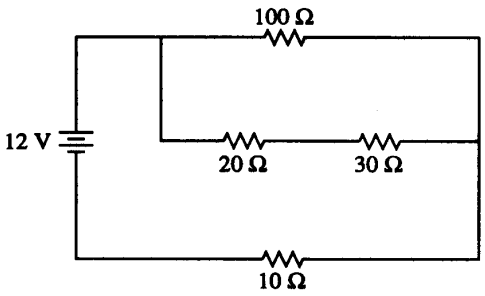
1996 Q4 (15 points)

A student is provided with a 12.0-V battery of negligible internal resistance and four resistors with the following resistances: 100 Ω, 30 Ω, 20 Ω, and 10 Ω. The student also has plenty of wire of negligible resistance available to make connections as desired.

(a) Using all of these components, draw a circuit diagram in which each resistor has nonzero current flowing through it, but in which the current from the battery is as small as possible.

(b) Using all of these components, draw a circuit diagram in which each resistor has nonzero current flowing through it, but in which the current from the battery is as large as possible (without short circuiting the battery).



The battery and resistors are now connected in the circuit shown above.

(c) Determine the following for this circuit.

i. The current in the 10-Ω resistor

ii. The total power consumption of the circuit

(d) Assuming that the current remains constant, how long will it take to provide a total of 10 kJ of electrical energy to the circuit?

2002 Q3 (15 points)

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

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

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

ii. Determine the resistance of the bulb rated 40 W 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 120 V source.

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

ii. Determine the resistance of the bulb rated 40 W 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)

__30 W bulb in the parallel circuit

__40 W bulb in the parallel circuit

__30 W bulb in the series circuit

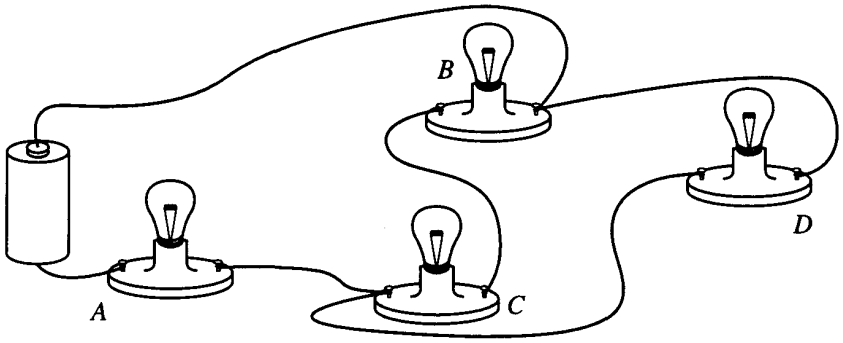
__40 W bulb in the series circuit

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

i. The parallel circuit

ii. The series circuit

1998 Q4 (10 points)



In the circuit shown above, A, B. C, and D are identical light bulbs. Assume that the battery maintains a constant potential difference between its terminals (i.e., the internal resistance of the battery is assumed to be negligible) and the resistance of each light bulb remains constant.

(a) Draw a diagram of the circuit in the box below, using the following symbols to represent the components in your diagram. Label the resistors A, B. C, and D to refer to the corresponding light bulbs.

Battery

Resistors

Draw your diagram in this box only.

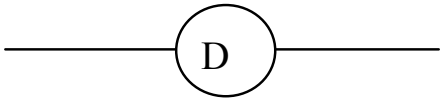
(b) List the bulbs in order of their brightnesses, from brightest to least bright. If any two or more bulbs have the same brightness, state which ones. Justify your answer.

(c) Bulb D is then removed from its socket.

i. Describe the change in the brightness, if any, of bulb A when bulb D is removed from its socket. Justify your answer.

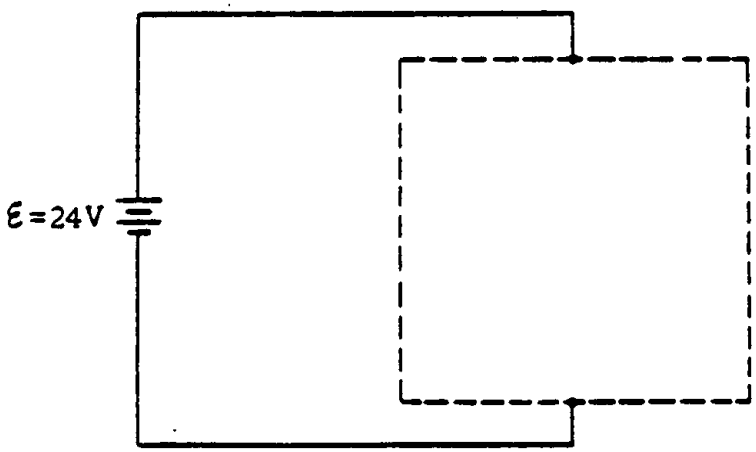
ii. Describe the change in the brightness, if any, of bulb B when bulb D is removed from its socket. Justify your answer.

1980 Q2



The electrical device whose symbol is shown above requires a terminal voltage of 12 volts and a current of 2 amperes for proper operation.

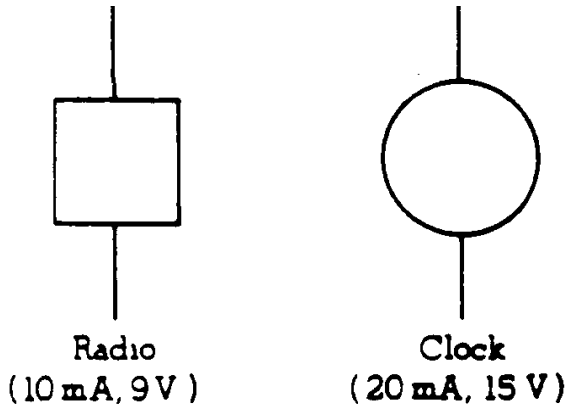
a. Using only this device and one or more 3-ohm resistors design a circuit so that the device will operate properly when the circuit is connected across a battery of emf 24 volts and negligible internal resistance. Within the dashed-line box in the diagram below, draw the circuit using the symbol for the device and the appropriate symbol for each 3-ohm resistor.



b. Using only this device and one or more 3-ohm resistors, design a circuit so that the device will operate properly when connected to a source that supplies a fixed current of 6 amperes. Within the dashed-line box in the diagram below, draw the circuit using the symbol for the device and the appropriate symbol.

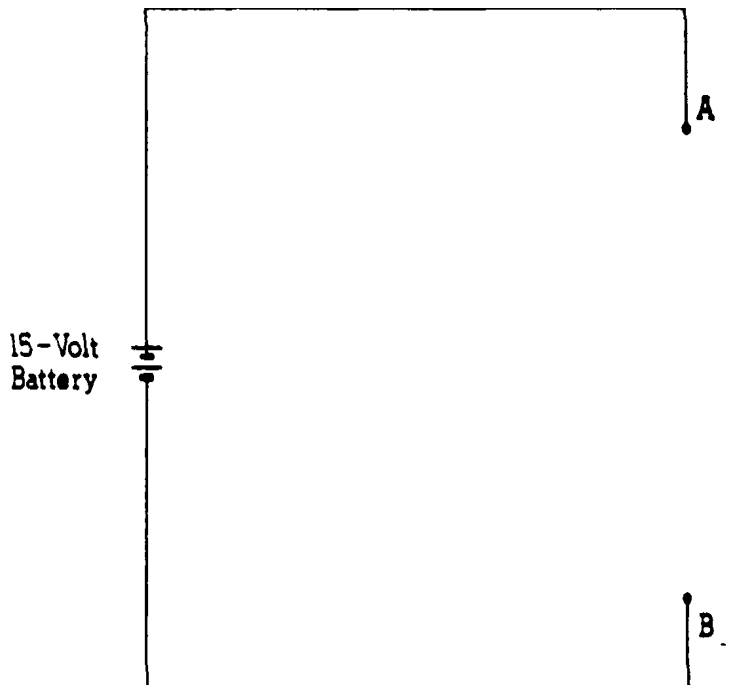
c. Calculate the power dissipation in each 3-ohm resistor used in the circuit in part (b).

1982 Q4



A cabin contains only two small electrical appliances: a radio that requires 10 milliamperes of current at 9 volts, and a clock that requires 20 milliamperes at 15 volts. A 15-volt battery with negligible internal resistance supplies the electrical energy to operate the radio and the clock.

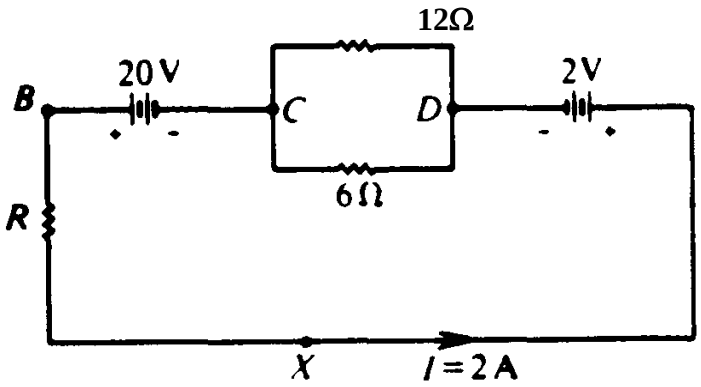
(a) Complete the diagram below to show how the radio, the clock, and a single resistor R can be connected between points A and B so that the correct potential difference is applied across each appliance. Use the symbols in the diagram above to indicate the radio and the clock.



(b) Calculate the resistance of R.

(c) Calculate the electrical energy that must be supplied by the battery to operate the circuits for 1 minute.

1983 Q3



The circuit shown above is constructed with two batteries and three resistors. The connecting wires may be considered to have negligible resistance. The current I is 2 amperes.

(a) Calculate the resistance R.

(b) Calculate the current in the

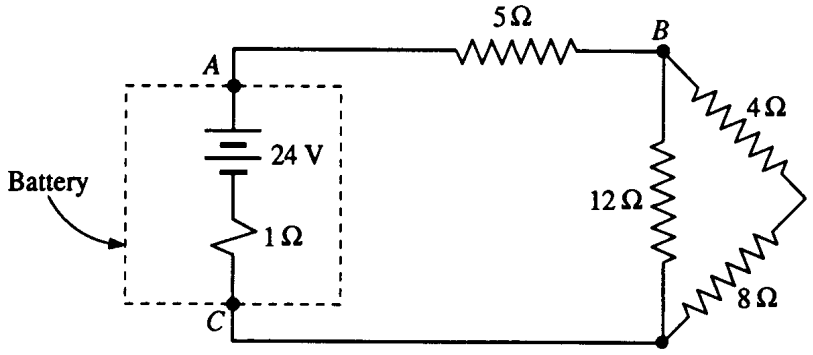
i. 6-ohm resistor

ii. 12-ohm resistor

(c) The potential at point X is 0 volts. Calculate the electric potential at points B. C, and D in the circuit.

(d) Calculate the power supplied by the 20-volt battery.

1990 Q3



A battery with an emf of 24 volts and an internal resistance of I ohm is connected to an external circuit as shown above. Determine each of the following:

(a) the equivalent resistance of the combination of the 4-ohm, 8-ohm, and 12-ohm resistors

(b) the current in the 5-ohm resistor

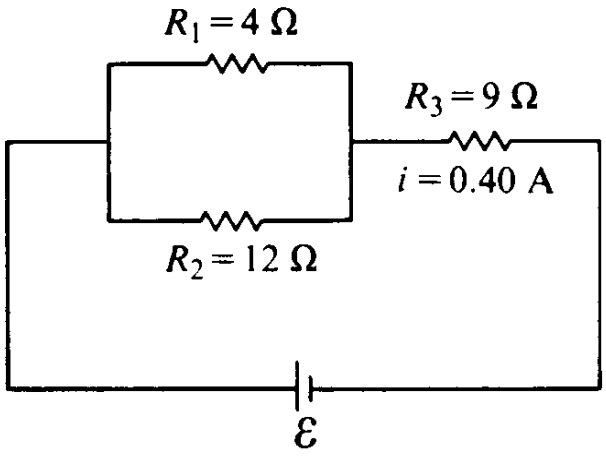
(c) the terminal voltage, V_{AC} of the battery

(d) the rate at which energy is dissipated in the 12-ohm resistor

(e) the magnitude of the potential difference V_{BC}

(f) the power delivered by the battery to the external circuit

1987 Q4



Three resistors are arranged in a circuit as shown above. The battery has an unknown but constant emf ε and a negligible internal resistance.

(a) Determine the equivalent resistance of the three resistors.

The current I in resistor R_3 is 0.40 ampere.

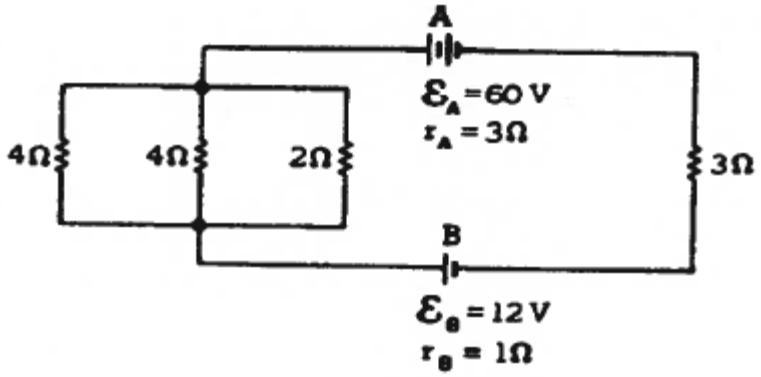
(b) Determine the emf ε (Voltage) of the battery.

(c) Determine the potential difference across resistor R_1

(d) Determine the power dissipated in resistor R_1

(e) Determine the amount of charge that passes through resistor R_3 in one minute.

1981 Q4



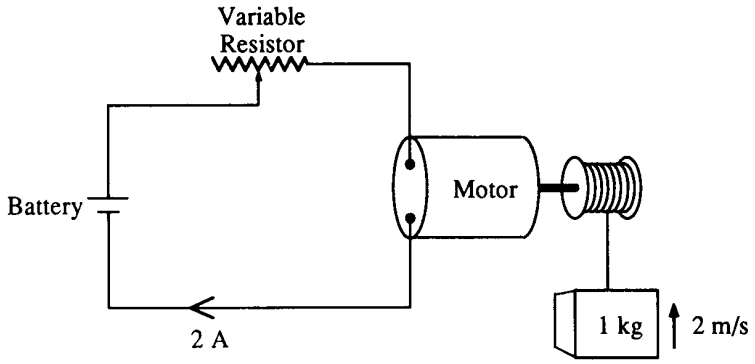
A circuit consists of battery A of emf $\mathcal{E}_A$ = 60 volts and Internal resistance r_A = 3 ohms; battery B of emf $\mathcal{E}_B$ = 12 volts and internal resistance r_B = 1 ohm; and four resistors connected as shown in the diagram above.

(a) Calculate the current in the 2-ohm resistor.

(b) Calculate the power dissipated in the 3-ohm resistor.

(c) Calculate the terminal voltage of battery B.

1989 Q3



A series circuit consists of a battery of negligible internal resistance, a variable resistor, and an electric motor of negligible resistance. The current in the circuit is 2 amperes when the resistance in the circuit is adjusted to 10 ohms. Under these conditions the motor lifts a l-kilogram mass vertically at a constant speed of 2 meters per second.

(a) Determine the electrical power that is

i. dissipated in the resistor

ii. used by the motor in lifting the mass

iii. supplied by the battery

(b) Determine the potential difference across

i. the resistor

ii. the motor

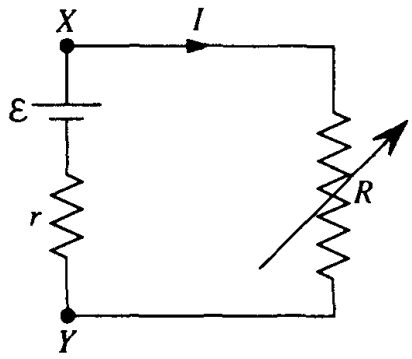
iii. the battery

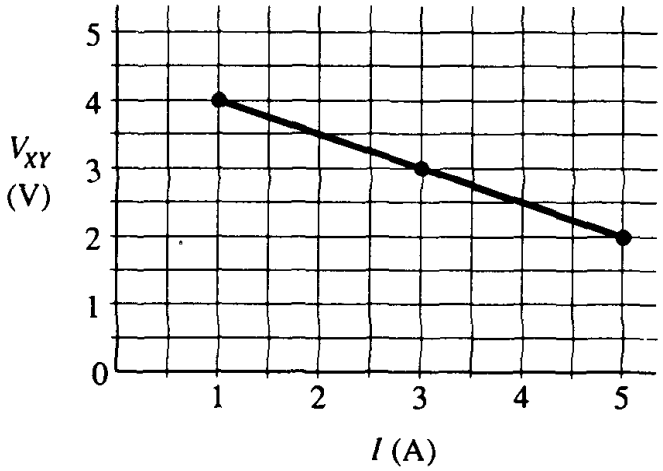
The resistor is now adjusted until the mass rises vertically at a constant speed of 3 meters per second. The voltage drop across the motor is proportional to the speed of the motor, and the current remains constant.

(c) Determine the voltage drop across the motor.

(d) Determine the new resistance in the circuit.

1991 Q4





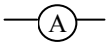
A battery with emf ε and internal resistance r is connected to a variable resistance *R* at points *X* and *Y*. as shown above on the left. Varying *R* changes both the current I and the terminal voltage V_{XY}. The quantities *I* and V_{XY} are measured for several values of *R* and the data are plotted in a graph, as shown above on the right.

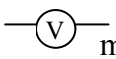
(a) Determine the emf ε of the battery.

(b) Determine the internal resistance r of the battery.

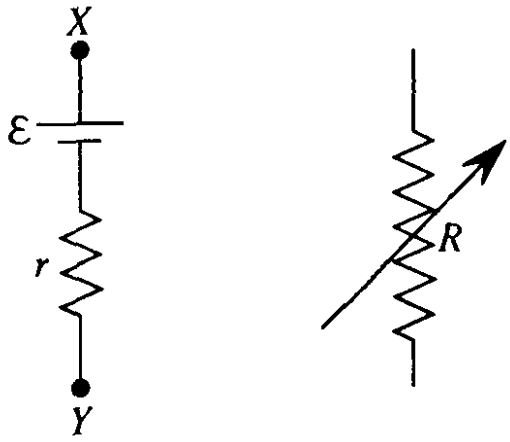
(c) Determine the value of the resistance *R* that will produce a current *I* of 3 amperes.

(d) Determine the maximum current that the battery can produce.

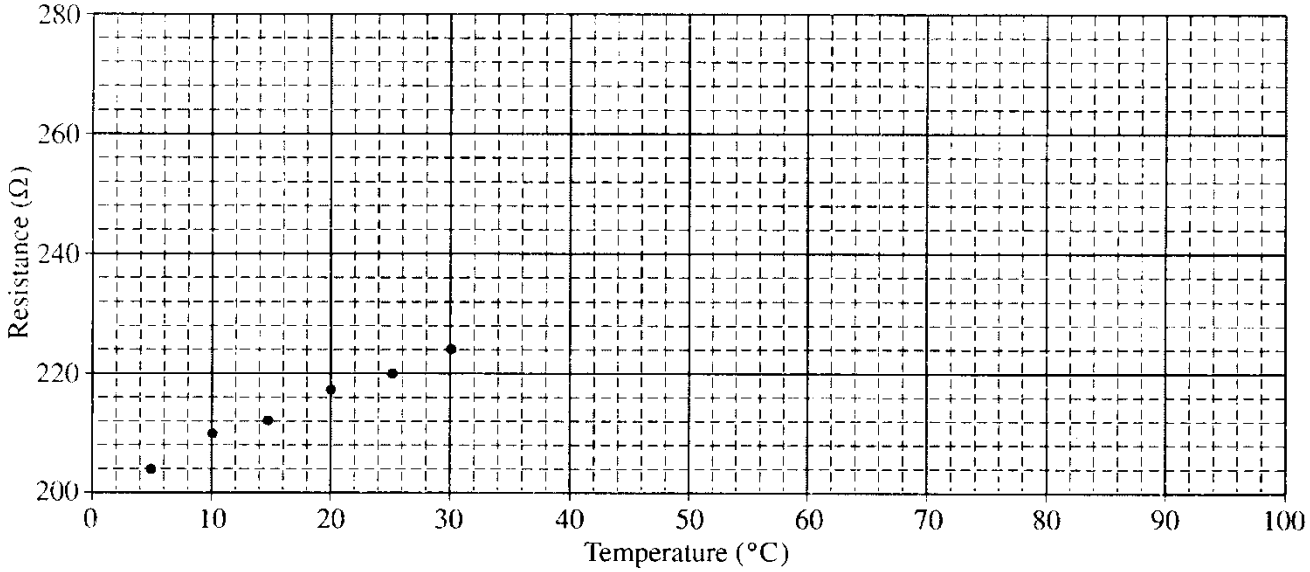
(e) The current and voltage measurements were made with an ammeter and a voltmeter. On the diagram below, show a proper circuit for performing these 



measurements. Use to represent the ammeter and to represent the voltmeter.



2001 Q5 (10 points)



A platinum resistor has a resistance that changes with temperature. Values of the resistance were obtained experimentally for several temperatures from 5°C to 30°C only and plotted on the graph above. Design a procedure in which this resistor can be used as a thermometer to measure the temperature of a liquid that is in the 50°C to 75°C range. The resistor can be safely immersed in liquids. Along with the resistor and the container of the liquid of unknown temperature, the following equipment and materials may be used.

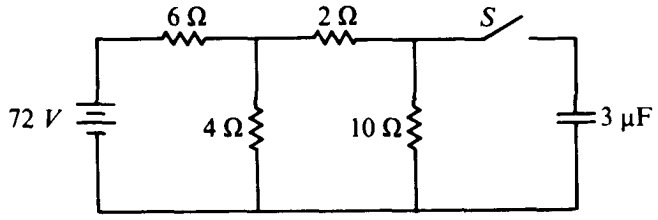
Power supply
Ammeter (Note: The ammeter and the voltmeter cannot
Voltmeter be used directly as an ohmmeter.)
Connecting wires
Ice-water bath
Boiling-water bath

(a) Sketch a diagram (with labels) to show how equipment is to be connected to make the necessary measurements, and briefly outline the steps to be followed.

(b) Discuss what measurements will be taken to determine the temperature of the unknown liquid.

(c) Discuss <u>one</u> assumption that must be made regarding equipment or procedure in order to use the method you have described.

1988 Q3



The circuit shown above includes a switch *S*, which can be closed to connect the 3-microfarad capacitor in parallel with the 10-ohm resistor or opened to disconnect the capacitor from the circuit.

Case 1: Switch *S* is open. The capacitor is not connected. Under these conditions determine:

(a) the current in the battery

(b) the current in the 10-ohm resistor

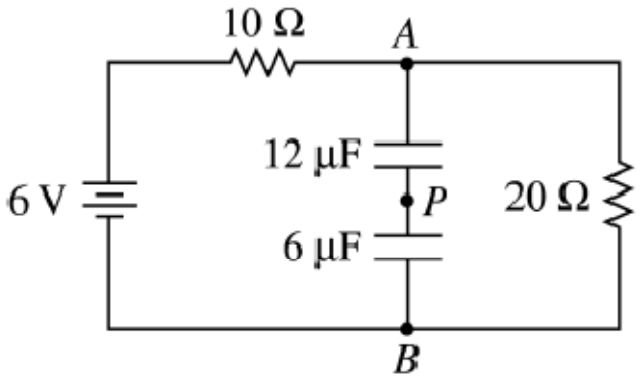
(c) the potential difference across the 10-ohm resistor

Case II: Switch *S* is closed. The capacitor is connected. After some time, the currents reach constant values. Under these conditions determine:

(d) the charge on the capacitor

(e) the energy stored in the capacitor

2003 Q2 (15 points)



A circuit contains two resistors (10 Ω and 20 Ω) and two capacitors (12 μF and 6 μF) connected to a 6 V battery, as shown in the diagram above. The circuit has been connected for a long time.

(a) Calculate the total capacitance of the circuit.

(b) Calculate the current in the 10 Ω resistor.

(c) Calculate the potential difference between points *A* and *B*.

(d) Calculate the charge stored on one plate of the 6 μF capacitor.

(e) The wire is cut at point *P*. Will the potential difference between points *A* and *B* increase, decrease, or remain the same?

____ increase ____ decrease ____ remain the same

Justify your answer.