

chapter 20 static electricity answer key

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Chapter 20 Static Electricity Answer Key: A Comprehensive Guide

When you're tackling physics problems, the right answer key can be a lifesaver. It not only confirms your solutions but also helps you understand the underlying concepts. In this article, we'll dive deep into the **chapter 20 static electricity answer key**, exploring the core topics covered, common pitfalls, and how to use the key to boost your learning. Whether you're a high school student, a college freshman, or a lifelong learner, this guide will equip you with everything you need to master static electricity.

Understanding Static Electricity: The Core Concepts

Static electricity is the result of an imbalance of electric charges within or on the surface of a material. Unlike current electricity, static electricity does not involve continuous flow; instead, it builds up until it discharges, often in the form of sparks or a sudden jolt.

Key Terms You Should Know

- Electron – The negatively charged subatomic particle that carries most of the charge in static systems.
- Proton – The positively charged subatomic particle found in the nucleus of an atom.
- Charge – A property of matter that causes it to experience forces when placed in an electric field.
- Conductors – Materials that allow electrons to move freely, such as metals.
- Insulators – Materials that restrict electron movement, like rubber or plastic.
- Electrostatic Induction – The process of redistributing charge in a conductor by bringing a charged object nearby.

Why Chapter 20 Focuses on Static Electricity

Chapter 20 usually builds on earlier chapters that introduce basic electric concepts, such as Coulomb's law and electric fields. By the time students reach this chapter, they should already be comfortable with:

1. Understanding the concept of charge and its conservation.
2. Applying Coulomb's law to calculate forces between point charges.
3. Visualizing electric fields and potential.

Chapter 20 then deepens these ideas by exploring how static charges accumulate, interact, and can be measured. It also introduces real-world applications, like how static electricity can be harnessed in photocopying machines or how it can be a hazard in industrial settings.

Chapter 20 Summary: What You'll Learn

Below is a concise outline of the main sections typically found in chapter 20 of most physics textbooks. This overview will help you locate the relevant sections in your answer key.

1. Introduction to Static Charges – Basic principles and examples.
2. Charge Conservation – Why the total charge remains constant.
3. Coulomb's Law Revisited – Applying the law to multiple charges.
4. Electric Field and Potential from Static Charges – Calculations and field lines.

5. Induction and Redistribution of Charge – How nearby charges influence conductors.
6. Static Electricity in Everyday Life – From dusting to lightning.
7. Practical Applications – Photocopiers, particle accelerators, and more.
8. Problem-Solving Techniques – Common strategies for static electricity questions.

Sample Answer Key: A Walkthrough

Below we provide a sample answer key for a typical set of problems that might appear in chapter 20. This is not the official key for any textbook, but it mirrors the structure and difficulty level of standard questions. Use it as a model for how to approach similar problems.

Problem 1: Calculating the Force Between Two Charges

Question: Two point charges, $+3 \mu\text{C}$ and $-4 \mu\text{C}$, are separated by 0.05 m in a vacuum. What is the magnitude of the electrostatic force between them?

Solution:

1. Convert microcoulombs to coulombs: $3 \mu\text{C} = 3 \times 10^{-6} \text{ C}$, $-4 \mu\text{C} = -4 \times 10^{-6} \text{ C}$.
2. Apply Coulomb's law: $F = k |q_1 q_2| / r^2$, where $k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$.
3. Calculate: $F = (8.99 \times 10^9) \times (3 \times 10^{-6})(4 \times 10^{-6}) / (0.05)^2$.
4. $F = 8.99 \times 10^9 \times 12 \times 10^{-12} / 0.0025$.
5. $F = 8.99 \times 10^9 \times 4.8 \times 10^{-3} = 43.15 \text{ N}$.

Answer: 43.2 N (attractive).

Problem 2: Electric Field from a Uniformly Charged Rod

Question: A straight rod of length 0.2 m carries a uniform linear charge density $\lambda = 5 \mu\text{C/m}$. What is the electric field at a point 0.1 m away from the rod's center, perpendicular to its length?

Solution:

1. Use the formula for the field of a finite line charge: $E = (1/(4\pi\epsilon_0)) (2\lambda / r^2) (1 + (L^2 / 4r^2))^{1/2}$.
2. Plug in values: $E = (9 \times 10^9) (2 \times 5 \times 10^{-6} / 0.1^2) (1 + (0.2^2 / 4 \times 0.1^2))^{1/2}$.
3. Compute: $E = (9 \times 10^9) \times (2 \times 5 \times 10^{-6} / 0.1) \times (1 + (1)^2)^{1/2}$.
4. $E = 9 \times 10^9 \times (1 \times 10^{-5}) \times (1 + 1)^{1/2} = 9 \times 10^4 \times 0.707 = 6.36 \times 10^4 \text{ N/C}$.

Answer: $6.4 \times 10^4 \text{ N/C}$.

Problem 3: Induced Charge on a Conducting Sphere

Question: A neutral conducting sphere of radius 0.05 m is placed 0.15 m from a point charge of $+10 \mu\text{C}$. How much charge will be induced on the sphere's surface?

Solution:

1. Induced charge on a neutral conductor equals the negative of the charge induced on the side nearest the external charge.
2. The amount of induced charge is equal in magnitude to the external charge but opposite in sign, distributed over the surface.
3. Thus, the sphere acquires $-10 \mu\text{C}$ on the near side, totaling zero net charge.

Answer: Induced charges: $-10 \mu\text{C}$ on near side; net zero.

How to Use the Chapter 20 Static Electricity Answer Key Effectively

Merely having an answer key isn't enough. You must integrate it into your study routine to truly master static electricity concepts.

1. Work Through Problems First

Attempt each question before consulting the key. This encourages active learning and helps you identify where you're going wrong.

2. Compare Your Work with the Key

Once you've finished, cross-check your steps against the answer key. If you got the answer wrong, see if you made a calculation error, misapplied a formula, or misunderstood the question.

3. Study the Rationale

Many answer keys include brief explanations. Pay close attention to the reasoning behind each step. Understanding the logic is more valuable than memorizing the result.

4. Create a Summary Sheet

After reviewing several problems, jot down the key formulas and concepts. A concise cheat sheet helps reinforce memory and serves as a quick reference during revision.

5. Practice Variations

Change numbers or conditions in the problems to test your flexibility. For instance, alter the distance or charge magnitude and recalculate. This deepens comprehension and prepares you for unexpected exam questions.

Common Mistakes and How to Avoid Them

Static electricity problems can trip up even seasoned students. Below are frequent errors and strategies to sidestep them.

Misidentifying Charge Sign

Always double-check the sign of each charge. A single sign error can flip the direction of force or field calculations.

Ignoring Units

Unit consistency is critical. Convert microcoulombs to coulombs before plugging into formulas. Neglecting this can lead to off by orders-of-magnitude mistakes.

Using the Wrong Formula

Static electricity has several overlapping laws—Coulomb's law, the principle of superposition, Gauss's law. Make sure you're applying the appropriate one for the problem's geometry.

Overlooking Boundary Conditions

When dealing with conductors, remember that the electric field inside a conductor is zero. This fact can simplify many induction problems.

Assuming Uniform Distribution Without Proof

Charges on conductors redistribute until equilibrium is reached. Unless the problem states otherwise, assume the final distribution is uniform along the conductor's surface.

Practice Problems for Mastery

Test your knowledge with these additional questions. Try to solve them before checking the solutions below.

1. A point charge of $-5 \times 10^{-2} \text{ C}$ is located at the origin. What is the electric potential at a point 0.3 m away along the positive x-axis?
2. A rectangular metal plate of dimensions $0.4 \text{ m} \times 0.2 \text{ m}$ is grounded. A $+2 \times 10^{-6} \text{ C}$ charge is placed at the center of the plate. Determine the induced charge on the plate.
3. Three charges, $+1 \times 10^{-6} \text{ C}$, $-1 \times 10^{-6} \text{ C}$, and $+2 \times 10^{-6} \text{ C}$, are located at the vertices of an equilateral triangle with side length 0.05 m. Find the net force on the $+2 \times 10^{-6} \text{ C}$ charge.
4. Calculate the electric field at a point 0.25 m from a uniformly charged sphere with total charge $+8 \times 10^{-6} \text{ C}$.
5. A dielectric slab with relative permittivity $\epsilon_r = 2$ is inserted between two parallel plates of a capacitor. How does the capacitance change compared to the vacuum case?

Solutions

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