How Far From A 6.50 C Point Charge Will The Potential Be 250 V?_____. MAt What Distance Will It Be 5.00

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Understanding the relationship between electric potential and distance from a point charge is fundamental in electrostatics. When dealing with point charges, the electric potential at a given distance depends on the magnitude of the charge and the distance from it. This article provides an in-depth explanation of how to determine the distance from a point charge at which the electric potential reaches specific values—namely 250 volts and 5.00 volts—focusing on a charge of 6.50 coulombs. It will explore the relevant formulas, step-by-step calculations, and the physical interpretation of the results.

Fundamental Concepts in Electric Potential and Point Charges

Electric Potential Due to a Point Charge

Electric potential (V) at a point in space due to a point charge (Q) is given by the formula:

- $V = \frac{k Q}{r}$

where:

- V is the electric potential at the point,
- k is Coulomb's constant ($8.99 \times 10^9 \, \mathrm{Nm^2/C^2}$),
- Q is the magnitude of the point charge,
- r is the distance from the charge to the point where the potential is measured.

This formula assumes the point charge is isolated, and the potential is measured relative to an infinite distance where the potential is zero.

Implication of the Formula

From the formula, it is evident that:

- The potential is directly proportional to the charge Q,
- The potential decreases with increasing r,
- To find the distance at a given potential, rearrange the formula:

$$
r = \frac{k Q}{V}
$$

This simple relation allows us to compute the distance from the charge where the potential reaches a specified value.

Calculating the Distance for a Potential of 250 V

Given Data

- Charge, $Q = 6.50\, \mathrm{C}$,
- Desired potential, $V = 250\, \mathrm{V}$,
- Coulomb's constant, $k = 8.99 \times 10^9\, \mathrm{Nm^2/C^2}$.

Step-by-Step Calculation

Applying the rearranged formula:

$$
r = \frac{k Q}{V}
$$

Plugging in the known values:

$$
r = \frac{(8.99 \times 10^9\, \mathrm{Nm^2/C^2}) \times 6.50\, \mathrm{C}}{250\, \mathrm{V}}
$$

Calculating numerator:

$$
8.99 \times 10^9 \times 6.50 = 5.8435 \times 10^{10}
$$

Dividing by 250:

$$
r = \frac{5.8435 \times 10^{10}}{250} = 2.3374 \times 10^8\, \mathrm{m}
$$

Result:

$$
\boxed{
r \approx 2.34 \times 10^{8}\, \mathrm{meters}
}
$$

Physical Interpretation:

The distance is approximately 234 million meters, or about 234,000 kilometers, which is roughly 60% of the distance from Earth to the Moon. This enormous distance reflects the fact that the charge's potential diminishes very slowly due to the large magnitude of the charge.

Calculating the Distance for a Potential of 5.00 V

Given Data

- Charge, $Q = 6.50\, \mathrm{C}$,
- Desired potential, $V = 5.00\, \mathrm{V}$,
- Coulomb's constant, $k = 8.99 \times 10^9\, \mathrm{Nm^2/C^2}$.

Step-by-Step Calculation

Using the same formula:

$$
r = \frac{k Q}{V}
$$

Plugging in the values:

$$
r = \frac{8.99 \times 10^9 \times 6.50}{5.00}
$$

Calculating numerator:

$$
8.99 \times 10^9 \times 6.50 = 5.8435 \times 10^{10}
$$

Dividing by 5:

$$
r = \frac{5.8435 \times 10^{10}}{5} = 1.1687 \times 10^{10}\, \mathrm{m}
$$

Result:

$$
\boxed{
r \approx 1.17 \times 10^{10}\, \mathrm{meters}
}
$$

which is approximately 11.7 billion meters, or about 78 times the distance from Earth to the Moon.

Discussion of Results and Physical Significance

Magnitude of Distances

The calculated distances for both potentials are extremely large, illustrating the fact that for a very large charge of 6.50 C, the potential remains significant only at very large distances. This is consistent with the inverse relationship between potential and distance: as potential decreases, the distance increases proportionally.

Practical Considerations

In real-world scenarios, charges of this magnitude are not common and would usually involve significant energy and safety concerns. These calculations serve more as theoretical demonstrations of electrostatic principles.

Effect of Changing Charge Magnitude

If the charge were smaller, the distances at which the potential reaches the same values would be proportionally smaller. Conversely, larger charges result in potential values at greater distances, emphasizing the proportionality embedded in Coulomb’s law.

Summary of Key Points

- The electric potential due to a point charge is given by $V = \frac{kQ}{r}$.
- To find the distance at a specific potential, rearrange to $r = \frac{kQ}{V}$.
- For a charge of 6.50 C:
    - Potential of 250 V occurs approximately 2.34×10^8 meters away.
    - Potential of 5.00 V occurs approximately 1.17×10^{10} meters away.

Conclusion

The calculations clearly demonstrate how the potential varies with distance from a point charge. By applying the fundamental formula, we can determine the distances at which the potential reaches any specified value, provided the charge magnitude is known. These concepts are essential in understanding electrostatic fields, designing electrical systems, and interpreting phenomena in physics and engineering.

Understanding the scale of these distances also underscores the importance of magnitude in electrostatics. Large charges produce significant potentials only at vast distances, illustrating the long-range nature of Coulombic interactions. Conversely, for smaller charges, the potential drops off more rapidly with distance, confining the influence to relatively shorter ranges.

In practical applications, such calculations help in the design of shielding, sensors, and other devices where electric potentials and fields are critical. The analytical approach outlined here provides a foundation for exploring more complex electrostatic systems and phenomena.

Frequently Asked Questions

How do you calculate the distance from a 6.50 C point charge where the potential is 250 V?

Use the formula V = k Q / r, where V is potential, Q is charge, r is distance, and k is Coulomb's constant (9×10^9 Nm^2/C^2). Rearranged as r = k Q / V, so plug in the values to find the distance.

What is the distance from a 6.50 C charge where the potential drops to 250 V?

Using r = (9×10^9 Nm^2/C^2 6.50 C) / 250 V, the distance is approximately 234,000 meters or 234 km.

At what distance from a 6.50 C point charge is the potential 5.00 V?

Using r = (9×10^9 Nm^2/C^2 6.50 C) / 5.00 V, the distance is approximately 11,700,000 meters or 11,700 km.

Why does the potential decrease as the distance from the charge increases?

Because electric potential due to a point charge follows the inverse relationship V = kQ / r; as r increases, V decreases proportionally.

How does the magnitude of the charge affect the distance at which the potential has a specific value?

A larger charge results in a higher potential at a given distance, so to achieve the same potential, the distance must be proportionally larger; conversely, for a fixed potential, increasing the charge increases the required distance.

Additional Resources

How Far From A 6.50 C Point Charge Will The Potential Be 250 V? At What Distance Will It Be 5.00 V?
Understanding the relationship between electric potential and distance from a point charge is fundamental in electrostatics. Whether you're a student working through a physics problem set or a professional analyzing electric fields in a lab, knowing how to determine the distance at which a certain potential occurs is crucial. This article provides a comprehensive guide to calculating these distances, illustrating the physics principles involved, step-by-step procedures, and practical considerations.

Introduction to Electric Potential and Point Charges

Before diving into calculations, it's essential to understand the core concepts:

- Electric Potential (V): The electric potential at a point in space is the work done per unit charge in bringing a test charge from infinity to that point, without acceleration. It is a scalar quantity, measured in volts (V).

- Point Charge: An idealized charge concentrated at a single point in space. The electric potential due to a point charge is described by Coulomb's law.

- Coulomb's Law for Electric Potential:
The potential V at a distance r from a point charge Q is given by:

$$
V = \frac{k \cdot Q}{r}
$$

where:
- V is the electric potential at distance r (in volts),
- Q is the charge (in coulombs),
- r is the radial distance from the charge (in meters),
- k is Coulomb's constant, approximately $8.988 \times 10^9 \, \mathrm{N\,m^2/C^2}$.

Problem Breakdown: Key Objectives

Given these principles, our goal is to determine:

1. The distance from a 6.50 C point charge where the potential is 250 V.
2. The distance where the potential is 5.00 V.

Both are straightforward applications of the potential formula, but the key is careful substitution and understanding the physical implications.

Step-by-Step Calculation Method

Step 1: Write Down Known Variables

- Charge, Q: 6.50 C
- Potential, V: 250 V and 5.00 V (two separate calculations)
- Coulomb's constant, k: $8.988 \times 10^9 \, \mathrm{N\,m^2/C^2}$

Step 2: Rearrange the Potential Formula

From the formula:

$$
V = \frac{k Q}{r}
$$

solving for r:

$$
r = \frac{k Q}{V}
$$

This allows direct calculation of the distance for each potential.

Step 3: Calculate Distance for $V = 250\,V$

Insert the known values:

$$
r_{250} = \frac{8.988 \times 10^9 \times 6.50}{250}
$$

Calculating numerator:

$$
8.988 \times 10^9 \times 6.50 = 58.422 \times 10^9
$$

Dividing:

$$
r_{250} = \frac{58.422 \times 10^9}{250} = 0.233688 \times 10^9 \,
\text{meters}
$$

Expressed in standard form:

$$
r_{250} \approx 2.34 \times 10^{8} \, \text{meters}
$$

This is approximately 234 million meters, or about 234,000 kilometers—roughly half the distance from Earth to the Moon.

Step 4: Calculate Distance for $V = 5.00\,V$

Similarly:

$$
r_{5} = \frac{8.988 \times 10^9 \times 6.50}{5.00}
$$

Calculate numerator:

$$
8.988 \times 10^9 \times 6.50 = 58.422 \times 10^9
$$

Divide:

$$
r_{5} = \frac{58.422 \times 10^9}{5} = 11.6844 \times 10^9 \, \text{meters}
$$

Expressed more simply:

$$
r_{5} \approx 1.17 \times 10^{10} \, \text{meters}
$$

which is about 11.7 billion meters, or roughly 78 astronomical units, far beyond the orbit of Pluto.

Interpreting the Results

The calculation reveals that the potential drops off very slowly with distance because of the large charge magnitude. Specifically:

- To reach a potential of 250 V, you need to be approximately 234,000 km away from the charge.
- To reach 5.00 V, you need to be approximately 11.7 billion meters away.

These enormous distances underscore the fact that a 6.50 C charge is extremely large—comparable to a large static charge buildup or a charge stored in a large capacitor—making the potential influence significant over vast spatial scales.

Practical Considerations and Real-World Context

While the theoretical calculations are straightforward, in real-world scenarios, several factors come into play:

- Physical Limitations: Generating and maintaining a charge of 6.50 C is practically impossible with typical materials. Such a charge would cause dielectric breakdown or discharge.

- Environmental Factors: Air, humidity, and other environmental factors influence electric fields and potentials, especially at large distances.

- Safety Concerns: Large static charges pose safety risks, including electric shocks and sparks.

Additional Applications and Related Concepts

Understanding how potential varies with distance is essential in various fields:

- Electrostatics Design: Designing capacitors, sensors, and other devices.
- Astrophysics: Gravitational analogs where potential varies with distance.
- Electric Field Mapping: Visualizing field lines and equipotential surfaces.

Summary and Key Takeaways

- The electric potential from a point charge is directly proportional to the charge and inversely proportional to the distance ($V = \frac{kQ}{r}$).

- For a 6.50 C charge:
- The distance to reach 250 V is approximately 234,000 km.
- The distance to reach 5.00 V is approximately 11.7 billion meters.

- These large distances highlight the significant influence of large charges on electric potential.

- Always double-check calculations and consider physical constraints when applying these formulas to real-world problems.

Final Thoughts

Mastering these calculations empowers you to analyze electric potentials in theoretical and practical contexts. Whether designing electrostatic equipment or understanding natural phenomena, grasping the relationship between charge, potential, and distance forms a cornerstone of physics and engineering.

Remember: Always consider the scale of your problem and the physical feasibility when dealing with large charges or potentials.

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