General instruction :-

Read the following instructions very carefully and strictly follow them :

(i) This question paper contains **35** questions. **All questions** are **compulsory**.

(ii) This question paper is divided into five sections – **A, B, C, D** and **E.**

(iii) In **Section A** – Questions no. **1** to **18** are Multiple choice (MCQ) type questions, carrying **1** mark each.

(iv) In **Section B** – Questions no. **19** to **25** are Very Short Answer (VSA) type questions, carrying **2** marks each.

(v) In **Section C** – Questions no. **26** to **30** are Short Answer (SA) type questions, carrying **3** marks each.

(vi) In **Section D** – Questions no. **31** to **33** are Long Answer (LA) type questions, carrying **5** marks each.

(vii) In **Section E** – Questions no. **34** to **35** are case-based questions carrying **4** marks each.

(viii) There is no overall choice. However, an internal choice has been provided in 2 questions in Section **B**, 2 questions in Section C,3 questions in section D and 2 questions in Section E .

(ix) Use of calculators is **not** allowed.

Use the following values of physical constants, if required :

$c = 3 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\varepsilon_0 = 8.854 \times 10^{-12}\ C^2N^{-1}m^{-2}$

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}\ Nm^2C^{-2}$

Mass of electron (m_e) = 9.1×10^{-31} kg

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = $1.38 \times 10^{-23}\ JK^{-1}$

Section A -

1. A point charge q is kept at a distance r from infinity long straight wire with charge density λ .The magnitude of the electrostatic force experienced by charge q is :

A) Zero
C) $\frac{q\lambda}{2\pi\varepsilon_o r}$
B) $\frac{q\lambda}{4\pi\varepsilon_o r}$
D) $\frac{q\lambda}{\varepsilon_o r}$

2. A charge q μC is placed at the centre of a cube of side 0.1 m. Then the electric flux diverging from each of this cube is [CBSE 2001]

A) $\frac{q\ x\ 10^{-6}}{\varepsilon_0}$
C) $\frac{q}{\varepsilon_0}$ x 10^{-4}
B) $\frac{q\ x\ 10^{-6}}{6\varepsilon_0}$
D) $\frac{q\ x\ 10^{-4}}{6\varepsilon_0}$

3. An electric dipole is placed at an angle of 30° with an electric field of intensity 2 x 10^5 N C^{-1} . It experiences a torque equal to 4 N m. Calculate the magnitude of charge on the dipole, if the dipole length is 2 cm. [NEET 2023]

A) 8 mC
C) 6 mC
B) 4 mC
D) 2 mC

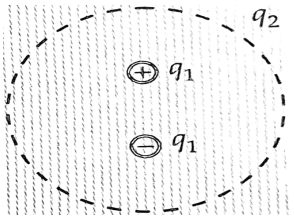
4. If $\oint_s \vec{E}.\overrightarrow{dS}$ = 0 over a surface, then : [IIT]

A) The number of flux lines entering the surface must be equal to the number of flux lines leaving it.
B) The magnitude of electric field on the surface is constant.
C) All the charges must necessarily be inside the surface.
D) The electric field inside the surface is necessarily uniform.

5. A charge q is placed at the centre of the line joining two equal positive charges Q. The system of the three charges will be in equilibrium, if q is equal to [IIT]

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

6. A metallic solid is placed in a uniform electric field. The lines of force follow the path(s) shown in the figure as : [IIT]



A) 1
B) 2
C) 3
D) 4

7. Let $[\varepsilon_0]$ denote the dimensional formula of the permittivity of vacuum. If M = mass, L = length, T = time and A = electric current, then [JEE Main 13]

A) $[\varepsilon_0] = [M^{-1}L^{-3}T^2A]$
B) $[\varepsilon_0] = [M^{-1}L^{-3}T^4A^2]$
C) $[\varepsilon_0] = [M^{-1}L^2T^{-1}A^{-2}]$
D) $[\varepsilon_0] = [M^{-1}L^2T^{-1}A]$

8. Four charges equal to -Q are placed at the four corners of a square and a charge q is at its centre. If the system is in equilibrium, the value of q is [Imp.Q]

A) $-\frac{Q}{4}(1 + 2\sqrt{2})$
B) $\frac{Q}{4}(1 + 2\sqrt{2})$
C) $-\frac{Q}{2}(1 + 2\sqrt{2})$
D) $\frac{Q}{2}(1 + 2\sqrt{2})$

9. A charge Q is placed at each of the opposite corners of a square. A charge q is placed at each of the other two corners. If the net electrical force on Q is zero then Q / q equals {Imp.Q]

A) $-2\sqrt{2}$
B) -1
C) 1
D) $-\frac{1}{\sqrt{2}}$

10. Two charges of equal magnitudes and at a distance r exerts a force F on each other. If the charges are halved and distance between them is doubled, then the new force acting on each charge is [Delhi All India]

A) $\frac{F}{8}$
B) $\frac{F}{4}$
C) 4F
D) $\frac{F}{16}$

11. Two charged spheres are separated by 2 mm. Which of the following would yield the greatest attractive force ?

A) + 2q and - 2 q
B) + 2q and + 2q
C) - 2q and -2q
D) - 1q and - 4q

12. For a given surface the Gauss'law is stated as $\int \vec{E}.\overrightarrow{dS} = 0$. from this we can conclude that [Imp. Q]

A) E is necessarily zero on the surface
B) E is perpendicular to the surface at every point
C) The total flux through the surface is zero
D) The flux is only going out of the surface

13. According to the Gauss law, electric field of an infinity long straight wire is proportional to [Imp. Q]

A) R
B) $\frac{1}{r^2}$
C) $\frac{1}{r^3}$
D) $\frac{1}{r}$

14. A body can be negatively charged by [AIIMS]

A) Giving excess of electrons to it
B) Removing some electrons from it
C) Giving some protons to it
D) Removing some neutrons from it

15. The number of electrons for one coulomb of charge is [AIIMS]

A) 6.25×10^{18}
B) 6.25×10^{19}
C) 6.25×10^{21}
D) 6.25×10^{23}

16. Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

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

d) A is false and R is also false

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

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

17. Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

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

b) Both A and R are true and R is NOT the correct explanation of A

c) A is true but R is false

ASSERTION (A) : Away from a charge field lines gets weaker and density of field lines is less, resulting in well separated lines.

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

18. Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

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

b) Both A and R are true and R is NOT the correct explanation of A

c)A is true but R is false

ASSERTION (A) : Electric lines of force cross each other.

Reason (R) : Electric field at a point does not superimposes to give one resultant electric field.

Section B -

19. Given a uniform electric field $\vec{E} = 5 \times 10^3 \hat{i}$ N /C, find the flux of this field through a square of 10 cm on a side whose plane is parallel to the y-z plane. What would be the flux through the same square if the plane makes a 30° angle with the x-axis ? [Delhi]

20. Given a uniform electric field $\vec{E} = 4 \times 10^3 \hat{i}$ N /C. Find the flux of this field through a square of 5 cm on a side whose plane is parallel to the Y-Z plane. What

would be the flux through the same square if the plane makes a 30° angle with the x-axis ? [Delhi]

21. Charges $\pm$20nC are separated by 5mm. Calculate the magnitude and direction of dipole moment.

22. A dipole, of dipole moment $\vec{p}$, is present in a uniform electric field $\vec{E}$. Write the value of the angle between $\vec{p}$ and $\vec{E}$ for which the torque, experienced by the dipole, is minimum.

23. Consider three charges q_1, q_2, q_3 each equal to q at the vertices of an equilateral triangle of side l. What is the force on a charge Q (with the same sign as q) placed at the centroid of the triangle ?

24. A charge of 17.7 x 10^{-4} C is distributed uniformly over a large sheet of area 200 m^2. Calculate the electric field intensity at a distance of 20 cm from it in air.

25. What is the force between two small charged spheres having charges of 2 x 10^{-7} C and 3 x 10^{-7} C placed 30 cm apart in air ?

Section C –

26. State Gauss's theorem in electrostatic. Using this theorem, derive an expression for the electric field intensity due to an infinitely long, straight wire of linear charge density λ Cm^{-1} .

27. Derive an expression for the torque on an electric dipole placed in a uniform electric field. Hence define dipole moment.

28. Two point charges of 2.0 x 10^{-7} C and 1.0 x 10^{-7} C are 1.0 cm apart. What is the magnitude of the field produced by either charge at the site of the other ? Use standard value of $1/4\pi\varepsilon_0$.

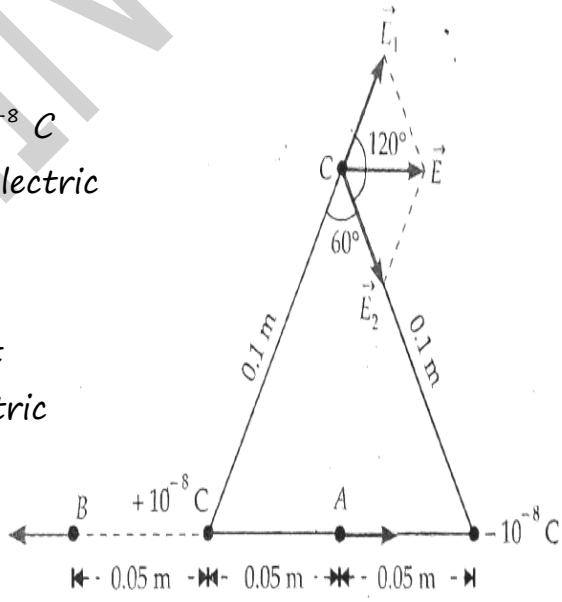
29. A point charge of 2.0 μC is at the centre of a cubic Gaussian surface 9.0 cm on edge. What is the net electric flux through the surface ?

30. Suppose the spheres A and B have identical sizes. A third sphere of the same size but charged is brought in contact with the first, then brought in contact with the second, and finally removed from both. What is the new force of repulsion between A and B ? (given - $q = 6.5 \times 10^{-7}$ C and $r = 50$ cm)

Section D -

31. A point charge causes an electric flux of -1.0×10^{3} Nm^2 / C to pass through a spherical Gaussian surface of 10.0 cm radius centered on the charge. (a) If the radius of the Gaussian surface were doubled, how much flux would pass through the surface? (b) What is the value of the point charge ?

32. Two point charges q_1 and q_2 of 10^{-8} C and -10^{-8} C respectively are placed 0.1 m apart. Calculate the electric fields at points A, B and C **shown in figure**.



33. (i) Derive and expression for the electric field at any point on the axial line of an axial line of an electric dipole.

(ii) Derive an expression for the electric field at any point on the equatorial line of an electric dipole.

Section E -

34. An electric field line in general is a curve drawn in such a way that the tangent to it at each point is in the direction of the electric field at that point. A field line is a space curve, i.e. a curve in three dimensions/

Electric field lines are thus use to pictorially map the electric field around a charge or a configuration of charges.

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

1. Electric field lines always move from
   (a) Higher to lower potential
   (b) Lower to higher potential
   (c) Infinity to zero potential
   (d) None of the above

2. Choose the correct statement regarding electric lines of force.
   (a) Emerges from negative charge and meet at positive charge.
   (b) A closely spaced region of electric lines of force represents strong electric field.
   (c) Representation of field lines for a point charge and a solid sphere are same.
   (d) They have physical nature.

3. The spacing between two electric field lines indicates its
(a) Charge (b). position (c) strength (d) None of these

4. The electric field lines of a negatively charged particle are
   (a) Radial and outwards
   (b) Radial and inwards
   (c) Circular and anticlockwise
   (d) Circular and clockwise

35. The physical property of matter that causes it to experience a force when placed in an electromagnetic field is called electric charge. Electric charge is a characteristics that accompanies fundamental particles, whenever they exist.
The process of charging a neutral body by bringing a charged body nearby it without making contact between the two bodies is known as charging by induction.
1. When a glass rod is rubbed with silk, it becomes positively charged because

(a) Protons are transferred to silk
(b) Electrons are transferred to silk
(c) Protons are added to it
(d) Electrons are added to it

2. Which of the following method can be used to charge a metal sphere positively without touching it ?
   (a) Connect the positive terminal of battery and float the other end of battery.
   (b) Rub it with a piece of fur
   (c) Bring a negatively charged rod near it and touch it to ground for some time.
   (d) Rub it with a piece of silk.

3. If an object is positively charged, theoretically, the mass of the object
   (a) Increases slightly by a factor of 9.11×10^{-31} kg
   (b) Decrease slightly by a factor of 9.11×10^{-31} kg
   (c) Remains the same
   (d) May increase of decrease

4. The value of charge on a body which carries 30 excess electrons is
   (a) -4.8×10^{-18} C (c) -4×10^{-18} C
   (b) 4.8×10^{-18} C (d) 48×10^{-18} C