One Two Academy | Electrostatics

Maximum Marks : 25 **PHYSICS** **Time: 50 Minutes**

Choose the correct answer :- **3x1=3**

1.Which charge configuration produces a uniform electric field?
(a) point charge (b) uniformly charged infinite line
(c) uniformly charged infinite plane (d) uniformly charged spherical shell

2. If voltage applied on a capacitor is increased from V to 2V, choose the correct conclusion.
(a) Q remains the same, C is doubled (b) Q is doubled, C doubled
(c) C remains same, Q doubled (d) Both Q and C remain same

3. Two points A and B are maintained at a potential of 7 V and -4 V respectively. The work done in moving 50 electrons from A to B is
(a) $8.80 \times 10^{-17} J$ (b) $-8.80 \times 10^{-17} J$ (c) $4.40 \times 10^{-17} J$ (d) $5.80 \times 10^{-17} J$

Answer the following :- **3x2=6**

4. Define 'electrostatic potential".

5. State Coulomb's Law in Electrostatics.

6. A sample of HCl gas is placed in a uniform electric field of magnitude 3×10^4 N C^{-1}. The dipole moment of each HCl molecule is 3.4×10^{-30} Cm. Calculate the maximum torque experienced by each HCl molecule.

Answer any two of the following:- **2x3=6**

7. What is an equipotential surface and what are the properties of an equipotential surface?
8. Derive an expression for the torque experienced by a dipole due to a uniform electric field.
9. Obtain the expression for energy stored in the parallel plate capacitor.

Answer the following :- **2x5=10**

10. (a) Explain in detail the construction and working of a Van de Graaff generator

(OR)

(b) Obtain the expression for electric field due to an infinitely long charged wire.

11. i) Define 'electric field'.
ii) A parallel plate capacitor has square plates of side 5 cm and separated by a distance of 1 mm. (a) Calculate the capacitance of this capacitor. (b) If a 10 V battery is connected to the capacitor, what is the charge stored in any one of the plates?

(The value of $\varepsilon_0 = 8.85 \times 10^{-12}$ **)**

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Answer key attached in next page!!!

This page is to prevent seeing answer key

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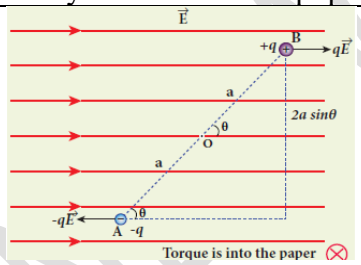
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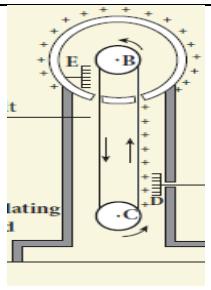
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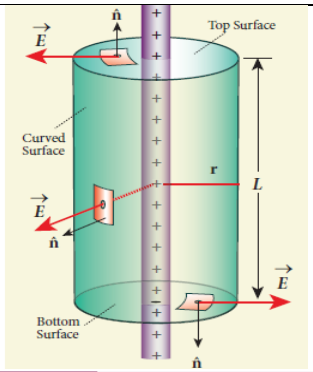
ANSWER KEY

Q NO	ANSWERS	MARKS
1.	(C) uniformly charged infinite plane	1
2.	(C) C remains same, Q doubled	1
3.	(A) 8.80×10^{-17} J	1
4.	the electric potential at a point P is equal to the work done by an external force to bring a unit positive charge with constant velocity from infinity to the point P in the region of the external electric field $\vec{E}$.	2
5.	Coulomb's law states that the electrostatic force is directly proportional to the product of the magnitude of the two point charges and is inversely proportional to the square of the distance between the two point charges. $\overrightarrow{F_{21}} = k\frac{q_1 q_2}{r^2}\widehat{r_{12}}$	2
6.	$\tau_{max} = pE\sin 90^\circ = 3.4\times10^{-30}\times3\times10^{4}$ $\tau_{max} = 10.2\times10^{-26}\,\text{Nm}$	2
7.	An equipotential surface is a surface on which all the points are at the same electric potential. Properties : **(i)** The work done to move a charge q between any two points A and B, $W = q\,(V_B - V_A)$. If the points A and B lie on the same equipotential surface, work done is zero because $V_A = V_B$. **(ii)** The electric field is normal to an equipotential surface. If it is not normal, then there is a component of the field parallel to the surface. Then work must be done to move a charge between two points on the same surface. This is a contradiction. Therefore the electric field must always be normal to equipotential surface.	3
8.	 $\vec{\tau} = \overrightarrow{OA}\times(-q\vec{E}) + \overrightarrow{OB}\times q\vec{E}$ $\tau = \lvert OA\rvert\lvert(-qE)\rvert\sin\theta + \lvert OB\rvert\lvert qE\rvert\sin\theta$ $\tau = qE\cdot 2a\sin\theta$ $\vec{\tau} = \vec{p}\times\vec{E}$	3
9.	$dW = V\,dQ$ $W = \int_0^Q \frac{Q}{C}dQ = \frac{Q^2}{2C}$ $U_E = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}\epsilon_0(Ad)E^2$ $u_E = \frac{1}{2}\epsilon_o E^2$	3

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10. a	 53 Van de Graaff Principle : electrostatic induction and action at points. Construction : • A large hollow spherical conductor is fixed on the insulating stand. • A pulley B is mounted at the centre of the hollow sphere and another pulley C is fixed at the bottom. • A belt made up of insulating materials like silk or rubber runs over both pulleys. The pulley C is driven continuously by the electric motor. Two comb shaped metallic conductors E and D are fixed near the pulleys. • The comb D is maintained at a positive potential of 104 V by a power supply. The upper comb E is connected to the inner side of the hollow metal sphere. Working : • Due to the high electric field near comb D, air between the belt and comb D gets ionized by the action of points. • The positive charges are pushed towards the belt and negative charges are attracted towards the comb D. • The positive charges stick to the belt and move up. When the positive charges on the belt reach the point near the comb E, the comb E acquires negative charge and the sphere acquires positive charge due to electrostatic induction. • As a result, the positive charges are pushed away from the comb E and they reach the outer surface of the sphere. • the positive charges are distributed uniformly on the outer surface of the hollow sphere. At the same time, the negative charges nullify the positive charges in the belt due to corona discharge before it passes over the pulley. • When the belt descends, it has almost no net charge. At the bottom, it again gains a large positive charge. The belt goes up and delivers the positive charges to the outer surface of the sphere. This process continues until the outer surface produces the potential difference of the order of 10^7 which is the limiting value. • Leakage can occur if charges are stored beyond the limit. This can be prevented by enclosing the machine in gas filled steel chamber at very high pressure.	**5**

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10. b	 $\Phi_E = \oint \vec{E} \cdot d\vec{A}$ $= \int_{\text{Curved surface}} \vec{E} \cdot d\vec{A} + \int_{\text{top surface}} \vec{E} \cdot d\vec{A} + \int_{\text{bottom surface}} \vec{E} \cdot d\vec{A}$ $\Phi_E = \int_{curved\ suface} EdA = \frac{Q_{encl}}{\epsilon_o}$ $E \cdot 2\pi rL = \frac{\lambda L}{\epsilon_0}$ $E = \frac{1}{2\pi\epsilon_o}\frac{\lambda}{r}$	**5**
11	i) The electric field at the point P at a distance r from the point charge q is defined as the force that would be experienced by a unit positive charge placed at that point P. $\vec{E} = k\frac{q}{r^2}\hat{r}$ ii) $C = \frac{\epsilon_0 A}{d} = 22.12\ pF$ $Q = CV = 221.2\ pF$	**5**

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