P 1.8 $n = \dfrac{35 \times 10^{-6}\ \text{C/s}}{1.6022 \times 10^{-19}\ \text{C/elec}} = 2.18 \times 10^{14}\ \text{elec/s}$

P 1.9 First we use Eq. (1.2) to relate current and charge:

$$i = \frac{dq}{dt} = 24\cos 4000t$$

Therefore, $dq = 24\cos 4000t\, dt$

To find the charge, we can integrate both sides of the last equation. Note that we substitute x for q on the left side of the integral, and y for t on the right side of the integral:

$$\int_{q(0)}^{q(t)} dx = 24\int_0^t \cos 4000y\, dy$$

We solve the integral and make the substitutions for the limits of the integral, remembering that $\sin 0 = 0$:

$$q(t) - q(0) = 24\frac{\sin 4000y}{4000}\bigg|_0^t = \frac{24}{4000}\sin 4000t - \frac{24}{4000}\sin 4000(0) = \frac{24}{4000}\sin 4000t$$

But $q(0) = 0$ by hypothesis, i.e., the current passes through its maximum value at $t = 0$, so $q(t) = 6 \times 10^{-3}\sin 4000t\,\text{C} = 6\sin 4000t\,\text{mC}$

P 1.10 $w = qV = (1.6022 \times 10^{-19})(6) = 9.61 \times 10^{-19} = 0.961\ \text{aJ}$

P 1.11 $p = (9)(100 \times 10^{-3}) = 0.9\ \text{W};\qquad 5\ \text{hr} \cdot \dfrac{3600\ \text{s}}{1\ \text{hr}} = 18{,}000\ \text{s}$

$$w(t) = \int_0^t p\, dt \qquad w(18{,}000) = \int_0^{18{,}000} 0.9\, dt = 0.9(18{,}000) = 16.2\ \text{kJ}$$

P 1.12 Assume we are standing at box A looking toward box B. Then, using the passive sign convention $p = vi$, since the current i is flowing into the + terminal of the voltage v. Now we just substitute the values for v and i into the equation for power. Remember that if the power is positive, B is absorbing power, so the power must be flowing from A to B. If the power is negative, B is generating power so the power must be flowing from B to A.

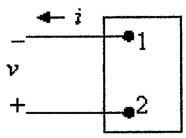
[a] $p = (120)(5) = 600$ W 600 W from A to B

[b] $p = (250)(-8) = -2000$ W 2000 W from B to A

[c] $p = (-150)(16) = -2400$ W 2400 W from B to A

[d] $p = (-480)(-10) = 4800$ W 4800 W from A to B

P 1.13 [a]



$p = vi = (40)(-10) = -400$ W
Power is being delivered by the box.

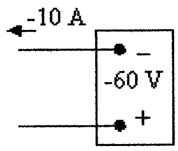
[b] Leaving

[c] Gaining

P 1.14 [a] $p = vi = (-60)(-10) = 600$ W, so power is being absorbed by the box.

[b] Entering

[c] Losing



P 1.15 [a] In Car A, the current i is in the direction of the voltage drop across the 12 V battery(the current i flows into the + terminal of the battery of Car A). Therefore using the passive sign convention,
$p = vi = (30)(12) = 360$ W.
Since the power is positive, the battery in Car A is absorbing power, so Car A must have the "dead" battery.

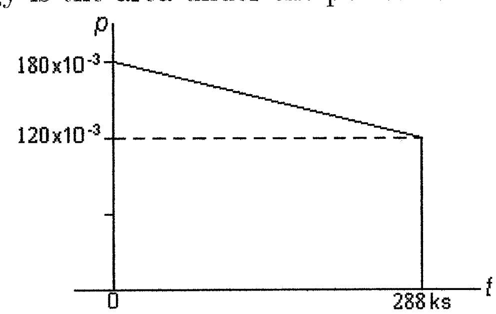
[b] $w(t) = \int_0^t p\,dx; \qquad 1 \text{ min} = 60 \text{ s}$

$$w(60) = \int_0^{60} 360\,dx$$

$$w = 360(60 - 0) = 360(60) = 21{,}600 \text{ J} = 21.6 \text{ kJ}$$

P 1.16 $p = vi; \qquad w = \int_0^t p\,dx$

Since the energy is the area under the power vs. time plot, let us plot p vs. t.



Note that in constructing the plot above, we used the fact that 80 hr = 288,000 s = 288 ks

$p(0) = (9)(20 \times 10^{-3}) = 180 \times 10^{-3}$ W

$$p(288\text{ ks}) = (6)(20 \times 10^{-3}) = 120 \times 10^{-3}\text{ W}$$

$$w = (120 \times 10^{-3})(288 \times 10^3) + \frac{1}{2}(180 \times 10^{-3} - 120 \times 10^{-3})(288 \times 10^3) = 43.2\text{ kJ}$$

P 1.17 [a] $p = vi = 30e^{-500t} - 30e^{-1500t} - 40e^{-1000t} + 50e^{-2000t} - 10e^{-3000t}$

$p(1\text{ ms}) = 3.1\text{ mW}$

[b]
$$\begin{aligned} w(t) &= \int_0^t (30e^{-500x} - 30e^{-1500x} - 40e^{-1000x} + \\ &\qquad 50e^{-2000x} - 10e^{-3000x})dx \\ &= 21.67 - 60e^{-500t} + 20e^{-1500t} + 40e^{-1000t} - \\ &\qquad 25e^{-2000t} + 3.33e^{-3000t}\mu\text{J} \\ w(1\text{ ms}) &= 1.24\mu\text{J} \end{aligned}$$

[c] $w_{\text{total}} = 21.67\mu\text{J}$

P 1.18 [a] $v(10\text{ ms}) = 400e^{-1}\sin 2 = 133.8\text{ V}$

$i(10\text{ ms}) = 5e^{-1}\sin 2 = 1.67\text{ A}$

$p(10\text{ ms}) = vi = 223.79\text{ W}$

[b]
$$\begin{aligned} p &= vi = 2000e^{-200t}\sin^2 200t \\ &= 2000e^{-200t}\left[\frac{1}{2} - \frac{1}{2}\cos 400t\right] \\ &= 1000e^{-200t} - 1000e^{-200t}\cos 400t \\ w &= \int_0^\infty 1000e^{-200t}\,dt - \int_0^\infty 1000e^{-200t}\cos 400t\,dt \\ &= 1000\left.\frac{e^{-200t}}{-200}\right|_0^\infty \\ &\quad -1000\left.\left\{\frac{e^{-200t}}{(200)^2 + (400)^2}[-200\cos 400t + 400\sin 400t]\right\}\right|_0^\infty \\ &= 5 - 1000\left[\frac{200}{4 \times 10^4 + 16 \times 10^4}\right] = 5 - 1 \\ \text{w} &= 4\text{ J} \end{aligned}$$

P 1.19 [a] $0\text{ s} \le t < 4\text{ s}$:

$v = 2.5t$ V; $i = 1\,\mu$A; $p = 2.5t\,\mu$W

$4\text{ s} < t \le 8\text{ s}$:

$v = 10$ V; $i = 0$ A; $p = 0$ W

$8\text{ s} \le t < 16\text{ s}$:

$v = -2.5t + 30$ V; $i = -1\,\mu$A; $p = 2.5t - 30\,\mu$W

$16\text{ s} < t \le 20\text{ s}$:

$v = -10$ V; $i = 0$ A; $p = 0$ W

$20\text{ s} \le t < 36\text{ s}$:

$v = t - 30$ V; $i = 0.4\,\mu$A; $p = 0.4t - 12\,\mu$W

$36\text{ s} < t \le 46\text{ s}$:

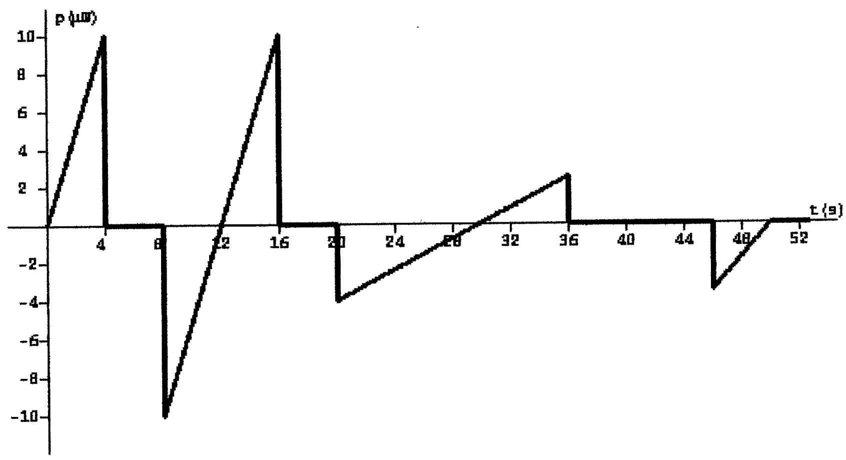
$v = 6$ V; $i = 0$ A; $p = 0$ W

$46\text{ s} \le t < 50\text{ s}$:

$v = -1.5t + 75$ V; $i = -0.6\,\mu$A; $p = 0.9t - 45\,\mu$W

$t > 50$ s:

$v = 0$ V; $i = 0$ A; $p = 0$ W



[b] Calculate the area under the curve from zero up to the desired time:

$$w(4) = \tfrac{1}{2}(4)(10) = 20\,\mu\text{J}$$

$$w(12) = w(4) - \tfrac{1}{2}(4)(10) = 0\text{ J}$$

$$w(36) = w(12) + \tfrac{1}{2}(4)(10) - \tfrac{1}{2}(10)(4) + \tfrac{1}{2}(6)(2.4) = 7.2\,\mu\text{J}$$

$$w(50) = w(36) - \tfrac{1}{2}(4)(3.6) = 0\text{ J}$$

$$\sum P_{\text{del}} = 2000 + 2100 = 4100 \text{ W}$$
$$\sum P_{\text{abs}} = 750 + 500 + 600 + 50 + 1400 + 800 = 4100 \text{ W}$$

Now the power delivered equals the power absorbed and the power balances for the circuit.

P 1.28

$$p_{\text{a}} = -v_{\text{a}}i_{\text{a}} = -(36)(250 \times 10^{-6}) = -9 \text{ mW}$$
$$p_{\text{b}} = v_{\text{b}}i_{\text{b}} = (44)(-250 \times 10^{-6}) = -11 \text{ mW}$$
$$p_{\text{c}} = v_{\text{c}}i_{\text{c}} = (28)(-250 \times 10^{-6}) = -7 \text{ mW}$$
$$p_{\text{d}} = v_{\text{d}}i_{\text{d}} = (-108)(100 \times 10^{-6}) = -10.8 \text{ mW}$$
$$p_{\text{e}} = v_{\text{e}}i_{\text{e}} = (-32)(150 \times 10^{-6}) = -4.8 \text{ mW}$$
$$p_{\text{f}} = -v_{\text{f}}i_{\text{f}} = -(60)(-350 \times 10^{-6}) = 21 \text{ mW}$$
$$p_{\text{g}} = v_{\text{g}}i_{\text{g}} = (-48)(-200 \times 10^{-6}) = 9.6 \text{ mW}$$
$$p_{\text{h}} = v_{\text{h}}i_{\text{h}} = (80)(-150 \times 10^{-6}) = -12 \text{ mW}$$
$$p_{\text{j}} = -v_{\text{j}}i_{\text{j}} = -(80)(-300 \times 10^{-6}) = 24 \text{ mW}$$

Therefore,

$$\sum P_{\text{abs}} = 21 + 9.6 + 24 = 54.6 \text{ mW}$$

$$\sum P_{\text{del}} = 9 + 11 + 7 + 10.8 + 4.8 + 12 = 54.6 \text{ W}$$

$$\sum P_{\text{abs}} = \sum P_{\text{del}}$$

Thus, the interconnection satisfies the power check

P 1.29

$$p_{\text{a}} = -v_{\text{a}}i_{\text{a}} = -(1.6)(0.080) = -128 \text{ mW}$$
$$p_{\text{b}} = -v_{\text{b}}i_{\text{b}} = -(2.6)(0.060) = -156 \text{ mW}$$
$$p_{\text{c}} = v_{\text{c}}i_{\text{c}} = (-4.2)(-0.050) = 210 \text{ mW}$$
$$p_{\text{d}} = -v_{\text{d}}i_{\text{d}} = -(1.2)(0.020) = -24 \text{ mW}$$
$$p_{\text{e}} = v_{\text{e}}i_{\text{e}} = (1.8)(0.030) = 54 \text{ mW}$$
$$p_{\text{f}} = -v_{\text{f}}i_{\text{f}} = -(-1.8)(-0.040) = -72 \text{ mW}$$
$$p_{\text{g}} = v_{\text{g}}i_{\text{g}} = (-3.6)(-0.030) = 108 \text{ mW}$$
$$p_{\text{h}} = v_{\text{h}}i_{\text{h}} = (3.2)(-0.020) = -64 \text{ mW}$$
$$p_{\text{j}} = -v_{\text{j}}i_{\text{j}} = -(-2.4)(0.030) = 72 \text{ mW}$$
$$\sum P_{\text{del}} = 128 + 156 + 24 + 72 + 64 = 444 \text{ mW}$$
$$\sum P_{\text{abs}} = 210 + 54 + 108 + 72 = 444 \text{ mW}$$