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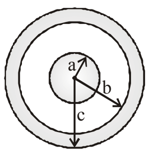
ELECTRIC CHARGES AND FIELDS

MCQs with One Correct Answer

1. A solid conducting sphere of radius a has a net positive charge 2Q. A conducting spherical shell of inner radius b and outer radius c is concentric with the solid sphere and has a net charge – Q.



The surface charge density on the inner and outer surfaces of the spherical shell will be

(a) $-\frac{2Q}{4\pi b^2}, \frac{Q}{4\pi c^2}$ (b) $-\frac{Q}{4\pi b^2}, \frac{Q}{4\pi c^2}$

(c) $0, \frac{Q}{4\pi c^2}$ (d) None of the above

2. Two spheres carrying charges $+6\mu C$ and $+ 9\mu C$, separated by a distance d, experiences a force of repulsion F. when a charge of $-3\mu C$ is given to both the sphere and kept at the same distance as before, the new force of repulsion is

(a) $3F$ (b) $F/9$

(c) F (d) $F/3$

3. Two equally charged, identical metal spheres A and B repel each other with a force ‘F’. The spheres are kept fixed with a distance ‘r’ between them. A third identical, but uncharged sphere C is brought in contact with A and then placed at the mid point of the line joining A and B. The magnitude of the net electric force on C is

(a) F (b) $\frac{3F}{4}$

(c) $\frac{F}{2}$ (d) $\frac{F}{4}$

4. Five point charges, each of value +q, are placed on five vertices of a regular hexagon of side L. The magnitude of the force on a point charge of value –q coulomb placed at the center of the hexagon is

(a) $\frac{1}{\pi\varepsilon_0}\left(\frac{q}{L}\right)^2$ (b) $\frac{2}{\pi\varepsilon_0}\left(\frac{q}{L}\right)^2$

(c) $\frac{1}{2\pi\varepsilon_0}\left(\frac{q}{L}\right)^2$ (d) $\frac{1}{4\pi\varepsilon_0}\left(\frac{q}{L}\right)^2$

5. Two balls of same mass and carrying equal charge are hung from a fixed support of length l. At electrostatic equilibrium, assuming that angles made by each thread is small, the separation, x between the balls is proportional to :

(a) l (b) l^2

(c) $l^{2/3}$ (d) $l^{1/3}$

6. Three charges $+Q_1$, $+Q_2$ and q are placed on a straight line such that q is somewhere in between $+Q_1$ and $+Q_2$. If this system of charges is in equilibrium, what should be he magnitude and sign of charge q?

(a) $\frac{Q_1Q_2}{\sqrt{(Q_1+Q_2)^2}}, +$ (b) $\frac{Q_1+Q_2}{2}, -$

(c) $\frac{Q_1Q_2}{\left(\sqrt{Q_1}+\sqrt{Q_2}\right)^2}, -$ (d) $\frac{Q_1+Q_2}{2}, -$

7. Three point charges +q, –2q and +q are placed at points (x = 0, y = a, z = 0), (x = 0, y = 0, z = 0) and (x = a, y = 0, z = 0) respectively. The magnitude and direction of the electric dipole moment vector of this charge assembly are

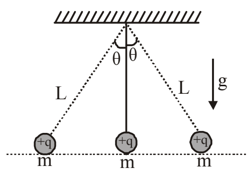
(a) $\sqrt{2}qa$ along the line joining points (x = 0, y = 0, z = 0) and (x = a, y = a, z = 0)

(b) qa along the line joining points (x = 0, y = 0, z = 0) and (x = a, y = a, z = 0)

(c) $\sqrt{2}qa$ along +ve x direction

(d) $\sqrt{2}qa$ along +ve y direction

8. Three identical point charge, each of mass m and charge q, hang from three strings as shown in Fig. The value of q in terms of m, L and q is



(a) $q = \sqrt{(16/5)\pi\varepsilon_0 mgL^2 \sin^2\theta \tan\theta}$

(b) $q = \sqrt{(16/15)\pi\varepsilon_0 mgL^2 \sin^2\theta \tan\theta}$

(c) $q = \sqrt{(15/16)\pi\varepsilon_0 mgL^2 \sin^2\theta \tan\theta}$

(d) None of these

9. The electric field at a distance $\frac{3R}{2}$ from the centre of a charged conducting spherical shell of radius R is E. The electric field at a distance $\frac{R}{2}$ from the centre of the sphere is

(a) $\frac{E}{2}$ (b) zero

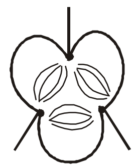
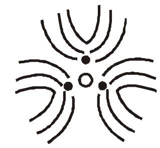
(c) E (d) $\frac{E}{2}$

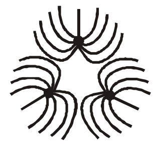
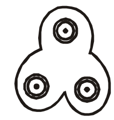
10. Three concentric metallic spherical shells of radii R, $2R$, $3R$, are given charges Q_1, Q_2, Q_3, respectively. It is found that the surface charge densities on the outer surfaces of the shells are equal. Then, the ratio of the charges given to the shells, $Q_1 : Q_2 : Q_3$, is

(a) 1 : 2 : 3 (b) 1 : 3 : 5

(c) 1 : 4 : 9 (d) 1 : 8 : 18

11. Three positive charges of equal value q are placed at vertices of an equilateral triangle. The resulting lines of force should be sketched as in

(a)  (b) 

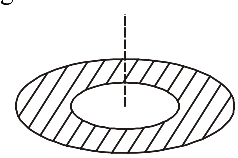
(c)  (d) 

12. Two point charges + 8q and –2q are located at x = 0 and x = L respectively. The location of a point on the x-axis at which the net electric field due to these two point charges is zero

(a) 8L (b) 4L

(c) 2L (d) $\frac{L}{4}$

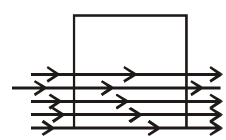
13. A thin disc of radius $b = 2a$ has a concentric hole of radius 'a' in it (see figure). It carries uniform surface charge 'σ' on it. If the electric field on its axis at height 'h' ($h << a$) from its centre is given as 'Ch' then value of 'C' is :



(a) $\frac{\sigma}{4a\epsilon_0}$ (b) $\frac{\sigma}{8a\epsilon_0}$

(c) $\frac{\sigma}{a\epsilon_0}$ (d) $\frac{\sigma}{2a\epsilon_0}$

14. A square surface of side L metres is in the plane of the paper. A uniform electric field $\vec{E}$ (volt /m), also in the plane of the paper, is limited only to the lower half of the square surface (see figure). The electric flux in SI units associated with the surface is



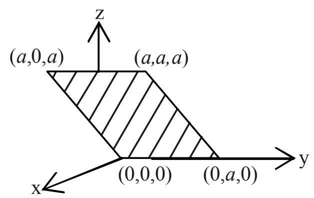
(a) $EL^2/2$

(b) zero

(c) EL^2

(d) $EL^2/(2\varepsilon_0)$

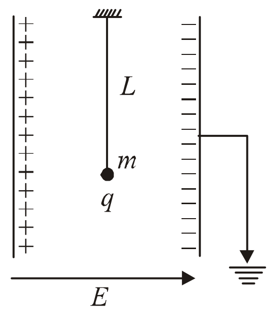
15. Consider an electric field $\vec{E} = E_0\hat{x}$ where E_0 is a constant. The flux through the shaded area (as shown in the figure) due to this field is



(a) $2E_0a_2$ (b) $\sqrt{2}E_0a^2$

(c) E_0 a^2 (d) $\frac{E_0a^2}{\sqrt{2}}$

16. A simple pendulum of length L is placed between the plates of a parallel plate capacitor having electric field E, as shown in figure. Its bob has mass m and charge q. The time period of the pendulum is given by :



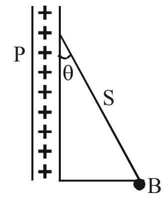
(a) $2\pi\sqrt{\frac{L}{\left(g+\frac{qE}{m}\right)}}$

(b) $2\pi\sqrt{\frac{L}{\sqrt{g^2-\frac{q^2E^2}{m^2}}}}$

(c) $2\pi\sqrt{\frac{L}{\left(g-\frac{qE}{m}\right)}}$

(d) $2\pi\sqrt{\frac{L}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$

17. A charged ball B hangs from a silk thread S, which makes an angle θ with a large charged conducting sheet P, as shown in the figure. The surface charge density σ of the sheet is proportional to



(a) cot θ (b) cos θ

(c) tan θ (d) sin θ

18. 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) $\frac{1}{4\pi\varepsilon_0}\frac{8p_1p_2}{x^4}$

19. If the electric flux entering and leaving an enclosed surface respectively is ϕ_1 and ϕ_2, the electric charge inside the surface will be

(a) $(\phi_2 - \phi_1)\varepsilon_o$ (b) $(\phi_1 - \phi_2)/\varepsilon_o$

(c) $(\phi_2 - \phi_1)/\varepsilon_o$ (d) $(\phi_1 - \phi_2)\varepsilon_o$

20. An electric dipole is placed at an angle of 30° to a non-uniform electric field. The dipole will experience

(a) a translational force only in the direction of the field

(b) a translational force only in a direction normal to the direction of the field

(c) a torque as well as a translational force

(d) a torque only

Numeric Value Answer

21. An electric dipole, consisting of two opposite charges of 2×10^{-6} C each separated by a distance 3 cm is placed in an electric field of 2×10^5 N/C. Maximum torque (in Nm) acting on the dipole is

22. A pendulum bob of mass 30.7×10^{-6} kg carrying a charge 2×10^{-8} C is at rest in a horizontal uniform electric field of 20000 V/m. The tension (in N) in the thread of the pendulum is (g = 9.8 m/s^2)

23. A liquid drop having 6 excess electrons is kept stationary under a uniform electric field of 25.5 kVm^{-1}. The density of liquid is 1.26×10^3 kg m^{-3}. The radius (in m) of the drop is (neglect buoyancy).

24. The electric field in a region of space is given by, $\vec{E} = E_0\hat{i} + 2E_0\hat{j}$ where E_o = 100 N/C. The flux (in Nm^2/C) of the field through a circular surface of radius 0.02 m parallel to the Y-Z plane is nearly:

25. A charge Q is placed at each of the opposite corners of a square. A charge q is placed at each of the other two corners. If the net electrical force on Q is zero, then Q/q equals:

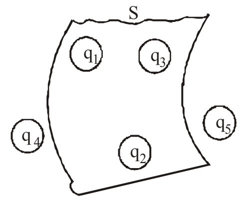
26. A sphere of radius R carries charge such that its volume charge density is proportional to the square of the distance from the center. What is the ratio of the magnitude of the eletric field at a distance 2R from the center to the magnitude of the electric field at a distance of R/2 from the center?

27. The surface charge density of a thin charged disc of radius R is σ. The value of the electric field at the centre of the disc is $\frac{\sigma}{2\epsilon_0}$. With respect to the field at the centre, the electric field along the axis at a distance R from the centre of the disc reduces by %

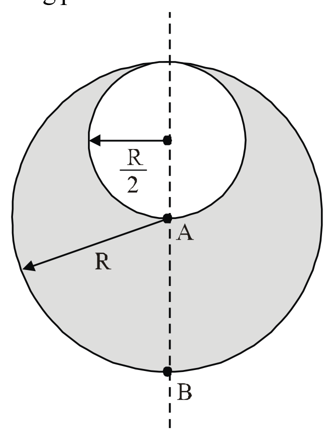
28. A solid sphere of radius R has a charge Q distributed in its volume with a charge density $\rho = \kappa r^a$, where κ and a are constants and r is the distance from its centre.

If the electric field at $r = \frac{R}{2}$ is $\frac{1}{8}$ times that at $r = R$, find the value of a.

29. Figure shows five charged lumps of plastic. The cross-section of Gaussian surface S is indicated. Assuming $q_1 = q_4 = 3.1$ nC, $q_2 = q_5 = -5.9$ nC, and $q_3 = -3.1$ nC, the net electric flux (in Nm^2/C) through the surface is



30. Consider a sphere of radius R which carries a uniform charge density ρ. If a sphere of radius $\frac{R}{2}$ is carved out of it, as shown, the ratio $\frac{|\vec{E}_A|}{|\vec{E}_B|}$ of magnitude of electric field $\vec{E}_A$ and $\vec{E}_B$, respectively, at points A and B due to the remaining portion is:



ANSWER KEY																			
1	(a)	**4**	(d)	**7**	(a)	**10**	(b)	**13**	(a)	**16**	(d)	**19**	(a)	**22**	(5×10^{-4})	**25**	$(-2\sqrt{2})$	**28**	(2)
2	(d)	**5**	(d)	**8**	(a)	**11**	(c)	**14**	(b)	**17**	(c)	**20**	(c)	**23**	(7.8×10^{-7})	**26**	(2)	**29**	(–670)
3	(a)	**6**	(c)	**9**	(b)	**12**	(c)	**15**	(c)	**18**	(c)	**21**	(12×10^{-3})	**24**	(0.125)	**27**	(70.7%)	**30**	(0.53)