# N.B.Navale

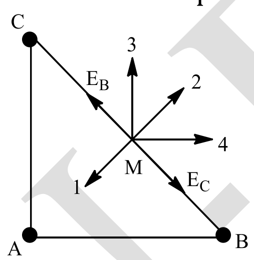
**Date** : 28.03.2025
**Time** : 01:04:48
**Marks** : 72

**TEST ID: 43**
**PHYSICS**

ELECTROSTATICS

**Single Correct Answer Type**

1. If charge q is placed at the centre of the line joining two equal charges Q, the system of these charges will be in equilibrium, if q is
   a) –4Q  b) $-\frac{Q}{4}$
   c) $-\frac{Q}{2}$  d) $+\frac{Q}{2}$
2. A particle of mass m and charge q is placed at rest in a uniform electric field E and then released, the kinetic energy attained by the particle after moving a distance y will be
   a) $q^2$E y  b) q E y
   c) q $E^2$ y  d) q E $y^2$
3. Three charges each of $+1\mu C$ are placed at the corners of an equilateral triangle. If the force between any two charges be F, then the net force on either charge will be
   a) $\sqrt{2}F$  b) $F\sqrt{3}$
   c) 2 F  d) 3 F
4. Three identical point charges as shown in figure, are placed at the vertices of an isosceles right angled triangle. Which of the numbered vectors coincides in direction with the electric field at the mid-point M of the hypotaneous?




   a) 4  b) 3
   c) 2  d) 1
5. Charge $q_2$ of mass m revolves around a stationary charge $q_1$ in a circular orbit of radius r . The orbital periodic time of $q_2$ would be
   a) $\left[\frac{4\pi^2mr^3}{kq_1q_2}\right]^{1/2}$  b) $\left[\frac{kq_1q_2}{4\pi^2mr^3}\right]^{1/2}$
   c) $\left[\frac{4\pi^2mr^4}{kq_1q_2}\right]^{1/2}$  d) $\left[\frac{4\pi^2mr^2}{kq_1q_2}\right]^{1/2}$
6. Pick out the statement which is incorrect?
   a) A negative test charge experiences a force opposite to the direction of the field.
   b) The tangent drawn to a line of force represents the direction of electric field.
   c) Field lines never intersect.
   d) The electric field lines form closed loop.
7. In hydrogen atom an electron revolves around a proton (in nucleus) at a distance ‘r’ m. The intensity of electric field due to the proton at distance ‘r’ is $5 \times 10^{11}$ $NC^{-1}$, the magnitude of force between the electron and proton is [charge on electron= $1.6 \times 10^{-19}$ C]
   a) $4 \times 10^{8}$ N  b) $8 \times 10^{8}$ N
   c) $4 \times 10^{-8}$ N  d) $8 \times 10^{-8}$ N
8. A charge ‘Q’ μC is placed at the centre of a cube. The flux through one face and two opposite faces of the cube is respectively
   a) $\frac{Q}{12\varepsilon_0}$ μVm, $\frac{Q}{3\varepsilon_0}$ μVm  b) $\frac{Q}{6\varepsilon_0}$ μVm, $\frac{Q}{2\varepsilon_0}$ μVm
   c) $\frac{Q}{6\varepsilon_0}$ μVm, $\frac{Q}{3\varepsilon_0}$ μVm  d) $\frac{Q}{12\varepsilon_0}$ μVm, $\frac{Q}{\varepsilon_0}$ μVm
9. Two charges + 4 e and + e are at a distance apart. At what distance, a charge q must be placed from charge + e, so that it is in equilibrium?
   a) x / 2  b) 2x / 3
   c) x / 3  d) x / 4
10. ‘F’ is the force between the two identical charged particles placed at a distance ‘Y’ from each other. If the distance between the charges is reduced to half the previous distance then force between them becomes
    a) $\frac{F}{4}$  b) 4F
    c) 2F  d) $\frac{F}{2}$
11. An electron of mass ‘m’ and charge ‘q’ is accelerated from rest in a uniform electric field of strength ‘E’. The velocity acquired by the electron when it travels a distance ‘L’ is

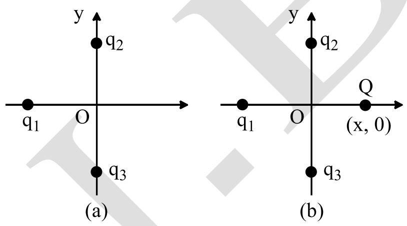
a) $\sqrt{\frac{2qE}{mL}}$ b) $\sqrt{\frac{2Em}{qL}}$
c) $\sqrt{\frac{2qEL}{m}}$ d) $x\sqrt{\frac{qE}{mL}}$

12. Two positive ions, each carrying a charge q, are separated by a distance d. If F is the force of repulsion between the ions, the number of electrons mission from each ion will be (e being the charge on an electron)
a) $\frac{4\pi\varepsilon_0 Fd^2}{e}$ b) $\sqrt{\frac{4\pi\varepsilon_0 Fe^2}{d^2}}$
c) $\sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e^2}}$ d) $\frac{4\pi\varepsilon_0 Fd^2}{e^2}$

13. An electron at rest is accelerated by a potential '$V_1$', in uniform field experiences a force '$F_1$'. When potential is changed to '$V_2$', the force experienced by the electron gets doubled. The ratio of $V_1$ to $V_2$ is
a) 1:4 b) 4:1
c) 1:2 d) 2:1

14. When $10^{14}$ electrons are removed from a neutral metal sphere, then the charge on the sphere becomes
a) 16μ C b) -26μ C
c) 32μ C d) -33μ C

15. In figure, two positive charge $q_2$ and $q_3$ fixed along the Y-axis, exerts a net electric force in the + x - direction on a charge $q_1$ fixed along the X-axis. If a positive charge Q is added at (x, 0), the force on $q_1$




a) will increase along the positive X-axis b) will decrease along the positive X-axis
c) will point along the negative X-axis d) will increase but the direction changes because of the intersection of Q with $q_2$ and $q_3$

16. Two point charges +2 C and + 6 C repel each other with a force of 12 N. If a charge of - 4 C is given to each of these charges, the force now is
a) 4 N (repulsive) b) 4 N (attractive)
c) 12 N (attractive) d) 8 N (repulsive)

17. An electron of mass 'm' and charge 'q' is accelerated from rest in electric field 'E'. The velocity acquired by electron in travelling a distance 'x' is
a) $\left(\frac{Eq}{mx}\right)^{1/2}$ b) $\left(\frac{2Eq}{mx}\right)^{1/2}$
c) $\left(\frac{2Eqx}{m}\right)^{1/2}$ d) $\left(\frac{Em}{qx}\right)^{1/2}$

18. If $10^{10}$ electrons are acquired by a body every second, the time required for the body to get a total charge of 1 C will be
a) 2 h b) 2 days
c) 2 yr d) 20 yr

19. The bob of a simple pendulum has mass 2g and a charge of 5.0 μ C. If is at rest in a uniform horizontal electric field of intensity 2000 V/m. At equilibrium, the angle that the pendulum makes with the vertical is (Take, g = 10 m/S²)
a) $\tan^{-1}(2.0)$ b) $\tan^{-1}(0.2)$
c) $\tan^{-1}(5.0)$ d) $\tan^{-1}(0.5)$

20. There are two charged identical metal spheres A and B repel each other with a force $3\times 10^{-5}$ N. another identical uncharged sphere C is touched with A and then placed at the mid-point between A and B. Net force on C is
a) $1\times 10^{-5}$ N b) $2\times 10^{-5}$ N
c) $1.5\times 10^{-5}$ N d) $3\times 10^{-5}$ N

21. Two parallel plates separated by 'd' mm are kept at potential difference of 'V' volt. A particle of mass 'm' and charge 'q' enters in it with some velocity. The acceleration of the particle will be
a) $\frac{qV}{dm}$ b) $\frac{q}{dmV}$
c) $\frac{qm}{Vd}$ d) $\frac{qd}{Vm}$

22. Suppose the charge of a proton and an electron differ slightly. One of them is - e and the other is (d + Δe). If the net of electrostatic force and gravitational force between two hydrogen atoms placed at a distance d (much greater than atomic size) apart is zero, then Δe is of the order (Take, mass of hydrogen, $m_h = 1.67\times 10^{-27}$ kg)
a) $10^{-20}$ C b) $10^{-23}$ C
c) $10^{-37}$ C d) $10^{-47}$ C

23. A proton of mass $1.67\times 10^{27}$ kg and charge $1.6\times 10^{-19}$ C is placed in uniform electric field of intensity $3.25\times 10^{4}$ N/C in air. The force experienced by proton is
a) $5.2\times 10^{-15}$ N b) $52\times 10^{-15}$ N

c) $5.2 \times 10^{-23}$ N d) $52 \times 10^{-23}$ N

24. A conductor has been given a charge $-3 \times 10^{-7}$ C by transferring electron. Mass increase (in kg) of the conductor and the number of electrons added to the conductor are respectively
a) $2\times 10^{-16}$ and $2\times 10^{31}$ b) $5\times 10^{-31}$ and $5\times 10^{19}$
c) $3\times 10^{-19}$ and $9\times 10^{16}$ d) $2\times 10^{-18}$ and $2\times 10^{12}$

25. If the charge on the body is 1 nC, then how many electrons are present on the body?
a) $1.6\times 10^{-19}$ b) $6.25\times 10^{9}$
c) $6.25\times 10^{27}$ d) $6.25\times 10^{28}$

26. Two point charges $+3\ \mu C$ and $+8\ \mu C$ repel each other with a force of 40 N. If a charge of $-5\ \mu C$ is added to each of them, then force between them will become
a) $-10$ N b) 10 N
c) 20 N d) $-20$ N

27. Two positive ions, each carrying a charge 'q' are separated by a distance 'd'. If 'F' is the force of repulsion between the ions, the number of electrons from each ion will be ($\varepsilon$ = charge on electron, $\varepsilon_k$ = permittivity of free space)
a) $\sqrt{\frac{4\pi\varepsilon_0 d^2}{e^2}}$ b) $\sqrt{\frac{4\pi\varepsilon_0 Fd}{e^2}}$
c) $\sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e}}$ d) $\sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e^2}}$

28. Two point charges $q_1$ and $q_2$ are 'l' distance apart. If one of the charges is doubled and distance between them is halved, the magnitude of force becomes n times, where n is
a) 2 b) 1
c) 16 d) 8

29. An electron of mass 'm' and charge 'q' is accelerated from rest in a uniform electric field of strength 'E'. The velocity acquired by the electron when it travels a distance 'L' is
a) $\sqrt{\frac{2qE}{mL}}$ b) $\sqrt{\frac{2Em}{qL}}$
c) $\sqrt{\frac{2qEL}{m}}$ d) $x\sqrt{\frac{qE}{mL}}$

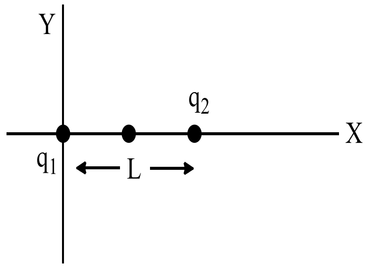
30. Identify the WRONG statement in the case of electric field lines.
a) They do not pass through a conductor b) They do not pass through an insulator
c) They start from a positive charge and end on a negative charge d) They do not intersect each other

31. Two parallel plates separated by 'd' mm are kept at potential difference of 'V' volt. A particle of mass 'm' and charge 'q' enters in it with some velocity. The acceleration of the particle will be
a) $\frac{qV}{dm}$ b) $\frac{qd}{Vm}$
c) $\frac{qm}{Vd}$ d) $\frac{q}{dmV}$

32. Four charges Q, q, Q and q are kept at the four corners of a square as shown below. If the net force on charge q is zero, then the value ratio $\frac{q}{Q}$ is
a) $-2\sqrt{2}$ b) $-\frac{1}{2\sqrt{2}}$
c) $-\sqrt{2}$ d) $-\frac{1}{\sqrt{2}}$

33. Dimensions of mass in electric field dipole moment are respectively
a) 0, 0 b) 1, 1
c) 0, 1 d) 1, 0

34. Two particles of charges $q_1 = +8q$ and $q_2 = -2q$ placed as shown in figure. At what point away from $q_2$ on the X-axis, can a proton be placed, so that it is in equilibrium?




a) x = 2 L b) x = 2.5 L
c) x = 3.0 L d) x = 3.2 L

35. An infinite number of charges, each of charge 1μ C are placed on the X-axis with coordinates x = 1, 2, 4, 8,……∞. If a charge of 1 C is kept at the origin, then what is the net force acting on 1C charge?
a) 9000 N b) 12000 N
c) 24000 N d) 36000 N

36. Equal charges q are placed at the four corners A, B, C and D of a square of length a . The magnitude of the force on the charge at B will be
a) $\frac{3q^2}{4\pi\varepsilon_o a^2}$ b) $\frac{q^2}{4\pi\varepsilon_o a^2}$

c) $\left(\frac{1+2\sqrt{2}}{2}\right)\frac{q^2}{4\pi\varepsilon_o a^2}$ d) $\left(2+\frac{1}{\sqrt{2}}\right)\frac{q^2}{4\pi\varepsilon_o a^2}$

37. A charge of magnitude '2e' and mass '4m' is moving in an electric field $\vec{E}$. The acceleration imparted to the above charge is
a) $\frac{2m}{3Ee}$ b) $\frac{Ee}{2m}$
c) $\frac{2Ee}{3m}$ d) $\frac{3m}{2Ee}$

38. Two point charges each having charge 'q' μC are kept n such a way that the distance between them is 'r' m and force experienced by them is 'F' newton. They are moved so that the force becomes $\left(\frac{F}{4}\right)$ N, then the distance between them is
a) 4r b) r
c) 2r d) 3r

39. A charge Q is enclosed by a Gaussian surface of radius R. If the radius is doubled then the outward electric flux will
a) Remain the same b) Be reduced to half
c) Increase four times d) Be doubled

40. The ratio of electrostatic and gravitational forces acting between electron and proton separated by a distance $5\times 10^{-11}$ m, will be (Take, charge on electron= $16\times 10^{-19}$ C, mass of electron = $9.1\times 10^{-31}$ kg, mass of proton = $1.6\times 10^{-27}$ kg and G = $6.7\times 10^{-11}$ N-m²/kg²)
a) $2.36\times 10^{39}$ b) $2.36\times 10^{40}$
c) $2.34\times 10^{41}$ d) $2.34\times 10^{42}$

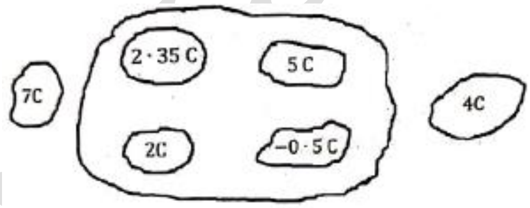
41. An electric field over a certain region is given by $\hat{E} = 2E_0\hat{i} + 3E_0\hat{j} - 5E_0\hat{k}$, where $E_0 = 100\,\frac{N}{C}$. A rectangular surface of area 0.2 m² is kept in this region parallel to y-axis. The flux passing through this surface is
a) $40\,\frac{Nm^2}{C}$ b) $80\,\frac{Nm^2}{C}$
c) $60\,\frac{Nm^2}{C}$ d) $20\,\frac{Nm^2}{C}$

42. A charge Q μC is placed at the centre of a cube. If $\epsilon_0$ is the permittivity of vacuum then the flux through one face and two opposite faces of the cube is respectively.
a) $\frac{Q}{6\,\epsilon_0}, \frac{Q}{3\,\epsilon_0}$ b) $\frac{Q}{3\,\epsilon_0}, \frac{Q}{2\,\epsilon_0}$
c) $\frac{Q}{12\,\epsilon_0}, \frac{Q}{6\,\epsilon_0}$ d) $\frac{Q}{\epsilon_0}, \frac{Q}{2\,\epsilon_0}$

43. Two small identical metal balls are equally charged and placed at a fixed distance away from each other. They experience the electrostatic force 'F'. A similar uncharged ball after touching one of them is placed at the middle point between the two balls. The force experienced by this ball is
a) 2F b) F
c) $\frac{F}{2}$ d) 4F

44. The electric field in the space between the plates of a discharge tube is $3.25\times 10^{4}$ NC$^{-1}$ . If mass of proton is $1.67\times 10^{-27}$ kg and its charge is $1.67\times 10^{-19}$ C, the force on the proton in the field is
a) $10.4\times 10^{-15}$ N b) $2.0\times 10^{-23}$ N
c) $5.40\times 10^{-15}$ N d) $5.20\times 10^{-15}$ N

45. The electric flux linked with the closed surface in $Nm^2C^{-1}$ is
($\epsilon_0 = 8.85\times 10^{-12}C^2N^{-1}m^{-2}$)




a) $8.85\times 10^{-13}$ b) $10^{10}$
c) $10^{11}$ d) $10^{12}$

46. A particle of mass 'm' and charge 'q' is placed at rest in a uniform electric field 'E' and then released. The momentum gained by the particle after moving a distance 's' will be
a) $2\sqrt{mEqs}$ b) $\sqrt{2Eqs}$
c) $\sqrt{\frac{2Eqs}{m}}$ d) $\sqrt{2mEqs}$

47. There are two charged identical metal sphere A and B repel each other with a force $3\times 10^{-5}$ N. Another identical uncharged sphere C is touched with A and then placed at the mid-point between A and B. Net force on C is
a) $1\times 10^{-5}$ N b) $2\times 10^{-5}$ N
c) $1.5\times 10^{-5}$ N d) $3\times 10^{-5}$ N

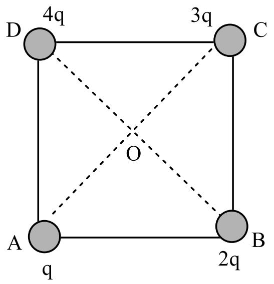
48. A charge of magnitude 3e and mass 2m is moving in an electric field $\vec{E}$. The acceleration imparted to the charge is
a) $\frac{2Ee}{3m}$ b) $\frac{3m}{2Ee}$
c) $\frac{2m}{3Ee}$ d) $\frac{3Ee}{2m}$

49. A small particle carrying negative charge of $1.6\times 10^{-19}$C is suspended in equilibrium between two horizontal metal plates 10 mm apart having a potential difference of 490 volt

across them. The mass of the particle will be $[g = 9.8 \text{ ms}^{-2}]$

a) $16 \times 10^{-15}$ kg
b) $8 \times 10^{-16}$ kg
c) $4 \times 10^{-16}$ kg
d) $30 \times 10^{-15}$ kg

50. Charges q, 2q, 3q and 4q are placed at the corners A, B, C and D of a square as shown in the figure. The direction of electric field at the center of the square is along

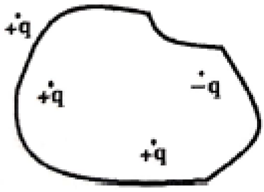



a) AB
b) CB
c) BD
d) AC

51. Figure shows the electric field lines around three point charges A, B and C. Which charge has the largest magnitude?

a) Charge A
b) Charge B
c) Charge A and B
d) Charge C

52. The total electric flux due to all charges shown in figure is




a) Zero
b) $+\frac{3q}{\varepsilon_0}$
c) $+\frac{2q}{\varepsilon_0}$
d) $+\frac{q}{\varepsilon_0}$

53. A uniform electric field of intensity 400 N/C, exists in a certain region. How much flux will cross a given area of 10 $\text{cm}^2$ in this region, if the area vector is inclined at $60^0$ to the direction of the field?

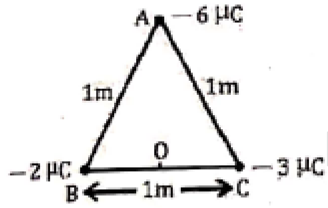
a) 0.1 $\text{Nm}^2/\text{C}$
b) 0.2 $\text{Nm}^2/\text{C}$
c) 0.5 $\text{Nm}^2/\text{C}$
d) 2 $\text{Nm}^2/\text{C}$

54. Two spherical conductors B and C having equal radii and carrying equal charges in them repel each other with a force F, when kept apart at same distance. A third spherical conductor having same radius as that of B but uncharged is brought in contact with B, then brought in contact with C and finally removed away from both. The new force of repulsion between B and C is

a) F/4
b) 3F/4
c) F/8
d) 3F/8

55. ABC is an equilateral triangle of side 1 m. Charges are placed at its corners as shown in figure. 'O' is the midpoint of side BC. The potential at point 'O' is

$$\left(\frac{1}{4\pi \epsilon_0} = 9 \times 10^9 \text{ SI unit}\right)\left(\sin 60^0 = \frac{\sqrt{3}}{2}\right)$$




a) $1.52 \times 10^5$ V
b) $1.3 \times 10^3$ V
c) $-1.52 \times 10^5$ V
d) $2.7 \times 10^3$ V

56. Two equally charged small balls placed at a fixed distance experiences a force F. A similar uncharged ball after touching one of them is placed at the middle point between the two balls. The force experienced by this ball is

a) $\frac{F}{2}$
b) F
c) 2 F
d) 4 F

57. Three equal charges are placed on the three corners of a square. If the force between $q_1$ and $q_2$ is $F_{12}$ and that between $q_1$ and $q_3$ is $F_{13}$, then the ratio of magnitudes $(F_{12}/F_{13})$ is

a) 1/2
b) 2
c) $1/\sqrt{2}$
d) $\sqrt{2}$

58. 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

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) $\frac{Q}{2}(1 + 2\sqrt{2})$

59. Two point charges placed at a certain distance r in air exert a force F on each other. then the distance r' at which these charges will exert the same force in a medium of dielectric constant K is given by

a) r
b) r / K
c) r / $\sqrt{K}$
d) r $\sqrt{K}$

60. Two point charges +3μ C and +8μ C repel each other with a force of 40 N. If a charge of -5 μ C is added to each of them, then force between them will become

a) - 10 N
b) 10 N
c) 20 N
d) - 20 N

61. Two spheres carrying charges +6μ C and +9μ

C separated by a distance d, experiences a force of repulsion F . When a charge of -3μ C is given to both the spheres and kept at the same distance as before, the new force of repulsion is

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

c) $\frac{F}{9}$ d) 3F

62. Two electrons are separated by a distance of 1 A. what is the Coulomb force between them?

a) $2.3\times 10^{-8}$ N b) $4.6\times 10^{-8}$ N

c) $1.5\times 10^{-8}$ N d) None of the above

63. An electron of mass '$m_e$' and a proton of mass '$m_p$' are kept in a uniform electric field. The ratio of the acceleration of electron ($a_e$) to the acceleration of proton ($a_p$) is

a) $\frac{m_p}{m_e}$ b) $\frac{m_e}{m_p}$

c) Infinity d) One

64. An electron experience a force equal to its weight, when placed in an electric field. The intensity of the field will be

a) $1.7\times 10^{-11}$ N/C b) $5.0\times 10^{-11}$ N/C

c) $5.5\times 10^{-11}$ N/C d) 56 N/C

65. An electron and a proton are freely placed in an electric field. If '$a_p$' and '$a_e$' are the accelerations produced in them respectively, by the electric field, then

a) $a_p > a_e$ b) $a_p = a_e$

c) $a_p > a_e$ d) $\frac{a_p}{a_e} = 0$

66. The electrostatic force of repulsion between two positively charged ions carrying equal charge is $3.7\times 10^{-9}$ N, when they are separated by a distance of 5 A. How much electrons are missing from each ion?

a) 10 b) 8

c) 2 d) 1

67. Two small conducting spheres of equal radii have charge + 10μ C and -20μ C respectively and placed at a distance of R from each other experience a force $F_1$. If they are brought in contact and placed at the same distance, they experience the force $F_2$. The ratio $F_1 : F_2$ is

a) 1 : 2 b) -8 : 1

c) 8 : 1 d) -2 : 1

68. The electric field at a point is

a) always continuous b) continuous, if there is no charge at that point

c) continuous, if there is a charge at that point d) None of the above

69. Charge $q_1 = +6.0$ nC is on Y-axis at y = + 3 cm and charge $q_2 = -6.0$ nC is on Y-axis at y = -3 cm. Calculate force on a test charge $q_o = 2$ nC placed on X-axis at x = 4 cm.

a) -51.8 j μ N b) + 51.8 j μ N

c) -5. 18 j μ N d) 5. 18 j μ N

70. When a piece of polythene is rubbed with wool, a negative charge of $4\times 10^{-7}$ C is developed on the polythene. The number of electrons transferred from wool to polythene is [$e = 1.6\times 10^{-19}$ C]

a) $1.5\times 10^{12}$ b) $3.5\times 10^{13}$

c) $2.5\times 10^{13}$ d) $2.5\times 10^{12}$

71. Two point charges $+q_1$ and $+q_2$ repel each other with a force of 100 N. Keeping the distance between them unchanged, if $q_1$ is increased by 10% and $q_2$ is decreased by 10%, the force of repulsion between them will

a) Decrease by 10 N b) Increase by 10 N

c) Decrease by 1 N d) Remain same

72. In hydrogen atom an electron revolves around a proton (in nucleus) at a distance 'r' m. The intensity of electric field due to the proton at distance 'r' is $5\times 10^{11}$ $NC^{-1}$, the magnitude of force between the electron and proton is [charge on electron= $1.6\times 10^{-19}$ C]

a) $4\times 10^{8}$Nv b) $8\times 10^{8}$N

c) $4\times 10^{-8}$N d) $8\times 10^{-8}$N

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## : ANSWER KEY :

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1) | b | 2) | b | 3) | b | 4) | c | 41) | c | 42) | a | 43) | b | 44) | d |
| 5) | a | 6) | d | 7) | d | 8) | c | 45) | d | 46) | d | 47) | c | 48) | d |
| 9) | d | 10) | b | 11) | c | 12) | c | 49) | b | 50) | b | 51) | d | 52) | d |
| 13) | c | 14) | a | 15) | a | 16) | b | 53) | b | 54) | d | 55) | a | 56) | b |
| 17) | c | 18) | d | 19) | d | 20) | d | 57) | b | 58) | b | 59) | c | 60) | a |
| 21) | a | 22) | c | 23) | a | 24) | d | 61) | a | 62) | a | 63) | a | 64) | c |
| 25) | b | 26) | a | 27) | d | 28) | d | 65) | a | 66) | c | 67) | b | 68) | b |
| 29) | c | 30) | b | 31) | a | 32) | a | 69) | a | 70) | d | 71) | c | 72) | d |
| 33) | d | 34) | a | 35) | b | 36) | c | | | | | | | | |
| 37) | b | 38) | c | 39) | a | 40) | a | | | | | | | | |

# N.B.Navale

**Date** : 28.03.2025
**Time** : 01:04:48
**Marks** : 72

**TEST ID: 43**
**PHYSICS**

ELECTROSTATICS

## : HINTS AND SOLUTIONS :

**Single Correct Answer Type**

1 **(b)**

For equilibrium, net force on $q = 0$

$$\therefore \frac{kQQ}{(2x)^2} + \frac{kqQ}{x^2} = 0$$

$$Q \longleftarrow x \overset{q}{\longrightarrow\longleftarrow} x \longrightarrow Q$$

$$\therefore q = -Q/4$$

2 **(b)**

Force on charged particle in a uniform electric field,

$$F = ma = Eq$$

Or

$$a = \frac{Eq}{m}$$

From the equation of motion, we have

$$v^2 = u^2 + 2as = 0 + 2 \times \frac{Eq}{m} \times y = \frac{2Eqy}{m}$$

Now, kinetic energy of the particle,

$$KE = \frac{1}{2}mv^2$$

$$= \frac{m}{2} \times \frac{2Eqy}{m} = Eqy$$

3 **(b)**

Angle between two forces due to individual charge is equal to 60°.

$$\therefore R = \sqrt{F^2 + F^2 + 2FF\cos 60^\circ} = F\sqrt{3}$$

4 **(c)**

Let $E_A$ = electric field at $M$ due to charge placed at $A$. $E_B$ = electric field at $M$ due to charge placed at $B$ and $E_C$ = electric field at $M$ due to charge placed at $C$.

As seen from the figure $|E_B| = |E_C|$, so that net electric field at $M$, $E_{\text{net}} = E_A$ in the direction of vector 2 .

5 **(a)**

Force between both charges,

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

and centripetal force, $F = mr\omega^2$

$$\therefore \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} = mr\omega^2 = \frac{4\pi^2 mr}{T^2}$$

$$\Rightarrow T^2 = \frac{(4\pi\varepsilon_0)r^2(4\pi^2 mr)}{q_1 q_2}$$

$$T = \left[\frac{4\pi^2 mr^3}{kq_1 q_2}\right]^{\frac{1}{2}}$$

$$\left(\because \frac{1}{k} = 4\pi\varepsilon_0\right)$$

6 **(d)**

Electric field lines do not form closed loop, as field lines can never start and end on the same charge. So, the option D is incorrect.

7 **(d)**

$$\mathrm{F} = \mathrm{qE} = 1.6 \times 10^{-19} \times 5 \times 10^{11}$$

$$= 8 \times 10^{-8}\ \mathrm{N}$$

8 **(c)**

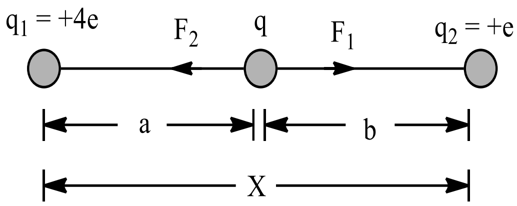
Total flux radiated $= \dfrac{Q}{\varepsilon_0}$

$\therefore$ from one side $\dfrac{Q}{6\varepsilon_0}$

from two opposite sides $\dfrac{Q}{3\varepsilon_0}$

9 **(d)**

For equilibrium of charge $q$, forces on charge $q$ due to charges $q_1$ and $q_2$ should be equal.




$\therefore F_2 = \dfrac{1}{4\pi\varepsilon_0} \cdot \dfrac{(4e)(q)}{a^2}$

and $F_1 = \dfrac{1}{4\pi\varepsilon_0} \cdot \dfrac{(e)(q)}{b^2}$

Also $x = a + b \Rightarrow b = x - a$

$\therefore \dfrac{1}{4\pi\varepsilon_0}\dfrac{(4e)(q)}{a^2} = \dfrac{1}{4\pi\varepsilon_0} \cdot \dfrac{(e)q}{(x-a)^2}$

or

$\dfrac{4}{a^2} = \dfrac{1}{(x-a)^2}$

$\therefore \frac{2}{a} = \frac{1}{x-a}$ or $2x - 2a = a$

$a = \dfrac{2x}{3} \Rightarrow b = x/3$

10 **(b)**

$\mathrm{F} = \dfrac{1}{4\pi\varepsilon_0} \cdot \dfrac{\mathrm{q}^2}{\mathrm{r}^2}$

$\therefore \dfrac{\mathrm{F}_2}{\mathrm{F}_1} = \left(\dfrac{\mathrm{r}_1}{\mathrm{r}_2}\right)^2 = (2)^2 = 4$

$\therefore \mathrm{F}_2 = 4\mathrm{F}_1$

11 **(c)**

Force on the electron $\mathrm{F} = \mathrm{qE}$

Work done by the force $\mathrm{W} = \mathrm{qEL}$

Work done is equal to gain in kinetic energy

$\therefore \dfrac{1}{2}\mathrm{mv}^2 = \mathrm{qEL}$

$\therefore \mathrm{v} = \sqrt{\dfrac{2\mathrm{qEL}}{\mathrm{m}}}$

12 **(c)**

Force of repulsion between the charge,

$F = \dfrac{kqq}{d^2} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{qq}{d^2}$

Since, $q = ne$ (where, $n$ is the number of electrons missing from each ion)

$\therefore F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{n^2e^2}{d^2}$

$\Rightarrow n = \sqrt{\dfrac{4\pi\varepsilon_0 F d^2}{e^2}}$

13 **(c)**

$= \dfrac{\mathrm{eV}_1}{\mathrm{d}}$

$2\mathrm{F}_1 = \dfrac{\mathrm{eV}_2}{\mathrm{d}}$

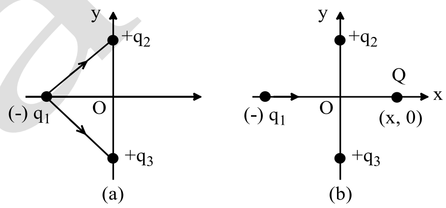
$\dfrac{\mathrm{V}_1}{\mathrm{V}_2} = \dfrac{1}{2}$

14 **(a)**

Charge, $q = ne = 10^{14} \times 1.6 \times 10^{-19} = 16\mu\mathrm{C}$

15 **(a)**

As, $q_2, q_3$ are positive charges and net force on $q_1$ is along $+x$-direction, therefore $q_1$ must be negative as shown in figure.




When a positive charge $Q$ is added at $(x, 0)$, it will attract $(-q_1)$ along $+x$-direction as shown in Fig. (b). Therefore force on $q_1$ will increase along the positive $X$-axis.

16 **(b)**

Force, $F = k\frac{q_1q_2}{r^2}$

$\Rightarrow 12 = k\frac{2\times 6}{r^2}$ ....(i)

A charge of $-4C$ is given to each of these charges

$\therefore q_1 = -2\mathrm{C}$ and $q_2 = 2\mathrm{C}$

and $F' = k\frac{(+2)(-2)}{r^2}$ .....(ii)

On dividing Eq. (ii) by Eq. (i), we get

$\dfrac{F'}{12} = \dfrac{-4}{12}$

$F' = 4N$ (attractive)

17 **(c)**

The force acting on the electron is

$F = qE$

If it moves through a distance x, then work done

$W = Fx = qEx$

It is equal to gain in kinetic energy

$\therefore \frac{1}{2}mv^2 = qEx$

$\therefore v = \left(\frac{2Eqx}{m}\right)^{1/2}$

18 **(d)**
1 electron has a charge of $1.6 \times 10^{-19}$C. $10^{10}$ electrons would have a charge of

$q = ne = 1.6 \times 10^{-19} \times 10^{10} = 1.6 \times 10^{-9}$C

Thus, in 1 s, charge accumulated $= 1.6 \times 10^{-9}$C

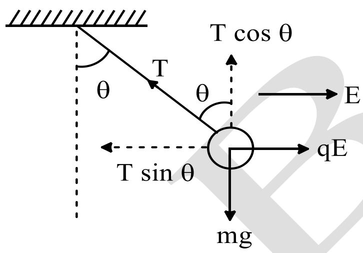
So, time taken to accumulate 1C

$= \frac{1}{1.6 \times 10^{-9}} = 0.625 \times 10^9$

$= 6.25 \times 10^8$ s $= 173611$ h

$= 7233.8$ days $= 19.8$yr $\simeq 20$yr

19 **(d)**
Forces on the bob are as shown




For equilibrium, $T\cos\theta = mg$

and $T\sin\theta = qE$

On dividing Eq. (ii) by Eq. (i), we get

$\tan\theta = \frac{qE}{mg}$

Here, $q = 5\mu C = 5 \times 10^{-6}$C,

$E = 2000\frac{V}{m}$

$m = 2$ g $= 2 \times 10^{-3}$ kg,

$g = 10$ ms$^{-2}$

$\therefore \tan\theta = \frac{5 \times 10^{-6} \times 2000}{2 \times 10^{-3} \times 10} = \frac{1}{2} = 0.5$

So, the angle made by the string of the pendulum with the vertical,

$\theta = \tan^{-1}(0.5)$

20 **(d)**
If same charges on spheres $A$ and $B$ are $q$,

Force, $F = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2} = 3 \times 10^{-5}$ N

Charge on $A$ and $C$ after touching, $q_A' = q_C = \frac{q}{2}$

$\therefore$ Net force on $C$,

$F = F_A + F_B$

$F = \frac{1}{4\pi\varepsilon_0}\frac{(q/2)(q/2)}{(r/2)^2} - \frac{1}{4\pi\varepsilon_0}\frac{(q/2) \times q}{(r/2)^2}$

$= \frac{1}{4\pi\varepsilon_0 r}\frac{q^2}{r^2} - 2\frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2} = -\left(\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r^2}\right)$

$= -3 \times 10^{-5}$ N

$\Rightarrow |F| = 3 \times 10^{-5}$ N

21 **(a)**
Force $F = qE = \frac{qV}{d}$ $\left[\because E = \frac{V}{d}\right]$

Acceleration $a = \frac{F}{m} = \frac{qV}{md}$

22 **(c)**
Net charge on one H-atom

$q = -e + (e + \Delta e) = \Delta e$

Net electrostatic repulsive force between two H-atoms,

$F_r = \frac{kq^2}{d^2} = \frac{k(\Delta e)^2}{d^2}$

where, $q$ = charge on H-atom $= \Delta\theta$ and $d$ = distance between H-atom.
Similarly, net gravitational attractive force between two H-atoms,

$F_G = \frac{Gm_n^2}{d^2}$

where, $m_h$ = mass of H-atom and $G$ = gravitational constant.

It is given that, $F_f - F_G = 0$

$$\Rightarrow \frac{k(\Delta e)^2}{d^2} - \frac{Gm_n^2}{d^2} = 0$$

$$\Rightarrow (\Delta e)^2 = \frac{Gm_h^2}{k}$$

$$(\Delta e)^2 = \frac{(6.67 \times 10^{-11})(1.67 \times 10^{-27})^2}{9 \times 10^9}$$

$(\because G = 6.67 \times 10^{-11} \mathrm{Nkg^{-2}\ m^2}, m_h = 167 \times 10^{-27}\ \mathrm{kg}$

and $k = 9 \times 10^9\ \mathrm{N - m^2C^{-2}}$)

$$\Rightarrow \Delta e = 1.437 \times 10^{-37}\mathrm{C}$$

$\therefore$ So, the order of $\Delta e$ is $10^{-37}$C.

23 **(a)**
$F = qE = 1.6 \times 10^{-19} \times 3.25 \times 10^4$

$= 5.2 \times 10^{-15}$ N

24 **(d)**
Given, $q = -3 \times 10^{-7}$C

Number of electrons transferred to the conductor,

$$n = \frac{q}{e} = \frac{-3 \times 10^{-7}\mathrm{C}}{-1.6 \times 10^{-19}\mathrm{C}} = 2 \times 10^{12}$$

Mass of one electron, $m_e = 9.1 \times 10^{-31}$ kg

Mass increase of the conductor $= m_e \times n$

$= 9.1 \times 10^{-31} \times 2 \times 10^{12}$

$= 18.2 \times 10^{-19}$ kg

$= 1.82 \times 10^{-18}$ kg

$= 2 \times 10^{-18}$ kg

25 **(b)**
Given,

From the property of quantisation charge, $q = ne$

Number of electrons, $n = \frac{q}{e} = \frac{1\times10^{-9}}{1.6\times10^{-19}}$

$= 0.625 \times 10^{-9} \times 10^{19}$

$= 0.625 \times 10^{10} = 6.25 \times 10^9$

26 **(a)**
Redistribution of charges takes place.

Charge $q_1 = 3\mu C$ and Charge $q_2 = 8\mu C$

When third charge $q_3 = -5\mu C$ is added to each, then new charges on $q_1$ and $q_2$ will be

$q_1 = 3 - 5 = -2\mu C$

and $q_2 = 8 - 5 = 3\mu C$

Now,

$$\text{Case I: } 40 = \frac{1}{4\pi\varepsilon_0} . \frac{3 \times 8}{r^2}$$

$$\text{Case II: } F = \frac{1}{4\pi\varepsilon_0} \times \frac{(-2 \times 3)}{r^2}$$

$$\therefore \frac{F}{40} = -\frac{2 \times 3}{3 \times 8} \Longrightarrow F = -10\ \mathrm{N}$$

27 **(d)**
$$F = \frac{1}{4\pi\varepsilon_0} . \frac{q^2}{d^2} = \frac{1}{4\pi\varepsilon_0} . \frac{(ne)^2}{d^2} = \frac{1}{4\pi\varepsilon_0} . \frac{n^2q^2}{d^2}$$

$$\therefore n = \sqrt{\frac{4\pi\varepsilon_0 F d^2}{e^2}}$$

28 **(d)**
$$F = \frac{1}{4\pi\varepsilon_0} . \frac{q_1q_2}{l^2}, F' = \frac{1}{4\pi\varepsilon_0} . \frac{2q_1q_2}{\left(\frac{l}{2}\right)^2} = 8F$$

29 **(c)**
Force on the electron $F = qE$

Work done by the force $W = qEL$

Work done is equal to gain in kinetic energy

$$\therefore \frac{1}{2}mv^2 = qEL$$

$$\therefore v = \sqrt{\frac{2qEL}{m}}$$

30 **(b)**
The electric field lines pass through an insulator.

31 **(a)**
Electric field between the plates

$$E = \frac{V}{d}$$

Force on charge q: $F = qE = \frac{qV}{d}$

Acceleration a: $a = \frac{F}{m} = \frac{qV}{dm}$

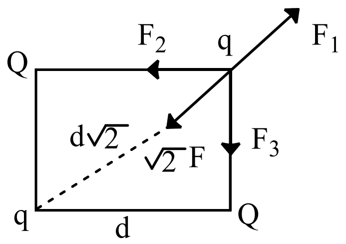
32 **(a)**

Here, both the $q$ will have same sign either positive or negative. Similarly, both the $Q$ will have same sign. Let us make the force on upper right corner $q$ equal to zero.
Lower $q$ will apply a repelling force $F_1$ on upper $q$ because both the charges have same sign. To balance this force both $Q$ must apply attractive forces $F_2$ and $F_3$ of equal magnitude, hence $Q$ and $q$ will have opposite signs. Now, the resultant of $F_2$ and $F_3$ will be $F\sqrt{2}$ (Parallelogram law of vector addition), if $|F_2| = |F_3| = F$. Also note that $F\sqrt{2}$ will be exactly opposite to $F_1$.

So,

$F_1 = F\sqrt{2}$

From Coulomb's law,




$$F_1 = \frac{kq^2}{(d\sqrt{2})^2}$$

and

$$F = \frac{kQq}{d^2}$$

$\because F_1 = \sqrt{2}F$

$$\therefore \frac{q^2}{(d\sqrt{2})^2} = \frac{\sqrt{2}Qq}{d^2}$$

$$\therefore Q = \frac{q}{2\sqrt{2}}$$

But as we said $Q$ and $q$ have opposite sign, so $q = -2\sqrt{2}Q$

$$\therefore \frac{q}{Q} = -2\sqrt{2}$$

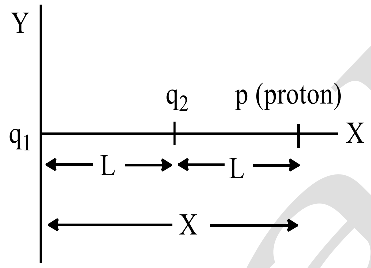
33 **(d)**

Electric field $E = \frac{F}{q} = \frac{M^1L^1T^{-2}}{IT} = M^1L^1T^{-3}I^{-1}$

Electric dipole moment $p = qL = I^1T^1L^1M^0$

34 **(a)**

The given situation is shown below




Proton is placed at point $P$ at a distance $x$ from $q_1$.

Charge on proton, $q_p = e$

At equilibrium, net force on proton = 0

i.e. $k \cdot \frac{q_1 q_p}{x^2} + \frac{k q_2 q_p}{(x-L)^2} = 0$

$$\Rightarrow \frac{q_1}{x^2} + \frac{q_2}{(x-L)^2} = 0$$

$$\Rightarrow \frac{4}{x^2} = \frac{1}{(x-L)^2}$$

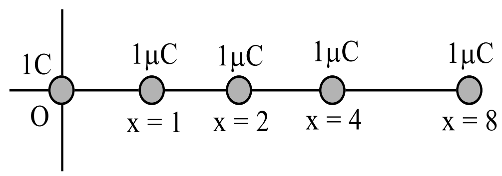
$$\Rightarrow \frac{2}{x} = \frac{1}{x-L}$$

$$\Rightarrow x = 2x - 2L$$

$$\Rightarrow x = 2L$$

35 **(b)**

The schematic diagram of distribution of charges on $X$-axis is shown in figure below.




Total force acting on 1C charge is given by

$$F = \frac{1}{4\pi\varepsilon_0}\left[\frac{1 \times 1 \times 10^{-6}}{(1)^2} + \frac{1 \times 1 \times 10^{-6}}{(2)^2} + \frac{1 \times 1 \times 10^{-6}}{(4)^2} + \frac{1 \times 1 \times 10^{-6}}{(8)^2} + \cdots \infty\right]$$

$$= \frac{10^{-6}}{4\pi\varepsilon_0}\left(\frac{1}{1}+\frac{1}{4}+\frac{1}{16}+\frac{1}{64}+\cdots\infty\right)$$

$$= \frac{10^{-6}}{4\pi\varepsilon_0}\left(\frac{1}{1}+\frac{1}{4}+\frac{1}{16}+\frac{1}{64}+\cdots\infty\right)$$

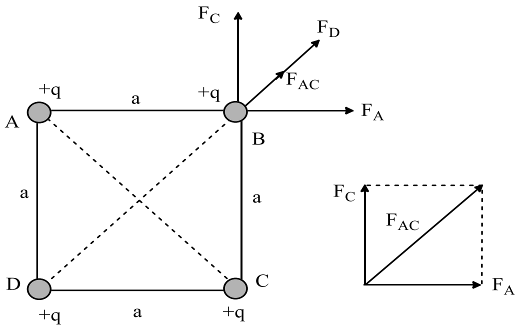
$$= 9\times 10^9 \times 10^{-6}\left(\frac{1}{1-(1/4)}\right)$$

$$= 9\times 10^9 \times 10^{-6}\times\frac{4}{3}$$

$$= 9\times\frac{4}{3}\times 10^3 = 12000 \text{ N}$$

36 **(c)**

The given situation is shown below




Here, $F_A = \frac{1}{4\pi\varepsilon_0} + \frac{q^2}{a^2}$

$$\Rightarrow\ F_C = \frac{1}{4\pi\varepsilon_0} + \frac{q^2}{a^2}$$

Net force on $B$,

$$F_{\text{net}} = F_{AC} + F_D$$

$$= \sqrt{F_A^2 + F_C^2 + F_D}$$

$$= \sqrt{\left\{\left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a^2}\right)^2 + \left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a^2}\right)^2\right\} + \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{(a\sqrt{2})^2}}$$

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{a^2}\left(\sqrt{2}+\frac{1}{2}\right)$$

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{a^2}\left(\frac{1+2\sqrt{2}}{2}\right)$$

37 **(b)**

Force,

$$\text{F} = \text{charge} \times \text{Electric field} = 2\text{eE}$$

$$\text{Acceleration} = \frac{\text{Force}}{\text{Mass}} = \frac{2\text{eE}}{4\text{m}} = \frac{\text{eE}}{2\text{m}}$$

38 **(c)**

$$\text{F} = \frac{1}{4\pi\,\epsilon_0}\cdot\frac{\text{q}^2}{\text{r}^2}$$

$$\Longrightarrow \text{F}' = \frac{\text{F}}{4} = \frac{1}{4\pi\,\epsilon_0}\cdot\frac{\text{q}^2}{\text{r}^2}$$

$$\therefore \frac{1}{4}\times\frac{1}{4\pi\,\epsilon_0}\cdot\frac{\text{q}^2}{\text{r}^2} = \frac{1}{4\pi\,\epsilon_0}\cdot\frac{\text{q}^2}{\text{r}'^2}$$

$$\therefore 4\text{r}^2 = \text{r}'^2$$

$$\Longrightarrow\therefore 2\text{r} = \text{r}'$$

39 **(a)**

Electric flux

$$= \frac{\text{Q}}{\epsilon_0}$$

Since charge remains same, the electric flux remains same.

40 **(a)**

Gravitational force,

$$F_G = \frac{Gm_e m_p}{r^2}$$

$$F_G = \frac{6.7\times 10^{-11}\times 9.1\times 10^{-31}\times 1.6\times 10^{-27}}{(5\times 10^{-11})^2}$$

$$= 3.9\times 10^{-47}\text{ N}$$

Electrostatic force,

$$F_e = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$$

$$F_\theta = \frac{9\times 10^9\times 1.6\times 10^{-19}\times 1.6\times 10^{-19}}{(5\times 10^{-11})^2}$$

$$= 9.22\times 10^{-8}\text{ N}$$

So, $\frac{F_\theta}{F_G} = \frac{9.22\times 10^{-8}}{3.9\times 10^{-47}} = 2.36\times 10^{39}$

41 **(c)**

$\vec{\text{E}} = 2\text{E}_0\hat{\imath} + 3\text{E}_0\hat{\jmath} - 5\text{E}_0\hat{\text{k}}, \text{E}_0 = 100\text{ N/C}$

Area vector is taken parallel to Y-axis then

$$\vec{\text{A}} = 0.2\,\hat{\jmath}\text{m}^2$$

$$\text{Flux } \phi = \vec{\text{E}}.\vec{\text{A}}$$

$$= (2\text{E}_0\hat{\imath} + 3\text{E}_0\hat{\jmath} - 5\text{E}_0\hat{\text{k}}).(0.2\hat{\jmath})$$

$$= 0.6\text{E}_0$$

$= 0.6 \times 100$

$= 60\ \mathrm{Nm^2/C}$

42 **(a)**

Flux passing through all the six faces of the cube

$\phi = \dfrac{q}{\epsilon_0}$

Hence flux through one face

$= \dfrac{\phi}{6} = \dfrac{q}{6\ \epsilon_0}$

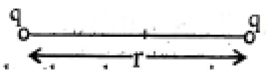
Flux through two faces

$= \dfrac{2q}{6\ \epsilon_0} = \dfrac{q}{3\ \epsilon_0}$

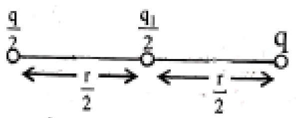
43 **(b)**

In the first case:

$F = K\dfrac{q^2}{r^2}\ \left(K = \dfrac{1}{4\pi\ \epsilon_0}\right)$




When unchanged ball is touched to one or the balls, the charge q is equally shaved by them. Hence each has charge $\frac{q}{2}$



The forces on the middle sphere due the two spheres are opposite in direction. The resultant force in given by

$F' = K\dfrac{q.\frac{q}{2}}{\left(\frac{r}{2}\right)^2} = K\dfrac{\frac{q}{2}.\frac{q}{2}}{\left(\frac{r}{2}\right)^2} = K\left(\dfrac{2q^2}{r^2} - \dfrac{q^2}{r^2}\right)$

$= K\dfrac{q^2}{r^2} = F$

44 **(d)**

As, the force on the proton,

$F\ = qE = 1.6 \times 10^{-19} \times 3.25 \times 10^4$

$= 5.20 \times 10^{-15}\ \mathrm{N}$

45 **(d)**

Electric flux $\phi = \dfrac{q}{\epsilon_0}$

Net change $q = 2.35 + 5 + 2 - 0.5 = 8.85\ \mathrm{C}$

$\therefore \phi = \dfrac{8.85}{8.85 \times 10^{-12}} = 10^{12}\mathrm{Vm}$

46 **(d)**

Force on the particle, $F = qE$

Acceleration $a = \dfrac{F}{m} = \dfrac{qE}{m}$

$v^2 = 2as = 2\dfrac{qE}{m}s$

$\therefore v = \sqrt{\dfrac{2Eqs}{m}}$

Momentum $mv = \sqrt{\dfrac{2Eqs}{m}}.m = \sqrt{2mEqs}$

47 **(c)**

If the charge on spheres $A$ and $B$ is $q$,

Force, $F = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2} = 3 \times 10^{-5}\ \mathrm{N}$

Charge on $A$ and $C$ after touching, $q'_A = q_C = \frac{q}{2}$

$\therefore$ Net force on $C, F = F_A + F_B$

$\therefore\ F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{\left(\frac{q}{2}\right)\left(\frac{q}{2}\right)}{(r/2)^2} - \dfrac{1}{4\pi\varepsilon_0}\dfrac{\left(\frac{q}{2}\right) \times q}{(r/2)^2}$

$= \left(\dfrac{1}{4\pi\varepsilon_0 r}\right)\dfrac{q^2}{r^2} - \dfrac{1}{2}\left(\dfrac{1}{4\pi\varepsilon_0}\right)\dfrac{q^2}{r^2} = \dfrac{1}{2}\left(\dfrac{1}{4\pi\varepsilon_0}\cdot\dfrac{q^2}{r^2}\right)$

$= \dfrac{3 \times 10^{-5}}{2}\ \mathrm{N} = 1.5 \times 10^{-5}\ \mathrm{N}$

48 **(d)**

Force $F = 3eE$

Acceleration $= \dfrac{\text{Force}}{\text{mass}} = \dfrac{3eE}{2m}$

49 **(b)**

$q = -1.6 \times 10^{-19}\mathrm{C}, d = 10\ \mathrm{mm} = 10^{-2}\ \mathrm{m}$

$V = 490\ \mathrm{V}, g = 9.8\dfrac{m}{s^2}$

Magnitude of the force due to the electric field

$F = qE = \frac{qV}{d}$

This should be equal to the weight of the particle

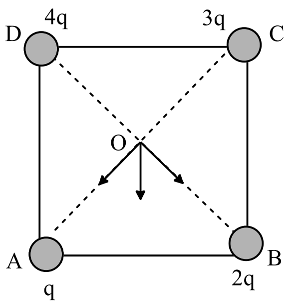
$\therefore mg = \frac{qV}{d}$

$\therefore m = \frac{qV}{gd} = \frac{1.6 \times 10^{-19} \times 490}{9.8 \times 10^{-2}}$

$= 8 \times 10^{-16}$ kg

50 **(b)**

Charges at $A$ and $C$ produce net electric field along $OA($ as $q_C > q_A)$. Similarly, charges at $B$ and $D$ produce net electric field along $OB$ (as $q_D > q_B$ ). The direction of the fields is as shown in the figure below




So, the net electric field will be along bisector of angle $AOB$ which parallel to $CB$.

51 **(d)**

Charge $C$ has the largest magnitude, since maximum number of field lines are associated with it.

52 **(d)**

Total charge enclosed by the surface is $(-q + q - q) = +q$

Hence electric flux $= +\frac{q}{\varepsilon_0}$

(According to Gauss's Theorem)

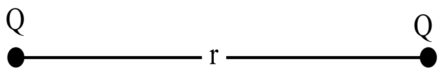
53 **(b)**

$\phi = \vec{E}.\vec{A} = EA\cos\theta$

$= 400 \times 10 \times 10^{-4} \times \frac{1}{2} = 0.2\ Nm^2/C$

54 **(d)**

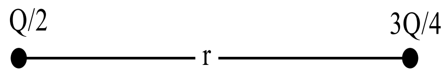
Initially force, $F = k\frac{Q^2}{r^2}$




Finally when a third spherical conductor comes in contact alternately with $B$ and $C$ then removed,

so charge on $B = \frac{0+Q}{2} = \frac{Q}{2}$

Charge on $C = \frac{Q+Q/2}{2} = \frac{3Q}{4}$




New force, $F' = k\frac{\left(\frac{Q}{2}\right)\left(\frac{3Q}{4}\right)}{r^2} = \frac{3}{8}F$

55 **(a)**

$AO = AB\sin 60^0 = 1 \times \frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{2}$ m

$BO = CO = 0.5$ m

Potential at O is given by

$V = \frac{1}{4\pi \in_0}\left(\frac{q_1}{AB} + \frac{q_2}{CO} + \frac{q_3}{BO}\right)$

$= 9 \times 10^9\left(\frac{-6 \times 10^{-6} \times 2}{\sqrt{3}} - \frac{3 \times 10^{-6}}{0.5} - \frac{2 \times 10^{-6}}{0.5}\right)$

$= 9 \times 10^9 \times 10^{-6}(4\sqrt{3} - 6 - 4)$

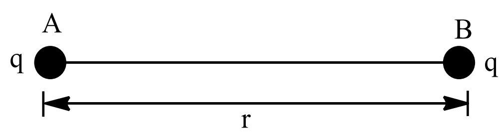
$\Rightarrow = -9 \times 10^3(6.928 + 10)$

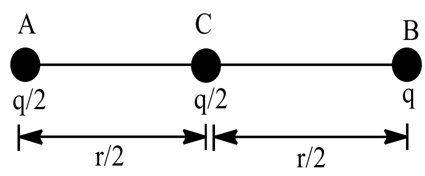
$= -9 \times 10^3 \times 16.928$

$\Rightarrow = -152 \times 10^3 = -1.52 \times 10^5$ V

56 **(b)**

Initially, $F_{AB} = F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q \cdot q}{r^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{r^2}$




Finally, force on $C, F_C = F_{BC} - F_{CA}$

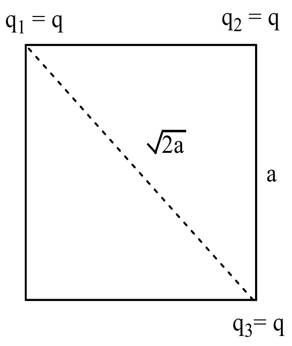
$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{\left(\frac{q}{2}\right)(q)}{\left(\frac{r}{2}\right)^2} - \frac{1}{4\pi\varepsilon_0} \cdot \frac{\left(\frac{q}{2}\right)\left(\frac{q}{2}\right)}{\left(\frac{r}{2}\right)^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{r^2}$

$\Rightarrow F_C = F_{AB} = F$

57 **(b)**

The given situation is shown below.

Force, $F_{12} = \frac{k(q^2)}{a^2}$




$q_1 = q \; a \; q_2 = q$

$\sqrt{2}a$

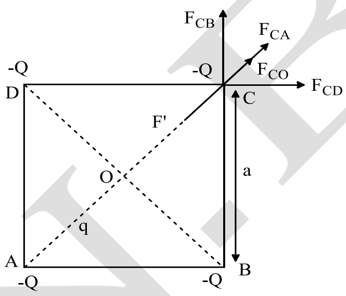
$a$ Force,

$$F_{13} = \frac{k(q^2)}{(\sqrt{2}a)^2} = \frac{kq^2}{2a^2}$$

$\therefore$ Ratio, $\frac{F_{12}}{F_{13}} = \frac{2}{1}$

58 **(b)**

The system is in equilibrium which means that the net force experienced by each charge is zero, i.e. total horizontal and vertical components of forces are separately zero.




At point $C$,

$$F_{CD} + F_{CA}\cos 45° + F_{CO}\cos 45° = 0$$

$$\Rightarrow \frac{1}{4\pi\varepsilon_0}\cdot\frac{(-Q)(-Q)}{a^2} + \frac{1}{4\pi\varepsilon_0}\frac{(-Q)(-Q)}{(\sqrt{2}a)^2} + \frac{1}{\sqrt{2}}$$

$$+ \frac{1}{4\pi\varepsilon_0}\frac{(-Q)q}{(\sqrt{2}a/2)^2} \times \frac{1}{\sqrt{2}} = 0$$

$$\Rightarrow Q + \frac{Q}{2\sqrt{2}} - \sqrt{2q} = 0$$

$$\Rightarrow 2\sqrt{2}Q + Q - 4q = 0$$

$$\Rightarrow q = \frac{Q}{4}(2\sqrt{2}+1)$$

59 **(c)**

Force exerted between two point charges in air,

$$F\frac{q_1q_2}{4\pi\varepsilon_0 r^2}$$

So, force exerted between two point charges in a medium of dielectric constant $K$,

$F' = \frac{q_1q_2}{4\pi\varepsilon_0 K(r')^2}$ where, $r'$ is the distance.

Given, $F = F'$

$$\Rightarrow \frac{q_1q_2}{4\pi\varepsilon_0 r^2} = \frac{q_1q_2}{4\pi\varepsilon_0 K(r')^2}$$

$$\Rightarrow \frac{1}{r^2} = \frac{1}{K(r')^2}$$

$$\Rightarrow r^2 = K(r')^2$$

$$\Rightarrow r = \sqrt{K}r'$$

$$\therefore r' = \frac{r}{\sqrt{K}}$$

60 **(a)**

Initially, charge, $q_1 = 3\mu$C and charge, $q_2 = 8\mu$C When third charge $q_3 = -5\mu$C is added to each, then new charges on $q_1$ and $q_2$ will be

$$q_1' = 3 - 5 = -2\mu C$$

and $q_2' = 8 - 5 = 3\mu$C

Now,

Case I $40 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{3\times8}{r^2}$ $\left(\because F = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{r^2}\right)$

Case II $F = \frac{1}{4\pi\varepsilon_0}\times\frac{(-2\times3)}{r^2}$

$$\therefore \frac{F}{40} = \frac{-2\times3}{3\times8}$$

$$\Rightarrow F = -10 \text{ N}$$

61 **(a)**

When two spheres separated by a distance $d$, experience a force of repulsion $F$, such that

$q_1 = 6\mu$C and $q_2 = 9\mu$C

$F = \frac{k \times 6 \times 9}{d^2}$ ......(i)

When charge $-3\mu C$ is given to both spheres, the new charges on the sphere are

$q_1 = +6\mu\text{C} - 3\mu\text{C} = 3\mu\text{C}$

$q_2 = 9\mu\text{C} - 3\mu\text{C} = 6\mu\text{C}$

New force,

$F' = \frac{k \times 3 \times 6}{d^2}$ ......(ii)

On dividing Eq. (ii) by Eq. (i), we get

$$\frac{F'}{F} = \frac{1}{3} \Rightarrow F' = \frac{1}{3}F$$

62 **(a)**
Using the relation, $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$

Here,
$q_1 = q_2 = 16 \times 10^{-19}\text{C}$,
$r = 1A = 10^{-10}$ m

So, force between the electrons,

$$F = \frac{9 \times 10^9 \times (16 \times 10^{-19})^2}{(10^{-10})^2}$$

$= 2.3 \times 10^{-8}$ N

63 **(a)**
Force on electron = Force on proton= Ee

Acceleration of electron $a_e = \frac{Ee}{m_e}$

Acceleration of electron $a_p = \frac{Ee}{m_p}$

$$\therefore \frac{a_e}{a_p} = \frac{m_p}{m_e}$$

64 **(c)**
Force acting on electron, F = qE
$\Longrightarrow E = \frac{F}{q} = \frac{mg}{e} = \frac{9 \times 10^{-31} \times 9.8}{1.6 \times 10^{-19}}$
$\Longrightarrow E = 5.5 \times 10^{-11}\ \text{NC}^{-1}$

65 **(a)**
$F = qE = eE$

$a_p = \frac{F}{m_p}, q_e = \frac{F}{m_e}$

$\therefore m_p > m_e, a_p < a_e$

66 **(c)**
Here, $F = 3.7 \times 10^{-9}$ N

Let $q_1 = q_2 = q \Rightarrow r = 5\text{Å} = 5 \times 10^{-10}$ m

$\because$ The force between two positively charged particles,

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

$\Rightarrow 3.7 \times 10^{-9}$

$$= 9 \times 10^9 \times \frac{q \times q}{(5 \times 10^{-10})^2}$$

or $q^2 = \frac{3.7 \times 10^{-9} \times 25 \times 10^{-20}}{9 \times 10^9} = 10.28 \times 10^{-38}$

Charge, $q = 3.2 \times 10^{-19}$C

Now, $q = ne \Rightarrow n = \frac{q}{e} = \frac{3.2 \times 10^{-19}}{1.6 \times 10^{-19}} = 2$

67 **(b)**
Here, $F_1 = \frac{k(+10)(-20)}{R^2} = \frac{-k \times 200}{R^2}$ ......... (i)

As, spheres are of equal radii, so their capacities are also same.

$\therefore$ On touching, the net charge $= (10 - 20)\mu\text{C} = -10\mu\text{C}$, is shared equally between them, i.e. each sphere carries - $5\mu$ Charge.

$$F_2 = \frac{k(-5)(-5)}{R^2}$$

$F_2 = \frac{k \times 25}{R^2}$ ........(ii)

On dividing Eq. (i) by Eq. (ii), we get

$$\frac{F_1}{F_2} = \frac{-8}{1} \Rightarrow F_1 : F_2 = -8 : 1$$

68 **(b)**
The electric field due to a charge $Q$ at a point in space may be defined as the force that a unit positive charge would experience, if placed at that point.

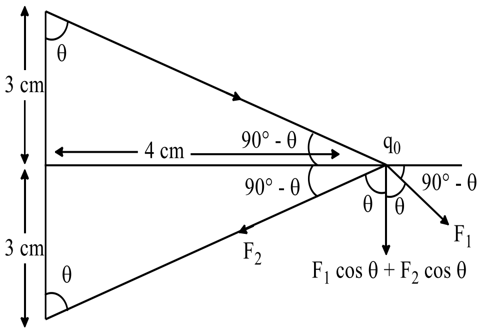
Thus, electric field due to the charge $Q$ will be continuous, if there is no charge at that point.

It will be discontinuous, if there is a charge at that point.

69 **(a)**

Here, $q = |q_1| = |q_2| = 6.0\text{nC} = 6.0 \times 10^{-9}\text{C}$

$2a = 6 \text{ cm} = 6 \times 10^{-2} \text{ m}$




$d = 4$ cm (on equatorial line)

$= 4 \times 10^{-2}$ m

$\therefore\ r = \sqrt{3^2 + 4^2} = 5$ cm

$= 5 \times 10^{-2}$ m

and

$q_0 = 2\text{nC} = 2 \times 10^{-9}\text{C}. F = ?$

$F = F_1 \cos\theta + F_2 \cos\theta$

$= 2 \times \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_0}{r^2} \cos\theta$

$= 2 \times 9 \times 10^9 \times \frac{6 \times 10^{-9} \times 2 \times 10^{-9}}{(5 \times 10^{-2})^2} \times \frac{3}{5}$

or $F = 5.18 \times 10^{-5}$ N $= 51.8\mu$N

Clearly, this force is along **-ĵ**.

So, $F = -51.8\hat{j}\mu$N

70 **(d)**

$q = 4 \times 10^{-7}$

$q = Ne$

$N = \frac{q}{e} = \frac{4 \times 10^{-7}}{1.6 \times 10^{-19}} = 2.5 \times 10^{12}$

71 **(c)**

$F_1 = \frac{1}{4\pi \in_0} . \frac{q_1 q_2}{r^2} = 100$ N

$F_2 = \frac{1}{4\pi \in_0} . \frac{1.1q_1 \times 0.9q_2}{r_2} = \frac{0.99}{4\pi \in_0} . \frac{q_1 q_2}{r^2}$

$= 0.99 \times 100 = 99$ N

$\therefore F_1 - F_2 = 1$ N

72 **(d)**

$F = qE = 1.6 \times 10^{-19} \times 5 \times 10^{11}$

$= 8 \times 10^{-8}$N