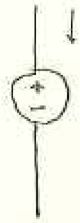
Question 1



$\downarrow i = 4A$

$v(t) = 12\left(1 + e^{-t/20}\right) V$
(t is in hours)

Note that battery is being charged, implying that it is absorbing power.

We have $p(t) = i\,v(t) = 48\left(1 + e^{-t/20}\right) W$

Energy is defined as $$w = \underbrace{\int_{t_0}^{t_1} p(t)\,dt}_{\text{need this part of the energy calculation for } t = 0 \text{ to } 20 \text{ hours}} + w(t_0)$$

$$w = 48\int_0^{20}\left(1 + e^{-t/20}\right) dt = 48\left[t - 20e^{-t/20}\right]\Big|_0^{20}$$
$$= 48\left[20 - 20e^{-20/20} - 0 + 20\right]$$
$$= 48\left[32.642\right] = 1566.836 \text{ Wh}$$

so $w = 1.5668$ kWh

Given the cost of \$0.19 per kWh, the cost over 20 hours is

$$\text{cost} = \$0.19/\text{kWh} \times 1.5668 \text{ kWh}$$
$$= \boxed{\$\,0.2977}$$

Question 2

We have $i(t) = 120\left(1 + \cos(100\pi t)\right)$ A. Relating current and charge q, we also have

$$i(t) = \frac{d\,q(t)}{dt} \quad \text{and} \quad q(t) = \underbrace{\int_{t_0}^{t_1} i(t)\,dt}_{\text{need this part of the calculation for } t_0 = 0 \text{ and } t_1 = 0.01 \text{ s.}} + q(t_0)$$

$$q = 120 \int_0^{0.01} (1 + \cos(100\pi t))\, dt$$

$$\text{so} \quad q = 120 \left[t + \frac{1}{100\pi} \sin(100\pi t) \right] \Big|_0^{0.01}$$

$$\text{giving} \quad q = 120 \left[0.01 + \frac{1}{100\pi} \cancelto{0}{\sin(\pi)} - 0 - \frac{1}{100\pi} \cancelto{0}{\sin(0)} \right]$$

$$q = 120\,(0.01)\ C = \boxed{1.2\ C}$$

Question 3

There are different ways to solve this. Below is one way

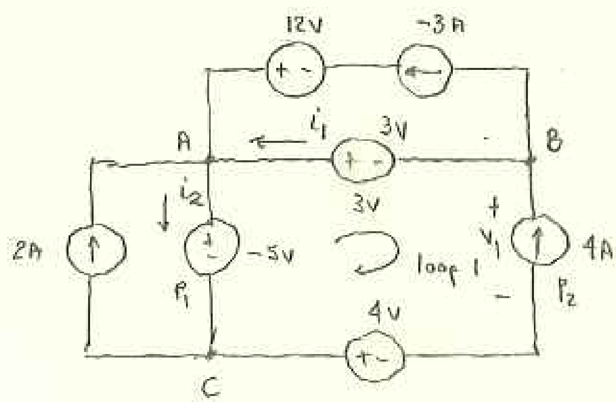
In loop ECFG, KVL gives $5 + V_E + 11 + 13 = 0$
$V_E = -29\ V$

In loop EAJG, KVL gives $5 + V_E + 13 - V_J = 0$
$5 - 29 + 13 - V_J = 0$
$V_J = -11\ V$

In loop FDA, KVL gives $-13 - 7 - V_H = 0$
$V_H = -20\ V$

Finally, $V_E + V_H + V_J = -29 - 11 - 20$
$= \boxed{-60\ V}$

Question 4



At node B, KCL gives

$4 - i_1 - (-3) = 0$
so $i_1 = 7\ A$

At node A, KCL gives

$(-3) + i_1 + 2 - i_2 = 0$
$-3 + 7 + 2 = i_2$
so $i_2 = 6\ A$

Observation: Performing KCL at node B was unnecessary; it would have been fine to recognize that the 4A splits at B, then recombines at A, $4 + 2 - i_2 = 0$, so $i_2 = 6\,A$.

Alternatively, KCL at node C!

Power $p_1 = (-5)\,i_2 = -30\,W$

Now, KVL around loop 1 gives $-(-5) + 3 + V_1 - 4 = 0$

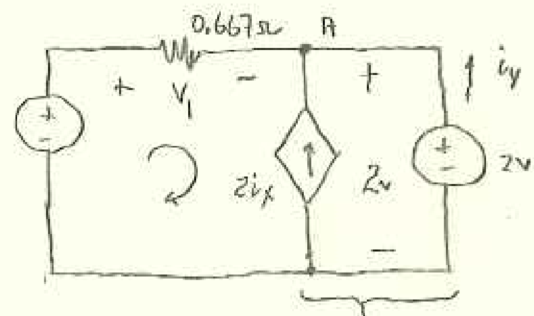
so $V_1 = -4\,V$

Power $p_2 = -V_1(4) = 4 \times 4 = 16\,W$

Therefore, $p_1 + p_2 = -30 + 16 = \boxed{-14\,W}$

<u>Question 5</u>

Combining the two resistors in parallel,

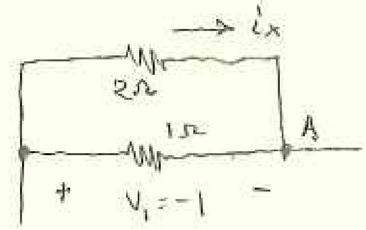


in parallel with the same voltage 2v

KVL around the loop gives $-1 + V_1 + 2 = 0$

$V_1 = -1\,V$

Now consider the parallel resistors



Ohm's law gives

$$i_x = \frac{V_1}{2\Omega} = -0.5\,A$$

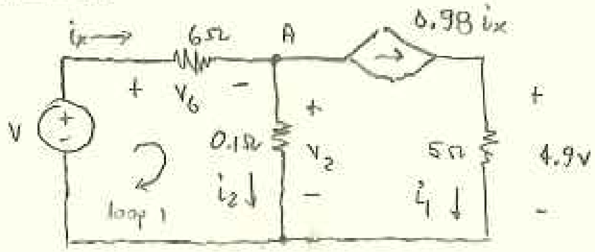
At node A in the circuit, KCL gives

$$\frac{V_1}{1\Omega} + i_x + 2i_x + i_y = 0$$

$$\frac{-1}{1\Omega} - 0.5 + 2(-0.5) + i_y = 0$$

$$i_y = \boxed{2.5\text{ A}}$$

Question 6



With 4.9v across the 5Ω resistor, $i_1 = \frac{4.9}{5} = 0.98\text{ A}$

This must also be the current in the dependent current source

$$0.98 i_x = i_1 = 0.98\text{ A}$$

so that $i_x = 1\text{ A}$

Then KCL at node A gives

$$i_x - i_2 - 0.98\, i_x = 0$$
$$1 - 0.98 = i_2$$
so $i_2 = 0.02\text{ A}$

This gives $V_2 = 0.02 \times 0.1\,\Omega = 0.002\text{ V}$

KVL around loop 1: $-V + 6i_x + 0.002 = 0$
$$V = 6.002\text{ v}$$

Power in the voltage source: $p = -V i_x = -6.002 \times 1$

$$p = \boxed{-6.002\text{ W}}$$