Demonstrate understanding of aspects of electricity and magnetism

Circuits

2020:2

Harrison learned in school that Play-Doh is a conductor.

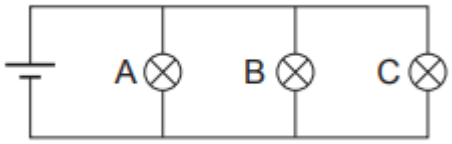
(a) Describe the difference between a conductor and an insulator, in terms of movement of charge.

(b) Harrison wants to create a series circuit. Draw a series circuit with the following components: • 9 V battery • open switch • 2 identical light bulbs • voltmeter wired to measure the battery voltage • ammeter.

(c) (i) Harrison is interested in how much energy a light bulb uses in the series circuit from (b). Calculate the energy used by ONE light bulb in ONE hour, if the overall resistance of the circuit is 150 Ω. Start by calculating the total current in the circuit.

(ii) An average 9 V battery can supply 500 mA (500×10^{-3} A) for one hour before becoming "flat". How many hours could Harrison leave the light bulbs on before his 9 V battery becomes "flat"?

(d) Harrison creates a parallel circuit. It has three light bulbs, A, B, and C, as shown in the diagram below.



Bulbs A and B have the same resistance, while bulb C has half the resistance. What would Harrison notice about the brightness of the light bulb C compared to A and B? Explain why.

2019:2

(a) Nick buys a set of battery-powered lights for Christmas. He finds that when he removes one of the light bulbs from its socket, all of the other light bulbs in the set stop working. Nick realises that this means all the light bulbs are connected in series. Explain why removing one of the light bulbs causes all the others to stop working.

(b) Nick connects the light bulb he removed from the set to a circuit to measure its resistance. The circuit Nick made used the following circuit components:
• a 1.5 V cell • a switch • a light bulb • an ammeter to measure the current through the light bulb
• a voltmeter to measure the voltage of the light bulb.
Draw a circuit diagram of the circuit Nick made.

(c) Nick's set of lights has a total of 20 light bulbs connected in series, and is powered by a 9.0 V battery. Calculate the total current in the set of lights if the resistance of each bulb is 0.40 ohms.

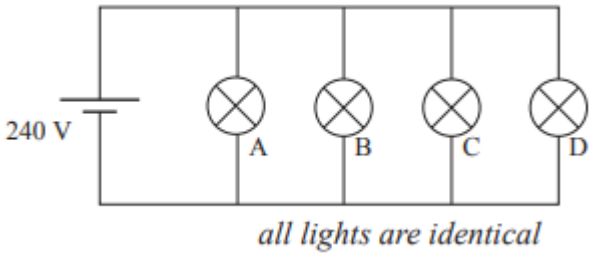
(d) One of the light bulbs in the set breaks, so Nick replaces it with another light bulb. The new light bulb has a lower resistance than the rest of the light bulbs in the set. Explain how replacing one of the light bulbs with one with a lower resistance will affect the total power output of the circuit and the life of the battery.

2018:2

Andrew is a DJ, and often needs multiple plugs to power his equipment and lights. Andrew plugs the power strip, as seen at right, into a wall outlet that provides 240 V. He then plugs in four identical lights each with a power of 60 W. A power strip is always wired in parallel.

(a) Describe why a power strip must be wired in parallel.

(b) Andrew connects four identical 60 W lights in parallel with a 240 V DC power supply to test them, as shown in the diagram below.
Show by calculation that the current through one of the lights is 0.25 A.



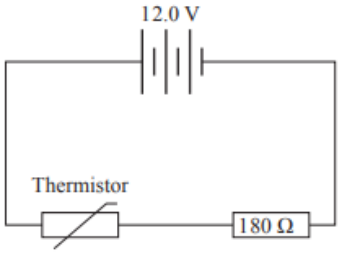
all lights are identical

(c) Bulb C is replaced by an energy-efficient light that has a lower power rating than the original light, but has the same brightness. Explain whether the energy-efficient light bulb has a higher or lower resistance than the original light.

(d) Andrew decided to replace all four lights with energy-efficient light bulbs. When this happened, the total current for all four lights was 0.20 A.
Calculate the electrical energy used by ONE energy-efficient bulb over a period of two hours, AND compare this with the energy used by ONE 60 W light bulb over two hours.

2017:2

A thermostat is a circuit that is used to switch equipment on and off, depending on the temperature. A simple thermostat circuit consists of a power supply, resistor, and thermistor connected in series as shown below. A thermistor is a special type of resistor that changes resistance as temperature changes.



(a) A voltmeter is added to the circuit to measure the voltage applied to the thermistor. On the diagram above, draw the symbol for a voltmeter correctly connected to make this measurement.

(b) (i) At a temperature of 25°C the current in the circuit is 0.014 A.
Show that the total resistance of the circuit at 25°C is 860 Ω.
(ii) Calculate the resistance of the thermistor at 25°C.

(c) As the temperature decreases, the resistance of the thermistor increases. Explain how the current in the circuit will change if the temperature decreases.

(d) Explain how the power expended in the 180 Ω resistor will change if the temperature decreases.