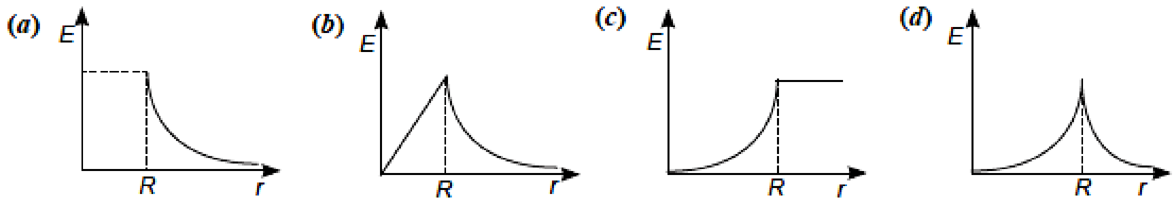
PRACTICE PAPER 01
CHAPTER 01 ELECTRIC CHARGES AND FIELDS

SUBJECT: PHYSICS | **MAX. MARKS : 40**
CLASS : XII | **DURATION : 1½ hrs**

General Instructions:
(i). **All** questions are compulsory.
(ii). This question paper contains 2**0** questions divided into five Sections A, B, C, D and E.
(iii). **Section A** comprises of **10 MCQs** of **1 mark** each. **Section B** comprises of 4 questions of **2 marks** each. **Section C** comprises of 3 questions of **3 marks** each. **Section D** comprises of 1 question of **5 marks** each and **Section E** comprises of 2 Case Study Based Questions of **4 marks** each.
(iv). There is no overall choice.
(v). Use of Calculators is not permitted

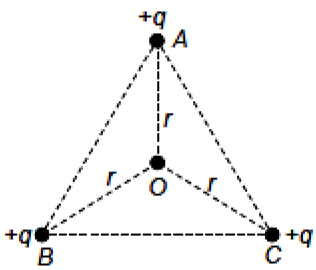
SECTION – A
Questions 1 to 10 carry 1 mark each.

1. Which of the following graphs shows the variation of electric field E due to a hollow spherical conductor of radius R as a function of distance from the centre of the sphere?



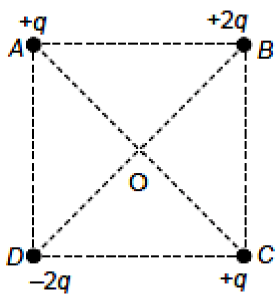
2. An electric dipole of moment p is placed in the position of stable equilibrium in uniform electric field of intensity E. It is rotated through an angle θ from the initial position. The potential energy of electric dipole in the final position is
(a) pE cos θ (b) pE sin θ (c) pE(1 − cos θ) (d) −pE cos θ

3. ABC is an equilateral triangle. Three charges +q are placed at each corner. The electric intensity at O will be



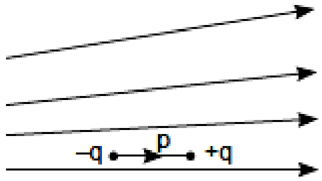
(a) 1. q/4πε0 . r^2 (b) 1. q/4πε0r (c) Zero (d) 1. 3q/4πε0r^2

4. Four charges are arranged at the corners of a square ABCD, as shown. The force on the charge kept at the centre O is



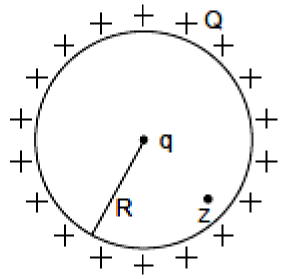
(a) zero (b) along the diagonal AC
(c) along the diagonal BD (d) perpendicular to side AB

5. Figure shows electric field lines in which an electric dipole p is placed as shown. Which of the following statements is correct?



(a) The dipole will not experience any force.
(b) The dipole will experience a force towards right.
(c) The dipole will experience a force towards left.
(d) The dipole will experience a force upwards.

6. A positive charge Q is uniformly distributed along a circular ring of radius R. A small test charge q is placed at the centre of the ring.
Which of the following statement is not correct?



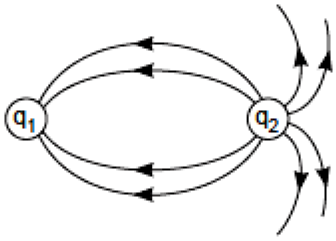
(a) If q > 0 and is displaced away from the centre in the plane of the ring, it will be pushed back towards the centre.
(b) If q < 0 and is displaced away from the centre in the plane of the ring, it will never return to the centre and will continue moving till it hits the ring.
(c) If q < 0, it will perform SHM for small displacement along the axis.
(d) q at the centre of the ring is in an unstable equilibrium within the plane of the ring for q > 0.

7. Two similar spheres having +Q and −Q charges are kept at a certain distance. F force acts between the two. If at the middle of two spheres, another similar sphere having +Q charge is kept, then it experiences a force in magnitude and direction as
(a) zero having no direction. (b) 8F towards +Q charge.
(c) 8F towards −Q charge. (d) 4F towards +Q charge.

8. A charge Q is divided into two parts of q and Q − q. If the coulomb repulsion between them when they are separated is to be maximum, the ratio of Q:q should be
(a) 2 : 1 (b) 1 : 2 (c) 4 : 1 (d) 1 : 4

In the following questions 9 and 10, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).
(c) Assertion (A) is true but reason (R) is false.
(d) Assertion (A) is false but reason (R) is true.

9. **Assertion (A):** In the given figure q_1 is positive and q_2 is negative.
Reason (R): Electric field lines emerge from positive and terminate at negative charge.

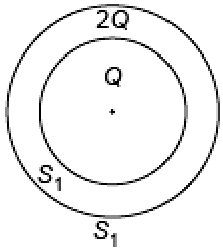


10. Assertion (A): An electric dipole is placed in an electric field antiparallel to it. If it is displaced then it will come back to initial position.
Reason (R): Dipole is in stable equilibrium.

SECTION – B

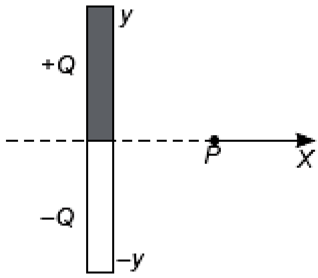
Questions 11 to 14 carry 2 marks each.

11. S_1 and S_2 are two hollow concentric spheres enclosing charge Q and $2Q$ respectively as shown in figure.
(i) What is the ratio of the electric flux through S_1 and S_2?
(ii) How will the electric flux through the sphere S_1 change, if a medium of dielectric constant 5 is introduced in the space inside S_1 in place of air?

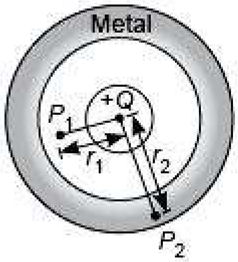


12. Define electric flux. Write its SI units. A spherical rubber balloon carries a charge that is uniformly distributed over its surface. As the balloon is blown up and increases in size, how does the total electric flux coming out of the surface change? Give reason.

13. The figure given below shows a uniformly charged non-conducting rod. What is the direction of electric field at point P due to the charge on the rod?



14. A small metal sphere carrying the charge $+Q$ is located at the centre of a spherical cavity in a large uncharged metal sphere
as shown in the figure.
Use the Gauss's theorem to find the electric flux at points P_1 and P_2.



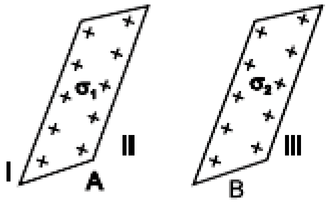
SECTION – C

Questions 15 to 17 carry 3 marks each.

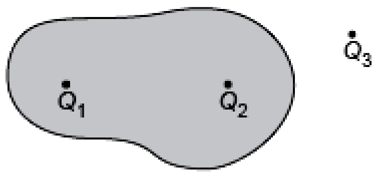
15. Define the term 'electric dipole moment'. Is it a scalar or vector?
Deduce an expression for the electric field at a point on the equatorial plane of an electric dipole of length $2a$.

16. (a) A point charge ($+Q$) is kept in the vicinity of uncharged conducting plate. Sketch electric field lines between the charge and the plate.

(b) Two infinitely large plane thin parallel sheets having surface charge densities σ_1 and σ_2 ($\sigma_1 > \sigma_2$) are shown in the figure. Write the magnitudes and directions of net fields in the regions marked II and III.



17. Three charges Q_1, Q_2 and Q_3 are placed inside and outside a closed Gaussian surface as shown in the figure.



Answer the following:

(a) Which charges contribute to the electric field at any point on the Gaussian surface?

(b) Which charges contribute to the net flux through this surface?

(c) If $Q_1 = -Q_2$, will electric field on the surface be zero?

SECTION – D

Questions 18 carry 5 marks.

18. (a) State Gauss's law. Use it to deduce the expression for the electric field due to a uniformly charged thin spherical shell at points (i) inside and (ii) outside the shell.

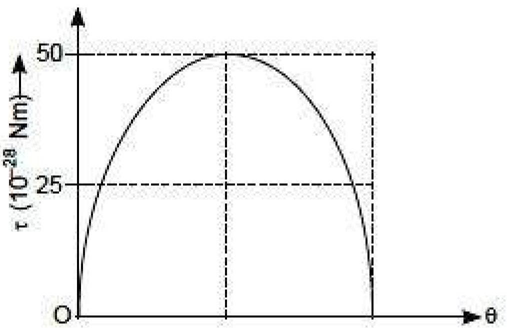
(b) Two identical metallic spheres *A* and *B* having charges $+4Q$ and $-10Q$ are kept a certain distance apart. A third identical uncharged sphere C is first placed in contact with sphere *A* and then with sphere *B*.

Spheres A and B are then brought in contact and then separated. Find the charges on the spheres *A* and *B*.

SECTION – E (Case Study Based Questions)

Questions 19 to 20 carry 4 marks each.

19. An electric dipole consists of two equal and opposite charge separated by a small distance. When an electric dipole is placed in a uniform electric field, it experiences a torque but no force. Consider an electric dipole of dipole moment 'P' is placed in an electric field of magnitude 40 N/C. A graph for torque experienced by a dipole versus its angular position with respect to electric field is shown below.



(i) What is the torque when the dipole is placed perpendicular to the electric field?

(a) 5×10^{28} N-m

(b) 5×10^{-28} N-m
(c) 50×10^{-28} N-m
(d) $50 \times 10^{+28}$ N-m

(ii) What is the value of electric field at the centre of the electric dipole?
(a) It is twice the electric field due to one charge at centre.
(b) It is thrice the electric field due to one charge at centre.
(c) It is half the electric field due to one charge at centre.
(d) Zero.

(iii) What is the value of electric dipole moment calculated with the help of given graph?
(a) 2.25×10^{-28} Cm
(b) 2.5×10^{-29} Cm
(c) 1.25×10^{-28} Cm
(d) 2.5×10^{-29} Cm

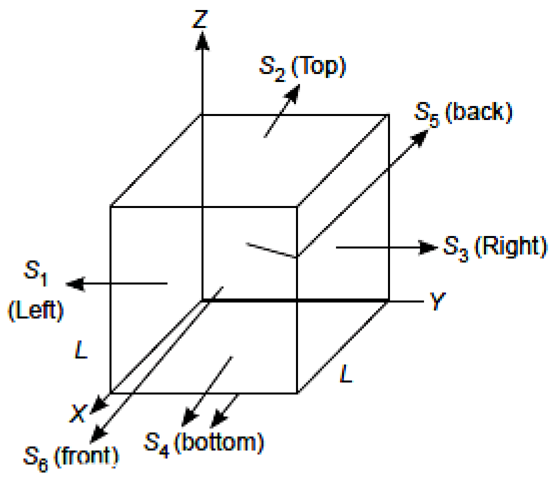
(iv) Two charge 20 C and –20 C are separated from each other by a distance of 2 cm. Then what is the magnitude of electric dipole moment
(a) 0
(b) 0.2 cm
(c) 0.4 cm
(d) 0.8 cm

OR

(iv) An electric dipole of dipole moment P is placed in an electric field E. The torque exerted by the field on the dipole is:
(a) Parallel to both the field and the dipole moment.
(b) Perpendicular to both the field and the dipole moment.
(c) Parallel to the field and perpendicular to the dipole moment.
(d) Parallel to dipole moment and perpendicular to the field.

20. In electrostatics, electric flux is the measure of the electric field through a given surface, although an electric field in itself cannot flow. It is a way of describing the electric field strength at any distance from the charge causing the field. Now, consider a cube of each edge 0.30 m is placed with its one corner at the origin. The cube is placed in a non-uniform electric field.

$$\vec{E} = (-2x\hat{i} + 3\hat{j}) \text{ N/C}$$



(i) The surfaces that have zero electric flux are
(a) S_1 and S_2
(b) S_1 and S_6
(c) S_2 and S_4
(d) S_1 and S_3

(ii) Electric flux passing through surface S_1 is

(a) $-0.27\ Nm^2C^{-1}$

(b) $0.27\ Nm^2C^{-1}$

(c) $-0.18\ Nm^2C^{-1}$

(d) $-0.18\ Nm^2C^{-1}$

(iii)Electric flux passing through surface S_4 is

(a) $-0.18\ Nm^2C^{-1}$

(b) $+0.18\ Nm^2C^{-1}$

(c) $+0.27\ Nm^2C^{-1}$

(d) zero

(iv)Total net flux passing through the cube if $\vec{E} = 2\hat{i}$ N/C

(a) zero

(b) $-0.18\ Nm^2C^{-1}$

(c) $0.18\ Nm^2C^{-1}$

(d) $0.27\ Nm^2C^{-1}$

OR

(iv)Total charge enclosed inside the cube is

(a) 0

(b) –1.62 pC

(c) +1.62 pC

(d) 2.4 pC

PRACTICE PAPER 01
CHAPTER 01 ELECTRIC CHARGES AND FIELDS
(ANSWERS)

SUBJECT: PHYSICS — **MAX. MARKS : 40**
CLASS : XII — **DURATION : 1½ hrs**

General Instructions:
(i). **All** questions are compulsory.
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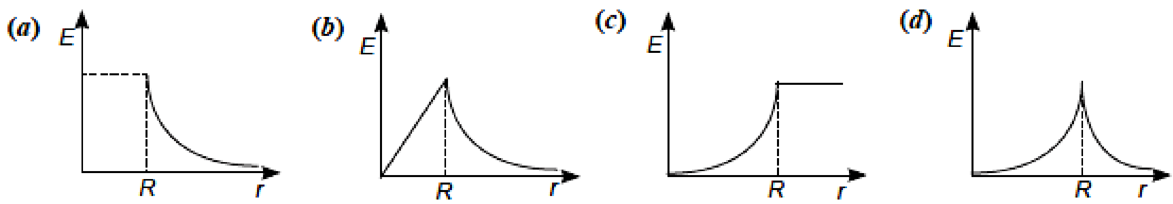
(iv). There is no overall choice.
(v). Use of Calculators is not permitted

SECTION – A

Questions 1 to 10 carry 1 mark each.

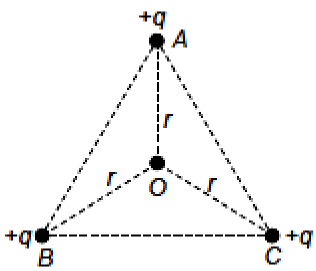
1. Which of the following graphs shows the variation of electric field E due to a hollow spherical conductor of radius R as a function of distance from the centre of the sphere?



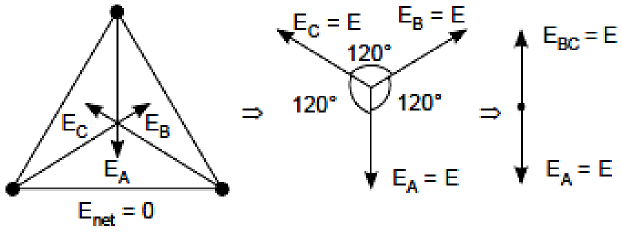
Ans: (a)
Electric field due to a hollow spherical conductor is governed by equations
E = 0, for $r < R$ ...(i) and
$E = Q/4\pi\varepsilon 0 r^2$ for $r \geq R$ ....(ii)
i.e. inside the conductor, electric field will be zero and outside the conductor it will vary according to $E \propto 1/r^2$.

2. An electric dipole of moment p is placed in the position of stable equilibrium in uniform electric field of intensity E. It is rotated through an angle θ from the initial position. The potential energy of electric dipole in the final position is
(a) pE cos θ (b) pE sin θ (c) pE(1 − cos θ) (d) −pE cos θ
Ans: (d) −pE cos θ

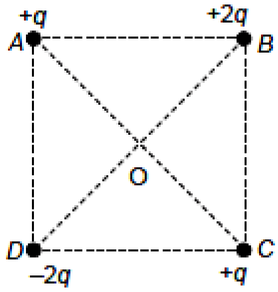
3. ABC is an equilateral triangle. Three charges +q are placed at each corner. The electric intensity at O will be



(a) 1. $q/4\pi\varepsilon 0 \,.\, r^2$ (b) 1. $q/4\pi\varepsilon 0 r$ (c) Zero (d) 1. $3q/4\pi\varepsilon 0 r^2$
Ans: (c)

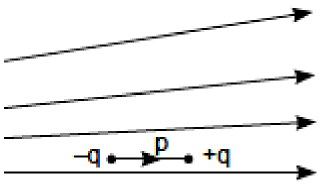


4. Four charges are arranged at the corners of a square ABCD, as shown. The force on the charge kept at the centre O is



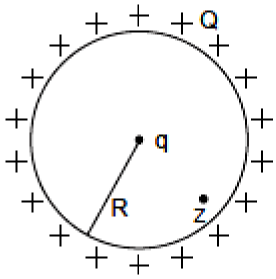
(a) zero (b) along the diagonal AC
(c) along the diagonal BD (d) perpendicular to side AB
Ans: (c) along the diagonal BD
Place a unit positive charge at O. Resultant force due to the charges placed at A and C is zero and resultant charge due to B and D is towards D along the diagonal BD.

5. Figure shows electric field lines in which an electric dipole p is placed as shown. Which of the following statements is correct?



(a) The dipole will not experience any force.
(b) The dipole will experience a force towards right.
(c) The dipole will experience a force towards left.
(d) The dipole will experience a force upwards.
Ans: (c) The dipole will experience a force towards left.

6. A positive charge Q is uniformly distributed along a circular ring of radius R. A small test charge q is placed at the centre of the ring.
Which of the following statement is not correct?



(a) If $q > 0$ and is displaced away from the centre in the plane of the ring, it will be pushed back towards the centre.
(b) If $q < 0$ and is displaced away from the centre in the plane of the ring, it will never return to the centre and will continue moving till it hits the ring.
(c) If $q < 0$, it will perform SHM for small displacement along the axis.
(d) q at the centre of the ring is in an unstable equilibrium within the plane of the ring for $q > 0$.
Ans: (c) If $q < 0$, it will perform SHM for small displacement along the axis.
The charge is displaced away from the centre in the plane of the ring. There will be net

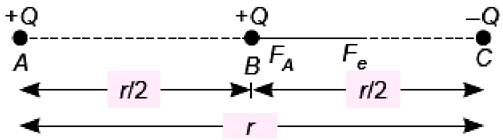
electric field opposite to displacement will push back the charge towards the centre of the ring if the charge is positive. If charge is negative, it will experience net force in the direction of displacement and the charge will continue moving till it hits the ring. Also this negative charge is in an unstable equilibrium.

7. Two similar spheres having +Q and −Q charges are kept at a certain distance. F force acts between the two. If at the middle of two spheres, another similar sphere having +Q charge is kept, then it experiences a force in magnitude and direction as

(a) zero having no direction. (b) 8F towards +Q charge.
(c) 8F towards −Q charge. (d) 4F towards +Q charge.

Ans: (c) 8F towards −Q charge.

Initially, force between A and C, $F = \frac{kQ^2}{r^2}$



When a similar sphere B having charge $+Q$ is kept at the mid-point of line joining A and C, then net force on B is

$$F_{net} = F_A + F_C = \frac{kQ^2}{\left(\frac{r}{2}\right)^2} + \frac{kQ^2}{\left(\frac{r}{2}\right)^2} = \frac{8kQ^2}{r^2} = 8F$$

The direction is shown in figure.

8. A charge Q is divided into two parts of q and Q − q. If the coulomb repulsion between them when they are separated is to be maximum, the ratio of Q:q should be

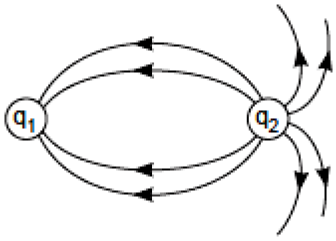
(a) 2 : 1 (b) 1 : 2 (c) 4 : 1 (d) 1 : 4

Ans: (a) 2 : 1

Let separation between two parts be r, then $F = k.q(Q - q)/r^2$, For F to be maximum dF/dq = 0 then Q/q = 2/1 = 2 : 1

In the following questions 9 and 10, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).
(c) Assertion (A) is true but reason (R) is false.
(d) Assertion (A) is false but reason (R) is true.

9. **Assertion (A):** In the given figure q_1 is positive and q_2 is negative.
Reason (R): Electric field lines emerge from positive and terminate at negative charge.



Ans: (d) Assertion (A) is false but reason (R) is true.

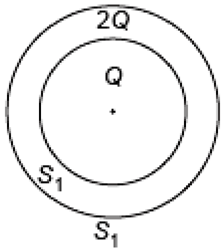
10. **Assertion (A):** An electric dipole is placed in an electric field antiparallel to it. If it is displaced then it will come back to initial position.
Reason (R): Dipole is in stable equilibrium.

Ans: (d) Assertion (A) is false but reason (R) is true.

SECTION – B

Questions 11 to 14 carry 2 marks each.

11. S_1 and S_2 are two hollow concentric spheres enclosing charge Q and $2Q$ respectively as shown in figure.
(i) What is the ratio of the electric flux through S_1 and S_2?
(ii) How will the electric flux through the sphere S_1 change, if a medium of dielectric constant 5 is introduced in the space inside S_1 in place of air?



Ans: (*i*) According to the Gauss's law, electric flux (Φ) is given by

$$\phi = \frac{q_{enclosed}}{\varepsilon_0}$$

$$\therefore \quad \frac{\phi_{S_1}}{\phi_{S_2}} = \frac{\left(\frac{Q}{\varepsilon_0}\right)}{\frac{(2Q+Q)}{\varepsilon_0}} = \frac{1}{3}$$

(ii) When a medium of dielectric constant $K = 5$ is introduced inside S_1, then the electric flux through S_1

$$\phi_1' = \frac{Q}{\varepsilon} = \frac{Q}{K\varepsilon_0} = \frac{\phi}{K}$$

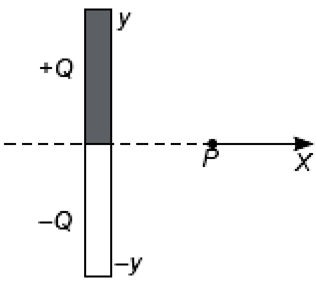
i.e. the flux will be reduced to $\frac{1}{5}$th of its initial value.

12. Define electric flux. Write its SI units. A spherical rubber balloon carries a charge that is uniformly distributed over its surface. As the balloon is blown up and increases in size, how does the total electric flux coming out of the surface change? Give reason.
Ans: The total number of electric lines of force passing through a given area normally is called electric flux through that area.

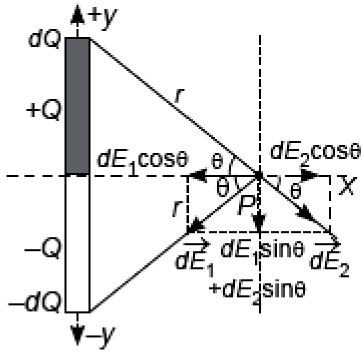
$$\phi_E = \vec{E} \cdot \vec{A}$$

Its SI unit is N m^2 C^{-1}.
As electric flux does not depend upon the shape and size of the closed surface. The electric flux coming out of the surface will remain same as long as the charge enclosed by it remains same.

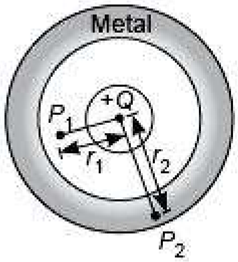
13. The figure given below shows a uniformly charged non-conducting rod. What is the direction of electric field at point P due to the charge on the rod?



Ans: From the figure, we see that *x*-axis components of electric field due to upper and lower halves of the rod will get cancelled out. Therefore, net electric field will be in – *y*-axis.

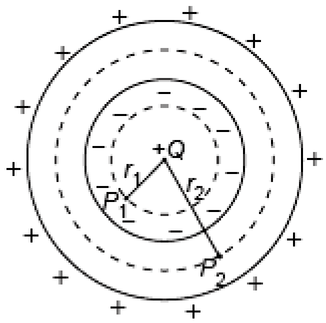


14. A small metal sphere carrying the charge $+Q$ is located at the centre of a spherical cavity in a large uncharged metal sphere
as shown in the figure.
Use the Gauss's theorem to find the electric flux at points P_1 and P_2.



Ans:
Let us draw a Gaussian sphere of radius r, passing through point P_1, then net electric flux through the sphere

$$\phi_{P_1} = \frac{\text{Charge enclosed}}{\varepsilon_0} = \frac{Q}{\varepsilon_0}$$



Now, we draw another Gaussian sphere of radius r_2 passing through point P_2.
As we can see, $-Q$ charge will be induced on the inner side of the cavity of metal sphere.

$\because$ Net electric charge enclosed $= Q - Q = 0$

$\therefore \quad \phi_{P_2} = 0$

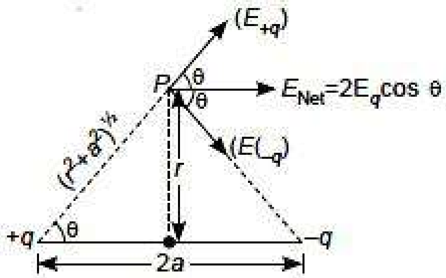
SECTION – C

Questions 15 to 17 carry 3 marks each.

15. Define the term 'electric dipole moment'. Is it a scalar or vector? Deduce an expression for the electric field at a point on the equatorial plane of an electric dipole of length $2a$.
Ans: Electric dipole moment is a measurement of the strength of electric dipole. It is given by $\vec{p} = q(\overrightarrow{2a})$ cm where $\vec{p}$ is the electric dipole moment and $2a$ is the separation between the charges. It is a vector quantity directed from negative to positive charge on the line joining them.
Let the dipole be made of two equal and opposite charges $+q$ and $-q$, separated by $2a$. Consider a

point P at a distance r from the mid-point.

Field at P due to each charge will be of equal magnitude $\vec{E}_{\pm q} = \frac{kq}{(r^2 + a^2)}$ pointing as shown.



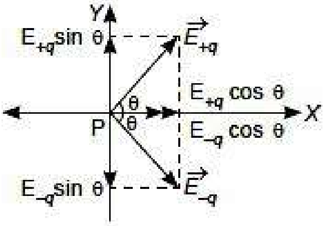
Resolving electric fields due to two charges. We can see that Y-axis components get cancelled out.

∴ Net field at P, $E = 2E_q \cos\theta$

$$E = \frac{2kq}{(r^2+a^2)}\cdot\frac{a}{(r^2+a^2)^{1/2}} = \frac{2aqk}{(r^2+a^2)^{3/2}} = \frac{kp}{(r^2+a^2)^{3/2}}$$

$$\left(\because \cos\theta = \frac{a}{(r^2+a^2)^{1/2}}\right)$$

(pointing anti-parallel to dipole moment)

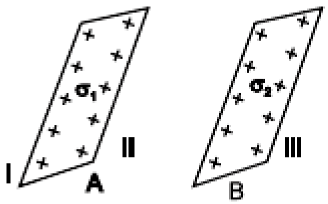


If $r >> a$, i.e. a^2 can be neglected in comparison to r^2.

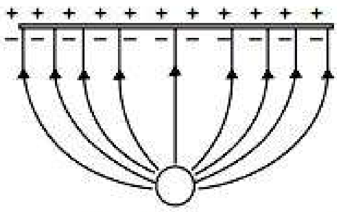
∴ $E = \frac{kp}{r^3}$ (anti-parallel to $\vec{p}$)

16. (a) A point charge (+Q) is kept in the vicinity of uncharged conducting plate. Sketch electric field lines between the charge and the plate.

(b) Two infinitely large plane thin parallel sheets having surface charge densities σ_1 and σ_2 ($\sigma_1 > \sigma_2$) are shown in the figure. Write the magnitudes and directions of net fields in the regions marked II and III.



Ans: (a) The lines of force due to a positive charge placed near a metal plate are as shown in the figure.



(b) In the region II between the plates $\vec{E}_A$ and $\vec{E}_B$ are opposite to each other.

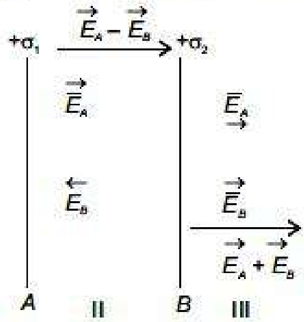
As $\sigma_1 > \sigma_2$, $|\vec{E}_A| > |\vec{E}_B|$

and resultant field $= E_A - E_B = \frac{\sigma_1}{2\varepsilon_0} - \frac{\sigma_2}{2\varepsilon_0}$

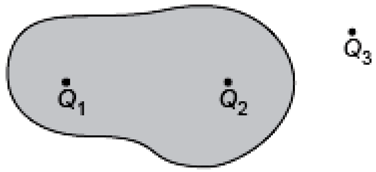
∴ $\vec{E}_{II} = \frac{1}{2\varepsilon_0}(\sigma_1 + \sigma_2)$ from A to B

In the region III, both $\vec{E}_A$ and $\vec{E}_B$ are supporting each other.

∴ $\vec{E}_{III} = \frac{1}{2\varepsilon_0}(\sigma_1 + \sigma_2)$ away from B.



17. Three charges Q_1, Q_2 and Q_3 are placed inside and outside a closed Gaussian surface as shown in the figure.



Answer the following:
(a) Which charges contribute to the electric field at any point on the Gaussian surface?
(b) Which charges contribute to the net flux through this surface?
(c) If $Q_1 = -Q_2$, will electric field on the surface be zero?
Ans: (a) All three charges Q_1, Q_2 and Q_3 will contribute to the electric field.
(b) Only the enclosed charges, i.e. Q_1 and Q_2.
(c) No, the electric field will exist on the surface.

SECTION – D

Questions 18 carry 5 marks.

18. (a) State Gauss's law. Use it to deduce the expression for the electric field due to a uniformly charged thin spherical shell at points (i) inside and (ii) outside the shell.
(b) Two identical metallic spheres *A* and *B* having charges $+4Q$ and $-10Q$ are kept a certain distance apart. A third identical uncharged sphere C is first placed in contact with sphere *A* and then with sphere *B*.
Spheres A and B are then brought in contact and then separated. Find the charges on the spheres *A* and *B*.

Ans: (a) Gauss's Law states that the net outward flux through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times the charge enclosed by the closed surface.
(i) When the point *P* is inside the shell.
In this case, the Gaussian surface lies inside the spherical shell and hence no charge is enclosed by it.

$$\oint \vec{E}.\vec{ds} = \oint E\,ds\cos 0 = E\oint ds = E \times 4\pi r_1^2 \qquad ...(i)$$

and by Gauss's law

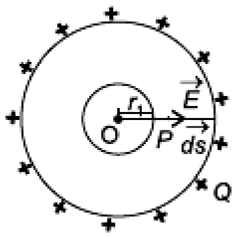
$$\oint \vec{E}.\vec{ds} = \frac{1}{\varepsilon_0}\times 0 = 0 \qquad ...(ii)$$

(since no charge is enclosed)

∴ From (i) and (ii), we have

$$E \times 4\pi r_1^2 = 0$$

or $E = 0$, i.e. there is no electric field inside a charged spherical shell.



(ii) When the point *P* lies outside the shell
Consider a spherical shell of radius *R* having charge *Q*. To find the electric intensity at a point *P* at a distance r_2 from the centre of the spherical shell imagine a spherical Gaussian surface of radius r_2 to be drawn around the charged shell. At every point of this shell, the $\vec{E}$ vector and $\vec{ds}$ vector are directed outwards in the same direction, i.e. $\theta = 0$.

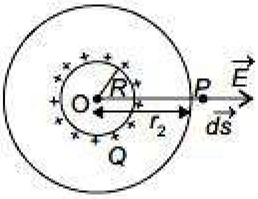
$\therefore \quad \oint \vec{E}.\vec{ds} = \oint E.ds = E\oint ds = E \times 4\pi r_2^2 \quad ...(i)$

Also, by Gauss's law

$$\oint \vec{E}.\vec{ds} = \frac{1}{\varepsilon_0}.Q \quad ...(ii)$$

From (i) and (ii), we get

$$E \times 4\pi r^2 = \frac{1}{\varepsilon_0}.Q \Rightarrow E = \frac{1}{4\pi\varepsilon_0}.\frac{Q}{r^2} \quad [\because r = r_2]$$



Initial charge on the sphere $A = +4Q$
Initial charge on the sphere $B = -10Q$
Since, all the three spheres are identical, they have the same capacity. When uncharged sphere C is placed in contact with A, the total charge is equally shared between them.

$\therefore$ Charge on C after contact with $A = \frac{0+4}{2}Q = 2Q$

and charge on A after contact with $C = 2Q$.
When sphere C carrying a charge 2 C is placed in contact with B, again charges are equally shared between C and B.

Charge on C after it is in contact with $B = \frac{2-10}{2}Q = -4Q$

Now, when sphere A with a charge of 2 Q is placed in contact with B, with charge – 4 Q.

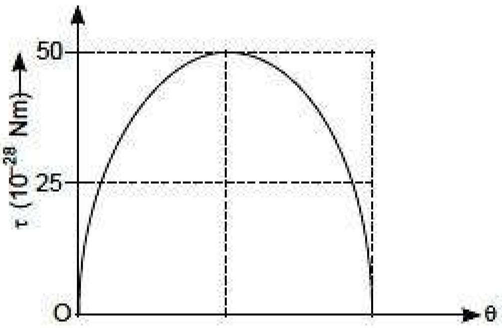
Charge on A = $\frac{2-4}{2} = -Q$

and Charge on B = $-1Q$

SECTION – E (Case Study Based Questions)

Questions 19 to 20 carry 4 marks each.

19. An electric dipole consists of two equal and opposite charge separated by a small distance. When an electric dipole is placed in a uniform electric field, it experiences a torque but no force. Consider an electric dipole of dipole moment 'P' is placed in an electric field of magnitude 40 N/C. A graph for torque experienced by a dipole versus its angular position with respect to electric field is shown below.



(i) What is the torque when the dipole is placed perpendicular to the electric field?
(a) 5×10^{28} N-m
(b) 5×10^{-28} N-m
(c) 50×10^{-28} N-m

(d) 50 × 10^{+28} N-m

(ii) What is the value of electric field at the centre of the electric dipole?
(a) It is twice the electric field due to one charge at centre.
(b) It is thrice the electric field due to one charge at centre.
(c) It is half the electric field due to one charge at centre.
(d) Zero.

(iii) What is the value of electric dipole moment calculated with the help of given graph?
(a) 2.25 × 10^{-28} Cm
(b) 2.5 × 10^{-29} Cm
(c) 1.25 × 10^{-28} Cm
(d) 2.5 × 10^{-29} Cm

(iv) Two charge 20 C and –20 C are separated from each other by a distance of 2 cm. Then what is the magnitude of electric dipole moment
(a) 0
(b) 0.2 cm
(c) 0.4 cm
(d) 0.8 cm

OR

(iv) An electric dipole of dipole moment P is placed in an electric field E. The torque exerted by the field on the dipole is:
(a) Parallel to both the field and the dipole moment.
(b) Perpendicular to both the field and the dipole moment.
(c) Parallel to the field and perpendicular to the dipole moment.
(d) Parallel to dipole moment and perpendicular to the field.

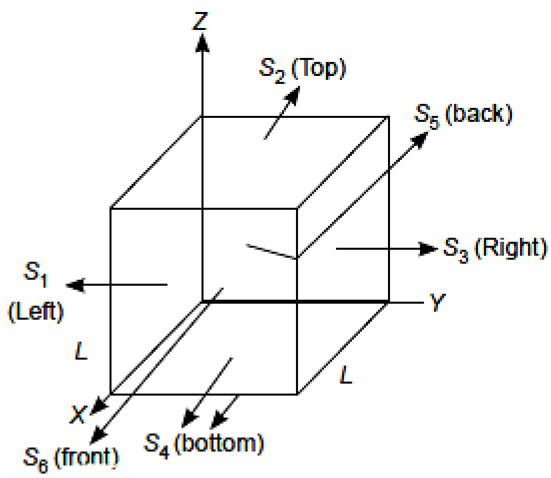
Ans: (i) (c)
(ii) (a)
(iii) (c)
(iv) (c) $p = q(2l)$
$= 20 \times 2 \times 10^{-2}$
$= 40 \times 10^{-2} = 0.4$ cm

OR

(iv)(b)

20. In electrostatics, electric flux is the measure of the electric field through a given surface, although an electric field in itself cannot flow. It is a way of describing the electric field strength at any distance from the charge causing the field. Now, consider a cube of each edge 0.30 m is placed with its one corner at the origin. The cube is placed in a non-uniform electric field.

$$\vec{E} = (-2x\hat{i} + 3\hat{j}) \text{ N/C}$$



(i) The surfaces that have zero electric flux are
(a) S_1 and S_2
(b) S_1 and S_6
(c) S_2 and S_4
(d) S_1 and S_3

(ii) Electric flux passing through surface S_1 is
(a) $-0.27\ Nm^2C^{-1}$
(b) $0.27\ Nm^2C^{-1}$
(c) $-0.18\ Nm^2C^{-1}$
(d) $-0.18\ Nm^2C^{-1}$

(iii) Electric flux passing through surface S_4 is
(a) $-0.18\ Nm^2C^{-1}$
(b) $+0.18\ Nm^2C^{-1}$
(c) $+0.27\ Nm^2C^{-1}$
(d) zero

(iv) Total net flux passing through the cube if $\vec{E} = 2\hat{i}$ N/C
(a) zero
(b) $-0.18\ Nm^2C^{-1}$
(c) $0.18\ Nm^2C^{-1}$
(d) $0.27\ Nm^2C^{-1}$

OR

(iv) Total charge enclosed inside the cube is
(a) 0
(b) –1.62 pC
(c) +1.62 pC
(d) 2.4 pC

Ans:

$\vec{E} = (-2x\hat{i} + 3\hat{j})$ N/C

$L = 0.3$ m; $L^2 = 0.09$ m^2

$\vec{A_1} = -0.09\ \hat{j},\ \vec{A_2} = 0.09\ \hat{k},\ \vec{A_3} = 0.09\ \hat{j}$

$\vec{A_4} = -0.09\ \hat{k},\ \vec{A_5} = 0.09\ \hat{i},\ \vec{A_6} = -0.09\ \hat{i}$

$\because\quad \hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1$

$\hat{i}.\hat{j} = \hat{j}.\hat{k} = \hat{k}.\hat{i} = 0$

(*i*) (*c*)

(*ii*) (*a*) Reasons:

$$\phi_1 = \vec{E} \cdot \vec{A_1}$$
$$= (-2x\hat{i} + 3\hat{j}) \cdot (-0.09\hat{j})$$
$$= -0.27 \text{ Nm}^2\text{C}^{-1}$$

(*iii*) (*d*) Reason:

$$\phi_4 = \vec{E} \cdot \vec{A_4}$$
$$= (-2x\hat{i} + 3\hat{j}) \cdot (-0.09\hat{k}) = 0$$

(*iv*) (*a*) Reason:

$$\phi_{net} = \vec{E} \cdot [\vec{A_1} + \vec{A_2} + \vec{A_3} + \vec{A_4} + \vec{A_5} + \vec{A_6}]$$

$$\phi_{net} = 2\hat{i} \cdot [-0.09\hat{j} + 0.09\hat{k} + 0.09\hat{j} + (-0.09\hat{k}) + 0.09\hat{i} - 0.09\hat{i}] = 0$$

$$\phi_{net} = 0$$

Or

(*iv*) (*a*) $\because \quad q_{enclosed} = \varepsilon_0 \cdot \phi_{net} = 0$