→ Electric field & Potential 1
→ Gauss law 2
→ Capacitors 3

14 ELECTROSTATICS

→ Electric current 4

Dhruv Jha

Only one Option is Correct

E1

1. The minimum electrostatic force between two charged particles placed at a distance of 1 m is :
(a) 2.3×10^{-28} N
(b) 6.2×10^{-34} N
(c) 1.02×10^{-26} N
(d) 4.2×10^{-27} N

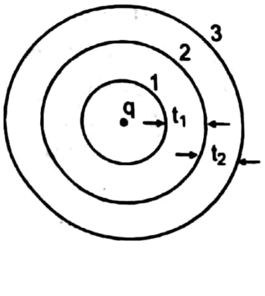
2. Electric field on the axis of a small electric dipole at a distance r is $\vec{E}_1$ and $\vec{E}_2$ at a distance of $2r$ on a line of perpendicular bisector. Then : M1
(a) $\vec{E}_2 = -\vec{E}_1/8$
(b) $\vec{E}_2 = -\vec{E}_1/16$
(c) $\vec{E}_2 = -\vec{E}_1/4$
(d) $\vec{E}_2 = \vec{E}_1/8$

3. Three point charges q, $-2q$ and $-2q$ are placed at the vertices of an equilateral triangle of side a. The work done by some external force to increase their separation to $2a$ will be : M1
(a) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{2q^2}{a}$
(b) negative
(c) zero
(d) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{3q^2}{a}$

4. A point charge q is placed inside a conducting spherical shell of inner radius $2R$ and outer radius $3R$ at a distance of R from the centre of the shell. The electric potential at the centre of shell will be $\frac{1}{4\pi\varepsilon_0}$ times : M2
(a) $\frac{q}{2R}$
(b) $\frac{4q}{3R}$
(c) $\frac{5q}{6R}$
(d) $\frac{2q}{3R}$

5. The potential field of an electric field $\vec{E} = (y\,\hat{i} + x\,\hat{j})$ is : E1
(a) $V = -xy$ + constant
(b) $V = -(x+y)$ + constant
(c) $V = -(x^2+y^2)$ + constant
(d) V = constant

6. Figure shows three spherical and equipotential surfaces 1, 2 and 3 round a point charge q. The potential difference $V_1 - V_2 = V_2 - V_3$. If t_1 and t_2 be the distance between them. Then :

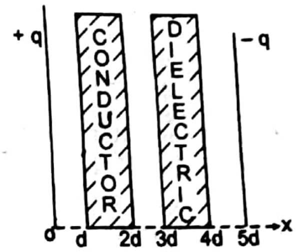


(a) $t_1 = t_2$
(b) $t_1 > t_2$
(c) $t_1 < t_2$
(d) $t_1 \le t_2$

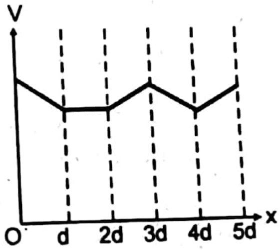
M2

M3

7. The distance between plates of a parallel plate capacitor is $5d$. The positively charged plate is at $x = 0$ and negatively charged plate is at $x = 5d$. Two slabs one of conductor and the other of a dielectric of same thickness d are inserted between the plates as shown in figure. Potential (V) versus distance x graph will be :

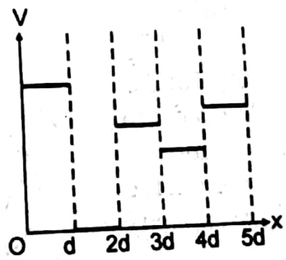


(a)

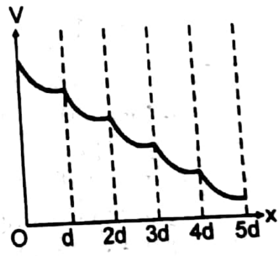


(b)

(c)



(d)



8. A point charge q is placed at a distance of r from the centre of an uncharged conducting sphere of radius R $(< r)$. The potential at any point on the sphere is : M1
(a) zero
(b) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}$
(c) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{qR}{r^2}$
(d) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{qr^2}{R}$

9. An electric field is given by $\vec{E} = (y\,\hat{i} + x\,\hat{j})$ N/C. The work done in moving a 1C charge from $\vec{r}_A = (2\hat{i} + 2\hat{j})\,m$ to $\vec{r}_B = (4\hat{i} + \hat{j})\,m$ is : E1
(a) + 4 J
(b) − 4 J
(c) + 8 J
(d) zero

10. Capacity of a spherical capacitor is C_1 when inner sphere is charged and outer sphere is earthed and C_2 when inner

M3

sphere is earthed and outer sphere is charged. Then $\frac{C_1}{C_2}$ is :

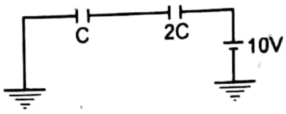
(a = radius of inner sphere, b = radius of outer sphere)

(a) 1 (b) $\frac{a}{b}$

(c) $\frac{b}{a}$ (d) $\frac{a+b}{a-b}$

11. In the circuit shown in figure $C = 6\,\mu F$. The charge stored in capacitor of capacity C is :

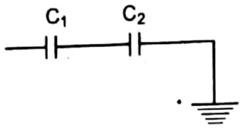
3E



(a) zero (b) $90\,\mu C$
(c) $40\,\mu C$ (d) $60\,\mu C$

12. A capacitor of capacity $C_1 = 1\mu$ F is charged to a potential of 100 V. The charging battery is then removed and it is connected to another capacitor of capacity $C_2 = 2\mu F$. One plate of C_2 is earthed as shown in figure. The charges on C_1 and C_2 in steady state will be :

M3



(a) $50\,\mu C$, $50\,\mu C$ (b) $100\,\mu C$, zero
(c) $\frac{100}{3}\,\mu C$, $\frac{200}{3}\,\mu C$ (d) zero, zero

13. Capacity of an isolated sphere is increased n times when it is enclosed by an earthed concentric sphere. The ratio of their radii is :

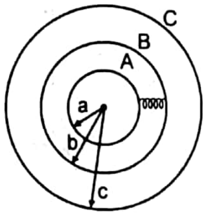
M3

(a) $\frac{n^2}{n-1}$ (b) $\frac{n}{n-1}$

(c) $\frac{2n}{n+1}$ (d) $\frac{2n+1}{n+1}$

14. Three conducting spheres A, B and C are as shown in figure. The radii of the spheres are a, b and c respectively. A and B are connected by a conducting wire. The capacity of the system is :

(M, (1,3))



(a) $4\pi\varepsilon_0(a+b+c)$ (b) $4\pi\varepsilon_0\left(\frac{bc}{c-b}\right)$

(c) $4\pi\varepsilon_0\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}\right)$ (d) $4\pi\varepsilon_0\left(\frac{abc}{ab+bc+ca}\right)$

15. Capacitance of a capacitor becomes $\frac{4}{3}$ times its original value if a dielectric slab of thickness $t = d/2$ is inserted between the plates (d = separation between the plates). The dielectric constant of the slab is :

M3

(a) 2 (b) 4
(c) 6 (d) 8

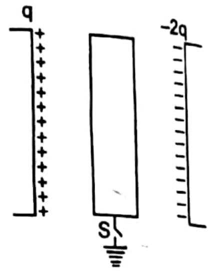
16. The plates of a parallel plate capacitor are charged upto 100 V. A 2 mm thick insulator sheet is inserted between the plates. Then to maintain the same potential difference, the distance between the capacitor plates is increased by 1.6 mm. The dielectric constant of the insulator is :

M3

(a) 6 (b) 8
(c) 5 (d) 4

17. The metal plate on the left in figure carries a charge $+q$. The metal plate on the right has a charge of $-2q$. What charge will flow through S from ground when it is closed, if central plate is initially neutral :

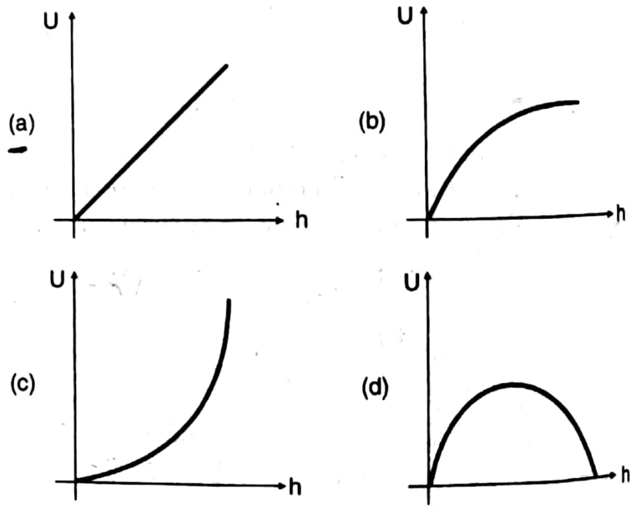
M3



(a) zero
(b) $-q$
(c) $+q$
(d) $+2q$

18. A particle of mass m and charge q is projected vertically upwards. A uniform electric field $\vec{E}$ is acted vertically downwards. The most appropriate graph between potential energy U (gravitational plus electrostatic) and height h ($<<$ radius of earth) is : (assume U to be zero on surface of earth)

E1



19. A capacitor is connected to a battery. The force of attraction between the plates when the separation between them is halved :

M3

(a) remains the same
(b) becomes eight times
(c) becomes four times
(d) becomes two times

20. A number of spherical conductors of different radii have same potential. Then the surface charge density on them :
(a) is proportional to their radii
(b) is inversely proportional to their radii 1E
(c) are equal
(d) is proportional to square of their radii

21. Three charged particles are initially in position 1. They are free to move and they come in position 2 after some time. Let U_1 and U_2 be the electrostatic potential energies in position 1 and 2. Then : 1E
(a) $U_1 > U_2$ (b) $U_2 > U_1$
(c) $U_1 = U_2$ (d) $U_2 \geq U_1$

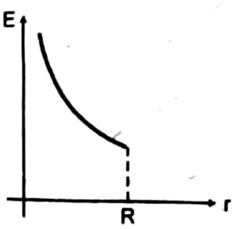
22. A conducting sphere of radius R is charged to a potential of V volts. Then the electric field at a distance r (> R) from the centre of the sphere would be : M1
(a) $\frac{V}{r}$ (b) $\frac{R^2 V}{r^3}$ (c) $\frac{R V}{r^2}$ (d) $\frac{r V}{R^2}$

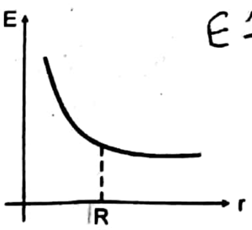
23. A spherical charged conductor has surface charged density σ. The electric field on its surface is E and electric potential of conductor is V. Now the radius of the sphere is halved keeping the charge to be constant. The new values of electric field and potential would be : M1
(a) $2E$, 2 V (b) $4E$, 2 V
(c) $4E$, 4 V (d) $2E$, 4 V

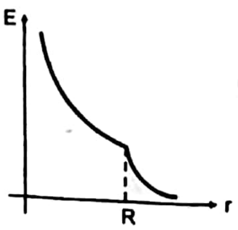
24. In the above problem, radius is halved keeping surface charge density to be constant. Then the new values will be : M1
(a) E, $\frac{V}{2}$ (b) E, 2 V (c) $2E$, V (d) $\frac{E}{2}$, V

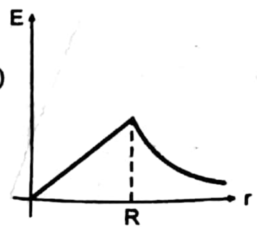
25. Two concentric spherical conducting shells of radii R and $2R$ carry charges Q and $2Q$ respectively. Change in electric potential on the outer shell when both are connected by a conducting wire is : $\left(k = \frac{1}{4\pi\varepsilon_0}\right)$ M1
(a) zero (b) $\frac{3kQ}{2R}$
(c) $\frac{kQ}{R}$ (d) $\frac{2kQ}{R}$

26. A conducting shell of radius R carries charge $-Q$. A point charge $+Q$ is placed at the centre. The electric field E varies with distance r (from the centre of the shell) as : E1

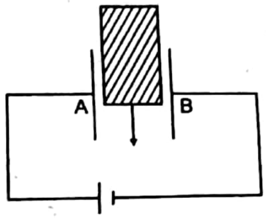
(a)


(b)


(c)


(d)


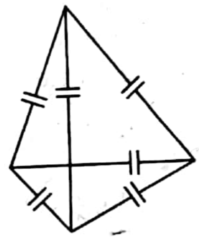
27. An insulator plate is passed between the plates of a capacitor. Then current in outer circuit : 1,3 M



(a) always flows from A to B
(b) always flows from B to A
(c) first flows from A to B and then from B to A
(d) first flows from B to A and then from A to B

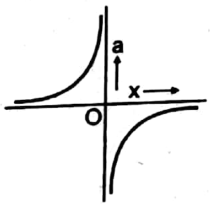
28. The gap between the plates of a parallel plate capacitor is filled with glass of resistivity ρ. The capacitance of the capacitor without glass equals C. The leakage current of the capacitor when a voltage V is applied to it is : 3E
(a) $\frac{V\rho}{C\,\varepsilon_0}$ (b) $\frac{CV}{\rho\,\varepsilon_0}$
(c) $\frac{V\varepsilon_0}{C\rho}$ (d) $\frac{CV\rho}{\varepsilon_0}$

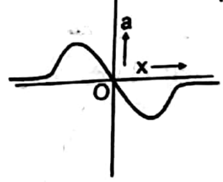
29. If the capacitance of each capacitor is C, then effective capacitance of the shown network across any two junctions is : 3E

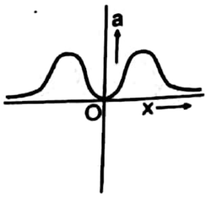


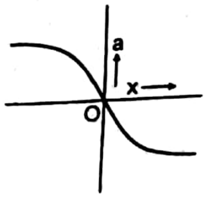
(a) $2C$
(b) C
(c) $\frac{C}{2}$
(d) $5C$

30. Two identical positive charges are fixed on the y-axis, at equal distances from the origin O. A particle with a large negative charge starts on the negative x-axis at a large distance from O, moves along the x-axis, passed through O and moves far away from O. Its acceleration a is taken as positive along its direction of motion. The particle's acceleration a is plotted against its x-co-ordinate. Which of the following best represents the plot? M1

(a)


(b)


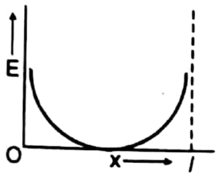
(c)


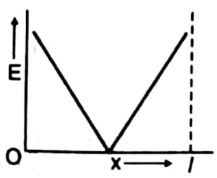
(d)


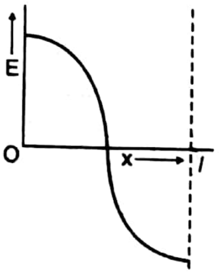
3 ~~E~~ ~~4~~

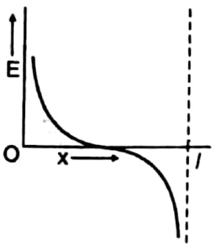
31. Two identical point charges are placed at a separation of l. P is a point on the line joining the charges, at a distance x from any one charge. The field at P is E. E is plotted against x for values of x from close to zero to slightly less than l. Which of the following best represents the resulting curve?

ML

(a) 

(b) 

(c) 

(d) 

32. An air capacitor consists of two parallel plates A and B as shown in the figure. Plate A is given a charge Q and plate B is given a charge $3Q$. P is the median plane of the capacitor. If C_0 is the capacitance of the capacitor, then :

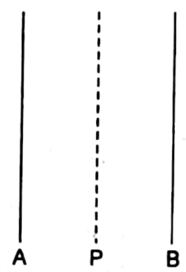
3M

(a) $V_P - V_A = \dfrac{Q}{4C_0}$

(b) $V_P - V_A = \dfrac{Q}{2C_0}$

(c) $V_P - V_A = -\dfrac{Q}{C_0}$

(d) $V_P - V_B = -\dfrac{Q}{4C_0}$



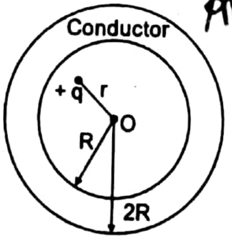
33. A hollow sphere of radius $2R$ is charged to V volts and another smaller sphere of radius R is charged to $V/2$ volts. Now the smaller sphere is placed inside the bigger sphere without changing the net charge on each sphere. The potential difference between the two spheres would be :

2M

(a) $\dfrac{3V}{2}$ (b) $\dfrac{V}{4}$ (c) $\dfrac{V}{2}$ (d) V

34. A point charge q is placed at a distance r from the centre O of a uncharged spherical shell of inner radius R and outer radius $2R$. The distance $r < R$. The electric potential at the centre of the shell will be :

2M

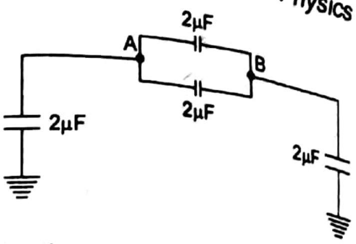


(a) $\dfrac{q}{4\pi\varepsilon_0}\left(\dfrac{1}{r} - \dfrac{1}{2R}\right)$ (b) $\dfrac{q}{4\pi\varepsilon_0 r}$

(c) $\dfrac{q}{4\pi\varepsilon_0}\left(\dfrac{1}{r} + \dfrac{1}{2R}\right)$ (d) none of these

35. Find equivalent capacitance between A and B :

Ans. wrong



(a) $5\,\mu F$
(b) $4\,\mu F$
(c) $3\,\mu F$
(d) $2\,\mu F$

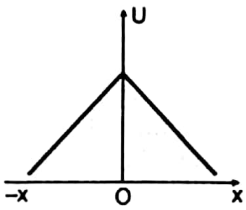
36. A small electric dipole is placed at origin with its dipole moment directed along positive x-axis. The direction of electric field at point $(2, 2\sqrt{2}, 0)$ is :

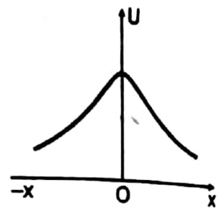
1E

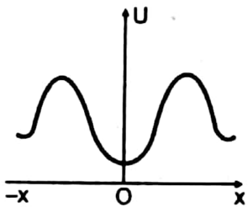
(a) along z-axis (b) along y-axis
(c) along negative y-axis (d) along negative z-axis

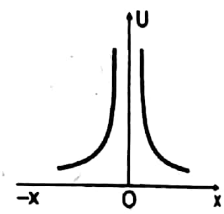
37. Four equal charges of magnitude q each are placed at four corners of a square with its centre at origin and lying in y-z plane. A fifth charge $+Q$ is moved along x-axis. The electrostatic potential energy (U) varies on x-axis as :

1M

(a) 

(b) 

(c) 

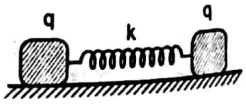
(d) 

38. A solid conducting sphere of radius 10 cm is enclosed by a thin metallic shell of radius 20 cm. A charge $q = 20\mu C$ is given to the inner sphere. Find the heat generated in the process, the inner sphere is connected to the shell by a conducting wire :

2E

(a) 12 J (b) 9 J
(c) 24 J (d) zero

39. Two identical particles of charge q each are connected by a massless spring of force constant k. They are placed over a smooth horizontal surface. They are released when the separation between them is r and spring is unstretched. If maximum extension of the spring is r, the value of k is : (neglect gravitational effect)



Ans. wrong

1M

(a) $\dfrac{q}{4r}\sqrt{\dfrac{1}{\pi\varepsilon_0 r}}$

(b) $\dfrac{q}{2r}\sqrt{\dfrac{1}{\pi\varepsilon_0 r}}$

(c) $\dfrac{2q}{r}\sqrt{\dfrac{1}{\pi\varepsilon_0 r}}$

(d) $\dfrac{q}{r}\sqrt{\dfrac{1}{\pi\varepsilon_0 r}}$

40. Two point charges $2q$ and $8q$ are placed at a distance r apart. Where should a third charge $-q$ be placed between them so that the electrical potential energy of the system is a minimum :

(a) at a distance of $r/3$ from $2q$ 1E
(b) at a distance of $2r/3$ from $2q$
(c) at a distance of $r/16$ from $2q$
(d) none of the above

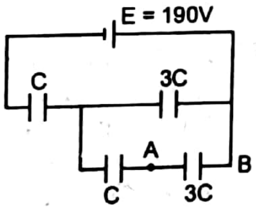
41. A capacitor of capacitance $10\,\mu F$ is charged to a potential 50 V with a battery. The battery is now disconnected and an additional charge $200\,\mu C$ is given to the positive plate of the capacitor. The potential difference across the capacitor will be :

(a) 50 V (b) 80 V 3E
(c) 100 V (d) 60 V

42. A capacitor is filled with an insulator and a certain potential difference is applied to its plates. The energy stored in the capacitor is U. Now the capacitor is disconnected from the source and the insulator is pulled out of the capacitor. The work performed against the forces of electric field in pulling out the insulator is $4U$. Then dielectric constant of the insulator is :

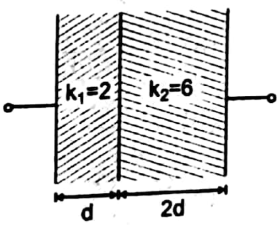
(a) 4 (b) 8 3M
(c) 5 (d) 3

43. In the circuit shown in figure potential difference between A and B is :



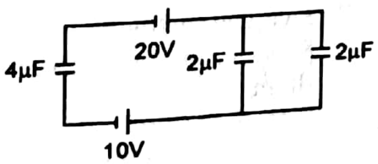
(a) 30 V 3E
(b) 60 V
(c) 10 V
(d) 90 V

44. A parallel plate capacitor has two layers of dielectrics as shown in figure. This capacitor is connected across a battery, then the ratio of potential difference across the dielectric layers is :



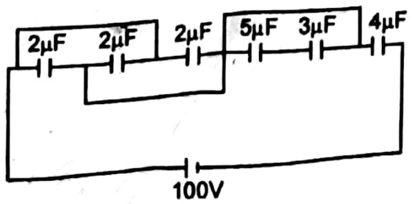
(a) 4/3 3M (b) 1/2
(c) 1/3 (d) 3/2

45. In the circuit shown in figure charge stored in $4\,\mu F$ capacitor is :



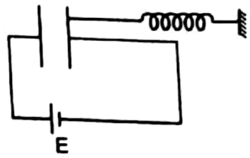
(a) $20\,\mu C$
(b) $40\,\mu C$ 3E
(c) $10\,\mu C$
(d) $120\,\mu C$

46. In the circuit shown in figure charge stored in the capacitor of capacity $5\,\mu F$ is :



(a) $60\,\mu C$
(d) $20\,\mu C$
(c) $30\,\mu C$ 3E
(d) zero

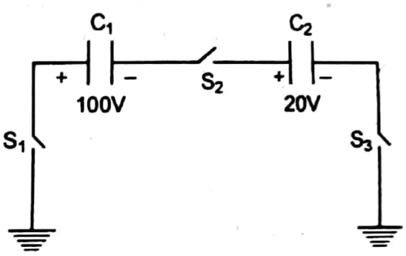
47. One plate of a capacitor is connected to a spring as shown in figure. Area of both the plates is A. In steady state separation between the plates is $0.8\,d$ (spring was unstretched and the distance between the plates was d when the capacitor was uncharged). The force constant of the spring is approximately :



3M

(a) $\dfrac{4\varepsilon_0 AE^2}{d^3}$ (b) $\dfrac{2\varepsilon_0 AE}{d^2}$
(c) $\dfrac{6\varepsilon_0 E^2}{Ad^3}$ (d) $\dfrac{\varepsilon_0 AE^3}{2d^3}$

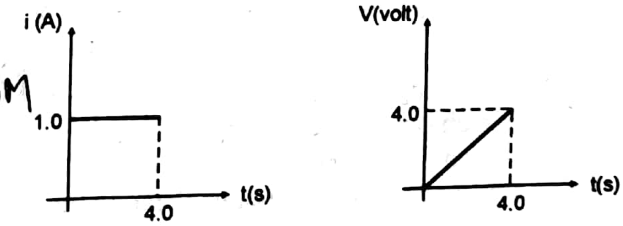
48. In the circuit shown in figure $C_1 = 1\,\mu F$ and $C_2 = 2\,\mu F$. Capacitor C_1 is charged to 100 V and C_2 is charged to 20 V. After charging they are connected as shown. When the switches S_1, S_2 and S_3 all are closed : 3M



(a) no charge will flow through S_2
(b) $80\,\mu C$ charge will flow through S_1
(c) $40\,\mu C$ charge will flow through S_2
(d) $60\,\mu C$ charge will flow through S_3

49. Current *versus* time and voltage *versus* time graph of a circuit element is shown below :

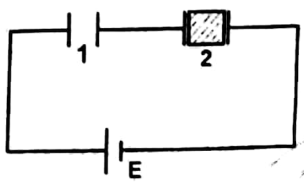
(3,4)M



The type of the circuit element is :

(a) capacitance of 2 F
(b) resistance of 2Ω
(c) capacitance of 1 F
(d) a voltage source of emf 1 V

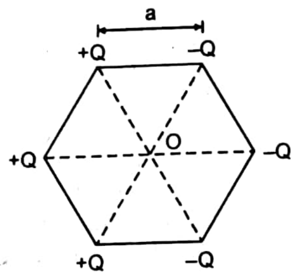
50. Two identical capacitors 1 and 2 are connected in series to a battery as shown in figure. Capacitor 2 contains a dielectric slab of dielectric constant K as shown. Q_1 and Q_2 are the charges stored in the capacitors. Now the dielectric slab is removed and the corresponding charges are Q'_1 and Q'_2. Then : (3,4) M



(a) $\dfrac{Q'_1}{Q_1} = \dfrac{K+1}{K}$ (b) $\dfrac{Q'_2}{Q_2} = \dfrac{K+1}{2}$
(c) $\dfrac{Q'_2}{Q_2} = \dfrac{K+1}{2K}$ (d) $\dfrac{Q'_1}{Q_1} = \dfrac{K}{2}$

1 M

51. Six charges are placed at the vertices of a regular hexagon as shown in the figure. The electric field on the line passing through point O and perpendicular to the plane of the figure at a distance of $x\ (>> a)$ from O is :



(a) $\dfrac{Qa}{\pi\varepsilon_0 x^3}$ (b) $\dfrac{2Qa}{\pi\varepsilon_0 x^3}$

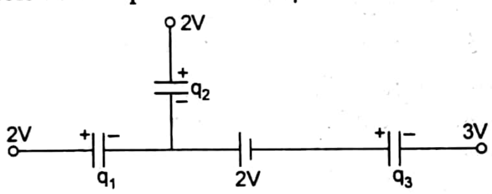
(c) $\dfrac{\sqrt{3}Qa}{\pi\varepsilon_0 x^3}$ (d) zero

52. If an electron enters into a space between the plates of a parallel plate capacitor at an angle α with the plates and leaves at an angle β to the plates. The ratio of its kinetic energy while entering the capacitor to that while leaving will be :

(a) $\left(\dfrac{\cos\alpha}{\cos\beta}\right)^2$ (b) $\left(\dfrac{\cos\beta}{\cos\alpha}\right)^2$ 3 M

(c) $\left(\dfrac{\sin\alpha}{\sin\beta}\right)^2$ (d) $\left(\dfrac{\sin\beta}{\sin\alpha}\right)^2$

53. A part of the circuit is shown in the figure. All the capacitors have capacitance of $2\mu F$:



3 M

(a) Charge on capacitor C_1 is zero
(b) Charge on capacitor C_2 is zero
(c) Charge on capacitor C_3 is zero
(d) Charge on capacitor cannot be determined

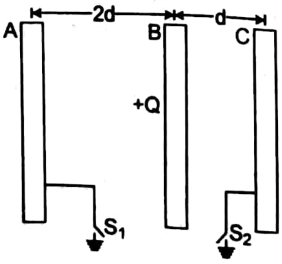
54. A capacitor of capacitance C is charged to a potential difference V from a cell and then disconnected from it. A charge $+Q$ is now given to its positive plate. The potential difference across the capacitor is now :

(a) V (b) $V + \dfrac{Q}{C}$ 3 M

(c) $V + \dfrac{Q}{2C}$ (d) none of these

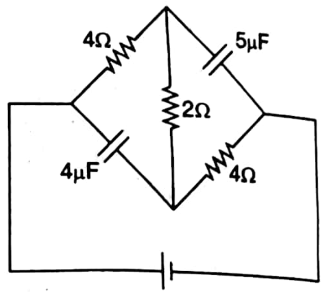
55. Three identical, parallel conducting plates A, B and C are placed as shown. Switches S_1 and S_2 are open, and can connect A and C to earth when closed. $+Q$ charge is given to B, then :

3 M



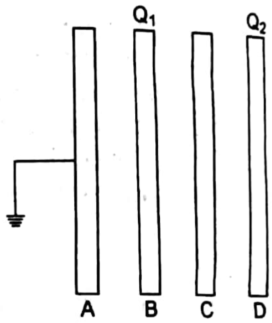
(a) if S_1 is closed with S_2 open, a charge of amount Q will pass through S_1
(b) if S_2 is closed with S_1 open, a charge of amount Q will pass through S_2
(c) if S_1 and S_2 are closed together, a charge of amount $Q/3$ will pass through S_1 and a charge of amount $\dfrac{2Q}{3}$ will pass through S_2
(d) all of the above

56. The ratio between the energy stored in $5\mu F$ capacitor to the $4\mu F$ capacitor in the given circuit is :



(a) 1.2
(b) 1 [3, 4 M]
(c) 1.25
(d) 3.6

57. What will be the charge on earthed side of plate A ?

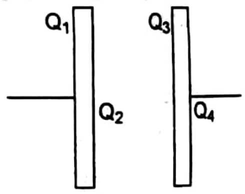


(a) $\dfrac{Q_1+Q_2}{2}$ (3 M)

(b) $\dfrac{Q_1-Q_2}{2}$

(c) zero
(d) none of these

58. In an insulated parallel-plate capacitor of capacitance C, the four surfaces have charge Q_1, Q_2, Q_3 and Q_4, as shown. The potential difference between the plates is :



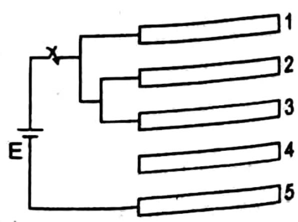
(a) $\dfrac{Q_1+Q_2+Q_3+Q_4}{2C}$

(b) $\dfrac{Q_2+Q_3}{2C}$ (3, 4)

(c) $\dfrac{Q_2-Q_3}{2C}$

(d) $\dfrac{Q_1+Q_4}{2C}$

59. Five conducting plates are placed parallel to each other. Separation between them is d and area of each plate is A. Plate number 1, 2 and 3 are connected with each other and at the same time through a cell of emf E. The charge on plate number 1 is :



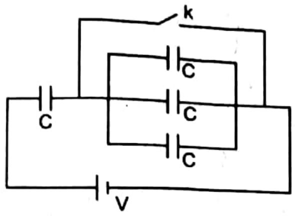
(a) $\dfrac{E\varepsilon_0 A}{d}$ (b) $\dfrac{E\varepsilon_0 A}{2d}$

(c) $\dfrac{2E\varepsilon_0 A}{d}$ (d) zero

(1, M)

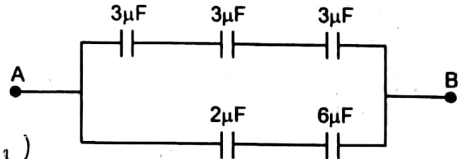
60. The charge flowing through the cell on closing the key k is equal to :
(a) $\frac{CV}{4}$
(b) $4CV$
(c) $\frac{4}{3}CV$
(d) $\frac{3}{4}CV$

(3, M)

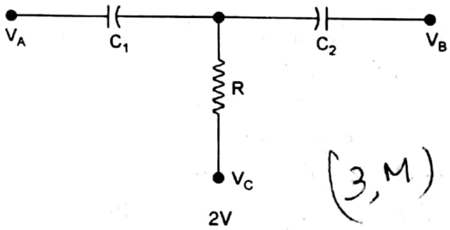


61. In the given arrangement of the capacitors, one $3\,\mu F$ capacitor has got $600\,\mu J$ of energy. Then the potential difference across $2\,\mu F$ capacitor is :
(a) 40 V
(b) 15 V
(c) 60 V
(d) 45 V

(M, 3)



62. For given circuit, charge on capacitor C_1 and C_2 in steady state will be equal to :



(3, M)

(a) $C_1(V_A - V_C), C_2(V_C - V_B)$ respectively
(b) $C_1(V_A - V_B), C_2(V_A - V_B)$ respectively
(c) $(C_1 + C_2)(V_A - V_B)$ on each capacitor
(d) $\left(\frac{C_1C_2}{C_1 + C_2}\right)(V_A - V_B)$ on each capacitor

63. An alpha particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of :
(a) 1 Å
(b) 10^{-10} cm
(c) 10^{-12} cm
(d) 10^{-15} cm

(1, M)

64. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at the centre of the sphere is :
(a) zero
(b) 10 V
(c) same as at a point 5 cm away from the surface
(d) same as at a point 25 cm away from the surface

65. Two equal negative charges $-q$ each are fixed at points $(0,-a)$ and $(0, a)$ on y-axis. A positive charge Q is released from rest at the point $(2a, 0)$ on the the x-axis. The charge Q will :
(a) execute simple harmonic motion about the origin
(b) move to the origin and remain at rest
(c) move to infinity
(d) execute oscillatory but not simple harmonic motion

(1, M)

66. A charge q is placed at the centre of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to :
(a) $-\frac{Q}{2}$
(b) $-\frac{Q}{4}$
(c) $+\frac{Q}{4}$
(d) $+\frac{Q}{2}$

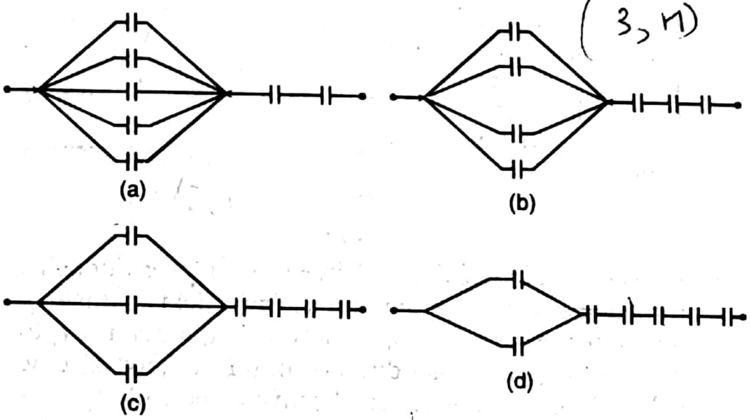
(1, E)

67. A solid conducting sphere having a charge Q is surrounded by an uncharged concentric conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. If the shell is now given a charge of $-3Q$, the new potential difference between the same two surfaces is :
(a) V
(b) $2V$
(c) $4V$
(d) $-2V$

(2, M)

68. Seven capacitors each of capacitance $2\,\mu F$ are connected in a configuration to obtain an effective capacitance $\frac{10}{11}\,\mu F$. Which of the following combination will achieve the desired result ?

(3, M)



69. Two identical thin rings, each of radius R, are coaxially placed a distance R apart. If Q_1 and Q_2 are respectively the charges uniformly spread on the two rings, the work done in moving a charge q from the centre of one ring to that of the other is :
(a) zero
(b) $q(Q_1 - Q_2)(\sqrt{2} - 1)/(\sqrt{2}\, 4\pi\varepsilon_0 R)$
(c) $q\sqrt{2}(Q_1 + Q_2)/(4\pi\varepsilon_0 R)$
(d) $q(Q_1/Q_2)(\sqrt{2} + 1)(\sqrt{2}\, 4\pi\varepsilon_0 R)$

(1, H)

70. Two point charges $+q$ and $-q$ are held fixed at $(-d, 0)$ and $(d, 0)$ respectively of a x-y co-ordinate system. Then :
(a) the electric field E at all points on the x-axis has the same direction
(b) work has to be done in bringing a test charge from ∞ to the origin
(c) electric field at all points on y-axis is along x-axis
(d) the dipole moment is $2qd$ along the positive x-axis

(1, M)

(3, H)

71. A parallel plate capacitor of capacitance C is connected to a battery and is charged to a potential difference V. Another capacitor of capacitance $2C$ is similarly charged to a potential difference $2V$. The charging battery is now disconnected and the capacitors are connected in parallel to each other in such a way that the positive terminal of one is connected to the negative terminal of the other. The final energy of the configuration is :

(a) zero (b) $\frac{3}{2}CV^2$

(c) $\frac{25}{6}CV^2$ (d) $\frac{9}{2}CV^2$

72. The magnitude of electric field $\vec{E}$ in the annular region of a charged cylindrical capacitor : (3, H)

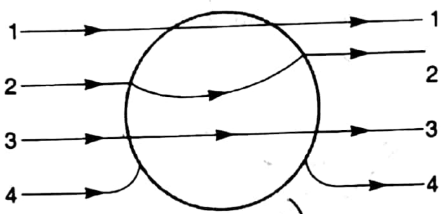
(a) is same throughout

(b) is higher near the outer cylinder than near the inner cylinder

(c) varies as $1/r$ where r is the distance from the axis

(d) varies as $1/r^2$ where r is the distance from the axis

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



(a) 1 (b) 2

(c) 3 (d) 4

(E, 1)

74. An electron of mass m_e, initially at rest, moves through a certain distance in a uniform electric field in time t_1. A proton of mass m_p, also, initially at rest, takes time t_2 to move through an equal distance in this uniform electric field. Neglecting the effect of gravity, the ratio t_2/t_1 is nearly equal to : (M, 1)

(a) 1 (b) $(m_p/m_e)^{1/2}$

(c) $(m_e/m_p)^{1/2}$ (d) 1836

75. A non-conducting ring of radius 0.5 m carries a total charge of 1.11×10^{-10} C distributed non-uniformly on its circumference producing an electric field E everywhere in space. The value of the integral $\int_{l=\infty}^{l=0} -E\,dl$ (1, M)

($l = 0$ being centre of the ring) in volt is :

(a) +2 (b) −1

(c) −2 (d) zero

76. A parallel combination of 0.1 M Ω resistor and a 10 μF capacitor is connected across a 1.5 V source of negligible resistance. The time required for the capacitor to get charged upto 0.75 V is approximately (in second) : (3, H)

(a) ∞ (b) $\log_e 2$

(c) $\log_{10} 2$ (d) zero

77. A charge $+q$ is fixed at each of the points $x = x_0, x = 3x_0, x = 5x_0 \ldots \infty$ on the x-axis and a charge $-q$ is fixed at each of the points $x = 2x_0, x = 4x_0, x = 6x_0 \ldots \infty$. Here, x_0 is a positive constant. Take the electric potential at a point due to a charge Q at a distance r from it to be $Q/4\pi\varepsilon_0 r$. Then the potential at the origin due to the above system of charges is : (1, E)

(a) 0 (b) $\frac{q}{8\pi\varepsilon_0 x_0 \ln 2}$

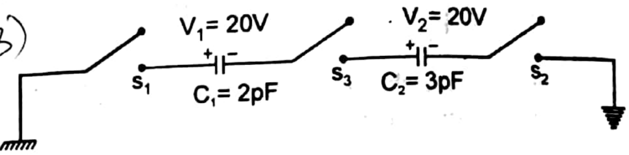
(c) ∞ (d) $\frac{q \ln(2)}{4\pi\varepsilon_0 x_0}$

78. Two identical metal plates are given positive charges Q_1 and Q_2 ($<Q_1$) respectively. If they are now brought close together to form a parallel plate capacitor with capacitance C, the potential difference between them is : (M, 3)

(a) $(Q_1 + Q_2)/2C$ (b) $(Q_1 + Q_2)/C$

(c) $(Q_1 - Q_2)/C$ (d) $(Q_1 - Q_2)/2C$

79. For the circuit shown, which of the following statements is true ? (E, 3)



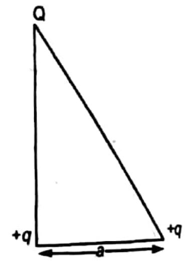
(a) With S_1 closed, $V_1 = 15$ V, $V_2 = 20$ V

(b) With S_3 closed, $V_1 = V_2 = 25$ V

(c) With S_1 and S_2 closed, $V_1 = V_2 = 0$

(d) With S_1 and S_3 closed, $V_1 = 30$ V, $V_2 = 20$ V

80. Three charges Q, $+q$ and $+q$ are placed at the vertices of a right angle triangle (isosceles triangle) as shown. The net electrostatic energy of the configuration is zero, if Q is equal to : (1, M)



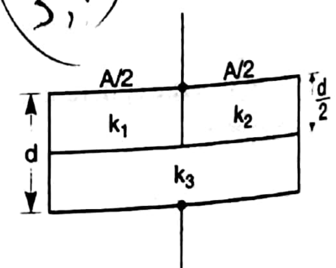
(a) $\frac{-q}{1+\sqrt{2}}$

(b) $\frac{-2q}{2+\sqrt{2}}$

(c) $-2q$

(d) $+q$

81. A parallel plate capacitor of area A, plate separation d and capacitance C is filled with three different dielectric materials having dielectric constants K_1, K_2 and K_3 as shown. If a single dielectric material is to be used to have the same capacitance C in this capacitor then its dielectric constant K is given by : (3, H)

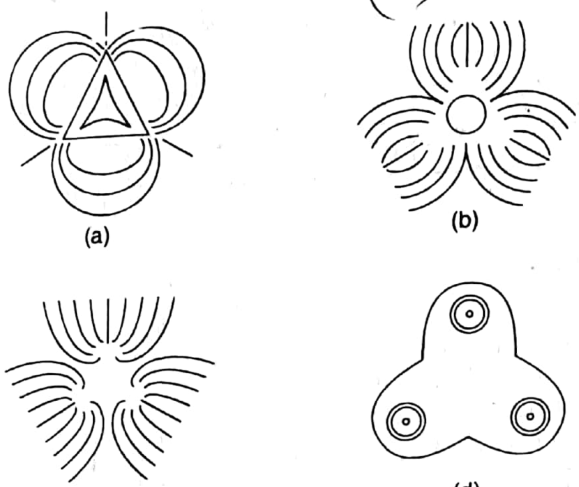


A=Area of plates

(a) $\frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{2K_3}$ (b) $\frac{1}{K} = \frac{1}{K_1 + K_2} + \frac{1}{2K_3}$

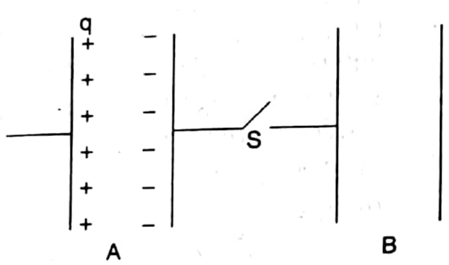
(c) $\frac{1}{K} = \frac{K_1K_2}{K_1 + K_2} + 2K_3$ (d) $K = \frac{K_1K_3}{K_1 + K_2} + \frac{K_2K_3}{K_2 + K_3}$

82. Three positive charges of equal value q are placed at the vertices of an equilateral triangle. The resulting lines of force should be sketched as in : (M,1)



(a) (b) (c) (d)

83. Consider the situation shown in the figure. The capacitor A has a charge q on it whereas B is uncharged. The charge appearing on the capacitor B a long time after the switch is closed is : (3,E)



(a) zero
(b) $q/2$
(c) q
(d) $2q$

84. A uniform electric field pointing in positive x-direction exists in a region. Let A be the origin, B be the point on the x-axis at $x = +1$ cm and C be the point on the y-axis at $y = +1$ cm. Then the potentials at the points A, B and C satisfy : (1,E)

(a) $V_A < V_B$
(b) $V_A > V_B$
(c) $V_A < V_C$
(d) $V_A > V_C$

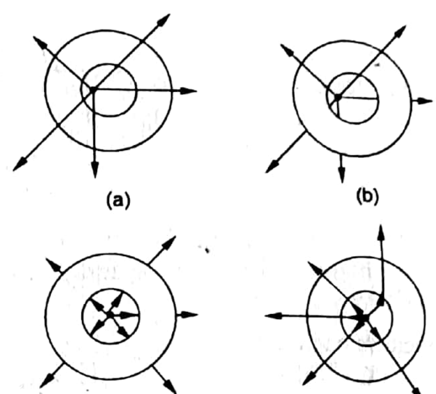
85. Two equal point charges are fixed at $x = -a$ and $x = +a$ on the x-axis. Another point charge Q is placed at the origin. The change in the electrical potential energy of Q, when it is displaced by a small distance x along the x-axis, is appoximately proportional to : (1,E)

(a) x
(b) x^2
(c) x^3
(d) $1/x$

86. Two identical capacitors, have the same capcacitance C. One of them is charged to potential V_1 and the other to V_2. The negative ends are also connected, the decrease in energy of the combined system is : (B,M)

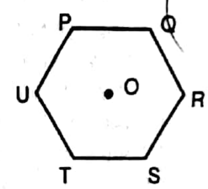
(a) $\frac{1}{4}C(V_1^2 - V_2^2)$
(b) $\frac{1}{4}C(V_1^2 + V_2^2)$
(c) $\frac{1}{4}C(V_1 - V_2)^2$
(d) $\frac{1}{4}C(V_1 + V_2)^2$

87. A metallic shell has a point charge q kept inside its cavity. Which one of the following diagrams correctly represents the electric lines of forces ? (E,2)



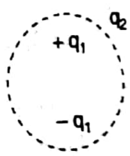
(a) (b) (c) (d)

88. Six charges, three positive and three negative of equal magnitude are to be placed at the vertices of a regular hexagon such that the electric field at O is double the electric field when only one positive charge of same magnitude is placed at R. Which of the following arrangements of charge is possible for, P, Q, R, S, T and U respectively ? (M,1)



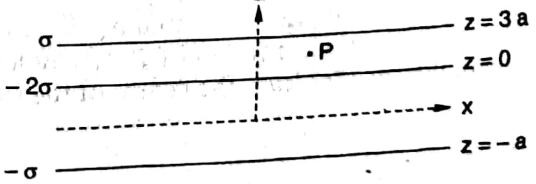
(a) +, −, +, −, −, +
(b) +, −, +, −, +, −
(c) +, +, −, +, −, −
(d) −, +, +, −, +, −

89. Consider the charge configuration and a spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface, the electric field will be due to : (2,E)



(a) q_2
(b) only the positive charges
(c) all the charges
(d) $+q_1$ and $-q_1$

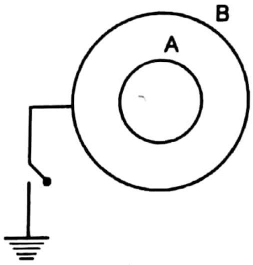
90. Three infinitely long charge sheets are placed as shown in figure. The electric field at point P is : (2,M)



(a) $\frac{2\sigma}{\varepsilon_0}\hat{k}$
(b) $-\frac{2\sigma}{\varepsilon_0}\hat{k}$
(c) $\frac{4\sigma}{\varepsilon_0}\hat{k}$
(d) $-\frac{4\sigma}{\varepsilon_0}\hat{k}$

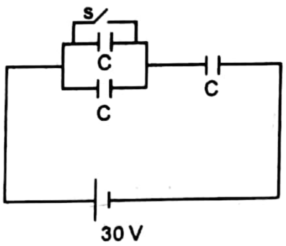
B More than one Option is Correct

1. Two concentric shells have radii R and $2R$ charges q_A and q_B and potentials $2\,\text{V}$ and $(3/2)\,\text{V}$ respectively. Now shell B is earthed and let charges on them become q'_A and q'_B. Then :



   (a) $q_A/q_B = 1/2$
   (b) $q'_A/q'_B = 1$
   (c) potential of A after earthing becomes $(3/2)\,\text{V}$
   (d) potential difference between A and B after earthing becomes $V/2$

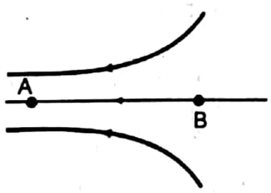
2. Three capacitors each having capacitance $C = 2\mu\text{F}$ are connected with a battery of emf 30 V as shown in figure. When the switch S is closed :



   (a) the amount of charge flown through the battery is $20\,\mu\text{C}$
   (b) the heat generated in the circuit is 0.6 mJ
   (c) the energy supplied by the battery is 0.6 mJ
   (d) the amount of charge flown through the switch S is $60\,\mu\text{C}$

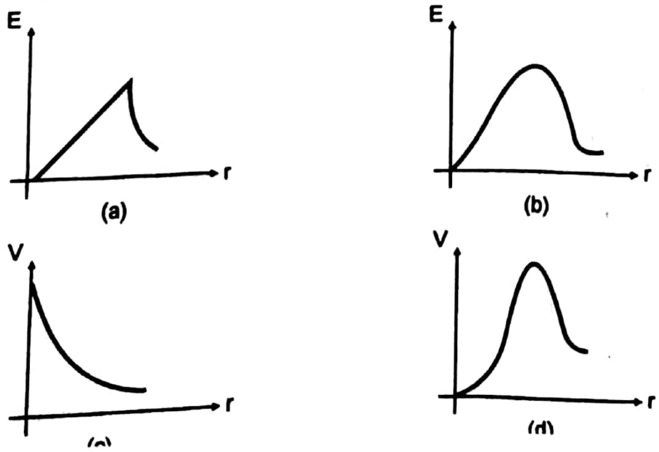
3. A point charge q is placed at origin. Let $\vec{E}_A$, $\vec{E}_B$ and $\vec{E}_C$ be the electric field at three points A (1, 2, 3), B (1, 1, – 1) and C (2, 2, 2) due to charge q. Then :
   (a) $\vec{E}_A \perp \vec{E}_B$ (b) $\vec{E}_A \parallel \vec{E}_C$
   (c) $|\vec{E}_B| = 4|\vec{E}_C|$ (d) $|\vec{E}_B| = 8|\vec{E}_C|$

4. Figure shows some of the electric field lines corresponding to an electric field. The figure suggests that (E = electric field, V = potential) :

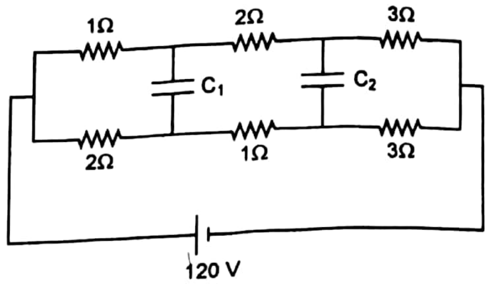


   (a) $E_A > E_B$ (b) $E_A < E_B$
   (c) $V_A > V_B$ (d) $V_A < V_B$

5. A circular ring carries a uniformly distributed positive charge. The electric field (E) and potential (V) varies with distance (r) from the centre of the ring along its axis as :

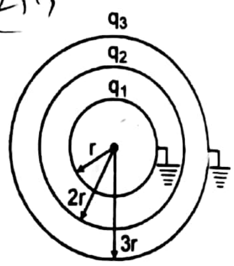


6. In the circuit shown in figure $C_1 = C_2 = 2\mu\text{F}$. Then charge stored in : (3, 4, 4)



   (a) capacitor C_1 is zero
   (b) capacitor C_2 is zero
   (c) both capacitors is zero
   (d) capacitor C_1 is $40\,\mu\text{C}$

7. Three concentric conducting spherical shells have radii r, $2r$ and $3r$ and charges q_1, q_2 and q_3 respectively. Innermost and outermost shells are earthed as shown in figure. Select the correct alternative(s) : (2, 1, E)

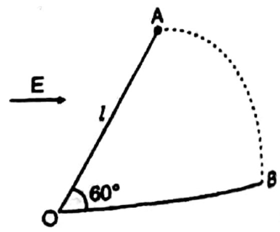


   (a) $q_1 + q_3 = -q_2$
   (b) $q_1 = -\dfrac{q_2}{4}$
   (c) $\dfrac{q_3}{q_1} = 3$
   (d) $\dfrac{q_3}{q_2} = -\dfrac{1}{3}$

8. A particle of charge q and mass m moves rectilinearly under the action of an electric field $E = \alpha - \beta x$. Here, α and β are positive constants and x is the distance from the point where the particle was initially at rest. Then : 1, 4
   (a) the motion of the particle is oscillatory
   (b) the amplitude of the particle is $\dfrac{\alpha}{\beta}$
   (c) the mean position of the particle is at $x = \dfrac{\alpha}{\beta}$
   (d) the maximum acceleration of the particle is $\dfrac{q\alpha}{m}$

9. Which of the following is/are incorrect statement ? 1, C
   (a) Electric field is always conservative
   (b) Electric field due to a varying magnetic field is non-conservative
   (c) Electric field due to a stationary charge is conservative
   (d) Electric field lines are always closed loops

10. A particle of mass m and charge q is fastened to one end of a string fixed at point O. The whole system lies on a frictionless horizontal plane. Initially, the mass is at rest at 1, 4



A. A uniform electric field in the direction shown is then switched on. Then :

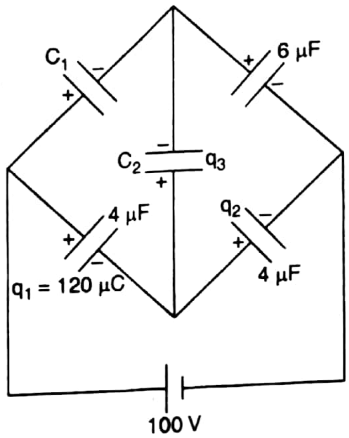
(a) the speed of the particle when it reaches B is $\sqrt{\frac{2qEl}{m}}$

(b) the speed of the particle when it reaches B is $\sqrt{\frac{qEl}{m}}$

(c) the tension in the string when particles reaches at B is $2qE$

(d) the tension in the string when the particle reaches at B is qE

11. In the circuit shown (3,E)



(a) $|q_2| = 280\,\mu C$

(b) $|q_3| = 160\,\mu C$

(c) $|q_2| = 120\,\mu C$, q_3 = zero

(d) It is impossible to find q_2 and q_3 unless C_1 and C_2 are known

12. A capacitor C is charged to a potential V by a battery. The emf of the battery is V. It is then disconnected from the battery and again connected with its polarity reversed to the battery : (3, M)

(a) The work done by the battery is CV^2

(b) The total charge that passes through battery is $2CV$

(c) The initial and final energy of the capacitor is same

(d) The work done is by the battery is $2CV^2$

13. Five charges each q are placed at five corners of a regular pentagon. Distance from corner to the centre of pentagon is r. Then : $\left(K = \frac{1}{4\pi\varepsilon_0}\right)$ 1, M

(a) potential at centre is $\frac{5kq}{r}$

(b) potential at centre is zero

(c) electric field at centre is non zero

(d) electric field at centre is zero

14. Two point charges q each are fixed at $(a, 0)$ and $(-a, 0)$. A third charge Q is placed at origin. Electrostatic potential energy of the system will : (1, M)

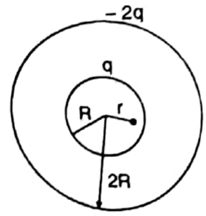
(a) increase if Q is slightly displaced along x-axis

(b) decrease if Q is slightly displaced along x-axis

(c) increase if Q is slightly displaced along y-axis

(d) decrease if Q is slightly displaced along y-axis

15. Two concentric shells of radii R and $2R$ have given charges q and $-2q$ as shown in figure. In a region $r < R$:



(a) $E = 0$

(b) $E \neq 0$

(c) $V = 0$

(d) $V \neq 0$

(1 ,E)

16. A positive charge particle when moves from higher potential to lower potential : (1, E)

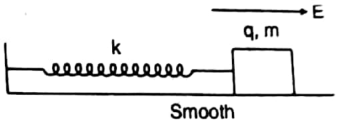
(a) its potential energy must decrease

(b) its potential energy may decrease

(c) its kinetic energy must increase

(d) its kinetic energy may increase

17. A block of mass m is attached to a spring of force constant k. Charge on the block is q. A horizontal electric field E is acting in the direction as shown. Block is released with the spring in unstretched position :



(a) Block will execute SHM (1, M)

(b) Time period of oscillation is $2\pi\sqrt{\frac{m}{k}}$

(c) Amplitude of oscillation is $\frac{qE}{k}$

(d) Block will oscillate but not simple harmonically

18. An electric dipole of dipole moment 10^{-6} C-m is released from rest in uniform electric field 10^2 V/m at angle $\theta = 60°$. Maximum rotational kinetic energy of the dipole is say K and maximum torque during the motion is τ, then :

(a) $K = 5.0 \times 10^{-5}$ J

(b) $K = 2.0 \times 10^{-4}$ J (1, E)

(c) $\tau = 5.0 \times 10^{-4}$ N-m

(d) $\tau = 8.7 \times 10^{-5}$ N-m

19. A parallel plate air capacitor is connected to a battery. The quantities charge, voltage, electric field and energy associated with this capacitor are given by Q_0, V_0, E_0 and U_0 respectively. A dielectric slab is now introduced to fill the space between the plates with the battery still in connection. The corresponding quantities now given by Q, V, E and U are related to the previous one as :

(a) $Q > Q_0$

(b) $V > V_0$ (3, M)

(c) $E > E_0$

(d) $U > U_0$

20. A parallel plate capacitor is charged and the charging battery is then disconnected. If the plates of the capacitor are moved farther apart by means of insulating handles :

(a) the charge on the capacitor increases (3, E)

(b) the voltage across the plates increases

(c) the capacitance increases

(d) the electrostatic energy stored in the capacitor increases

21. A parallel plate capacitor of plate area A and plate separation d is charged to potential difference V and then

(3, M)

the battery is disconnected. A slab of dielecric constant K is then inserted between the plates of the capacitor so as to fill the space between the plates. If Q, E and W denote respectively, the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted), and work done on the system, in the process of inserting the slab, then :

(a) $Q = \frac{\varepsilon_0 AV}{d}$ (b) $Q = \frac{\varepsilon_0 KAV}{d}$

(c) $E = \frac{V}{Kd}$ (d) $W = \frac{\varepsilon_0 AV^2}{2d}\left[1 - \frac{1}{K}\right]$

3, M

22. A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at $x = 0$ and positive plate is at $x = 3d$. The slab is equidistant from the plates. The capacitor is given some charge. As x goes from 0 to $3d$:

(a) the magnitude of the electric field remains the same
(b) the direction of the electric field remains the same
(c) the electric potential increases continuously
(d) the electric potential increases at first, then decreases and again increases

(3, 2, M)

23. A positively charged thin metal ring of radius R is fixed in the x-y plane with its centre at the origin O. A negatively charged particle P is released from rest at the point $(0, 0, z_0)$ where $z_0 > 0$. Then the motion of P is :

(a) periodic for all values of z_0 satisfying $0 < z_0 < \infty$
(b) simple harmonic for all values of z_0 satisfying $0 < z_0 \le R$
(c) approximately simple harmonic provided $z_0 << R$
(d) such that P crosses O and continues to move along the negative z-axis towards $z = -\infty$

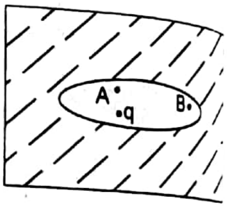
(3, M)

24. A non-conducting solid sphere of radius R is uniformly charged. The magnitude of the electric field due to the sphere at a distance r from its centre :

(a) increases as r increases for $r < R$
(b) decreases as r increases for $0 < r < \infty$
(c) decreases as r increases for $R < r < \infty$
(d) is discontinuous at $r = R$

(1, M)

25. An elliptical cavity is carved within a perfect conductor. A positive charge q is placed at the centre of the cavity. The points A and B are on the cavity surface as shown in the figure. Then :



(a) electric field near A in the cavity = electric field near B in the cavity
(b) charge density at A = charge density at B
(c) potential at A = potential at B
(d) total electric field flux through the surface of the cavity is q / ε_0

C Match the Column & Assertion-Reason Type Questions

1. Match the followings :

Table-1		Table-2	
(A)	σ^2/ε_0	(P)	C^2/J-m
(B)	ε_0	(Q)	Farad
(C)	$\frac{\text{ampere-second}}{\text{volt}}$	(R)	J/m^3
(D)	$\frac{V}{E}$	(S)	metre

2. When an independent positive charge moves from higher potential to lower potential :

Table-1		Table-2	
(A)	its kinetic energy	(P)	will remain constant
(B)	its potential energy	(Q)	will decrease
(C)	its mechanical energy	(R)	will increase

3. Two parallel metallic plates have surface charge densities σ_1 and σ_2 as shown in figure. Match the following :

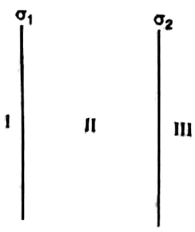


Table-1		Table-2	
(A)	If $\sigma_1 + \sigma_2 = 0$	(P)	Electric field in region III is towards right
(B)	If $\sigma_1 + \sigma_2 > 0$	(Q)	Electric field in region ... is zero
(C)	If $\sigma_1 + \sigma_2 < 0$	(R)	Electric field in region ... is towards right
		(S)	None
		(T)	Nothing can be said

4. Two spherical shells are as shown in figure. Suppose r is the distance of a point from their common centre. Then

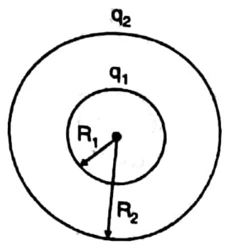


Table-1		Table-2	
(A)	Electric field for $r < R_1$	(P)	is constant for q_1 and vary for q_1