

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

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

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.

1. The surface charge density is most negative at

A circuit is connected as shown below. The voltage across R_1 is 0.5 V. The voltage across R_2 is 0.8 V.

- (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

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

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.

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

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 $R_3 = 20 \Omega$.

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
13. The filament in bulb A is 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?
- (a) Bulb A
 - (b) Bulb B
 - (c) Neither, because they have the same resistance

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

9. What is the voltage across R_1 ?
- (a) 2 V
 - (b) 5 V
 - (c) 4 V
 - (d) 1 V
 - (e) 3 V
10. What is the voltage across R_3 ?
- (a) 5 V
 - (b) 4 V
 - (c) 3 V
 - (d) 2 V
 - (e) 1 V
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
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
15. Which bulb has the greatest current?
- (a) Bulb 1
 - (b) Bulb 2
 - (c) Neither, because they have the same current.
16. Which bulb will be brightest?
- (a) Bulb 1
 - (b) Bulb 2
 - (c) Neither, because they will have the same brightness.

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

17. Which bulb has the greatest current?

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

18. Which bulb has the greatest voltage?

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

19. Which bulb will be brightest?

- (a) Bulb 1
- (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
- (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

- (a) remains the same.
- (b) 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

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

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

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

30. A $100\ \Omega$ 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.

Section 2. Problem Solving

31. An RC circuit has a 1.5-V battery, a $100\text{k}\Omega$ resistor, and a $5\ \mu\text{F}$ 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?

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

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

(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?

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

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

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

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.

(b) Which of the resistors shown in the circuit above are in parallel? If none are in parallel, then say this explicitly.

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.

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

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

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

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