Physics 212, Spring 2009
Quiz 4, Form: A

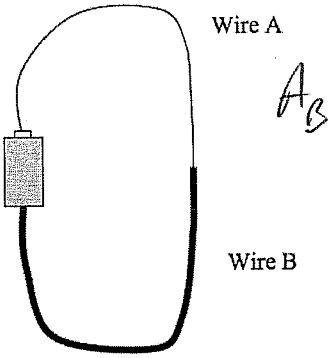
Name: Key

Date: 3/23/09

Magnitude of the charge of an electron or proton: $e = 1.6\times10^{-19}$ C.

Section 1. Multiple Choice

1. 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.



$A_B = 2A_A$

The current through Wire B is

- (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.

Conservation of charge
$I_{in} = I_{out}$
so $I_A = I_B$

2. For the previous question, the drift speed of electrons in Wire B is

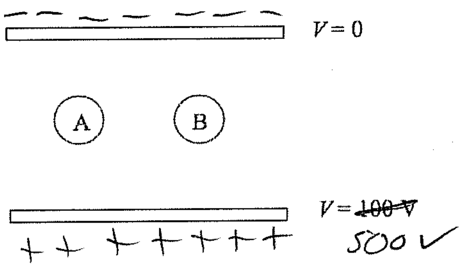
- (a) twice the drift speed of electrons in Wire A.
- [✓ (b)] half the drift speed of electrons in Wire A.
- (c) four times the drift speed of electrons in Wire A.
- (d) one-fourth the drift speed of electrons in Wire A.
- (e) equal to the drift speed of electrons in Wire A.

$I = neAv_d$
so $A_A v_{d_A} = A_B v_{d_B}$
$2A$ gives $\frac{1}{2}v$

3. The filament of a light bulb is non-ohmic, which means that its resistance is not constant. Which has a greater resistance, a cool filament (lower temperature) or a hot filament (higher temperature). (Think about your model for current in which mobile electrons collide with atoms as they flow through the metal.)

- (a) a cool filament
- [✓ (b)] a hot filament
- (c) neither; they will have the same resistance because the resistance will not depend on temperature

Questions 4–5 srefer to the following situation: Gel electrophoresis is a technique used to identify molecules such as certain proteins or nucleotides, for example. Two such molecules are shown below.



4. If the molecules are negatively charged, toward which plate will they migrate?

- (a) 0 V plate
- [✓ (b)] 500 V plate

5. Suppose that $q_A = 2q_B$ and suppose that the drag coefficient is the same for the two molecules. Which molecule will have a greater terminal speed and will thus travel farther between the plates in one hour?

- [✓ (a)] A
- (b) B
- (c) Neither, because they will have the same terminal speed.

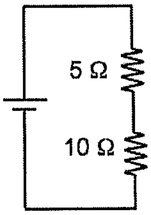
$I = \frac{\Delta V}{R}$

6. If you double the area of the plates of a capacitor, its capacitance will

$C = \frac{K\epsilon_0 A}{d}$

- (a) remain the same.
- (b) increase by a factor of 4.
- (c) decrease by a factor of 1/4.
- [✓ (d) increase by a factor of 2.]
- (e) decrease by a factor of 1/2.

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



$R_{eq} = R_1 + R_2$

$= 15\Omega$

- (a) 0.3 Ω
- (b) 5 Ω
- (c) 3.3 Ω
- [✓ (d) 15 Ω]
- (e) 25 Ω

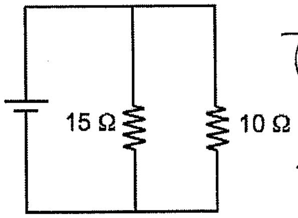
8. For the circuit in the previous question, if you add a third resistor in series with those shown, the current through the battery will

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

increase R_1
decrease I

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

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



$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

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

$= \frac{2}{30} + \frac{3}{30}$

$= \frac{5}{30}$

$\frac{1}{R_{eq}}$

$R_{eq} = \frac{30}{5} = 6\,\Omega$

- (a) 1/6 Ω
- (b) 5 Ω
- [✓ (c) 6 Ω]
- (d) 15 Ω
- (e) 25 Ω

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

decrease
increase

- [✓ (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

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

$1A = \left(\frac{1C}{s}\right)\left(\frac{1 \text{ electron}}{1.6\times10^{-19}C}\right)$

So $(0.5A)\left(\frac{1 \text{ electron}}{1.6\times10^{-19}C}\right)$

$\sim 3.125 \times 10^{18}$ elect

- (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

12. 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 $P = I\Delta V$

So bigger ΔV, bri

$\Delta V = IR$, so bigger R is brighter

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

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

Same ΔV, so bigger I is brighter. Smaller R will have bigger I

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

14. If you double the length of a wire, its resistance changes by a factor

$R = \rho\frac{L}{A}$ So $R \propto L$

2L gives 2R

- (a) 1/2
- (b) 1/4
- (c) 1; its resistance stays the same.
- [✓ (d) 2]
- (e) 4

15. If you decrease the radius of a wire by 1/2, its resistance changes by a factor

$R = \rho\frac{L}{A} = \rho\frac{L}{\pi r^2}$

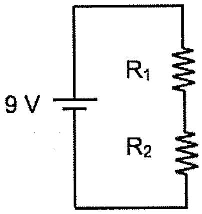
↑ radius

$R \propto \frac{1}{r^2}$

$\frac{1}{(\frac{1}{2})^2} = 4$

- (a) 1/2
- (b) 1/4
- (c) 1; its resistance stays the same.
- (d) 2
- [✓ (e) 4]

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



Loop Rule:

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

$= \Delta V_1 + 2V$

$\Delta V_1 = 9 - 2$

$= 7V$

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

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

(a) less than 0.1 A
(b) greater than 0.1 A
[✓ (c)] 0.1 A

Same I since R_1 and R_2 are in series

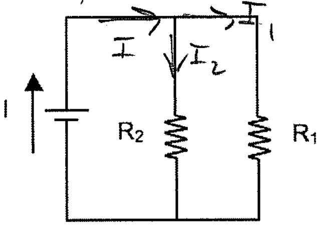
18. Suppose that you use a 10 Ω bulb when charging a 1 F capacitor, and you measure the time required to charge the capacitor. You then disconnect the charged capacitor from the circuit and connect it to a 5 Ω bulb, and it discharges. The time it takes to discharge through the 5 Ω bulb will be

(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.

time constant

$\tau = RC$

19. 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?



$I = 0.05 A$

$= I_1 + I_2$

$0.05 = I_1 + 0.02$

$I_1 = 0.05 - 0.02$

$= 0.03 A$

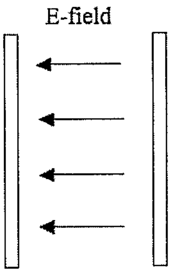
(a) 0.07 A
(b) 0.02 A
(c) 0.05 A
(d) 0.04 A
[✓ (e)] 0.03 A

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

(a) less than 3.0 V
(b) greater than 3.0 V
[✓ (c)] 3.0 V

Elements in parallel have the same voltage.

21. The electric field between oppositely charged plates is shown below.

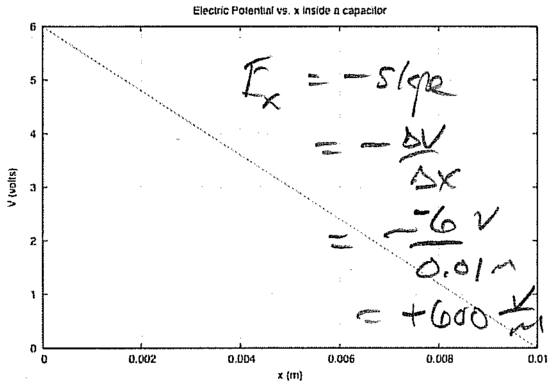


$\vec{E}$ points "downhill" toward lower V

Which plate is at a higher electric potential? (i.e. higher volts)

[✓ (a)] the plate on the right
(b) the plate on the left
(c) neither, because the plates are at the same potential

22. In lab, you measured the electric potential at various points inside and outside a capacitor, and you plotted the potential vs. x to find the electric field inside the capacitor. For the graph, shown below, what is the electric field?



$E_x = -\text{slope} = -\frac{\Delta V}{\Delta x} = \frac{-6\ V}{0.01\ m} = +600\ \frac{V}{m}$

(a) 6 V/m
[✓ (b)] 600 V/m
(c) -0.01 V/m
(d) -0.06 V/m
(e) -6 V/m

23. If you connect a 3.0 V battery across a 0.5-m long copper wire, what will be the electric field within the wire that causes current to flow through the wire?

(a) 1.5 N/C
(b) 2.5 N/C
(c) 3.0 N/C
(d) 3.5 N/C
[✓ (e)] 6.0 N/C

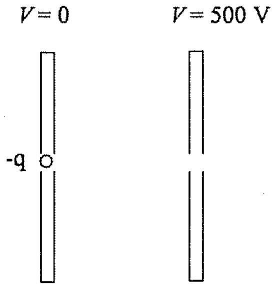
$|\Delta V| = |E| L$ since

E is constant

$E = \frac{\Delta V}{L} = \frac{3\ V}{0.5\ m} = 6\ \frac{V}{m}$

Note: a $\frac{V}{m}$ is the same unit as a $\frac{N}{C}$

24. An electron ($q = -1.6 \times 10^{-19}$ C) that is initially at rest is accelerated across plates that have a potential difference of 500 V.



$\Delta KE + \Delta PE = 0$

$K_f - \cancel{K_i} + q\Delta V = 0$

at rest

$K_f = -q\Delta V$

What is the final kinetic energy of the electron, in joules?

(a) -1.6×10^{-19} J
(b) 500 J
(c) 313 J
(d) 8000 J
[✓ (e)] 8×10^{-17} J

$K_f = -(-1.6 \times 10^{-19}\ C)(500\ V) = 8 \times 10^{-17}\ J$

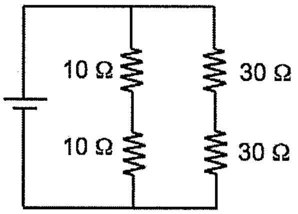
25. A real battery has internal resistance. The voltage across the terminals of a real battery, when current flows through the battery, will be

(a) equal to the emf of the battery.
(b) greater than the emf of the battery.
[✓ (c)] less than the emf of the battery.

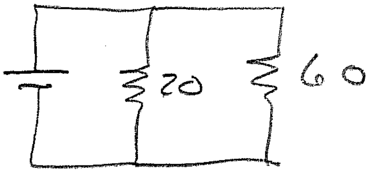
$\Delta V_{batt} = \mathcal{E} - Ir$

Section 2. Problem Solving

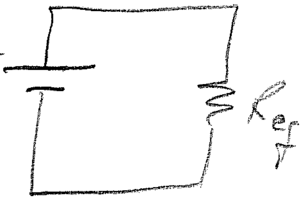
26. (a) What is the equivalent resistance of the circuit below?



Same $\Rightarrow$ as



Same $\Rightarrow$ as



combine:
$10 + 10 = 20\,\Omega$

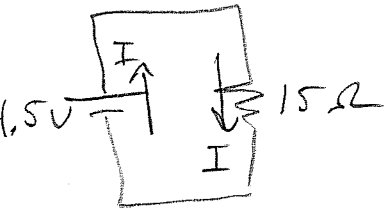
combine!
$30 + 30 = 60\,\Omega$

$$\frac{1}{R_{eq}} = \frac{1}{20} + \frac{1}{60} = \frac{3}{60} + \frac{1}{60}$$

$$\frac{1}{R_{eq}} = \frac{4}{60}$$

$$R_{eq} = \frac{60}{4} = \boxed{15\,\Omega}$$

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

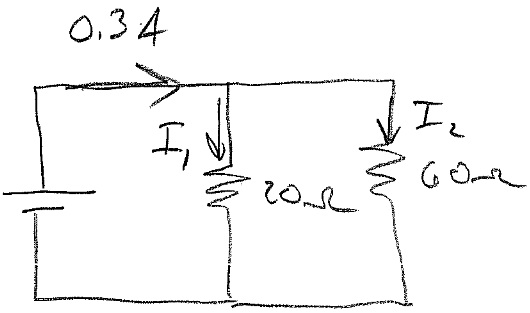


$$\Delta V_R = \Delta V_{bat}$$

$$= 4.5\,V = IR$$

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

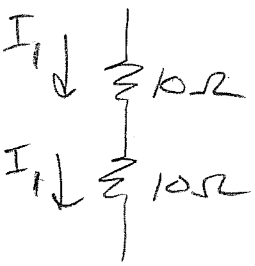
(c) What is the current through each resistor?



$\Delta V = 4.5\,V$ across each resistor.

$$\text{so} \quad I_1 = \frac{\Delta V}{R} = \frac{4.5\,V}{20\,\Omega} = \boxed{0.225\ A}$$

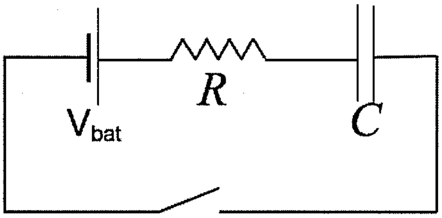
$$I_2 = 0.3 - 0.225 = \boxed{0.075\ A}$$



I through each 10 Ω resistor is 0.225A

I through each 60 Ω resistor is 0.075A

27. A 0.5 F capacitor is charged by connecting it in series with a 1.5 V battery and a 10.0 light bulb, as shown in the circuit below. The capacitor is initially uncharged when the circuit is completed by closing the switch.



(a) What is the current through the bulb at t=0 just after the switch is closed?

$I = \frac{\Delta V_R}{R} = \frac{1.5\ V}{10\ \Omega} = \boxed{0.15\ A}$

(b) What is the current through the bulb when the capacitor is charged to 3/4 of its maximum charge?

$\Delta V_{c\,max} = 1.5\ V$

so at $\frac{3}{4}$ max, $\Delta V_c = 1.125\ V$

$\Delta V_c + \Delta V_R = 1.5$ so

$\Delta V_R = 1.5 - 1.125$

$= 0.375\ V$

$I = \frac{0.375}{10\ \Omega}$

$\boxed{I = 0.0375}$

(c) What is the current through the bulb when the capacitor is fully charged to its maximum possible charge?

$\Delta V_{max} = 1.5\ V$

then $\Delta V_R = 0$ and since $I = \frac{\Delta V_R}{R}$, then $I = 0$

(d) Sketch a graph of ΔV_C vs. t as the capacitor is charging, and sketch a graph of ΔV_R vs. t as the capacitor is charging.

$\Delta V_c = \frac{Q}{C}$

and Q increases from 0

$\Delta V_R = \Delta V_{bat} - \Delta V_c = 1.5\ V - \Delta V_c$

so it starts at 1.5 V and decreases to 0.