CHAPTER-1

ELECTRIC CHARGES AND FIELDS

SECTION A

(1 MARK QUESTION)

Q1. In an experiment three microscopic latex spheres are sprayed into a chamber and became charged with charges +3e, +5e and -3e respectively. All the spheres came in contact simultaneously for a moment and got separated. Which one of the following possible values for the final charge on spheres?

(a) +5e, -4e, +5e (b) +6e, +6e, -7e (c) -4e, +3.5e, +5.5e (d) +5e, -8e, +7e

Q2. An object has charge of 1 C and gains 5.0 x 10^{18} electrons. The net charge on the object becomes

(a) -0.80 C (b) +0.80 C (c) +1.80 C (d) +0.20 C

Q3. Two equal balls having equal positive charge 'q' coulombs are suspended by two insulating strings of equal length. What would be the effect on the force when a plastic sheet is inserted between the two? (CBSE 2014)

Q4. Sketch the electric field line for +q and –q. [CBSE 2015]

Q5. Why do the electric field lines never cross each other? [CBSE AI 2014]

Q6. Why do the electrostatic field lines not form closed loops? [CBSE 2012,2014]

Q7. Draw the electric field lines of a point charge Q where (i) Q>0 (ii) Q<0 [CBSE 2007]

Q8. A proton is placed in a uniform electric field directed along the positive x-axis. In which direction will it tend to move? [CBSE 2011]

Assertion & Reason

Direction: (FOR ALL THE ASSERTION & REASON QUESTIONS)

Two statements are given. One labelled Assertion (A) and the other labelled reasoning. Select the correct answers to their questions from the codes (a), (b), (c) and (d) are given below.

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R true but R is not the correct explanation of A.
(c) A is true but R is false.

(d) A is false but R is also false.

Q9. Assertion: A point charge is brought in an electric field, then electric field at a nearby point may increase or decrease.

Reason: The electric field is dependent on the nature of charge

Q10. Assertion: Electronic lines of force cross each other.

Reason: Electric field at a point does not superimpose to give one resultant electric field.

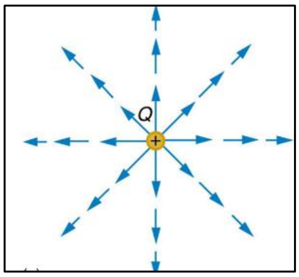
Q11. Assertion: A way from a charge filed lines gets weaker and density of field lines is less resulting in well separated lines.

Reason: Only a finite number of lines can be drawn from a charge.

Case Based MCQs

Direction: Answer the questions from Q12 to Q14 on the following case.

An electric field lines in general is a curve drawn in such way that the tangent to it at each point is in the direction of the electric field at that point. A field lines is a space curve, i.e. a curve in three dimensions. Electric field lines are then used to pictorially map the electric field around a charge or a configuration of charges:



The density of field lines in more near the charge. Away from the charge, the field is weak, so the density of field lines is less.

Q12. Direction of electric field on field lines is determined by

(a) Field lines moving from –ve to +ve charge.

(b) At the point of intersection of field lines.

(c) By the tangent at that point on the field lines.

(d) None of above.

Q13. The electric field lines of negatively charged particles are

(a) Radial and outwards. (c) Radial and inwards.

(b) Circular and anti-clockwise. (d)Circular and clockwise.

Q14. The spacing between two electric field lines indicate it

(a) Charge (b) Position (c) Strength (d) None of the above

<u>**Assertions & Reasons**</u>

Q15. The dimensional formula of electric flux is

(a) $[M^1L^2T^{-2}A^{-1}]$ (b) $[M^{-1}L^3T^{-3}A^1]$ (c) $[M^1L^3T^{-3}A^{-1}]$ (d) $[M^1L^{-3}T^{-3}A^{-1}]$

Q16. What is the SI unit of electric flux

(a) $\frac{N}{C}$ x m^2 (b) N x m^2 (c) $\frac{N}{m^2}$ x C (d) $\frac{N^2}{m^2}$ x C^2

Q17. If $\oint_s \vec{E}.\,\overrightarrow{dS} = 0$ inside a surface, that means:

(a) There is no net charge present inside the surface

(b) Uniform electric field inside the surface

(c) Discontinuous field lines inside the surface

(d) Charge present inside the surface

Q18. Four charges +8Q -3Q +5Q and -10Q are kept inside a closed surface. What will be the outgoing flux through the surface

(a) 26 V-m (b) 0 V-m (c) 10 V-m (d) 8 V-m

Q19. Electric flux over an area in an electric field represents the ……….. crossing this area.

Q20. A charge Q is enclosed by a Gaussian spherical surface of radius R. If the radius is doubled, then the ………. will remain the same.

Q21. If $\oint_s \vec{E}.\,\overrightarrow{dS}$ =0 over a surface, then

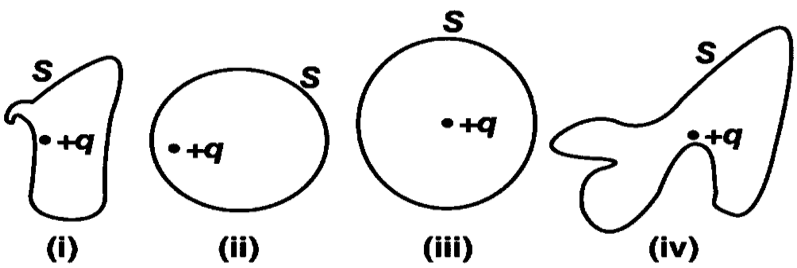
(a) the electric field inside the surface and on it is zero

(b) the electric field inside the surface is necessarily uniform

(c) the number of flux lines entering the surface must be equal to the number of flux lines leaving it

(d) all charges must necessarily be outside the surface

Q22. The electric flux through the surface



(a) In fig (iv) is the largest

(b) fig (iii) is the least

(c) fig (ii) is same as fig (iii) but is smaller than fig (iv)

(d) is the same for all the figures

Q23. **Assertion**- Electric flux is a vector quantity.

Reason- Electric flux is expressed as vector product of electric field vector and area vector.

Q24. **Assertion**- Electric flux through closed spherical surface enclosing an electric dipole is zero.

Reason- Net charge enclosed inside a spherical surface when a dipole is inside it is zero.

Q25. **Assertion**- Gaussian surface is purely imaginary surface.

Reason- Electric field at every point on a Gaussian surface is same.

Q26. **Assertion**- Gaussian surface can be drawn outside the body or within the body.

Reason- It is purely imaginary surface.

Q27. **Assertion**- Electric field at a point inside spherical shell with a charge uniformly spread on its outer surface is zero.

Reason- There is no charge enclosed within the closed shell.

Q28. **Assertion**- Electric field at any point away from linear charge distribution decreases with distance.

Reason- Electric field at any point away from linear charge distribution is expressed as $E= \frac{\lambda}{2\pi\epsilon_o r}$.

Two-mark questions

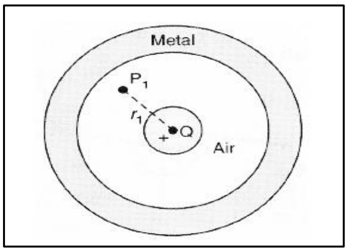
Q29. State the superposition principle for electrostatic force on a charge due to number of charges.

Q30. A force F is acting between two point charges q_1 and q_2. If a third charge q_3 is placed quite close to q_2, what happens to the force between q_1 and q_2? (2011)

Q31. i) The electric field E due to a point charge at any point near it is defined as $E=\lim_{q\to 0} E/q$, where q is the test charge and F is the force acting on it. What is the physical significance of $\lim_{q\to 0}$ in this expression?

(ii) Draw electric field lines of a point charge Q when a. Q>0 b. Q<0 [CBSE 2007]

Q32. A small metal sphere carrying a charge +Q is located at the center of a spherical cavity is a large uncharged metallic spherical shell. Write the charges on the inner and outer surfaces of the shell. Write the expression for the electric field at the point P_1. [CBSE 2014]



Q33. Two point charges q_1 and q_2 are located at point (a,0,0) and (0, b,0) respect. Find the electric field due to both these charges at the point (0,0, e). [CBSE 2013]

Q34. What is Gaussian surface? What is its use?

Q35. S_1 and S_2 are two hollow concentric spheres (S_2 outer sphere and S_1 inner sphere) enclosing charges 9Q and 3Q respectively. What is the ratio of electric flux through S_1 and S_2? What would be electric flux through S_1, if air inside S_1 is replaced by a medium of dielectric constant 3?

Q36. A hollow cube of side 5cm encloses a charge of 6C at its centre. What is the net flux through one of the square face of cube? How would flux through square face change if 6C charge is placed as 4C and 2C inside the cube at two different points?

Three-mark questions

Q37. A particle of charge 2μC and mass 1.6g is moving with a velocity $4\hat{i}$ ms^{-1}. At t = 0 the particles enters in a region having an electric field E (in N C^{-1}) = $80\hat{i} + 60\hat{j}$. Find the velocity of particle at t = 5s. (CBSE2020)

Q38. A particle of mass 10^{-3} kg and charge 5C enters into a uniform electric field of 2 x 10^5 N/C, moving with a velocity of 20 m/s in a direction opposite to that of the field. Calculate the distance it would travel before coming to rest. [CBSE 2012]

Q39. State and prove Gauss Theorem.

Q40. Using Gauss theorem obtain an expression for electric field intensity at a point due to infinitely long line charge distribution. Sketch graphically variation of E with distance r.

Q41. Using Gauss theorem obtain an expression for electric field intensity at a point due to thin infinite sheet.

Four-mark questions

Q42. Read the following passage and answer questions below it.

A spherical dome in an expo consists of magical fan fixed inside it. The blades of fan have a total charge of 6 C deposited on it. The dome is also surrounded by four such identical fans fixed outside it, each carrying a charge of 6 C on its blade. When a fan inside the dome is switched ON, the charge deposited on the blades of a fan flies off but remains inside the dome. However, when the fans outside the dome are switched ON charge deposited on the blades remain confined to blades. The dome is covered by electrosensitive glittering sheet whose glittering intensity varies directly as the electric flux falling upon its surface varies.

1. What is the net electric flux through the closed surface of dome, when all the fans are switched OFF?

   a) $6C/\epsilon_o$ b) $1\ C/\epsilon_o$ c) $30C/\epsilon_o$ d) $1\ C/12\epsilon_o$

2. What is the net electric flux through the closed surface of dome, when all the fans are switched ON?

   a) $30C/\epsilon_o$ b) $1\ C/\epsilon_o$ c) $6C/\epsilon_o$ d) $1\ C/12\epsilon_o$

3. Which of the following observations is correct for glittering intensity of electrosensitive sheet covering the dome?

   a) Glittering intensity is zero when fan inside the dome is switched OFF
   b) Glittering intensity is maximum when fan inside the dome is switched ON
   c) Glittering intensity is always constant whether the fan inside is switched ON or OFF
   d) Glittering intensity varies as outside fans are switched ON

4. Name the principle which explains the observation of glittering intensity of electrosensitive sheet.

   a) Coulomb's law in electrostatics b) Gauss theorem in electrostatics
   c) Superposition principle of charge d) None of the above

Five-mark questions

Q43. Two point charges of +1 μC and +4 μC are kept 30 cm apart. How far from the +1μC charge on the line joining the two charges will the net electric field be zero? (2020)

Q44. (a) Define electric field intensity. Write its SI unit.

(b) Two point charges 4 μc & 1 μc are separated by a distance of 2m in air. Find the point on the line joining the charges at which the net electric field of the system is zero.

Q45. Obtain the expression for electric field intensity due to a

(a) Point charge and

(b) due to system of charge Plot the graph for the variation for E and r.

SECTION A-ANSWER KEY

(1-MARK QUESTION)

1. (b)

2. (d) Q= ne

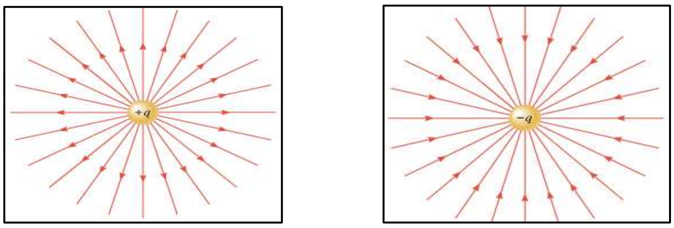
   Q= 5 x 10^{18} x 1.6 x 10^{-15} = 0.8 C

   So net charge = q + Q = 1 – 0.8 = 0.2C

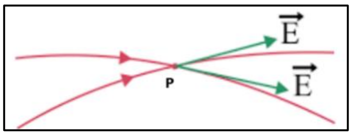
3. F' = F/K   Where K= dielectric constant

   Hence force is reduced when plastic sheet is inserted

4.

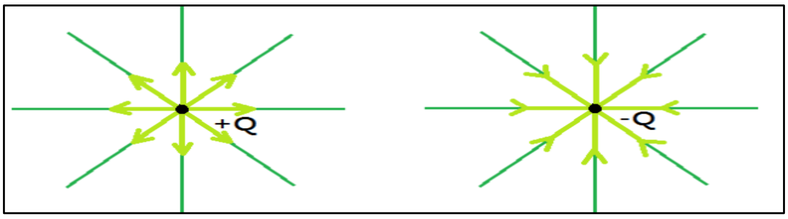


5. If electric field lines cross each other, then at the point of intersection at P, there will be two tangents which is impossible.



6. Since electric field lines emergent from positive charge and terminate at negative charge. If there is a single charge, then emerging field lines terminate at infinity. Therefore, they never form closed loop.

7. (i) Q>0   (ii) Q<0



8. The proton will move in the direction of electric field as it is positively charged. i.e. towards the positive x-axis.

9. (a) 10. (d) 11. (c) 12. (c) 13. (b) 14. (c)

15. (c) [$M^1 L^3 T^{-3} A^{-1}$]

16. (a) $\frac{N}{C}$ x m^2

17. a) There is no net charge present inside the surface.

18. (b) 0 V-m

19.. Total number of electric field lines.

20. Electric Flux.

21. (c) the number of flux lines entering the surface must be equal to the number of flux lines leaving it

22. (d) is the same for all the figures

23. D) 24. A) 25. B) 26. A) 27. A) 28. A)

Answer for Two-mark questions

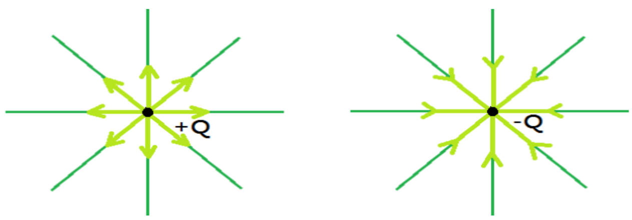
29. The principle of superposition states that the total force on a given charge is the vector sum of the individual forces exerted on it by all other charges, the force between two charges being exerted in such a manner as if all other charges were absent

$F = F_{12} + F_{13} + \ldots\ldots + F_{1N}$

30. The force between q_1 and q_2 remains equal to F.

31. (i) $\lim\limits_{q \to 0}$ tells is that test charge is so small that it does not charge (affect) the source charge.

(ii)



32. Inner surface charge = -Q Outer surface charge = +Q

$E = Q/4\pi\varepsilon_0 r_1^2$

33.. $\overrightarrow{E_{net}} = \vec{E_1} + \vec{E_2}$

$= K\ (\ q_1/r_1^3\ \vec{r_1} + (\ q_2/r_2^3\ \vec{r_2})$

Where $\vec{r}_1 = -a\hat{i} + c\hat{k}$ $\vec{r_2} = -\ b\hat{j} + c\hat{k}$

$\vec{E}\ net = 1/4\pi E_0\ [q_1\ (-a\hat{i} + c\hat{k})/(a^2 + c^2)^{3/2} + q_2\ (-\hat{j} + c\hat{k})/\ (b^2 + c^2)^{3/2}$

34. A Gaussian surface is an imaginary surface at every point of which electric field is same.

By conveniently choosing the Gaussian surface one can evaluate $\oint_S \vec{E}.\vec{dS}$ over it and find out expression for electric field intensity.

35. Electric flux through S_1, $\Phi_1 = 9Q/\epsilon_o$

Electric flux through S_2, $\Phi_2 = 9Q/\epsilon_o + 3Q/\epsilon_o = 12Q/\epsilon_o$ $\therefore \Phi_1/\Phi_2 = 3/4$

When air inside S_1 is replaced by a medium of $\epsilon_r = 3$

Then electric flux through $S_1 = \Phi_1 = 9Q/\epsilon = 9Q/\epsilon_o \epsilon_r = 9Q/3\,\epsilon_o = 3Q/\epsilon_o$.

36. Electric flux through cube, $\Phi_E = q/\epsilon_o = 6C/\epsilon_o$

Electric flux through square face, $= 1/6 \text{ x } \Phi_E = 1/6 \text{ x } 6C/\epsilon_o = 1/\epsilon_o$

Flux through a square face remains same even if 6C charge is distributed ass 4 C and 2 C at two different points since total charge inside the cube remains unchanged.

Answer to Three-mark questions

37. F = ma or qE= ma

$a = qE/m = 2 \text{ x } 10^{-6} \text{ x } (80\hat{i} + 60\hat{j}) / 1.6 \text{ x } 10^{-3}$

$= (100 \text{x } 10^{-3})\,\hat{i} + (75 \text{ x } 10^{-3})\,\hat{j}$

V = u + at

$= 4\,\hat{i} + ((100 \text{x } 10^{-3})\,\hat{i} + (75 \text{ x } 10^{-3})\,\hat{j})\text{x}5$

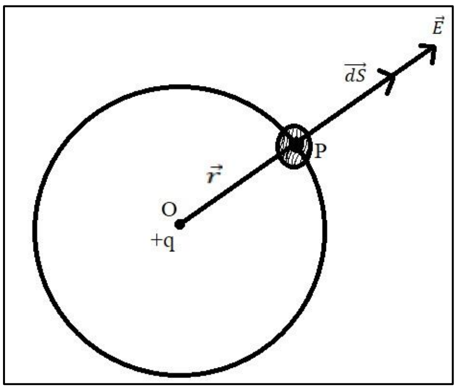
$= 4.5\hat{i} + 0.375\,\hat{j}$

38. Acceleration, $a = qE/m = 5 \text{ X } 10^{-6}\ X\ 2\ X\ 10^{-5}/\ 10^{-3} = 10^3 \text{m}/s^2$

Now $v^2 = u^2 - 2as$

$0 = (20)^2 - 2 \text{ X } 1000 \text{ X S}$

Therefore, S =400/2000 =1/5 =0.2m



39. Let +q be the point charge located at point O. Consider spherically symmetric Gaussian surface around it as shown. Let P be the point on its surrounding elemental area dS and $\vec{r}$ as the position vector of point P. Electric field $\vec{E}$ due to point charge +q and $\vec{dS}$ are in the same direction as shown. Then the total electric flux through closed surface S is

$$\Phi_{E\ Total} = \oint_S \vec{E}.\vec{dS}$$

$$=\oint_S E\, dS \cos\theta = \oint_S E\, dS \cos 0^o$$

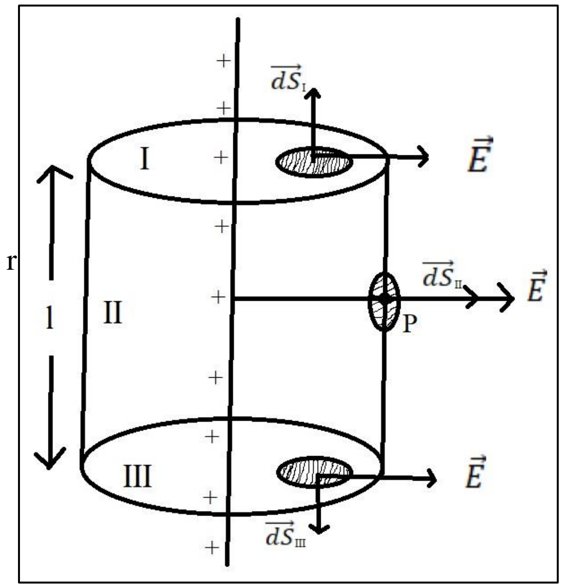
$$\Phi_{E\ Total} = E \oint_S dS = q/4\pi\epsilon_o r^2 \oint dS \quad (\because E = q/4\pi\epsilon_o r^2)$$

$$= q/4\pi\epsilon_o r^2 \times (4\pi r^2)$$

$$\Phi_{E\ Total} = q/\epsilon_o$$

40. <u>Electric field due to infinitely long uniformly charged straight wire</u>

Consider uniformly charged infinitely long straight wire. In order to find electric field intensity at point 'P' distance 'r' from the wire we consider cylindrical Gaussian surface with portion of length'l' of charged wire as axis.



Applying Gauss Theorem to this situation,

$$\oint_S \vec{E}.\overrightarrow{dS} = q/\epsilon_o \text{---------(1)}$$

but $\oint_S \vec{E}.\overrightarrow{dS} = \oint_I \vec{E}.\overrightarrow{dS} + \oint_{II} \vec{E}.\overrightarrow{dS} + \oint_{III} \vec{E}.\overrightarrow{dS}$

but $\oint_I \vec{E}.\overrightarrow{dS} = \oint_{III} \vec{E}.\overrightarrow{dS} = 0 \quad (\because \vec{E} \perp \overrightarrow{dS})$

$$\therefore \oint_S \vec{E}.\overrightarrow{dS} = \oint_{II} \vec{E}.\overrightarrow{dS} = \oint_{II} E\, dS \cos 0^o$$

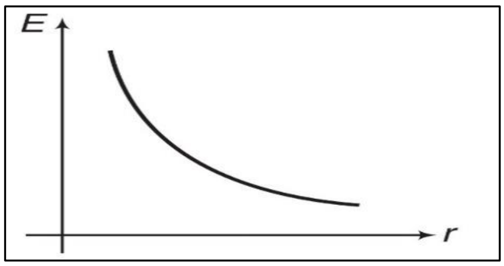
$$= E \oint_{II} dS = E\ 2\pi r l \text{ ---------(2)}$$

From (1) &(2), we get

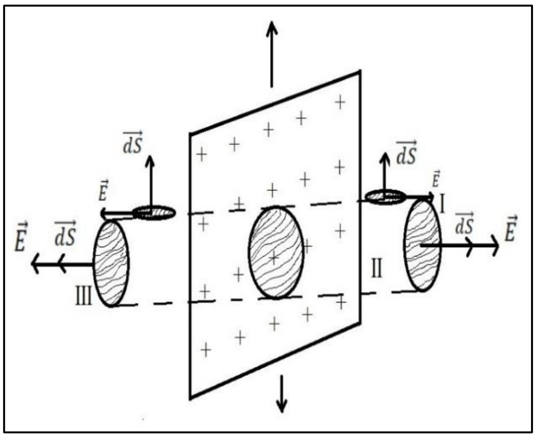
$$E\ 2\pi r l = q/\epsilon_o$$

$E = q/2\pi\epsilon_o r l = \lambda/2\pi\epsilon_o r \quad (\because \lambda = q/l$ is linear charge density)

$E = \lambda/2\pi\epsilon_o r = 2\lambda/4\pi\epsilon_o r$

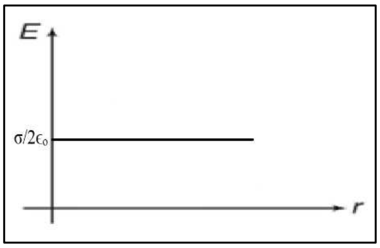


41. <u>Electric field intensity due to uniformly charged thin infinite plane sheet.</u>



Consider uniformly charged infinitely long thin plane sheet as shown in diagram. Let 'σ' be the surface charge density. In order to find out electric field intensity at point 'P' due plane charged sheet we consider circular elemental area 'A' of the sheet carrying total charge q. Considering cylindrical Gaussian surface enclosing the given charged area A and applying Gauss Theorem to situation

$$\oint_S \vec{E}.\vec{dS} = \oint_I \vec{E}.\vec{dS} + \oint_{II} \vec{E}.\vec{dS} + \oint_{III} \vec{E}.\vec{dS}$$



but $\oint_S \vec{E}.\vec{dS} = \oint_I \vec{E}.\vec{dS} + \oint_{III} \vec{E}.\vec{dS}$ $\quad (\because \oint_{II} \vec{E}.\vec{dS} = 0)$

$$= E\oint_I dS + E\oint_{III} dS$$

$$= E(A) + E(A) = 2EA$$

but $\oint_S \vec{E}.\vec{dS} = q/\epsilon_o = \sigma A/\epsilon_o$

$$\therefore 2EA = \sigma A/\epsilon_o$$

$$\boxed{E = \sigma/2\epsilon_o}$$

Answer for Four-mark questions

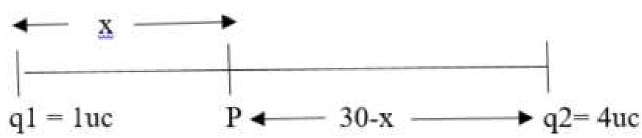
42. 1 a) $6C/\epsilon_o$ 2 c) $6C/\epsilon_o$

3 c) Glittering intensity is always constant whether the fan inside is switched ON or OFF

4 d) Gauss theorem in electrostatics

Answer to Five-mark questions

43. Let at point P, the net electric field is zero, then



$$1/x^2 = 4/(30-x)^2$$

After solving x = 10cm

44. a. Electric field Intensity – It is defined as the force per unit charge.

$\vec{E}$= F/q , SI unit of $\vec{E}$ = N/C or volt per meter V/m

b. Let the required point is at a distance x from $2\mu c$ charge k 4 μc / x^2= k 1 μc /$(2-x)^2$ = 4/x^2= 1/(4+x^2-2x)

= $(2/x)^2$ = $(1/2-x)^2$ = 2/x = +- 1/(2-x)

x=4/3m or 4m

x= 4 does not satisfy therefore, x=4/3m

45. Expression for intensity of electric field due to a point charge

According to coulomb's law,

F= 1/4π$\boldsymbol{\varepsilon}_0(q_0\ q/r^2)$

E= F/q_0 =1/4π$\boldsymbol{\varepsilon}_0(q_0\ q/q_0 r^2)$

E= 1/4π$\boldsymbol{\varepsilon}_0(q/r^2)$ N/C

E=9.0 X $10^9\ q/r^2$

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SECTION B

(1 MARK QUESTION)

Q1. Draw a pattern of electric field lines due to two positive charges placed a distance d apart? (2019) (given in NCERT book)

Q2. Why do the electrostatic field lines not form closed loop? (2012) (given in NCERT book)

Assertions and Reasons

Directions

In the following questions (3-8), a statement of Assertion (A) is followed be a statement of Reason (R). Mark the correct choice as:

(a) If both assertion and reason are true and reason is the correct explanation of the assertion.
(b) If both assertion and reason are true and reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reasons are false.

Q3. **Assertion:** A negative charge in an electric field moves along the direction of the electric field.

Reason: On a negative charge a force acts in the direction of electric field.

Q4. **Assertion:** Acceleration of a charged particle in non-uniform electric field does not depend on velocity of charged particle.

Reason: Charge is an invariant quantity. That is the amount of charge on particle does not depend on frame of reference.

Q5. **Assertion:** Net electric field inside a conductor is zero.

Reason: Total positive charge equals to the total negative charge in a charged conductor.

Q6. **Assertion:** All the charge in a conductor gets distributed on whole of its outer surface.

Reason: In dynamic system charges try to keep their potential energy minimum.

Q7. **Assertion:** The tires of aircrafts are made slightly conducting.

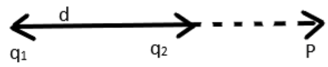
Reason: If a conductor is connected to the ground, the extra charge induced on the conductor will flow to the ground.

Q8. **Assertion:** The Coulomb force is the dominating force in the universe.

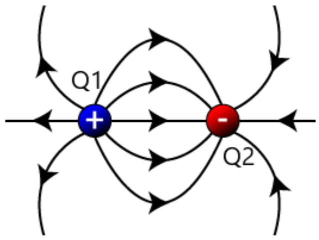
Reason: The Coulomb force is weaker than the gravitational force.

Q9. Draw the pattern of electric field lines when a point charge +Q is kept near an uncharged conducting plate. [CBSE 2019]

Q10. Two point charges q_1 and q_2 are placed at a distance d apart as shown in the fig. The electric filed intensity is zero at the point P on the line joining them as shown. Write two conclusions that you draw from this.

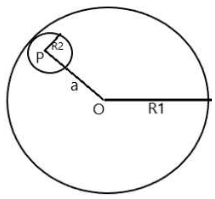


Q11. A few electric field lines for a system of two charges Q_1 and Q_2 are fixed at two different points on the x-axis are shown in the fig. What is the nature of charges? [IIT JEE 2010]



MCQ Types Question

Q12. Consider a uniform spherical distribution of Radius R1 centered at the origin O. In this distribution, a spherical cavity of Radius R2 centered at P with distance OP=a=R1-R2 is made. If the electric field inside the cavity at position $\vec{r}$ is E($\vec{r}$), then the correct statement is



(a) $\vec{E}$ is uniform, its magnitude is independent of R2, but its direction depends on $\vec{r}$

(b) $\vec{E}$ is uniform, its magnitude depends of R2, but its direction depends on $\vec{r}$

(c) $\vec{E}$ is uniform, its magnitude is independent of a, but its direction depends on a

(d) $\vec{E}$ is uniform and both its magnitude and direction depends on $\vec{a}$ [JEE Advanced 2015]

Q13. The surface densities on the surfaces of two charged spherical conductors of radii R1 and R2 are equal. The ratio of electric field intensity on the surface is

(a) $R1^2/R2^2$ (b) $R2^2/R1^2$ (c) R1/R2 (d) 1:1

Assertion/Reasoning Type MCQ

Q14. **Assertion:** Electric lines of force never cross each other.

Reason : Electric field at a point superimpose to give one resultant electric field.

Q15. **Assertion :** Electric lines of field cross each other.

Reason : Electric field at a point superimpose to give one resultant electric field.

Q16. **Assertion :** The electric lines of forces diverges from a positive charge and converge at a negative charge.

Reason : A charged particle free to move in an electric field always move along an electric line of force.

Q17. **Assertion :** A negative charge in an field moves along the direction of electric field.

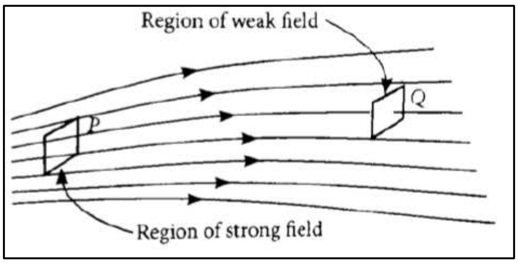
Reason : On a negative charge a force acts in the direction of electric field.

Q18. **Assertion :** In a non-uniform electric field a dipole will have translator as well as rotatory motion

Reason : In a non-uniform electric field a dipole experience a force as well as torque.

Case Study base type question

Electric field strength is proportional to the density of lines of force i.e., electric field strength at a point is proportional to the number of lines of force cutting a unit area element placed normal to the field at that point. As illustrated in given figure, the electric field at P is stronger than at Q.



Q19. Electric field lines are curved

(a) in the field of a single positive or negative charge

(b) in the field of two equal and opposite charges.

(c) in the field of two like charges.

(d) both (b) and (c)

Q20. **E**lectric lines of force about a positive point charge are

(a) radially outwards (b) circular clockwise

(c) radially inwards (d) parallel straight lines

Q21. Which of the following is false for electric lines of force?

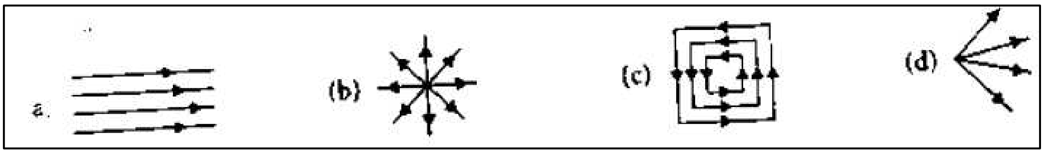
(a) They always start from positive charge and terminate on negative charges.

(b) They are always perpendicular to the surface of a charged conductor.

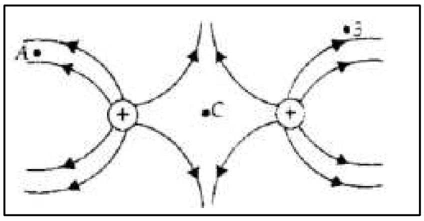
(c) They always form closed loops.

(d) They are parallel and equally spaced in a region of uniform electric field.

Q22. Which one of the following patterns of electric line of force is not possible in field due to stationary charges?



Q23. The figure below shows the electric field lines due to two positive charges. The magnitudes E_A, E_B and E_C of the electric fields at point A, B and C respectively are related as



(a)$E_A>E_B>E_C$ (b) $E_B>E_A>E_C$

(c) $E_A=E_B>E_C$ (d) $E_A>E_B=E_C$

Q24. A closed surface in vacuum encloses charges -q and +3q. Another charge -2q lies outside the surface. Total electric flux over the surface is

(a) Zero (b) $2q/\epsilon_o$ (c) $-3q/\epsilon_o$ (d) $4q/\epsilon_o$

Q25. The number of electric lines of force radiating from a closed surface in vacuum is 1.13×10^{11}. The charge enclosed by the surface is

(a)1 C (b) 1 μC (c) 0.1 C (d) 0.1 μC

Q26. The value of electric field inside a conducting sphere of radius R and charge Q will be:

(a)$\frac{KQ}{R^2}$ (b) $\frac{KQ}{R}$ (c) Zero (d) $\frac{KQ^2}{R^2}$

Q27. Charge Q is kept in a sphere of 5 cm radius first, then it is kept in a cube of side 15 cm, the outgoing flux will be

(a)More in case of sphere (b)More in case of cube

(c)Same in both cases (d)Information incomplete

Q28. Electric flux is a …….. quantity and its units are ……… .

Q29. Net electric flux from a closed surface does not depend upon distribution of ……. inside the surface.

ASSERTION & REASONING

Q30. Assertion- A closed spherical shell has inward electric flux.

Reason- Net charge enclosed inside spherical shell is negative.

Q31. Assertion- Electric field at any point due to infinitely long plain charged sheet is same.

Reason- Electric field at any point due to infinitely long plain charged sheet is expressed as $E=\sigma/\epsilon_0$.

Q32. Assertion- A charge Q is placed on a height of h/2 above the centre of a square of height h. The charge is displaced to point h/4 below. The flux through the square remains unchanged.

Reason- The flux associated with the square is independent of position of the charge inside cube but depends only on magnitude of charge.

Q33. Assertion- Number of electric lines of forces emanating from 1 μ C charge in vacuum is 1.13×10^5.

Reason- This follows from Gauss Theorem in Electrostatics.

Q34. Assertion- Electric flux through a given area changes as its orientation with field direction changes.

Reason- $\Phi_E = \oint_s \boldsymbol{E}\, \boldsymbol{dS} \cos\boldsymbol{\theta}$

Q35. Assertion- In case of charged spherical shells, E-r graph is discontinuous while V -r graph is continuous.

Reason- According to Gauss's theorem only the charge inside a closed surface can produce electric field at some point.

Q36. Assertion- Net electric flux through closed spherical surface of radius 5 cm enclosing charge +q is halved when radius is increased to 10 cm.

Reason- Electric flux through closed surface decreases with increase in its volume if charge enclosed is fixed.

Q37. Assertion- Displacing the charges within the closed surface does not affect net electric flux through the closed surface.

Reason- Net electric flux through a closed surface is independent of charge distribution/location within the closed surface.

Two-mark questions

Q38. State the law of conservation of charge. Give two examples to illustrate it. (2009)

Q39. How does the speed of an electrically charged particle affects its mass and charge?

Q40. Write Coulombs law in vector form. What is the importance of expressing it in vector form?

Q41. Two-point charge 4μc and 1μc are separated by a distance of 2m in air. Find the point on the line joining charges at which the net electric field of the system is zero. [OD2017]

Q42. Two identical point charges q each are kept 2m apart in air. A third point charge Q of unknown magnitude and sign is placed on the line joining the charges such that the system remains in equilibrium. Find the position and nature of Q. [CBSE 2019]

Q43. Explain briefly, using proper diagram in difference in behavior of conductor and dielectric in the presence of external electric field.

Q44. Write any two properties of electric field lines.

Q45. Three small spheres each of charge +q are placed on circumference of a circle such that they form an equilateral triangle. What is the electric field intensity at the center of the circle?

Q46. A surface element $\overrightarrow{dS} = 25\hat{\imath}$ is placed in an electric field $\vec{E} = 4\hat{\imath} + 8\hat{\jmath} + 14\hat{k}$. What is the electric flux emanating from the surface?

Q47. An infinite line charge produces a field of 9×10^4 N C-1 at a distance of 0.02 m. Calculate the linear charge density.

Three-mark questions

Q48. Give six properties of electric charges? (Given in NCERT book)

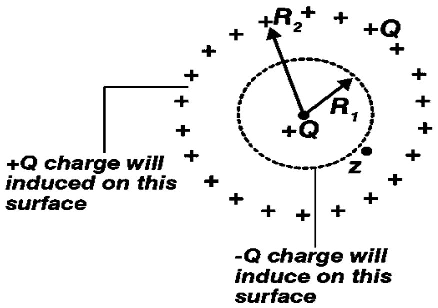
Q49. Two point charges q1 and q2 are located at points (a,0,0) and (0, b, 0) respectively. Find the electric field due to both these charges at the point (0, 0, c).

Q50. The electric field induced in a dielectric when placed in an external field 1/10 times the external field. Calculate relative permittivity of the dielectric.

Q51. S_1 and S_2 concentric spheres such that radius of S_2 is greater than that of S_1 , The spheres enclose charges of Q and 2Q respectively,

1. What is the ratio of electric flux through S_1 and S_2?
2. How will the electric flux through the sphere S_1 change, if a medium of dielectric constant K is introduced in the space inside S_1 in place of air?
3. How will the electric flux through the sphere S_1 change, if a medium of dielectric constant K is introduced in the space inside S_2 in place of air?

Q52. A metallic spherical shell has an inner radius R_1 and outer radius R_2. A charge Q is placed at the centre of the spherical cavity. What will be surface charge density on a) the inner surface b) the outer surface?



Five-mark questions

Q53. (a) Point charge (+Q) is kept in the vicinity of uncharged conducting plate sketch electric field lines between the charge and the plate.

(b) Plot a graph showing the variation of Coulomb force (F) versus $1/r^2$, where r is the distance between two charges of each pair of charges (1μC, 2μC) and (1μC, -3μC). Interpret the graphs.

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SECTION B -ANSWER KEY

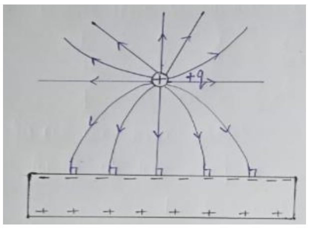
(1 MARK QUESTION)

Q1. Refer from NCERT textbook

Q2. Refer from NCERT textbook

Q3. d Q4. a Q5. c Q6. a Q7. a Q8. d

Q9.



Q10. 1. $q_{1\ and} q_2$ are opposite to each other 2. $q_1 > q_2$

Q11. Since field lines start from Q_1 and end at Q_2 therefore Q_1 is positive and Q_2 is negative

MCQ Types Question

Q12. (d) Explanation : Total field, $\vec{E} = \vec{E}_1 + \vec{E}_2$

$= \rho/3\boldsymbol{\varepsilon}_0\ \overrightarrow{OA} + \rho/3\boldsymbol{\varepsilon}_0\ \overrightarrow{AP}$

$= \rho/3\boldsymbol{\varepsilon}_0\ (\overrightarrow{OA} + \overrightarrow{AP})$

$E = \rho/3\boldsymbol{\varepsilon}_0 \overrightarrow{OP} = \rho/3\boldsymbol{\varepsilon}_0 \vec{a}$

Q13. (d) 1:1

Assertion/Reasoning

Q14. (b) Q15. (d) Q16. (c)

Q17. (d) Both statements are false.

Explanation: A –ve charge moves in opposite direction of electric field and force also acts in opposite direction of electric field.

Q18. (a) Both A and R are true and R is the correct explanation of A.

Case Study Base Type Question

Q19. (d) Q20. (a) Q21. (c) Q22. (c) Q23. (a) Q24. b) $2q/\epsilon_0$ Q25. a) 1 C

Q26. c) Zero Q27. c) Same in both cases Q28. Scalar, Nm^2C^{-1}. Q29. Charges. Q30. A

Q31. C Q32. A Q33. B Q34. A Q35. B Q36. D Q37. A

Answer for Two-mark questions

Q38. The total charge of an isolated system remains constant.

Ex: i) NaCl $\rightleftharpoons$ Na+ + Cl—

As the total charge is zero before & after the ionisation, so charge is conserved.

ii) When a glass rod is rubbed with a silk cloth it develops a positive charge. But at the same time silk cloth develop an equal negative charge. Thus, the net charge is zero as it was before rubbing.

Q39. According to special theory of relativity, the mass of body increases with its speed in accordance with the relation :

$m = m_0 /\sqrt{(1- v^2/c^2)}$

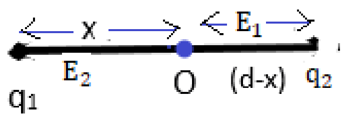
As v is less than c therefore m is greater than m_0.

In contrast to mass, the charge on a body remains constant and does not change as the speed of the body changes.

Q40. As r_{21} =- r_{12} , therefore F_{21}= - F_{12}

This means that the two charges exert equal and opposite forces on each other. So Coulombian forces obey Newton's third law of motion.

Q41. Therefore, E1=E2



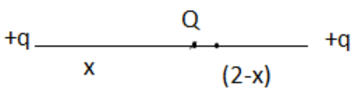
$kq_1 /(x)^2$=$kq_2 /(d-x)^2$

$1/4\pi\varepsilon_0\ (4x^2) = 1/4\pi\varepsilon_0\ (1/(2-X)^2)$

x/2 = 2-x

therefore, 3x=4 & x=4/3

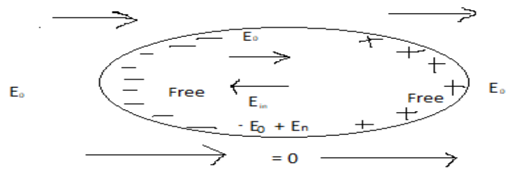
Q42.



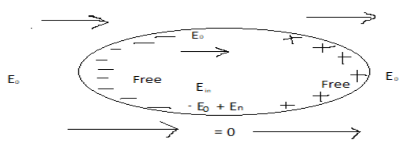
$$\frac{1}{4\pi\in_0}\frac{qQ}{x^2} = \frac{1}{4\pi\in_0}\cdot\frac{qQ}{(2-x)^2}$$

Total force on Q =0 & X=2-x Or 2x =2 or X=1m

Therefore, -Q charge is placed at a midpoint between the two charges of +q each.

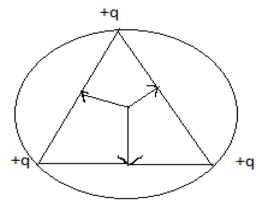


Q43. In conductor, net electric field is zero.



In case of dielectric: Induced electric filed inside is less than external electric field.

Q44. (i) Never intersect (ii) They are perpendicular on surface.



Q45. Resultant force (F=0) $\vec{E}$ at centre = 0

Three equal force make angle 120^0

Q46. Here, $\overrightarrow{dS} = 5\hat{\imath}$, $\vec{E} = 4\hat{\imath} + 8\hat{\jmath} + 14\hat{k}$

Electric flux, Φ= $\vec{E}.\overrightarrow{dS}$= $(4\hat{\imath} + 8\hat{\jmath} + 14\hat{k}).\,25\hat{\imath}$ or Φ= 100 units.

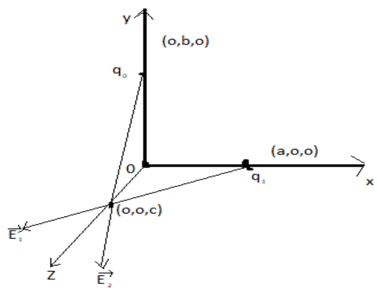
Q47. Here, E= 9 x 104 N C-1, r= 0.02 m, λ=?

As E= λ/2πϵor = 2λ/4πϵor ∴ λ= E (4πϵor)/2 = 9 x 104 x $\frac{1}{9*10^9}$ x $\frac{0.02}{2}$ = 10^{-7} C/m

Answer to Three-mark questions

Q48.- Refer from NCERT textbook

Q49. Net electric filed at the points (o,o,c) due to the charge q_1 & q_2 is



$\vec{E}\,net = \vec{E}_1 + \vec{E}_2 = 1/4\pi E_0\,[q_1/r_1^3\vec{r_1} + q_2/r_2^3\vec{r_2})$

But $r_1 = \vec{r} = -a\hat{\imath} + c\hat{k}$

⇒ $r_1 = (a^2 + c^2)^{1/2}$

$\vec{r_2}$ = $- b\hat{\jmath} + c\hat{k}$

⇒ $r_2 = (b^2 + c^2)^{1/2}$

$\vec{E}\,net = 1/4\pi E_0\,[q(-a\hat{\imath} + c\hat{k})/(a^2 + c^2)^{3/2} + q_2(- b\hat{\jmath} + c\hat{k})/(b^2 + c^2)^{3/2}$

Q50. K = E_0/E_0 = $E_0/E_{0/10}$ = 10

Q51. 1) From Gauss's theorem electric flux through S_1 is $\Phi_1=Q/\epsilon_o$

electric flux through S_2 is $\Phi_2= Q+2Q/\epsilon_o = 3Q/\epsilon_o$

∴ $\Phi_1/\Phi_2=1/3$

2) When a medium of dielectric constant K is introduced in the space inside S_1, then

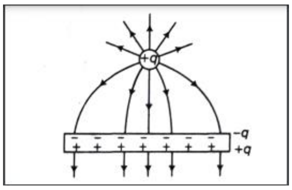
$\Phi_1'=\oint_S \vec{E}.\overrightarrow{dS} =\oint_S \frac{\vec{E}}{K}.\overrightarrow{dS}$= Q/ $K\epsilon_o$

3) On introducing dielectric medium inside S_2, electric flux through S_1 will not change.

Q52. +Q is the charge which is kept at the centre of the spherical cavity. –Q is the charge that is induced in the inner surface and +Q on the outer surface.

Answer for Five-mark questions

Q53. a) Equal charge of opposite nature induces in the surface of the conductor nearer to the source charge. Electric lines of forces should fall normally on the conducting plate.



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SECTION C

(1 MARK QUESTION)

1. Consider an uncharged conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is then,

(a) Negative and uniformly distributed over the surface of sphere.

(b) Positive and uniformly distributed over the surface of sphere.

(c) Negative and appears at a point surface of sphere closest to point charge.

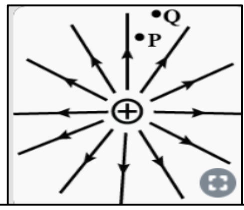
(d) Zero

2. Why do the electric field lines never cross each other?

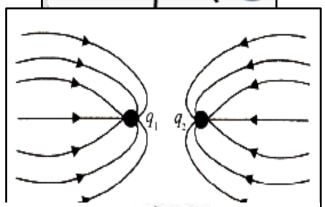
3. Two-point charges +8q and -2q are located at x = 0 and x = L respectively. The point on x-axis at which net electric field is zero due to these charges is (2021)

(a) 8L (b) 4L (c) 2L (d) L

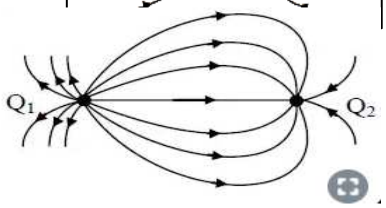
Q4. A point charge +Q is placed in the vicinity of a conducting surface. Draw the electric field lines between the surface and the charge. [CBSE 2014]



Q5. Figure shows the field lines on a positive charge. Is the work done by the field in moving a small positive charge from Q to P positive or negative? Give reason. [CBSE 2014]



Q6. The following fig. shows electric lines of force due to a point charges q_1 and q_2 placed at points A and B respectively. Write the nature of charge on them.



Q7. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the x-axis as shown in the fig. Where can be the electric field due to two charges be zero?

Q8. Two-point charges +8q and -2q are located at x=0 and x =L respectively. The location of a point on x-axis at which the net electric field due to these two-point charges is zero in

a) 2L b) L/4 c) 8L d) 4L [AIEEE 2005]

Assertion Reasoning

Q9. Assertion: Electric force acting on a proton and e^-, moving in a uniform electric field is same, whereas acceleration of e^- is 1836 times is lighter than that of a proton.

Reason – Electron is lighter than proton.

Q10. Assertion- As force is a vector quantity, hence electric field is also a vector quantity.

Reason – The unit of electric field intensity is newton per coulomb.

Q11. Assertion – The electric lines of forces from a point charge and can merge at a negative charge.

Reason – A charge of force to move in electric field moves along an electric line of force.

Q12. Assertion – Three equal charges are situated as a circle of radius r such that they form equilateral triangle, then the electric field intensity at the centre is zero.

Reason – The force on unit positive charge at the centre, due to three equal charges are represented by the three sides of a triangle taken in the same order. Therefore, electric field intensity at centre is zero.

Q13. Assertion –A point charge is brought in an electric field. The filed at a nearby point will increase whatever be the nature of the charge.

Reason – The electric field is independent of the nature of charge.

Q14. The electric field in a certain region is acting radially outwards and is given by E= Ar.

A charge contained in sphere of radius ‘a’ centred at origin of the field will be given by:

(a) Aϵoa2 (b) 4πϵoAa3 (c) ϵoAa3 (d) 4πϵoAa2

Q15. A charge q is placed at the point of intersection of body diagonals of a cube. The electric flux passing through any one of its faces is

(a) $\frac{q}{6\epsilon_o}$ (b) $\frac{3q}{\epsilon_o}$ (c) $\frac{6q}{\epsilon_o}$ (d) $\frac{q}{3\epsilon_o}$

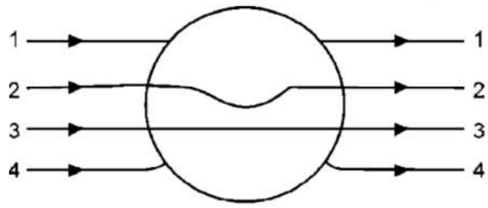
Q16. Name the principle which is mathematical equivalent to Coulomb’s law and superposition principle.

Q17. A charge q is placed at the centre of a cube of side ‘l’ what is the electric flux passing through two opposite faces of the cube?

Two-mark questions

Q18. State Coulomb’s law in vector form and prove that F_{21} = - F_{12}, where letters have their usual meaning. (Given in NCERT book)

Q19. Define electric field intensity. What is its S.I unit? What is the relation between electric field and force?



Q20. An infinite number of charges each equal to 4μc are placed along the x-axis at x=1m, x=2m & x=4m as so on. Find electric field at the origin due to given set of charges.

Q21. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path shown below. Which field lines follow the path?

Q21. If the total charge enclosed by a surface is zero, does it imply that the electric field everywhere on the surface is zero? Conversely, if the electric field everywhere on a surface is zero, does it imply that net charge inside is zero.

Q24. A wire AB of length L has linear charge density λ=Kx, where x is measured from the end A of the wire. This wire is enclosed by a Gaussian hollow surface. Find the expression for electric flux through the surface.

Q25.A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of 180 μC/m^2.

(a) Find the charge on the sphere.

(b) What is the total electric flux leaving the surface of the sphere?

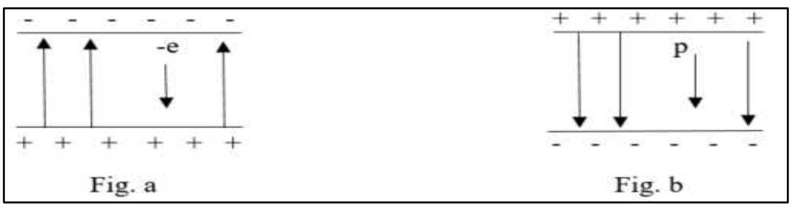
Q26. A charge of 17.7 x 10^{-4} C is distributed over a large sheet of area 400 cm^2. Calculate the electric field intensity at a distance of 10 cm from it.

Q27. A large plane sheet of charge having surface charge density 5 x 10^{-16} Cm^{-2} lies in XY plane. Find electric flux through a circular area of radius 1 cm. Given normal to the circular area makes an angle of 60^o with Z-axis.

Three-mark questions

Q28. Derive an expression for electric field intensity at a point due to (a) A point charge (b) A group of charges (c) Continues charge distribution.

Q29. An electron falls through a distance of 1.5 cm in a uniform electric field of value field is reversed, a proton falls through the same distance. Compare the



time of fall in each case. Contrast the situation with that of free fall under gravity. [CBSE 2018] [NCERT]

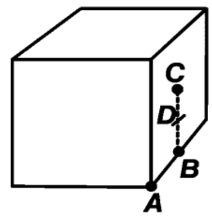
Q30. What will be the total flux through the faces of the cube with side of length a if a charge q is placed at

a) A: a corner of the cube

b) B: mid-point of an edge of the cube

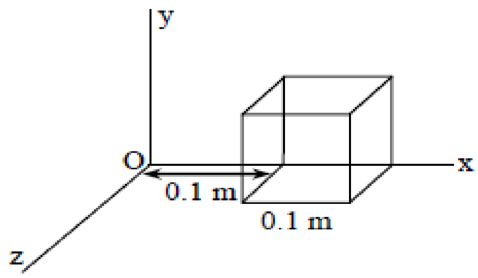
c) C: centre of a face of the cube

d) D: mid-point of B and C



Q31. Consider a uniform field $\vec{E}$= 30 x 10^3 $\hat{\imath}$ NC^{-1}. Calculate the flux of this field through a square surface area of 100 cm^2

(a)When its plane is parallel to Y-Z plane. (b) When the normal to its plane makes an angle of 60^o with X - axis. (c)When parallel to X-Y plane.



Q32.The electric field components due to a charge inside the cube of side 0.1 m are, E_x=α x, where α = 500 N/Cm^{-1}, E_y= 0, E_z=0. Calculate flux through the cube and charge inside the cube.

Five-mark questions

Q33. State the principle of superposition and use it to obtain the expression for the total force exerted on a point charge due to an assembly of (N -1) discrete point charges. (NCERT)

Case based question

Q34. Paragraph 1: Coulomb's law

This law is a quantitative statement of about the force between two-point charges. When the linear sizes of charged bodies are much smaller than the distance between them, their sizes may be ignored and the charge bodies are called point charges. After retiring from his active services as a military engineer in 1776, Coulomb discovered a torsion balance to measure a small quantity of force and used it for determination of forces of attraction or repulsion between small charged spheres. He thus arrived in 1785 at the inverse square law relation, now known as Coulomb's law. He found that the force between two-point charges varied inversely with the square of the distance between the charges and was directly proportional to the product of the magnitude of the charges and acted along the line joining the two charges. Coulomb's law is an electrical analogue of Newton's law of Universal Gravitation in mechanics.

$$|F_1| = |F_2| = k\,(q_1 \times q_2) / r^2$$

Q1. Answer the following questions

(I) Identify the wrong statement in the following Coulomb's law correctly describes the electric force that

(a) Blinds the electrons of an atom to its nucleus.

(b) Binds the protons and neutrons in the nucleus of an atom.

(c) Binds atoms together to form molecules.

(d) Binds atoms and molecules to form solids.

(II) Two charges 3×10^{-5}C and 5×10^{4}C are placed at a distance 10cm from each other. The value of electrostatic force acting between them is

(a) 13.5×10^{11} N (b) 40×10^{11} N © 180×10^{9} N (d) 13.5×10^{10} N

2. Each of two point charges is doubles and their distance is halved. Force of interaction becomes n times, where n is

(a) 4 (b) 1 (c) 18 (d) 16

3. The minimum value of force acting between two point charges placed 1 m apart from one another is

(a) ke^2 (b) ke (c) ke/4 (d) $ke^2/2$

4. A and B are two identical spherical charged bodies which repel each other with force F, kept at a finite distance. A third uncharged sphere of same size is brought in contact with sphere B and removed. It is then kept at a mid-point of A and B. Find the magnitude of the force on C.

(a) F/2 (b) F/8 (c) F (d) Zero

Q35. Paragraph 2:

Smallest charge that can exist in nature is the charge of an electron. During friction it is the only transfer of electrons which makes the body charged. Hence net charge on any body is an integral multiple of charge of an electron [1.6×10^{-19}C] i.e. I.e. q=ne

Where n=1, 2, 3……

Hence nobody can have a charge represented as 1.1e, 2.7e…etc.

Recently, it has been discovered that elementary particles such as protons or neutrons are composed of more elemental units called quarks.

Q1. Answer the following questions:

1.Which of the following properties is not satisfied by an electric charge?

(a) Total charge conservation.
(b) Quantization of charge.
(c) Two type of charge.
(d) Circular line of force.

2. Which one of the following charges is possible?

(a) 5.8x 10^{-18}C (b) 3.2x10^{-18}C
© 4.5x10^{-19}C (d) 8.6x10^{-19}C

3. If a charge on a body is 1nC, then how many electrons present on the body?

(a) 6.25x10^{27} (b)1.6x10^{19}
© 6.25x10^{28} (d) 6.25x10^{9}

4. If a body gives out 10^9 electrons every second, how much time is required to get a total charge of 1C from it?

(a)190.19 years (b)159.12 years
© 198.19 years (d) 188, 21 years

5.A polythene piece rubbed with wool is found to have a negative charge of 3.2x10^{-7}C.

Calculate the number of electrons transferred.

(a) 2x10^{12} (b)3x10^{12}
© 2x10^{14} (d)3x10^{14}

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SECTION-C

ANSWER KEY

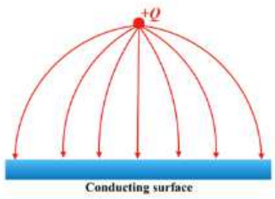
(1 MARK QUESTION)

1. d

2. If two lines of forces intersect, then there would be two tangents and two directions of electric field at the point of intersection, which is impossible.

3. c

4.



5. Work done by field is negative. Since charge is moved against the force exerted by the field.

6. q_1 and q_2 must be -ve charges. As field lines are pointing towards q_1 and q_2.

7. The electric field due to the system of two charges will be zero at a point to the right of charge.

MCQ Types Question

8. (a) Explanation: Let net electric field due to two given charges be zero at P, where OP = x

$E_{AP} = B_{BP} = K8q/x^2 = K(2q)/(x-L)^2$ or $2/x = 1/x\text{-}L$

Or $2x - 2L = x$

$X = 2L$

Assertion/Reasoning

9. (A) 10. (B) 11. (C) 12.(B) 13. (D) 14.b) $4\pi\epsilon_o Aa^3$

15.a) $\frac{q}{6\epsilon_o}$ 16. Gauss' Theorem in electrostatics

17. Flux through each face = $\frac{q}{6\epsilon_o}$

Flux through two opposite faces $= \frac{q}{6\epsilon_o} + \frac{q}{6\epsilon_o} = \frac{q}{3\epsilon_o}$

Answer for Two-mark questions

18. Refer from textbook

19. Electric field intensity at a point defined as the electrostatic force per unit test charge acting on a vanishingly small positive test charge placed at that point .

SI unit of intensity is N/C.

Electrostatic force = charge x electric field.

20. E at origin, $E = 9x10^9 [4x10^{-6}/ (1)^2 + 4x10^{-6}/22] +$ ----

$= 36x10^3[1+1/22+1/42 +--]$

(Geometric series)

Therefore, Sum = a/1-r

a= first term = 1

r = common ratio = ¼

$E= 36x10\ ^3x1/ (1-1/4) = 48x10^3$

21. 4^{th}

Explanation: When metallic solid sphere is placed in uniform electric field the electrons of the sphere move against the direction of electric field. Consequently, the left face acquires negative charge while the right face attains +ve charge. The filed lines will terminate at the left face of sphere and restart from right face. The electric field inside the sphere is zero. On the other surface of the sphere, the filed lines are normal at energy point. i.e., directed towards the centre. Therefore, the correct field is represented.

22. Refer from NCERT textbook

23. The total charge enclosed by a surface is zero, it doesn't imply that the electric field everywhere on the surface is zero. As $\oint_S \vec{E}.\,\vec{dS} = q/\epsilon_o$, therefore, the field may be normal to the surface. Also, the conversely it does imply that net charge inside is zero if electric field everywhere on the surface is zero.

24. Here, $\lambda=\frac{dq}{dx}= Kx$; $\phi=?$

$dq=Kx\ dx$

Total charge on the wire

$q= \int_0^L Kx\ dx= [\frac{Kx^2}{2}]=KL^2/2$

Total electric flux through the Gaussian hollow surface is

$\Phi= q/\epsilon_o= KL^2/2\epsilon_o$

25. (a) d=2.4m r=1.2m

Surface charge density, $\sigma =180.0\ \mu C/m^2 =180 \times 10^{-6} C/m^2$

Total charge on surface of sphere,

$Q = \sigma \times 4\pi r^2 = 180 \times 10^{-6} \times 4 \times 3.14 \times (1.2)^2$

$= 3.25 \times 10^{-3}$ C

(b) $\Phi_{Total} = Q/\epsilon_o$

$\Phi_{Total} = \frac{3.25*10^{-3}}{8.85*10^{-12}} = 3.67 \text{ X } 10^8 \text{ Nm}^2\text{C}^{-1}$

26. Here, q= 17.7×10^{-4} C, A= 400 cm^2, E=?, r =10 cm = 10^{-1}m

In case of a large plane sheet, distance of the point (=r) doesn't matter.

$E = \sigma/2\epsilon_o = q/2\epsilon_o A = \frac{17.7*10^{-4}}{2*(8.85*10^{-12})*400} = 2.5 \times 10^5$ N/C

27. Here, $\sigma = 5 \times 10^{-16}$ Cm^{-2}, ϕ=?

r= 1 cm =10^{-2}m, θ=60^o

$\phi = E(\Delta S)\cos\theta = (\sigma/2\epsilon_o)\, \pi r^2 \cos 60^o$

$= \frac{5*10^{-16}*3.14*(10^{-4})*1/2}{2*8.85*10^{-12}} = 4.44 \times 10^{-9} \text{Nm}^2\text{C}^{-1}$.

Answer to Three-mark questions

28. Refer from NCERT textbook

29. For electron

Y_1= 1.5 cm = 1.5 x10^{-2}m

E_1= 2x10^4N/C

q_0 = (-) 1.6x10^{-19} C

m_1 = 9x10^{-3} kg

$Y_1 = u_1 t_1 + ½ a_1 t_1^2$

$= 0 + ½ a_1 t_1^2$

$t_1 = \sqrt{\frac{2y_1}{a_1}} = \sqrt{\frac{2 \times 1.5 \times 10^{-2}}{3.55 \times 10^{15}}}$ = 2.9 X 10^{-9}sec

therefore,

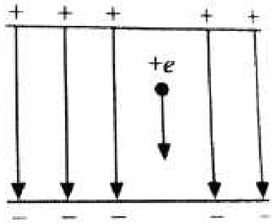
$a_1 = F_1/m_1 = q_0 E_1/m_1$

$a_1 = 1.6 \times 10^{-19} \times 2 \times 10^4 / 9 \times 10^{-37}$

$a_1 = 3.55 \times 10^{15}$ m/s^2

For proton

When electric field is reversed



$q_0 = +1.6 \times 10^{-19}$C.

$m_2 = 1.67 \times 10^{-27}$kg.

acceleration $a_2 = F_2/m_2 = q_0E/m_2$

a = 1.6 x 10 -19x 2 x 104/ 1.67 x 10-27 = 1.92 x 1012 m/s2

Similarly, $t2 = \sqrt{\frac{2y_2}{a_2}} = \sqrt{\frac{2\times1.5\times10^{-2}}{1.92\times10^{12}}}$

t1/t2 = 2.9 x 10-9/1.25 x 10-7 = 2.3 x 10-2

Observation:

Acceleration of $e^- = 10^{15}$ m/s^2

Acceleration of $p^+ = 10^{12}$ m/s^2

Acceleration of g = 9.8 m/s^2 = 10 m/s^2 (negligible), Effect of gravity can be ignored.

30. a) When we consider the charged particle to be placed at the centre of the cube whose side is 2a, then the charge is equally distributed among 8 cubes. Therefore, the total flux through the faces of the cube=q/8 ϵ_o.

b) When the charge is placed at B, the charge is equally distributed among the 4 cubes. Therefore, the total flux through the four faces is given as = q/4 ϵ_o.

c) When the charge is placed at C, the charge is shared among 2 cubes equally. Therefore, the total flux through these faces is given as = q/2 ϵ_o.

d) When the charge is place at D, the charge is distributed among two cubes and therefore, the total flux is given as = q/2 ϵ_o.

31. Here, $\vec{E} = 30 \times 10^3\, \hat{\imath}$ NC^{-1}

A= 10^{-2} m^2

(a)As normal to the area is in the direction of electric field, therefore θ=0°

Φ= EA cos θ= $30\times10^3\times10^{-2}$ cos 0^0
= 300Nm^{2}C^{-1}

(b)In this case, θ=60°

Φ` = EA cos θ= $30\times10^3\times10^{-2}$ cos 60^0
= 150 Nm^{2}C^{-1}.

(c)In this case, $\theta=90^o$

Φ= EA cos θ= $30x10^3x10^{-2}$ cos 90^0

= 0 Nm^2C

32. Through the left face

Φ_1= $E_{x.}$ A cos 180^o

=500 x 0.1 x 10^{-2}(-1) = -0.5

Through the right face

Φ_2= E_x. A cos 0^o

=500 x 0.2 x 10^{-2}= 1.0

∴ Net flux through the cube

$\Phi=\Phi_1+\Phi_2$= 0.5 Nm^2C^{-1}

Charge inside the cube =$\epsilon_o\Phi$

= 8.85 x 10^{-12} x 0.5= 4.425 x 10^{-12} C.

Answer to Five-mark questions

Q33. Refer from NCERT textbook

Q34. Refer from NCERT textbook

1. b 2. a 3. d 4. a 5. c

Q35. 1. d 2. b 3. d 4. c 5. a

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