A 10-ohm Resistor Has A Constant Current. If 1200 C Of Charge Flow Through It In 4 Minutes Whatis The

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Understanding the behavior of resistors in electrical circuits is fundamental to mastering electronics and electrical engineering. The scenario involving a 10-ohm resistor with a constant current, through which a specified amount of charge flows over a certain period, presents an excellent opportunity to explore core concepts like current, charge, voltage, resistance, and how they interrelate. In this article, we will analyze the problem step-by-step, introduce relevant electrical principles, and derive the missing quantity to provide a comprehensive understanding of the situation.

Fundamental Concepts in Electricity and Resistance

Before delving into the problem, it is essential to review some fundamental concepts that form the foundation of electrical circuit analysis.

Ohm's Law

Ohm's Law is a fundamental principle that relates the voltage (V), current (I), and resistance (R) in an electrical circuit:

- $V = I \times R$

This relationship indicates that the voltage across a resistor is proportional to the current flowing through it, with the resistance as the proportionality constant.

Charge and Current

- Charge (Q): Measured in coulombs (C), charge represents the quantity of electricity transferred.
- Current (I): The rate at which charge flows through a conductor, measured in amperes (A). One ampere equals one coulomb per second:

- $I = Q / t$

where t is the time in seconds.

Power Dissipation in Resistors

- Power (P) dissipated as heat in a resistor is given by:

- $P = V \times I = I^2 \times R = V^2 / R$

This is useful for understanding energy transfer and safety considerations.

Analyzing the Problem

The problem states:

“A 10-ohm resistor has a constant current. If 1200 C of charge flow through it in 4 minutes, what is the voltage across the resistor?”

Let's break down the information provided:

- Resistance, $R = 10\ \Omega$
- Total charge flow, $Q = 1200$ C
- Time, $t = 4$ minutes

Our goal: To find the voltage across the resistor during this time frame.

Step 1: Convert Time to Seconds

Since electrical measurements are typically in SI units, convert minutes to seconds:

- 4 minutes = $4 \times 60 = 240$ seconds

Step 2: Calculate the Current (I)

Using the relationship:

- $I = Q / t$

Substitute the known values:

- $I = 1200\text{ C} / 240\text{ s} = 5\text{ A}$

This indicates a constant current of 5 amperes flowing through the resistor during the 4-minute interval.

Step 3: Find the Voltage Across the Resistor

Applying Ohm's Law:

- $V = I \times R$

Substitute the known values:

- $V = 5\ A \times 10\ \Omega = 50\ V$

Therefore, the voltage across the resistor is 50 volts.

Additional Insights and Related Concepts

Understanding this problem also allows us to explore related topics, including power dissipation, energy transferred, and the significance of constant current flow.

Power Dissipation

Using the power formula:

- $P = V \times I = 50\ V \times 5\ A = 250\ W$

This indicates that the resistor dissipates 250 watts of power during the period. It's important to ensure that the resistor can safely handle this power level to prevent overheating or damage.

Energy Transferred

The total energy (E) dissipated as heat can be calculated:

- $E = P \times t$

Substitute known values:

- $E = 250\ W \times 240\ s = 60{,}000$ Joules

This reflects the total energy converted from electrical energy to heat within the resistor over 4 minutes.

Understanding the Significance of Constant

Current

In the scenario, the resistor has a constant current flow. This usually implies that the circuit is configured to maintain a steady current, such as in a regulated power supply or a controlled laboratory experiment. Constant current conditions are essential in applications like:

- Charging batteries
- Testing electronic components
- Certain manufacturing processes

Maintaining a constant current ensures predictable energy transfer and prevents damage due to voltage spikes or fluctuations.

Practical Applications and Considerations

Understanding how charge, current, voltage, and resistance interact is vital for designing safe and efficient electrical systems. Here are some practical considerations:

- Resistor Power Ratings: Ensure the resistor can dissipate the calculated power (250 W in this case). Most resistors have specific power ratings; exceeding them can lead to failure.
- Circuit Safety: Proper insulation and circuit protection devices are essential when dealing with high voltages and power levels.
- Energy Efficiency: Minimizing unnecessary power dissipation can lead to more energy-efficient systems.

Summary of Key Calculations

Quantity	Calculation	Result
Time in seconds	4 minutes × 60	240 seconds
Current (I)	Q / t	1200 C / 240 s = 5 A
Voltage (V)	I × R	5 A × 10 Ω = 50 V
Power (P)	V × I	50 V × 5 A = 250 W
Energy (E)	P × t	250 W × 240 s = 60,000 J

In conclusion, the voltage across the 10-ohm resistor during the flow of 1200 C over 4 minutes is 50 volts. This analysis demonstrates the interconnectedness of electrical quantities and the importance of fundamental laws like Ohm’s Law in solving real-world electrical problems.

Further Reading and Resources

- Books:
- Introduction to Electric Circuits by Richard C. Dorf and James A. Svoboda
- Fundamentals of Electric Circuits by Charles K. Alexander and Matthew N.O. Sadiku

- Online Resources:
- [Khan Academy - Ohm's Law](https://www.khanacademy.org/science/electrical-engineering/ee-circuit-analysis)
- [All About Circuits](https://www.allaboutcircuits.com)

- Tools:
- Circuit simulation software such as LTspice or Multisim can help visualize and analyze similar problems.

By mastering these concepts, students and professionals can better understand electrical systems, troubleshoot issues, and design more effective circuits.

Note: Always consider the safety implications when working with electrical components, especially at high power levels. Proper precautions, equipment ratings, and safety protocols should be followed to prevent accidents or equipment damage.

Frequently Asked Questions

What is the voltage across a 10-ohm resistor when 1200 C of charge flows through it in 4 minutes?

The voltage is 20 volts, calculated using V = IR, where current I is 0.05 A, so V = 10 ohms × 0.05 A = 0.5 volts.

How do you determine the current flowing through the resistor in this scenario?

Current I is calculated as total charge Q divided by time t: I = Q / t. So, I = 1200 C / 240 s = 5 A.

What is the power dissipated by the resistor during this process?

Power P is given by $P = I^2R$. With I = 5 A and R = 10 ohms, P = 25 W.

Is the current in the resistor steady or changing in this scenario?

The question states the resistor has a constant current, so the current remains steady at 5 A during the flow of charge.

What is the total energy dissipated as heat in the resistor over 4 minutes?

Total energy E = Power × time = 25 W × 240 s = 6000 joules.

Additional Resources

A 10-ohm resistor has a constant current. If 1200 C of charge flow through it in 4 minutes, what is the current? This fundamental question in electrical engineering combines concepts of charge, current, resistance, and time to determine the flow of electrical energy through a resistor. Understanding how to analyze such problems is essential for students, engineers, and hobbyists alike. In this detailed guide, we will dissect the problem, explore the underlying principles, and walk through the step-by-step process to arrive at the solution, providing clarity on each component involved.

Introduction

In electrical circuits, resistors are passive components that oppose the flow of current, converting electrical energy into heat. When a resistor maintains a constant current, understanding the relationship between charge, current, resistance, and time becomes crucial. The question at hand involves a 10-ohm resistor through which a specific amount of charge flows over a given period.

The key phrase, "A 10-ohm resistor has a constant current. If 1200 C of charge flow through it in 4 minutes, what is the current?", encapsulates a typical problem that requires integrating multiple electrical concepts. Before diving into the calculations, let's revisit the fundamental principles involved.

Fundamental Concepts

1. Electric Charge (Q)
- Definition: The quantity of electricity transported by a current.
- Unit: Coulombs (C).
- Relationship: The total charge that passes through a circuit or component over a period.

2. Electric Current (I)
- Definition: The rate at which charge flows through a point in a circuit.
- Formula:
$$
I = \frac{Q}{t}
$$
where:
- I is current in amperes (A),
- Q is charge in coulombs (C),
- t is time in seconds (s).

3. Resistance (R)
- Definition: A measure of the opposition to current flow.
- Ohm's Law:
$$
V = I \times R
$$
where:
- V is voltage in volts (V),
- I is current in amperes,
- R is resistance in ohms (Ω).

4. Power Dissipation
- Power in a resistor:
$$
P = V \times I = I^2 \times R
$$
- Useful for understanding heat generated but not directly needed for calculating current here.

Step-by-Step Solution to the Problem

Step 1: Understanding the Given Data
- Resistance, $R = 10\, \Omega$
- Total charge, $Q = 1200\, C$
- Time, $t = 4\, \text{minutes}$

Step 2: Convert Time to Seconds
Since SI units are standard in electrical calculations, convert minutes to seconds:
$$
t = 4\, \text{minutes} \times 60\, \text{seconds/minute} = 240\, \text{seconds}
$$

Step 3: Apply the Basic Relationship for Current
The fundamental relationship for current is:
$$
I = \frac{Q}{t}
$$
Substituting the known values:
$$
I = \frac{1200\, C}{240\, s}
$$
Calculating:
$$
I = 5\, \text{A}
$$

Answer: The current flowing through the resistor is 5 amperes.

Additional Analysis: Confirming with Ohm’s Law

While the question primarily asks for current, it’s instructive to see how resistance and voltage relate to this current.

Step 4: Calculate the Voltage Across the Resistor

Using Ohm's Law:

$$
V = I \times R
$$

$$
V = 5\, A \times 10\, \Omega = 50\, V
$$

This calculation indicates that a voltage of 50 volts is necessary to sustain a current of 5 amperes through a 10-ohm resistor.

Step 5: Power Dissipation

Power dissipated as heat:

$$
P = V \times I = 50\, V \times 5\, A = 250\, W
$$

This high power suggests significant heat generation, which is typical in resistors dissipating large amounts of energy.

Broader Implications and Practical Considerations

1. Resistance and Current Relationship
The direct proportionality between voltage and current, as per Ohm's Law, allows engineers to design circuits with specific current and voltage levels based on resistor values.

2. Power Ratings
Resistors have power ratings; dissipating 250 W would require a resistor with a high power rating or proper heat sinking.

3. Safety and Efficiency
Understanding how charge flow relates to resistance and voltage helps in designing safe and efficient electrical systems, especially where high currents or power levels are involved.

Summary of Key Points

- The total charge flowing through a resistor over a given period can be used to find the current using the relationship $I = \frac{Q}{t}$.
- In this problem, with 1200 C of charge flowing over 240 seconds through a 10-ohm resistor, the current is 5 amperes.
- Applying Ohm's Law confirms the voltage across the resistor is 50 volts.

- Power dissipation calculations reveal the heat generated, emphasizing the importance of considering resistor power ratings in practical applications.

Final Thoughts

Problems like these illustrate the interconnected nature of electrical concepts, where charge, current, resistance, and voltage interrelate seamlessly. Mastery of these fundamental relationships enables engineers and students to analyze complex circuits, troubleshoot issues, and design effective electrical systems. Remember, always convert units to SI base units for consistency and clarity, and consider the practical aspects like power ratings and safety when applying these principles in real-world scenarios.

By understanding how charge flows through resistors and applying fundamental laws, you can confidently analyze and solve a wide range of electrical problems with precision and clarity.

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