Physics 1520, Fall 2011
Quiz 4, Form: A

Name: Key

Date: _____

Numeric answers must include units. Sketches must be labeled. All short-answer questions must include your reasoning, for full credit. A correct answer with no reasoning will only receive partial credit.

Resistance of a wire: $R = \frac{\rho L}{A}$

3 pts. for mc. questions

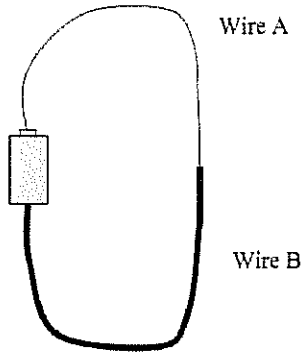
Section 1. Multiple Choice

1. A current of 0.5 A flows through a resistor. How many electrons flow through the resistor in 1 second?

$\left(0.5\ \frac{C}{s}\right)\left(\frac{1\ e^-}{1.6\times10^{-19}C}\right) = 3.125\times10^{18}$ electrons

   (a) 1 electron
   (b) 1.6×10^{-19} electrons
   (c) 6.25×10^{18} electrons
   (d) 3.125×10^{18} electrons
   (e) 1.6×10^{19} electrons

Questions 2–3: Two wires of the same length are connected in series to a battery, as shown below. Wire B has a cross-sectional area that is twice the cross-sectional area of Wire A.



2. Which wire has a greater resistance?

$R = \frac{\rho L}{A}$ so $R \propto \frac{1}{A}$

small A, large R

   (a) Wire A
   (b) Wire B
   (c) Neither. They have the same resistance since they have the same length.

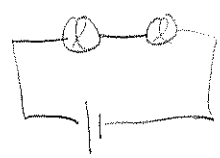
3. The current through Wire B is

Conservation of charge.

wires are in series!

   (a) twice the current through Wire A.
   (b) half the current through Wire A.
   (c) four times the current through Wire A.
   (d) one-fourth the current through Wire A.
   (e) equal to the current through Wire A.

4. A 5 Ω bulb and a 10 Ω bulb are connected in series with a 1.5 V battery. Which bulb will be brighter?



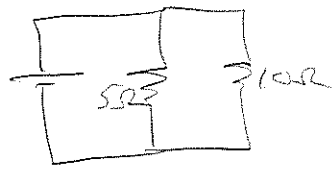
same I

   (a) 5 Ω bulb
   (b) 10 Ω bulb
   (c) Neither; they will have the same brightness

$P = I\Delta V$ $\quad \Delta V = IR$

larger R has larger ΔV and larger P

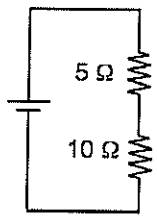
5. A 5 Ω bulb and a 10 Ω bulb are connected in parallel with a 1.5 V battery. Which bulb will be brighter?



(a) 5 Ω bulb
(b) 10 Ω bulb
(c) Neither; they will have the same brightness

Same ΔV.
Smaller R has larger I and larger P.

6. What is the equivalent resistance of the resistors shown below?



(a) 0.3 Ω
(b) 5 Ω
(c) 3.3 Ω
(d) 15 Ω
(e) 25 Ω

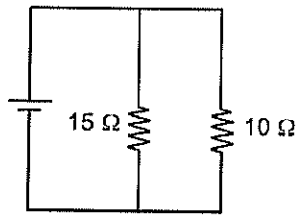
$R_{eq} = 5 + 10$
$= 15\,\Omega$

7. For the circuit in the previous question, if you add a third resistor in series with those shown, the current through the battery will

(a) be more than with the two resistors
(b) be less than with the two resistors
(c) stay the same as with the two resistors

as $R_{eq} \uparrow$, $I \downarrow$

8. What is the equivalent resistance of the resistors shown below?



$\frac{1}{R_{eq}} = \frac{1}{15\Omega} + \frac{1}{10\Omega}$

$R_{eq} = 6\,\Omega$

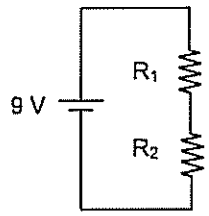
(a) 1/6 Ω
(b) 5 Ω
(c) 6 Ω
(d) 15 Ω
(e) 25 Ω

9. For the circuit in the previous question, if you add a third resistor in parallel with those shown, the current through the battery will

(a) be more than with the two resistors
(b) stay the same as with the two resistors
(c) be less than with the two resistors

Adding a R in parallel decreases R_{eq}.
If $R_{eq} \downarrow$, then $I \uparrow$

10. For the resistors in the circuit below, $\Delta V_2 = 2.0$ V. What is ΔV_1?



$\Delta V_1 + \Delta V_2 = 9.0\,V$

$\Delta V_1 = 9V - \Delta V_2$

$= 9V - 2V = 7V$

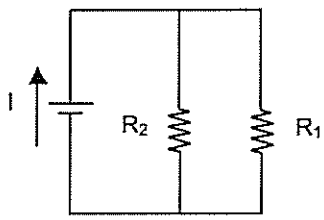
(a) 11.0 V
(b) 2.0 V
(c) 9.0 V
(d) 7.0 V
(e) 4.0 V

11. For the circuit in the previous question, if the current through R_1 is 0.1 A, then the current through R_2 is

I is the same because they are in series.

(a) less than 0.1 A
(b) greater than 0.1 A
(c) 0.1 A

12. For the resistors in the circuit below, the current flowing through the battery is 0.05 A. If the current through R_2 is 0.02 A, what is the current through R_1?



$I = I_1 + I_2$

$I_1 = I - I_2$

$= 0.05A - 0.02A$

$= 0.03A$

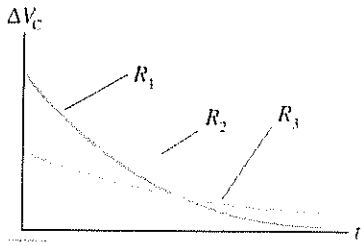
(a) 0.07 A
(b) 0.02 A
(c) 0.05 A
(d) 0.04 A
(e) 0.03 A

13. For the circuit in the previous question, if the voltage across the battery is 3.0 V, the voltage across R_2 is

ΔV is the same for elements in parallel.

(a) less than 3.0 V
(b) greater than 3.0 V
(c) 3.0 V

14. In an experiment, the voltage across a discharging capacitor is graphed as a function of time. The resistance in the circuit is changed, and the experiment is repeated. A graph of ΔV_C vs. t for three different resistances is shown below.



Rank, in order from largest to smallest, the values of the resistances R_1, R_2, and R_3.

(a) $R_1 > R_2 > R_3$

(b) $R_3 > R_2 > R_1$

(c) $R_2 > R_1 > R_3$

(d) $R_1 > R_3 > R_2$

(e) $R_2 > R_3 > R_1$

RC is the time constant, so longer R gives longer decay time.

$R_2 > R_3 > R_1$

15. Suppose that you use a 10 Ω bulb when charging a 1 F capacitor, and you measure the time required to charge the capacitor. You then disconnect the charged capacitor from the circuit and connect it to a 5 Ω bulb, and it discharges. The time it takes to discharge through the 5 Ω bulb will be

(a) greater than the time it took to charge through the 10 Ω bulb.

(b) less than the time it took to charge through the 10 Ω bulb.

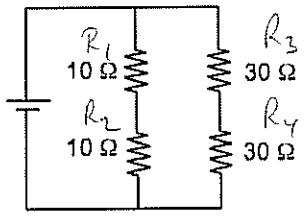
(c) equal to the time it took to charge through the 10 Ω bulb.

$\tau = RC$

Smaller R will give smaller τ.

Section 2. Problem Solving

16. (a) What is the equivalent resistance of the circuit below?



+10

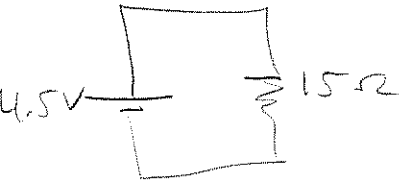
$R_1 + R_2 = 20\,\Omega$

$R_3 + R_4 = 60\,\Omega$

$\frac{1}{R_{eq}} = \frac{1}{20\,\Omega} + \frac{1}{60\,\Omega}$

$R_{eq} = 15\,\Omega$

(b) What is the current through the battery if the voltage across the battery is 4.5 V?

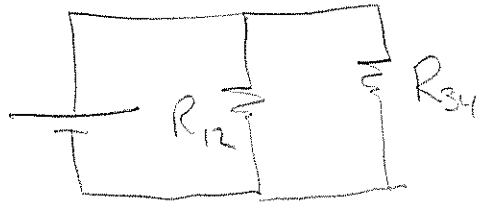


$I = \frac{\Delta V}{R}$

$= \frac{4.5\,V}{15\,\Omega} = 0.3A$

+10

(c) What is the current through each resistor?



I through battery is 0.3A

$I_{12} = \frac{\Delta V_{12}}{R_{12}} = \frac{4.5\,V}{20\,\Omega} = 0.225A$

$I_{34} = \frac{4.5\,V}{60\,\Omega} = 0.075A$

Note: $0.3A = 0.225A + 0.075A$ as it should.

$I_1 = I_2 = 0.225A$

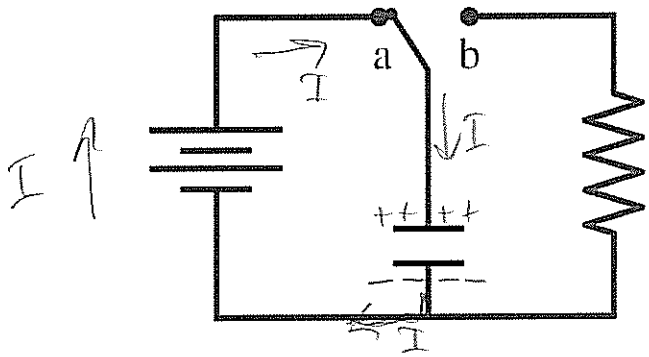
$I_3 = I_4 = 0.075A$

since R_1 and R_2 are in series and R_3 and R_4 are in series.

+10

30

17. A 0.5 F capacitor is charged by connecting it in series with a 1.5 V battery (when the switch is in position a). Then, the capacitor is disconnected from the battery and is connected to a 10.0 Ω light bulb (when the switch is in position b). The capacitor is fully charged when it is connected to the light bulb. Assume that the light bulb is an ohmic resistor and thus obeys Ohm's law.



I is flow of positive charge – conventional current.

(a) Sketch charge on the top plate and on the bottom plate to show which plate is positively charged and which plate is negatively charged. +4

(b) What is the initial voltage across the capacitor when it is connected to the light bulb?

$\Delta V = 1.5\,V = \Delta V_{bat}$ when fully charged by the battery. (KVL applied to bat. and cap.) +5

(c) What is the time constant τ for this circuit?

$\tau = RC = (0.5\,F)(10\,\Omega) = 5\,s$ +8

(d) What is the voltage across the capacitor at $t = 5$ s?

$\Delta V = \Delta V_{max} e^{-t/RC}$

$= (1.5\,V) e^{-\frac{t}{5s}}$ +8

$= (1.5\,V) e^{-1}$

$= \boxed{0.55\,V}$

25