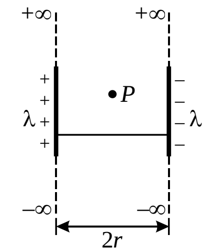
JEE Main Practice Test-13
Electrostatics

Topic : ELECTROSTATICS **Time: 75Min** **Marking +4 –1**

Section - A : MCQs with Single Option Correct

1. Electric field at a mid point P for the shown arrangement :



(A) $\frac{\lambda}{2\pi\varepsilon_0 r}$ (B) $\frac{\lambda}{\pi\varepsilon_0 r}$

(C) $\frac{2\lambda}{\pi\varepsilon_0 r}$ (D) $\frac{\lambda}{4\pi\varepsilon_0 r}$

2. A spherically symmetric charge distribution is characterised by a charge density having the following variations

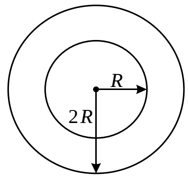
$\rho(r) = \rho_0\left(1-\frac{r}{R}\right)$ for $r < R$

$\rho(r) = 0$ for $r \geq R$

Where r is the distance from the centre of the charge distribution ρ_0 is a constant. The electric field at an internal point ($r < R$) is :

(A) $\frac{\rho_0}{4\varepsilon_0}\left(\frac{r}{3}-\frac{r^2}{4R}\right)$ (B) $\frac{\rho_0}{\varepsilon_0}\left(\frac{r}{3}-\frac{r^2}{4R}\right)$ (C) $\frac{\rho_0}{3\varepsilon_0}\left(\frac{r}{3}-\frac{r^2}{4R}\right)$ (D) $\frac{\rho_0}{12\varepsilon_0}\left(\frac{r}{3}-\frac{r^2}{4R}\right)$

3. In the figure two concentric conducting shells of radius R & $2R$ are shown. The inner shell is charged with Q and the outer shell is uncharged. The amount of energy dissipated when the shells are connected by a conducting wire is (where $K = \frac{1}{4\pi \in_0}$)



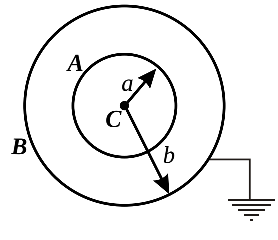
(A) $\frac{KQ^2}{4R}$ (B) $\frac{KQ^2}{2R}$

(C) $\frac{KQ^2}{8R}$ (D) $\frac{3KQ^2}{4}$

4. Eight mercury droplets having a radius of 1 mm and a charge of 0.066 pC. Each merge into one droplet. Find it's potential :

(A) 2.4V (B) 1.2V (C) 3.6V (D) 0.6V

5. A conducting sphere A of radius a, with charge Q, is placed concentrically inside a conducting shell B of radius b. B is earthed. C is the common centre of the A and B. Then choose the incorrect statement :



(A) The field at a distance r from C, where $a < r < b$ is $\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

(B) The potential at a distance r from C, where $a < r < b$, is $\frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

(C) The potential difference between A and B is $\frac{1}{4\pi\varepsilon_0}Q\left(\frac{1}{a}-\frac{1}{b}\right)$

(D) The potential at a distance r from C, where $a < r < b$, $\frac{1}{4\pi\varepsilon_0}Q\left(\frac{1}{r}-\frac{1}{b}\right)$

6. An electron of mass M_e, initially at rest, moves through a certain distance in a uniform electric field in time t_1. A proton of mass M_p also initially at rest, takes time t_2 to move through an equal distance in this uniform electric field. Neglecting the effect of gravity, the ratio t_2/t_1 is nearly equal to :

(A) 1 (B) $\sqrt{M_p / M_e}$ (C) $\sqrt{M_e / M_p}$ (D) 1836

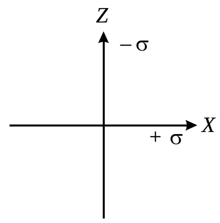
7. Three identical positive charges Q are arranged at the vertices of an equilateral triangle. The side of the triangle is a. Find the intensity of the field at the vertex of a regular tetrahedron of which the triangle is the base.

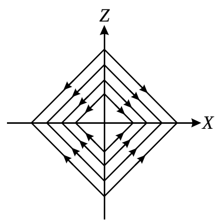
(A) $\sqrt{6}\frac{KQ}{a^2}$ (B) $\sqrt{2}\frac{KQ}{a^2}$ (C) $\sqrt{3}\frac{KQ}{a^2}$ (D) None of these

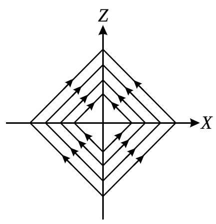
8. Three identical metallic uncharged spheres A, B and C of radius a are kept on the corners of an equilateral triangle of side $d(d >> a)$. A fourth sphere (radius a) which has charge Q touches A and is then removed to a position far away. B is earthed and then the earth connection is removed. C is then earthed. The charge on C is :

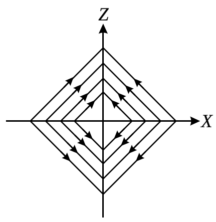
(A) $\frac{Qa}{2d}\left(\frac{2d-a}{2d}\right)$ (B) $\frac{Qa}{2d}\left(\frac{2d-a}{d}\right)$ (C) $\frac{Qa}{2d}\left(\frac{a-d}{d}\right)$ (D) $\frac{2Qa}{d}\left(\frac{d-a}{2d}\right)$

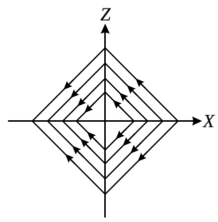
9. Two infinitely large charged non-conducting planes having uniform surface charge density $+\sigma$ and $-\sigma$ are placed along x-y and y-z plane respectively as shown in the figure. Then the nature of the electric lines of forces in x-z plane is best represented by :



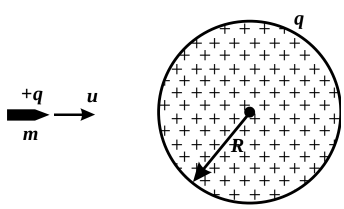
(A)


(B)


(C)


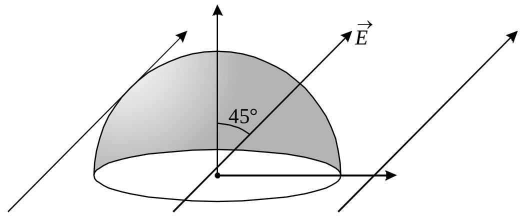
(D)


10. A bullet of mass m and charge q is fired towards a solid uniformly charged sphere of radius R and total charge $+ q$. If it strikes the surface of sphere with speed u, find the minimum value of u so that it can penetrate through the sphere. (Neglect all resistnace forces or friction acting on bullet except electrostatic forces)



(A) $\frac{q}{\sqrt{2\pi\varepsilon_0 mR}}$ (B) $\frac{q}{\sqrt{4\pi\varepsilon_0 mR}}$ (C) $\frac{q}{\sqrt{8\pi\varepsilon_0 mR}}$ (D) $\frac{\sqrt{3}q}{\sqrt{4\pi\varepsilon_0 mR}}$

11. The flat base of a hemisphere of radius a with no charge inside it lies in a horizontal plane. A uniform electric field $\vec{E}$ is applied at an angle $\pi/4$ with the vertical direction. The electric flux through the curved surface of the hemisphere is :



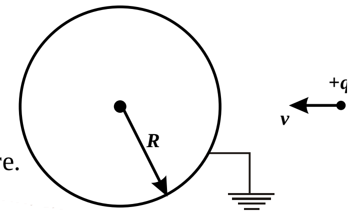
(A) $\pi a^2 E$ (B) $\dfrac{\pi a^2 E}{\sqrt{2}}$

(C) $\dfrac{\pi a^2 E}{2\sqrt{2}}$ (D) $\dfrac{(\pi + 2a\pi)^2 E}{(2\sqrt{2}^2)}$

12. A large flat metal surface has a uniform charge density $+\sigma$. An electron of mass m and charge e leaves the surface at point A with speed u, and returns to it at point B. Disregard gravity. The maximum value of AB is :

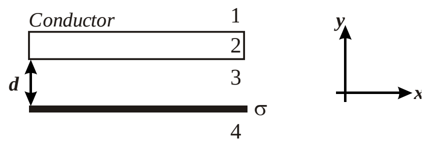
(A) $\dfrac{u^2 m \epsilon_0}{\sigma e}$ (B) $\dfrac{u^2 e \epsilon_0}{m\sigma}$ (C) $\dfrac{u^2 e}{\epsilon_0 \sigma m}$ (D) $\dfrac{u^2 \sigma e}{\epsilon_0 m}$

13. Consider a solid metallic sphere which is grounded. Consider a charge $+q$ which is moved towards the sphere with a constant velocity by an external agent as shown. Then



(A) The charge distribution on the surface of the sphere will not change with time.
(B) The surface charge density of the sphere will increase with time.
(C) The surface charge density of the sphere will decrease with time.
(D) The potential of the sphere will decrease as the charge moves towards the sphere.

14. Figure shows an infinitely wide conductor parallel and distance d from an infinitely wide plane of charge with surface charge density σ. What are fields $\vec{E}_1, \vec{E}_2, \vec{E}_3$ and $\vec{E}_4$ in regions 1 to 4 ?



(A) $\dfrac{\sigma}{2\varepsilon_0}\hat{j}, 0, \dfrac{\sigma}{2\varepsilon_0}\hat{j}, \dfrac{\sigma}{2\varepsilon_0}\hat{j}$ (B) $-\dfrac{\sigma}{2\varepsilon_0}\hat{j}, 0, \dfrac{\sigma}{2\varepsilon_0}\hat{j}, \dfrac{\sigma}{2\varepsilon_0}\hat{j}$

(C) $\dfrac{\sigma}{2\varepsilon_0}\hat{j}, 0, \dfrac{\sigma}{2\varepsilon_0}\hat{j}, -\dfrac{\sigma}{2\varepsilon_0}\hat{j}$ (D) $\dfrac{\sigma}{2\varepsilon_0}\hat{j}, 0, -\dfrac{\sigma}{2\varepsilon_0}\hat{j}, \dfrac{\sigma}{2\varepsilon_0}\hat{j}$

15. Which of the following aspects is incorrect, when an uncharged metal sphere is placed in a uniform electric field ?
(A) The metal sphere is an equipotential region.
(B) The induced charges appearing on the surface of the sphere produce an electric field equal and opposite to the external field, at each point within the sphere.
(C) The electric lines of force, just outside the sphere are normal to the spherical surface.
(D) The electric lines of force in the spherical region increase, as soon as the sphere is placed.

16. A solid sphere of radius R, and dielectric constant 'k' has spherical cavity of radius $R/4$. A point charge q_1 is placed in the cavity. Another charge q_2 is placed outside the sphere at a distance of r from q. Then Coulombic force of interaction between them is found to be 'F_1'. When the same charges are separated by same distance in vacuum then the force of interaction between them is found to be F_2 then :
(A) $F_1 = F_2/k$ (B) $F_2 = F_1/k$ (C) $F_1 . F_2 = 1$ (D) $F_1 = F_2$

17. Two point dipoles of dipole moment $\vec{P}_1$ and $\vec{P}_2$ are at a distance x from each other and $\vec{P}_1 \parallel \vec{P}_2$. The force between the dipoles is :

(A) $\frac{1}{4\pi\varepsilon_0}\frac{4p_1p_2}{x^4}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{3p_1p_2}{x^3}$ (C) $\frac{1}{4\pi\varepsilon_0}\frac{6p_1p_2}{x^4}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{8p_1p_2}{x^4}$

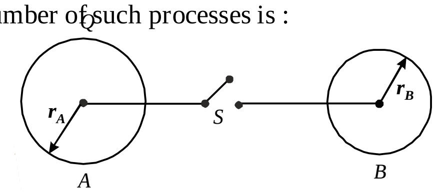
18. Two identical spheres of same mass and specific gravity (which is the ratio of density of a substance and density of water) 2.4 have different charges of Q and $-3Q$. They are suspended from two strings of same length l fixed to points at the same horizontal level, but distant l from each other. When the entire set up is transferred inside a liquid of specific gravity 0.8, if is observed that the inclination of each string in equilibrium remains unchanged. Then the dielectric constant of the liquid is :

(A) 2 (B) 3 (C) 1.5 (D) None of these

19. A conducting sphere A of radius r_A carries a charge Q. Another conducting sphere B of radius r_B is uncharged initially. Both the spheres are separated by a very large distance. Sphere A is connected with sphere B through a long conducting wire of zero resistance through a switch S as shown in the figure. At $t = 0$ switch S is closed. As soon as the current flow through the wire vanishes, switch S is opened, sphere A is again charged to a total charge Q and then switch S is again closed and the process is continued for infinite times. If q is the charge transferred to sphere B when the switch S is closed for the first time, then total charge on the sphere B after large number of such processes is :

(A) Q (B) $\frac{qQ}{Q-q}$

(C) $Q\,\frac{r_B}{r_A}$ (D) None of these



20. A point charge of magnitude + 1 μC is fixed at (0, 0, 0). An isolated uncharged spherical conductor, is fixed with its center at (4, 0, 0). The potential and the induced electric field at the centre of the sphere is :

(A) 1.8×10^5 V and -5.625×10^6 V/m (B) 0 V and 0 V/m

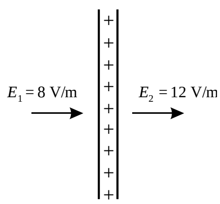
(C) 2.25×10^5 V and -5.625×10^6 V/m (D) 2.25×10^5 V and 0 V/m

Section- B: INTEGER Answer Type Questions

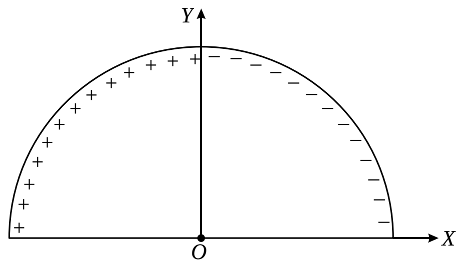
21. A long straight wire carries a charge with linear density λ. A particle of mass m and a charge q is released at a distance r from the wire. The speed of the particle as it crosses a point distance $2r$ is $\sqrt{\frac{q\lambda \ln 2}{n\pi m\varepsilon_0}}$. Find n.

22. A point charge q is placed at one corner of a cube of edge. The flux through each of the cube faces is $\frac{1}{8x}\frac{q}{\varepsilon_0}$, where ε_0 is permittivity of medium. Find value of x, taking all in SI units.

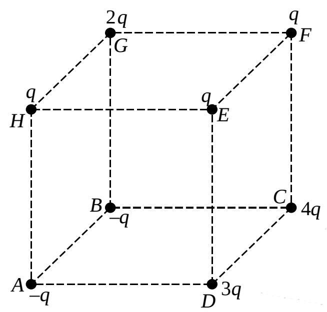
23. The electric field on two sides of a charged plate is shown in the figure. If the charge density on the plate is $n\varepsilon_0$, then calculate the value of n.



24. A wire of length L (= 20 cm), is bent into a semicircular arc. If the two equal halves of the arc were each to be uniformly charged with charges $\pm Q$, ($|Q| = 10^3\varepsilon_0$ Coulomb where ε_0 is the permittivity in SI units of free space) the net electric field at the centre O of the semicircular arc is $n \times 10^3\,\hat{i}$ N/C. Calculate n.



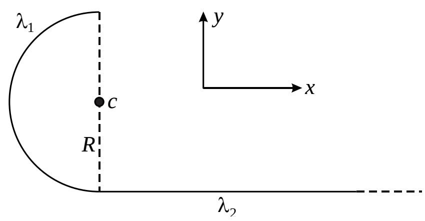
25. Eight point charges are placed at eight corners of a cube as shown in figure. If maximum value of flux passing through one of the surface of cube is $\frac{nq}{24\varepsilon_0}$. Find the value of n.



26. The electrostatic potential inside a charged spherical ball is given by $\phi = ar^2 + b$ where r is the distance from the centre; a, b are constant. Then the charge density inside the ball is $-na \in_0$. Find n.

27. A cylinder of radius, R and length, L is placed in a uniform electric field, E parallel to the cylinder axis. The total flux for the surface of the cylinder is given by.

28. In the figure shown. The value of $\frac{2\lambda_1}{\lambda_2}$ so that electric field at centre 'c' is along y-axis only, where λ_1 and λ_2 are linear charge densities on semicircular and straight wire respectively.



29. The electric field in a region is radially outwards with magnitude $E = \alpha r/\in_0$. In a sphere of radius R centered at the origin, calculate the value of charge in coulombs if $\alpha = \frac{5}{\pi}$ V/m^2 and $R = \left(\frac{3}{10}\right)^{1/3}$ m. r is radial distance from centre.

30. A long string with a charge of λ per unit length passes through an imaginary cube of edge a. The maximum flux of the electric field through the cube will be $\sqrt{n}\,\lambda a/\in_0$. Find the value of n.

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ANSWER KEY

Section - A : MCQs with Single Option Correct

1. (B)	**2.** (B)	**3.** (A)	**4.** (A)
5. (B)	**6.** (B)	**7.** (A)	**8.** (C)
9. (C)	**10.** (B)	**11.** (B)	**12.** (A)
13. (B)	**14.** (C)	**15.** (D)	**16.** (D)
17. (C)	**18.** (C)	**19.** (B)	**20.** (C)

Section- B: INTEGER Answer Type Questions

21. [1]	**22.** [3]	**23.** [4]	**24.** [25]
25. [9]	**26.** [6]	**27.** [0]	**28.** [1]
29. [6]	**30.** [3]		

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