1.

a) Current flows from B to A.
b) The 12 volt battery is doing positive work.
c) B is at a higher potential.

2.

Need I first.

$$I = \frac{\sum \mathcal{E}}{\sum R} = \frac{100}{5} = 20\,\text{amps}$$

$$V_Q + 150 - 20(2\Omega) = V_P = 100$$

$$V_Q = -10\,\text{volts}$$

5.

$$5\text{amps} = 5\frac{\text{coul}}{\text{sec}}$$

$$6\text{volts} = 6\frac{\text{joule}}{\text{coul}}$$

$$6\text{min} = 360\text{sec}$$

$$\left(5\frac{\text{coul}}{\text{sec}}\right)\left(6\frac{\text{joule}}{\text{coul}}\right)(360\text{sec}) = 11.8\text{kj}$$

10.

a) $I = \dfrac{\sum \mathcal{E}}{\sum R}$

$$.001 = \frac{+3-2}{3+3+R}$$

$$6 + R = 1000$$

$$R = 994\Omega$$

b) $P = i^2R = (.001)^2(994)$

$$P = 9.9 \times 10^{-4}\ \text{watts}$$

18.

First we need the currents.

$@(d): i_1 + i_3 - i_2 = 0$

Left hand loop (LHL), cc (counter clockwise):

$\mathcal{E}_1 - i_1R_1 + i_3R_3 = 0$

Right hand loop (RHL), cc:

$-i_3R_3 - i_2R_2 - \mathcal{E}_2 = 0$

After some algebra:

$$i_1 = \frac{55}{200}, i_2 = \frac{5}{200}, i_3 = -\frac{50}{200}$$

$V_d - V_c = ?$

$$c \to d: V_d - V_c = i_2R_2 = \left(\frac{5}{200}\right)(10) = .25 \text{ volts}$$

$$c \to b \to d: V_d - V_c = -\mathcal{E}_2 - i_3R_3$$

$$V_d - V_c = -1 - \left(-\frac{50}{200}\right)(5) = .25 \text{ volts}$$

$$c \to b \to a \to d: V_d - V_c = -\mathcal{E}_2 + \mathcal{E}_1 - i_1R_1$$

$$V_d - V_c = -1 + 4 - \left(\frac{55}{200}\right)(10) = .25 \text{ volts}$$

23.

At node N:

$i_2 - i_3 - i_1 = 0$

Top loop:

$6V - 5V - 4V = 50i_2$

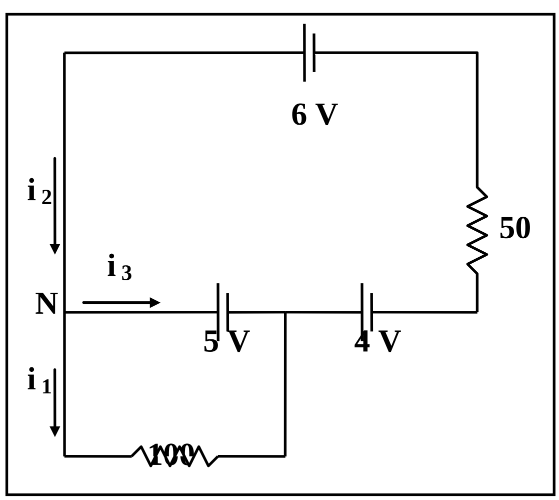
$$i_2 = -\frac{3}{50} = -60 \text{ ma}$$

Bottom loop:

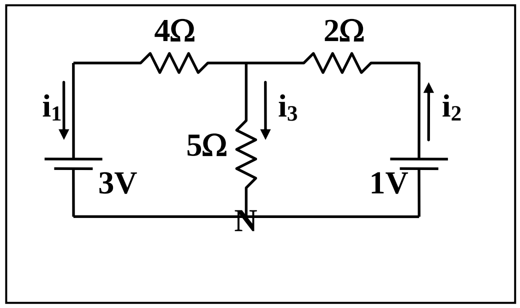
$5V = 100 i_1$

$i_1 = 50 \text{ ma}$

$V_{ab} = 5V + 4V = 9V$



41.



At node N :

$i_1 \quad i_2 + i_3 = 0$

$i_2 = i_1 + i_3$ (1)

LHL, cc :

$3 \quad 4i_1 + 5i_3 = 0$

$4i_1 + 5i_3 = 3$ (2)

RHL, cc :

$5i_3 \quad 2i_2 + 1 = 0$

$2i_2 + 5i_3 = 1$ (3)

$2(i_1 + i_3) + 5i_3 = 1$ sub(1)

$2i_1 + 7i_3 = 1$

$2(2i_1 + 7i_3 = 1)$

$+(\quad 4i_1 + 5i_3 = 3)$(2)

$19i_3 = 5$

$i_3 = .26$ amps

$i_2 = \quad .16$ amps from(3)

$i_1 = \quad .42$ amps from(2)

c) $P_1 = (i_1)^2 4 = .71$

b) $P_2 = (i_2)^2 2 = .051$

a) $P_3 = (i_3)^2 5 = .338$

Power supplied by E_1?

d) $P_1 = i_1 E_1 = (.42)(3) = 1.26$

e) $P_2 = i_2 E_2 = (.16)(1) = .16$

The negative signs indicate the currents direction.

45.

At node N:

$i_1 + i_2 + i_3 = 0$

LHL, cw (clockwise):

$+2 - 4 - 2i_1 + 2i_2 = 0$

$2 = -2i_1 + 2i_2$

RHL, cc:

$+4 - 4 - 2i_3 + 2i_2 = 0$

$\therefore i_3 = i_2$

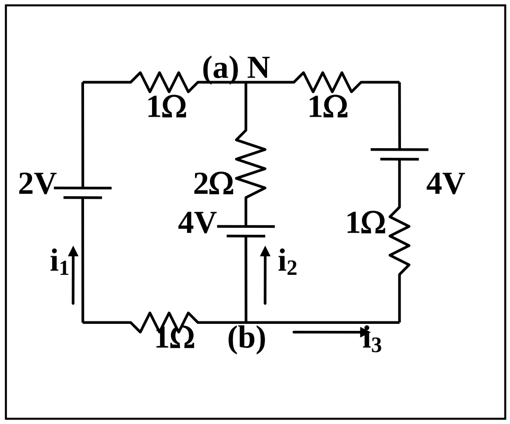
$i_1 + i_2 + i_3 = i_1 + 2i_2 = 0$

$$\begin{array}{rl} & -2i_1 + 2i_2 = 2 \\ + & -(i_1 + 2i_2) = 0 \\ \hline & -3i_1 \qquad = 2 \end{array}$$

$i_1 = -\frac{2}{3}$ amps

$-2i_1 + 2i_2 = 2 \Rightarrow i_2 = \frac{1}{3}$ amps

$i_3 = i_2 = \frac{1}{3}$ amps



b) $V_a - 2(1/3) - 4 = V_b$

$V_a - V_b = 4 - 2/3 = 3.3$ volts

53.

$$\text{Suppose } R_V = 0.$$

$$i = \frac{\sum E}{\sum R} = \frac{3}{650} = .0046\text{amps}$$

Now put meter in parallel with R_1.

$$\frac{1}{R_{eq}} = \frac{1}{250} + \frac{1}{5000}$$

$$R_{eq} = 238\Omega$$

$$\text{New } i = \frac{\sum E}{\sum R} = \frac{3}{638} = .0047\text{amps}$$

With out volt meter:

$$V(R_1) = .0046(250) = 1.15\text{volts}$$

With volt meter:

$$V(R_1) = .0047(238) = 1.12\text{volts}$$

$$\frac{1.12 - 1.15}{1.15} = -2.6\%$$

58.

a) t_C = Time constant

$$t_C = RC = (1.4 \times 10^6\,\Omega)(1.8 \times 10^{-6}\,F)$$

$$t_C = 2.5\text{ seconds}$$

b) As $t \to \infty \quad \exp\left[-\left(\frac{t}{RC}\right)\right] \to 0$

$$Q = C\mathcal{E}\left(1 - \exp\left[-\left(\frac{t}{RC}\right)\right]\right) \approx C\mathcal{E}$$

When t is large.

$$Q = C\mathcal{E} = (1.8\mu F)(12\,V) = 21.6\mu C$$

c) $Q = 16\mu C = (21.6\mu C)\left(1 - \exp\left[-\left(\frac{t}{RC}\right)\right]\right)$

$$.74 = 1 - \exp\left[-\left(\frac{t}{RC}\right)\right]$$

$$.26 = \exp\left[-\left(\frac{t}{RC}\right)\right]$$

$$\ln(.26) = -1.35 = -\frac{t}{RC}$$

$$\frac{t}{2.5} = 1.35$$

$$t = 3.36\text{ seconds}$$

59.

$$\text{Want } Q = (99\%)(Q_F).$$

$$Q = VC\left(1 - \exp\left[\left(-\frac{t}{RC}\right)\right]\right)$$

$$Q = Q_F\left(1 - \exp\left[\left(-\frac{t}{RC}\right)\right]\right)$$

$$.99Q_F = Q_F\left(1 - \exp\left[\left(-\frac{t}{RC}\right)\right]\right)$$

$$.99 = 1 - \exp\left[\left(-\frac{t}{RC}\right)\right]$$

$$.01 = \exp\left[\left(-\frac{t}{RC}\right)\right]$$

$$\ln(.01) = -4.6 = \left(-\frac{t}{RC}\right)$$

$$4.6 = \frac{t}{RC}$$

$\therefore$ It takes 4.6 time constants.

Units?

$$RC = \text{ohms} \cdot \text{farads} = \frac{\text{volts}}{\text{amps}}\frac{\text{coulomb}}{\text{volts}}$$

$$RC = \frac{\text{coulomb}}{\text{amps}} = \frac{\text{coulomb}}{\left(\frac{\text{coulomb}}{\text{second}}\right)} = \text{second}$$

78.

$$\text{Suppose } R_A = 0.$$

$$i = \frac{\sum \varepsilon}{\sum R} = \frac{5}{11} = .4545 \text{ amps}$$

$$\text{With ammeter: } R_A = 0.10\,\Omega$$

$$i = \frac{\sum \varepsilon}{\sum R} = \frac{5}{11.1} = .4504 \text{ amps}$$

$$\frac{.4545 - .4504}{.4545} = .9\%$$

82.

$$V_{ac} = \mathcal{E}_2 - iR - ir_2$$

$$V_{ac} = 4.0 - .25(5) - .25(2)$$

$$V_{ac} = 2.25\ \text{volts}$$

90.

a) $$i = \frac{\mathcal{E}}{r+R}$$

Joule heating: i^2R

$$P = i^2R = \left(\frac{\mathcal{E}}{r+R}\right)^2 R = \frac{\mathcal{E}^2}{(r+R)^2}R$$

$$\text{Maximize?}\ \frac{dP}{dR} = 0$$

$$\frac{dP}{dR} = \frac{-2\mathcal{E}^2R}{(r+R)^3} + \frac{\mathcal{E}^2}{(r+R)^2}$$

$$\frac{dP}{dR} = \frac{-2\mathcal{E}^2R + \mathcal{E}^2(r+R)}{(r+R)^3} = \frac{\mathcal{E}^2(r-R)}{(r+R)^3}$$

$$\frac{dP}{dR} = 0 \Rightarrow r = R$$

b) $$P(R=r) = i^2R = \frac{\mathcal{E}^2}{(r+R)^2}R = \frac{\mathcal{E}^2}{(r+r)^2}r$$

$$P = \frac{\mathcal{E}^2}{(2r)^2}r = \frac{\mathcal{E}^2}{4r}$$

Additional Problem

114. Power is a peak when r = R. See problem # 20