PHYSICS

The following questions given below consist of an "Assertion" (A) and "Reason" (R) Type questions. Use the following Key to choose the appropriate answer.

(A) If both (A) and (R) are true, and (R) is the correct explanation of (A).

(B) If both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) If (A) is true but (R) is false.

(D) If (A) is false but (R) is true.

Q.1 **Assertion** : Electric flux through a closed surface does not depend on charge outside the surface

Reason : Outside charged particle does not contribute net electric field to the surface

[C]

Q.2 **Assertion** : It is advisable to remain inside the car in the presence of thundershower

Reason : Electric field inside the conductor is zero. **[A]**

Q.3 **Assertion** : Electric flux through a plane surface will be maximum when electric field falls normally on the surface.

Reason : Maximum number of electric lines of force passes through the surface. **[A]**

Q.4 **Assertion** : Gauss's law cannot tell about the magnitude of electric field if no charge is enclosed by the surface, but can tell about the direction.

Reason : Gauss's Law can tell about the electric field for symmetric charge distribution **[D]**

Q.5 **Statement I :** Electrons move away from a region of lower potential to a region of higher potential.

Statement II : Since an e^- has negative charge. **[A]**

Q.6 **Statement I :** If a point charge q is placed in front of an infinite grounded conducting plane surface, the point charge will experience a force.

Statement II : The force is due to the induced charge on the conducting surface which is at zero potential. **[A]**

Q.7 **Statement I :** Work done in moving a charge between any two points in an electric field is independent of the path followed by the charge, between these points.

Statement II : Electrostatic forces are non conservative. **[C]**

Q.8 **Statement I :** Force between two charges decreases when air separating the charges is replaced by water.

Statement II : Medium intervening the charges has no effect on force. **[C]**

Q.9 **Statement I :** The no. of lines of force emanating from 1μC charge in vacuum is 1.13×10^5.

Statement II : This follow from Gauss's theorem in electrostatics. **[A]**

Q.10 This question contains Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement-I :

For a mass M kept at the centre of a cube of side 'a', the flux of gravitational field passing through its sides is 4 πGM.

and

Statement-II :

If the direction of a field due to a point source is radial and its dependence on the distance 'r' from the source is given as $\frac{1}{r^2}$, its flux through a closed surface depends only on the strength of the source enclosed by the surface and not on the size or shape of the surface. **[AIEEE-2008]**

[A]

Q.11 **Statement-I** : For a charged particle moving from point P to point Q, the net work done by an electrostatic field on the particle is independent of the path connecting point P to point Q.

Statement-II : The net work done by a conservative force on an object moving along a closed loop is zero. **[AIEEE-2009]**

[A]

Q.1 Consider the figure.

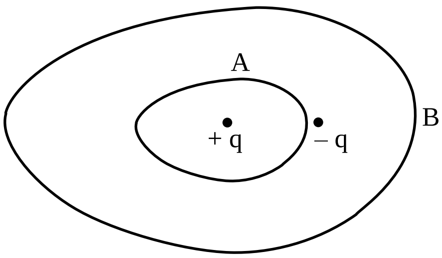


Fig.

Column-I	**Column-II**
(A) Electric flux through A	(P) > 0
(B) Electric flux through B	(Q) = 0
(C) Electric field inside A	(R) < 0
(D) Electric field inside B	(S) None

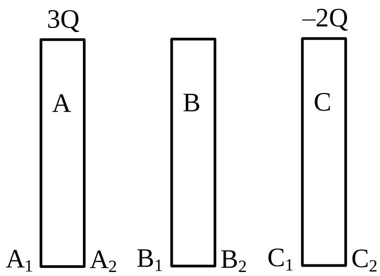
Sol. (A) → (P); (B) → (Q); (C) → (P); (D) → (Q)

Q.2 Charges Q_1 and Q_2 lie inside and outside respectively of a closed surface S. Let E be the field at any point on S and ϕ be the flux of E over S.

Column-I	**Column-II**
(A) If $Q_1 = 0$ and $Q_2 \neq 0$ then	(P) both E and ϕ will change
(B) If $Q_1 \neq 0$ and $Q_2 = 0$ then	(Q) $E = 0$ but $\phi \neq 0$
(C) If Q_2 changes	(R) E will change but ϕ will not change
(D) If Q_1 changes	(S) $E \neq 0$ but $\phi = 0$

Sol. (A) → (S), (B) → (Q), (C) → (R), (D) → (P)

Q. 1 Three identical metal plates A, B and C with large surface areas are kept parallel to each other at small distance apart. The left most plate is given a charge 3Q, the right most a charge –2Q and the middle one remains neutral. Then –



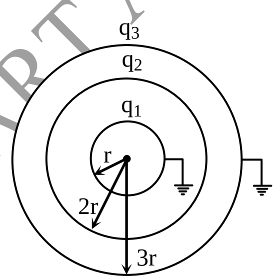
(A) Charge on outer surface C_2 of the right most plate is + Q

(B) Charge on left surface B_1 of middle plate is +2Q

(C) Charge on right surface B_2 of middle plate is +2.5 Q

(D) Charge on right surface A_2 of left plate is +2.5 Q **[C,D]**

Q.2 Three concentric conducting spherical shells have radii r, 2r and 3r and charges q_1, q_2 and q_3 respectively. Innermost and outermost shells are earthed as shown in figure. Select the correct alternative(s) :



(A) $q_1 + q_3 = -q_2$ (B) $q_1 = -\frac{q_2}{4}$

(C) $\frac{q_3}{q_1} = 3$ (D) $\frac{q_3}{q_2} = -\frac{1}{3}$

Sol. **[A,B,C]**

Potential of innermost shell is zero

$$\therefore \frac{q_1}{r} + \frac{q_2}{2r} + \frac{q_3}{3r} = 0$$

or $6q_1 + 3q_2 + 2q_3 = 0$ ... (1)

Similarly, potential on outermost shell is also zero.

$$\therefore \frac{q_1}{3r} + \frac{q_2}{3r} + \frac{q_3}{3r} = 0$$

or $q_1 + q_3 = -q_2$ ... (2)

Solving Eqs. (1) and (2), we get

$$q_1 = -\frac{q_2}{4}, \frac{q_3}{q_1} = 3$$

and $\frac{q_3}{q_2} = -\frac{3}{4}$

Q.3 An electric dipole is placed at the centre of a sphere. Mark the correct options -

(A) the flux of the electric field through the sphere is zero.

(B) the electric field is zero at every point of the sphere

(C) the electric field is not zero anywhere on the sphere.

(D) The electric field is zero on a circle on the sphere **[A,C]**

Q.4 If the flux of the electric field through a closed surface is zero -

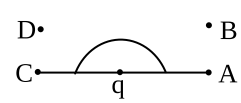
(A) the electric field must be zero everywhere on the surface

(B) the electric field may be zero everywhere on the surface

(C) the charge inside the surface must be zero

(D) the charge in the vicinity of the surface must be zero **[B,C]**

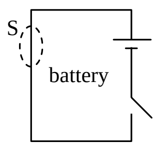
Q.5 Figure shows a charge q placed at the centre of a hemisphere. A, B, C and D In which position(s) of this second charge, the flux of the electric field through the hemisphere remains unchanged - **[A,C]**



(A) A (B) B

(C) C (D) D

Q.6 A closed surface S is constructed around a conducting wire connected to a battery and a switch (figure) As the switch is closed, the free electrons in the wire start moving along the wire. In any time interval, the number of electrons entering the closed surface S is equal to the number of electrons leaving it. On closing the switch, the flux of the electric field through the closed surface - **[C,D]**



(A) is increased

(B) is decreased

(C) remains unchanged

(D) remain zero

Q.7 Charges Q_1 and Q_2 lie inside and outside respectively of a closed surface S. Let E be the field at any point on S and ϕ be the flux of E over S–

(A) If Q_1 changes, both E and ϕ will change

(B) If Q_2 changes, E will changes but ϕ will not change

(C) If $Q_1 = 0$ and $Q_2 \neq 0$ then $E \neq 0$ but $\phi = 0$

(D) If $Q_1 \neq 0$ and $Q_2 = 0$ then $E = 0$ but $\phi \neq 0$

[A,B,C]

Q.8 A spherical conductor A lie inside a hollow spherical conductor B. Charge Q_1 and Q_2 are given to A and B respectively –

(A) Charge Q_1 will appear on the outer surface of A

(B) Charge $-Q_1$ will appear on the inner surface of B

(C) Charge Q_2 will appear on the outer surface of B

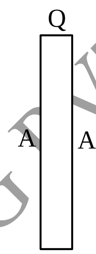
(D) Charge $Q_1 + Q_2$ will appear on the outer surface of B **[A,B,D]**

Q.9 When a charge of amount Q is given to an isolated metal plate 'X' of surface area A, its surface charge density becomes σ_1. When an isolated identical plate 'Y' is brought closer to X, the surface charge density on X becomes σ_2. When Y is earthed, the surface charge density becomes σ_3. Then –

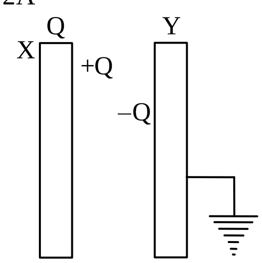
(A) $\sigma_1 = \frac{Q}{A}$ (B) $\sigma_1 = \frac{Q}{2A}$

(C) $\sigma_1 = \sigma_2$ (D) $\sigma_3 = \frac{Q}{A}$ **[B,C]**

Sol.



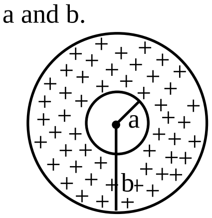
$\sigma_1 = \frac{Q}{2A}$



$\therefore \sigma_1 = \sigma_2$

$\sigma_3 = \frac{Q}{A}$

Q.10 A hollow sphere has inner and outer radii equals a and b. Charge +Q is distributed uniformly between a and b.



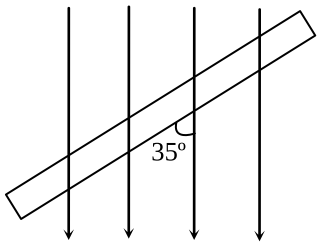
(A) The electric field for x < a is zero

(B) The electric field for a < x < b is given by $\frac{Q}{4\pi\epsilon_0 x^2} \cdot \frac{x^3 - a^3}{b^3 - a^3}$

(C) The electric field for a < x < b is given by $\frac{Q}{4\pi\epsilon_0 x^2} \cdot \frac{b^3 - a^3}{x^3 - a^3}$

(D) The electric field for x > b is given by $\frac{Q}{4\pi\epsilon_0 x^2}$ **[A,B,D]**

Q.1 A flat plate with dimensions 4 cm × 6 cm is set with its plane at 37º to a uniform electric field $\vec{E} = 600\,\hat{j}$ N/C, as shown below. What is the flux through the plate ?



(A) 2.15 N-m^2/C (B) 1.15 N-m^2/C

(C) 0.15 N-m^2/C (D) 3.15 N-m^2/C

[B]

Q.2 Mark the correct options -

(A) Gauss's Law is valid only for symmetrical charge distributions

(B) Gauss's Law is valid only for charges placed in vacuum

(C) The electric field calculated by Gauss's Law is the field due to the charges enclosed by the surface

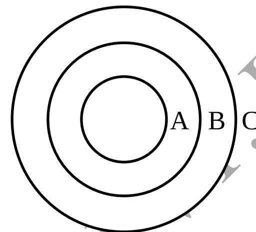
(D) The flux of the electric field through a closed surface due to all the charges is equal to the flux due to the charges enclosed by the surface **[D]**

Q.3 A charge Q is uniformly distributed over a large plastic plate. The electric field at a point P close to the centre of the plate is 10 V/m. If the plastic plate is replaced by a copper plate of the same geometrical dimensions and carrying the same charge Q, the electric field at the point P will become -

(A) Zero (B) 5 V/m

(C) 10 V/m (D) 20 V/m **[C]**

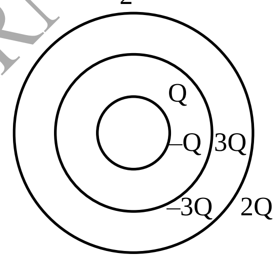
Q.4 Charges Q, 2Q, –Q are given to three concentric conducting spherical shells A, B, and C respectively, as shown in the figure. The ratio of charges on the inner and the outer surfaces of the shell C will be -



(A) $+\frac{3}{4}$ (B) $-\frac{3}{4}$ (C) $\frac{3}{2}$ (D) $-\frac{3}{2}$

[D]

Sol. Ratio $= -\frac{3}{2}$



Q.5 A positive point charge Q is brought near an isolated metal cube -

(A) The cube becomes negatively charged

(B) The cube becomes positively charged

(C) The interior becomes positively charged and the surface becomes negatively charged

(D) The interior remains charge free and the surface gets non-uniform charge distribution due to induction **[D]**

Q.6 In a region of space, the electric field is in the x-direction and proportional to x, i.e., $\vec{E} = E_0\, x\, \hat{i}$. Consider an imaginary cubical volume of edge a, with its edges parallel to the axis of co-ordinates. The charge inside this volume is -

(A) zero (B) $\varepsilon_0 E_0 a^3$

(C) $\frac{1}{\varepsilon_0} E_0 a^3$ (D) $\frac{1}{6} \varepsilon_0 E_0 a^2$ **[B]**

Q.7 A metallic particle having no net charge is placed near a finite metal plate carrying a positive charge. The electric force on the particle will be -

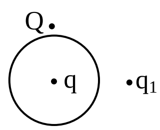
(A) towards the plate

(B) away from the plate

(C) parallel to the plate

(D) zero **[A]**

Q.8 A thin, metallic spherical shell contains a charge Q on it.



A point charge q is placed at the centre of the shell and another charge q_1 is placed outside it. All the three charges are positive. The force on the charge at the centre is -

(A) towards left

(B) towards right

(C) upward

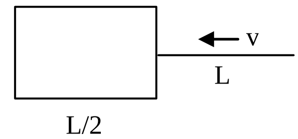
(D) zero **[D]**

Q.9 Consider the situation of the previous problem. The force on the central charge due to the shell is -

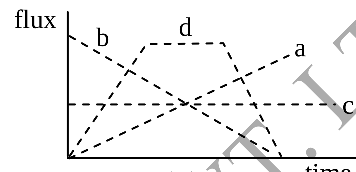
(A) towards left (B) towards right

(C) upward (D) zero **[B]**

Q.10 Figure (A) shows an imaginary cube of edge L/2. A uniformly charged rod of length L moves towards left at a small but constant speed v. At t = 0 the left end just touches the centre of the face of the cube opposite it. Which of the graphs shown in figure (B) represents the flux of the electric field through the cube as the rod goes through it –



(A)

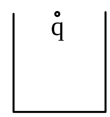


(B)

(A) a (B) b

(C) c (D) d **[D]**

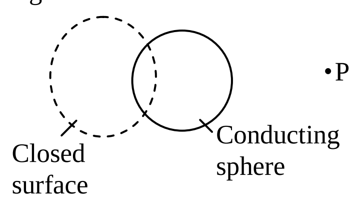
Q.11 A charge q is placed at the centre of the open end of a cylindrical vessel (figure). The flux of the electric field through the surface of the vessel is -



(A) zero (B) q/ε_0

(C) $q/2\varepsilon_0$ (D) $2q/\varepsilon_0$ **[C]**

Q.12 Figure shows a closed surface which intersects a conducting sphere. If a positive charge is placed at the point P, the flux of the electric field through the closed surface-



(A) wil remain zero

(B) will become positive

(C) wll become negative

(D) will become undefined **[B]**

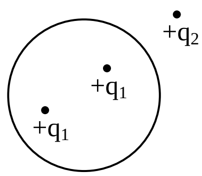
Q.13 A long string with a charge of λ per unit length passes through an imaginary cube of edge a. The maximum flux of the electric field through the cube will be

(A) $\lambda a/\varepsilon_0$ (B) $\sqrt{2}\,\lambda a/\varepsilon_0$

(C) $6\lambda a^2/\varepsilon_0$ (D) $\sqrt{3}\,\lambda a/\varepsilon_0$ **[D]**

Q.14 In the given figure, charges q_1 and $-q_1$ are inside a Gaussian surface. Where as charges q_2 is outside the surface. Electric field on the Gaussian surface will be–

[IIT- 2003]



(A) only due to q_2

(B) zero on the Gaussian surface

(C) uniform on the Gaussian surface

(D) due to all **[D]**

Q. 15 A Gaussian sphere encloses an electric dipole within it. The total electric flux across the sphere is -

(A) zero

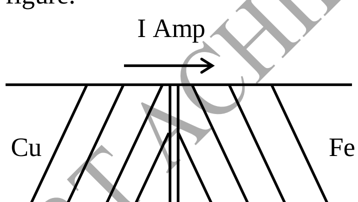
(B) half that due to a single charge

(C) double that due to a single charge

(D) dependent on the position of the dipole

[A]

Q.16 A current of I Amp flow through a wire made of a piece of copper and a piece of iron of identical cross sections welded end to end as shown in the figure.



How much electric charge accumulates at the boundary between the two metals? ρ_{Fe} & ρ_{Cu} are resistivity of Fe & Cu respectively -

(A) $\epsilon_0 I(\rho_{Fe} + \rho_{Cu})$ (B) $\epsilon_0 I(\rho_{Fe} - \rho_{Cu})$

(C) $\epsilon_0 I(\rho_{Fe} + 3\rho_{Cu})$ (D) $\epsilon_0 I(\rho_{Fe} + 2\rho_{Cu})$

[B]

Sol. I = current in wire

A = cross section Area of wire

$$V = I \times R = \frac{I\rho L}{A}$$

$$E = \frac{V}{L} = \frac{\rho I}{A}$$

According to gauss Law

$$\frac{Q}{\epsilon_0} = \left(\frac{\rho_{Fe} I}{A}\right) A - \left(\frac{\rho_{Cu} I}{A}\right) A$$

$$\frac{Q}{\epsilon_0} = (\rho_{Fe} - \rho_{Cu})\, I$$

$$Q = \epsilon_0 I(\rho_{Fe} - \rho_{Cu})$$

Q.17 The region between two concentric spheres of radius a < b contain volume charge density $\rho(r) = \frac{c}{r}$, where c is constant and r is radial distance, as shown in figure. A point charge q is placed at the origin, r = 0. Value of c is in such a way for which the electric field in the region between the spheres is constant (i.e. independent of r). Find the value of c –

(A) $\frac{q}{2\pi a^2}$ (B) $\frac{q}{4\pi a^2}$

(C) $\frac{q}{\pi a^2}$ (D) $\frac{q}{a^2}$ **[B]**

Sol. Total flux = $\frac{\text{Total charge}}{\varepsilon_0}$ (Gauss law)

$$E \times 4\pi r^2 = \frac{q}{\varepsilon_0} + \frac{4\pi}{\varepsilon_0}\int_a^r \frac{c}{r} \times r^2 dr$$

$$E \times 4\pi r^2 = \frac{q}{\varepsilon_0} + \frac{4\pi c[r^2 - a^2]}{\varepsilon_0}$$

$$E = \frac{q}{4\pi r^2 \varepsilon_0} + \frac{c[r^2 - a^2]}{r^2 \varepsilon_0}$$

$$E = \frac{q}{4\pi r^2 \varepsilon_0} + \frac{c}{\varepsilon_0} - \frac{ca^2}{r^2 \varepsilon_0}$$

as E is independent of r

$$\therefore \frac{q}{4\pi r^2 \varepsilon_0} = \frac{ca^2}{r^2 \varepsilon_0}$$

$$c = \frac{q}{4\pi a^2}$$

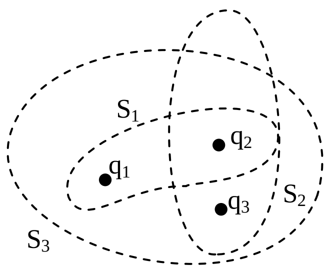
Now E is $\frac{q}{4\pi\varepsilon_0 a^2}$

Q.18 A charge q is placed at the centre of the open end of a cylindrical vessel. The flux of the electric field through the surface of the vessel is

(A) zero (B) q/ε_0

(C) $q/2\varepsilon_0$ (D) none of these **[C]**

Q.19 Three charges $q_1 = 1 \times 10^{-6}$C, $q_2 = 2 \times 10^{-6}$C and $q_3 = -3 \times 10^{-6}$C have been placed as shown in the figure. Then the outward electric flux will be maximum for the surface -

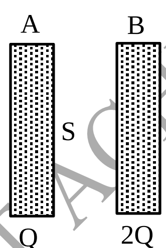


(A) S_1 (B) S_2

(C) S_3 (D) same for all three

[A]

Q.20 Two large conducting plates A and B are placed parallel to each other. A is given a charge Q and B is given a charge 2Q. Then the charge on the inner surface S of the plate A is –



(A) –Q/2 (B) +Q/2

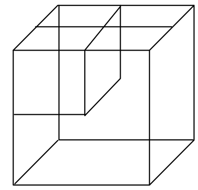
(C) +Q (D) +3Q/2 **[A]**

Q.21 Consider a solid cube of uniform charge density of insulating material. What is the ratio of the electrostatic potential at a corner to that at the centre : (Take the potential to be zero at infinity, as usual)

(A) $\frac{1}{1}$ (B) $\frac{1}{2}$

(C) $\frac{1}{4}$ (D) $\frac{1}{9}$ **[B]**

Sol.



ρ – Charge density of the cube

V_ℓ^{corner} – Potential at the corner of a cube of side ℓ

V_ℓ^{centre} – Potential at the centre of a cube of side ℓ

$V_{\ell/2}^{centre}$ – Potential at the center of a cube of side $\frac{\ell}{2}$

$V_{\ell/2}^{corner}$ – Potential at the corner of a cube of side $\frac{\ell}{2}$

By dimensional analysis

$V_\ell^{corner} \propto \frac{Q}{\ell} = \rho\ell^2$

$V_\ell^{corner} = 4\,V_{\ell/2}^{corner}$

But by superposition $V_\ell^{centre} = 8V_{\ell/2}^{corner}$

Because of the centre of the larger cube lies at a corner of the eight smaller cubes of which it is made

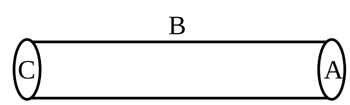
Therefore, $\frac{V_\ell^{corner}}{V_\ell^{centre}} = \frac{4V_{\ell/2}^{corner}}{8V_{\ell/2}^{corner}} = \frac{1}{2}$

Q.22 A point charge Q is placed at centre of a cylinder. If flux passing through it's curved surface is ϕ_1 then the flux associated with it's circular part will be -

(A) $\frac{Q}{3\varepsilon_0}$ (B) $\frac{\frac{Q}{\varepsilon_0} + \phi_1}{2}$

(C) $\frac{\frac{Q}{\varepsilon_0} - \phi_1}{2}$ (D) $\frac{Q}{\varepsilon_0} - \frac{\phi_1}{2}$ **[C]**

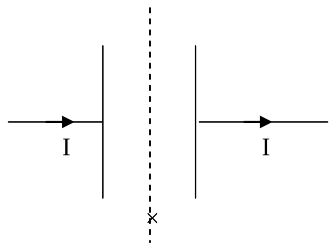
Q.23 A hollow cylinder has a charge q coulomb with in it. If ϕ is the electric flux in unit of voltmeter associated with the curved surface B, the flux linked with the plane A in unit of voltmeter will be -



(A) $\frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right)$ (B) $\frac{q}{2\varepsilon_0}$

(C) $\frac{\phi}{3}$ (D) $\frac{q}{\varepsilon_0} - \phi$ **[A]**

Q.24 A circular parallel plate capacitor of radius R and distance d between the plate is given. A capacitor is being charged with a current I flowing through the wire. Neglect fringing effect.



What is the rate of change of electric flux through plane in middle of capacitor with respect to time (i.e. $\frac{d\phi}{dt}$) –

(A) $\frac{2I}{\varepsilon_0}$ (B) $\frac{I}{\varepsilon_0}$

(C) $\frac{4I}{\varepsilon_0}$ (D) $\frac{6I}{\varepsilon_0}$ **[B]**

Sol. $\phi = \frac{Q}{A\varepsilon_0} \times A$

$\phi = \frac{Q}{\varepsilon_0}$

$\frac{d\phi}{dt} = \frac{1}{\varepsilon_0} \times \frac{dQ}{dt} = \frac{I}{\varepsilon_0}$

Q.25 Charge is uniformly distributed in a space. The net flux passing through the surface of an imaginary cube of side a in the space is ϕ. The net flux passing through the surface of an imaginary sphere of radius a in the space will be

(A) ϕ (B) $\frac{3}{4\pi}\phi$

(C) $\frac{2\pi}{3}\phi$ (D) $\frac{4\pi}{3}\phi$ **[D]**

Sol. $\phi = \frac{\rho \times a^3}{\epsilon_0}$

$\phi_2 = \rho \times \frac{4\pi a^3}{3\epsilon_0}$

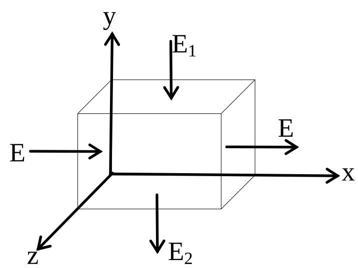
$\phi_2 = \phi \times \frac{4}{3}\pi$

Q.26 An electric field given by $E = 4\hat{i} - 3(y^2 + 2)\hat{j}$ pierces Gaussian cube of side 1m placed at origin such that its three sides represent x, y and z axes. The net charge enclosed within cube is -

(A) $4\epsilon_0$ (B) $3\epsilon_0$

(C) $5\epsilon_0$ (D) zero **[B]**

Sol.



$E_1 = 3(1^2 + 2) = 9$

$E_2 = 3(0 + 2) = 6$

Net flux = (9 – 6) × |x|

$\frac{q}{\epsilon_0} = 3$

$q = 3\epsilon_0$

Q.27 The tangent drawn at a point on a line of electric force shows the-

(A) intensity of gravity field

(B) intensity of magnetic field

(C) intensity of electric field

(D) direction of electric field **[D]**

Q.28 Which of the following statements concerning the electrostatics is correct-

(A) electric line of force never intersect each other

(B) electric lines of force start from positive charge and end at the negative charge

(C) electric lines of force start or ends perpendicular to the surface of a charged metal.

(D) all of the above **[D]**

Q.29 When no charge is confined with in the Gauss's surface, it implies that-

(A) E = 0

(B) $\vec{E}$ and $\vec{ds}$ are parallel

(C) $\vec{E}$ and $\vec{ds}$ are mutually perpendicular

(D) $\vec{E}$ and $\vec{ds}$ are inclined at some angle **[C]**

Q.30 If electric field flux coming out of a closed surface is zero, the electric field at the surface will be-

(A) zero

(B) same at all places

(C) dependent upon the location of points

(D) infinites **[C]**

Q.31 If three electric dipoles are placed in some closed surface, then the electric flux emitting from the surface will be-

(A) zero (B) positive

(C) negative (D) None **[A]**

Q.32 For which of the following fields, Gauss's law is valid-

(A) fields following square inverse law

(B) uniform field

(C) all types of field

(D) this law has no concern with the field **[A]**

Q.33 The electric flux coming out of the equi-potential surface is-

(A) perpendicular to the surface

(B) parallel to the surface

(C) in all directions

(D) zero **[A]**

Q.34 A charge of Q coulomb is located at the centre of a cube. If the corner of the cube is taken as the origin, then the flux coming out from the faces of the cube in the direction of X- axis will be-

(A) $4 \pi Q$ (B) $Q/6 \in_0$

(C) $Q/3 \in_0$ (D) $Q/4 \in_0$ **[C]**

Q.35 A rectangular surface of 2 metre width and 4 metre length, is placed in an electric field of intensity 20 Newton/C, there is an angle of 60^o between the perpendicular to surface and electrical field intensity. Then total flux emitted from the surface will be- (In Volt- metre)

(A) 80 (B) 40

(C) 20 (D) 160 **[A]**

Q.36 A charge q is inside a closed surface and charge – q is outside. The out going electric flux is-

(A) $– q/ \in_0$ (B) zero

(C) $q/ \in_0$ (D) $2q/ \in_0$ **[C]**

Q.37 If the electric field is uniform, then the electric lines of forces are-

(A) Divergent (B) Convergent

(C) Circular (D) Parallel **[D]**

Q.38 Electric lines of forces-

(A) Exist everywhere

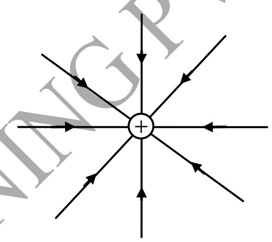
(B) Are imaginary

(C) Exist only in the immediate vicinity of electric charges

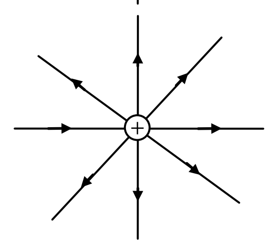
(D) None of the above **[B]**

Q.39 Which one of the following diagrams shows the correct lines of force ?

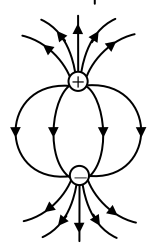
(A)



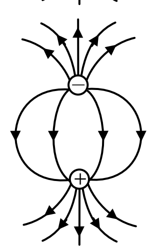
(B)



(C)

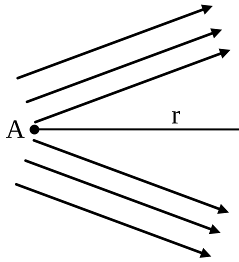


(D)



[B]

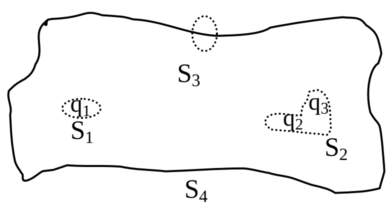
Q.40 In fig. shown the electric lines of force emerging from a charged body. If the electric fields at A and B are E_A and E_B are respectively, If the distance between A and B is r then -



(A) $E_A > E_B$ (B) $E_A < E_B$

(C) $E_A = E_B$ (D) $E_A = (E_B)/r^2$ **[A]**

Q.41 Three charges q_1 = 1μC, q_2 = 2 μC and q_3 = –3 μC and four surfaces S_1, S_2, S_3 and S_4 are shown. The flux emerging through surface S_2 in N-m^2/ C is -



(A) 36×10^3 (B) -36×10^3

(C) 36×10^9 (D) -36×10^9 **[B]**

Q.42 A surface enclosed an electric dipole, the flux through the surface is-

(A) Infinite (B) Positive

(C) Negative (D) Zero **[D]**

Q.43 Total flux coming out of some closed surface is-

(A) $q/\in_0$ (B) $\in_0/q$

(C) $q\in_0$ (D) $\sqrt{\dfrac{q}{\in_0}}$ **[A]**

Q.44 A square of side 20 cm is enclosed by a surface of sphere of 80 cm radius. Square and sphere have the same centre. four charges $+2 \times 10^{-6}$ C, -5×10^{-6} C, -3×10^{-6} C, $+6 \times 10^{-6}$C are located at the four corners of a square, Then out going total flux from spherical surface in N-m^2/C will be-

(A) zero (B) $(16\pi) \times 10^{-6}$

(C) $(8\pi) \times 10^{-6}$ (D) $(36\,\pi) \times 10^{-6}$ **[A]**

Q.45 The flux emerging out from any one face of the cube will be -

(A) $\dfrac{q}{6\varepsilon_0}$ (B) $\dfrac{q}{3\varepsilon_0}$

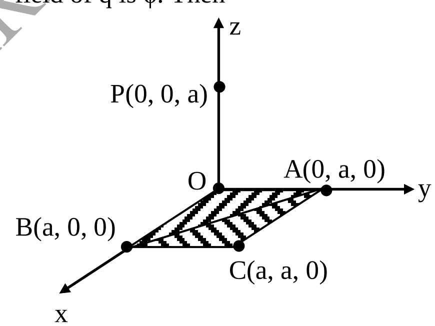
(C) $\dfrac{q}{\varepsilon_0}$ (D) $\dfrac{q}{4\varepsilon_0}$ **[A]**

Q.46 A charge Q is distributed over two concentric hollow spheres of radii (r) and (R) > (r) such the surface densities are equal. Find the potential at the common centre-

(A) $\dfrac{Q}{4\pi\varepsilon_0}\times\dfrac{(r+R)}{(R+r)^2}$ (B) $\dfrac{Q(R^2+r)^2}{4\pi\varepsilon_0(r+R)}$

(C) $\dfrac{Q(r+R)}{4\pi\varepsilon_0(R^2+r^2)}$ (D) none of these **[C]**

Q.47 A point charge q is placed at P(0, 0, a). The electric flux through CAB due to the electric field of q is ϕ. Then –

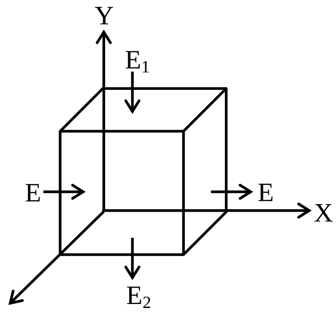


(A) $\phi = \dfrac{q}{48\varepsilon_0}$ (B) $\phi < \dfrac{q}{48\varepsilon_0}$

(C) $\dfrac{q}{48\varepsilon_0} < \phi > \dfrac{q}{24\varepsilon_0}$ (D) $\phi > \dfrac{q}{24\varepsilon_0}$

Sol. **[B]**
The flux is greater in the nearer half of the square OACB.

Q.48 An electric field given by $E = 4\hat{i} - 3\,(y^2 + 2)\,\hat{j}$ pierces Gaussian cube of side 1 m placed at origin such that its three sides represent x, y and z axes. The net charge enclosed within cube is -



(A) $4\epsilon_0$ (B) $3\epsilon_0$ (C) $5\epsilon_0$ (D) zero

Sol. **[B]**

$E_1 = 3\,(1^2 + 2) = 9$

$E_2 = 3\,(0 + 2) = 6$

Net flux = (9 – 6) × 1 × 1

$\frac{q}{\epsilon_0} = 3$

$q = 3\,\epsilon_0$

Q.49 The electric potential at the surface of an atomic nucleus (Z = 50) of radius 9×10^{-15} m is -

(A) 80V (B) 8×10^6 V

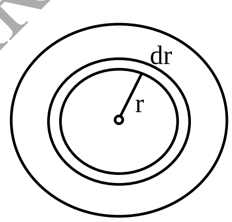
(C) 8×10^4 V (D) 8×10^2 V **[B]**

Q.50 An insulating solid sphere of radius R is charged in a non-uniform manner such that volume charge density $\rho = \frac{A}{r}$, where A is a positive constant and r is the distance from centre. Potential difference between centre and surface of sphere is -

(A) $\frac{AR}{\epsilon_0}$ (B) $\frac{AR}{4\epsilon_0}$

(C) $\frac{AR}{\pi\epsilon_0}$ (D) $\frac{AR}{2\epsilon_0}$

Sol. [D]



$E \times 4\pi r^2 = \frac{q}{\epsilon_0}$

$E \times 4\pi r^2 = \int_0^r \frac{A}{r} \times 4\pi r^2\, dr$

$E = \frac{A}{2\epsilon_0}$

Potential difference = E × d

$= \frac{A}{2\epsilon_0} \times R = \frac{AR}{2\epsilon_0}$

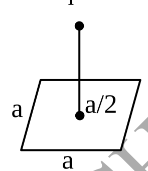
Q.1 The electric field in a region is given by $\vec{E} = \frac{3}{5}E_0\vec{i} + \frac{4}{5}E_0\vec{j}$ with $E_0 = 2.0 \times 10^3$ N/C. Find the flux of this field through a rectangular surface of area 0.2 m^2 parallel to the Y–Z plane.

Ans. $\frac{240\,Nm^2}{C}$

Q.2 A charge Q is uniformly distributed over a rod of length ℓ. Consider a hypothetical cube of edge ℓ with the centre of the cube at one end of the rod. Find the minimum possible flux of the electric field through the entire surface of the cube.

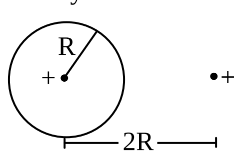
Ans. $\frac{Q}{2\varepsilon_0}$

Q.3 A charge Q is placed at a distance a/2 above the centre of a horizontal, square surface of edge a as shown in figure. Find the flux of the electric field through the square surface.



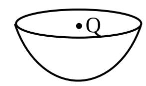
Ans. $\frac{Q}{6\varepsilon_0}$

Q.4 Find the flux of the electric field through a spherical surface of radius R due to a charge of 10^{-7} C at the centre and another equal charge at a point 2R away from the centre (figure)



Ans. $1.1 \times 10^4 \frac{Nm^2}{C}$

Q.5 A charge Q is placed at the centre of an imaginary hemispherical surface. Using symmetry arguments and the Gauss's law, find the flux of the electric field due to this charge through the surface of the hemisphere (figure).



Ans. $\frac{Q}{2\varepsilon_0}$

Q.6 A charge Q is placed at the centre of an uncharged, hollow metallic sphere of radius a.

(a) Find the surface charge density on the inner surface and on the outer surface.

(b) If a charge q is put on the sphere, what would be the surface charge densities on the inner and the outer surfaces ?

(c) Find the electric field inside the sphere at a distance x from the centre in the situations (a) and (b).

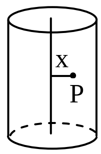
Ans. (a) $\frac{-Q}{4\pi a^2}, \frac{Q}{4\pi a^2}$, (b) $\frac{Q}{4\pi a^2}, \frac{Q+q}{4\pi a^2}$,

(c) $\frac{Q}{4\pi\varepsilon_0 x^2}$ in both situations

Q.7 Consider the following very rough model of a beryllium atom. The nucleus has four protons and four neutrons confined to a small volume of radius 10^{-15} m. The two 1s electrons make a spherical charge cloud at an average distance of 1.3×10^{-11} m from the nucleus, whereas the two 2s electrons make another spherical cloud at an average distance of 5.2×10^{-11}m from the nucleus. Find the electric field at (a) a point just inside the 1s cloud and (b) a point just inside the 2s cloud.

Ans. (a) 3.4×10^{13} N/C, (b) 1.1×10^{12} N/C

Q.8 A long cylindrical volume contains a uniformly distributed charge of density ρ. Find the electric field at a point P inside the cylindrical volume at a distance x from its axis (figure)

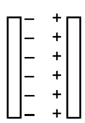


Ans. $\frac{\rho x}{2\varepsilon_0}$

Q.9 A charged particle having a charge of -2.0×10^{-6} C is placed close to a non conducting plate having a surface charge density 4.0×10^{-6} C/m^2. Find the force of attraction between the particle and the plate.

Ans. 0.45 N

Q.10 Two large conducting plates are placed parallel to each other and they carry equal and opposite charges with surface density σ as shown in figure. Find the electric field



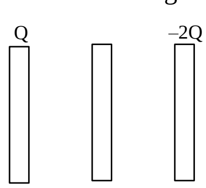
(a) at the left of the plates

(b) in between the plates and

(c) at the right of the plates

Ans. (a) 0, (b) $6/\varepsilon_0$ (c) 0

Q.11 Three identical metal plates with large surface areas are kept parallel to each other as shown in figure. The leftmost plate is given a charge Q, the rightmost a charge –2Q and the middle one remains neutral. Find the charge appearing on the outer surface of the rightmost plate



Ans. $-\frac{Q}{2}$

Q.12 How many excess electrons must be added to an isolated spherical conductor 32.0 cm in diameter to produce an electric field of 1150N/C just outside the surface ?

Ans. 2.04×10^{10} electron

Q.13 A very long uniform line of charge has charge per unit length 4.80 μC/m and lies along the x-axis. A second long uniform line of charge has charge per unit length –2.40 μC/m and is parallel to the x-axis at y = 0.400m. What is the net electric field (magnitude and direction) at the following points on the y-axis (a) y = 0.200 m? (b) y = 0.600 m ?

Ans. (a) 6.47×10^5 N/C, +y direction

(b) 7.2×10^4 N/C, –y direction

Q.14 An insulating sphere with radius 0.220 m has charge distributed uniformly through its volume. What must the total charge of the sphere be if the electric field 0.110 m from the centre of the sphere is 950 N/C ?

Ans. 10.2 nC

Q.15 A negative charge –Q is placed inside the cavity of a hollow metal solid. The outside of the solid is grounded, by connecting a conducting wire between it and the earth.

a) Is there any excess charge induced on the inner surface of the piece of metal ? If so, find its sign and magnitude.

b) Is there any excess charge on the outside of the piece of metal ? Why, or why not ?

c) Is there an electric field in the cavity ? Explain

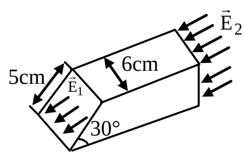
d) Is there an electric field within the metal ? Why, or why not ? Is there an electric field outside the piece of metal ? Explain why or why not.

e) Would someone outside the solid measure an electric field due to the charge –Q ? Is it reasonable to say that the grounded conductor has shielded the region from the effects of the charge –Q ? In principle, could the same thing be done for gravity. Why or why not ?

Ans. (a) yes, +Q, (b) no, (c) yes, (d) no, no

(e) no, yes, no

Q.16 The electric field $\vec{E}_1$ at one face of a parallelepiped is uniform over the entire face and is directed out of the face. At the opposite face, the electric field $\vec{E}_2$ is also uniform over the entire face and is directed into that face (figure). The two faces in question are inclined at 30.0º from the horizontal, while $\vec{E}_1$ and $\vec{E}_2$ are both horizontal; $\vec{E}_1$ has a magnitude of 2.50×10^4 N/C, and $\vec{E}_2$ a magnitude of 7.00×10^4 N/C.



a) Assuming that no other electric field lines cross the surfaces of the parallelepiped, determine the net charge contained within.

b) Is the electric field produced only by the charges within the parallelepiped, or is the field also due to charges outside the parallelepiped ? How can you tell ?

Ans. (a) -5.98×10^{-10} C

Q.17 A solid conducting sphere with radius R, that carries positive charge Q, is concentric with a very thin insulating shell of radius 2R that also carries charge Q. The charge Q is distributed uniformly over the insulating shell.

a) Find the electric field (magnitude and direction) in each of the regions
$0 < r < R$, $R < r < 2R$, and $r > 2R$.

b) Graph the electric field magnitude as a function of r.

Ans. (a) $0 < r < R$, $E = 0$; $R < r < 2R$, $E = \frac{Q}{4\pi\varepsilon_0 r^2}$;

$r > 2R$, $E = \frac{2Q}{4\pi\varepsilon_0 r^2}$

Q.18 The field potential in a certain region of space depends only on the x coordinate as $\varphi = -ax^3 + b$, where a and b are constants. Find the distribution of the space charge ρ (x).

Ans. $\rho = 6\epsilon_0 ax$

Q.19 A uniformly distributed space charge fills up the space between two large parallel plates separated by a distance d. The potential difference between the plates is equal to $\Delta\varphi$. At what value of charge density ρ is the field strength in the vicinity of one of the plates equal to zero ? What will then be the field strength near the other plate ?

Ans. $\rho = 2\epsilon_0 \Delta\varphi/d^2$, $E = \rho d/\epsilon_0$

Q.20 The field potential inside a charged ball depends only on the distance from its centre as $\varphi = ar^2 + b$, where a and b are constants. Find the space charge distribution $\rho(r)$ inside the ball.

Ans. $\rho = -6\epsilon_0 a$