

Chapter	9 Electrostatics and Current Electricity	Class	1 st Year	Subject	Physics
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Give Short Answers of the Following Questions

1. Electric lines of force never cross each other. Why?

Ans. Reason:

This is because electric field $\vec{E}$ has only direction (along the tangent) at any given point. If the lines cross then at the point of intersection, $\vec{E}$ will have more than direction (i.e., more than one tangents) which is physically not possible.

2. Is E necessary zero inside a charged rubber balloon if the balloon is spherical? Assume that charge is distributed uniformly over the surface.

Ans. Yes $\vec{E}$ is necessary zero inside a charged rubber balloon.

Reason:

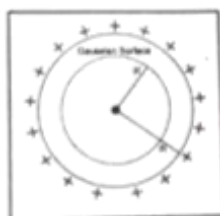
Imagine a spherical Gaussian surface inside the balloon. The charge enclosed by it, $q = 0$
Applying Gauss's law, we have

$$\Phi_e = \frac{q}{\epsilon_0}$$

$$\Phi_e = 0$$

$$\vec{E} \cdot \vec{A} = 0$$

As $\vec{A} \neq 0$, so, $\vec{E} = 0$



3. Electrostatic force is 10^{38} times stronger than gravitational force. Argue that our galaxy should be almost electrically neutral.

Ans. Reason:

The electrostatic force is stronger than the gravitational force by a factor of 10^{38} , but still galaxies (stars or planets) carried no net electric charge.

Galaxies being large collection of stars, gases and dust maintain their neutrality positive charge of protons in atomic nuclei balance their positive charge with negatively charged orbiting electrons.

If, electrostatic forces would cause massive repulsion between them.

4. An uncharged conducting hollow sphere is placed in the field of a positive charge q . What will be the net flux through the shell?

Ans. The net electric flux through the shell is zero.

Reason: According to Gauss's law

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$$\Phi_e = \frac{q}{\epsilon_0}$$

Since, the sphere is uncharged and hollow.

So, $q = 0$

Thus $\Phi_e = \frac{0}{\epsilon_0} = 0$

Note: The external positive charge induces charges on the sphere's surface, but net flux through the shell remains zero.

5. A potential difference is applied across the ends of a copper wire. What is the effect on the drift velocity of free electrons by:
- increasing the potential difference?
 - Decreasing the length and the temperature of the wire?

Ans. (i) Increasing the potential difference?

The drift velocity of free electrons increases by increasing the potential difference.

Reason: The drift velocity of free electrons in conductor of length (l) and area of cross-section (A) is given by

$$V_d = \frac{I}{neA} \text{ where } n \text{ is charge carrier per unit volume (i.e., carrier density)}$$

$$V_d = \frac{V}{neAR} \quad \because I = \frac{V}{R}$$

This equation shows that by increasing potential difference, current (I) and hence drift velocity (V_d) increases.

(ii) Decreasing the length and the temperature of the wire?

The drift velocity (v_d) of electrons increases by decreasing the length and temperature.

Reason: The drift velocity of free electrons in conductor of length (l) and area of cross-section (A) is given by

$$V_d = \frac{I}{neA}$$

Or $V_d = \frac{V}{neAR}$

As $R \propto l$ and $R \propto T$

When length and temperature decreases, the resistance of conductor decreases, so 'I' increases ($\because I = \frac{V}{R}$) Hence V_d increases.

6. Why the terminal potential difference of a battery decreases when the current drawn from it is increased?

Ans. Reason: When the current drawn from the battery is increases, the potential drop across the internal resistance also increases (i.e., the energy dissipation as heat into the battery is increased).

Therefore, according to following relation,

$$V_t = E - Ir$$

The terminal potential is decreased.

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7. How does a moving conductor like an aeroplane acquire charge as it flies through the air? Describe briefly.

Ans. A moving conductor like an aeroplane can acquire charge due to:

- (i) Friction between the aeroplane and air particles dust and charged particles. This friction causes electrostatic charging due to transfer of electrons.
- (ii) Friction between different mechanical parts can transfer electrons, leading to charging.
- (iii) Motion through Earth's magnetic field, a motional electromotive force (emf) is also induced.

8. Define electric intensity and electric potential.

Ans. Electric intensity: The electric intensity of the field or simply electric field at any point is defined as the force experienced by a unit positive charge placed at that point. Mathematically,

$$E = \frac{F}{q_o} = \frac{1}{4\pi\epsilon_o} \frac{q}{r^2}$$

It is a vector quantity. Its direction is same as that of electric force. Its SI unit is N C⁻¹.

Electric potential: The electric potential at a point is defined as the amount of work done in bringing a unit positive charge from infinity to that point keeping it in equilibrium. Mathematically,

$$V = \frac{W}{q_o} = \frac{1}{4\pi\epsilon_o} \frac{q}{r}$$

It is a scalar quantity. Its SI unit is volt.

9. A battery is rated at 100 Ah (ampere-hour). How much charge can this battery supply?

Ans. The charge Q supplied by a battery is given by the formula

$$Q = I \times T$$

According to given data:

$$I = 100 \text{ A} \quad \text{and} \quad t = 1 \text{ hour} = 3600 \text{ s}$$

$$\text{So,} \quad Q = 100 \times 3600$$

$$Q = 3.6 \times 10^5 \text{ coulombs}$$

10. Is electron-volt a unit of potential difference or energy? Explain.

Ans. An electron-volt (eV) is a unit of energy, not potential difference.

Electron volt is defined as "the amount of energy acquired or lost by an electron as it traverses by a potential difference of one volt."

Mathematically, $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$

11. A copper wire of length L has resistance R. it is stretched to double of its length. What will be the resistance of the new length of wire?

Ans. Resistance (R) of a wire is given by

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$$R = \rho \frac{L}{A}$$

Where ρ = Resistivity, L = Length, A = Cross-sectional area

When the wire is stretched to double its length ($2L$), the volume remains constant.

Now, the new resistance (R') is given by

$$R' = \rho \frac{L'}{A'} \quad \text{Where } L' = 2L \text{ and } A' = \frac{A}{2}$$

Thus
$$R' = \rho \frac{2L}{A/2}$$

$$R' = 4\left(\rho \frac{L}{A}\right)$$

$$R' = 4R$$

Therefore, new resistance will be 4 times the original.

12. Why does the resistance of a conductor rise with increase in temperature?

Ans. As the temperature of the conductor rises, the amplitude of vibration of the atoms in the lattice increases and hence the probability of their collision with free electrons also increases. We can say that the atoms then offer a bigger target i.e., collision cross-section of the atoms increases with temperature. So, the resistance of conductor increases.

13. Is the filament resistance lower or higher in a 500 W – 220 V light bulb than in a 100 W 220 V bulb?

Ans. To compare resistance, use the formula

$$R = \frac{V^2}{P} \quad \left(\because P = \frac{V^2}{R} \right)$$

For the 500W bulb

$$R_1 = \frac{V^2}{P_1} \quad R_1 = \frac{(220)^2}{500} = \frac{48400}{500}$$

$$R_1 = 96.8\Omega$$

For the 100W bulb

$$R_2 = \frac{V^2}{P_2} \quad R_2 = \frac{(220)^2}{100} = \frac{48400}{100}$$

$$R_2 = 484\Omega$$

So, the filament resistance is lower in the 500W bulb than in the 100W bulb (i.e., $R_1 < R_2$)

14. Why does resistance of a thermistor decrease as temperature increases?

Ans. Thermistors are made from semiconductor materials that exhibit a decrease in resistance as temperature increases (i.e., having negative temperature coefficients). This is because increasing temperature provides more energy to the charge carriers (electrons or holes), enabling them to move more freely and thus reducing resistance.

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15. Which materials can be used to construct Faraday's cage and why?

Ans. A Faraday cage, also known as a Faraday shield can be constructed using conductive materials to block electromagnetic fields.

For that material like copper, aluminum and steel are used, because they allow electric charges to move freely on their surface. When an external electric field is applied, the free electrons rearrange themselves to cancel the field inside the cage. This shielding effect is why the electric field inside a Faraday cage is zero. Therefore, conductive materials are essential for proper functioning of the cage.