ANSWER KEY

Physics 1B(b) Quiz 3

Winter 2010

Version B

Reff in series > Reff in parallel

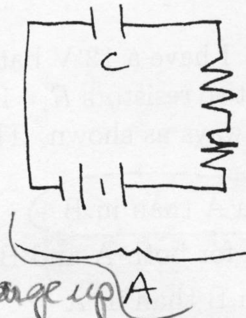
$\Rightarrow \tau_{series} > \tau_{parallel} \Rightarrow$ B charges up faster than A

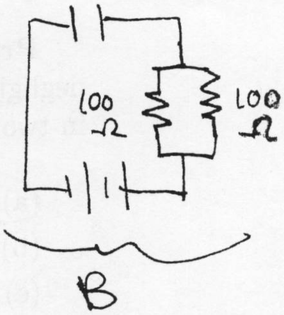
Problem 1: I charge up a capacitor C in the following configurations. Which configuration charges the capacitor faster?

(a) A charges up faster than B

[✓ (b) B charges up faster than A]

(c) Both A and B charge up at the same rate





- Time constant = $\tau = RC$
- Bigger time constant means longer time to charge up

Problem 2: The resistivity of tungsten is 5.6×10^{-8} ohms-m. If I make a light bulb filament from tungsten wire that has a radius of .01 mm designed for a 100 W light bulb with 120 V, what is the length of the wire I need in the filament?

(a) 0.340 m

(b) 0.100 m

(c) 0.679 m

[✓ (d) 0.808 m]

$R = \frac{\rho L}{A}$ and $P = \frac{(\Delta V)^2}{R} \Rightarrow R = \frac{(\Delta V)^2}{P}$

$\Rightarrow \frac{(\Delta V)^2}{P} = \frac{\rho L}{A} \Rightarrow L = \frac{A(\Delta V)^2}{\rho P} = \frac{\pi(10^{-5}m)^2\cdot(120V)^2}{(5.6\times10^{-8}\Omega\cdot m)(100W)}$

$\approx \boxed{.808\,m}$

Problem 3: When I close the switch in the circuit shown, the capacitor begins to charge. What is the current in the resistor after 50 milliseconds?

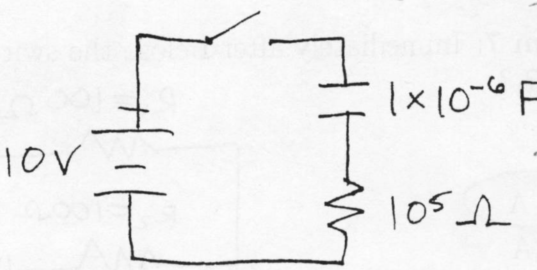
$\rightarrow t = 50ms = 5\times10^{-2}s$

(a) 1.21 ×10^{-4} A

(b) 6.07 ×10^{-3} A

[✓ (c) 6.07 ×10^{-5} A]

(d) Zero



$\tau = RC = (10^{-6}F)(10^5\Omega) = 0.1s$

Kirchhoff's Loop Rule:

$\mathcal{E} - IR - \frac{Q}{C} = 0$

At Q_{max}, $I = 0$

$\Rightarrow \mathcal{E} - \cancel{IR}^{0} - \frac{Q_{max}}{C} = 0$

$\Rightarrow Q_{max} = \mathcal{E}C$

Capacitor charge-up eqn:

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

$= \mathcal{E}C(1 - e^{-5\times10^{-2}s/0.1s}) = \mathcal{E}C(1 - e^{-0.5})$

$= (10V)(10^{-6}F)(.393) = 3.93\times10^{-6}C$

Back to Loop Rule, $10V - I(10^5\Omega) - \frac{3.93\times10^{-6}C}{10^{-6}F} = 0$

$\Rightarrow \boxed{I = 6.07\times10^{-5}A}$

Version B

Problem 4: Referring to the previous problem, what is the charge on the capacitor after 100 milliseconds?

(a) 5.18 ×10^{-5} C

[✓ (b) 6.32 ×10^{-6} C]

(c) 3.68 ×10^{-8} C

(d) Zero

After 100 ms,

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

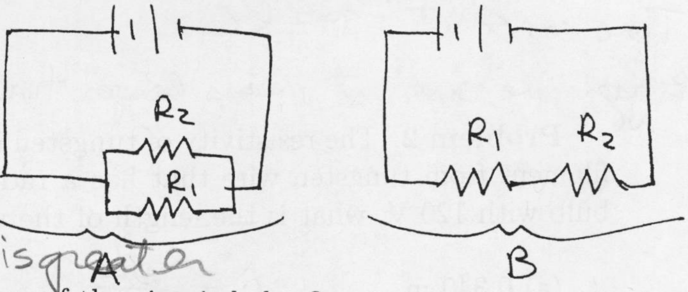
$$\Rightarrow Q = (10V)(10^{-6}F)(1-e^{-0.1s/0.1s}) = \boxed{6.32\times10^{-6}C}$$

Problem 5: I have a 12 V battery with an internal resistance that is low (i.e., r = negligible) with two resistors R_1=100 ohms and R_2=50 ohms. I wire up the components in two different ways as shown. The power dissipated in the circuits is

[✓ (a) greater in A than in B]

(b) the same for both A and B

(c) greater in B than in A



$P = \frac{(\Delta V)^2}{R}$ $R_{eff, series} > R_{eff, parallel}$

$\Rightarrow$ Power dissipated in A is greater

Problem 6: What is the total resistance of the circuit below?

(a) 1400.0 ohms

(b) 666.7 ohms

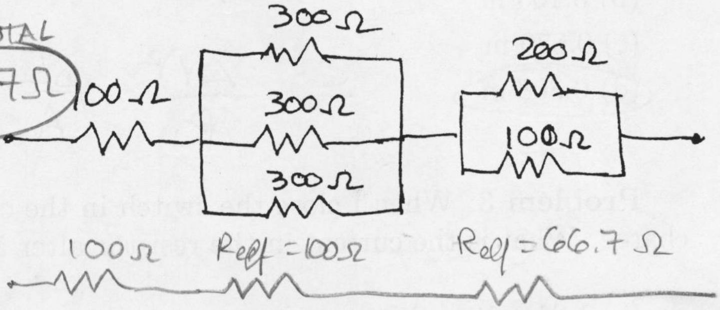
(c) 366.7 ohms

(d) 837.2 ohms

[✓ (e) None of the above]

$\Rightarrow R_{eff, TOTAL}$

$= \boxed{266.7\Omega}$



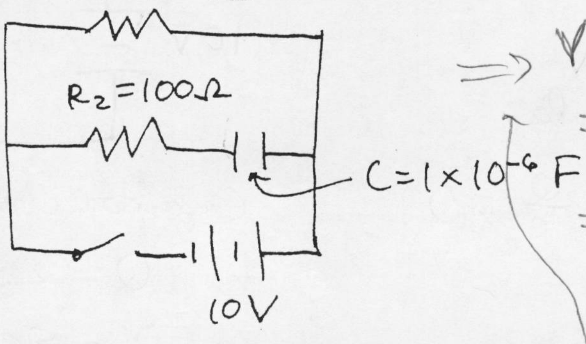
Problem 7: Immediately after I close the switch in the circuit shown, what is the current in R_1?

(a) zero

[✓ (b) 0.10 A]

(c) 0.20 A

(d) 0.05 A



$\Rightarrow V = IR_1$

$\Rightarrow I = \frac{V}{R_1}$

$\Rightarrow I = \frac{10V}{100\Omega}$

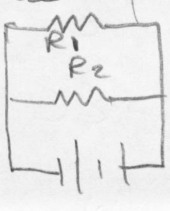
$\Rightarrow \boxed{I = 0.1 A}$

Immediately after I close the switch, $t \sim 0$.

$\Rightarrow Q = Q_{max}(1-e^{-0s/\tau})$

$= Q_{max}(1-1) = 0$

$\Rightarrow Q = 0$, $\rightarrow$ therefore, circuit essentially becomes



Version B

Problem 8: Referring to the circuit above, what is the charge on the capacitor after a long time? Is there a current in R_1?

(a) 10^{-7} C and no current in R_1

[✓ (b) 10^{-5} C and yes, there is a current in R_1]

(c) 10^{-7} C and yes, there is a current in R_1

(d) 10^{-5} C and no current in R_1

After a long time, $t \to \infty$

$$\Rightarrow Q_{max} = \mathcal{E} C$$
$$= (10V)(10^{-6} F) = 10^{5} C$$

And since R_1 is in a separate branch, it will still have a current

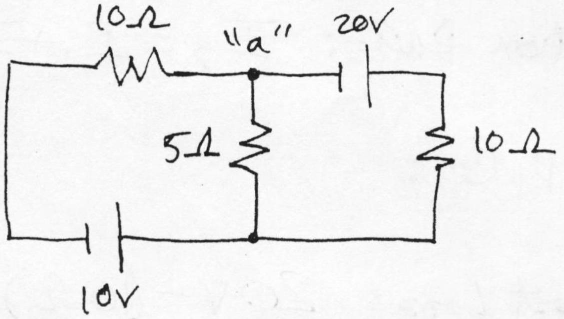
Problem 9: Use Kirchoff's rules to solve the following circuit. What is the current through the 5 ohm resistor? (Hint: Start at point "a" and go around each of the loops. Define a current direction.)

(a) 1.00 A

(b) 1.25 A

[✓ (c) 1.50 A]

(d) 2.00 A



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Problem 10: A long, long time ago when I was young, one of the things at Christmas that drove me crazy was the Christmas tree lights because very often none of them lit up. How could this have happened?

(a) I forgot to plug the string of lights in

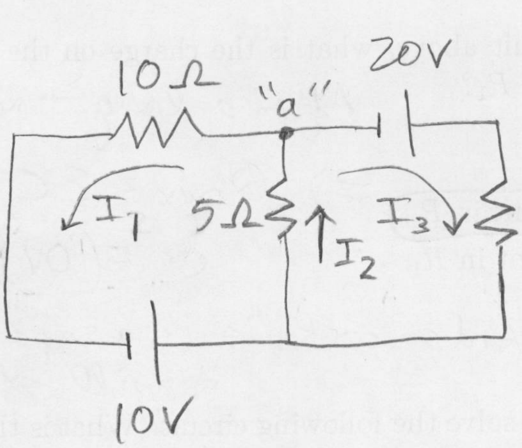
(b) They were connected in series and one burnt out bulb opened the circuit

(c) Too many strings were connected together and a fuse blew

[✓ (d) All of these]

(e) None of these

Mark Version B on your Scantron



Junction Rule: $I_2 = I_1 + I_3$

Loop Rule:

Rightmost Loop: $20V - (10\Omega)I_3 - (5\Omega)I_2 = 0$

$$\Rightarrow 4A - 2I_3 - I_2 = 0$$

Leftmost Loop: $10V - (5\Omega)I_2 - (10\Omega)I_1 = 0$

$$\Rightarrow 2A - I_2 - 2I_1 = 0$$

$$\Rightarrow 6A - 2(I_1 + I_3) - 2I_2 = 0$$

$$\Rightarrow 6A - 2I_2 - 2I_2 = 0$$

$$\Rightarrow 6A = 4I_2$$

$$\Rightarrow \boxed{I_2 = 1.5\ A}$$