Electric Current & DC Circuits

PSI AP Physics 1 Name_____

Multiple-Choice

- 1. The length and radius of an aluminum wire is quadrupled. By which factor does the resistance change?
 - (A) 2 (B) 1/2 (C) 1/4 (D) 1
- 2. A copper wire has a length L and cross-sectional area A. What happens to the resistivity of the wire if the length is doubled and cross-sectional area halved?
- (A) Four times as large (B) Stays the same (C) Half as large (D) Quarter as large



Which circuit has greater resistance between the terminals?
 (A) A
 (B) B
 (C) C
 (D) D



4. Which circuits have the same resistance between the terminals? (A) A and B (B) B and C (C) C and D (D) A and D

Questions 5-7



5. In the circuit shown above, what is the value of the net resistance?

(A) 0.75Ω (B) 4.5Ω (C) 6Ω (D) 13Ω

6. What is the current in 4 - Ω resistor?

(A) 2A (B) 3A (C) 9A (D) 12A

7. What is the voltage between points L and M?

(A) 2 V (B) 4 V (C) 8 V (D) 12 V



- 8. A lamp L1, a voltmeter V, an ammeter A, and a battery with zero internal resistance are connected as shown above. Connecting another lamp L2 in series with the first lamp as shown by the dashed lines would
 - (A) Increase the ammeter reading
- (C) Decrease the ammeter reading
- (B) Increase the voltmeter reading
- (D) Decrease the voltmeter reading
- 9. The four resistors shown below have the lengths and cross-sectional areas indicated and are made of material with the same resistivity. Which has the smallest resistance?





10. The circuit shown above left is made up of a variable resistor and a battery with negligible internal resistance. A graph of the power P dissipated in the resistor as a function of the current I supplied by the battery is given above right. What is the emf of the battery?
(A) 0.125 V (B) 5 V (C) 8 V (D) 40 V



- 11. The total equivalent resistance of the circuit shown on the diagram is: (A) 2 Ω (B) 6 Ω (C) 9 Ω (D) 18 Ω
- 12. A heating spiral of resistance R converts electrical energy into thermal energy that is transferred to the liquid in which the spiral is immersed. If the voltage across the spiral is V, the thermal energy transferred to the liquid in time t is:
 - (A) Vrt (B) V^2Rt (C) VR^2t (D) V^2t/R



13. In the circuit two identical resistors R are connected in series with 8-Ω resistor and 12-V battery. What is the value of R if the current in the circuit I = 1 A?
(A) 2 Ω
(B) 4 Ω
(C) 8 Ω
(D) 12 Ω



<u>Questions 14-16</u> relate to the following circuit diagram which shows a battery with an internal resistance of 2.0 ohms connected to an 8-ohm and a 10-ohm resistor in series. The current in the 10-ohm resistor is 0.2 amperes.

- 14. What is the emf of the battery? (A) 0.4 V (B) 3.6 V (C) 4 V (D) 12 V
- 15. What is the potential difference across the terminals A and B of the battery? (A) 1.2 V (B) 2.4 V (C) 3.6 V (D) 12.2 V
- 16. What power is dissipated by the 2-ohm internal resistance of the battery? (A) 0.08 W (B) 0.8 W (C) 1.2 W (D) 6.5 W



- 17. In the diagrams above, resistors R_1 and R_2 are shown in two different connections to the same source of emf ε that has no internal resistance. How does the power dissipated by the resistors in these two cases compare?
 - (A) It is greater for the series connection.
 - (B) It is greater for the parallel connection.
 - (C) It is the same for both connections.
 - (D) One must know the values of R_1 and R_2 to know which is greater.

18. The product 3 amperes x 3 volts x 3 seconds is equal to (A) 27 C (B) 27 N (C) 27 J (D) 27 W

Questions 19-20 refer to the following diagram that shows part of a closed electrical circuit.



19. The electrical resistance of the part of the circuit shown between point X and point Y is

(A) 1.4Ω (B) 2.5Ω (C) 6.2Ω (D) 10Ω

- 20. When there is a steady current in the circuit, the amount of charge passing a point per unit of time is:
 - (A) the same everywhere in the circuit
 - (B) greater at point X than at point Y
 - (C) greater in the 2 Ω resistor than in the 5 Ω resistor
 - (D) the same in the 2 Ω resistor and in the 5 Ω resistor

- 21. A certain coffeepot draws 2.0 A of current when it is operated on 110 V household lines. If electrical energy costs 10 cents per kilowatt-hour, how much does it cost to operate the coffeepot for 5 hours?
 - (A) 2.4 cents (B) 4.8 cents (C) 8.0 cents (D) 11 cents

Questions 22-24



Five identical light bulbs are connected to a 120 V power supply. Each light bulb has a resistance of 15 Ω . The switch is closed.

22. What is the net resistance of the circuit?

(A) 3 Ω (B) 30.1 Ω (C) 40 Ω (D) 75 Ω

23. What is the current in the light bulb L1?

(A) 1.6 A (B) 3 A (C) 8 A (D) 40 A

24. Which light bulb or bulbs could burn out without causing any others to go out?

 $(A) \ Only \ L_1 \qquad (B) \ Only \ L_2 \qquad (C) \ Only \ L_4 \qquad (D) \ Only \ L_5$



A circuit, shown above, has three resisters $R_1 = 60\Omega$, $R_2 = 30\Omega$, and $R_3 = 20\Omega$, an internal resistance $r = 4\Omega$, and a battery 120V. Use this circuit to answer questions 25 - 27.

25. What is the relationship between the three labeled currents?

- 26. If V₁ represents the potential difference across the first resistor, V₂ across the second resistor, V₃ across the third resistor and V the terminal voltage in the battery. What is the relationship between the V₁, V₂, V₃, and V?
 - (A) $V_1 = V_2 = V V_3$ (B) $V_1 + V_2 + V_3 = V$ (C) $V_1 = V_2 = V_3 < V$ (D) $V > V_3 > V_2 > V_1$
- 27. What is the ratio of current I_1 in resistor R_1 to the current in I_2 in resistor R_2 ?
 - (A) $\frac{l_1}{l_2} = \frac{1}{3}$ (B) $\frac{l_1}{l_2} = \frac{1}{2}$ (C) $\frac{l_1}{l_2} = \frac{2}{3}$ (D) $\frac{l_1}{l_2} = \frac{2}{1}$
- 28. A battery has an emf of \mathcal{E} and an internal resistance of r. What resistance R, when connected across the terminals of the battery will make the terminal voltage to be $\frac{1}{2}\mathcal{E}$?
 - (A) ½ r (B) 2r (C) r (D) 4r

Multi-correct Section: For each question or incomplete statement, two of the answers are correct. For each questions you must select both answers.



- 29. In reference to the circuit above, which of the follow statements are true? Choose two answers.
 - (A) The current in R_1 must be the same as the current in R_2 .
 - (B) The current in R_3 must be the same as the current in the battery.
 - (C) The voltage across R_1 must be the same as the voltage across R_2 .
 - (D) The voltage across R_3 must be the same as the voltage across the battery.
- 30. A single resistor is connected across the terminals of a battery. Which of the following will leave the power output unaffected? Choose two answers.
 - (A) Reducing both the resistance and the voltage by a factor of 4.
 - (B) Reducing the resistance by a factor of 4 and the voltage by a factor of 2.
 - (C) Doubling both the resistance and the voltage.
 - (D) Doubling the voltage and increasing the resistance by a factor of 4.



- 31. The diagrams above so four light bulbs of the same type. Two are in series and two are in parallel. Which of the following statements are true? Choose two answers.
 - (A) The light bulbs in the series circuit are brightest since they get the total current.
 - (B) The light bulbs in the parallel circuit draw more power than in the series circuit.
 - (C) The series circuit has more total resistance than the parallel circuit.
 - (D) The parallel circuit has the less total current than the series circuit.

32. The following diagrams show resistors in four different circuits. Which two have the same total resistance? Choose two answers.





(B)





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(D)
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Free-Response Problems

1. A physics student has an assignment to make an electrical heating system with the set of materials listed below:



a. In a space below draw a diagram showing all the elements connected in one electrical circuit that can provide the maximum rate of heat produced. Use two meters in your circuit, they will help to measure the heat rate.



The battery has an emf of 12 V and an internal resistance of 0.5 Ω and each heating coil has a resistance of 17.3 $\Omega.$

- b. When the switch is closed, what is the current running through the battery?
- c. What is the terminal voltage on the battery?
- d. What is the rate of energy delivered by the heating system?
- e. If the switch is closed for 5 min, what is the total energy dissipated in the coils?

- An electric motor in a toy car can operate when connected to a 6 V battery and has a current of 0.5 A. A physics student wants to run the toy car but unfortunately he could find a 12 V battery in the physics lab. The student also found a box with a set of five 6-Ω resistors.
 - a. Use given materials design an electric circuit in which the electric motor will operate properly.
 - i. Draw the circuit including all devices.
 - ii. Explain your reasoning in designing this particular circuit.
 - b. Calculate the net resistance of the circuit.
 - c. Calculate the power dissipated in the circuit.



- 3. Three light bulbs are connected in the circuit show on the diagram. Each light bulb can develop a maximum power of 75 W when connected to a 120-V power supply. The circuit of three light bulbs is connected to a 120 V power supply.
 - a. What is the resistance of the circuit?
 - b. What is the power dissipated by the circuit?
 - c. How would you compare this power to the power when all bulbs are connected in parallel?
 - d. What is the current in light bulb L_1 ?
 - e. What is the voltage across light bulb L_1 ?
 - f. What is the voltage across light bulb L₂?



- 4. Four resistors are connected in a circuit. The circuit is connected to a battery with emf ϵ and negligible internal resistance. The current through 9.6 Ω resistor is 0.25 A.
 - a. What is the net resistance of the circuit?
 - b. What is the voltage drop across 6- Ω resistor?
 - c. What is the current in 4- Ω resistor?
 - d. What is the emf of the battery?
 - e. What is the net power dissipation?



- 5. Five resistors are connected to a battery with an emf of 12 V and an internal resistance of 1 Ω .
 - a. Calculate the external resistance of the circuit.
 - b. Calculate the current in the battery.
 - c. Calculate the terminal voltage of the battery.
 - d. Calculate the power dissipation in the 3- Ω resistor.
 - e. Calculate the power dissipation in the internal resistance.

6. Students in the physics lab have a 30W light bulb and a 40W light bulb. Both are meant to be used in a 120V outlet. They experiment connecting the bulbs in series and in parallel to 120V.

The first student thinks that the 40W bulb will be brighter than the 30W bulb regardless of the connection since brightness depends on the power output and the 40W bulb has a lower resistance therefore a higher power output.

The second student thinks that the 30W bulb will be brighter in either case because, for the same current, the greater the resistance, the greater the power output and the 30W bulb has the greater resistance.

- a. Ignoring if the prediction is correct, what aspect of the first student's argument is correct and incorrect? Explain your reasoning.
- b. Ignoring if the prediction is correct, what aspect of the second student's argument is correct and incorrect? Explain your reasoning.
- c. Rank the following light bulbs from 1 to 4, 1 being the brightest and 4 being the least bright. Justify your answer.

_____ the 30W bulb in parallel

_____ the 40W bulb in parallel

_____ the 30W bulb in series

_____ the 40W bulb in series

Multiple Choice Answers

- 1. B
- 2. B
- 3. B 4. D
- 5. D
- 6. A
- 7. B
- 8. C
- 9. B
- 10. C 11. C
- 12. D
- 13. A
- 14. C
- 15. C
- 16. A 17. B
- 18. C
- 19. B
- 20. D
- 21. D
- 22. C
- 23. B
- 24. D
- 25. D 26. A
- 27. B
- 28. C
- 29. A, D
- 30. B, D
- 31. B, C
- 32. A, D

Free Response Answers

- 1. a) Heating coils in parallel, voltmeter in parallel, ammeter in series.
 - b) 1.3 A
 - c) 11.35 V
 - d) 14.9 W
 - e) 4470 J

- a) Two resistors in series with the motor. This reduces the currents to the required 0.5 A.
 b) 24 Ω
 - c) 6 W
- 3. a) 288 Ω
 - b) 50 W
 - c) The power is less.
 - d) 0.42 A
 - e) 80 V f) 40 V
 - ,
- 4. a) 24 Ω
 - b) 0.6 V
 - c) 0.15 A
 - d) 6 V
 - e) 1.5 W
- 5. a) 8 Ω
 - b) 1.3 A
 - c) 10.7 V
 - d) 2.25 W
 - e) 1.7 W
- 6. a) The 40W bulb does have a lower resistance than the 30W bulb so when the voltage across each is the same, the lower the resistance the higher the power. However the voltage is only the same for each bulb when they are connected in parallel.

b) The 30W bulb does have a higher resistance than the 40W bulb so when the current though each light bulb is the same the higher the resistance, the higher the power. However, they will only have the same current when they are connected in series.
c) Ranking: 2, 1, 3, 4 Corresponding powers: 40W, 30W,

9.4W, 7.1W