Q28.29 Suppose $\varepsilon = 12\text{ V}$ and each lamp has $R = 2\ \Omega$. Before the switch is closed the current is $\dfrac{12\text{ V}}{6\ \Omega} = 2\text{ A}$. The potential difference across each lamp is $(2\text{ A})(2\ \Omega) = 4\text{ V}$. The power of each lamp is $(2\text{ A})(4\text{ V}) = 8\text{ W}$, totaling 24 W for the circuit. Closing the switch makes the switch and the wires connected to it a zero-resistance branch. All of the current through A and B will go through the switch and (b) lamp C goes out, with zero voltage across it. With less total resistance, the (c) current in the battery $\dfrac{12\text{ V}}{4\ \Omega} = 3\text{ A}$ becomes larger than before and (a) lamps A and B get brighter. (d) The voltage across each of A and B is $(3\text{ A})(2\ \Omega) = 6\text{ V}$, larger than before. Each converts power $(3\text{ A})(6\text{ V}) = 18\text{ W}$, totaling 36 W, which is (e) an increase.

P28.1 (a) $\mathscr{P} = \frac{(\Delta V)^2}{R}$

becomes $20.0 \text{ W} = \frac{(11.6 \text{ V})^2}{R}$

so $R = \boxed{6.73\ \Omega}$.

(b) $\Delta V = IR$

so $11.6 \text{ V} = I(6.73\ \Omega)$

and $I = 1.72 \text{ A}$

$\varepsilon = IR + Ir$

so $15.0 \text{ V} = 11.6 \text{ V} + (1.72 \text{ A})r$

$r = \boxed{1.97\ \Omega}$.

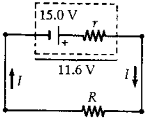

FIG. P28.1

P28.4 (a) Here $\varepsilon = I(R+r)$, so $I = \frac{\varepsilon}{R+r} = \frac{12.6\text{ V}}{(5.00\ \Omega + 0.080\,0\ \Omega)} = 2.48\text{ A}$.

Then, $\Delta V = IR = (2.48\text{ A})(5.00\ \Omega) = \boxed{12.4\text{ V}}$.

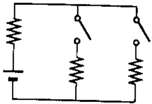

FIG. P28.4

(b) Let I_1 and I_2 be the currents flowing through the battery and the headlights, respectively.

Then, $I_1 = I_2 + 35.0\text{ A}$, and $\varepsilon - I_1 r - I_2 r = 0$

so $\varepsilon = (I_2 + 35.0\text{ A})(0.080\,0\ \Omega) + I_2(5.00\ \Omega) = 12.6\text{ V}$

giving $I_2 = 1.93\text{ A}$.

Thus, $\Delta V_2 = (1.93\text{ A})(5.00\ \Omega) = \boxed{9.65\text{ V}}$.

P28.6 (a) $R_p = \dfrac{1}{(1/7.00\ \Omega) + (1/10.0\ \Omega)} = 4.12\ \Omega$

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

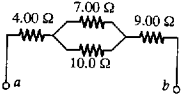

FIG. P28.6

(b) $\Delta V = IR$

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

$I = \boxed{1.99\ \text{A}}$ for $4.00\ \Omega$, $9.00\ \Omega$ 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 $7.00\ \Omega$ resistor

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

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

P28.11 (a) Since all the current in the circuit must pass through the series $100\ \Omega$ resistor, $\mathscr{P} = I^2R$

$$\mathscr{P}_{max} = RI_{max}^2$$

so $$I_{max} = \sqrt{\frac{\mathscr{P}}{R}} = \sqrt{\frac{25.0\ \text{W}}{100\ \Omega}} = 0.500\ \text{A}$$

$$R_{eq} = 100\ \Omega + \left(\frac{1}{100} + \frac{1}{100}\right)^{-1}\ \Omega = 150\ \Omega$$

$$\Delta V_{max} = R_{eq} I_{max} = \boxed{75.0\ \text{V}}$$

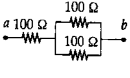

FIG. P28.11

(b) $$\mathscr{P} = I\Delta V = (0.500\ \text{A})(75.0\ \text{V}) = \boxed{37.5\ \text{W}}\ \text{total power}$$

$$\mathscr{P}_1 = \boxed{25.0\ \text{W}}$$

$$\mathscr{P}_2 = \mathscr{P}_3 = RI^2(100\ \Omega)(0.250\ \text{A})^2 = \boxed{6.25\ \text{W}}$$

P28.15 $R_p = \left(\frac{1}{3.00} + \frac{1}{1.00}\right)^{-1} = 0.750\ \Omega$

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

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

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

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

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

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

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

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

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

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

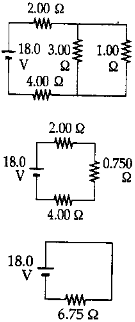

FIG. P28.15

P28.18 (a) $\Delta V = IR$: $33.0\text{ V} = I_1(11.0\ \Omega)$ $33.0\text{ V} = I_2(22.0\ \Omega)$

$I_3 = 3.00\text{ A}$ $I_2 = 1.50\text{ A}$

$\mathcal{P} = I^2R$: $\mathcal{P}_1 = (3.00\text{ A})^2(11.0\ \Omega)$ $\mathcal{P}_2 = (1.50\text{ A})^2(22.0\ \Omega)$

$\mathcal{P}_1 = 99.0\text{ W}$ $\mathcal{P}_2 = 49.5\text{ W}$

The 11.0-Ω resistor uses more power.

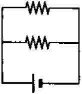

FIG. P28.18(a)

(b) $\mathcal{P}_1 + \mathcal{P}_2 = \boxed{148\text{ W}}$ $\mathcal{P} = I(\Delta V) = (4.50)(33.0) = \boxed{148\text{ W}}$

(c) $R_s = R_1 + R_2 = 11.0\ \Omega + 22.0\ \Omega = 33.0\ \Omega$

$\Delta V = IR$: $33.0\text{ V} = I(33.0\ \Omega)$, so $I = 1.00\text{ A}$

$\mathcal{P} = I^2R$: $\mathcal{P}_1 = (1.00\text{ A})^2(11.0\ \Omega)$ $\mathcal{P}_2 = (1.00\text{ A})^2(22.0\ \Omega)$

$\mathcal{P}_1 = 11.0\text{ W}$ $\mathcal{P}_2 = 22.0\text{ W}$

The 22.0-Ω resistor uses more power.

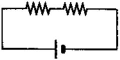

FIG. P28.18(c)

(d) $\mathcal{P}_1 + \mathcal{P}_2 = I^2(R_1 + R_2) = (1.00\text{ A})^2(33.0\ \Omega) = \boxed{33.0\text{ W}}$

$\mathcal{P} = I(\Delta V) = (1.00\text{ A})(33.0\text{ V}) = \boxed{33.0\text{ W}}$

(e) **The parallel configuration uses more power.**

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,

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

$$8.00 = (4.00)I_3 + (6.00)I_2$$

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

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

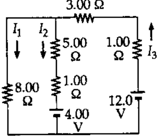

FIG. P28.21

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.

P28.27 Using Kirchhoff's rules,

$$12.0-(0.010\,0)I_1-(0.060\,0)I_3=0$$

$$10.0+(1.00)I_2-(0.060\,0)I_3=0$$

and $I_1=I_2+I_3$

$$12.0-(0.010\,0)I_2-(0.070\,0)I_3=0$$

$$10.0+(1.00)I_2-(0.060\,0)I_3=0$$

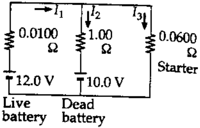

FIG. P28.27

Solving simultaneously,

$I_2=$ $\boxed{0.283 \text{ A downward}}$ in the dead battery

and $I_3=$ $\boxed{171 \text{ A downward}}$ in the starter.

#10-13 Answers in the textbook.