Physics 222, Spring 2010
Quiz 5 – Chapters 19-20, Form: A

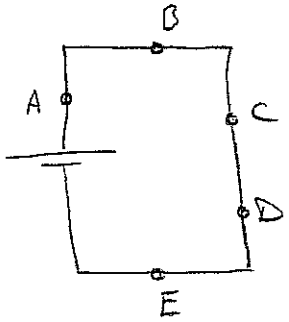
Name: Key
Date: _____

Instructions
You must sketch correct pictures and vectors, you must show all calculations, and you must explain all answers for full credit. Neatness and organization is required. Points will be taken off for sloppy work.

Section 1. Multiple Choice

1.5 pts each; total = 45 pts.

Questions 1–4: A single wire is connected across the terminals of a battery as shown below.



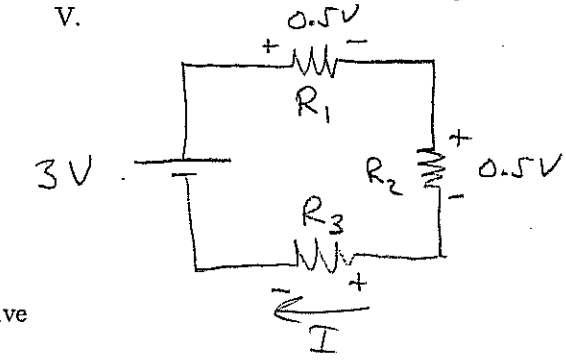
1. The surface charge density is most negative at
   (a) point A
   (b) point B
   (c) point C
   (d) point D
   (e) point E

2. The surface charge density is least negative at
   (a) point A
   (b) point B
   (c) point C
   (d) point D
   (e) point E

3. At which point is the electric field within the wire due to surface charge the greatest?
   (a) point A
   (b) point B
   (c) point C
   (d) point D
   (e) point E
   (f) None of the above, because it is the same at all points.

4. At which point is the current the greatest?
   (a) point A
   (b) point B
   (c) point C
   (d) point D
   (e) point E
   (f) None of the above, because it is the same at all points.

A circuit is connected as shown below. The voltage across R_1 is 0.5 V. The voltage across R_2 is ~~0.5~~ 0.5 V.



5. What is the voltage across R_3?
   (a) 0.5 V
   (b) 1.0 V
   (c) 2.0 V
   (d) 2.5 V
   (e) 3.0 V

KVL:
$\Delta V_{bat} = \Delta V_1 + \Delta V_2 + \Delta V_3$
$3V = 0.5V + 0.5V + \Delta V_3$
$\Delta V_3 = 2V$

6. What is the current through R_1 if $R_1 = 100\ \Omega$?
   (a) 0.005 A
   (b) 0.02 A
   (c) 0.03 A
   (d) 0.5 A
   (e) 50 A

$\Delta V = IR$
$I = \frac{0.5V}{100}$
$= 0.005\ A$

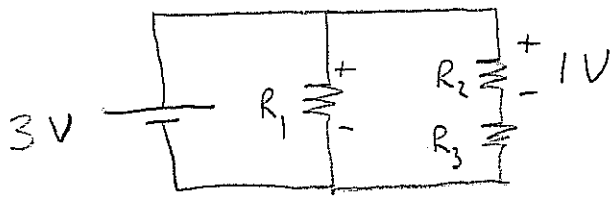
7. In what direction (in the diagram) does conventional current flow through R_3

(a) to the left
(b) to the right

8. In what direction (in the diagram) does electron current flow through R_3

(a) to the left
(b) to the right

A circuit is connected as shown below. The voltage across R_2 is 1.0 V. The resistances are $R_1 = 10\ \Omega$, $R_2 = 10\ \Omega$, and $R_3 = 20\ \Omega$.



9. What is the voltage across R_1?

(a) 2 V
(b) 5 V
(c) 4 V
(d) 1 V
(e) 3 V

R_1 is in parallel with the battery

10. What is the voltage across R_3?

(a) 5 V
(b) 4 V
(c) 3 V
(d) 2 V
(e) 1 V

$\Delta V_{total} = \Delta V_1 + \Delta V_3$

$3V = 1V + \Delta V_3$

11. What is the current through R_1?

(a) 0.075 A
(b) 0.15 A
(c) 0.1 A
(d) 0.3 A
(e) 0.4 A

$I_1 = \frac{\Delta V_1}{R_1} = \frac{3V}{10\Omega} = 0.3A$

12. What is the current through R_3?

(a) 0.05 A
(b) 0.4 A
(c) 0.15 A
(d) 0.2 A
(e) 0.1 A

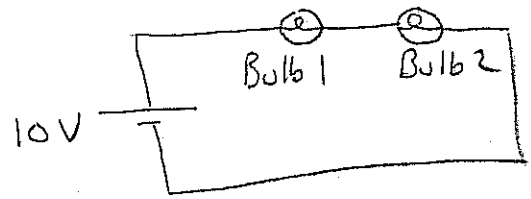
$I_3 = \frac{\Delta V_3}{R_3} = \frac{2V}{20\Omega} = 0.1A$

13. The filament in bulb A as twice the length and twice the radius as the filament in bulb B. The filaments are made of the same material. Which bulb has the *greatest* resistance?

$R \propto \frac{L}{A}$ $\frac{2}{4} = \frac{1}{2}$

(a) Bulb A
(b) Bulb B
(c) Neither, because they have the same resistance

In the circuit below, bulb 1 has a resistance of 10 Ω and bulb 2 has a resistance of 30 Ω.



14. What is the voltage across bulb 1?

(a) 1 V
(b) 1.33 V
(c) 3.33 V
(d) 2.5 V
(e) 3.5 V

Voltage divider

$V_1 = 10V\left(\frac{10}{10+30}\right) = \frac{1}{4}(10V) = 2.5V$

15. Which bulb has the greatest current?

(a) Bulb 1
(b) Bulb 2
(c) Neither, because the have the same current.

KCL

16. Which bulb will be brightest?

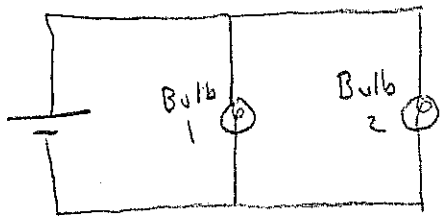
(a) Bulb 1
(b) Bulb 2
(c) Neither, because they will have the same brightness.

power!

$P = IV$

$V_2 > V_1$ so $V_2 = 7.5V$

In the circuit below, bulb 1 has a resistance of 10 Ω and bulb 2 has a resistance of 30 Ω.



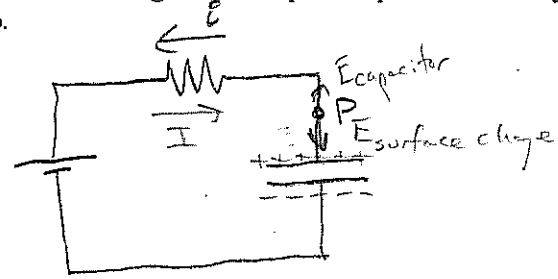
10V

17. Which bulb has the greatest current?
    (a) Bulb 1 less R, greater I
    (b) Bulb 2
    (c) Neither, because they have the same current.

18. Which bulb has the greatest voltage?
    (a) Bulb 1 they are in parallel
    (b) Bulb 2
    (c) Neither, because the have the same voltage.

19. Which bulb will be brightest?
    (a) Bulb 1 $P = I\Delta V$
    (b) Bulb 2
    (c) Neither, because they will have the same brightness.

A capacitor and resistor are connected to a battery as shown below. At $t = 0$, the circuit is connected. The charge on the capacitor plates is initially zero.



20. What is the direction of the electron current through the resistor?
    (a) to the left (as shown in the diagram)
    (b) to the right (as shown in the diagram)

21. In what direction is the electric field due to surface charge on the wire at point P?
    (a) down, toward the bottom of the diagram Same as I
    (b) up, toward the top of the diagram

22. In what direction is the electric field due to the capacitor at point P after some charge builds up on the capacitor?
    (a) down, toward the bottom of the diagram
    (b) up, toward the top of the diagram

23. Which capacitor plate becomes negatively charged?
    (a) the bottom plate shown in the diagram
    (b) the top plate shown in the diagram

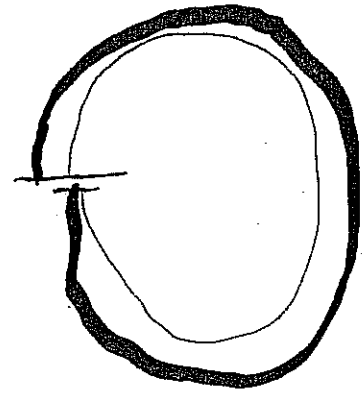
24. As the temperature of a wire increases, the mobility of the wire $V_d = \mu E$
    (a) remains the same.
    (b) decreases. V_d decreased, so μ decreases
    (c) increases.

25. As temperature of a wire increases, the resistance of the wire
    (a) remains the same.
    (b) decreases.
    (c) increases.

26. Which of the following changes will increase the capacitance of a capacitor?
    (a) increase the separation distance, s
    (b) decrease the area of the capacitor plates, A
    (c) increase the dielectric constant, K
    (d) all of the above
    (e) none of the above

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

A thin wire and a thick wire are connected in parallel to the terminals of a battery as shown below. Wire 2 has twice the radius as wire 1.



27. The voltage across wire 2 is

(a) $(1/2)\Delta V_1$
(b) $2\Delta V_1$
(c) $(1/4)\Delta V_1$
(d) $4\Delta V_1$
(e) ΔV_1

they are in parallel

28. The electric field in wire 2 is

(a) $(1/2)E_1$
(b) $2E_1$
(c) $(1/4)E_1$
(d) $4E_1$
(e) E_1

$\Delta V = EL$

so E is the same

29. The current through wire 2 is

(a) $(1/2)I_1$
(b) $2I_1$
(c) $(1/4)I_1$
(d) $4I_1$
(e) I_1

$A = \pi R^2$
$2R \rightarrow 4A$

V_d is the same
$I = neAv_d$
larger area, greater current

30. A 100 Ω resistor is connected to a battery and the current through the battery is 0.01 A. If you add another resistor in parallel with this one, the current through the battery will be

(a) greater than 0.01 A.
(b) less than 0.01 A.
(c) the same, 0.01 A.
(d) it depends on the resistance of the second resistor; the current might be greater than 0.01 A or less than 0.01 A or equal to 0.01 A, depending on the value of this resistor.

R_{eq} for resistors in parallel is less.

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

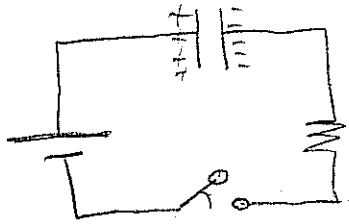
Adding resistors in parallel decreases the equivalent resistance.

So current increased.

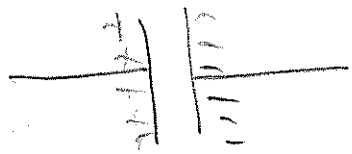
+3 pts each

Section 2. Problem Solving

31. An RC circuit has a 1.5-V battery, a 100kΩ resistor, and a 5 μF capacitor. At $t = 0$, there is no charge on the capacitor plates. At $t = 0$, the switch is closed, and the capacitor begins to charge.



(a) Sketch the charge on the capacitor plates in the picture above.



(b) What is the time constant τ of the RC circuit?

$$\tau = RC = (100 \times 10^3\,\Omega)(5 \times 10^{-6}\,F) = \boxed{0.5\ s}$$

(c) What is the voltage across the capacitor at $t = \infty$?

$$\Delta V_{batt} = \Delta V_C + \Delta V_R$$

at $t = \infty$, $I = 0$ and $\Delta V_R = 0$, so

$$\Delta V_C = \Delta V_{batt} = \boxed{1.5\ V}$$

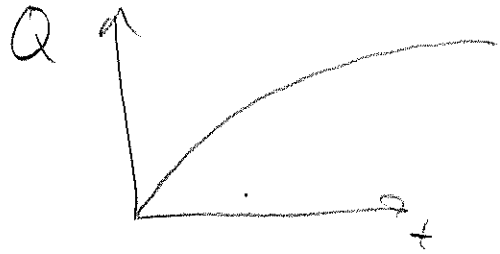
(d) What is the magnitude of the charge on each capacitor plate at $t = \infty$?

$$Q = C\,\Delta V$$

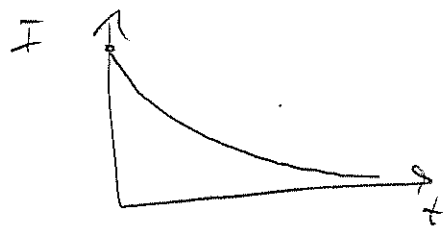
$$Q_{t=\infty} = C\,\Delta V_{t=\infty}$$

$$= (5 \times 10^{-6}\,F)(1.5\,V) = \boxed{7.5 \times 10^{-6}\,C}$$

(e) Sketch a graph of Q vs. t for the charging capacitor.



(f) Sketch a graph of I vs. t for the charging capacitor.



(g) What is the voltage across the capacitor at t=0.25 s?

$$\Delta V_c = \Delta V_{c_0}\left(1 - e^{-\frac{t}{RC}}\right)$$

$$= (1.5\text{V})\left(1 - e^{-\frac{0.25\text{s}}{0.5\text{s}}}\right) = 1.5\left(1 - e^{-\frac{1}{2}}\right)$$

$$= \boxed{0.59\text{ V}}$$

(h) What is the voltage across the resistor at t=0.25 s?

KVL: $\Delta V_{bat} = \Delta V_c + \Delta V_R$

$$1.5 = 0.59 + \Delta V_R$$

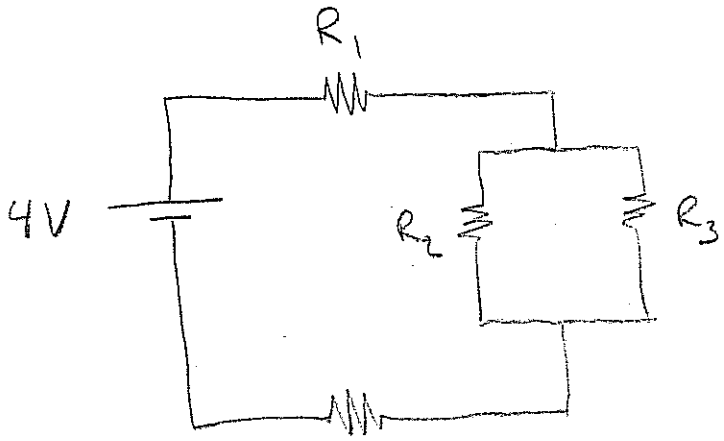
$$\Delta V_R = 1.5 - 0.59 = \boxed{0.91\text{ V}}$$

(i) What is the voltage across the resistor at $t = \infty$?

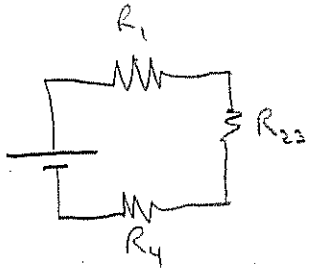
$\Delta V_R = 0$ since $I = 0$ in $\lim t \to \infty$.

32. What is the current through R_4 in the circuit below?

$R_1 = 10\,\Omega$
$R_2 = 20\,\Omega$
$R_3 = 50\,\Omega$
$R_4 = 20\,\Omega$



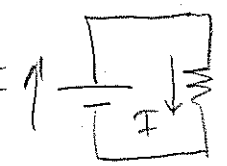
Combine R_2 and R_3



$$\frac{1}{R_{23}} = \frac{1}{R_2} + \frac{1}{R_3}$$

$$R_{23} = \left(\frac{1}{20} + \frac{1}{50}\right)^{-1} = 14.3\,\Omega$$

Combine all resistors



$$R_1 + R_{23} + R_4 = 10 + 14.3 + 20 = 44.3\,\Omega$$

$$\Delta V = IR$$

$$I = \frac{4V}{44.3\,\Omega} = 0.09\,A$$

Current is the same for resistors in series, so

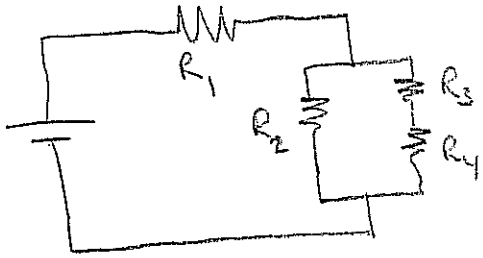
$$I_4 = 0.09\,A$$

which is the same as I_{bat} and I_1.

+25

Section 3. LAB

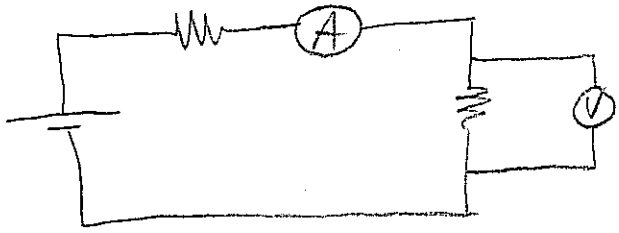
33. (a) Which of the resistors shown in the circuit below are in series? If none are in series, then say this explicitly.



R_3 and R_4 are in series.

(b) Which of the resistors shown in the circuit above are in parallel? If none are in parallel, then say this explicitly. None. No two resistors have both of their terminals connected to each other.

34. Two meters are shown in the picture below. Label the meter that is used as an ammeter to measure current and label the meter that is used as a voltmeter to measure voltage.



○ represents a meter.

Ammeter is connected in series.

Voltmeter is connected in parallel.

35. In an RC circuit, you measure the decay constant to be $\beta = 0.5\ s^{-1}$. What is the time constant τ?

$\tau = \frac{1}{\beta} = \frac{1}{0.5\ s^{-1}} = 2\ s$

36. For an RC circuit where the capacitor is discharging, describe what you would change in order to discharge the capacitor in less time?

$\tau = RC$, so decrease R. Sometimes this is done by using a low resistance wire across the terminals of the capacitor.

37. What is the underlying physical principle that is the basis for Kirchhoff's voltage law?

Conservation of Energy

38. What is the underlying physical principle that is the basis for Kirchhoff's current law?

Conservation of Charge

39. What is the advantage of arranging lights (such as those on a Christmas tree or those in your home) in parallel?

If one light burns out, it does not cause all other lights to turn off. You can take out one bulb, and all others will stay lit.