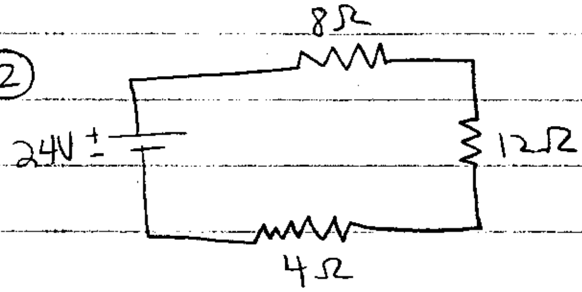
HW#4 – SOL^N – ADAM COHEN

Chapter 18 – DC circuits

(2)



*in series ⇒ $R_{eq} = R_1 + R_2 + R_3$

$$\boxed{R_{eq} = 24\ \Omega}$$

*each resistor has the same current I

$$I = \frac{\Delta V}{R_{eq}} = \frac{24V}{24\Omega} = \boxed{1A}$$

*in parallel ⇒ $R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots\right)^{-1}$

$$= \left(\frac{1}{4} + \frac{1}{8} + \frac{1}{12}\right)^{-1} \Omega$$

$$= 2.18\ \Omega$$

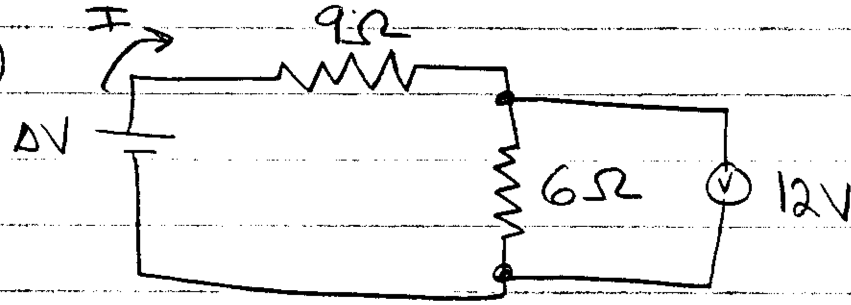
*each resistor has the same voltage ΔV

$$\Rightarrow I_4 = \frac{\Delta V}{R_4} = \frac{24}{4} A = 6A$$

$$I_8 = \frac{24}{8} A = 3A$$

$$I_{12} = \frac{24}{12} A = 2A$$

(4)



* in <u>series</u> each resistor has the <u>same</u> <u>current</u>.

$$\Rightarrow \quad I_9 = I_6 = \frac{\Delta V_6}{R_6} = \frac{12}{6} A = 2A$$

$$\Rightarrow \quad I_9 = 2A = \frac{\Delta V_9}{R_9} = \frac{\Delta V_9}{9\Omega}$$

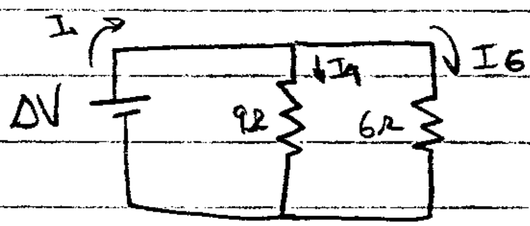
$$\text{so} \quad \Delta V_9 = 18\,V$$

* the loop rule says:

$$\Delta V_{total} = \Delta V_6 + \Delta V_9$$

$$= 12V + 18V$$

$$= \boxed{30\,V}$$



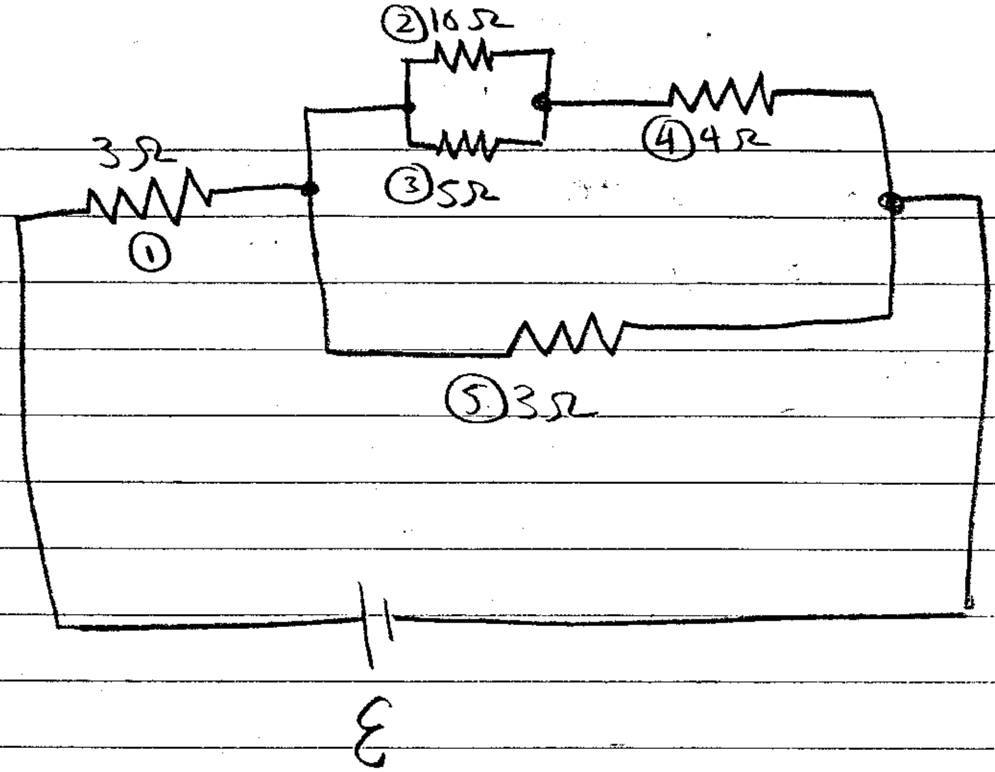
$I_9 = 0.25\,A$
(measured)

* in <u>parallel</u>, each resistor has <u>same potential difference</u>

$$\Rightarrow \quad \Delta V = I R = (0.25A)(9A) = 2.3V$$

<u>This the the ΔV of the power supply.</u>

(8)



- Combine 10 Ω (2) and 5 Ω (3) resistor:

$$R_{23} = \left(\frac{1}{10\,\Omega} + \frac{1}{5\,\Omega}\right)^{-1} = \frac{10}{3}\,\Omega$$

- combine R_{23} and R_4:

$$R_{234} = R_{23} + R_4 = \left(\frac{10}{3} + \frac{12}{3}\right)\Omega = \frac{22}{3}\,\Omega$$

- Combine R_{234} and R_5:

$$R_{2345} = \left(\frac{1}{R_{234}} + \frac{1}{R_5}\right)^{-1} = \left(\frac{3}{22} + \frac{1}{3}\right)^{-1}\Omega$$

$$= \left(\frac{9}{66} + \frac{22}{66}\right)^{-1} = \left(\frac{31}{66}\right)^{-1} = \frac{66}{31}\,\Omega$$

- combine R_{2345} and R_1:

$$R_{12345} = \left(\frac{66}{31} + 3\right)\Omega = \boxed{5.13\,\Omega}$$

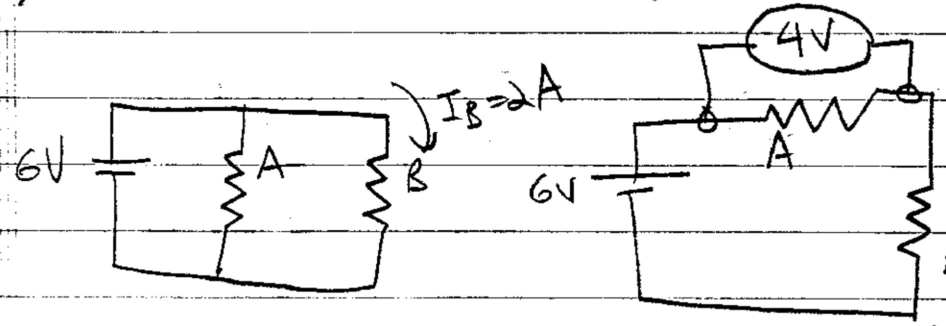
power can be written as:

$$P = \frac{\Delta V^2}{R} \Rightarrow \Delta V = \sqrt{PR}$$

$$= \sqrt{(4\,W)(5.13\,\Omega)}$$

$$\boxed{\Delta V = 4.53\,V}$$

(10)



• In parallel, $\Delta V_A = \Delta V_B = 6V$

so $$R_B = \frac{\Delta V}{I} = \frac{6V}{2A} = \boxed{3\,\Omega = R_B}$$

• In series: $$\Delta V_{total} = \Delta V_A + \Delta V_B$$

$$6V = 4V + \Delta V_B$$

$$\Rightarrow \Delta V_B = 2V$$

also, $I_A = I_B \Rightarrow I_B = \frac{\Delta V_B}{R_B} = \frac{2V}{3\Omega} = \frac{2}{3}A$

so

$$I_A = \frac{2}{3}A = \frac{\Delta V_A}{R_A} = \frac{4V}{R_A}$$

$$\Rightarrow \boxed{R_A = 6\,\Omega}$$

(30) $\tau = RC$

$= [\Omega][F]$

Ohm's Law: $\Delta V = IR$

$\Rightarrow R = \frac{\Delta V}{I} = \frac{[V]}{[A]}$

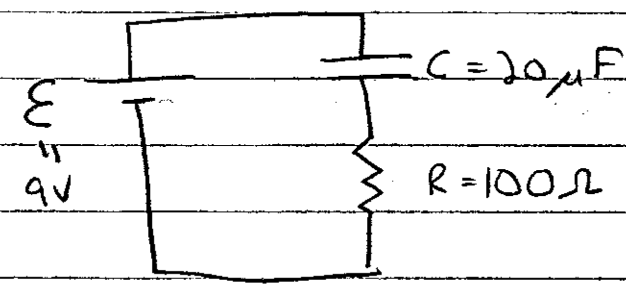
Def^{n}: $C \equiv \frac{Q}{\Delta V} = \frac{[C]}{[V]}$

so $\tau = \left[\frac{V}{A}\right]\left[\frac{C}{V}\right] = \left[\frac{C}{A}\right]$

Def'n: and $I = \frac{Q}{\Delta t} = \frac{[C]}{[s]} = [A]$

so $\tau = \frac{[C]}{[C]/[s]} = \boxed{[s]}$

(32)



time constant $\tau = RC = (100\Omega)(20\times10^{-6}\,F)$

$= 2\times10^{-3}\,s$

$\boxed{\tau = 2\,ms}$

max charge $Q_{max} = C\mathcal{E}$ (recall: $C \equiv \frac{Q}{\Delta V}$)

$= (20\,\mu F)(9V) = \boxed{180\,\mu C}$

Charge on a capacitor:

$$q = Q_{max}\left(1 - e^{-t/\tau}\right)$$

at $t = \tau$,

$$q = [180\,\mu C]\left(1 - e^{-1}\right)$$ ← $1/2.718\ldots$

$$\boxed{q(\tau) = 114\,\mu C}$$

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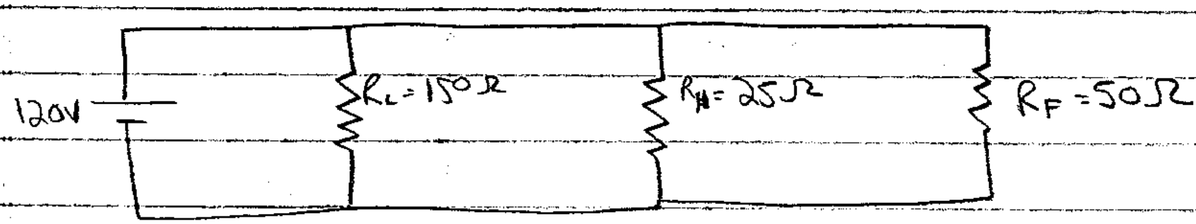

- The equivalent resistance (parallel)

$$R_{eq} = \left(\frac{1}{150} + \frac{1}{25} + \frac{1}{50}\right)^{-1} = 15\,\Omega$$

- By Ohm's Law,

$$\Delta V = IR \Rightarrow I = \frac{\Delta V}{R} = \frac{120V}{15\Omega} = \boxed{8A}$$

- Since in parallel $\Delta V = \Delta V_F = \Delta V_H = \Delta V_L = \boxed{120V}$

- Current varies (must be split), so

$$I_L = \frac{\Delta V_L}{R_L} = \frac{120V}{150\Omega} = \boxed{0.8A}$$

• so, $\Delta V_H = 120V$

$$P_H = \frac{(\Delta V_H)^2}{R_H} = \frac{(120V)^2}{25\Omega} = \boxed{576\ W}$$

(40) The maximum current to our line is:

$$P_{max} = \Delta V I_{max} = (120V)(15A) = 1800\ W.$$

(If we draw more than 15A, the circuit breaks.)

The power needed by the two appliances is 2400 W.

$\Rightarrow$ $P_{needed} > P_{max}$

So we can't operate both at the same time.

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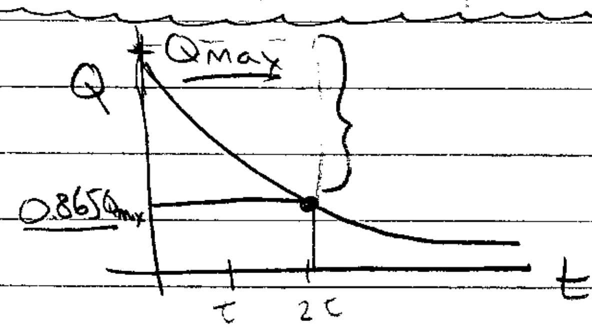

$$Q = Q_{max}(1 - e^{-t/\tau})$$

ratio: $\frac{Q(2\tau)}{Q_{max}} = \frac{Q_{max}(1-e^{-2\tau/\tau})}{Q_{max}}$

$$= 1 - e^{-2} = 1 - \frac{1}{e^2} = \boxed{86.5\%}$$

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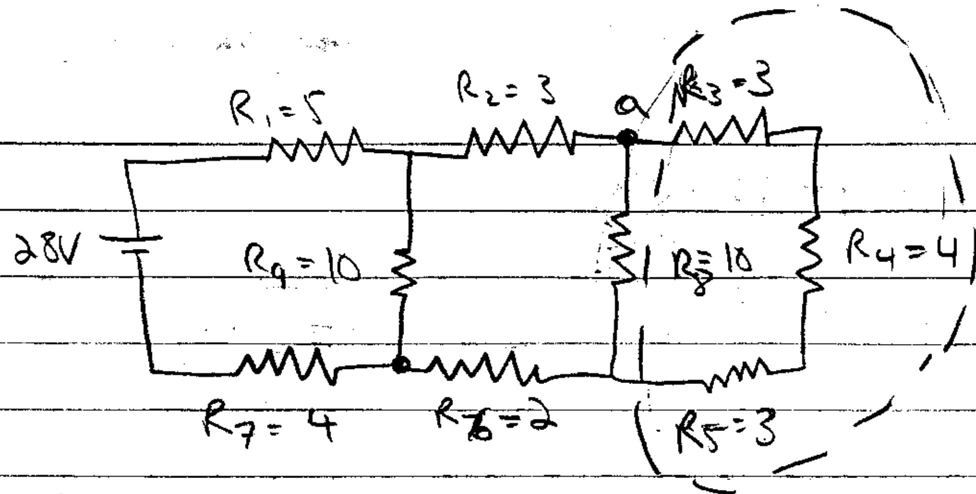
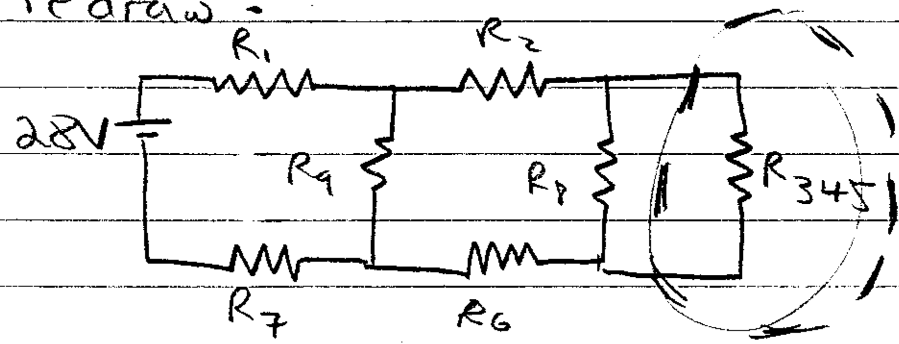
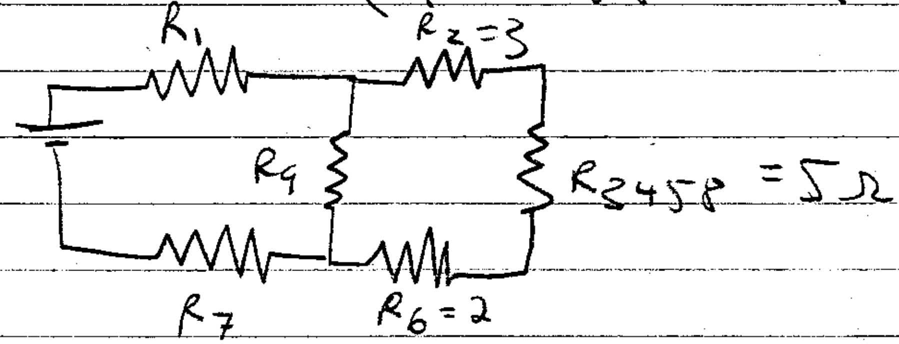


- R_3, R_4, R_5 are is series
  $\Rightarrow R_{345} = 3\Omega + 4\Omega + 3\Omega = 10\Omega$

- redraw:



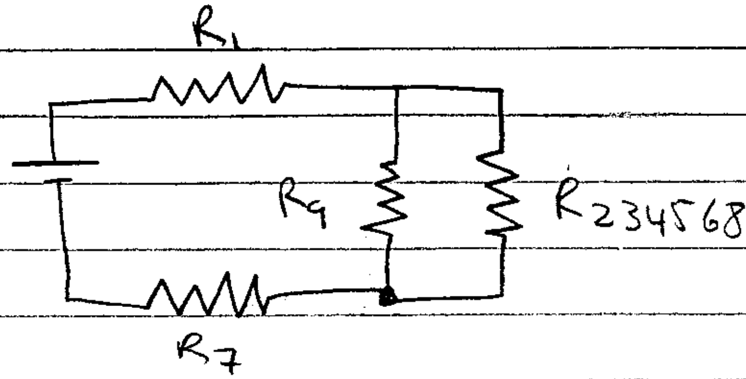
- R_8 and R_{345} are in paralle:
  $\Rightarrow R_{3458} = \left(\frac{1}{R_8} + \frac{1}{R_{345}}\right)^{-1} = \left(\frac{1}{10} + \frac{1}{10}\right)^{-1} = 5\Omega$

- 

- R_2, R_6, R_{3458} are in series, so

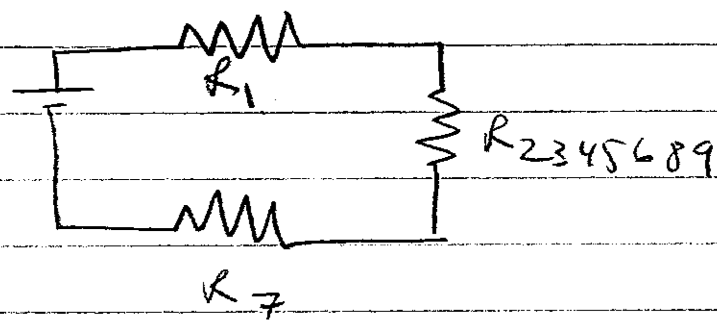
  $R_{234568} = 10\,\Omega$

cont →



• R_9, R_{234568} are in parallel

$$R_{2345689} = \left(\frac{1}{R_9} + \frac{1}{R_{234568}}\right)^{-1} = 5\,\Omega$$



• the rest are in series, so

$$R_{eq} = 5\,\Omega + 5\,\Omega + 4\,\Omega = \boxed{14\,\Omega}$$

• Power $= P = \dfrac{\Delta V^2}{R_{eq}} = \dfrac{(28\,V)^2}{14\,\Omega} = \boxed{56\,W}$

• The $5\,\Omega$ resistor "sees" all the current before it's split at a junction

so $I_5 = \dfrac{\Delta V}{R_{eq}} = \dfrac{28\,V}{14\,\Omega} = \boxed{2\,A}$