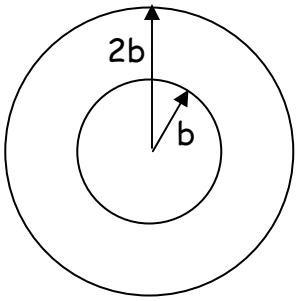
A.P. Physics – B

UNIT 9 TEST REVIEW

Electricity and Circuits: Chapters 18-19

Multiple Choice Review: On this portion of the test, you will not be allowed to use your calculator or AP formula sheet. (You may, however, use your AP table of information.) Approximate $g=10m/s^2$ for simplicity of calculations. No partial credit will be given.

1. Two concentric circular loops of radii b and 2b, made of the same type of wire, lie in the plane of the page, as shown above. If the total resistance of the b-radius loop is R, what is the resistance of the 2b-radius loop?



a. R/4
b. R/2
c. R
d. 2R
e. 4R

2. The total capacitance of several capacitors in parallel is the sum of the individual capacitances for which one of the following reasons?

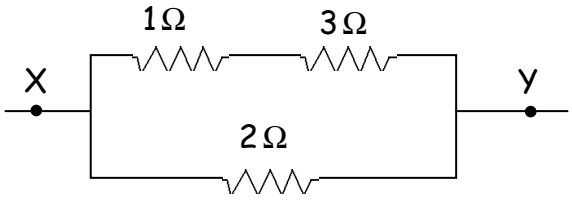
a. The charge on each capacitor depends on its capacitance, but the potential difference across each is the same.
b. The charge is the same on each capacitor, but the potential difference across each capacitor depends on its capacitance.
c. Equivalent capacitance is <u>always</u> greater than the largest individual capacitance.
d. Capacitance in a circuit <u>always</u> combine like resistors in series.
e. The parallel combination increases the effective separation of the plates.

3. How much does it cost to operate a 60W light bulb for 600 minutes, if energy costs 10 cents per kilowatt-hour?

a. 6 cents
b. 10 cents
c. 36 cents
d. 60 cents
e. $3.60

4. Three resistors are connected as shown in the diagram. What is the electrical resistance of the part of the circuit shown?

a. 4/3 Ω
b. 2 Ω
c. 2 ¾ Ω
d. 4 Ω
e. 6 Ω



5. If the group of resistors in #4 is attached to a source of emf, the amount of charge passing a point per unit of time is…

a. the same everywhere in the whole circuit.
b. greater at point X than at point Y.
c. greater in the 1Ω resistor than in the 2Ω resistor.
d. greater in the 1Ω resistor than in the 3Ω resistor.
e. greater in the 2Ω resistor than in the 3Ω resistor.

6. A current of 2A passes through a 50Ω resistor. This resistor must be connected to an emf source of…

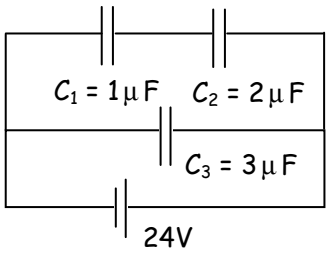
a. .04V
b. 0.4V
c. 2.5V
d. 25V
e. 100V

7. A wire of length L and radius r has a resistance R. What is the resistance of a second wire made from the same material that has length L/2 and radius r/2?

a. 4R
b. 2R
c. R
d. R/2
e. R/4

8. Three capacitors are connected as shown in the diagram. What is the equivalent capacitance of the entire circuit?

a. 6 μF
b. 4.5 μF
c. 3 ⅔ μF
d. 1.5 μF
e. 2/3 μF

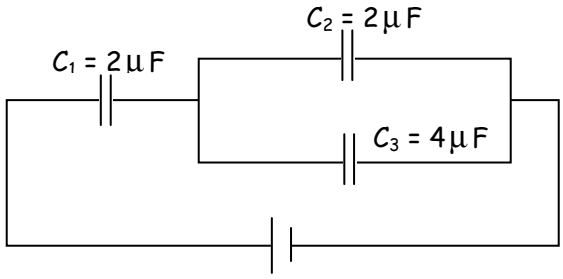


9. Which of the following is NOT true about a circuit (containing a battery) with a 100W light bulb (resistor) connected in series with a 60W light bulb?

a. If one bulb burns out, they'll both go out.
b. The voltage across each bulb is different.
c. The equivalent resistance of the circuit is less than that of either bulb.
d. The current in each bulb is the same.
e. The 60W bulb is brighter than the 100W bulb.

10. Three capacitors are connected in a circuit as shown in the diagram. Once the capacitors have been connected long enough for them to all charge fully, how do the amounts of charge stored by the capacitors compare?

a. $Q_1 > Q_2 > Q_3$
b. $Q_1 > Q_3 > Q_2$
c. $Q_2 > Q_1 > Q_3$
d. $Q_3 > Q_2 > Q_1$
e. $Q_3 > Q_1 > Q_2$



11. A certain battery has an emf of 12V and internal resistance of $2\,\Omega$. If this battery is connected to a circuit in such a way that a current of 0.3A flows through the circuit, what is the terminal voltage of the battery?

a. 11.4V
b. 11.7V
c. 12V
d. 12.3V
e. 12.6V

Problem Review: On this portion of the test, you may use your calculator, AP formula sheet, and AP table of information. Partial credit will be given on these problems.

13. A current of 15 A exists in a wire. How many seconds does it take for 8.0×10^{20} electrons to flow through a given cross section of the wire?

Material	Resistivity	Temp. Coeff. Of Resistivity
Tungsten	5.6×10^{-8}	4.5×10^{-3}
Carbon	3.5×10^{5}	-0.5×10^{-3}
Copper	1.7×10^{-8}	3.9×10^{-3}

***All resistivities are for materials at 20 degrees Celsius. All quantities are in standard SI units.**

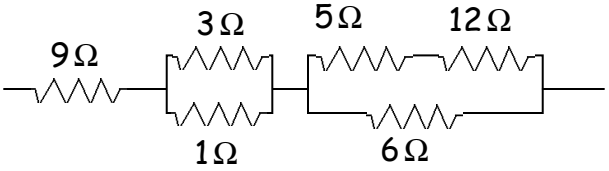
14. Calculate the cross-sectional area of a 2.00cm length of tungsten filament in a small lightbulb if a potential difference of 120V sets up a current in it of 0.24A.

15. How much resistance is present in a 240V generator dissipating 120kW of power?

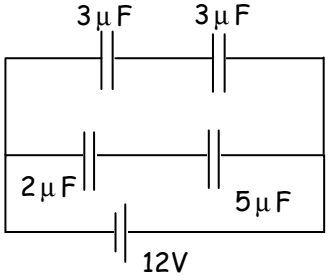
How much energy is dissipated by this resistor in 10 minutes?

16. A certain circuit has been assembled incorrectly, because a $250\,\Omega$ resistor was soldered in the location where a $100\,\Omega$ resistor was meant to be. How can the circuit be fixed without disassembling it?

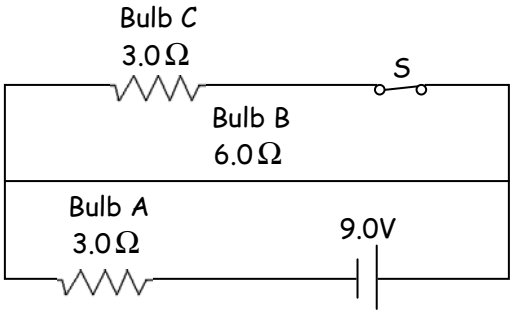
17. Use the rules for resistors connected in parallel and series to calculate the current through the $5\,\Omega$ resistor in the figure, when the complex circuit is attached to a 12V battery.



18. For the circuit shown, find the equivalent capacitance of the circuit, and the charge stored by the $5\,\mu F$ capacitor.



19. Actual A.P. Physics B Free-Response Question (2002):



Lightbulbs of fixed resistance 3.0 Ω and 6.0 Ω, a 9.0V battery, and switch S are connected as shown in the schematic diagram above. The switch S is closed.

a. Calculate the current in bulb A.

b. Which lightbulb is brightest? Justify your answer.

c. Switch S is then opened. By checking the appropriate spaces below, indicate whether the brightness of each lightbulb increases, decreases, or remains the same. Explain your reasoning for each lightbulb.

Bulb A:

The brightness _____ increases _____decreases _____stays the same

Explanation:

Bulb B:

The brightness _____ increases _____decreases _____stays the same

Explanation:

20. Actual A.P. Physics B Free-Response Question (2002):

Two lightbulbs, one rated 30W at 120V and another rated 40W at 120V, are arranged in two different circuits.

a. The two bulbs are first connected in parallel to a 120V source.

i. Determine the resistance of the bulb rated 30W and the current in it when it is connected in this circuit.

ii. Determine the resistance of the bulb rated 40W and the current in it when it is connected in this circuit.

b. The bulbs are now connected in series with each other and a 120V source.

i. Determine the resistance of the bulb rated 30W and the current in it when it is connected in this circuit.

ii. Determine the resistance of the bulb rated 40W and the current in it when it is connected in this circuit.

c. In the spaces below, number the bulbs in each situation described, in order of their brightness. (1 = brightest, 4 = dimmest)

_____ 30W bulb in the parallel circuit
_____ 40W bulb in the parallel circuit
_____ 30W bulb in the series circuit
_____ 40W bulb in the series circuit

d. Calculate the total power dissipated by the two bulbs in each of the following cases:

i. The parallel circuit.

ii. The series circuit.

Answers:

13. $I = \frac{\Delta Q}{\Delta t}$ so $\Delta t = \frac{(8\times10^{20})(1.6\times10^{-19})}{15} = 8.53s$

14. $R = \frac{\Delta V}{I} = \frac{120}{.24} = 500\Omega$ and $R = \rho\frac{L}{A}$ so $A = \frac{(5.6\times10^{-8})(.02)}{500} = 2.24\times10^{-12}m^2$

15. $P = \frac{\Delta V^2}{R}$ so $R = \frac{240^2}{120{,}000} = .48\Omega$

Energy = (P)(t) = (120,000W)(600s) = 7.2×10^7 J (Which is also 20kWh.)

16. Because you want the resistance of the circuit to decrease from 250Ω to 100Ω, you need to solder another resistor in parallel with the existing resistor. $100^{-1} = 250^{-1} + R^{-1}$ and R = 166.7Ω

17. The equivalent resistance = $9 + \left(3^{-1} + 1^{-1}\right)^{-1} + (6^{-1} + (12+5)^{-1})^{-1} = 14.19\Omega$
So, the current through each component in series = 0.846A.
Since $I_{4.44}$ = 0.846A, $\Delta V_{4.44}$ =3.76V. This means ΔV_{17} = 3.76V.
So, I_{17} = 0.221A, which is also the current through the 5Ω resistor!

18. Combine the top series to get $1.5\mu F$, and combine the middle series to get $1.429\mu F$. Then combine these two parallel branches to get $2.929\mu F$ total of equivalent capacitance.
Start determining voltage and/or charge in your combined branches, and find that $V_{1.429}$ = 12V, so $Q_{1.429}$ = (1.429)(12) = $17.148\mu C$. And then since the $5\mu F$ capacitor is a part of the $1.429\mu F$ series, and since charge stored by capacitors in series are all the same, Q_5 = $17.148\mu C$.

19.a. The current through bulb A is the current through the entire circuit, so find R_{eq} of the circuit to be 5Ω. Then I_A = 9/5 = 1.8A.

b. A is the brightest, because it's the one dissipating the most power (I^2R).

c. Bulb A decreases, because the overall resistance of the circuit increases, so there's less current in the circuit and therefore less power (I^2R).
Bulb B increases, because there's more current through bulb B, and therefore more power dissipated (I^2R).

20.a.i. For part a, the voltage across each bulb is 120V because they're in parallel. By the power formula and Ohm's law, R = 480Ω and I = 0.25A.

ii. Similarly to part i, R = 360Ω and I = 0.33A.

b.i. R of the bulb is still 480Ω like it was in part a.
Current will be the same across both bulbs in series, based on the R_{eq} of the two bulbs. This is found through simple addition to be 840Ω.
So $I_{total} = I_{"30"} = 0.14A$.

ii. R of the bulb is still 360Ω like it was in part a. $I_{"40"} = 0.14A$ like it was for the other bulb, since current is the same for both bulbs in series.

c. 2, 1, 3, 4

d.i. $P_{total} = 40 + 30 = 70W$

ii. $P_{total} = \frac{V^2}{R_{total}} = \frac{120^2}{840} = 17W$