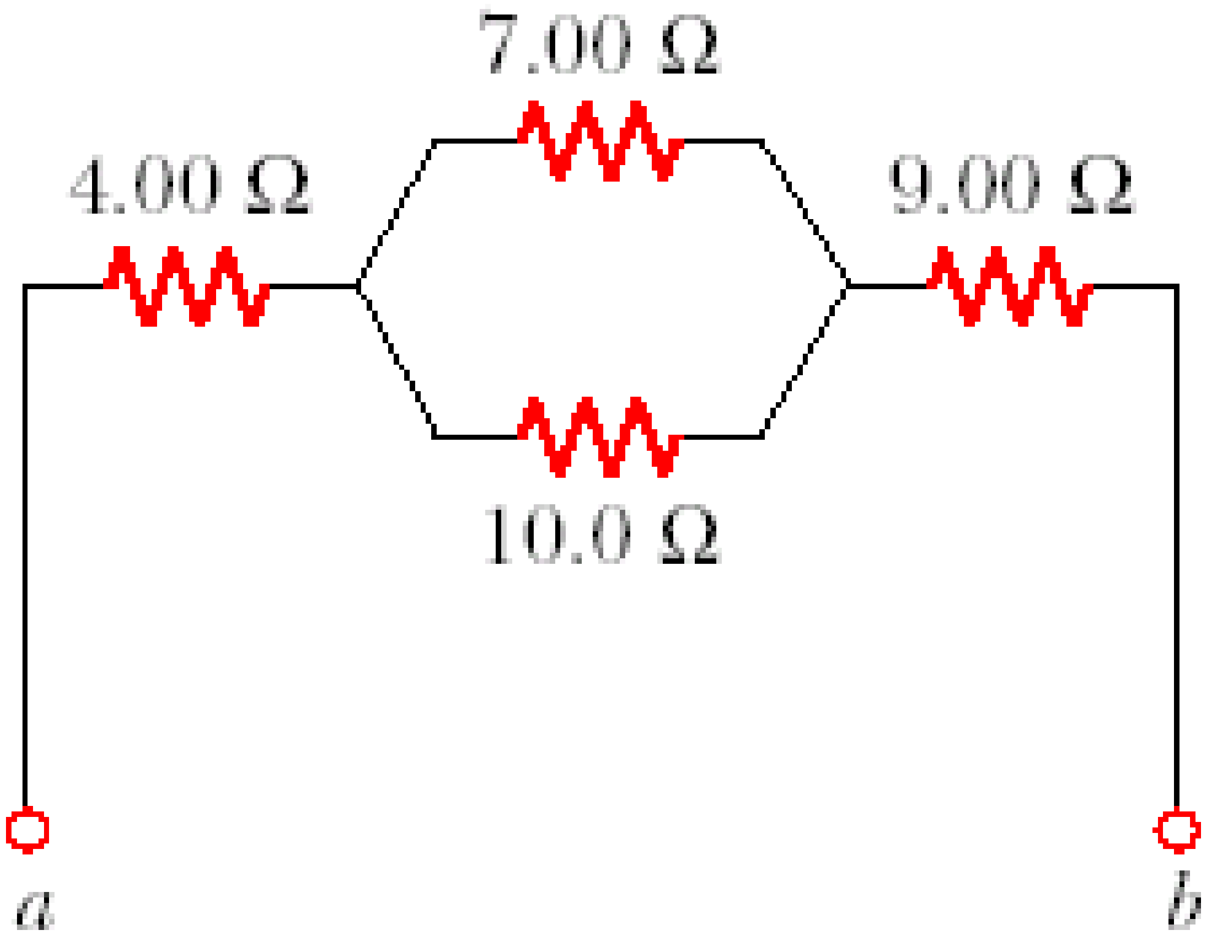
so $I = \boxed{1.79\text{ A}}$.

(b) $\Delta V_{\text{term}} = \varepsilon - Ir$

becomes $10.0\text{ V} = \varepsilon - (1.79\text{ A})(0.200\ \Omega)$

so $\varepsilon = \boxed{10.4\text{ V}}$.

6. (a) Find the equivalent resistance between points *a* and *b* in Figure P28.6. (b) A potential difference of 34.0 V is applied between points *a* and *b*. Calculate the current in each resistor.



(a) $$R_p = \frac{1}{(1/7.00\ \Omega) + (1/10.0\ \Omega)} = 4.12\ \Omega$$

$$R_s = R_1 + R_2 + R_3 = 4.00 + 4.12 + 9.00 = \boxed{17.1\ \Omega}$$

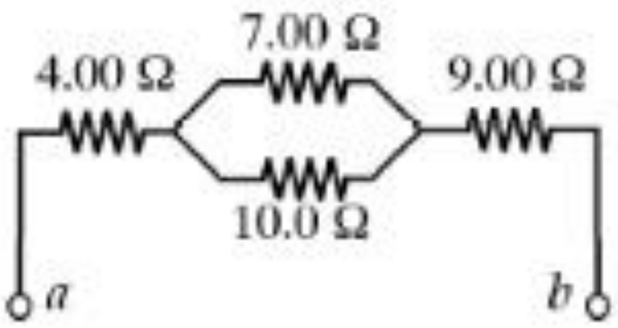


FIG. P28.6

(b) $\Delta V = IR$

$34.0\ \text{V} = I(17.1\ \Omega)$

$I = \boxed{1.99\ \text{A}}$ for 4.00 Ω, 9.00 Ω resistors.

Applying $\Delta V = IR$, $(1.99\ \text{A})(4.12\ \Omega) = 8.18\ \text{V}$

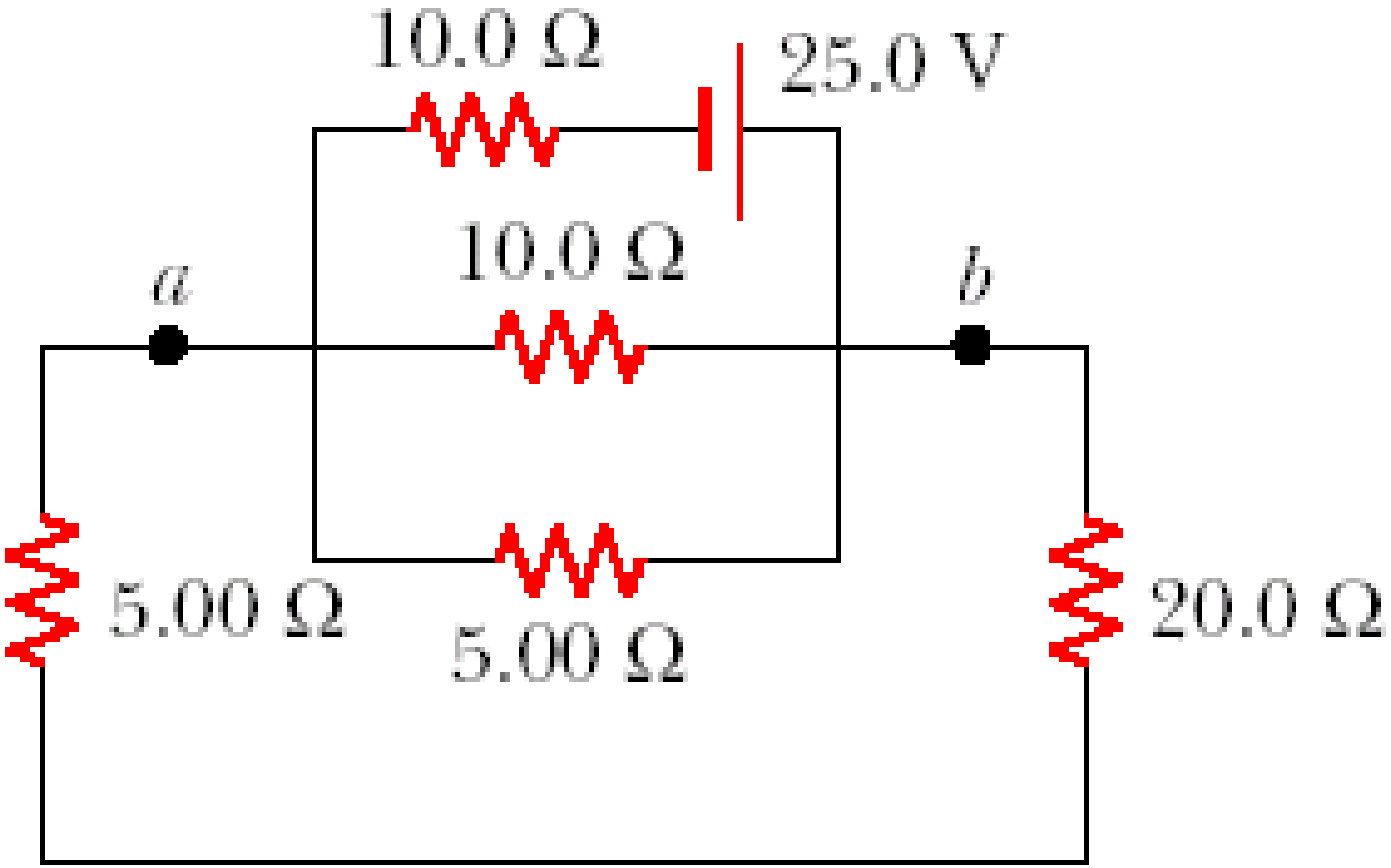
$8.18\ \text{V} = I(7.00\ \Omega)$

so $I = \boxed{1.17\ \text{A}}$ for 7.00 Ω resistor

$8.18\ \text{V} = I(10.0\ \Omega)$

so $I = \boxed{0.818\ \text{A}}$ for 10.0 Ω resistor.

9. Consider the circuit shown in Figure P28.9. Find (a) the current in the 20.0-**Ω** resistor and (b) the potential difference between points *a* and *b*.



If we turn the given diagram on its side, we find that it is the same as figure (a). The 20.0 Ω and 5.00 Ω resistors are in series, so the first reduction is shown in (b). In addition, since the 10.0 Ω, 5.00 Ω, and 25.0 Ω resistors are then in parallel, we can solve for their equivalent resistance as:

$$R_{eq} = \frac{1}{\left(\frac{1}{10.0\ \Omega} + \frac{1}{5.00\ \Omega} + \frac{1}{25.0\ \Omega}\right)} = 2.94\ \Omega.$$

This is shown in figure (c), which in turn reduces to the circuit shown in figure (d).

Next, we work backwards through the diagrams applying $I = \frac{\Delta V}{R}$ and $\Delta V = IR$ alternately to every resistor, real and equivalent. The 12.94 Ω resistor is connected across 25.0 V, so the current through the battery in every diagram is

$$I = \frac{\Delta V}{R} = \frac{25.0\ \text{V}}{12.94\ \Omega} = 1.93\ \text{A}.$$

In figure (c), this 1.93 A goes through the 2.94 Ω equivalent resistor to give a potential difference of:

$$\Delta V = IR = (1.93\ \text{A})(2.94\ \Omega) = 5.68\ \text{V}.$$

From figure (b), we see that this potential difference is the same across ΔV_{ab}, the 10 Ω resistor, and the 5.00 Ω resistor.

(b) Therefore, $\Delta V_{ab} = \boxed{5.68\ \text{V}}$.

(a) Since the current through the 20.0 Ω resistor is also the current through the 25.0 Ω line *ab*,

$$I = \frac{\Delta V_{ab}}{R_{ab}} = \frac{5.68\ \text{V}}{25.0\ \Omega} = 0.227\ \text{A} = \boxed{227\ \text{mA}}.$$

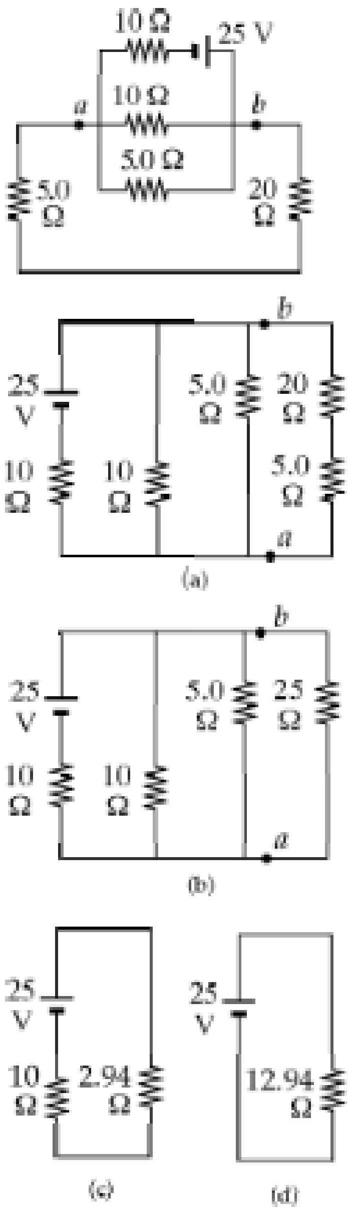
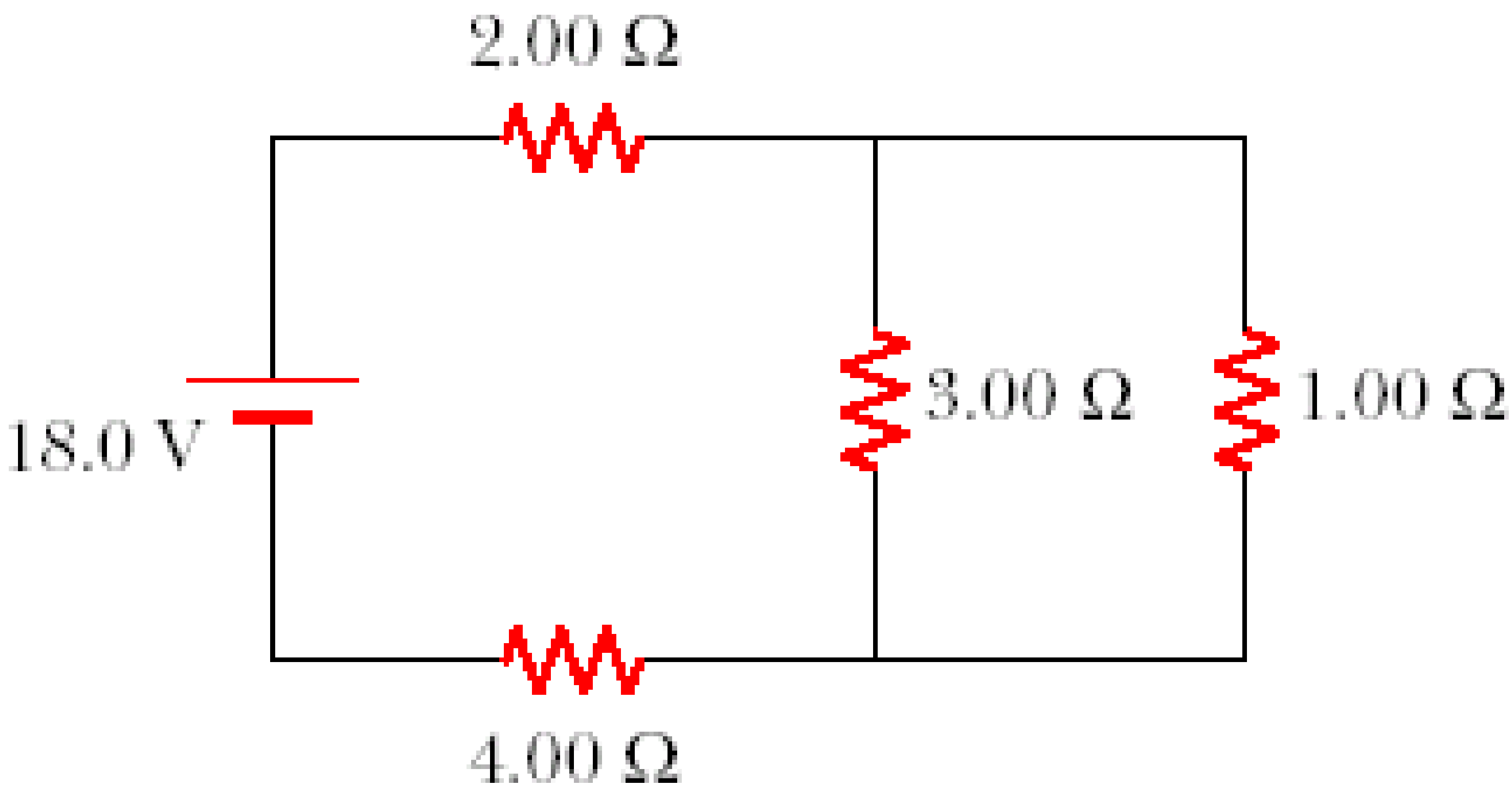


FIG. P28.9

15. Calculate the power delivered to each resistor in the circuit shown in Figure P28.15.



$$R_p = \left(\frac{1}{3.00} + \frac{1}{1.00} \right)^{-1} = 0.750\ \Omega$$

$$R_s = (2.00 + 0.750 + 4.00)\ \Omega = 6.75\ \Omega$$

$$I_{\text{battery}} = \frac{\Delta V}{R_s} = \frac{18.0\ \text{V}}{6.75\ \Omega} = 2.67\ \text{A}$$

$$\mathscr{P} = I^2 R: \qquad \mathscr{P}_2 = (2.67\ \text{A})^2 (2.00\ \Omega)$$

$$\mathscr{P}_2 = \boxed{14.2\ \text{W}} \text{ in } 2.00\ \Omega$$

$$\mathscr{P}_4 = (2.67\ \text{A})^2 (4.00\ \text{A}) = \boxed{28.4\ \text{W}} \text{ in } 4.00\ \Omega$$

$$\Delta V_2 = (2.67\ \text{A})(2.00\ \Omega) = 5.33\ \text{V},$$

$$\Delta V_4 = (2.67\ \text{A})(4.00\ \Omega) = 10.67\ \text{V}$$

$$\Delta V_p = 18.0\ \text{V} - \Delta V_2 - \Delta V_4 = 2.00\ \text{V} (= \Delta V_3 = \Delta V_1)$$

$$\mathscr{P}_3 = \frac{(\Delta V_3)^2}{R_3} = \frac{(2.00\ \text{V})^2}{3.00\ \Omega} = \boxed{1.33\ \text{W}} \text{ in } 3.00\ \Omega$$

$$\mathscr{P}_1 = \frac{(\Delta V_1)}{R_1} = \frac{(2.00\ \text{V})^2}{1.00\ \Omega} = \boxed{4.00\ \text{W}} \text{ in } 1.00\ \Omega$$

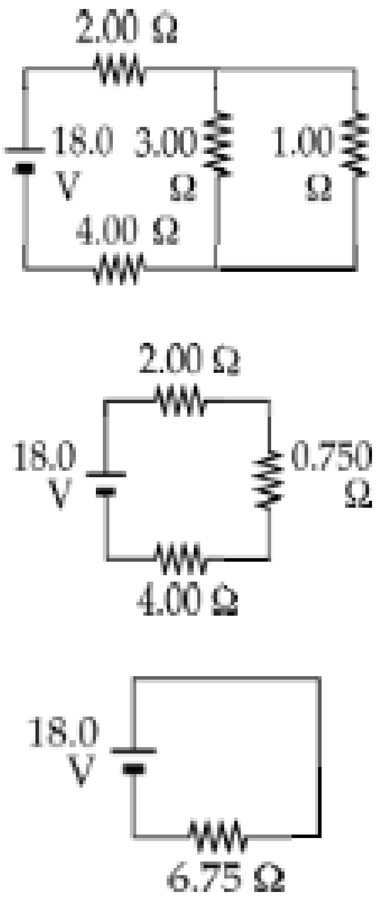
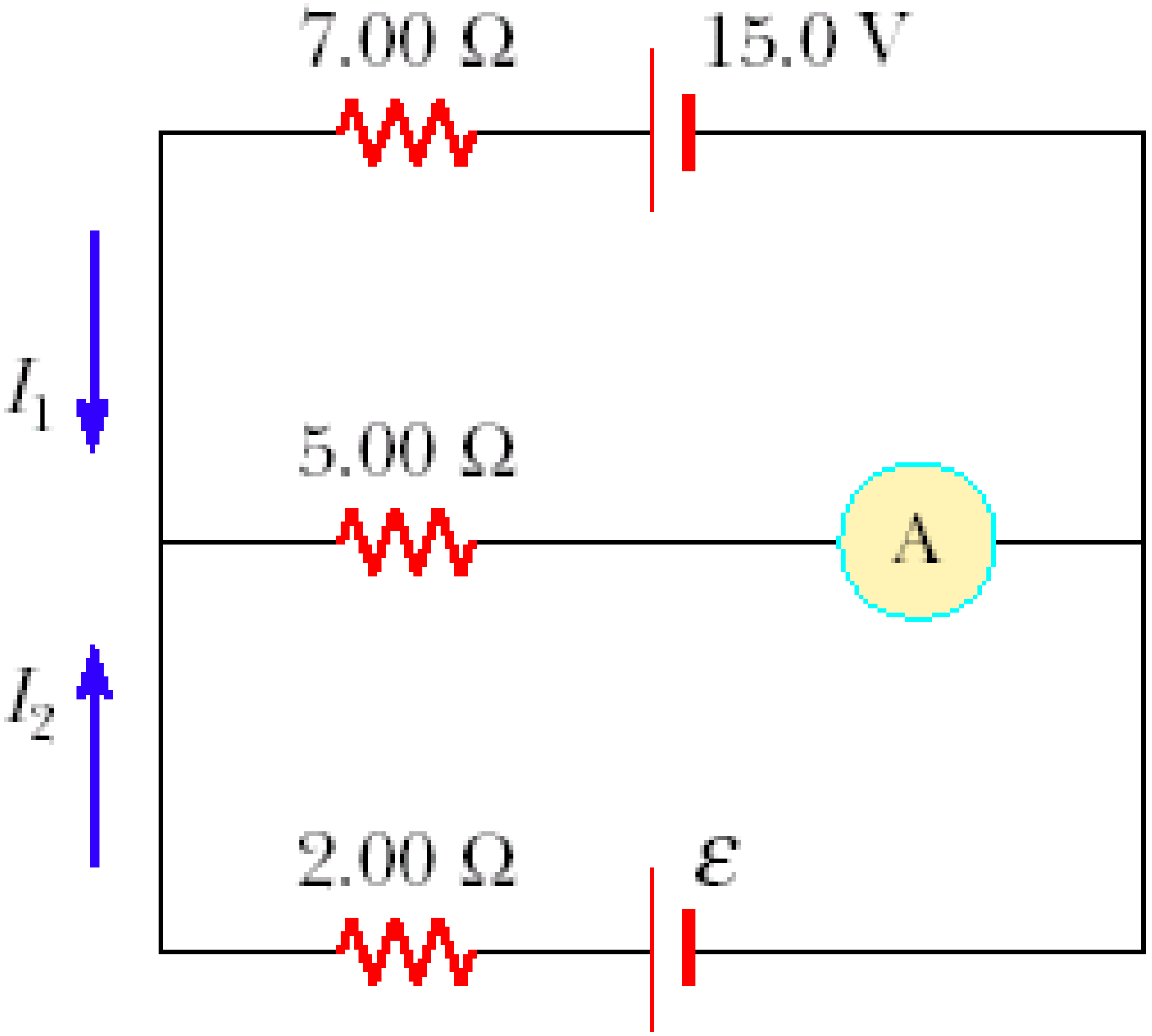


FIG. P28.15

20. The ammeter shown in Figure P28.20 reads 2.00 A. Find I_1, I_2, and ε.



28.3 Kirchhoff's Rules

$$+15.0-(7.00)I_1-(2.00)(5.00)=0$$

$5.00=7.00I_1$ so $\boxed{I_1=0.714\text{ A}}$

$I_3=I_1+I_2=2.00\text{ A}$

$0.714+I_2=2.00$ so $\boxed{I_2=1.29\text{ A}}$

$+\varepsilon-2.00(1.29)-5.00(2.00)=0$ $\boxed{\varepsilon=12.6\text{ V}}$

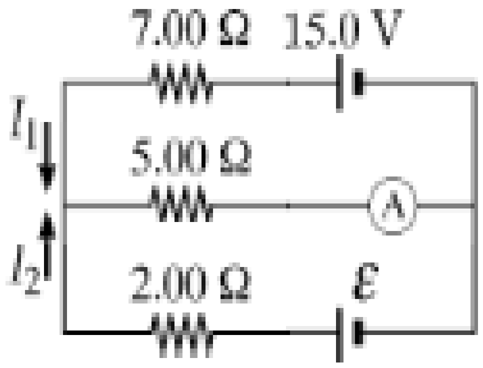
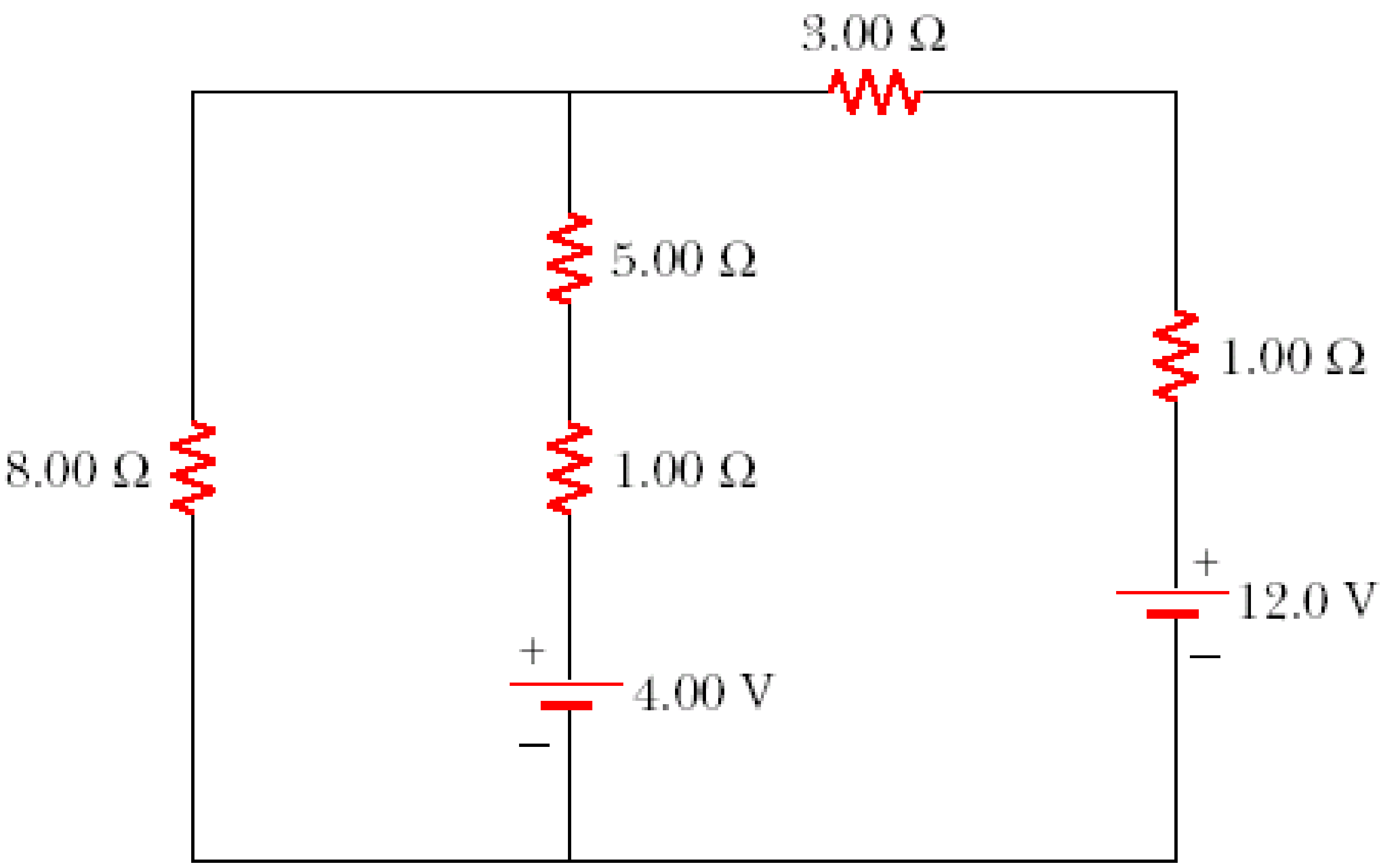


FIG. P28.20

21. Determine the current in each branch of the circuit shown in Figure P28.21.



We name currents I_1, I_2, and I_3 as shown.

From Kirchhoff's current rule, $I_3 = I_1 + I_2$.

Applying Kirchhoff's voltage rule to the loop containing I_2 and I_3,

$$12.0 \text{ V} - (4.00)I_3 - (6.00)I_2 - 4.00 \text{ V} = 0$$
$$8.00 = (4.00)I_3 + (6.00)I_2$$

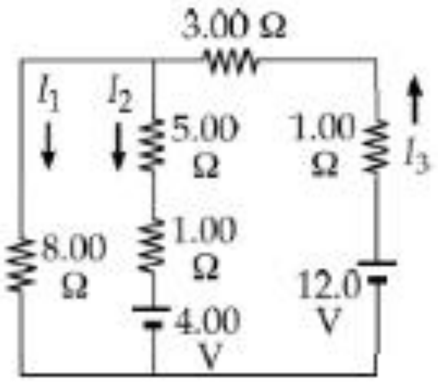


FIG. P28.21

Applying Kirchhoff's voltage rule to the loop containing I_1 and I_2,

$$-(6.00)I_2 - 4.00 \text{ V} + (8.00)I_1 = 0 \qquad (8.00)I_1 = 4.00 + (6.00)I_2.$$

Solving the above linear system, we proceed to the pair of simultaneous equations:

$$\begin{cases} 8 = 4I_1 + 4I_2 + 6I_2 \\ 8I_1 = 4 + 6I_2 \end{cases} \quad \text{or} \quad \begin{cases} 8 = 4I_1 + 10I_2 \\ I_2 = 1.33I_1 - 0.667 \end{cases}$$

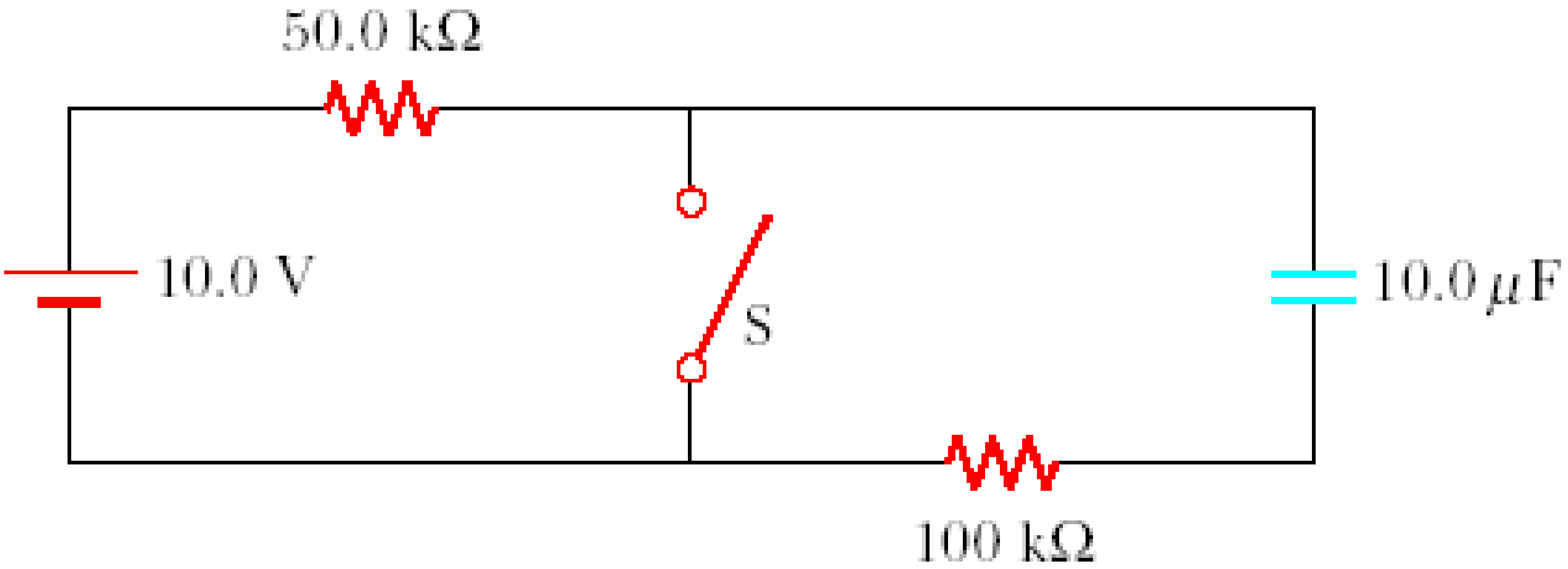
and to the single equation $8 = 4I_1 + 13.3I_1 - 6.67$

$$I_1 = \frac{14.7 \text{ V}}{17.3\ \Omega} = 0.846 \text{ A}. \qquad \text{Then} \qquad I_2 = 1.33(0.846 \text{ A}) - 0.667$$

and $\quad I_3 = I_1 + I_2 \quad$ give $\quad \boxed{I_1 = 846 \text{ mA},\ I_2 = 462 \text{ mA},\ I_3 = 1.31 \text{ A}}$.

All currents are in the directions indicated by the arrows in the circuit diagram.

36. In the circuit of Figure P28.36, the switch S has been open for a long time. It is then suddenly closed. Determine the time constant (a) before the switch is closed and (b) after the switch is closed. (c) Let the switch be closed at $t = 0$. Determine the current in the switch as a function of time.



(a) $\tau = RC = (1.50 \times 10^5\ \Omega)(10.0 \times 10^{-6}\ \text{F}) = \boxed{1.50\ \text{s}}$

(b) $\tau = (1.00 \times 10^5\ \Omega)(10.0 \times 10^{-6}\ \text{F}) = \boxed{1.00\ \text{s}}$

(c) The battery carries current $\dfrac{10.0\ \text{V}}{50.0 \times 10^3\ \Omega} = 200\ \mu\text{A}$.

The 100 kΩ carries current of magnitude $I = I_0 e^{-t/RC} = \left(\dfrac{10.0\ \text{V}}{100 \times 10^3\ \Omega}\right) e^{-t/1.00\ \text{s}}$.

So the switch carries downward current $\boxed{200\ \mu\text{A} + (100\ \mu\text{A}) e^{-t/1.00\ \text{s}}}$.