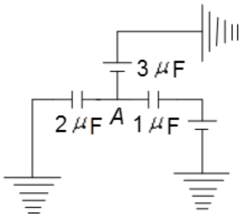
2.ELECTROSTATIC POTENTIAL AND CAPACITANCE

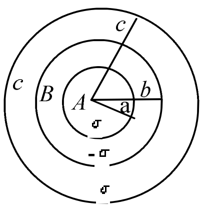
Single Correct Answer Type

1. In the given arrangement of capacitors, 6 μC charge is added to point a. Find the charge on upper capacitor



a) 3 μC b) 1 μC c) 2 μC d) 6 μC

2. Consider three concentric shells of metal A, B and C are having radii a, b and c respectively as shown in the figure ($a < b < c$). Their surface charge densities are $\sigma, -\sigma$ and σ respectively. Calculate the electric potential on the surface of shell A



a) $\frac{\sigma}{\varepsilon_0}(a-b+c)$ b) $\frac{\sigma}{\varepsilon_0}(a-b-c)$ c) $\frac{\sigma}{\varepsilon_0}(a^2+b^2+c^2)$ d) $\frac{\sigma}{\varepsilon_0}(a+b-c)$

3. Three capacitors of capacitance 1μF, 2μF and 3μF are connected in series and a potential difference of 11 V is applied across the combination. Then, the potential difference across the plate of 1μF capacitor is

a) 2 V b) 4 V c) 1 V d) 6 V

4. An electric charge 10^{-3}μC is placed at the origin (0, 0) of X-Y coordinate system. Two points A and B are situated at $(\sqrt{2}, \sqrt{2})$ and (2,0) respectively. The potential difference between the points A and B will be

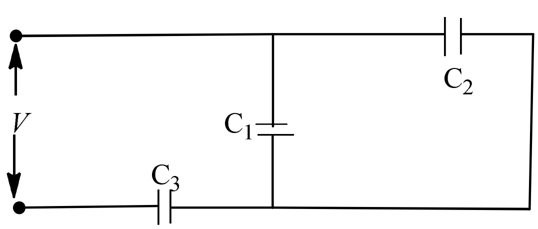
a) 9V b) Zero c) 2V d) 4.5V

5. The potential to which a conductor is raised, depends on

a) The amount of charge b) Geometry and size of the conductor

c) Both (a) and (b) d) Only on (a)

6. Three capacitors C_1, C_2 and C_3 are connected as shown in the figure to a battery of V volt. If the capacitor C_3 breaks down electrically the change in total charge on the combination of capacitors is



a) $(C_1+C_2)V\left[1-\left(\frac{C_3}{C_1+C_2+C_3}\right)\right]$ b) $(C_1+C_2)V\left[1-\left(\frac{(C_1+C_2)}{C_1+C_2+C_3}\right)\right]$

c) $(C_1+C_2)V\left[1+\left(\frac{C_3}{C_1+C_2+C_3}\right)\right]$ d) $(C_1+C_2)V\left[1+\left(\frac{C_2}{C_1+C_2+C_3}\right)\right]$

7. Two charges $+q$ and $-q$ are kept apart. Then at any point on the right bisector of line joining the two charges

a) The electric field strength is zero

b) The electric potential is zero

c) Both electric potential and electric field strength are zero.

d) Both electric potential and electric field strength are non-zero.

8. An electric field is expressed as $\vec{E} = 2\hat{\imath} + 3\hat{\jmath}$. Find the potential difference $(V_A - V_B)$ between two points A and B whose position vectors are given by $r_A = \hat{\imath} + 2\hat{\jmath}$ and $r_B = 2\hat{\imath} + \hat{\jmath} + 3\hat{k}$

a) -1 V b) 1 V c) 2 V d) 3 V

9. A hollow conducting sphere is placed in an electric field produced by a point charge placed at P as shown in figure. V_A, V_B, V_c be the potentials at points A, B and C respectively. Then

a) $V_C > V_B$ b) $V_B > V_C$ c) $V_A > V_B$ d) $V_A = V_C$

10. When a 2 μC of charge is carried from point A to point B, the amount of work done by electric field is 50μJ. What is the potential difference and which point is at a higher potential?

a) 25 V, B b) 25 V, A

c) 20 V, B d) Both are at same potential

11. Three capacitors of capacitance 1 μF, 2 μF and 4μF are connected first in a series combination, and then in a parallel combination. The ratio of their equivalent capacitance will be

a) 2 : 49 b) 49 :2 c) 4 : 49 d) 49 : 4

12. In a charged capacitor the energy stored in

a) The positive charges b) The negative charges

c) The field between the plates d) None of the above

13. Figure shows two parallel surfaces A and B at the same potential, kept at a small distance r from each other. A point charge q is taken from the surface A to B

The amount of work done is

a) $\dfrac{q^2}{2\pi\varepsilon_0 r}$ b) $\dfrac{q^2}{8\pi\varepsilon_0 r}$ c) $\dfrac{q^2}{4\pi\varepsilon_0 r}$ d) Zero

14. 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 dieletric material is to be used to have the same capacitance C is this capacitors, then its dielectric constant K is given by

a) $\dfrac{1}{K} = \dfrac{1}{K_1} + \dfrac{1}{K_2} + \dfrac{1}{2K_3}$ b) $\dfrac{1}{K} = \dfrac{1}{K_1 + K_2} + \dfrac{1}{2K_3}$ c) $K = \dfrac{K_1K_2}{K_1 + K_2} + 2K_3$ d) $K = K_1 + K_2 + 2K_3$

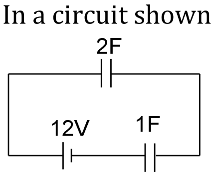
15. A uniform electric field pointing in positive x-direction exists in a region. Let A be the origin, B be the point on the x-axis at x=+1 cm and C be the point on the y-axis at y=+1 cm. them the potentials at the points A, B and C satisfy the condition

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

16. A 4μF capacitor is charged to 400V and then its plates are joined through a resistance. The heat produced in the resistance is

a) 0.16 J b) 0.32 J c) 0.64 J d) 1.28 J

17. In a circuit shown in figure, the potential difference across the capacitor of 2 F is

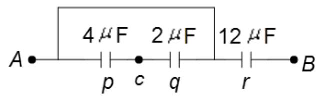


a) 8 V b) 4 V c) 12 d) 6 V

as

a) b) c) d)

19. Find the equivalent capacitance between C and$B$.



a) 6/5 μF b) 5/6 μF c) 4 μF d) None of these

20. A capacitor of capacity 10μF is charged to a potential of 400V. When its both plates are connected by a conducting wire , then heat generated will be

a) 80 J b) 0.8 J c) 8×10^{-3} J d) 8×10^{-6} J

21. A 2μF capacitor is charged as shown in the figure. The percentage of its stored energy dissipated after the switch s is turned to positions 2 is

a) 0 % b) 20 % c) 75% d) 80%

22. Two point changes $+q$ and $-q$ are held fixed at $(-d, 0)$ and $(d, 0)$ respectively of a (x, y) coordinate system, then

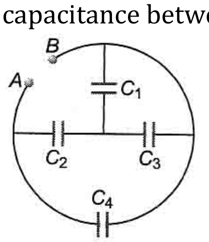
a) The electric field $\vec{E}$ at all points on the x-axis has the same direction.

b) $\vec{E}$ at all points on the y-axis is along $\vec{\jmath}$

c) Work has to be done in bringing a test charge from infinity to the origin.

d) The dipole moment is 2 qd directed along $\hat{\jmath}$.

23. In the arrangement of capacitors shown in figure, each capacitor is of 9 μF, Then the equivalent capacitance between in points A and B is



a) 9 μF b) 18 μF c) 4.5 μF d) 15 μF

24. A parallel plate capacitor of capacitance 100 pF is to be constructed by using paper sheets of 1 mm thickness as dielectric. If the dielectric constant of paper is 4, the number of circular metal foils of diameter 2 cm each required for the purpose is

a) 40 b) 20 c) 30 d) 10

25. A solid sphere of radius R is charged uniformly. At what distance from its surface is the electrostatic potential half of the potential at the centre?

a) R b) $R/2$ c) $R/3$ d) $2R$

26. When two conductors of charges and potentials C_1, V_1 and C_2, V_2 respectively are joined, the common

a) $\frac{C_1V_1 + C_2V_2}{V_1 + V_2}$ b) $\frac{C_1V_1^2 + C_2V_2^2}{V_1^2 + V_2^2}$ c) $C_1 + C_2$ d) $\frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

27. Two point charges Q and $-Q/4$ placed along the x-axis are separated by a distance r. Take $-Q/4$ as origin and it is placed on right of Q. Then, the potential is zero
a) at $x = r/3$ only
b) at $x = -r/5$ only
c) Both at $x = r/3$ and at $x = -r/5$
d) There exist two points on the axis where the electric field is zero

28. The charges$Q$, +q and +q are placed at the vertices of an equilateral triangle of side l. If the net electrostatic potential energy of the system is zero, then Q is equal to
a) $-\frac{q}{2}$ b) $-q$ c) $\frac{+q}{2}$ d) Zero

29. The work done in moving an alpha particle between two points having potential difference 25 V is
a) 8×10^{-18}J b) 8×10^{-19}J c) 8×10^{-20}J d) 8×10^{-16}J

30. The plates of a parallel plate capacitor are charged upto 200 V. A dielectric slab of thickness 4 mm is inserted between its plates. Then, to maintain the same potential difference between the plates of the capacitor, the distance between the plates is increased by 3.2 mm. The dielectric constant of the dielectric slab is
a) 1 b) 4 c) 5 d) 6

31. Two parallel plate capacitors of capacitance C and $2C$ are connected in parallel and charged to a potential difference V_0. The battery is then disconnected and the region between the plates of the capacitor C is completely filled with a material of dielectric constant 2. The potential difference across the capacitors now becomes
a) $\frac{F_0}{4}$ b) $\frac{V_0}{2}$ c) $\frac{3V_0}{4}$ d) V_0

32. A small conducting sphere of radius r is lying concentrically inside a bigger hollow conducting sphere of radius R. The bigger and smaller spheres are charged with Q and q ($Q > q$) and are insulated from each other. The potential difference between the spheres will be
a) $\frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r} - \frac{q}{R}\right)$ b) $\frac{1}{4\pi\varepsilon_0}\left(\frac{q}{R} - \frac{Q}{r}\right)$ c) $\frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r} - \frac{Q}{R}\right)$ d) $\frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{R} - \frac{q}{r}\right)$

33. On increasing the plate separation of a charged capacitor, the energy
a) Increases b) Decreases c) Remains unchanged d) Becomes zero

34. At a distance r from a point located at origin in space, the electric potential varies as$V = 10r$. Find the electric field at$\vec{r} = 3\hat{\imath} + 4\hat{\jmath} - 5\hat{k}$
a) $\sqrt{2}(3\hat{\imath} + 4\hat{\jmath} - 5\hat{k})$ b) $-\sqrt{2}(3\hat{\imath} + 4\hat{\jmath} - 5\hat{k})$ c) $-\sqrt{3}(3\hat{\imath} + 4\hat{\jmath} - 5\hat{k})$ d) None of the above

35. A spherical drop of capacitance 1 μF is broken into eight drops of equal radius. Then, the capacitance of each small drop is
a) $\frac{1}{2}$μF b) $\frac{1}{4}$μF c) $\frac{1}{8}$μF d) 8μF

36. Three charges $2q, -q$ and $-q$ are located at the vertices of an equilateral triangle. At the centre of the triangle
a) The field is zero but potential is non-zero
b) The field is non-zero but potential is zero
c) Both field and potential are zero
d) Both field and potential are non-zero

37. A positive point charge q is carried from a point B to a point A in the electric field of a point charge $+Q$ at O. If the permittivity of free space is ε_0, the work done in the process is given by (where a $=OA$ and $b = OR$)
a) $\frac{qQ}{4\pi\varepsilon_0}\left(\frac{1}{a} + \frac{1}{b}\right)$ b) $\frac{qQ}{4\pi\varepsilon_0}\left(\frac{1}{a} - \frac{1}{b}\right)$ c) $\frac{qQ}{4\pi\varepsilon_0}\left(\frac{1}{a^2} - \frac{1}{b^2}\right)$ d) $\frac{qQ}{4\pi\varepsilon_0}\left(\frac{1}{a^2} + \frac{1}{b^2}\right)$

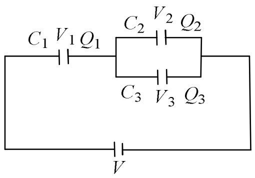
38. A parallel plate capacitor having air as dielectric medium is charged by a potential difference of V volt. After disconnecting the battery, the distance between the plates of the capacitor is increased using an insulated handle. As a result ,potential difference between the plates

a) Increases b) Does not change c) Becomes zero d) Decreases

39. The displacement of a charge Qin the electric field $\boldsymbol{E} = e_1\hat{\boldsymbol{i}} + e_2\hat{\boldsymbol{j}} + e_3\hat{\boldsymbol{k}}$ is $\boldsymbol{r} = a\hat{\boldsymbol{i}} + b\hat{\boldsymbol{j}}$. The work done is

a) $Q(ae_1 + be_2)$
b) $Q\sqrt{(ae_1)^2 + (be_2)^2}$
c) $Q(e_1 + e_2)\sqrt{a^2 + b^2}$
d) $Q\left(\sqrt{e_1^2 - e_2^2}\right)(a + b)$

40. In Fig, three capacitors C_1, C_2 and C_3 are joined to a battery. With symbols having their usual meaning, the correct conditions will be



a) $Q_1 = Q_2 = Q_3$and $V_1 = V_2 = V_3 + V$
b) $Q_1 = Q_2 + Q_3$ and $V = V_1 + V_2 + V_3$
c) $Q_1 = Q_2 + Q_3$and $V = V_1 + V_2$
d) $Q_2 = Q_3$ and $V_2 = V_3$

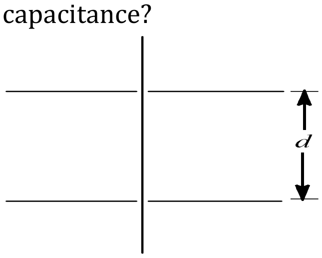
41. A solid conducting sphere having a charge Q is surrounded by an uncharged concentric conducting hollow spherical shell. The potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell is V. If the shell is now givn a charge of $-3Q$, the new potential difference between the same two surface is

a) V b) $2V$ c) $4V$ d) $-2V$

42. Three charges q, q and $-2q$ are fixed on the vertices of an equilateral triangular plate of edge length a. This plate is in equilibrium between two very large plates having surface charge density σ_1 and σ_2, respectively. Find the time period of small angular oscillation about an axis passing through its centroid and perpendicular to the plane. Moment of inertia of the system about this axis is l

a) $2\pi\sqrt{\dfrac{\varepsilon_0 l}{qa|\sigma_1 - \sigma_2|}}$ b) $2\pi\sqrt{\dfrac{\varepsilon_0 l}{2qa|\sigma_1 - \sigma_2|}}$ c) $2\pi\sqrt{\dfrac{2\varepsilon_0 l}{\sqrt{3}qa|\sigma_1 - \sigma_2|}}$ d) $2\pi\sqrt{\dfrac{2\varepsilon_0 l}{qa|\sigma_1 - \sigma_2|}}$

43. A capacitor of capacitance 1 μF is filled with two dielectrics of dielectric constant 4 and 6. What is the new capacitance?



a) 10 μF b) 5 μF c) 4 μF d) 7 μF

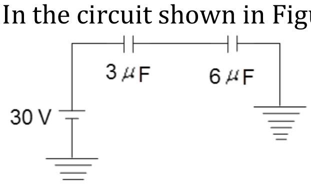
44. The work of electric field done during the displacement of a negatively charged particle towards a fixed positively charged particle is 9 J. As a result the distance between the charges has been decreased by half. What work is done by the electric field over the first half of this distance?

a) 3 J b) 6 J c) 1.5 J d) 9 J

45. Three charges $2q, -q, -q$are located at the vertices of an equilateral triangle. At the circumcentre of the triangle

a) The field is zero but potential is non-zero
b) Potential is zero and the field is infinity
c) Both the field and potential are zero
d) The field is non-zero but potential is zero

46. In the circuit shown in Figure, the charge stored on a – capacitor of capacitance 3 μF is



a) Zero b) 40 μC c) 60 μC d) 90 μC

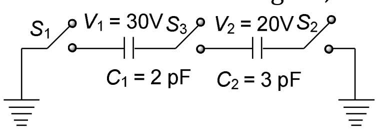
47. Three capacitors of capacitances 4 μF, 6 μF and 12 μF are connected first in series and then in parallel. What is the ratio of equivalent capacitance in the two cases?

a) 2 : 3 b) 1 : 11 c) 11 : 1 d) 1 : 3

48. For configuration of media of permittivity $\varepsilon_0, \varepsilon, \varepsilon_0$ between parallel plates each of area A, as shown in Fig, the equivalent capacitance is

a) $\varepsilon_0 A/d$ b) $\varepsilon\varepsilon_0 A/d$ c) $\dfrac{\varepsilon\varepsilon_0 A}{d(\varepsilon+\varepsilon_0)}$ d) $\dfrac{\varepsilon\varepsilon_0 A}{(2\varepsilon+\varepsilon_0)d}$

49. For the circuit shown figure, which of the following statements is true?



a) With S_1 closed, $V_1 = 15$ V, $V_2 = 20$ V b) With S_3 closed, $V_1 = V_2 = 20$ V

c) With $S_1$and, S_3 closed, $V_1 = V_2 = 0$ d) With S_1 and S_3closed, $V_1 = 30$ V, $V_2 = 20$ V

50. A capacitor connected to a 10 V battery collects a charge of 40 μC with air as dielectric and 100 μC with a given oil as dielectric. The dielectric constant of the oil is

a) 1.5 b) 2.0 c) 2.5 d) 3.0

51. In the given figure, a hollow spherical capacitor is shown. The electric field will not be zero at

a) $r < r_1$ b) $r_1 < r_2$ c) $r < r_2$ d) $r_1 < r < r_2$

52. A parallel plate capacitor of capacitance 10μF is connected across a battery of e.m.f. 5 mV. Now, the space between the plates of the capacitor is filled with a dielectric material of dielectric constant$K = 5$. Then, the charge that will flow through the battery till equilibrium is reached is

a) 250 μC b) 250 nC c) 200 nC d) 200 μC

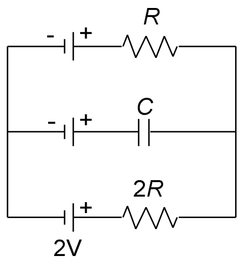
53. Three identical metallic uncharged spheres A, B and C each of radius a, are kept at the corners of an equilateral triangle of side $d (d \gg a)$ as shown in Fig. The fourth sphere (of radius a), which has a charge q, touches A and is then removed to a position far away. $B$is earthed and then the earth connection is removed. $C$is then earthed. The charge on C is

a) $\dfrac{qa}{2d}\left(\dfrac{2d-a}{2d}\right)$ b) $\dfrac{qa}{2d}\left(\dfrac{2d-a}{d}\right)$ c) $-\dfrac{qa}{2d}\left(\dfrac{d-a}{d}\right)$ d) $\dfrac{2qa}{d}\left(\dfrac{d-a}{2d}\right)$

54. The electric flux from a cube of edge l is ϕ. What will be its value if edge of cube is made 2 l and charge enclosed is halved

a) ϕ/2 b) 2 ϕ c) 4 ϕ d) 5 ϕ

55. In the given circuit of figure with steady current, the potential drop across the capacitor must be



a) V b) $\frac{V}{2}$ c) $\frac{V}{3}$ d) $\frac{2V}{3}$

56. Two parallel large thin metal sheets have equal surface charge densities ($\sigma = 26.4 \times 10^{-12}\text{Cm}^{-2}$)of opposite signs. The electric field between these sheets is
a) 1.5 NC^{-1} b) 1.5$\times 10^{-10}\text{NC}^{-1}$ c) 3 NC^{-1} d) 3×10^{-10} NC^{-1}

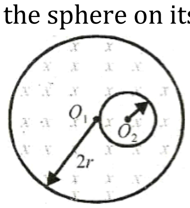
57. Mark the correct statements:
a) If E is zero at certain point, then V should be zero at that point
b) If E is not zero at certain point, then Vshould not be zero at that point
c) If V is zero at certain point, then Eshould be zero at that point
d) If $V$is zero at certain point, then E may or may not be zero

58. The points resembling equal potentials are

a) P and Q b) S and Q c) S and R d) P and R

59. Charge Q is given a displacement $\vec{r} = a\hat{\text{i}} + \text{b}\hat{\text{j}}$ in an electric field $\vec{E} = E_1\hat{\text{i}} + E_2\text{b}\hat{\text{j}}$. The work done is
a) $Q(E_1a + E_2b)$ b) $Q\sqrt{(E_1a)^2 + (E_2b)^2}$
c) $Q(E_1 + E_2)\sqrt{a^2 + b^2}$ d) $Q(\sqrt{E_1^2 + E_2^2})\sqrt{a^2 + b^2}$

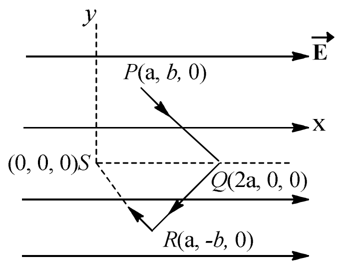
60. A non-conducting sphere with a cavity has volume charge densityρ. $O_1$and O_2 represent the two centres as shown. The electric field inside the cavity is E_0. Now, an equal and opposite charge is given uniformly to the sphere on its outer surface. The magnitude of electric field inside the cavity becomes



a) Zero b) E_0 c) $2E_0$ d) $3E_0$

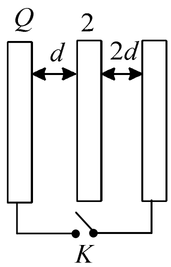
61. If a charged spherical conductor of radius 10 cm has potential Vat a point distant 5cm from its centre, then the potential at a point distant 15 cm from the centre will be
a) $\frac{1}{3}V$ b) $\frac{2}{3}V$ c) $\frac{3}{2}V$ d) 3V

62. A point charge q moves from point $\overset{P}{\rightarrow}$ to point S along the path $PQRS$in a uniform electric field $\vec{\text{E}}$ pointing parallel to the positive direction of the x-axis, figure. The coordinates of the points $P, Q, R$and $S$are (a, b, 0), (2a, 0, 0), (a, -b, 0) and (0, 0, 0) respectively. The work done by the field in the above process is given by the expression



a) qE b) $-qaE$ c) $q(\sqrt{a^2+b^2})E$ d) $3qE\sqrt{a^2+b^2}$

63. Three large plates are arranged as shown. How much charge will flow through the key k if it closed?



a) $\frac{5Q}{6}$ b) $\frac{4Q}{3}$ c) $\frac{3Q}{2}$ d) None

64. Two equally charged small balls placed at a fixed distance experience 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) $2F$ d) $4F$

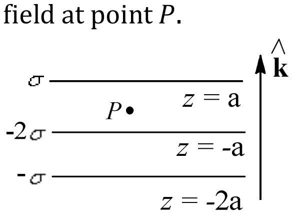
65. A hollow metal sphere of radius 10 cm is charged such that the potential on its surface becomes 80V. The potential at the centre of the sphere is

a) 80 V b) 800 V c) 8 V d) Zero

66. Two capacitors of capacitances C_1 and C_2 are connected in parallel across a battery. If Q_1 and Q_2 respectively be the charges on the capacitors, then $\frac{Q_1}{Q_2}$ will be equal to

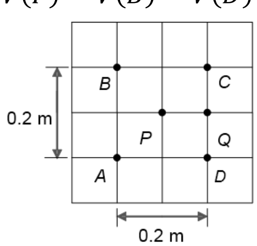
a) $\frac{C_2}{C_1}$ b) $\frac{C_1}{C_2}$ c) $\frac{C_1^2}{C_2^2}$ d) $\frac{C_2^2}{C_1^2}$

67. Three large parallel plates have uniform surface change densities as shown in the figure. Find the electric field at point P.



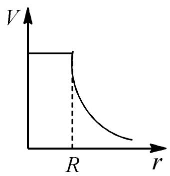
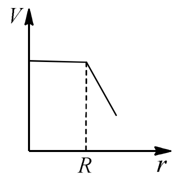
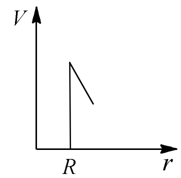
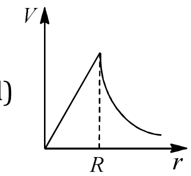
a) $\frac{-4\sigma}{\varepsilon_0}\hat{k}$ b) $\frac{4\sigma}{\varepsilon_0}\hat{k}$ c) $\frac{-2\sigma}{\varepsilon_0}\hat{k}$ d) $\frac{2\sigma}{\varepsilon_0}\hat{k}$

68. A, B, C, D, P And Q are points in a uniform electric field. The potentials at these points are $V(A) = 2$ V. $V(P) = V(B) = V(D) = 5$V. $V(C) = 8$V. the electric field at P is



a) 10 V/m along PQ b) $15\sqrt{2}$ V/m along PA c) 5 V/m along PC d) 5 V/m along PA

69. Which one of the following graphs figure shows the variation of electric potential V with distance r from the centre of a hollow charged sphere of radius R

a)  b)  c)  d) 

70. The work done in placing a charge of 8×10^{-18} C on a condenser of capacity 100 mF is

a) 32×10^{-32}J b) 16×10^{-32}J c) 3.1×10^{-26}J d) 4×10^{-10}J

71. The electric potential at a point (x, y) in the x-y plane is given by

$V = -Kxy$

The electric field intensity at a distance r from the origin varies as

a) r^2 b) r c) $2r$ d) $2r^2$

72. The capacitance of a spherical condenser is 1 μF. If the spacing between two spheres is 1 mm, the radius of the outer sphere is

a) 3 m b) 7 m c) 8 m d) 9 m

73. Two copper spheres of same radii, one hollow and the other solid, are charged to same potential. Then, which, if any, of the two will have more charge?

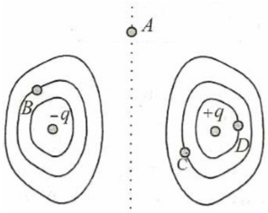
a) Hollow b) Solid

c) Both will have the same charge d) Nothing can be predicted

74. The SI unit of the line integral of electrical field I s

a) NC^{-1} b) Nm^2C^1 c) JC^{-1} d) Vm^{-1}

75. Figure shows equipotential surfaces for a two charges system. At which of the labelled points will an electron have the highest potential energy?



a) Point A b) Point B c) Point C d) Point D

76. If the potential of a capacitor having capacity 6μF is increased from 10 V to 20 V, then increase in its energy is

a) 12×10^{-6} J b) 9×10^{-4} J c) 4.5×10^{-6} J d) 2.25×10^{-6} J

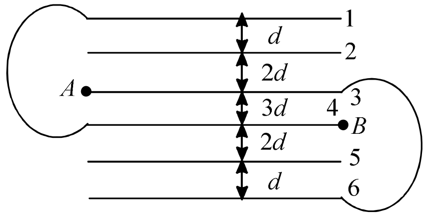
77. A 5.μF capacitor is charged to a potential difference of 800 V and discharged through a conductor. the energy given to the conductor during the discharge is

a) 1.6×10^{-2} J b) 3.2 J c) 1.6 J d) 4.2 J

78. Four charges equal to$-Q$ are placed at the four corners of a square and a charge and a charge q is at its centre. If the system is nequili8brium, the value of q is

a) $-\frac{Q}{4}(1+2\sqrt{2})$ b) $\frac{Q}{2}(1+2\sqrt{2})$ c) $-\frac{Q}{2}(1+2\sqrt{2})$ d) $\frac{Q}{4}(1+2\sqrt{2})$

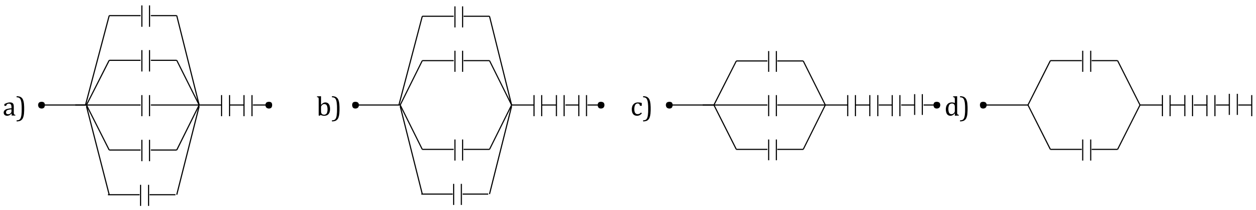
79. Six plates of equal area A and plate separation as shown (figure) are arranged. The equivalent capacitance between A and B is



a) $\frac{\varepsilon_0 A}{d}$ b) $\frac{2\varepsilon_0 A}{d}$ c) $\frac{3\varepsilon_0 A}{d}$ d) $\frac{\varepsilon_0 A}{3d}$

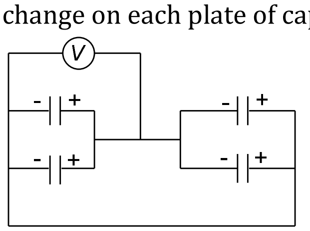
80. Seven capacitors each of the capacitance 2μF are be connected in a configuration to obtain an effective

capacitance of $\frac{10}{11}$ μ F. Which of the combination (S) shown in figure will achieve the desired result?



81. A capacitor of capacitance 10μF charged to 100V is connected to an uncharged capacitor. The effective potential now is 40 V. The capacitance of uncharged capacitor is
a) 12μF b) 15 μF c) 25 μF d) 30 μF
82. Identify the wrong statement.
a) In an electric field two equipotential surfaces can never intersect.
b) A charged particle free to move in an electric field shall always move in the direction of **E**.
c) Electric field at the surface of a charged conductor is always normal to the surface.
d) The electric potential decrease along a line of force in an electric field.
83. A parallel plate capacitor has the space between its plates filled by two slabs of thickness $\frac{d}{2}$ each and dielectric constant K_1andK_2. d Is the plate separation of the capacitor. The capacity of the capacitor is
a) $\frac{2\varepsilon_0 d}{A}\left(\frac{K_1+K_2}{K_1\,K_2}\right)$ b) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1\,K_2}{K_1+K_2}\right)$ c) $\frac{2\varepsilon_0 A}{A}(K_1+K_2)$ d) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1+K_2}{K_1\,K_2}\right)$
84. A particle of mass m carrying charge $'q'$ is projected with velocity $'v'$ from point $'P'$ towards an infinite line of charge from a distance $'a'$. Its speed reduces to zero momentarily at point Q which is at a distance $a/2$ from the line of charge. If another particle with mass m and charge $'-q'$ is projected with the same velocity $'v'$ from P towards the line of charge, what will be its speed at Q?
a) $v_1=\sqrt{2}v$ b) $v_1=2v$ c) $v_1=\sqrt{v}$ d) $v_1=\sqrt{2}$
85. A gang capacitor is formed by interlocking a number of plates as shown in figure. The distance between the consecutive plates is 0.885 cm and the overlapping area of the plates is 5 cm^2. The capacity of the unit is

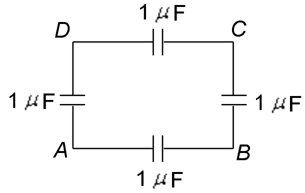
a) 1.06 pF b) 4 pF c) 6.36 pF d) 12.72 pF
86. The four capacitors, each of 25 μF are connected as shown in figure. The DC voltmeter reads 200 V. the change on each plate of capacitor is



a) $\pm 2\times10^{-3}$C b) $\pm 5\times10^{-3}$C c) $\pm 2\times10^{-2}$C d) $\pm 5\times10^{-2}$C
87. Four capacitors are connected in a circuit as shown in the following figure. Calculate the effective capacitance between the points A and B.

a) $\frac{4}{3}$ μF b) $\frac{24}{5}$ μF c) 9 μF d) 5 μF

88. A 20μF capacitor is connected to 45 V battery through a circuit whose resistance is 2000Ω. What is the final charge on the capacitor?
a) 9×10^{-4}C b) 9.154×10^{-4}C c) 9.8×10^{-4}C d) None of these

89. Four capacitors are connected as shown in figure. The equivalent capacitance between A and B is


a) 4 μF b) 0.25 μF c) 0.75 μF d) 1.33 μF

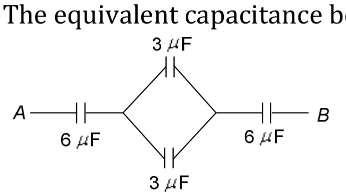
90. The work done in bringing a unit positive charge from infinity distance to a point at distance X from a positive charge Q is W. Then, the potential ϕ at the point is
a) $\frac{WQ}{X}$ b) W c) $\frac{W}{Q}$ d) WQ

91. A 10 μC capacitor is charged to a potential difference of 50 V and is connected to another uncharged capacitor in parallel. Now the common potential difference becomes 20 V. The capacitance of second capacitor is
a) 15 μF b) 30 μF c) 20 μF d) 10 μF

92. A wire of linear charge density λ passes through a cuboid of length l, breadth b and height $h(l > b > h)$ In such a manner that the flux through the cuboid I maximum. The position of the wire is now changed, so that the flux through the cuboid is minimum. The ratio of maximum flux to minimum flux will be
a) $\sqrt{\frac{l^2+b^2}{h}}$ b) $\sqrt{\frac{l^2+b^2+h^2}{h}}$ c) $\frac{h}{\sqrt{l^2+b^2}}$ d) $\frac{h}{\sqrt{l^2+b^2+h^2}}$

93. 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 dissector. Then
a) $\vec{E}_2 = -\frac{\vec{E}_1}{8}$ b) $\vec{E}_2 = -\frac{\vec{E}_1}{16}$ c) $\vec{E}_2 = -\frac{\vec{E}_1}{4}$ d) $\vec{E}_2 = \frac{\vec{E}_1}{8}$

94. A point charge q is placed at the centre of a closed cylindrical conductor of length l and radius. R. The flux crossing through the conducting cylinder would be
a) $\frac{ql}{2\varepsilon_0[R^2+l^2/4]^{1/2}}$ b) Zero c) $\frac{ql}{\varepsilon_0[R^2+l^2/4]^{1/2}}$ d) $\frac{q}{\varepsilon_0}$

95. The equivalent capacitance between A and B in figure is


a) 4 μF b) 2 μF c) 10.5 μF d) 3 μF

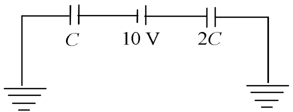
96. A solid conducting sphere having a charge Q us surrounded by an uncharged concentric conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. if the shell is now given a charge $-3Q$. the new potential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

97. A 10 μF capacitor is charges to 500 V and its plates are joined together through a resistance of 10 Ω. The heat produced in the resistance is
a) 500 J b) 125 J c) 250 J d) 1.25 J

98. There are 10 condensers each of capacity 5 μF. The radio between maximum and minimum capacities obtained from these condenses will be

a) 25 : 5 b) 40 : 1 c) 60 : 3 d) 100 : 1

99. A non-conducting ring of radius 0.5 m carries total charge of 1.11×10^{-10} C distributed non-uniformly on its circumference producting an electric field everywhere in space.
The value of the line integral $\int_{l=\infty}^{l=0} -E.dl$ ($l = 0$ being centre of ring) in volt is
a) +2
b) −1
c) −2
d) Zero

100. In the circuit shown Fig, $C = 6$ μF. The charge stored in the capacitor of capacity C is


a) Zero b) 90 μC c) 40 μC d) 60 μC

101. In a region of space having a uniform electric field E, a hemispherical bowl of radius r is placed. The electric flux ϕ through the bowl is
a) $2\pi rE$ b) $4\pi r^2 E$ c) $2\pi r^2 E$ d) $\pi r^2 E$

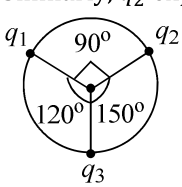
102. A spherical charged conductor has surface density of charge= σ, and electric field intensity on its surface is E. If radius of surface is doubled, point σ unchanged, what will be electric field intensity on the new sphere?
a) $E/2$ b) $2E$ c) $E/4$ d) E

103. Two identical parallel-plate capacitors are connected in series and then joined in series with a battery of 100 V. A slab of dielectric constant $K = 3$ is inserted between the plates of the first capacitor. Then, the potential difference across the capacitors will be, respectively,
a) 25 V, 75 V b) 75 V, 25 V c) 20 V, 80 V d) 50 V, 50 V

104. An air filled parallel plate capacitor has a capacity of 2pF. The separation of the plates is doubled and the interspace between the plates is filled with wax. If the capacity is increased to 6 pF, the dielectric constant of wax is
a) 2 b) 3 c) 4 d) 6

105. Two parallel-plate capacitors of capacitance C and $2C$ are connected in parallel and charged to potential difference V. The battery is then disconnected and the region between the plates of C is filled completely with a material of dielectric constant K. The common potential difference across the combination becomes
a) $\frac{2V}{K+2}$ b) $\frac{V}{K+2}$ c) $\frac{3V}{K+3}$ d) $\frac{3V}{K+2}$

106. An electron enters the space between the plates of a charged capacitor as shown. The charge density on the plate is σ. Electric intensity in the space between the plates is E.A uniform magnetic field Balso exists in the space perpendicular to the direction of E. The electron moves perpendicular to both **E** and **B** without any change in direction. The time taken by the electron to travel a distance l in the space is
a) $\frac{\sigma l}{\varepsilon_0 B}$ b) $\frac{\sigma B}{\varepsilon_0 l}$ c) $\frac{\varepsilon_0 lB}{\sigma}$ d) $\frac{\varepsilon_0 l}{\sigma B}$

107. There positive point charges q_1, q_2 and q_3 form an isolated system. Suppose the charges have generated a property due to which like charges also attract. The charges are moving along a circle with same speed maintaining angles as shown in the figure. The charge q_1 experiences a force f_1 due to other two charges. Similarly, q_2 experiences a force $f_2$and q_3, a force f_3 the ratio f_1: f_2: f_3 is


a) 1:1:1 b) q_1: q_2: q_3
c) 1:$\sqrt{3}$:2 d) This ratio cannot be calculated

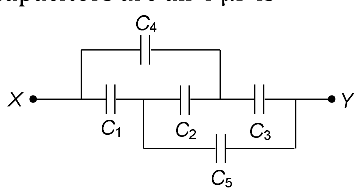
108. A 10 μF capacitor and a 20 μF capacitor are connected in series across 200 V supply line. The charged capacitors are then disconnected from the line and reconnected with their positive plates together and negative plates together and no external voltage is applied. What is the potential difference across each capacitor?

a) $\frac{800}{9}$ V b) $\frac{800}{3}$ V c) 400 V d) 200 V

109. Two large plates are given the charges as shown in Figure. Now, the left plate is earthed. Find the amount of charge that will flow from the earth to the plate

a) 14 μC b) −14 μC c) 7 μC d) −7 μC

110. The effective capacitance between points X and Y shown in figure. Assuming $C_2 = 10$ μF and that outer capacitors are all 4 μF is



a) 1 μF b) 3 μF c) 4 μF d) 5 μF

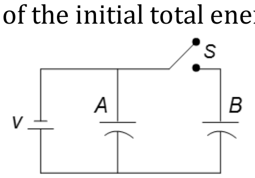
111. A spherical conductor A contains two spherical cavities. The total charge on the conductor itself is zero. However, there is a point charge q_b at the centre of one cavity and q_c at the Centre of the other. At considerable distance r away from the centre of the spherical conductor, there is another chargeq_d. Forces acting onq_b, q_c and q_d are F_1, F_2andF_3, respectively. [Assume all charges are positive]

a) $F_1 < F_2 < F_3$ b) $F_1 = F_2 < F_3$ c) $F_1 = F_2 > F_3$ d) $F_1 > F_2 > F_3$

112. Work done in carrying a charge Q' once round the circle of radius r with a charge Q at the centre is

a) $\frac{1}{4\pi\epsilon_0}\frac{Q}{r}$ b) $\frac{1}{4\pi\varepsilon_0}\frac{QQ'}{r}$ c) Zero d) $\frac{QQ'}{2r}$

113. Figure shows two identical parallel plate capacitors connected to a battery through a switch$S$. Initially, the switch is closed so that the capacitors are completely charged. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant 3. Find the ratio of the initial total energy stored in the capacitors to the final total energy stored.

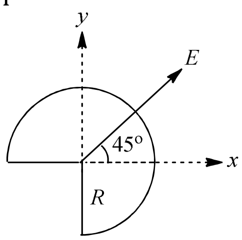


a) 9:16 b) 5:9 c) 2:3 d) 3:5

114. A 100 eV electron is projected directly towards a large metal plate that has surface charge density of -2.0×10^{-6} Cm^{-2}. From what distance must the electron be projected, if it is to just fail to strike that plate?

a) 0.44 mm b) 0.20 mm c) 1 mm d) 0.30 mm

115. One-fourth of a sphere of radius R is removed as shown (figure). An electric field E exists parallel to $x-y$ plane. Find the flux through the remaining curved part

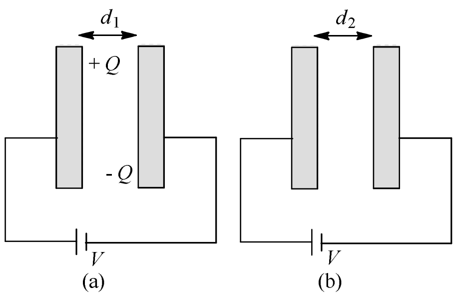


a) $\pi R^2 E$ b) $\sqrt{2}\pi R^2 E$ c) $\pi R^2 E\sqrt{2}$ d) None of these

116. If eight similar charge drops combine to form a bigger drop, then the ratio of capacitance of bigger drop to that of smaller drop will be

a) 2:1 b) 8:1 c) 4:1 d) 16:1

117. Consider a capacitor as shown in figure. If we pull the plates of capacitor apart to a final position as shown in Figure. Then we must perform some work against the electric force. For this situation, mark out the correct statement(s). [take area of plates as A]



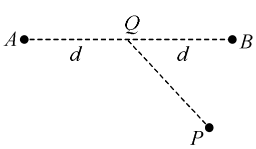
a) Work done is $\frac{Q^2}{2\varepsilon_0 A}(d_2-d_1)$ and is stored in volume $A(d_2-d_1)$

b) Work done is $+\frac{Q^2}{2\varepsilon_0 A}(d_2-d_1)$ and is stored in volumeAd_2

c) Work done is $+\frac{\varepsilon_0 AV^2}{2}\frac{(d_2-d_1)}{d_1 d_2}$and is stored in volume$A(d_2-d_1)$

d) Work done is $\frac{\varepsilon_0 AV^2}{2}\frac{(d_2-d_1)}{d_1 d_2}$and is stored in volume$Ad_2$

118. The work done in taking a unit positive charge from P to A is W_A and from P to B is W_B



Then

a) $W_A > W_B$ b) $W_A < W_B$ c) $W_A = W_B$ d) $W_A + W_B = 0$

119. A parallel-plate capacitor is connected across a battery. Now, keeping the battery connected, a dielectric slab is inserted between the plates. In this process,

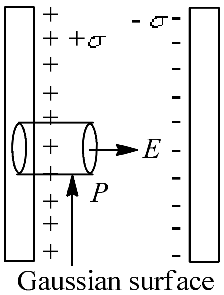
a) No work is done

b) Work is done by the battery and the stored energy increases

c) Work is done by the external agent and the stored energy decreases

d) Work is done by the battery as well as external agent but the stored energy does not change

120. Consider the situation show in Figure. we find electric filed E at point P using Gauss's law and it comes out to be $E=\sigma/\varepsilon_0$. this electric field is due to



a) All the amount of charges present on both the plates
b) All the charges present on positive plate only
c) Positive charge present only inside the Gaussian surface
d) Positive charge present inside the Gaussian surface plus equal magnitude of negative charge present on negative plate in front of Gaussian surface

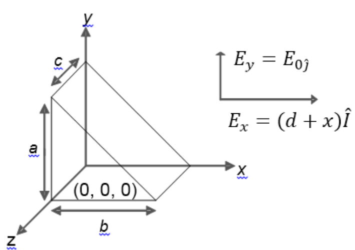
121. Two insulated metal spheres of adii 10 cm and 15 cm charged to a potential of 150V and 100 V respectively are connected by means of a metallic wire. What is the charge on the first sphere?

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

122. Two metallic spheres of radii 1 cm and 2 cm are given charges of 10^{-2} C and 5×10^{-2} C respectively. If these are connected by a conducting wire, the final charge on the smaller sphere is

a) 3×10^{-2} C b) 1×10^{-2} C c) 4×10^{-2} C d) 2×10^{-2} C

123. In the given electric field $\vec{E} = [a(d+x)\hat{\imath} + E_a\hat{\jmath}]$N/C; where $a = 1$N/C hypothetical closed surface is taken as shown in Figure.



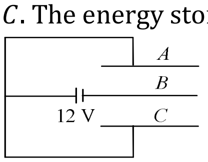
The total charge enclosed within the close surface is

a) $\frac{abc\varepsilon_0}{2}$ b) $\frac{acd\varepsilon_0}{2}$ c) $\frac{abd\varepsilon_0}{2}$ d) None of above

124. The work done in increasing the potential of a capacitor from V volt to $2V$ colt is W. Then, the work done in increasing the potential of the same capacitor from $2V$ volt to $4V$ volt will be

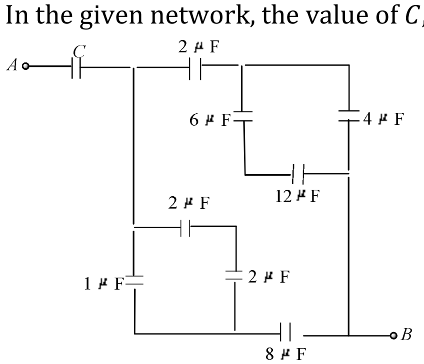
a) W b) $2W$ c) $4W$ d) $8W$

125. Three plates A, B, C each of area 50 cm^2 have separation 3 mm between A and B and 3 mm between B and C. The energy stored when the plates are fully charges is



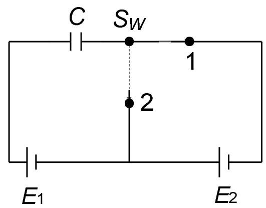
a) 6×10^{-9} J b) 3.12×10^{-9} J c) 2.12×10^{-9} J d) None of these

126. In the given network, the value of C, so that an equivalent capacitance between A and B is 3μF, is



a) 36μF b) 48μF c) $\frac{31}{5}$ μF d) $\frac{1}{5}$ μF

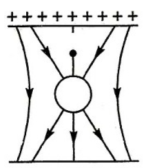
127. In the given circuit diagram (figure), switch S_W is shifted from position 1 to position 2. Then



a) A charge of amount CE_2 will be supplied to battery E_1
b) Heat generated in the circuit is $\frac{1}{2}CE_2^2$
c) A charge of amount CE_2 will be supplied by battery E_1
d) Heat generated in the circuit is $\frac{1}{2}CE_1E_2$

128. A 100 eV electron is fired directly towards a large metal plate having surface charge density -2×10^{-6} cm^{-2}. The distance from where the electrons be projected so that it just fails to strike the plate is
a) 0.22mm b) 0.44mm c) 0.66mm d) 0.88mm

129. An uncharged sphere of metal is placed inside a charged parallel plate capacitor. The lines of force will look like

a)  b) c) d)

130. If a charge is moved against the coulomb force of an electric field, then the
a) Positive work is done by the electric field
b) Energy is used from some outside source which does positive work
c) Strength of the field is decreased
d) Energy of the system is decreased

131. Two conducting spheres of radii r_1 and r_2 have same electric field near their surfaces. The ratio of their electrical potential is
a) r_1^2/r_2^2 b) r_2^2/r_1^2 c) r_1/r_2 d) r_2/r_1

132. Charges +q and –q are placed at points A and B respectively which are a distance $2L$ apart, C is the mid-point between A and B. The work done in moving a charge $+Q$ along the semicircle CRD is

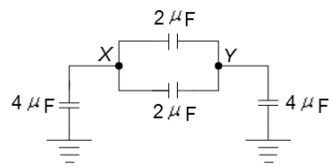
a) $\frac{qQ}{4\pi\varepsilon_0 L}$ b) $\frac{qQ}{2\pi\varepsilon_0 L}$ c) $\frac{qQ}{6\pi\varepsilon_0 L}$ d) $-\frac{qQ}{6\pi\varepsilon_0 L}$

133. The energy stored in a capacitor is in the form of
a) Kinetic energy b) Potential energy c) Elastic energy d) Magnetic energy

134. The work required to put the four charges at the corners of a square of side a, as shown in figure, is

a) $\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}$ b) $-\frac{2.6}{4\pi\varepsilon_0}\frac{q^2}{a}$ c) $+\frac{2.6}{4\pi\varepsilon_0}\frac{q^2}{a}$ d) None of these

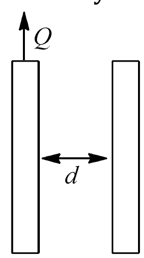
135. In the circuit shown (figure). The equivalent capacitance between the points X and Y is



a) 2 μF　b) 3 μF　c) 4 μF　d) 5 μF

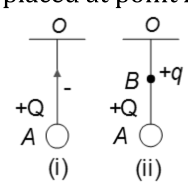
136. An electron is released from rest in a region of space with a non-zero electric field. Which of the following statements is true?
a) The electron will begin moving towards a region of higher potential
b) The electron will begin moving towards a region of lower potential
c) The electron will begin moving along a line of constant potential
d) Nothing can be concluded unless the direction of the electric field is known

137. Two parallel conducting plates, each of area$A$, are separated by a distance$d$. Now, the left plate is given a positive charge$Q$. A positive charge q of mass m is released from a point near the left plate. Find the time taken by the charge to reach the right plate



a) $\sqrt{\frac{3dm\varepsilon_0 A}{qQ}}$　b) $\sqrt{\frac{4dm\varepsilon_0 A}{qQ}}$　c) $\sqrt{\frac{2dm\varepsilon_0 A}{qQ}}$　d) None of these

138. The time period of simple pendulum of charged bob is T as shown in Figure. Now a massless charge q is placed at point B and time period of oscillation is T', then

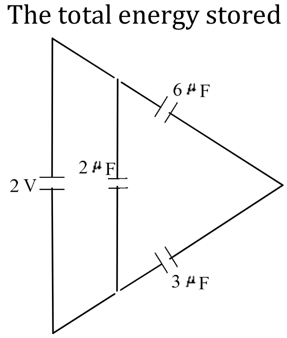


a) $T' > T$　b) $T < T$　c) $T' = T$　d) Cannot say

139. The electric flux for Gaussian surface A that encloses the charged particles in free space. (Given, $q_1 = -14$ nC, $q_2 = 78.85$ nC, $q_3 = -56$ nC)
a) $10^3 \text{Nm}^2\text{C}^{-1}$　b) $10^3 \text{CN}^{-1}\text{m}^{-2}$
c) $6.32 \times 10^3 \text{ Nm}^2\text{C}^{-1}$　d) $6.32 \times 10^3 \text{ CN}^{-1}\text{m}^{-2}$

140. The maximum field intensity on the axis of a uniformly charged ring of charge q and radius R will be
a) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{3\sqrt{3}R^2}$　b) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{2q}{3R^2}$　c) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{2q}{3\sqrt{3}R^2}$　d) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{3q}{3\sqrt{3}R^2}$

141. The total energy stored in the condenser system shown in the figure will be

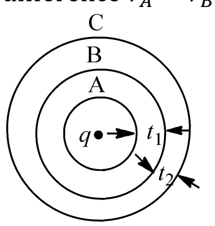


a) 2 μJ　b) 4 μJ　c) 8 μJ　d) 16 μJ

142. Identify the wrong statement.
a) The electrical potential energy of a system of two protons shall increase if the separation between the

two is decreased.
b) The electrical potential energy of a proton-electron system will increase if the separation between the two is decreased.
c) The electrical potential energy of a proton-electron system will increase if the separation between the two is increased.
d) The electrical potential energy of system of two electrons shall increase if the separation between the two is decreased.

143. Figure shows three spherical and equipotential surfaces A, B and C round a point charge q. The potential difference $V_A - V_B = V_B - V_C$. If t_1 and t_2 be the distance between them. Then



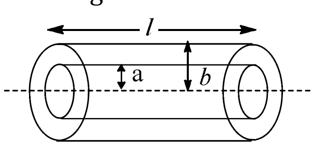
a) $t_1 = t_2$ b) $t_1 > t_2$ c) $t_1 < t_2$ d) $t_1 \leq t_2$

144. A spring block system undergoes vertical oscillations above a large horizontal metal sheet with uniform positive charge the time period of the oscillation is T. If the block is given a charge Q. Its time period of oscillation will be
a) T
b) $> T$
c) $< T$
d) $> T$ if Q is + ve and $< T$ if Q is –ve

145. A technician has only two capacitors. By using these singly, in series or in parallel he can obtain capacitances of 3 μF, 4 μF, 12 μF and 16 μF. The capacitances of these capacitors are
a) 6 μF and 10 μF b) 4 μF and 12 μF c) 7 μF and 9 μF d) 4 μF and 16 μF

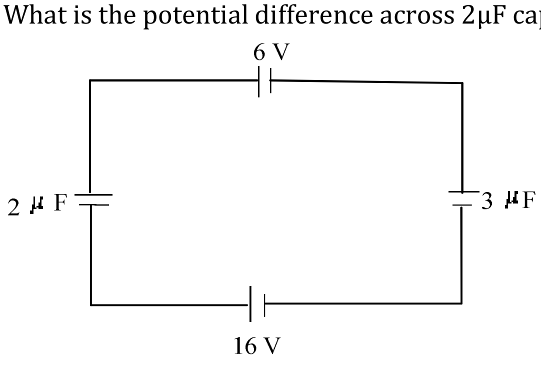
146. Potential energy of two equal negative point charges 2μC each held 1 m apart in air is
a) 2 J b) 2 eV c) 4 J d) 0.036 J

147. The magnitude of electric field $\vec{E}$ in the annual region of a charged cylindrical capacitor



a) Is same throughout
b) Is higher near the outer cylinder than near the inner cylinder
c) Varies as $\frac{1}{r}$, where r is the distance from the axis
d) Varies as $\frac{1}{r^2}$, where r is the distance from the axis

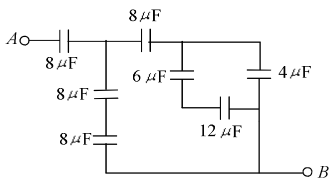
148. What is the potential difference across 2μF capacitor in the circuit shown?

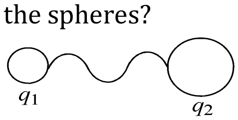


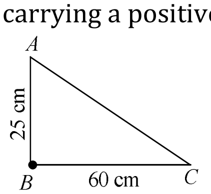
a) 12 V b) 4 V c) 6 V d) 18 V

149. The potential gradient at which dielectric of the condenser just gets punctured is called
a) Dielectric constant b) Dielectric strength c) Dielectric resistance d) Dielectric number

150. Five Styrofoam balls are suspended from insulating threads. Several experiments are performed on the balls and the following observations are made:
(i)Ball A repels C and attracts B

(ii)Ball D attracts B and has no effect on$E$
(iii)A negatively charged rod attracts both A and$E$
An electrically neutral Styrofoam ball gets attracted if placed nearby a charged body due to induced charge. What are the charges, if any, on each ball A, B, C, D and E?
a) $++-+0+$ b) $+-++0$ c) $+-+00$ d) $-+-00$
151. Mark out the correct statement about the electric lines of force
a) The number of lines of force leaving a +ve charge or entering a –ve charge is proportional to the magnitude of charge
b) The path of a charge particle in an electric field is not always along the field lines
c) The direction of electric lines of force is along the normal to the equipotential surface
d) All of the above
152. The equivalent capacitance across AB Fig is


a) 8 μF b) 12 μF c) 4 μF d) 24 μF
153. A large insulated sphere of radius r charged with Q units of electricity is placed in contact with a small insulated uncharged sphere of radius r' and in then separated. The charge on smaller sphere will now be
a) $Q(r+r')$ b) $\frac{Qr'}{r'+r}$ c) $Q(r-r')$ d) $\frac{Q}{r'+r}$
154. The plates of a parallel plate capacitor are charged up to 100 V. A 2 mm thick plate is inserted between the plates, then to maintain the same potential difference, the distance between the capacitor plated is increase by 1.6 mm. the dielectric constant of the plate, is
a) 5 b) 1.25 c) 4 d) 2.5
155. Capacitor of a capacitor is 48μF. When it is charged from 0.1 C to 0.5 C , change in the energy stored is
a) 2500 J b) 2.5×10^{-3} J c) 2.5×10^{6} J d) 2.42×10^{-2} J
156. Two spherical conductors of radii R_1 and R_2 are separated by a distance much larger than the radius of the either sphere. The spheres are connected by a conducting wire as shown in Fig. If the charges on the spheres in equilibrium are $q_1$and q_2, respectively, what is the ratio of the field strength at the surfaces of the spheres?


a) R_2/R_1 b) R_2^2/R_1^2 c) R_1/R_2 d) R_1^2/R_2^2
157. Two spheres of radii R_1 and R_2 joined by a fine wire are raised to a potential V. Let the surface charge densities at these two spheres be σ_1 and σ_2 respectively. Then the ratio $\frac{\sigma_2}{\sigma_1}$ has a value
a) $\frac{R_1}{R_2}$ b) $\frac{R_2}{R_1}$ c) 1 d) $\left(\frac{R_2}{R_1}\right)^2$
158. $ABC$is a right-angled triangle, where AB and BC are 25 and 60 cm, respectively. A metal sphere of 2 cm radius charged to a potential of 9×10^5 volt is placed at B as in Fig. Find the amount of work done in carrying a positive charge of 1 coulomb from C to A


a) 21 kJ b) 42 kJ c) 14 kJ d) 52 kJ
159. Mark out the correct statement(s).
a) Capacitance of an isolated sphere depends on its charge
b) Capacitance of a non-isolated sphere depends only on its shape and size

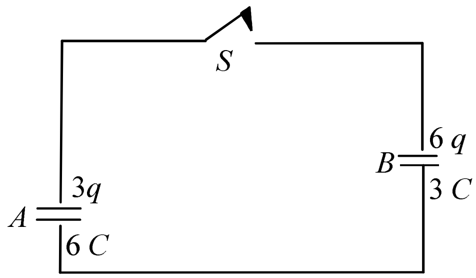
c) Capacitance of a non-isolated sphere Is increased because of the presence of other conducting bodies nearby it

d) Capacitance of a conductor cannot be affected because of the presence of other conducting bodies nearby it

160. A ring of radius R carries a charge $+q$. A test charge $-q_0$ is released on its axis at a distance from its centre. How much kinetic energy will be acquired by the test charge when it reaches the centre o the ring?

a) $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{R}$ b) $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{2R}$ c) $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{\sqrt{3}R}$ d) $\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{3R}$

161. In given circuit when switch S has been closed then charge on capacitor A and B respectively are

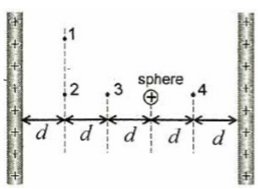


a) $3q$,$6q$ b) $6q$,$3q$ c) $4.5\ q$, $4.5\ q$ d) $5q$,$4q$

162. The ratio of momenta of an electron and proton which are accelerated from rest by a potential difference 50 V is

a) $\frac{m_e}{m_p}$ b) $\sqrt{\frac{m_e}{m_p}}$ c) $\frac{m_p}{m_e}$ d) $\sqrt{\frac{m_p}{m_e}}$

163. The figure shows two large, closely placed, parallel, non-conducting sheets with identical (positive) uniform surface charge densities, and a sphere with a uniform (positive) volume charge density. Four points marked as 1, 2, 3 and 4 are shown in the space in between. If $E_1, E_2, E_3$and E_4 are magnitude of net electric fields at these points, respectively, then



a) $E_1 > E_2 > E_3 > E_4$ b) $E_1 > E_2 > E_3 = E_4$ c) $E_3 = E_4 > E_2 > E_1$ d) $E_1 = E_2 = E_3 = E_4$

164. A parallel plate capacitor is made by stocking n equally spaced plates connected alternately. If the capacitance between any two plates is x, then the total capacitance is,

a) nx b) n/x c) nx^2 d) $(n-1)x$

165. The electric potential decreases uniformly from 120 V to 80 V as one moves on the X-axis from $x = -1$ cm to $x = +1$ cm. The electric field at the origin

a) Must be equal to 20 Vcm^{-1}
b) Must be equal to 20 Vm^{-1}
c) May be greater than 20 Vcm^{-1}
d) May be less than 20 Vcm^{-1}

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

a) 12 J b) 9 J c) 24 J d) Zero

167. Two positive point charges of 12 μ C and 8 μC are placed 10 cm, apart in air. The work done to bring them 4 cm closer is

a) Zero b) 3.5 J c) 4.8 J d) 5.8 J

168. A parallel plate capacitor is made by stacking n equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is C, then the resultant capacitance is

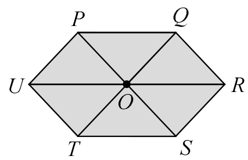
a) $(n-1)C$ b) $(n+1)C$ c) C d) nC

169. The distance between the plates of a parallel-plate capacitor is d. A metal plate of thickness $d/2$ is placed

between the plates. What will be its effect on the capacitance?

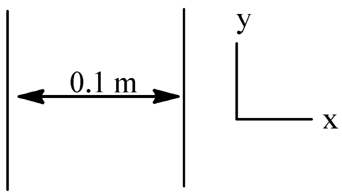
a) Capacitance will be halved
b) Capacitance will be doubled
c) Capacitance will not change
d) Capacitance will be become 1.5 times original

170. 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 charges is possible for P, Q, R, S, T and U respectively?



a) $+,-,+,-,-,+$
b) $+,-,+,-,+,-$
c) $+,+,-,+,-,-$
d) $-,+,+,-,+,-$

171. Two insulating plates are both uniformly charged in such a way that the potential difference between them is $V_2 - V_1 = 20\text{V}$. (*ie*, plate 2 is at a higher potential). The plates are separated by $d = 0.1\text{m}$ and can be treated as infinitely large. An electron is released from rest on the inner surface of plate 1. What is its speed when it hits plate 2? (e=1.6$\times 10^{-19}$C, $m_0 = 9.11 \times 10^{-31}$kg)



a) $2.65 \times 10^6 \text{ ms}^{-1}$
b) $7.02 \times 10^{12} \text{ ms}^{-1}$
c) $1.87 \times 10^6 \text{ ms}^{-1}$
d) $32 \times 10^{-19} \text{ ms}^{-1}$

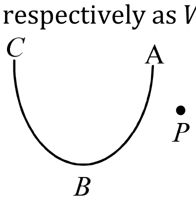
172. The electric potential V at any point x, y, z (all the metre) in space is given by $V = 4x^2$ volt. The electric field at the point (1m, 0, 2m) in Vm^{-1} is

a) $-8\hat{i}$
b) $+8\hat{i}$
c) $-16\hat{i}$
d) $16\hat{k}$

173. Two identical parallel plate capacitors are placed in series and connected to a constant voltage source of V volt. If one of the capacitor is completely immersed in a liquid of dielectric constant K, then the potential difference between the plates of the other capacitor will change to

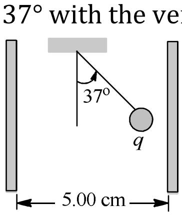
a) $\frac{K}{K+1}V$
b) $\frac{K+1}{K}$
c) $\frac{2K}{K+1}V$
d) $\frac{K+1}{2K}V$

174. In the following diagram the work done in moving a point charge from point P to point A, B and C is respectively as W_A, W_B and W_C then



a) $W_A = W_B = W_C$
b) $W_A = W_B = W_C = 0$
c) $W_A > W_B > W_C$
d) $W_A < W_B < W_C$

175. A small sphere with mass 1.2 g hangs by a thread between two parallel vertical plates 5.00 cm apart. The plates are insulating and have uniform surface charge densities $+\sigma$ and $-\sigma$. The charge on the sphere is $q = 9 \times 10^{-6}$C. What potential difference between the plates will cause the thread to assume an angle of 37° with the vertical as shown in Fig?



a) 30 V
b) 12 V
c) 50 V
d) 25 V

176. A charged particle of mass $m = 2$kg and charge 1μC is projected from a horizontal ground at an angle $\theta = 45°$ with speed $10 ms^{-1}$. In space, a horizontal electric field towards the direction of projection

$E = 2 \times 10^7\ NC^{-1}$ exists. The range of the projection is

a) 20 m b) 60 m c) 200 m d) 180 m

177. In the above question, if the capacitors were connected in series, find the potential difference (in V) across each capacitor

a) $\frac{300}{13}, \frac{600}{13}, \frac{400}{13}$ b) $\frac{600}{13}, \frac{300}{13}, \frac{400}{13}$ c) $\frac{300}{13}, \frac{400}{13}, \frac{600}{13}$ d) $\frac{600}{13}, \frac{400}{13}, \frac{300}{13}$

178. Three plates of common surface area A are connected as shown. The effective capacitance will be

a) $\frac{\varepsilon_0 A}{d}$ b) $\frac{3\varepsilon_0 A}{d}$ c) $\frac{3}{2}\frac{\varepsilon_0 A}{d}$ d) $\frac{2\varepsilon_0 A}{d}$

179. A square of side $a$has charge Qat its centre and charge q at one of the corners. The work required to be done in moving the charge q from the corner to the diagonally opposite corner is

a) Zero b) $\frac{Qq}{4\pi\varepsilon_0 a}$ c) $\frac{Qq\sqrt{2}}{4\pi\varepsilon_0 a}$ d) $\frac{Qq}{2\pi\varepsilon_0 a}$

180. Two condensers, one of capacity C and the other of capacity $\frac{C}{2}$, are connected to a V volt battery , as shown. The work done in charging fully both the condensers is

a) $2CV^2$ b) $\frac{1}{4}\ CV^2$ c) $\frac{3}{4}CV^2$ d)

181. A charge q is fixed. Another charge Q is brought near it and rotated in a circle of radius r around it. Work done during rotation is

a) Zero b) $\frac{Qq}{4\pi\varepsilon_0 r}$ c) $\frac{Qq}{2\pi\varepsilon_0 r}$ d) None of these

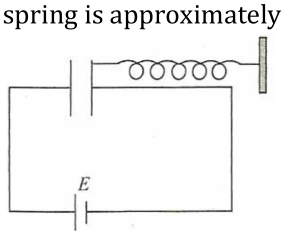
182. Two metal spheres (radii r_1, r_2 with$r_1 < r_2$) are very far apart but are connected by a thin wire. If their combined charge is Q, then what is their common potential?

a) $kQ/(r_1 + r_2)$ b) $kQ/(r_1 - r_2)$ c) $-kQ(r_1 + r_2)$ d) $-kQ/r_1 r_2$

183. Find the potential V of an electrostatic field $\vec{E} = a(y\hat{\imath} + x\hat{\jmath})$, where a is a constant

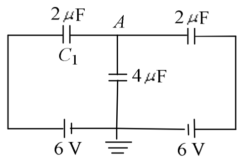
a) $axy + C$ b) $-axy + C$ c) axy d) $-axy$

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



a) $\frac{125}{32}\frac{\varepsilon_0 AE^2}{d^3}$ b) $\frac{2\varepsilon_0 AE^2}{d^3}$ c) $\frac{6\varepsilon_0 E^2}{Ad^2}$ d) $\frac{\varepsilon_0 AE^3}{2d^3}$

185. Three capacitors are connected as shown in Fig. Then, the charge on capacitor C_1 is

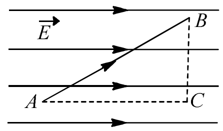


a) 6 μC b) 12 μC c) 18 μC d) 24 μC

186. 1000 similar electrified rain drops merge together into one drop so that their total charge remains unchanged. How is the electric energy affected?

a) 100 times b) 102 times c) 200 times d) 400 times

187. An electron is taken from point A to point B along the path AB in a uniform electric field of intensity $E = 10\ \text{Vm}^{-1}$. Side $AB = 5$ m and side $BC = 3$ m. Then, the amount of work done on electron by us is



a) 50 eV b) 40 eV c) −50 eV d) −40 eV

188. An infinite line charge produces a field of $9 \times 10^4\ \text{NC}^{-1}$ at a distance of 2 cm. the linear density is

a) $2 \times 10^{-7}\ \text{Cm}^{-1}$ b) $10^{-7}\ \text{Cm}^{-1}$ c) $9 \times 10^4\ \text{Cm}^{-1}$ d) None of these

189. Charge Q is given a displacement $\vec{r} = a\hat{\imath} + b\hat{\jmath} =$ in an electric field $\vec{E} = E_1\hat{\imath} + E_2\hat{\jmath}$. The work done is

a) $Q(E_1a + E_2b)$ b) $Q\sqrt{(E_1a)^2 + (E_2b)^2}$

c) $Q(E_1 + E_2)\sqrt{a^2 + b^2}$ d) $Q\sqrt{(E_1^2 + E_2^2)^2}\sqrt{a^2 + b^2}$

190. A ball of mass 1 g carrying a charge 10^{-8}C moves from a point A at potential 600 V to a point B at zero potential. The change in its K.E. is

a) -6×10^{-6}erg b) -6×10^{-6}J c) 6×10^{-6}J d) 6×10^{-6} erg

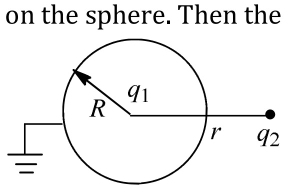
191. An insulated conductor initially free from charge is charged by repeated contacts with a plate which after each contact is replenished to a charge Q from an electrophorus. If q is the charge on the conductor after the first operation, find the maximum charge which can be given to the conductor in this way

a) $\frac{Qq}{Q+q}$ b) $\frac{3Qq}{2Q+q}$ c) $\frac{Qq}{Q-q}$ d) $\frac{2Qq}{Q+q}$

192. The energy required to charge a parallel plate condenser of plate separation d and plate area of cross-section A such that uniform electric field between the plates is E,is

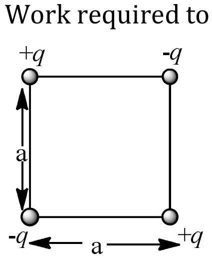
a) $\frac{1}{2}\frac{\varepsilon_0E^2}{Ad}$ b) $\frac{\varepsilon_0E^2}{Ad}$ c) ε_0E^2Ad d) $\frac{1}{2}\varepsilon_0E^2Ad$

193. A conducting spherical shell is earthed. A positive charge $+q_1$ is placed at the centre and another small positive charge $+q_2$ is placed at a distance r from q_1(figure). Ignore the effect of induced charge due to q_2 on the sphere. Then the coulomb force on q_2 is



a) Zero b) $\frac{q_1q_2}{4\pi\varepsilon_0r^2}$ c) $\frac{q_1q_2}{4\pi\varepsilon_0(r-R^2)}$ d) $\frac{q_1q_2}{4\pi\varepsilon_0(r^2-R^2)}$

194. Work required to set up the four charge configuration (as shown in the figure) is

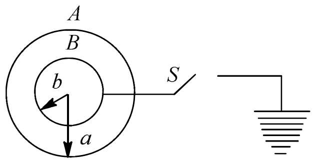


a) $-0.21\text{q}^2/\varepsilon_0\text{a}$ b) $-1.29\text{q}^2/\varepsilon_0\text{a}$ c) $-1.41\text{q}^2/\varepsilon_0\text{a}$ d) $+2.82\text{q}^2/\varepsilon_0\text{a}$

195. A battery is used to charge a parallel plate capacitor till the potential difference between the plates becomes equal to the electromotive force of the battery. The ratio of the energy stored in the capacitor and the work done by the battery will be

a) 1 b) 2 c) ¼ d) ½

196. Consider two concentric metal spheres. The outer sphere is given a charge $Q > 0$, then



a) The electrons will flow from earth to inner sphere is S is shorted

b) The electrons will flow from inner sphere to the earth if $S$is shorted

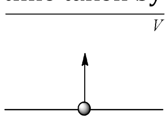
c) The shorting of S will produce a charge of – Q on the inner sphere

d) None o the above

197. A particle A has charge $+q$ and particle B has charge $+4q$ with each of them having the save mass m. when allowed to fall from rest through the same electrical potential difference, the ration of their steeds v_A/v_B will become

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

198. An electron having charge e and mass m starts from the lower plate of two metallic plates separated by a distance d. If potential difference between the plates is V, the time taken by the electron to reach the upper plate is given by



a) $\sqrt{\frac{2md^2}{eV}}$ b) $\sqrt{\frac{md^2}{eV}}$ c) $\sqrt{\frac{md^2}{2eV}}$ d) $\frac{2md^2}{eV}$

199. A cylindrical capacitor has charge Q and length L. If both the charge and length of the capacitors are doubled, by keeping other parameters fixed, the energy stored in the capacitor

a) Remains same b) Increases two times c) Decreases two times d) Increase four time

200. Three capacitors of capacitance C(μF) are connected in parallel to which a capacitor of capacitance C is connected in series. Effective capacitance is 3.75, then capacity of each capacitor is

a) 4 μF b) 5 μF c) 6 μF d) 8 μF

201. The work done in placing a charge of 8×10^{-18}C on a condenser of capacity 100μF is

a) 16×10^{-32} J b) 3.1×10^{-26}J c) 4×10^{-10}J d) 32×10^{-32}J

202. Minimum number of 8μF and 250 V capacitors are used to make a combination 16μF and 1000 V are

a) 4 b) 32 c) 8 d) 3

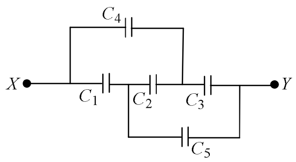
203. Two identical metal plates are given positive charges Q_1 and $Q_2(< Q_1)$ respectively. If they are now brought close together to form a parallel plates capacitor with capacitance C, the potential difference between them is

a) $\frac{Q_1 + Q_2}{2C}$ b) $\frac{Q_1 + Q_2}{C}$ c) $\frac{Q_1 - Q_2}{C}$ d) $\frac{Q_1 - Q_2}{2C}$

204. A spherical capacitor has an inner sphere of radius 12 cm and an outer sphere of radius 13 cm. The outer sphere is earthed and the inner sphere is given a charge of 2.5 μC. The space between the concentric spheres is filled with a liquid of dielectric constant 32. Determine the potential of the inner sphere

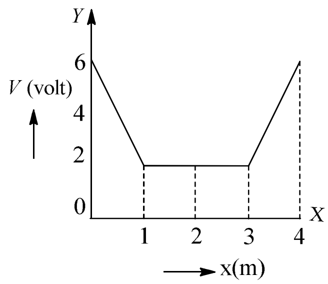
a) 400 V b) 450 V c) 500 V d) 300 V

205. The effective capacitance between points X and Y in Fig, assuming $C_2 = 10$ μF and that outer capacitors are all 4 μF each, is



a) 1 μF b) 3 μF c) 4 μF d) 5 μF

206. The variation of electric potential with distance from a fixed point is shown in figure. What is the value of electric field at x=2 m.



a) Zero b) 6/2 c) 6/1 d) 6/3

207. C, V, U and Q are capacitance, potential difference, energy stored and charge of a parallel plate capacitor respectively. The quantities that increase when a dielectric slab is introduced between the plates without disconnecting the battery are

a) V and C b) V and U c) U and Q d) V and Q

208. Three capacitors each of capacitance 1 μF are connected in parallel. To the combination, a fourth capacitor of capacitance 1 μF is connected in series. The resultant capacitance of the system is

a) 4 μF b) (4/3)μF c) 2 μF d) (3/4)μF

209. $ABCD$ is a rectangle. At corners B, C and D of the rectangle are placed charges $+10 \times 10^{-10}$C, -20×10^{-12}C, and 10×10^{-12}C, respectively. Calculate the potential at the fourth corner. (The side AB=4cm and BC=3cm)

a) 1.65 V b) 0.165V c) 16.5V d) 2.65V

210. The electric potential In a certain region of space is given by $V = -3x^2 + 4x$, where x is in metres and V is in volts. In this region, the equipotential surfaces are

a) Planes parallel to XY plane b) Planes parallel to YZ plane
c) Concentric cylinders with axis as x-axis d) Concentric spheres centered at origin

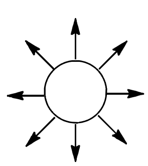
211. If a conductor is electrically neutrally, then

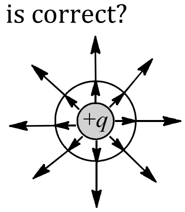
a) Net charge on it should be zero b) Potential on it should be zero
c) Both charge and potential should be zero d) None of them may not be zero

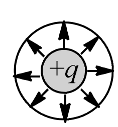
212. A charge particle moves in a circle around an infinite line charge with the centre of circle at the line and line being perpendicular to the plane o circle. Let r be the radius of circle. The velocity of the particle depends upon which power of r

a) 1 b) 2 c) -1 d) None of these

213. If a point charge q is placed at a point inside a hollow conducting sphere, then which of the following electric lines of force pattern is correct?

a) 

b) 

c) 

d) None of these

214. Two charged spheres of radii R_1 and R_2 having equal surface charge density. The ratio of their potential is

a) R_1/R_2 b) R_2/R_1 c) $\left(\frac{R_1}{R_2}\right)^2$ d) $\left(\frac{R_2}{R_1}\right)^1$

215. The capacitance C of a capacitor is

a) Independent of the charge and potential of the capacitor

b) Dependent on the charge and independent of potential
c) Independent of the geometrical configuration of the capacitor
d) Independent of the dielectric medium between the two conducting surface of the capacitor

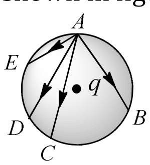
216. Two capacitors each of capacity 2μF are connected in parallel. If they are connected to 100 V battery ,then energy stored in them is
a) 0.02 J b) 0.04 J c) 0.01 J d) 200 J

217. In the above question, the potential of point A is
a) 3 V b) 6 V c) 9 V d) Zero

218. When a dielectric slab is introduced between the plates of an isolated charged capacitor, it
a) Increases the capacitance of the capacitor
b) Decreases the electric field between the plates
c) Decreases the amount of energy stored in the capacitor
d) All of the above

219. A parallel-plate capacitor is charged and then isolated. What is the effect of increasing the plate separation on charge, potential and capacitance, respectively?
a) Constant, decreases, decreases b) Increases, decreases, decreases
c) Constant, decreases, increase d) Constant, increases, decreases

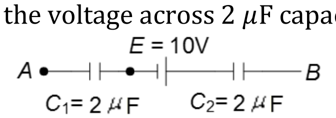
220. In the electric field of a point charge q, a certain point charges is carried from point A to B, C, D and E as shown in figure. The work done is



a) Least along the path AE b) Least along the path AC
c) Zero along any one of the paths d) Least along AB

221. Two point charges of $+Q$ each have been placed at the positions $(-a/2,0,0)$ and $(a/2,0,0)$. The locus of the points where – Q charge can be placed such that total electrostatic potential energy of the system can become equal to zero, can be represented by which of the following equations?
a) $z^2 + (y-a)^2 = 2a$ b) $z^2 + (y-a)^2 = 27a^2/4$
c) $z^2 + y^2 = 15a^2/4$ d) None

222. A circuit has a section AB (figure). Potential difference between points A and B (i.e. $V_A - V_B$) equals 5 V. the voltage across 2 μF capacitor is



a) 5 V b) 10 V c) 15 V d) Zero

223. A spherical charged conductor has surface density of charge as σ. The electric field intensity on its surface is E. If the radius of surface is doubled, keeping σ unchanged, what will be the electric field intensity on the new sphere?
a) $E/2$ b) $E/4$ c) $2E$ d) E

224. Two identical capacitors each of capacitance 5μF are charged to potentials 2kV and 1kV respectively. Their –ve ends are connected together. When the +ve ends are also connected together, the loss of energy of the system is
a) 160 J b) Zero c) 5 J d) 1.25 J

225. Two charged particles having charges 1 and −1μC and of mass 50 g each are held at rest while their separation is 2 m. Now the charges are released. Find the speed of the particles when their separation is 1 m
a) $\frac{1}{5}$ m/s b) $\frac{3}{5}$ m/s c) $\frac{3}{10}$ m/s d) $\frac{2}{7}$ m/s

226. 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. The charges shown are after earthing.

Select the correct alternative

a) $q_1 + q_3 = -q_2$ b) $q_1 = -q_2$ c) $\frac{q_3}{q_2} = -\frac{1}{3}$ d) None of these

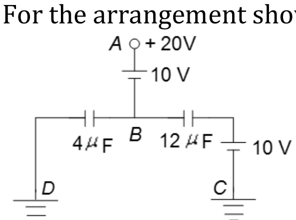
227. Each capacitor shown in figure is 2 μF. Then the equivalent capacitance between points A and B is

a) 2 μF b) 4 μF c) 6 μF d) 8 μF

228. A sphere of radius 1 m encloses a charge of 5 μC. Another charge of -5 μC is placed inside the sphere. The net electric flux would be

a) Double b) Four times c) Zero d) None of these

229. For the arrangement shown in Figure, identify the correct statement



a) The charge on the 12 μF capacitor is zero b) The charge on the 12 μF capacitor is 30 μC
c) The charge on the 4 μF capacitor is 30 μC d) None of these

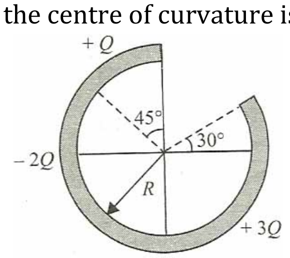
230. 27 identical drops of mercury are charged simultaneously to the same potential of 10 V each. Assuming drops to be spherical, if all the charged drops are made to combine to form one large drop, then the potential of larger drop would be

a) 45 V b) 135 c) 270 V d) 90 V

231. A ball of mass 1 carrying a charge 10^{-8} Cmoves from a point A at potential 600 V to a point Bat zero potential. The change in its KE is

a) -6×10^{-6} erg b) -6×10^{-6} J c) 6×10^{-6} J d) 6×10^{-6} erg

232. Figure shows three circular arcs, each of radius R and total charge a indicated. The net electric potential at the centre of curvature is



a) $\frac{Q}{2\pi\varepsilon_0 R}$ b) $\frac{Q}{4\pi\varepsilon_0 R}$ c) $\frac{2Q}{\pi\varepsilon_0 R}$ d) $\frac{Q}{\pi\varepsilon_0 R}$

233. The electric potential at the surface of an atomic nucleus ($Z = 50$) of radius of 9×10^{-15} m is

a) 80 V b) 8×10^6V c) 9V d) 9×10^5V

234. Capacitance of a parallel plate capacitor becomes $\frac{4}{3}$ times its original value, if a dielectric slab of thickness $t = \frac{d}{2}$ is inserted between the plates [d is the separation between the plates]. The dielectric constant of the slab is

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

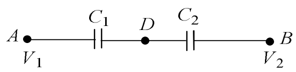
235. The electric potential at any point x, y, z in meters is given by $V = 3x^2$. The electric field at a point (2,0,1) is

a) $12\ \text{Vm}^{-1}$ b) $-6\ \text{Vm}^{-1}$ c) $6\ \text{Vm}^{-1}$ d) $-12\ \text{Vm}^{-1}$

236. A parallel-plate capacitor is charged and then disconnected from the source of potential difference. If the plates of the condenser are then moved farther apart by the use of insulated handle, which one of the following is true?

a) The charge on the capacitor increases
b) The charge on the capacitor decreases
c) The capacitance of the capacitor increases
d) The potential difference across the plates increases

237. Two condensers C_1 and C_2 in a circuit are joined as shown in Fig. The potential of point A is V_1 and that of B is V_2. The potential of point D will be



a) $\frac{1}{2}(V_1 + V_2)$ b) $\frac{C_1V_2 + C_2V_1}{C_1 + C_2}$ c) $\frac{C_1V_1 + C_2V_2}{C_1 + C_2}$ d) $\frac{C_2V_1 - C_1V_2}{C_1 + C_2}$

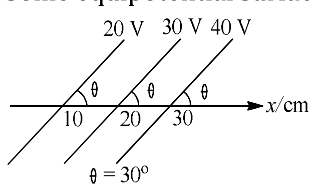
238. In a parallel plate capacitor , the capacity increases if

a) Area of the plate is decreased b) Distance between the plates increases
c) Area of the plate is increased d) Dielectric constant decrease

239. The electric potential at centre of metallic conducting sphere is

a) Zero b) Half from potential at surface of sphere
c) Equal from potential at surface of sphere d) Twice from potential at surface of sphere

240. Some equipotential surfaces are shown in Fig. The magnitude and direction of the electric field is



a) 100Vm^{-1} making angle 120° with the x-axis b) $200\ \text{Vm}^{-1}$ making angle 60° with the x-axis
c) 200Vm^{-1} making angle 120° with the x-axis d) None of the above

241. A thin spherical conducting shell of radius R has a charge q. Another charge Q is placed at the centre of the shell. The electrostatic potential at a point P at a distance $R/2$ from the centre of the shell is

a) $\frac{2Q}{4\pi\varepsilon_0 R}$ b) $\frac{2Q}{4\pi\varepsilon_0 R} - \frac{2q}{4\pi\varepsilon_0 R}$ c) $\frac{2Q}{4\pi\varepsilon_0 R} + \frac{q}{4\pi\varepsilon_0 R}$ d) $\frac{(q+Q)}{4\pi\varepsilon_0}\frac{2}{R}$

242. The plates of a parallel-plate capacitor have an area of 90 cm^2 each and are separately by 2 mm. The capacitor is charged by connecting it to a 400 V supply. Then the energy density of the energy stored (in Jm^{-3}) in the capacitor is
(Take $\varepsilon_0 = 8.8 \times 10^{-12}\text{Fm}^{-1}$)

a) 0.113 b) 0.117 c) 0.152 d) None of these

243. Two insulated charged conducting spheres of radii 20 cm and 15 cm respecting and having an equal charge of 10 μC are connected by a copper wire and then they are separated. Then

a) Both spheres will have equal charges b) Surface charge density on the 20 cm sphere will be greater than that on the 15 cm sphere
c) Surface charge density on the 15 cm sphere will be greater than that on the 20 cm sphere d) Surface charge density on the two sphere will be equal

244. A parallel plate capacitor or capacity C_0 is charged to a potential V_0.

I. The energy stored in the capacitor when the battery is disconnected and the plate separation is doubled is E_1.
II. The energy stored in the capacitor when the charging battery is kept connected and the separation between the capacitor plates is doubled is E_2. Then $\frac{E_1}{E_2}$ value is

a) $\frac{4}{1}$ b) $\frac{3}{2}$ c) 2 d) $\frac{1}{2}$

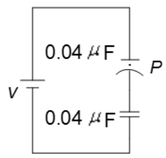
245. A capacitor of capacitance C is charged to a potential V. The flux of the electric field through a closed surface enclosing the capacitor is.

a) $\frac{CV}{\varepsilon_0}$ b) $\frac{2CV}{\varepsilon_0}$ c) $\frac{CV}{2\varepsilon_0}$ d) Zero

246. n Small drops of same size are charged to V volt each. If they coalesce to form a single large drop, then its potential will be

a) Vn b) Vn^{-1} c) $Vn^{1/3}$ d) $Vn^{2/3}$

247. The particle P shown in the figure has a mass of 10 mg and a charge of -0.01μC. Each plate has a surface area $10^{-2}m^2$ on one side. What potential difference V should be applied to the combination to hold the particle P in equilibrium?



a) 43 mV b) 35 mV c) 50 mV d) 55 mV

248. A hollow charged metal sphere has radius r. If the potential difference between its surface and a point at a distance $3r$ from the centre is V, then electric field intensity at a distance $3r$ is

a) $\frac{V}{2r}$ b) $\frac{V}{3r}$ c) $\frac{V}{6r}$ d) $\frac{V}{4r}$

249. Two concentric spheres of radii R and r have similar charges with equal surface densities(σ). What is the electric potential at their common centre?

a) $\frac{\sigma}{\varepsilon_0}$ b) $\frac{\sigma}{\varepsilon_0}(R-r)$ c) $\frac{\sigma}{\varepsilon_0}(R+r)$ d) None of these

250. If the plates of a parallel-plate capacitor are not equal in area, then

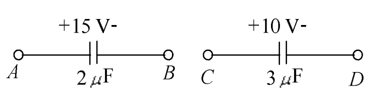
a) Quantity of charge on the plates will be the same, but nature of charge will differ

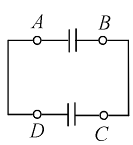
b) Quantity of charge as well as nature of charge on the plates will be different

c) Quantity of charge on the plates will be different. But nature of charge will be the same

d) Quantity of charge as well as nature of charge will be the same

251. In Fig, the initial status of capacitance and their connection is shown. Which of the following is incorrect about this circuit?





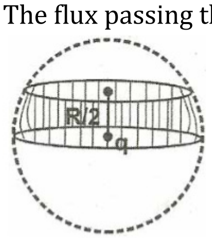
a) Final charge on each capacitor will be zero

b) Final total electrical energy of the capacitance will be zero

c) Total charge flown from A to D is 30 μC

d) Total charge flown from A to D is -30 μC

252. The flux passing through the shaded surface of a sphere when a point charge q is placed at the centre is



a) q/ε_0 b) $q/2\varepsilon_0$ c) $q/4\varepsilon_0$ d) Zero

253. 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

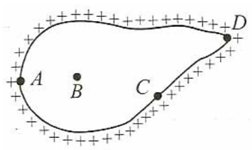
a) 0V b) 10V

c) Same as at point 5 cm away from the surface d) Same as at a point 20 cm away from the surface

254. 64 identical sphere of charge q and capacitance C each are combined to form a large sphere. The charge and capacitance of the large sphere is

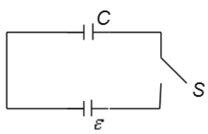
a) $64q, C$ b) $16\,q, 4C$ c) $64\,q, 4C$ d) $16\,q, 64C$

255. For an isolated charged conductor shown in Fig, the potentials at point A, B, C and D are V_A, V_B, V_C and V_D, respectively. Then



a) $V_A = V_B > V_C > V_D$ b) $V_D > V_C > V_B = V_A$ c) $V_D > V_C > V_B > V_A$ d) $V_D = V_C = V_B = V_A$

256. The left plate of the capacitor shown in the figure carries a charge $+Q$ while the right plate is uncharged. The total final charge on the right plate after closing the switch S will be



a) $\frac{Q}{2} + C\varepsilon$ b) $\frac{Q}{2} - C\varepsilon$ c) $-\frac{Q}{2}$ d) None of these

257. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the paths shown in figure

a) 1 b) 2 c) 3 d) 4

258. A wheel having mass μ has charges $+q$ and $-q$ on diametrically opposite points. It remains in equilibrium on a rough inclined plane in the presence of uniform vertical electric field $E =$

a) $\mu g/q$ b) $\mu g/2q$ c) $\mu g \tan\theta\,/2q$ d) None

259. A 16 μF capacitor, initially charged to 5 V, is started charging at $t = 0$ by a source at the rate of $40t\ \mu\mathrm{C}s^{-1}$. How long will it take to raise its potential to 10 V?

a) 1 s b) 2 s c) 3 s d) None of these

260. When a metal plate is introduced between the two plates of a charged capacitor and insulated from them, then

a) The metal plate divides the capacitor into two capacitors connected in parallel to each other

b) The metal plate divides the capacitor into two capacitors connected in series with each other

c) The metal plate is equivalent to a dielectric of zero dielectric constant

d) Capacitance of the capacitor decreases

261. The potential function of an electrostatic field is given by $V = 2x^2$. Determine the electric field strength at the point (2m, 0, 3m)

a) $\vec{E} = 4\hat{\imath}(\mathrm{NC^{-1}})$ b) $\vec{E} = -4\hat{\imath}(\mathrm{NC^{-1}})$ c) $\vec{E} = 8\hat{\imath}(\mathrm{NC^{-1}})$ d) $\vec{E} = -8\hat{\imath}(\mathrm{NC^{-1}})$

262. Mark the correct statement:

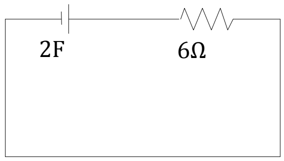
a) An electron and a proton when released from rest in a uniform electric field experience the same force and the same acceleration

b) Two equipotential surfaces may intersect

c) A solid conducting sphere holds more charge than a hollow conducting sphere of the same radius

d) No work is done in taking a positive charge from one point to another inside a negatively charged metallic sphere

263. In the capacitor shown in the circuit is changed to 5 V and left in the circuit, in 12s the charge on the capacitor will become $(e = 2.718)$

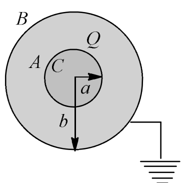


a) $\frac{10}{e}$C b) $\frac{e}{10}$C c) $\frac{10}{e^2}$C d) $\frac{e^2}{10}$C

264. Charges $2q, -q$ and $-q$ lie at the vertices of a triangle. The value of E and V at the centroid of equilateral triangle will be

a) $E \neq 0$ and $V \neq 0$ b) $E = 0$ and $V = 0$ c) $E \neq 0$ and $V = 0$ d) $E = 0$ and $V \neq 0$

265. A conducting sphere A of radius a, with charge Q, is placed concentrically inside a conducting shell B of radius b, B is earthed. C is the common centre of A and B. Study the following statements



i. The potential at a distance r from C, where $a \leq r \leq b$, is $\frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{r}\right)$

ii. The potential difference between A and B is

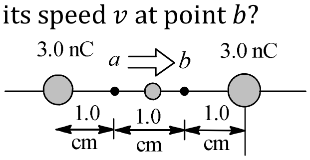
$\frac{1}{4\pi\varepsilon_0}Q\left(\frac{1}{a}-\frac{1}{b}\right)$

iii. The potential at a distance r from C, where $a \leq r \leq b$, is $\frac{1}{4\pi\varepsilon_0}Q\left(\frac{1}{r}-\frac{1}{b}\right)$

Which of the following statements are correct?

a) Only (i) and (ii) b) Only (ii) and (iii) c) Only (i) and (iii) d) All

266. As shown in Fig, a dust particle with mass $m = 5.0 \times 10^{-9}$kg and charge $q_0 = 2.0$ nC starts from rest at point a and moves in a straight line to point b. What is its speed v at point b?



a) 26 ms^{-1} b) 34 ms^{-1} c) 46 ms^{-1} d) 14 ms^{-1}

267. Two metal pieces having a potential difference of 800 V are 0.2 m apart horizontally. A particle of mass 1.96×10^{-15}kg is suspended in equilibrium between the plates. If e is an elementary charge, then charge on the particle is

a) 8 e b) 6 e c) 3 e d) e

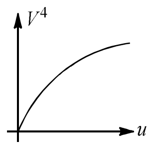
268. The potential energy of system of two equal negative point charges of 2μC each held 1m apart in air is $(k = 9 \times 10^9$ SI unit)

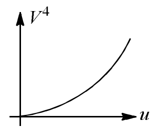
a) 36J b) 3.6×10^{-3} J c) 3.6J d) 3.6×10^{-2}J

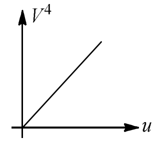
269. An air parallel plate capacitor has capacity C. The capacity and distance between plates are doubled when immersed in a liquid then dielectric constant of the liquid is

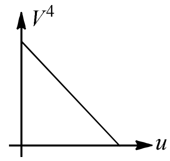
a) 1 b) 2 c) 3 d) 4

270. If V and u are electric potential and energy density, respectively, at a distance r from a positive point charge, then which of the following graph is correct?

a) 

b) 

c) 

d) 

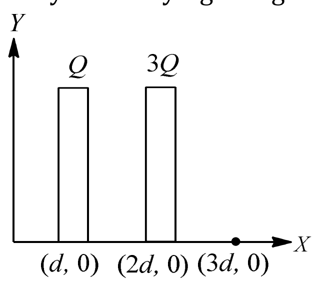
271. Large number of capacitors of rating 10 μF/200 V are available. The minimum number of capacitors required to design a 10 μF/700 capacitor is

a) 16 b) 4 c) 8 d) 7

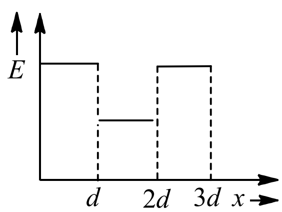
272. Two infinitely long parallel wires having linear charge densities λ_1 and λ_2, respectively, are placed at a distance$R$. The force per length on either wire will be

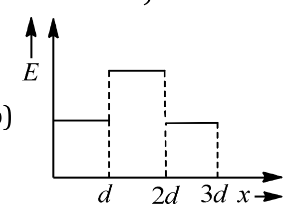
a) $k\frac{2\lambda_1\lambda_2}{R^2}$ b) $k\frac{2\lambda_1\lambda_2}{R}$ c) $k\frac{\lambda_1\lambda_2}{R^2}$ d) $k\frac{\lambda_1\lambda_2}{R}$

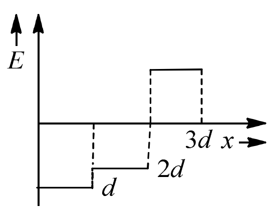
273. Two very large thin conducting plates having same cross-sectional area are placed as shown in figure. They are carrying charges Q and $3Q$ respectively

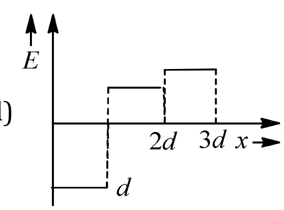


The variation of electric field as a function of x (for $x = 0$to $x = 3d$) will be best represented by

a) 

b) 

c) 

d) 

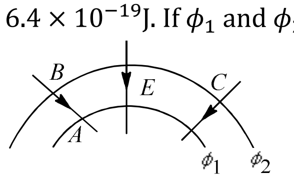
274. On moving a charge of 20 C by 2cm, 2J of work is done, then the potential difference between the points is

a) 0.1V b) 8V c) 2V d) 0.5V

275. In the above question, if plates P_1 and P_2 are connected by a thin conducting wire, then the amount of heat produced will be

a) $\frac{Q^2}{A\varepsilon_0}d$ b) $\frac{5Q^2}{A\varepsilon_0}d$ c) $\frac{2Q^2}{A\varepsilon_0}d$ d) None of these

276. In moving from A to B along an electric field line, the work done by the electric field on an electron is 6.4×10^{-19}J. If ϕ_1 and ϕ_2 are equipotential surfaces, then the potential difference $V_C - V_A$ is



a) −4 V b) 4 V c) Zero d) 6.4 V

277. Two tree protons are separated by a distance of 1Å. If they are released, the kinetic energy of each proton when at infinite separation is

a) 11.5×10^{-19} J b) 23×10^{-19} J c) 46×10^{-19} J d) 5.6×10^{-12} J

278. Two conducting spheres A and B of radius a and b respectively are at the same potential. The ratio of the

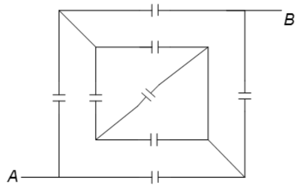
surface charge densities of A and B is

a) $\frac{b}{a}$ b) $\frac{a}{b}$ c) $\frac{a^2}{b^2}$ d) $\frac{b^2}{a^2}$

279. The potential field depends on the x- and y-coordinates as $V = x^2 - y^2$. The corresponding electric field lines in $x - y$ plane are as

a) b) c) d)

280. The effective capacitance between points A and B is (the capacitance of each of the capacitors is C)



a) C b) $C/2$ c) $36C/17$ d) $42C/17$

281. A charge $(-q)$ and another charge $(+Q)$ are kept at two points A and B respectively. Keeping the charge $(+Q)$ fixed at B, the charge $(-q)$ at A is moved to another point C such that ABC forms an equilateral triangle of side l. The net work done in moving the charge $(-q)$ is

a) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{l}$ b) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{l^2}$ c) $\frac{1}{4\pi\varepsilon_0}Qql$ d) Zero

282. The electric field in a region is given by

$\vec{E}' = \frac{E_0 x -}{l} i$

Find the charge contained inside a cubical volume bounded by the surfaces $x = 0, x = a, y = 0, y = a, z = 0$ and $z = a$. Take $E_0 = 5 \times 10^3$ N/C, $l = 0.02$ m and $a = 0.01$ m

a) 1.1×10^{-12}C b) 2.2×10^{-12}C c) 4.4×10^{-12}C d) 5.5×10^{-12}C

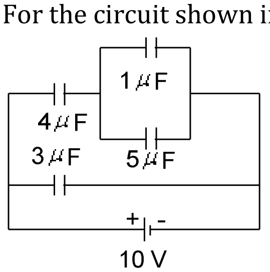
283. The plates of a parallel plate capacitor with air as medium are separated by a distance of 8 mm. A medium of dielectric constant 2 and thickness 4 mm having the same area is introduced between the plates. For the capacitance to remain the same , the distance between the plates is

a) 8 mm b) 6 mm c) 4 mm d) 12 mm

284. There is an infinite straight chain of alternating charges q and $-q$. The distance between the two neighbouring charges is equal to a. Find the interaction energy of any charge with all the other charges

a) $-\frac{2q^2}{4\pi\varepsilon_0 a}$ b) $\frac{2q^2 \log_e 2}{4\pi\varepsilon_0 a}$ c) $-\frac{2q^2 \log_e 2}{4\pi\varepsilon_0 a}$ d) None of these

285. For the circuit shown in figure the charge on 4 μF capacitor is



a) 40 μC b) 30 μC c) 24 μC d) 54 μC

286. A small positively charged sphere is placed inside a positively charged spherical shell. What happen if the inner sphere is connected with the outer shell by a conducting wire?

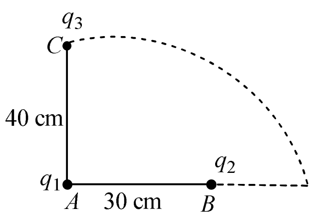
a) The entire charge of inner sphere will be transferred to outer shell and then both will be at same potential

b) The entire charge of inner sphere will be transferred to outer shell and then both will be at different potential

c) The entire charge of outer shell will be transferred to inner sphere and then both will be at same potential
d) Nothing can be predicted

287. Out of two copper spheres of the same size, x is hollow while y is solid. If they are charged at the same potential, what can be said about the charges on them?
a) Charge on both the spheres is zero
b) Charge on both the spheres is equal
c) Sphere y will have more charge
d) Sphere x will have more charge

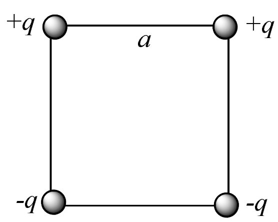
288. Two charges q_1 and q_2 are placed 30 cm apart, as shown in the figure. A third charge q_3 is moved along the arc of a circle of radius 40 cm from C to D. The change in the potential energy of the system is $\frac{q_3}{4\pi\varepsilon_0}k$, where k is



a) $8q_2$
b) $8q_1$
c) $6q_2$
d) $6q_1$

289. N identical drops of mercury are charged simultaneously to 10V. When combined to form one large drop, the potential is found to be 40V, the value of N is
a) 4
b) 6
c) 8
d) 10

290. Four charges are placed at four corners of a square as shown (Figure). The side of the square is a. Two charges are positive and two are negative but their magnitudes are the same, Now, an external agent starts decreasing all the sides of the square slowly and at the same rate. What happens to the electrical potential energy of the system and what will be the nature of work done by the agent?



a) Increase, positive
b) Increase, positive
c) Decreases, negative
d) Increases, positive

291. A hollow metallic sphere of radius R is given a charge Q. Then, the potential at the centre is
a) Zero
b) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{R}$
c) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{2Q}{R}$
d) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{2R}$

292. The electric potential V at any point (x, y, z) in space is given by $V = 4x^2$V. the electric field at (1,0,2) m inVm^{-1} is
a) 8, along negative X-axis
b) 8, along positive X-axis
c) 16,along negative X-axis
d) 16, along positive X-axis

293. A dielectric of dielectric constant K is introduced such that half of its area of a capacitor of capacitance C is occupied by it. The new capacity is
a) $2C$
b) $\frac{C}{2}$
c) $\frac{(1+K)C}{2}$
d) $2C(1+K)$

294. If the plates of a parallel plate capacitor are not equal in area, then quantity of charge
a) On the plates will be same but nature of charge will differ
b) On the plates as well as nature of charge will be different
c) On the plates will be different but nature of charge will be same
d) As well as nature of charge will be same

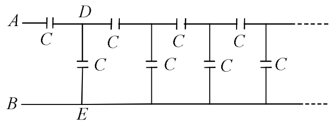
295. A parallel plate capacitor is charged. If the plates are pulled apart
a) The capacitance increases
b) The potential difference increases
c) The total charge increases
d) The charge and potential difference remain the

same

296. Three capacitors of capacitances 2, 3 and 4 pF are connected in parallel. What is the charge (in pC) on each capacitor if the combination is connected to a 100 V supply?

a) 200, 300, 400 b) 300, 200, 400 c) 400, 300, 200 d) 400, 200, 300

297. The capacitance of an infinite circuit formed by the repetition of the same link consisting of two identical capacitors, each with capacitance C (Fig), is



a) Zero b) $\frac{\sqrt{5}-1}{2}C$ c) $\frac{\sqrt{5}+1}{2}C$ d) Infinite

298. Two thin wire rings each having a radius R are placed at a distance d apart with their axes coinciding. The charges on the two rings are +q and −q. The potential difference between the centres of two rings is

a) $\frac{qR}{4\pi\varepsilon_0 d^2}$ b) $\frac{q}{2\pi\varepsilon_0}\left[\frac{1}{R}-\frac{1}{\sqrt{R^2+d^2}}\right]$

c) Zero d) $\frac{q}{4\pi\varepsilon_0}\left[\frac{1}{R}-\frac{1}{\sqrt{R^2+d^2}}\right]$

299. An uncharged parallel-plate capacitor having a dielectric of dielectric constant K is connected to a similar air cored parallel-plate capacitor charged to a potential V_0. The two share the charge and the common potential becomes V. The dielectric constant K is

a) $\frac{V_0}{V}-1$ b) $\frac{V_0}{V}+1$ c) $\frac{V}{V_0}-1$ d) $\frac{V}{V_0}+1$

300. The electric field in a certain region is A/x^3. Then, the potential at a point (x, y, z), assuming the potential at infinity to be zero, is

a) Zero b) $A/2x^2$ c) $3A/x^4$ d) A/x^2

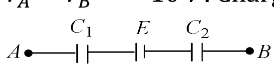
301. An automobile spring extends 0.2 m for 5000 N load. The ratio of potential energy stored in this spring when it has been compressed by 0.2 m to the potential energy stored in a 10μF capacitor at a potential difference of 10000 V will be

a) 1/4 b) 1 c) 1/2 d) 2

302. A 2 μF capacitor is charged to 100 V and then its plates are connected by a conducting wire. The heat produced is

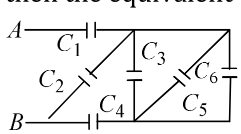
a) 0.001 J b) 0.01 J c) 0.1 J d) 1 J

303. For section AB of a circuit shown in Fig, $C_1 = 1$ μF, $C_2 = 2$ μF, $E = 10$ V and the potential difference $V_A - V_B = -10\ V$. Charge on capacitor C_1 is



a) 0 μC b) 20/3 μC c) 40/3 μC d) None of these

304. In the accompanying diagram, if $C_1 = 3$ μF, $C_2 = 6$ μF, $C_3 = 9$ μF, $C_4 = 12$ μF, $C_5 = 15$ μF and $C_6 = 18$ μF, then the equivalent capacitance between the ends A and B is

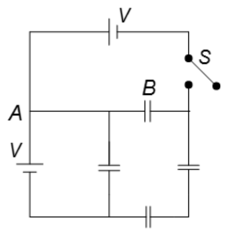


a) 1.22 μF b) 5.16 μF c) 2.25 μF d) 2.51 μF

305. In the previous question, if V is the electric potential of the first sphere, what would be the electric potential of the second sphere?

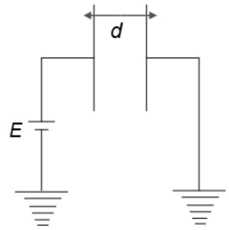
a) $2V$ b) $V/2$ c) $V/4$ d) V

306. Find the charge that will flow through the wire A to B if the switch S is closed. The capacitance of each capacitor shown in the figure is C



a) CV b) $CV/3$ c) Zero d) $2CV/3$

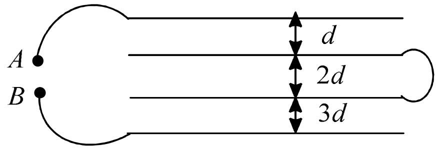
307. Two plates, each of area$A$, are placed parallel to each other at a distance d. One plate is connected to a battery of e.m.f. E and its negative is earthed. The other plate is also earthed.



The charge drawn by plate is

a) $\frac{2\varepsilon_0 AE}{d}$ b) $\frac{\varepsilon_0 AE}{d}$ c) $\frac{\varepsilon_0 AE}{2d}$ d) $\frac{3\varepsilon_0 AE}{d}$

308. If area of each plate is A and the successive separations are d, $2d$ and $3d$, then the equivalent capacitance across A and B is



a) $\frac{\varepsilon_0 A}{6d}$ b) $\frac{\varepsilon_0 A}{4d}$ c) $\frac{3\varepsilon_0 A}{4d}$ d) $\frac{\varepsilon_0 A}{3d}$

309. A sphere of radius r is charged to a potential V. The outward pull per unit area of its surface is given by

a) $\frac{4\pi\varepsilon_0 V^2}{r^2}$ b) $\frac{\varepsilon_0 V^2}{2r^2}$ c) $\frac{2\varepsilon_0 V^2}{r^2}$ d) $\frac{\varepsilon_0 V^2}{4r^2}$

310. In a capacitor of capacitance 20μF the distance between the plates is 2 mm. If a dielectric slab of width 1 mm and dielectric constant 2 is inserted between the plates , then the new capacitance will be

a) 22 μF b) 26.6 μF c) 52.2 μF d) 13 μF

311. Two point charges 4 μC and −2 μC are separated by a distance of 1m in air. At what point in between the charges and on the line joining the charges, is the electric potential zero?

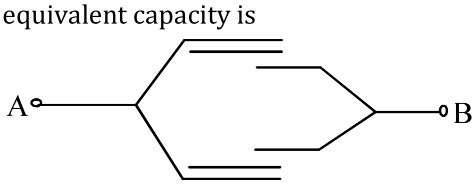
a) In the middle of the two charges b) 1/3 m from 4 μC

c) 1/3 m from −2 μC d) Nowhere the potential is zero

312. The SI unit of surface integral of electric field is

a) V-m b) V c) $NC^{-1}m$ d) Cm^{-3}

313. Four plates of equal area A are separated by equal distance d and are arranged as shown in the figure. The equivalent capacity is

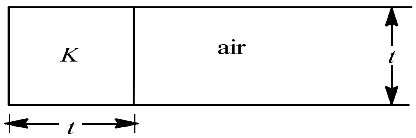


a) $\frac{2\varepsilon_0 A}{d}$ b) $\frac{3\varepsilon_0 A}{d}$ c) $\frac{3\varepsilon_0 A}{2d}$ d) $\frac{\varepsilon_0 A}{d}$

314. 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

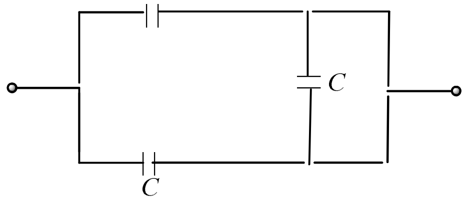
a) $\frac{Q_1 + Q_2}{2C}$ b) $\frac{Q_1 + Q_2}{C}$ c) $\frac{Q_1 - Q_2}{C}$ d) $\frac{Q_1 - Q_2}{2C}$

315. A parallel plate capacitor with air as the dielectric has capacitance C. A slab of dielectric constant K and having the same thickness as the separation between the plates is introduced so as to fill one-fourth of the capacitor as shown in the figure. The new capacitance will be



a) $(K+3)\frac{C}{4}$ b) $(K+2)\frac{C}{4}$ c) $(K+1)\frac{C}{4}$ d) $\frac{KC}{4}$

316. The equivalent capacitance of the combination shown in figure below is



a) $2C$ b) C c) $\frac{1}{2}C$ d) None of these

317. Which of the following is discontinuous across a charged conducting surface?

a) Electric potential b) Electric intensity
c) Both electric potential and intensity d) None of the above

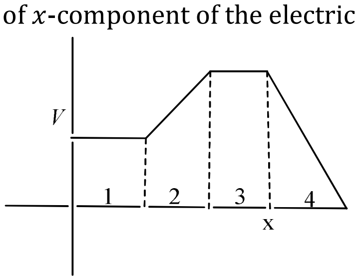
318. The capacitance of a metallic sphere is 1 μF, then its radius will be

a) 10 m b) 1.11 km c) 9 km d) 1.11 m

319. At a point in space, the electric field points towards north. In the region surrounding this point, the rate of change of potential will be zero along

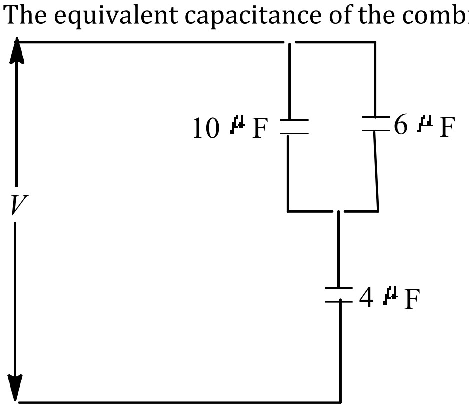
a) North b) South c) North-south d) East-west

320. The figure shows electric potential V as a function of x. Rank the four regions according to the magnitude of x-component of the electric field E within them, greatest first



a) $E_4 > E_2 > E_3 > E_1$ b) $E_2 > E_4 > E_1 = E_3$ c) $E_1 > E_2 > E_3 > E_4$ d) $E_1 > E_3 > E_2 > E_4$

321. The equivalent capacitance of the combination of the capacitors is

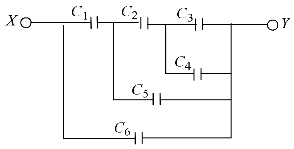


a) 3.20 μF b) 7.80 μF c) 3.90 μF d) 2.16 μF

322. A parallel plate condenser with oil (dielectric constant 2) between the plates has capacitance C. If oil is removed, the capacitance of capacitor becomes

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

323. In the given network of capacitors as shown in Fig, given that $C_1 = C_2 = C_3 = 400$ pF and $C_4 = C_5 = C_6 = 200$ pF. The effective capacitance of the circuit between X and Y is

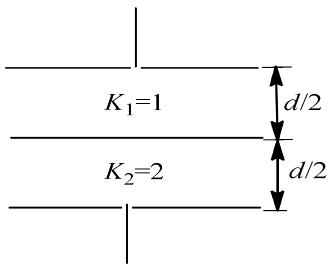


a) 810 pF b) 205 pF c) 600 pF d) 410 pF

324. If dielectric is inserted in charged capacitor (battery removed), then quantity that remains constant is

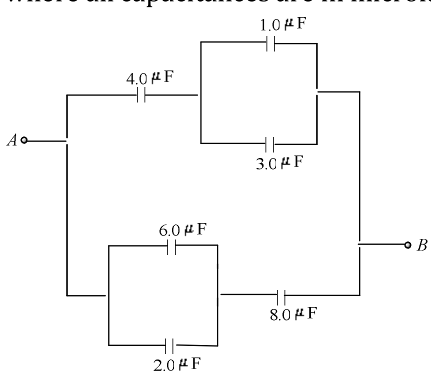
a) Capacitance b) Potential c) Intensity d) Charge

325. Two parallel plates of area A are separated by two different dielectric as shown in figure. The net capacitance is



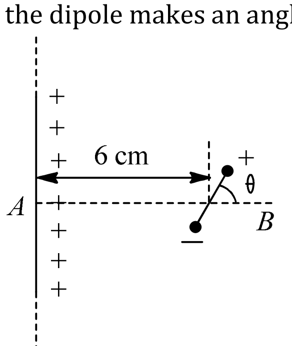
a) $\frac{\varepsilon_0 A}{2d}$ b) $\frac{\varepsilon_0 A}{d}$ c) $\frac{3\varepsilon_0 A}{d}$ d) $\frac{4\varepsilon_0 A}{3d}$

326. The equivalent capacitance between points A and B for the combination of capacitors shown in figure, where all capacitances are in microfarad is



a) 6.0 μF b) 4.0 μF c) 2.0 μF d) 3.0 μF

327. An electric dipole consists of charges $\pm 2.0 \times 10^{-8}$C separated by distance of $\pm 2.0 \times 10^{-3}$m. it is placed at a distance of 6 cm from a line charge of linear charge density $4.0 \times 10^{-4} Cm^{-1}$as shown in Figure. Such that the dipole makes an angle of $\theta = 60°$ with line AB find the force acting on the dipole



a) 0.012 N b) 1.8 N c) 0.04 N d) None of these

328. Four identical charges are placed at the points (1,0,0), (0,1,0),(−1,0,0) and (0, −1,0) Then,

a) The potential at the origin is zero

b) The electric field at the origin is not zero

c) The potential at all points on the z-axis, other than the origin, is zero
d) The field at all points on the z-axis, other than the origin, acts along the z-axis

329. A simple pendulum has a length l and the mass of the bob is m. The bob is given a change q coulomb. The pendulum is suspended between the vertical plates of a charged parallel plate capacitor. If E is the electric field strength between the plates, the time period of the pendulum is given by

a) $2\pi\frac{l}{g}$ b) $2\pi\sqrt{\frac{l}{\sqrt{g+\frac{qE}{m}}}}$ c) $2\pi\sqrt{\frac{1}{\sqrt{g-\frac{qE}{m}}}}$ d) $2\pi\sqrt{\frac{l}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$

330. A 10μF capacitors and a 20μF capacitor are connected in series across a 200 V supply line. The charged capacitors are then disconnected from the line and reconnected with their positive plates together and negative plates together and no external voltage is applied. The potential difference across each capacitor is

a) $\frac{400}{9}$ V b) $\frac{800}{3}$ V c) 400 V d) 200 V

331. The energy of a charged capacitor is U. Another identical capacitor is connected parallel to the first capacitor, after disconnecting the battery. The total energy of the system of these capacitors will be

a) $\frac{U}{4}$ b) $\frac{U}{2}$ c) $\frac{3U}{2}$ d) $\frac{2U}{4}$

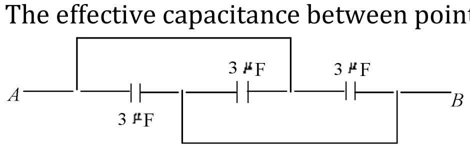
332. A parallel plate capacitor C is equally filled with parallel layers of materials of dielectric constant. K_1AndK_2. Then the ratio of new capacitance to the previous capacitor is

a) $\frac{2K_1K_2}{K_1+K_2}$ b) K_1+K_2 c) $\frac{K_1K_2}{K_1+K_2}$ d) None of the above

333. Seven capacitors, each of capacitance 2 μF, are to be combined to obtain a capacitance of 10/11 μF. Which of the following combination is possible?

a) 2 in parallel, 5 in series b) 3 in parallel, 4 in series
c) 4 in parallel, 3 in series d) 5 in parallel, 2 in series

334. The effective capacitance between points A and B is

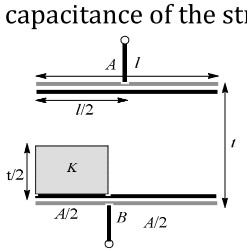


a) 9 μF b) 3 μF c) 6 μF d) 1 μF

335. A variable condenser is permanently connected to a 100 V battery. If capacity is changed from 2 μF and 10 μF, then energy change is equal to

a) 2×10^{-2} J b) 2.5×10^{-2} J c) 6.5×10^{-2} J d) 4×10^{-2} J

336. Two square plates ($l\times l$)and dielectric $\left(\frac{l}{2}\times\frac{t}{2}\times l\right)$ are arranged as shown in Fig.. Find the equivalent capacitance of the structure



a) $\frac{\varepsilon_0A}{t}\left(\frac{3K+1}{2(K+1)}\right)$ b) $\frac{2\varepsilon_0A}{t}\left(\frac{K+1}{K+3}\right)$ c) $\frac{\varepsilon_0A}{t}\left(\frac{K+1}{K+3}\right)$ d) $\frac{\varepsilon_0A}{t}\left(\frac{2K+1}{2K+3}\right)$

337. An electric dipole is placed in a uniform electric field $\vec{E}$ of magnitude 40 N/C. Graph shows the magnitude of the torque on the dipole versus the angle θ between the field $\vec{E}$ and the dipole moment $\vec{P}$. the magnitude of dipole moment$\vec{P}$ is equal to

a) 2.5×10^{-28}Cm b) 2.0×10^{-25}Cm c) 1.25×10^{-28}Cm d) 5.0×10^{-28}Cm

338. Two parallel-plate capacitors, each of capacitance 40 μF, are connected in series. The space between the plates of one capacitor is filled with a dielectric of dielectric constant K=3, then the equivalent capacitance of the combinations is

a) 30 μF b) 120 μF c) 40 μF d) 160 μF

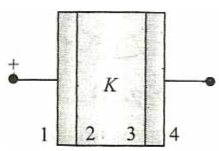
339. The electric field lines closer together near object A than they are near object B. We can conclude

a) The potential near A is greater than the potential near B
b) The potential near A is less than the potential near B
c) The potential near A is equal to the potential near B
d) Nothing about the relative potentials near A and B

340. The capacitance of an isolated conducting sphere of radius $R$is proportional to

a) R^{-1} b) R^2 c) R^{-2} d) R

341. An isolated capacitor of capacitance C is charged to a potential$V$. Then, a dielectric slab of dielectric constant K is inserted as shown in Figure. the net charge on four surface 1,2,3 and 4 would be respectively,



a) $0, CV, -CV, 0$ b) $0, \frac{CV}{K}, \frac{-CV}{K}, 0$ c) $CV, 0, 0, -CV$ d) $CV, \frac{-CV}{K}, \frac{CV}{K}, -CV$

342. Three identical metallic plates are kept parallel to one another at separations a and$b$. The outer plates are connected to the ground and the middle plate is given charge Q(figure).Then the charge on the right side of middle plate is

a) $Q/2$ b) $-\frac{Qb}{a+b}$ c) $\frac{Qb}{a+b}$ d) $\frac{Qa}{a+b}$

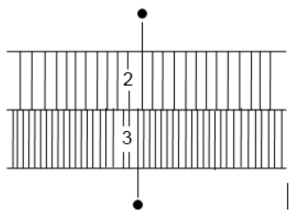
343. There is an electric field E in the x-direction. If the work done by electric field in moving a charge of 0.2 C through a distance of 2 m along a line making an angle 60° with the x-axis is 4 J, then what is the value of E?

a) $\sqrt{3}$ NC^{-1} b) 4 NC^{-1} c) 5 NC^{-1} d) 20 NC^{-1}

344. Small drops of the same size are charged to Vvolt each. If n such drops coalesce to form a single large drop, its potential will be

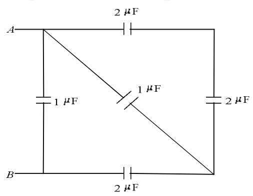
a) Vn b) V/n c) $Vn^{1/3}$ d) $Vn^{2/3}$

345. A parallel-plate capacitor with no dielectric has a capacitance of 0.5 μF. The space between the plates is filled with equal amounts of two dielectric materials of dielectric constant 2 and 3 as shown in Fig. Find the capacitance of the system now



a) 1.2 μF b) 1.8 μF c) 1.25 μF d) None of these

346. Equivalent capacitance between A and B is



a) 14 μF b) 4 μF c) 6 μF d) 2 μF

347. A parallel plate condenser with a dielectric of dielectric constant K between the plates has a capacity C and is charged to a potential V volt. The dielectric slab is slowly removed from between the plates and then reinserted. The net work done by the system in this process is

a) $\frac{1}{2}(K-1)CV^2$ b) $CV^2(K-1)/K$ c) $(K-1)CV^2$ d) Zero

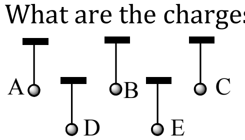
348. Five Styrofoam balls are suspended from insulating threads. Several experiments are performed on the balls and the following observations are made

(i)Ball A repels C and attracts B

(ii)Ball D attracts B and has no effect on E

(iii)a negatively charged rod attracts both A and E

An electrically neutral Styrofoam ball attracted if placed nearby a charged body due to induced charge What are the charges, if any, on each ball?

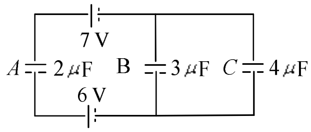


	A	B	C	D	E
a)	+	−	+	0	+
b)	+	−	+	+	0
c)	−	+	−	0	0
d)	−	−	+	0	0

349. A fully charged capacitor has a capacitance$C$. It is discharged through a small coil of resistance wire embedded in a thermally insulated block specific heat capacity s and mass$m$. If the temperature of the block is raised by T, the potential difference V across the capacitance is

a) $\frac{msT}{C}$ b) $\sqrt{\frac{2msT}{C}}$ c) $\sqrt{\frac{2msCT}{s}}$ d) $\frac{mCT}{s}$

350. Three capacitors A, B and C are connected in a circuit as shown in Fig. What is the charge in μC on the capacitor B?



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

351. A soap bubble is charged to a potential of 16V. Its radius is, then doubled. The potential of the bubble now will be

a) 16V b) 8V c) 4V d) 2V

352. A 600 pF capacitor is charged by a 200 V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. What is the common potential (in V) and energy lost (in J) after reconnection?

a) $100, 6 \times 10^{-6}$ b) $200, 6 \times 10^{-5}$ c) $200, 5 \times 10^{-6}$ d) $100, 6 \times 10^{-5}$

353. What is the potential difference between points A and B in the circuit shown?

a) 2 V b) 4 V c) 3 V d) 12 V

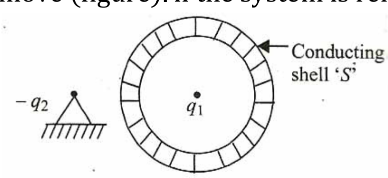
354. A spherical drop of mercury having a potential of 2.5V is obtained as a result of merging 125 droplets. The potential of a constituent droplets would be

a) 1.0V b) 0.5V c) 0.2V d) 0.1V

355. The following diagrams show the electric field lines between two opposite charges. The positive charge is indicated by the black circle, whereas the negative charge by the white circle. An electron starting from rest at the indicated position (X), and accelerated to high speed by the electric field will follow most likely which trajectory?

a) b) c) d)

356. The negative charge $-q_2$ is fixed, while positive charge q_1 as well as the conducting sphere $'S'$ is free to move (figure). if the system is released from rest,



a) Both S and q_1 move towards left b) q_1 moves towards right while S move towards left
c) q_1 remains at rest, S moves toward left d) Both q_1 and S remain at rest

357. The flux entering and leaving a closed surface are 5×10^5 and 4×10^5 MKS units respectively, then the charge inside the surface will be

a) -8.86×10^{-7}C b) 8.85×10^{-7}C c) 8.85×10^{7}C d) 6.85×10^{-7}C

358. A 40 μF capacitor in a defibrillator is charged to 3000 V. The energy stored in the capacitor is sent through the patient during a pulse of duration 2 ms. The power delivered to the patient is

a) 45 kW b) 90 kW c) 180 kW d) 360 kW

359. There exists a uniform electric field in the space as shown. Four points A, B, C and D are marked which are equidistant from the origin. If V_A, V_B, V_C and V_D are their potentials, respectively,

a) $V_B > V_A > V_C > V_D$ b) $V_A > V_B > V_D > V_C$ c) $V_A = V_B > V_C = V_D$ d) $V_B > V_C > V_A > V_D$

a) 1:1:1 b) $q_1 : q_2 : q_3$

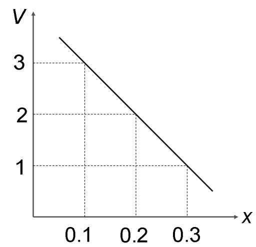
c) 1:$\sqrt{3}$:2 d) This ratio cannot be calculated

361. A dielectric slab is inserted between the plates of an isolated charged capacitor. Which of the following quantities remain unchanged?

a) The charge on the capacitor b) The stored energy in the capacitor

c) The potential difference between the plates d) The electric field in the capacitor

362. The variation of potential V with distance x from a fixed point charge is shown in figure. The electric field strength between $x = 0.1$ m and 0.3 m is



a) $+0.4\ \mathrm{Vm^{-1}}$ b) $-0.4\ \mathrm{Vm^{-1}}$ c) $+10\ \mathrm{Vm^{-1}}$ d) $-10\ \mathrm{Vm^{-1}}$

363. A capacitor is charged to store an energy U. the charging battery is disconnected. An identical capacitor is now connected to the first capacitor in parallel. The energy in each of the capacitor is

a) $3\,U/2$ b) U c) $U/4$ d) $U/2$

364. An uncharged conductor A is brought near a positively charged conductor$B$. The size of the conductor A is much greater than the size of conductor B. then,

a) The charge on B will increase but the potential of B will not change

b) The charge on B will not change but the potential of B will decrease

c) The charge on B will decrease but the potential of B will not change

d) The charge on B will not change but the potential of B will increase

365. The charge deposited on 4μF capacitor the circuit is

a) 6×10^{-6}C b) 12×10^{-6}C c) 24×10^{-6}C d) 36×10^{-6}C

366. We have three identical metallic spheres A, $B$and C, A is given a charge Q and B and C are uncharged. The following process of touching of two spheres one carried out in succession. Each process is carried out with sufficient time:

i. A and B ii. B and C

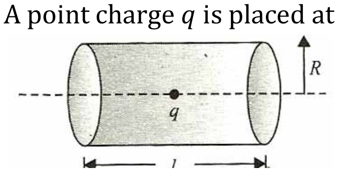
iii. C and A iv. A and B

v. B and C

The final charges on the spheres are

a) $\frac{11Q}{32}, \frac{5Q}{6}, \frac{11Q}{32}$ b) $\frac{11Q}{32}, \frac{11Q}{32}, \frac{5Q}{16}$ c) $\frac{8Q}{8}, \frac{5Q}{16}, \frac{5Q}{16}$ d) $\frac{5Q}{16}, \frac{11Q}{32}, \frac{11Q}{32}$

367. A point charge q is placed at the centre of an imaginary Gaussian surface as shown in Figure



Find the flux crossing through the curved surface

a) Zero

b) $\frac{q}{\varepsilon_0}\left[1-\frac{l}{\sqrt{R^2+(l^2/4)}}\right]$

c) $\frac{q}{2\varepsilon_0}\left[1-\frac{l}{2\sqrt{(l^2/4)+R^2}}\right]$

d) $\frac{ql}{2\varepsilon_0\sqrt{(l^2/4)+R^2}}$

368. A charge $+q$ is placed at each o the points $x=x_0, x=3x_0, x=5x_0$ at infinitum on the x-axis and a charge $-q$ is placed at each of the points $x=2x_0, x=4x_0, x=6x_0$ at infinitum. 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

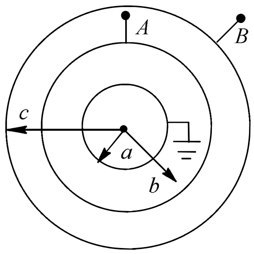
a) 0

b) $\frac{q}{8\pi\varepsilon_0 x_0 \log 2}$

c) ∞

d) $\frac{q\log 2}{4\pi\varepsilon_0 x_0}$

369. Three concentric spherical conductors are as shown in figure. Determine the equivalent capacitance of the system between A and B



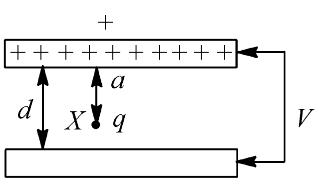
a) $\frac{4\pi\varepsilon_0 ac}{c-a}$

b) $\frac{4\pi\varepsilon_0 bc}{c-b}+\frac{4\pi\varepsilon_0 ab}{b-a}$

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

d) $\frac{4\pi\varepsilon_0 ac}{c-a}+4\pi\varepsilon_0 c$

370. A point charge q is situated at X between two parallel plates which have a potential difference V and carry charge $+Q$ and$-Q$. What is the electric field strength at X?



a) $\frac{V}{d}$

b) $\frac{Vq}{d}$

c) $\frac{Q}{4\pi\varepsilon_0 a^2}$

d) $\frac{qQ}{4\pi\varepsilon_0 a^2}$

371. A hollow conducting sphere or radius R has a charge $(+Q)$ on its surface. What is the electric potential within the sphere at a distance $r=R/3$ from its centre?

a) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{r}$

b) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{r^2}$

c) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{R}$

d) Zero

372. In a certain charge distribution, all points having zero potential can be joined by a circle$S$. Points inside S have positive potential, and pints outside S have negative potential. A positive charge, which is free to move, is placed inside S

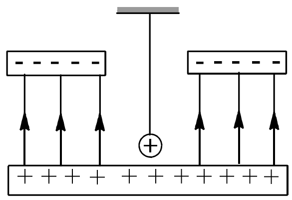
a) It will remain in equilibrium

b) It can move inside S, but it cannot cross S

c) It must cross S at some time

d) It may move but will ultimately return to its starting point

373. If a positively charged pendulum is oscillating in a uniform electric field as shown in figure. Its time period as compared to that when it was uncharged will



a) Increase
b) Decrease
c) Not change
d) First increase and then decrease

374. In question 32, if the conducting spherical shell is not earthed but is neutral, them the force on q_2 is
a) Zero
b) $\frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$
c) $\frac{q_1 q_2}{4\pi\varepsilon_0 (r - R^2)}$
d) None of these

375. A capacitor of capacitance $C_1 = 1\ \mu\text{F}$ charged up to a voltage $V = 110\ \text{V}$ is connected in parallel to the terminals of a circuit consisting of two uncharged capacitors connected in series and processing capacitances $C_2 = 2\ \mu\text{F}$ and $C_3 = 3\ \mu\text{F}$. Then, the amount of charge that will flow through the connecting wires is
a) 40 μC
b) 50 μC
c) 60 μC
d) 110 μC

376. Capacitance of a capacitor made by a thin metal foil is 2μF. If the foil is folded with paper of thickness 0.15 mm, dielectric constant of paper is 2.5 and width of paper is 400 mm, the length of foil will be
a) 0.34 m
b) 1.33 m
c) 13.4 m
d) 33.9 m

377. How does the electric field strength vary when we enter a uniformly charged spherical cloud?
a) Decreases inversely as the square of the distance from the surface
b) Decreases directly as the square of the distance from the surface
c) Decreases directly as the square of the distance from the centre
d) Decreases directly as the distance from the centre or $E \propto r$

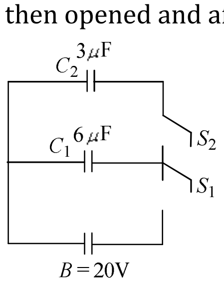
378. The electrostatic potential energy between proton and electron separated by a distance 1Å is
a) 13.6eV
b) 27.2eV
c) 14.4eV
d) 1.44eV

379. The capacitance of a parallel plate capacitor with air as medium is 3μF. With the introduction of a dielectric medium between the plates, the capacitance becomes 15μF. The permittivity of the medium is
a) $5\text{C}^2\text{N}^{-1}\text{m}^{-2}$
b) $15\text{C}^2\text{N}^{-1}\text{m}^{-2}$
c) $0.44 \times 10^{-10}\text{C}^2\text{N}^{-1}\text{m}^{-2}$
d) $8.854 \times 10^{-11}\text{C}^2\text{N}^{-1}\text{m}^{-2}$

380. When the separation between two charges is increased, the electric potential energy of the charges
a) Increase
b) Decrease
c) Remains the same
d) May increase or decrease

381. Ten capacitors are joined in parallel and charged with a battery up to a potential V. They are then disconnected from battery and joined in series. Then, the potential of this combination will be
a) 1 V
b) 10 V
c) 5 V
d) 2 V

382. In the circuit shown in Fig $C_1 = 6\ \mu\text{F}$, $C_2 = 3\ \mu\text{F}$ and battery $B = 20\ \text{V}$. The switch S_1 is first closed. It is then opened and afterwards S_2 is closed. What is the final charge on C_2?



a) 120 μC
b) 80 μC
c) 40 μC
d) 20 μC

383. A metal sphere having a radius r_1 charged to a potential V_1 is enveloped by a thin-walled conducting spherical shell of radiusr_2. Determine the potential V_1 acquired by the sphere after it has been connected for a short time to the shell by a conductor

a) $\frac{V_1 r_2}{r_1}$ b) $\frac{V_1 r_1}{r_2}$ c) V_1 d) $\frac{V_1(r_1+r_2)}{r_2}$

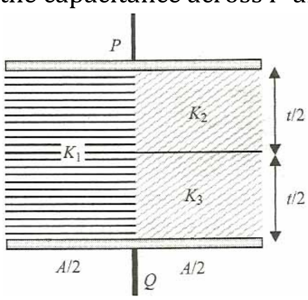
384. In the figure, a proton moves a distance d in a uniform electric field $\mathbf{E}$ as shown in the figure. Does the electric field do a positive or negative work on the proton? Does the electric potential energy of the proton increase or decrease?

a) Negative, increase b) Positive, decrease c) Negative, decrease d) Positive, increase

385. A metal foil of negligible thickness is introduced between two plates of a capacitor at the centre. The capacitance of capacitor will be

a) Same b) Double c) Half d) K times

386. A parallel-plate capacitor is constructed using three different dielectric materials as shown in Fig. What is the capacitance across P and Q?



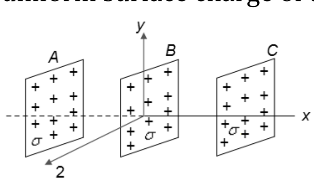
a) $\left(\frac{K_1}{2}+\frac{K_2K_3}{K_2+K_3}\right)\frac{\varepsilon_0 A}{t}$ b) $\left(K_1+\frac{K_2K_3}{K_2+K_3}\right)\frac{\varepsilon_0 A}{t}$

c) $\left(K_1+\frac{2K_2K_3}{K_2+K_3}\right)\frac{\varepsilon_0 A}{t}$ d) $\left(K_1+\frac{K_2K_3}{2(K_2+K_3)}\frac{\varepsilon_0 A}{t}\right)$

387. In bringing an electron towards another electron, the electrostatic potential energy of the system

a) Decreases b) Increases c) Remains same d) Becomes zero

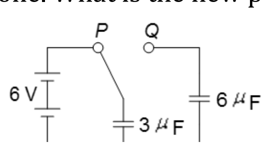
388. Three infinite planes have a uniform surface charge distribution σ on its surface. All charges are fixed. On each of the three infinite planes, parallel to the $y-z$ plane placed at $x=-a, x=0$ and $x=a$. There is a uniform surface charge of the same density, σ



The potential difference between A and C is

a) $\frac{\sigma}{2\varepsilon_0}a$ b) $\frac{\sigma}{\varepsilon_0}a$ c) $\frac{\sigma a}{2\varepsilon_0}$ d) None of the above

389. In the circuit shown, a capacitor of capacitance 3 μF is charged form a battery of e. m. f. 6 V with switch connected to terminal P. The switch is now connected to Q. This charges the 6μF capacitor from the 3 μF one. What is the new potential difference across combination?



a) 1 V b) 2 V c) 4 V d) 6 V

390. Two capacitor of capacity 6μF and 12μF in series are connected by potential of 150 V. the potential of capacitor of capacity 12μF will be

a) 25 V b) 50 V c) 100 V d) 150 V

391. A parallel plate air capacitor has a capacitance 18 μF.If the distance between the plates is trapled and a dielectric medium is introduced, the capacitance becomes 72 μF. The dielectric constant of the medium is

a) 4 b) 9 c) 12 d) 2

392. A parallel plate capacitor with air between the plates has a capacitance of 9 pF. The separation between its plates is d. The space between the plates is now filled with two dielectrics. One of the dielectrics has dielectric constant $K_1 = 3$ and thickness $\frac{d}{3}$ while the other one has dielectric constant $K_2 = 6$ and thickness$\frac{2d}{3}$.capacitance of the capacitor is now

a) 1.8 pF b) 45 pF c) 40.5 pF d) 20.25 pF

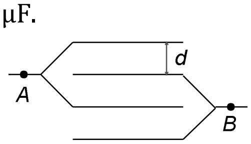
393. The capacitor plates are fixed on an inclined plane and connected to a battery of e. m. f. E. The capacitor plates have plate area a, length l and the distance between them is$d$. A dielectric slab of mass m and dielectric constant K is inserted into the capacitor and tied to mass M by a massless string as shown in the figure. Find the value of M for which the slab will stay in equilibrium. There is no friction between slab and plates.

a) $\frac{m}{2}+\frac{E^2\varepsilon_0 A(k-1)}{2lgd}$ b) $\frac{m}{2}-\frac{E^2\varepsilon_0 A(k-1)}{2lgd}$ c) $\frac{m}{2}+\frac{E^2\varepsilon_0 A(k-1)}{lgd}$ d) $\frac{m}{2}-\frac{E^2\varepsilon_0 A(k-1)}{lgd}$

394. A uniformly charged and infinitely long line having a linear charge density λ is placed at a normal distance y from a point$O$. Consider a sphere of radius R with O as centre and$R > y$. Electric flux through the surface of the sphere is

a) Zero b) $\frac{2\lambda R}{\varepsilon_0}$ c) $\frac{2\lambda\sqrt{R^2-y^2}}{\varepsilon_0}$ d) $\frac{\lambda\sqrt{R^2+y^2}}{\varepsilon_0}$

395. The equivalent capacity between points A and B in figure will be, while capacitance of each capacitor is 3 μF.



a) 2 μF b) 4 μF c) 7 μF d) 9 μF

396. Two capacitors of capacitance C are connected in series. If one of them is filled with dielectric substance K, what is the effective capacitance?

a) $\frac{KC}{(1+K)}$ b) $C(K+1)$ c) $\frac{2KC}{(1+K)}$ d) None of these

397. Two metallic charged spheres of radii R_1 and R_2 having charges Q_1 and Q_2, respectively, are connected to each other. There is

a) No change in the energy of the system

b) An increase in the energy of the system

c) Always a decrease in the energy of the system

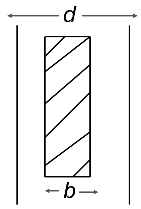
d) A decrease in energy of the system unless $Q_1R_2 = Q_2R_1$

398. Two charges -10C and +10 C are placed 10 cm apart. Potential at the centre of the line joining the two charges is

a) Zero b) 2 V c) -2 V d) None of these

a) 4.5 μC b) 9 μC c) 7 μC d) 30 μC

400. A slab of copper of thickness b is inserted in between the plates of parallel plate capacitor as shown in figure. The separation between the plates is d if $b = d/2$, then the ratio of capacities of capacitors after and before inserting the slab will be



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

401. A charged body has an electric flux ϕ associated with it the body is now placed inside a metallic container. The electric flux ϕ_1 associated with the container will be

a) $\phi_1 = 0$ b) $0 < \phi_1 < \phi$ c) $\phi_1 = \phi$ d) $\phi_1 > \phi$

402. Two positive point charges of 12μC and 5μC are placed 10 cm apart in air. The work needed to bring them 4 cm closer is

a) 2.4 J b) 3.6 J c) 1.6 J d) 6.0 J

403. The cross section of a cable is shown in Fig. The inner conductor has a radius of 10 mm and the dielectric has a thickness of 5 mm. the cable is 8 km long. Then, the capacitance of the cable is (given $\log_e 1.5 = 0.4$)

a) 3.8 μF b) 1.1 μF c) 4.8×10^{-10}F d) None of these

404. The variation of potential with distance R from fixed point is shown in Fig

The electric field at $R = 5$m is

a) 2.5 Vm^{-1} b) -2.5 Vm^{-1} c) 0.4 Vm^{-1} d) -0.4 Vm^{-1}

405. Three concentric conducting spherical shells carry charges as follows :$+Q$ on the inner shell, $-2Q$ on the middle shell and $-5\ Q$ on the outer shell. The charge in the inner surface of the outer shell is

a) Zero b) $+Q$ c) $-2\ Q$ d) $-3\ Q$

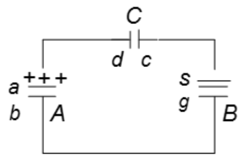
406. A fully charged capacitor has a capacitance C. It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity s and mass m. If the temperature of the block is raised by ΔT, the potential difference V across the capacitance is

a) $\sqrt{\frac{2mC\Delta T}{s}}$ b) $\frac{mC\Delta T}{s}$ c) $\frac{ms\Delta T}{C}$ d) $\sqrt{\frac{2m\,s\Delta T}{C}}$

407. The radius of nucleus of silver (atomic number Z=47) is 3.4×10^{-14}m.The electric potential on the surface of nucleus will be

a) $1.99 \times 10^6 V$ b) $2.99 \times 10^6 V$ c) $3.99 \times 10^6 V$ d) None of these

408. Two capacitors A and B with capacities C_1 and C_2 are charged to potential difference of V_1 andV_2, respectively. The plates of the capacitors are connected as shown in the figure with one wire free from each capacitor. The upper plate of A is positive and that of B is negative. An uncharged capacitor of capacitance C_3 and lead wires falls on the free ends to complete circuit, then



a) The final charge on each capacitor are same to each other
b) The final sum of charge on plates a and d is C_1V_1
c) The final sum of charge on plates b and g is $C_2V_2 - C_1V_1$
d) Both (b) and (c) are correct

409. A capacitor of capacitance C_0 charged to a potential V_0 and then isolated. A small capacitor C is then charged from C_0, discharged and charged again; the process being repeated n times. Due to this, potential of the larger capacitor us decreased to V. The value of C is

a) $C_0\left(\frac{V_0}{V}\right)^{1/n}$ b) $C_0\left[\left(\frac{V_0}{V}\right)^{1/n} - 1\right]$ c) $C_0\left[\left(\frac{V}{V_0}\right) - 1\right]^n$ d) $C_0\left[\left(\frac{V}{V_0}\right)^n + 1\right]$

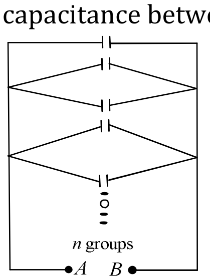
410. A photographic flash unit constant of a xenon-filled tube. It gives a flash of average power 2000 W for 0.04 s. The flash is due to discharge of a fully charged capacitor of 40 μF. The voltage to which it is charged before a flash is given by the unit is

a) 1500 V b) 2000 V c) 2500 V d) 3000 V

411. Inside a hollow charged spherical conductor, the potential

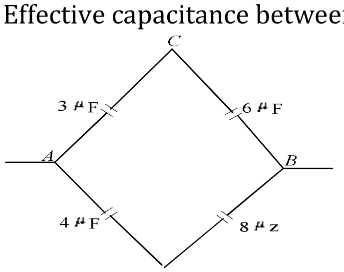
a) Is constant
b) Varies directly as the distance from the centre
c) Varies inversely as the distance from the centre
d) Varies inversely as the square of the distance from the centre

412. A number of capacitors, each of equal capacitance C, are arranged as shown in Fig. The equivalent capacitance between A and B is



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

413. Effective capacitance between points A and B in the figure, shown is



a) $\frac{3}{14}$μF b) $\frac{14}{3}$ μF c) 21 μF d) 23 μF

414. The potential at a point Pwhich is forming a corner of a square of side 93mm with charges, $Q_1 = 33$ nC,$Q_2 = -51$ nC, $Q_3 = 47$nC located at the other three corners is nearly

a) 16kV b) 4kV c) 400V d) 160V

415. Figure shows three points A, $B$and Cin a region of uniform electric field **E**. The line $AB$is perpendicular

and BC is parallel to the field lines. Then which of the following holds good?

Where V_A, V_B and V_C represent the electric potential at the points A, B and C respectively.

a) $V_A = V_B = V_C$ b) $V_A = V_B > V_c$ c) $V_A = V_B < V_C$ d) $V_A > V_B = V_C$

416. If dielectric constant and dielectric strength be denoted by K and X respectively, then a material suitable for use as a dielectric in a capacitor must have

a) High K and high X b) High K and low X c) Low K and high X d) Low K and low X

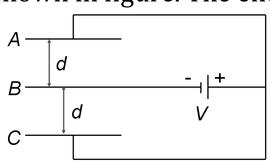
417. Two identical capacitors have the same capacitance C. One of them is charged to potential V_1 and the other to V_2. The negative ends of the capacitors are connected together. When the positive ends are also connected, the decrease in energy of the system is

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) $\frac{1}{4}C(V_1 + V_2)^2$

418. Work done in carrying a charge Q_1 once round a circle of radius R with a charge Q_2 at the centre I s

a) $\frac{Q_1Q_2}{4\pi\varepsilon_0 R^2}$ b) Zero c) $\frac{Q_1Q_2}{4\pi\varepsilon_0 R}$ d) Infinite

419. Consider the arrangement of three metal plates A, B, and C of equal surface area and separation d as shown in figure. The energy stored in the arrangement, when the plates are fully charged, is



a) $\frac{\varepsilon_0 AV^2}{2d}$ b) $\frac{\varepsilon_0 AV^2}{d}$ c) $\frac{2\varepsilon_0 AV^2}{d}$ d) $\frac{3\varepsilon_0 AV^2}{2d}$

420. Three charges are placed at the vertex of an equilateral triangle as shown in figure. For what value of Q, the electrostatic potential energy of the system is zero?

a) $-q$ b) $\frac{q}{2}$ c) $-2q$ d) $\frac{-q}{2}$

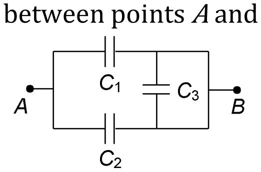
421. Charges $2q$, $-q$ and $-q$ lie at the vertices of an equilateral triangle. The value of E and V at the centroid of the triangle will be

a) $E \neq 0$ and $V \neq 0$ b) $E = 0$ and $V = 0$ c) $E \neq 0$ and $V = 0$ d) $E = 0$ and $V \neq 0$

422. Number of electric lines of force from 0.5 C if positive charge in a dielectric medium of constant 10 is

a) 5.65×10^9 b) 1.13×10^{11} c) 9×10^9 d) 8.85×10^{-12}

423. The equivalent capacitance of the combination of three capacitors, each of capacitance C shown in figure between points A and B is

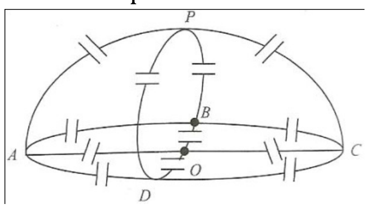


a) $\frac{C}{2}$ b) $\frac{3C}{2}$ c) $\frac{1}{3C}$ d) 2C

424. Three capacitors 2, 3 and 6 μF are joined with each other. What is the minimum effective capacitance?

a) $\frac{1}{2}$ μF b) 1 μF c) 2 μF d) 3 μF

425. Find the capacitance between P and O (Fig). Each capacitor has capacitance C.

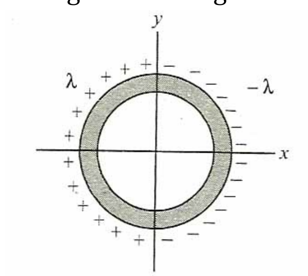


a) $2C$ b) $3C$ c) $8C$ d) $6C$

426. An uncharged conductor A is brought near a positively charged conductor B. Then

a) The charge on B will increase but the potential of B will not change
b) The charge on B will not change but the potential of B will decrease
c) The charge on B will decrease but the potential of B will not change
d) The charge on B will not change but the potential of B will increase

427. Find the electric dipole moment of a non-conducting ring of radius$a$, made of two semicircular rings having linear charge densities -1 and $+1$ as shown in Figure.



a) $2\lambda a^2$ b) $4\ \lambda a^2$ c) λa^2 d) $2\sqrt{2}\ \lambda a^2$

428. A 500 μF capacitor is charged at a steady rate of $100 \mu Cs^{-1}$. The potential difference across the capacitor will be 10 V after in interval of

a) 5 s b) 25 s c) 20 s d) 50 s

429. An air capacitor is charged with an amount of charge q and dipped into an oil tank. If the oil is pumped out , the electric field between the plates of capacitor will

a) Increase b) Decrease c) Remain the same d) Become zero

430. An electric dipole is placed at origin in the $x-y$ plane with its orientatin along the positive x-axis. The direction of electric field

a) At $(-x_0, 0{,}0)$ is along the positive x-axis
b) At $(0{,}y_0, 0)$ is along the negative x-axis
c) At $(0, 0{,}z_0)$ is along the negative x-axis
d) All the above

431. An AC source is rated at 220 V, 50 Hz. The time taken for voltage to change from its peak value to zero is

a) 50 s b) 0.02 s c) 5 s d) 5×10^{-3}s

432. Two plates are 20 cm apart and the potential difference between them is 10 V. The electric field between the plates is

a) 50 Vm^{-1} b) 500 Vm^{-1} c) 0.5 Vm^{-1} d) 20 Vm^{-1}

433. Four metallic plates, each with a surface area of one side A, are placed at a distance d from each other. The alternate plates are connected to point A and B as shown in Fig. Then the capacitance of the system is

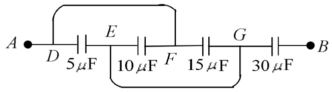
a) $\frac{\varepsilon_0 A}{d}$ b) $\frac{2\varepsilon_0 A}{d}$ c) $\frac{3\varepsilon_0 A}{d}$ d) $\frac{4\varepsilon_0 A}{d}$

434. The electric potential inside a conducting sphere

a) Increases from centre to surface
b) Decreases from centre to surface
c) Remains constant from centre to surface
d) Is zero at every point inside

435. A uniform electric field having a magnitude E_0 and direction along the positive X–axis, exists. If the potential V is zero at $x=0$, then its value at $x=+x$ will be

a) $V(x) = +x\ E_0$ b) $V(x) = -x\ \ E_0$ c) $V(x) = +x^2\ E_0$ d) $V(x) = -x^2\ E_0$



a) 15 μF b) 30 μF c) 60 μF d) 45 μF

437. A capacitor of capacitance value 1 μF is charged to 30 V and the battery is then disconnected. If the remaining circuit is connected across a 2μF capacitor, the remaining circuit is connected across a 2μF capacitor, the energy lost by the system is

a) 300 μJ b) 450 μJ c) 225 μJ d) 150 μJ

438. A parallel-plate capacitor has plates of area A and separation d and is charge to a potential difference V. The charging battery is then disconnected and the plates are pulled apart until their separation is $2d$. What is the work required to separate the plates?

a) $2\varepsilon_0 AV^2/d$ b) $\varepsilon_0 AV^2/d$ c) $3\varepsilon_0 AV^2/2d$ d) $\varepsilon_0 AV^2/2d$

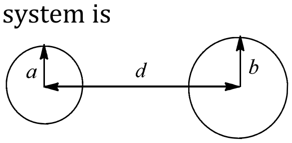
439. Two capacitors of capacitance 2 μF and 4μF respectively are connected in series. The combination is connected across a potential difference of 10 V. The ratio of energies stored by capacitors will be

a) $1 : \sqrt{2}$ b) 2 : 1 c) 1 : 4 d) 4 : 1

440. Two free protons are separated by a distance of 1 Å. If one proton is kept at least and the other is released, the kinetic energy of second proton when at infinite sparation is

a) 23.0×10^{-19} J b) 11.5×10^{-19} J c) 2.3×10^{-19} J d) Zero

441. Two metallic spheres of radii A and B are separated by a distance d as shown in Fig. The capacity of the system is

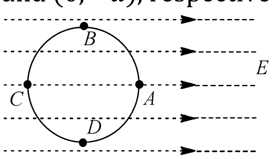


a) $\frac{4\pi\varepsilon_0}{\frac{1}{a}+\frac{1}{b}-\frac{2}{d}}$ b) $\frac{4\pi\varepsilon_0}{\frac{1}{a}+\frac{1}{b}+\frac{2}{d}}$ c) $\frac{4\pi\varepsilon_0}{\frac{1}{a}-\frac{1}{b}+\frac{2}{d}}$ d) $\frac{4\pi\varepsilon_0}{\frac{1}{a}-\frac{1}{b}-\frac{2}{d}}$

442. 27 small drops each having charge q and radius r coalesce to form big drop. How many times charge and capacitance will become?

a) 3, 27 b) 27, 3 c) 27, 27 d) 3, 3

443. The electric field in a region surrounding the origin is uniform and along the x-axis. A small circle is drawn with the centre at the origin cutting the axes at point A, B, C and D having coordinates $(a, 0)$, $(0, a)$, $(-a, 0)$ and $(0, -a)$, respectively, as shown in Fig. Then, the potential is minimum at



a) A b) B c) C d) D

444. Two identical rings P and Q of radius 0.1 m are mounted coaxially at a distance 0.5 m apart. The charges on the two rings are 2 and 4 μC, respectively. The work done in transferring a charge of 5μC from the centre of P to that of Q is

a) 1.28 J b) 0.72 J c) 0.144 J d) 2.24 J

445. 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. Find the electric potential at the centre of the shell

a) $\frac{1}{4\pi\varepsilon_0}\frac{q}{2R}$ b) $\frac{1}{4\pi\varepsilon_0}\frac{4q}{3R}$ c) $\frac{1}{4\pi\varepsilon_0}\frac{5q}{6R}$ d) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3R}$

446. A point charge $+Q$ is placed at the centroid of a equilateral triangle. When a second charge $+Q$ is placed at a vertex of the triangle, the magnitude of the electrostatic force on the central charge is 8 N. the magnitude of the net force on the central charge when a third charge $+Q$ is placed at another vertex of the triangle is

a) Zero b) 4 N c) $4\sqrt{2}$N d) 8 N

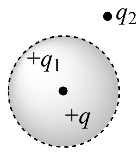
447. Variation in potential is maximum if one goes

a) Along the line of force b) Perpendicular to the line of force

c) In any direction
d) None of these

448. For making a parallel-plate capacitor you have two plates of copper, a sheet of a mica (thickness = 0.10 mm, $K = 5.4$), a sheet of glass (thickness = 0.20 mm, $K = 7$) and a slab of paraffin (thickness = 1.0 cm, $K = 2$). To obtain the largest capacitance, which sheet should you place between the copper plates?
a) Mica
b) Copper
c) Glass
d) Information is insufficient

449. 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



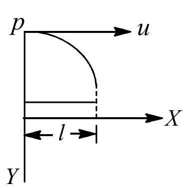
a) q_2
b) Only the positive charge
c) All the charges
d) $+q_1$ and $-q_1$

450. A capacitor is charged to store an energy U. The charging battery is disconnected. An identical capacitor is now connected to the first capacitor in parallel. The energy in each of the capacitor is now
a) $3U/2$
b) U
c) $U/4$
d) $U/2$

451. Electric potential at the centre of a charged hollow metal sphere is
a) Zero
b) Twice as that on the surface
c) Half of that on the surface
d) Same as that on the surface

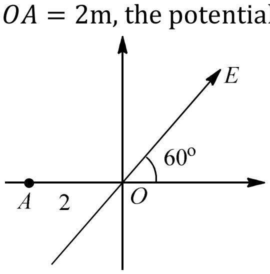
452. A small conducting sphere of radius a, carrying a charge of $+Q$, is placed inside an equal and oppositely charged conducting shell of radius b such that their centres coincide. Determine the potential at a point which is at a distance of c from centre such that $a < c < b$
a) $k(Q/c + Q/b)$
b) $k(Q/a + Q/b)$
c) $k(Q/a - Q/b)$
d) $k(Q/c - Q/b)$

453. The electron is projected from a distance d and with initial velocity u parallel to a uniformly charged flat conducting plate as shown in figure. It strikes the plate after travelling a distance l along the direction. The surface charge density of conducting plate is equal to



a) $\frac{2d\varepsilon_0 mu^2}{el^2}$
b) $\frac{2d\varepsilon_0 mu}{el}$
c) $\frac{d\varepsilon_0 mu^2}{el}$
d) $\frac{d\varepsilon_0 mu}{el}$

454. A uniform electric field of 100 Vm^{-1} is directed at 60° with the positive x-axis as shown in Figure. If $OA = 2$m, the potential difference $V_O - V_A$ is



a) 50 V
b) 50 V
c) 100 V
d) −100 V

455. A parallel-plate capacitor is made by stacking n equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is C, then the resultant capacitance is
a) nC
b) C
c) $(n+1)C$
d) $(n-1)C$

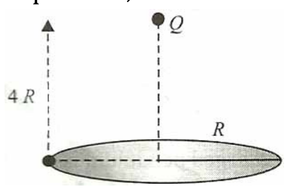
456. A parallel plate air capacitor has a capacitance C. When it is half filled with a dielectric constant 5, the percentage increase in the capacitance will be
a) 400 %
b) 66.6 %
c) 33.3 %
d) 200 %

457. Charges $+2Q$ and – Q are placed as shown is figure. The point at which electric filed intensity is zero will

be

a) Somewhere between – Q and $+2Q$
b) Somewhere on the left of – Q
c) Somewhere on the right of $+2Q$
d) Somewhere on the right bisector of line joining – Q and $+2Q$.

458. A charge Q is placed at a distance of $4R$ above the centre of a disk of radius$R$. The magnitude of flux through the disk isϕ. Now, a hemispherical shell of radius R is placed over the disk such that it forms a closed surface. The flux through the curved surface, taking direction of area vector along outward normal as positive, is



a) Zero
b) ϕ
c) $-\phi$
d) 2ϕ

459. The distance between plates of a parallel-plates capacitor us $5d$. 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 Fig. Potential V versus distance x graph will be

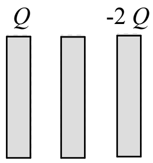
a)
b)
c)
d) None of these

460. A positively charged particle P enters the region between two parallel plate with a velocity$u$, in a direction parallel to the plate. There is a uniform electric field in this region. P Emerges from this region with a velocity v

Taking C as a constant, v will depend on u as

a) $v = Cu$
b) $v = \sqrt{u^2 + Cu}$
c) $v = \sqrt{u^2 + \frac{C}{u}}$
d) $v = \sqrt{u^2 + \frac{C}{u^2}}$

461. Three identical metal plates with large surface areas are kept parallel to each other as shown in Figure. The leftmost plate is given a charge$Q$. The rightmost a charge $-2Q$ and the middle one remains neutral. Find the charge appearing on the outer surface of the rightmost plate



a) $-Q/4$ b) $-2Q$ c) $-Q$ d) $-Q/2$

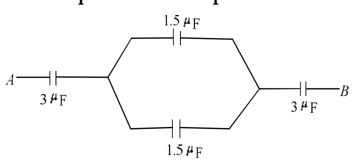
462. Three identical capacitors, each of capacitance C, are connected in series with a battery of e.m.f V and get fully charged. Now, the battery is removed and the capacitors are connected in parallel with positive terminals at one point and negative terminals at other point. Then, the common potential will be

a) V b) $3V$ c) $V/3$ d) Zero

463. A parallel-plate capacitor is connected to a battery. The plates are pulled apart with uniform speed. If x is the separation between the plates, then the rate of change of electrostatic energy of the capacitor is proportional to

a) x^2 b) x c) $\frac{1}{x}$ d) $\frac{1}{x^2}$

464. The equivalent capacitance between the points A and B in the following circuit is



a) 1 μF b) 2 μF c) 4 μF d) 8 μF

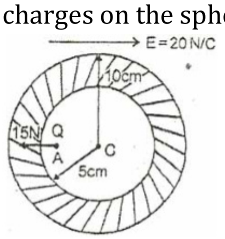
465. Two points $P$and Q are maintained at the potentials of 10V and -4V respectively. The work done in moving 100 electrons from $P$to Q is

a) -19×10^{-17}J b) 9.60×10^{-17}J c) -2.24×10^{-16}J d) 2.24×10^{-16}J

466. In a region of space, the electric field is given by $\vec{E} = 8\hat{\imath} + 4\hat{\jmath} + 3\hat{k}$. The electric flux through a surface of area of 100 units x-y plane is

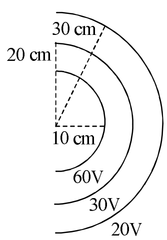
a) 800 units b) 300 units c) 400 units d) 1500 units

467. In a conducting hollow sphere of inner and outer radii 5 cm and 10 cm, respectively, a point charge 1 C is placed at point A, that is 3 cm from the centre C of the hollow sphere. An external uniform electric field of magnitude 20 N/C is also applied. Net electric force on this charge is 15 N, away from the centre of the sphere as shown. Find the magnitude of net force exerted on the charge placed at pint A by the induced charges on the sphere



a) 15 N b) 20 N c) 5 N d) 35 N

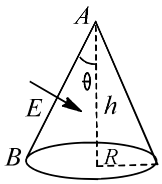
468. Figure shows equipotential surfaces concentric at O, the magnitude of electric field at a distance r measured from O is



a) $\frac{9}{r^2}(\text{Vm}^{-1})$ b) $\frac{6}{r^2}(\text{Vm}^{-1})$ c) $\frac{2}{r^2}(\text{Vm}^{-1})$ d) $\frac{16}{r^2}(\text{Vm}^{-1})$

469. A conic surface is placed in a uniform electric field E as shown such that field is perpendicular to the surface on the sideAB. The base of the cone is of radius R and height of the cone is h. The angle of cone is θ

as shown. Find the magnitude of that flux which only enters the cone curved surface. Do not count the outgoing flux. Take $\theta < 45°$

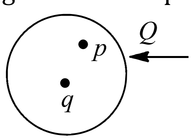


a) $ER[h\cos\theta + \pi(R/2)\sin\theta]$
b) $ER[h\sin\theta + \pi R\cos\theta]$
c) $ER[h\cos\theta + \pi R\sin\theta]$
d) None of these

470. Six identical capacitors are joined in parallel, charged to a potential difference of 10 V, separated and then connected in series, *ie*, the positive plate of one is connected to negative plate of other. Then potential difference between free plates is
a) 10 V
b) 30 V
c) 60 V
d) $\frac{10}{6}V$

471. A thin aluminium sheet is placed between the plates of a parallel-plate capacitor. Its capacitance will
a) Increases
b) Decreases
c) Remain same
d) Become infinite

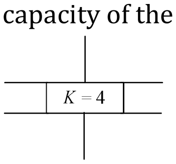
472. Inside a hollow conducting sphere, which is uncharged, a charge q is placed at its centre. Let electric field at a distance x From centre at point p bs E and potential at this point be$V$. Now, some positive charge Q is given to this sphere, then



a) E will remain the same
b) E will increase
c) V will decrease
d) V will the same

473. Two spherical conductors A and B of radii 1 mm and 2 mm are separated by a distance of 5 cm and are uniformly charged. If the spheres are connected by a conducting wire, then in equilibrium condition, the radio of the magnitude of the electric fields at the surfaces of spheres A and B is
a) 4 : 1
b) 1 : 2
c) 2 : 1
d) 1 : 4

474. Consider a parallel-plate capacitor of capacity 10 μF with air dilled in the gap between the plates. Now, one half of the space between the plates is filled with a dielectric of dielectric constant 4 as shown in Fig. The capacity of the capacitor changes to



a) 25 μF
b) 20 μF
c) 40 μF
d) 5 μF

475. Electric charges q, q and $-2q$ are placed at the corners of an equilateral triangle ABC of side l. The magnitude of electric dipole moment of the system is
a) ql
b) $2ql$
c) $\sqrt{3}ql$
d) ql

476. Three charges 1μC, 2μC, 3μC are kept at vertices of an equilateral triangle of side 1m. If they are brought nearer, so that they now form an equilateral triangle of side 0.5m, then work done is
a) 11J
b) 1.1J
c) 0.01J
d) 0.11J

477. The plates of a parallel capacitor are charged up to 100 V. Now, after removing the battery, a 2 mm thick plate is inserted between the plates. Then, to maintain the same potential difference, the distance between the capacitor plates is increased by 1.6 mm. Dielectric constant of the plate is
a) 5
b) 1.25
c) 4
d) 2.5

478. 4 point charges each +q is placed on the circumference of a circle of diameter $2d$ in such a way that they form a square. The potential at the centre is
a) 0
b) $\frac{4q}{d}$
c) $\frac{4d}{q}$
d) $\frac{q}{4d}$

479. A hollow metal sphere of radius 5 cm is charged such that potential at its surface is 10V. The potential at the centre of the sphere is

a) Zero
b) 10 V
c) Same as at point 5cm away from the surface
d) Same as at point 10cm away from the surface

480. The voltage of clouds is $4 \times 10^6 V$ with respect to ground. In a lightning strike lasting 100ms, a charge of 4C is delivered to the ground. The power of lightning strike is

a) 160 MW
b) 80 MW
c) 20 MW
d) 500 kW

481. Two points are at distances a and b $(a < b)$ from a long string of charge per unit lengthλ. The potential difference between the points is proportional to

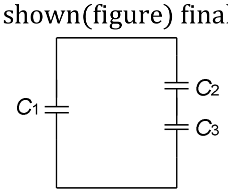
a) b/a
b) b^2/a^2
c) $\sqrt{b/a}$
d) $\log b/a$

482. A dielectric slab of area A and thickness d is inserted between the plates of a capacitor of are $2A$ with constant speed v as shown in Fig. Distance between the plates is d

The capacitor is connected to a battery of e.m.f. E. The current in the circuit varies with time as

a)
b)
c)
d)

483. Capacitor C_1 is connected to a battery and charged till the magnitude of the charge on each plate Is q_0 then, the battery is disconnected and C_1 is connected to two other uncharged capacitor C_2 and C_3 as shown(figure) final charge on the capacitors (q_1, q_2 and q_3) are related by



a) $q_0 = q_1 + q_2 + q_3$
b) $q_1 + q_2 + q_3 = 0$
c) $q_0 = q_3 + q_2 + q_1 = 0$
d) $q_0 = q_1 + q_2, q_2 = q_3$

484. $n$charged drops, each of radius r and charge q, coalesce to from a big drop of radius R and charge Q. If V is the electric potential and E is the electric field at the surface of a drop, then

a) $E_{\text{big}} = n^{2/3} E_{\text{small}}$
b) $V_{\text{big}} = n^{1/3} V_{\text{small}}$
c) $E_{\text{small}} = n^{2/3} E_{\text{big}}$
d) $V_{\text{big}} = n^{2/3} V_{\text{small}}$

485. An electric field is given by$\vec{E} = (y\hat{i} + x\hat{j})$m NC^{-1}. The work done in moving a 1 C charge from $\vec{r}_A = (2\hat{i} + 2\hat{j})$m to $\vec{r}_B = (4\hat{i} + 2\hat{j})$m is

a) +8 J
b) +4 J
c) Zero
d) −4 J

486. How many 6 μF, 200 V condensers are needed to make a condenser of 18 μF, 600 V?

a) 9
b) 18
c) 3
d) 27

487. In which of the states shown in figure is the potential energy of a electric dipole maximum?

a)
b)
c)
d)

488. Four identical metal plates, each with a surface area A(on one side), are placed at a distance d from each other as shown in Fig. The two inner plates are connected to point B and the other two plates to another point A. Then, the capacitance of the system is

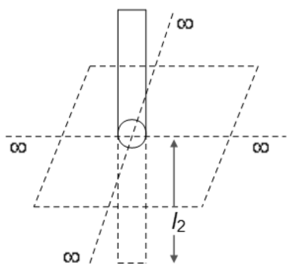
a) $\varepsilon_0 A/d$ b) $2\varepsilon_0 A/d$ c) $3\varepsilon_0 A/d$ d) $2\varepsilon_0 A/3d$

489. A network of six identical capacitors, each of value$C$, is made as shown in the figure.

The equivalent capacitance between the points A and B is

a) $\frac{4C}{11}$ b) $\frac{3C}{4}$ c) $\frac{3C}{2}$ d) $3C$

490. An infinite non-conducting sheet has surface charge density s. there is a small hole in the sheet as shown in the figure. A uniform rod of length ℓ having linear charge density λ is hinged in the hole as shown. If the mass of the rod is m, then the time period of oscillations for small angular displacement is

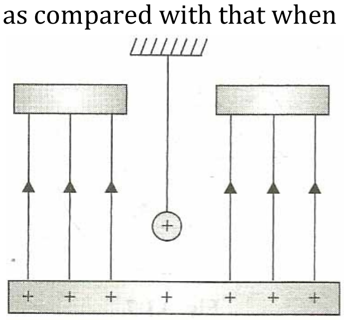


a) $\pi\sqrt{\frac{m\varepsilon_0}{3\sigma\lambda}}$ b) $2\pi\sqrt{\frac{2m\varepsilon_0}{3\sigma\lambda}}$ c) $\frac{\pi}{2}\sqrt{\frac{m\varepsilon_0}{3\sigma\lambda}}$ d) $4\pi\sqrt{\frac{m\varepsilon_0}{3\sigma\lambda}}$

491. Two identical conducting very large plates P_1 and P_2 having charges $+4Q$ and $+6Q$ are placed very closed to each other at separation d. The plate area of either face of the plate is$A$. The potential difference between plates P_1 and P_2 is

a) $V_{P_1} - V_{P_2} = \frac{Qd}{A\varepsilon_0}$ b) $V_{P_1} - V_{P_2} = \frac{-Qd}{A\varepsilon_0}$ c) $V_{P_1} - V_{P_2} = \frac{5Qd}{A\varepsilon_0}$ d) $V_{P_1} - V_{P_2} = \frac{-5Qd}{A\varepsilon_0}$

492. If a positively charged pendulum is oscillating in a uniform electric field as show in Figure. its time period as compared with that when it was uncharged



a) Will increase b) Will decrease
c) Will not change d) Will first increase and then decrease

493. Taking earth to be a metallic spheres, its capacity will approximately be

a) 6.4×10^6F b) 700 F c) 711 μF d) 700 pF

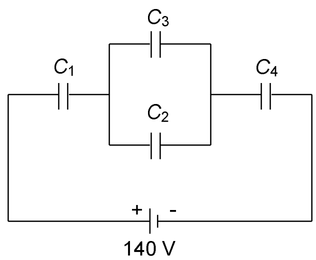
494. A positive charge is moved from a low potential point A to a high potential point B. Then, the electric potential energy of the system

a) Increase b) Decrease
c) Will remain the same d) Nothing definite can be predicted

495. Find the potential at the centre of a square of side $\sqrt{2}$m. Which carries at its four corners charges $q_1 = 3 \times 10^{-6}$C,$q_2 = -3 \times 10^{-6}$C, q_3=-4×10^{-6}C, $q_4 = 7 \times 10^{-6}C$

a) $2.7 \times 10^4 V$ b) $1.5 \times 10^3 V$ c) $3 \times 10^2 V$ d) $5 \times 10^3 V$

496. In the circuit arrangement shown in figure, the value of $C_1 = C_2 = C_3 = 30$ pF and $C_3 = 120$ pF. If the combination of capacitors is charged with 140V DC supply, the potential differences across the four capacitors will be respectively



a) 80, 40, 40 and 20 V b) 20, 40, 40 and 80 V c) 35, 35, 35 and 35 V d) 80, 20, 20 and 20 V

497. Two conducting sphere of radii r_1 and r_2 are at the same potential. The ratio of their charges is

a) r_1^2 / r_2^2 b) r_2^2 / r_1^2 c) r_1 / r_2 d) r_2 / r_1

498. Charges $-q$, Q and $-q$ are placed at an equal distance on a straight line. If the total potential energy of the system of three charges is zero, then find the ratio Q/q

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

499. Four charges $+q, -q, +q$ and $-q$ are put together at four corners of a square as shown in Fig. The work done by external agent in assembling this configuration is

a) Zero b) $-2.59\ kq^2/a$ c) $+2.59\ kq^2/a$ d) None of these

500. A large insulated sphere of radius r charged with Q units of electricity is placed in contact with a small insulated uncharged sphere of radius r' and is then separated. The charge on the smaller sphere will now be

a) $\frac{Q(r'+r)}{r'}$ b) $\frac{Q(r'+r)}{r}$ c) $\frac{Qr}{r'+r}$ d) $\frac{Qr'}{r'+r}$

501. In Fig, if the potential at point B is taken as zero, then the potential at point A will be

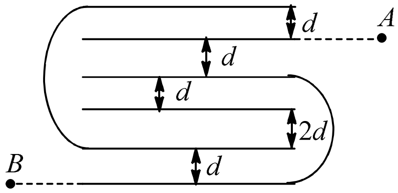
a) 8 V b) 16 V c) 24 V d) None of the above

502. Given a metallic uniformly charged sphere. The radius of the sphere is increased keeping its potential same. What is the effect on the value of electric field intensity at its surface?

a) Increases b) Decreases c) remains constant d) Cannot say

503. Find the equivalent capacitance between A and .[Assume each conducting plate is having same dimensions

and neglect the thickness of the plate, $\varepsilon_0 A/d = 7\ \mu$F [where A is area of plates, $A >> d$]



a) 7 μF b) 11 μF c) 12 μF d) 15 μF

504. A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor

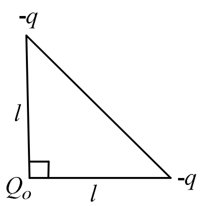
a) Decreases b) Remain unchanged c) Becomes infinite d) Increases

505. Across each of two capacitors 1 μF and 4 μF, a potential difference of 10 V is applied. Then positive plate of one is connected to the negative plate of the other, and negative plate of one is connected to the positive plate of the other. After contact

a) Charge on each is zero b) Charge on each is same but non-zero

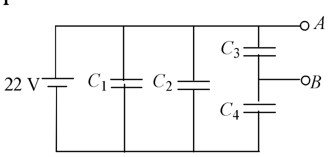
c) Charge on each is different but non-zero d) None of the above

506. Three charges $Q_0, -q$ and $-q$ are placed at the vertices of an isosceles right angle triangle as in the figure. The net electrostatic potential energy is zero if $Q_0$is equal to



a) $\frac{q}{4}$ b) $\frac{2q}{\sqrt{32}}$ c) $\sqrt{2q}$ d) +q

507. In Fig, given $C_1 = 3$ μF, $C_2 = 5$ μF, $C_3 = 9$ μF and $C_4 = 13$ μF. What is the potential difference between points A and B?



a) 13 V b) 9 V c) 0 V d) 11 V

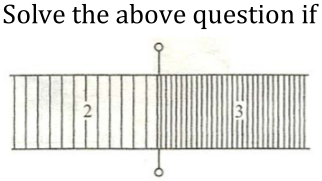
508. Two identical air core capacitors are connected in series to a voltage source of 15 V. If one of the capacitors is filled with a medium of dielectric constant 4, the new potential across this capacitor is

a) 5 V b) 8 V c) 10 V d) 12 V

509. If the electric flux entering and leaving an enclosed surface respectively is ϕ_1 and ϕ_1, then, charge enclosed in closed surface is

a) $\frac{\phi_2 - \phi_1}{\varepsilon_0}$ b) $\frac{\phi_1 + \phi_2}{\varepsilon_0}$ c) $\frac{\phi_1 - \phi_2}{\varepsilon_0}$ d) $\varepsilon_0(\phi_2 - \phi_1)$

510. Solve the above question if the dielectric materials were filled as shown in Fig



a) 1.2 μF b) 1.25 μF c) 1.80 μF d) None of these

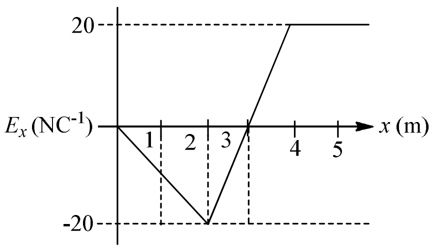
511. Along the x-axis, three charges $\frac{q}{2}, -q\ and\ \frac{q}{2}$ are placed at $x = 0, x = a$ and $x = 2$a respectively. The resultant electric potential at a point Plocated at a distance r from the charge $-q(a << r)$ is ($\varepsilon_0$is the permittivity of free space)

a) $\frac{qa}{4\pi\varepsilon_0 r^2}$ b) $\frac{qa^2}{4\pi\varepsilon_0 r^3}$ c) $\frac{q\left(\frac{a^2}{4}\right)}{4\pi\varepsilon_0 r^3}$ d) $\frac{q}{4\pi\varepsilon_0 r}$

512. We wish to obtain a capacitance of 5 μF, by using some capacitors, each of 2 μF. Then, the minimum number of capacitors required is

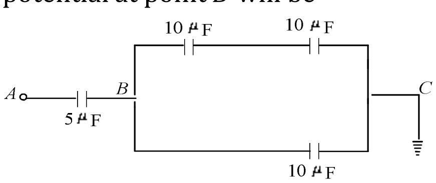
a) 3 b) 4 c) 5 d) Not possible

513. A graph of the x-component of the electric field as a function of x in a region of space is shown is Figure. The y-and z-components of the electric field are zero in this region. If the electric potential is 10 V at the origin, then the potential at $x = 2.0$ m is



a) 10 V b) 40 V c) −10 V d) 30 V

514. As shown in figure, if the point C is earthed and the point A is given a potential of 2000 V, then the potential at point B will be



a) 400 V b) 500 V c) 1000 V d) 1300 V

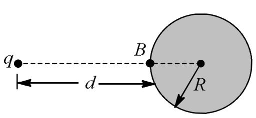
Multiple Correct Answers Type

515. A particle of mass 2 kg and charge 1 mC is projected vertically with a velocity $10ms^{-1}$. There is a uniform horizontal electric field of 10^4NC^{-1}. Then,

a) The horizontal range of the particle is 10 m b) The time of flight of the particle is 2 s

c) The maximum height reached is 5 m d) The horizontal range of the particle is 0

516. For the situation shown in Fig, mark out the correct statement(s)



a) Potential of the conductor is $q/[4\pi\varepsilon_0(d + R)]$

b) Potential of the conductor is $q/4\pi\varepsilon_0 d$

c) Potential of the conductor cannot be determined as nature of distribution of induced charges is not known

d) Potential at point B due to induced charges is $-qR[4\pi\varepsilon_0(d + R)d]$

517. Mark out the incorrect statement(s)

a) A proton tends to go from a region of low electric potential to a region of high electric potential

b) The electric potential of a negatively charged conductor must be negative

c) If $\vec{E} = 0$ at a point P, then V must be zero at P

d) If $V = 0$ at a point P, then $\vec{E}$ must be zero at P

518. The electric potential at a point certain distance from a point charge is 600 V and the electric field is 200NC^{-1}. Which of the following statements will be true?

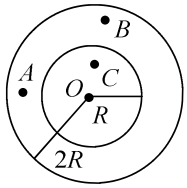
a) The magnitude of the charge is 20×10^{-3}C

b) The distance of the given point from the charge is 3 m

c) The potential at a distance of 9 m will be 200 V

d) The work done by an external agent in moving a point charge of 1 mC from the given point to a point to a point at a distance of 9 m will be 4×10^{-4}J

519. A hollow conducting sphere of inner radius r and outer radius $2R$ is given charge Q as shown in the figure. Then the



a) Potential at A and B is same
b) Potential at$O$ and B is same
c) Potential at O and C is same
d) Potential at A, B, C and O is same

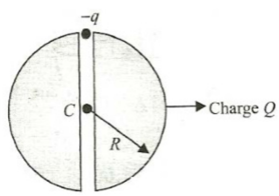
520. If a charged conductor is enclosed by a hollow charged conducting shell (assumed concentric and spherical in shape), and they are connected by a conducting wire, then which of the following statement(s) would be correct?

a) Potential difference between two conductors becomes zero
b) If charge on inner conductor is q and on outer conductor it is $2q$, then finally charge on outer conductor will be $3q$
c) The charge on the inner conductor is totally transferred to the outer conductor
d) If charge on the inner conductor is q and charge on the outer conductor is zero, then finally charge on each conductor will be $q/2$

521. A spherical metal shell A of radius $R_A$and a solid metal sphere $B$of radius R_B ($< R_A$) are kept far apart and each is given charge $+Q$. Now they are connected by a thin metal wire. Then

a) $E_A^{\text{inside}} = 0$
b) $Q_A > Q_B$
c) $\frac{\sigma_A}{\sigma_B} = \frac{R_B}{R_A}$
d) $\mathrm{E}_{\mathrm{A}}^{\text{on surface}} < \mathrm{E}_{\mathrm{B}}^{\text{on surface}}$

522. In a uniformly charged dielectric sphere, a very thin tunnel has been made along the diameter as shown in Figure below. A charge particle – q having mass m is released from rest at one end of the tunnel
For the situation described, mark out the correct statement(s) [neglect gravity]



a) Charge particle will perform S.H.M. about centre of the sphere as mean position
b) Time period of the particle is $2\pi\sqrt{\frac{2\pi\varepsilon_0 mR^3}{qQ}}$
c) Particle will perform oscillation but not S.H.M.
d) Speed of the particle while crossing the mean position is $\sqrt{\frac{qQ}{4\pi\varepsilon_0 mR}}$

523. A parallel plate capacitor of plate area A and plate separation d is charged to potential difference V and then the battery is disconnected. A Slab of dielectric 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 question, 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) $W = \frac{\varepsilon_0 AV^2}{2d}\left[1 - \frac{1}{K}\right]$

524. A parallel-plate air capacitor has initial capacitance C. If plate separation is slowly increased from d_1 to d_2, then mark the correct statement(s). [Take potential of the capacitor to be constant, i.e., throughout the process it remains connected to battery.]

a) Work done by electric force = −work done by external agent
b) Work done by electric force= $-\int \vec{F} \cdot \vec{d}x$, where $\vec{F}$ is the electric force of attraction between the plates of

plate separation is x

c) Work done by electric force $\neq$ −ve of work done by external agent

d) Work done by battery =2 times the change in electric potential energy stored in capacitor

525. A particle with a specific charge s start from rest in a region where the electric field hs a constant direction, but whose magnitude increases linearly with time. The particle acquires velocity v in time t

a) $v \propto s$ b) $v \propto \sqrt{s}$ c) $v \propto t$ d) $v \propto t^2$

526. Two point charges of different magnitudes and of opposite signs are separated by some distance. There can be

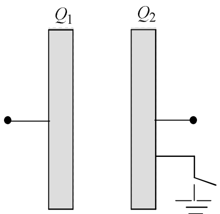
a) Only one point in space where net electric field intensity is zero

b) Only two points in space where net electric potential is zero

c) Infinite number of points in space where net electric field intensity is 0

d) Infinite number of points in space where net electric potential is zero

527. To two plates of a parallel-plate capacitors, charge Q_1 and Q_2 are given. The capacity of the capacitor is C. When the switch is closed, mark the correct statement(s). [Assume both Q_1, Q_2 to be +ve]



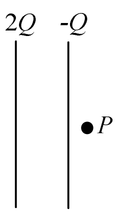
a) The charge flown through switch is zero

b) The charge flown through switch is $Q_1 + Q_2$

c) Potential difference across the capacitor plate is Q_1/C

d) The charge of the capacitor is Q_1

528. In figure the plates of a parallel plate capacitor have unequal charges. It capacitance is C. P is a point outside the capacitor and close to the plate of charge $-Q$. The distance between the plates is d



Then,

a) A point charge at point P will experience electric force due to the capacitor

b) The potential difference between the plates will be $3Q/2C$

c) The energy stored in the electric field in the region between the plates is $9Q^2/8C$

d) The force on one plate due to the other plate is $Q^2/2\pi\varepsilon_0 d^2$

529. A positive charge Q is located at the centre of a thin metallic spherical shell. Select the correct statement(s) from the following.

a) the electric field at any point outside the shell is zero

b) The electrostatic potential at any point outside the shell is $\frac{Q}{4\pi\varepsilon_0 r}$, where r is the distance of the points from centre.

c) The outer surface of the spherical shell is an equipotential surface

d) The electric field at any point inside the shell, other than centre point is, zero

530. The electric potential at a certain distance from a point charge is 600 V and the electric field is 200 NC^{-1}. Which of the following statements will be true?

a) The work done in moving a point charge of 1 μC from the given point to a point at a distance of 9 m will be 4×10^{-4} J

b) The distance of the given point from the charge is 3 m

c) The potential at a distance of 9 m will be 200 V

d) The magnitude of charge is 0.2×10^{-3}C

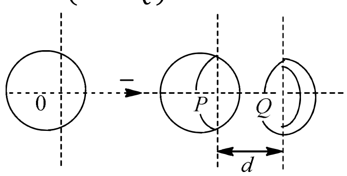
531. A point charge μ is placed at origin let $\vec{E}_A, \vec{E}_B$ and $\vec{E}_C$be the electric field at three points $A(1,2,3), B(1,1,-1)$ and $C(2,2,2)$ due to charge μ. Then

a) $\vec{E}_A \perp \vec{E}_B$ b) $\vec{E}_A \parallel \vec{E}_B$ c) $|\vec{E}_B| = 4|\vec{E}_C|$ d) $\vec{E}_B = 16|\vec{E}_C|$

532. An insulating spherical shell of uniform surface charge density is cut into two parts and placed at a distance d apart as shown in Figure

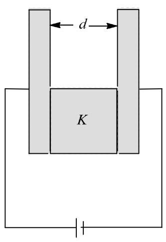
$\vec{E}_P$ and $\vec{E}_Q$ denote the electric fields at P and Q, respectively

As $d(\text{i.e.} PQ) \to \infty$



a) $|\vec{E}_P| > |\vec{E}_Q|$ b) $|\vec{E}_P| = |\vec{E}_Q|$ c) $|\vec{E}_P| < |\vec{E}_Q|$ d) $|\vec{E}_P| + |\vec{E}_Q| = 0$

533. A dielectric slab fills the lower half region of parallel-plate capacitor as shown in Fig. [Take plate area as A]



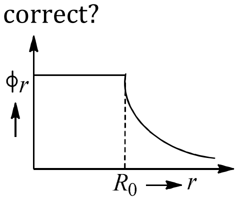
a) Equivalent capacity of the system is $\frac{\varepsilon_0 A}{2d}(1+K)$

b) The net charge of lower half of the left hand plate is $1/K$ times the charge on upper half of the plate

c) Net charges on lower and upper halves of left hand plate are different

d) Net charge on lower half of left hand plate is $\frac{K\varepsilon_0 A}{2d} \times V$

534. The electrostatic potential (ϕ_r) of a spherical symmetric system, kept at origin, is shown in the adjacent figure and given as $\phi_r = \frac{q}{4\pi\varepsilon_0 r}(r \geq R_0)$ and $\phi_r = \frac{q}{4\pi\varepsilon_0 r}(r \leq R_0)$ which of the following option (s) is/are correct?



a) For spherical regionr $\leq R_0$, total electrostatic energy stored is zero.

b) Within $r = 2R_{0,}$ total charge is q

c) There will be no charge anywhere except at $r = R_0$

d) Electric field is discontinuous at $r = R_0$

535. Four identical particles, each having mass m and charge q, are placed at the vertices of a square of side l. All the particles are free to move without any friction and released simultaneously from rest. Then,

a) At all instants, the particles remain at vertices of square whose edge length is changing

b) The configuration is changing (not remaining square) as the time passes

c) The speed of the particles when one of the particles gets displaced by $\frac{1}{\sqrt{2}}$ is $\sqrt{\frac{q^2}{8\pi\varepsilon_0 ml}\left(2+\frac{1}{\sqrt{2}}\right)}$

d) The speed of the particles cannot be found

536. An ellipsoidal cavity is curved 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

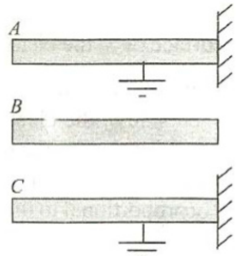
a) Electric field near A in the cavity = electric field near B in the cavity

b) Charge density at A=charge density at B

c) Potential at A=potential at B

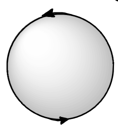
d) Total electric field flux through the surface of the cavity is $\frac{q}{\varepsilon_0}$

537. A, B and C are three large, parallel conducting plates, placed horizontally. A and C are rightly fixed and earthed (figure). B is given some charge. Under electrostatic and gravitation forces, B may be
a) In equilibrium if it is closer to A than to C
b) In equilibrium midway between A and C
c) B can never be in stable equilibrium
In equilibrium if it is closer to C than to A

d) 

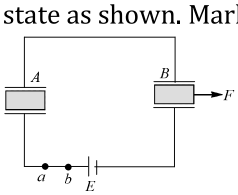
538. When a positively charged sphere is brought near a metallic sphere, it is observed that a force of attraction exists between the two. It means
a) The metallic sphere may be electrically neutral
b) The metallic sphere is necessarily negatively charged
c) Nothing can be said about the charge of the metallic sphere
d) The metallic sphere may be negatively charged

539. In the diagram a line of force of a particular field, shown out of the following options, can never represent



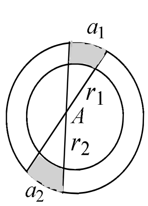
a) Induced electric field
b) Magnetostatic field
c) Gravitational field of a mass at rest
d) Electrostatic field

540. Two identical capacitors with identical dielectric slabs in between them are connected in series as shown in Fig. Now, the slab of one capacitor is pulled out slowly with the help of an external force F at steady state as shown. Mark out the correct statement(s)



a) During the process, charge (positive) flows from b to a
b) During the process, charge of capacitor B is equal to charge in A at all instants
c) Work done by F is positive
d) During the process, the battery has been charged

541. A wire having a uniform linear charge density λ, is bent in the form of a ring of radius R. Point A as shown in Fig, is in the plane of the ring but not at the centre. Two elements of the ring of lengths a_1 and a_2 subtend very small same angle at the point A. They are at distances r_1 and r_2 from the point A, respectively. $(r_2 > r_1)$
a) The ratio of charges of element a_1 to that of element a_2 is r_1/r_s
b) The element a_1 produced greater magnitude of electric field at A than element a_2
The elementsa_1 and a_2 produce same potential at A

c) 

d) The direction of net electric field produced by elements only at A is towards element a_2

542. Two infinite, parallel, non-conducting sheets carry equal positive charge density σ. One is placed in the $y-z$ plane and the other at distance $x=a$. Take potential $V=0$at $x=0$. Then

a) For $0 \leq x \leq a$, potential $V=0$

b) For $x \geq a, potential\ V=\frac{\sigma}{\varepsilon_0}(x-a)$

c) For $x \geq a$ potential $V=-\frac{\sigma}{\varepsilon_0}(x-a)$

d) For $x \leq 0$, potential $V=\frac{\sigma}{\varepsilon_0}x$

543. A small conducting sphere of radius a mounted on an insulted handle and a positive charge q is inserted through a hole in the wall of a hollow conducting sphere of inner radius b and outer radius c. The hollow sphere is supported on an insulating stand and is initially uncharged. The small sphere is placed at the centre of the hollow sphere. Neglect any effect of the hole. Which of the following statements will be true for this system?

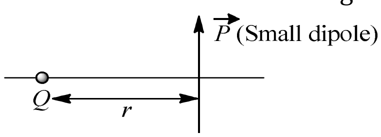
a) No work will be done in carrying a small charge from the inner conductor to the outer conductor

b) The electric field at a point in the region between the spheres at a distance r from the centre is equal to $q/4\pi\varepsilon_0 r^2$

c) The electric field at a point outside the hollow sphere at a distance r from the entre is $q/4\pi\varepsilon_0 r^2$

d) The potential of the inner sphere with respect to the outer sphere is given by $V_{ab}=\frac{q}{4\pi\varepsilon_0}\left(\frac{1}{a}-\frac{1}{b}\right)$

544. For the situation shown in Figure. (assume $r >>$ length of dipole)mark out the correct stament(s).



a) Force acting on the dipole is zero

b) Force acting on the dipole is approximately$\frac{pQ}{4\pi\varepsilon_0 r^3}$ and is acting upward

c) Torque acting on the dipole is $\frac{pQ}{4\pi\varepsilon_0 r^2}$ in clock-wise direction

d) Torque acting on the dipole is $\frac{pQ}{4\pi\varepsilon_0 r^3}$ in anti-clockwise direction

545. An electric charge $2\times10^{-8}C$ is placed at the point (1, 2, 4). At the point (3,2, 1), the electric

a) Field will increase by a factor K if the space between the points is filled with a dielectric of dielectric constant K

b) Field will be along the y-axis

c) Potential will be 49.9 V

d) Field will have no y-component

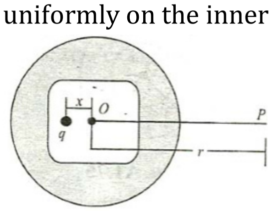
546. A point charge q is placed within the cavity of an electrically neutral conducting shell whose outer surface has spherical shape. Then,

a) The potential V at point P lying outside the shell at a distance r from the centre O of the outer surface depends upon the value of x

b) Potential at P does not depend upon the value of x

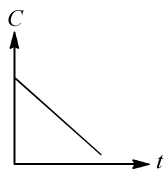
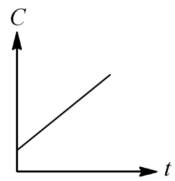
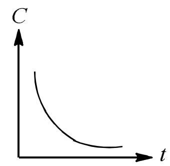
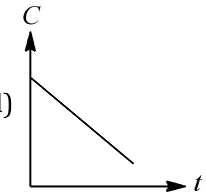
c) A total charge q will be induced on the outer surface of the shell which will be distributed uniformly on the outer surface

d) A total charge – q will be induced on the inner surface of the shell which will be distributed non-uniformly on the inner surface

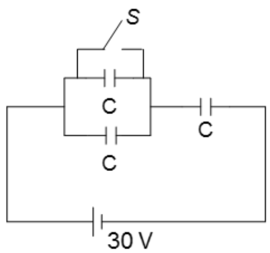


547. A parallel-plate capacitor has a dielectric slab in it. The slab just fills the space inside the capacitor. The capacitor is charged by a battery and then battery is disconnected. Now the slab is started to pull out slowly at $t=0$. If at difference between the plates capacitors is V, then which of the following graphs

is/are correct

a) 
b) 
c) 
d) 

548. Three capacitors, each having capacitance $C = 2\mu$F, are connected with a battery of e.m.f. 30 V as shown in the figure



When the switch S is closed

a) The amount of charge flown through the battery is 20μC
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 μC

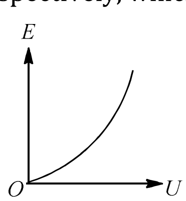
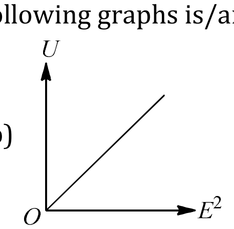
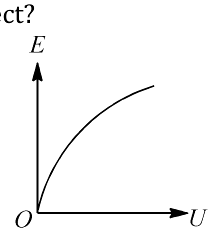
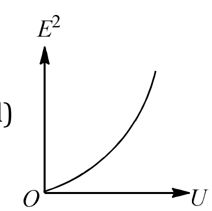
549. A small sphere is charged uniformly and placed at some point $A(x_0, y_0)$ so that at point $B(9m, 4m)$ electric field strength is $\vec{E} = (54\hat{\imath} + 72\hat{\jmath})NC^{-1}$ and potential is 1800 V. Then

a) The magnitude of charge on the sphere is 4 μC
b) The magnitude of charge on the sphere is 2 μC
c) Coordinates of A are $x_0 = -3$ m, $y_0 = -12$ m
d) Coordinates of A are $x_0 = 4$ m, $y_0 = -1$ m

550. A parallel-plate capacitor is charged from a cell and then isolated from it. The separation between the plates is now increased

a) The force of attraction between the plates will decrease
b) The field in the region between the plates will not change
c) The energy stored in the capacitor will increase
d) The potential difference between the plates will decreases

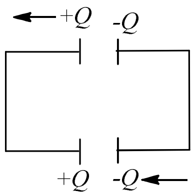
551. If at distance r from a positively charged particle, electric field strength and energy density are E and U, respectively, which of the following graphs is/are correct?

a) 
b) 
c) 
d) 

552. Mark out the correct statements.

a) A given conducting sphere cannot be charged to a potential greater than a certain value
b) A given conducting sphere can be charged to a potential less than a certain minimum value
c) A given conducting sphere can be charged to any extent
d) None of the above

553. A charge Q is imparted to two identical capacitors in parallel. Separation of the plates in each capacitor is d_0. Suddenly, the first plate of the first capacitor and the second plate of the second capacitor start moving to the left with speed v, then



Charges on the two capacitors as a function of time are

a) $\frac{Q(d_0 - vt)}{2d_0}, \frac{Q(d + vt)}{2d_0}$

Charges on the two capacitors as a function of time are

b) $\frac{Qd_0}{2(d_0 - vt)}, \frac{Qd_0}{2(d_0 + vt)}$

c) Current in the circuit will increase as time passes on

d) Current in the circuit will be constant

554. 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 $0 < r < \infty$

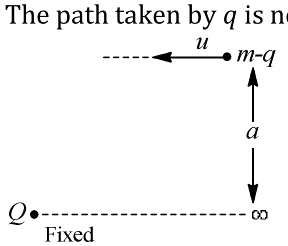
c) decreases as r increases for $R < r < \infty$

d) Is discontinuous at $r = R$

555. A charge particle q is projected in an electric field produced by a fixed point charge Q as shown in Figure Mark out the correct statements

a) The path taken by q is a straight line

The path taken by q is not a straight line

b) 

c) The minimum distance between the two particles is $\frac{\frac{qQ}{2\pi\varepsilon_0} + \sqrt{\left(\frac{qQ}{2\pi\varepsilon_0}\right)^2 + 4m^2u^2a^2}}{2mu^2}$

d) Velocity of the particle q is changing in both magnitude and direction

556. Two identical parallel- plate capacitors are connected in one case in parallel and in the other in series. In each case the plates of one capacitor are brought closer by a distance a and the plates of the other are moved apart by the same distance a. then

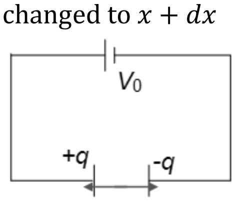
a) Total capacitance of first system increases

b) Total capacitance of first system decreases

c) Total capacitance of second system decreases

d) Total capacitance of second system remain constant

557. Two plates of a parallel-plate capacitors carry charge q and $-q$ and are separated by a distance a from each other. The capacitor is connected to a constant voltage source V_0. The distance between the plates is changed to $x + dx$



Then in steady state

a) Change in electrostatic energy stored in the capacitor is $-Udx/x$

b) Charge in electrostatic energy in the capacitor is$-Udx/dx$

c) Attraction force between the plates is $1/2qE$

d) Attraction force between the plates is qE(where E is electric field between the plates)

558. A thin-walled spherical conducting shell S of radius R is given charge Q. The same amount of charge is also placed at its centre C. Which of the following statements are correct?

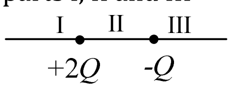
a) On the outer surface of S, the charge density is $\frac{1}{2}\frac{Q}{\pi R^2}$

b) The electric field is zero at all point inside S

c) At a point just outside S, the electric field is double the field at a point just inside S in the cavity

d) At any point inside S (i.e. within its cavity), the electric field is inversely proportional to the square of its distance from C

559. The figure shows two point charges $2Q(>0)$ and $-Q$. The charges divide the line joining them in three parts I, II and III



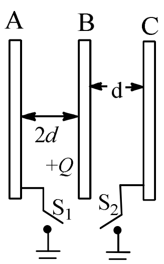
a) Region III has a local maxima of electric field

b) Region I has a local minima of electric field

c) Equilibrium position for a test charge lies in region II

d) The equilibrium (if there is any) is stable for a negative test charge

560. 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



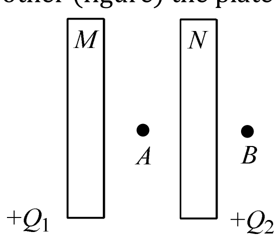
a) If S_1 is closed, with S_2 open, a charge of amount Q will pass through S_1

b) If instead S_2 were 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 $2Q/3$ will pas through S_2

d) If S_1 and S_2 are closed together, a charge of amount $2Q/3$ will pass through S_1 ,and a charge of amount $Q/3$ will pass through S_2

561. Two conducting plates M and N, each having large surface area A (on the side), are placed parallel to each other (figure) the plate M is given charge Q_1 and N, charge $Q_2(< Q_1)$. Then,



a) Electric field at point A is $\frac{Q_1-Q_2}{2A\varepsilon_0}$ towards right

b) Electric field at point B is $\frac{Q_1+Q_2}{2A\varepsilon_0}$ towards right

c) Electric potential of N is greater than M

d) All of the above

562. A conducting sphere of radius R has a charge. then,

a) The charge is uniformly distributed over its surface, if there is no external electric field

b) The distribution of charge over its surface will be non-uniform if an external electric field exists in the space

c) The potential at every point of the sphere must be the same

d) The electric field strength inside the sphere will be equal to zero only when no external electric field exists

563. A capacitor of 5 μF is charged to a potential of 100 V. Now, this charged capacitor is connected to a battery of 100 V with positive terminal of battery connected to negative plate for the capacitor. For the given

situation, mark the correct statement(s)

a) The charge flown through 100 V battery is 500 μC
b) The charge flown through 100 V battery is 1000 μC
c) Heat dissipated in the circuit is 0.1 J
d) Work done on the battery is 0.1 J

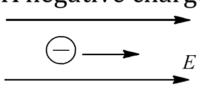
564. A dipole is placed in $x-y$ plane parallel to the line $y=2x$. There exists a uniform electric field along z-axis. Net force acting on the dipole will be zero. But it an experience some torque. We can show that the direction of this torque will be parallel to the line

a) $y=2x+1$
b) $y=-2x$
c) $y=\frac{1}{2}x$
d) $y=-\frac{1}{2}x+2$

565. A parallel plate capacitor is charged to a definite potential and the charging battery is disconnected. Now, if the plates of the capacitor are moved apart, then

a) The stored energy of the capacitor increases
b) Charge on the capacitor increases
c) Voltage of the capacitor increases
d) The capacitance increases

566. A negative charge is moved by an external agent in the direction of electric field



Then

a) Potential energy of the charge increase
b) Potential energy of the charge decrease
c) Positive work is done by the electric field
d) Negative work is done by the electric field

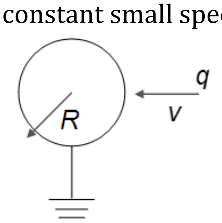
567. A positive charged thin metal ring of radius R is fixed in the x-y plane with the centre at the origin$O$. A negatively charged particle P is released from rest at the point $(0,0,z_0)$, where $z_0>0$. Then, the motion of P is

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

568. The electric potential in a region along the x-axis varies with x according to the relation $V(x)=4+5\times 2$. Then,

a) Potential difference between the points $x=1$ and $x=-2$ is 15 V
b) The force experienced by the above will be towards the $+x$-axis
c) A uniform electric field exists in this region along the $+x$-axis
d) Force experienced by a 1 C charge at $x=-1$ m will be 10 N

569. A charged particle having a positive charge q approaches a grounded metallic spheres of radius R with a constant small speed v as shown in Figure



In this situation,

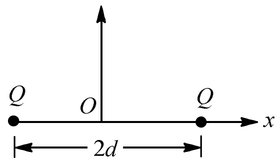
a) As the charge draws nearer to the surface of the sphere, a current flows into the ground
b) As the charge draws nearer to the surface of the sphere, a current flows out of the ground into the sphere
c) As the charged particle draws nearer, the magnitude of the current flowing in the connector joining the shell to the ground increases
d) As the charged particle draws nearer, the magnitude of the current flowing in the connector joining the sphere to the ground decreases

570. A circular ring of radius R with uniformly distributed charge q is placed in their y-z plane with its centre at the origin. Select the correct statement(s) out of the following.

a) The electric intensity is maximum at $x = \pm\sqrt{2}R$
b) The electric intensity is maximum at $x = \pm\frac{\sqrt{2}}{2}R$
c) The maximum intensity has a magnitude $\frac{q}{6\sqrt{3}\pi\varepsilon_0 R^2}$
d) The maximum intensity is $\frac{q}{6\sqrt{6}\pi\varepsilon_0 R^2}$

571. About an electric field, which of the following statements are false?
a) If $E = 0, V$ must be zero
b) If $V = 0, E$ must be zero
c) If $E \neq 0, V$ cannot be zero
d) If $V \neq 0, E$ cannot be zero

572. Consider two identical charges placed distance $2d$ apart, along the x-axis (figure). The equilibrium of a positive test charge placed at point O midway between them is



a) Stable for displacements along the x-axis
b) Neutral
c) Unstable for displacement along the y-axis
d) Stable for displacements along the y-axis

: ANSWER KEY :

1)	a	2)	a	3)	d	4)	b	189)	a	190)	c	191)	c	192)	c
5)	c	6)	a	7)	b	8)	a	193)	a	194)	a	195)	d	196)	a
9)	d	10)	b	11)	c	12)	c	197)	b	198)	a	199)	b	200)	b
13)	d	14)	b	15)	b	16)	b	201)	d	202)	b	203)	d	204)	b
17)	b	18)	c	19)	c	20)	b	205)	c	206)	a	207)	c	208)	d
21)	d	22)	b	23)	d	24)	d	209)	a	210)	b	211)	a	212)	d
25)	c	26)	d	27)	c	28)	a	213)	b	214)	b	215)	c	216)	a
29)	a	30)	c	31)	c	32)	a	217)	a	218)	d	219)	d	220)	c
33)	a	34)	b	35)	a	36)	b	221)	c	222)	a	223)	d	224)	d
37)	b	38)	a	39)	a	40)	c	225)	c	226)	a	227)	a	228)	c
41)	a	42)	c	43)	b	44)	a	229)	a	230)	d	231)	c	232)	a
45)	d	46)	c	47)	b	48)	d	233)	b	234)	c	235)	d	236)	d
49)	d	50)	c	51)	d	52)	c	237)	c	238)	c	239)	c	240)	c
53)	c	54)	a	55)	c	56)	c	241)	c	242)	b	243)	c	244)	a
57)	d	58)	a	59)	a	60)	b	245)	d	246)	d	247)	a	248)	c
61)	b	62)	b	63)	a	64)	b	249)	c	250)	a	251)	d	252)	c
65)	a	66)	b	67)	c	68)	b	253)	b	254)	c	255)	d	256)	b
69)	a	70)	a	71)	b	72)	a	257)	d	258)	b	259)	b	260)	b
73)	c	74)	c	75)	b	76)	b	261)	d	262)	d	263)	a	264)	c
77)	c	78)	d	79)	a	80)	a	265)	b	266)	c	267)	c	268)	d
81)	b	82)	c	83)	b	84)	a	269)	d	270)	c	271)	a	272)	b
85)	b	86)	b	87)	a	88)	a	273)	c	274)	a	275)	d	276)	b
89)	d	90)	c	91)	a	92)	b	277)	a	278)	a	279)	a	280)	a
93)	b	94)	b	95)	b	96)	a	281)	d	282)	b	283)	c	284)	c
97)	d	98)	d	99)	a	100)	c	285)	c	286)	a	287)	b	288)	a
101)	c	102)	d	103)	a	104)	d	289)	c	290)	c	291)	b	292)	a
105)	d	106)	c	107)	d	108)	a	293)	c	294)	a	295)	b	296)	a
109)	b	110)	c	111)	b	112)	c	297)	b	298)	b	299)	a	300)	b
113)	d	114)	a	115)	c	116)	a	301)	b	302)	b	303)	c	304)	d
117)	c	118)	c	119)	b	120)	a	305)	a	306)	d	307)	b	308)	b
121)	b	122)	d	123)	a	124)	c	309)	b	310)	b	311)	c	312)	a
125)	c	126)	b	127)	b	128)	b	313)	a	314)	d	315)	a	316)	d
129)	a	130)	b	131)	c	132)	d	317)	b	318)	c	319)	d	320)	b
133)	b	134)	b	135)	d	136)	a	321)	a	322)	d	323)	d	324)	d
137)	b	138)	c	139)	a	140)	c	325)	d	326)	a	327)	c	328)	d
141)	c	142)	c	143)	c	144)	a	329)	d	330)	a	331)	b	332)	a
145)	b	146)	d	147)	c	148)	c	333)	d	334)	a	335)	d	336)	a
149)	b	150)	c	151)	a	152)	c	337)	c	338)	a	339)	d	340)	d
153)	b	154)	a	155)	a	156)	a	341)	b	342)	d	343)	d	344)	d
157)	a	158)	b	159)	c	160)	b	345)	a	346)	d	347)	d	348)	d
161)	b	162)	b	163)	c	164)	d	349)	b	350)	b	351)	b	352)	a
165)	c	166)	b	167)	d	168)	a	353)	a	354)	d	355)	c	356)	c
169)	b	170)	d	171)	a	172)	a	357)	a	358)	b	359)	b	360)	c
173)	a	174)	a	175)	c	176)	a	361)	a	362)	c	363)	c	364)	b
177)	d	178)	d	179)	a	180)	d	365)	c	366)	d	367)	c	368)	d
181)	a	182)	a	183)	b	184)	a	369)	c	370)	a	371)	c	372)	c
185)	a	186)	a	187)	b	188)	b	373)	a	374)	b	375)	c	376)	d

377)	d	378)	c	379)	c	380)	d
381)	b	382)	c	383)	b	384)	d
385)	a	386)	a	387)	b	388)	d
389)	b	390)	b	391)	c	392)	c
393)	a	394)	c	395)	d	396)	a
397)	d	398)	a	399)	b	400)	b
401)	c	402)	b	403)	a	404)	a
405)	a	406)	d	407)	a	408)	d
409)	b	410)	b	411)	a	412)	d
413)	b	414)	b	415)	b	416)	a
417)	c	418)	b	419)	b	420)	d
421)	c	422)	a	423)	d	424)	b
425)	a	426)	b	427)	b	428)	d
429)	a	430)	d	431)	d	432)	a
433)	c	434)	c	435)	b	436)	a
437)	a	438)	d	439)	b	440)	b
441)	a	442)	b	443)	a	444)	b
445)	c	446)	d	447)	a	448)	a
449)	c	450)	c	451)	d	452)	d
453)	a	454)	d	455)	d	456)	b
457)	b	458)	c	459)	b	460)	d
461)	d	462)	c	463)	d	464)	a
465)	d	466)	b	467)	d	468)	b
469)	a	470)	c	471)	c	472)	a
473)	c	474)	a	475)	c	476)	c
477)	a	478)	b	479)	b	480)	a
481)	d	482)	b	483)	d	484)	d
485)	c	486)	d	487)	a	488)	b
489)	a	490)	b	491)	b	492)	a
493)	c	494)	a	495)	a	496)	a
497)	c	498)	b	499)	b	500)	d
501)	b	502)	b	503)	b	504)	b

505)	c	506)	b	507)	a	508)	c
509)	d	510)	b	511)	b	512)	b
513)	d	514)	b	1)	a,b,c	2)	a,d
3)	a,b,c,d	4)	b,c	5)	a,b,c,d	6)	a,b,c
7)	a,b,c,d	8)	a,b,d	9)	a,c,d	10)	a,b,d
11)	a,d	12)	a,d	13)	b,c,d	14)	a,b,c
15)	b,c	16)	a,b,c	17)	a,c	18)	b,d
19)	a,c,d	20)	a,b,c,d	21)	a,c	22)	c,d
23)	a,c	24)	a,d	25)	c,d	26)	b,c,d
27)	a,b,c,d	28)	a,c,d	29)	b,c,d	30)	b,c
31)	c,d	32)	b,c,d	33)	a,c	34)	a,c,d
35)	a,c	36)	b,c	37)	b,c	38)	a,b
39)	a,d	40)	a,c	41)	b,c,d	42)	a,d
43)	a,c	44)	a,c,d	45)	a,d	46)	a,b,c
47)	a,b	48)	a,b,c	49)	b,c	50)	c,d
51)	a,c	52)	a,d	53)	a,c	54)	a,c,d
55)	a,c	56)	b,c	57)	a,b,c,d	58)	a,c

: HINTS AND SOLUTIONS :

1 **(a)**

$\frac{q_1}{1} = \frac{q_2}{2} = \frac{q_3}{3} = K$

$q_1 + q_2 + q_3 = 6$

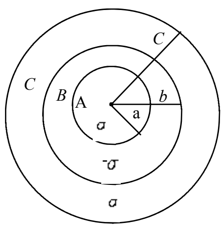
Solving, we get

$K = 1$

$\Rightarrow\ q_3 = 3\mu C$

2 **(a)**

The electric potential on the surface of shell A



$V_A = V_a + V_b + V_c$

$$V_A = \frac{1}{4\pi\varepsilon_0}.\frac{q_a}{a} + \frac{1}{4\pi\varepsilon_0} + \frac{q_b}{b} + \frac{1}{4\pi\varepsilon_0}.\frac{q_c}{c}$$

Or

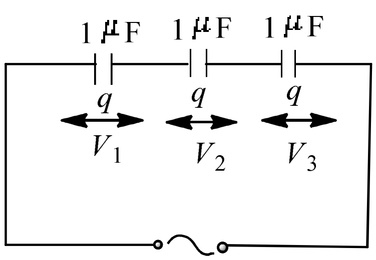
$$V_A = \frac{1}{4\pi\varepsilon_0}.\frac{4\pi a^2\sigma}{a} + \frac{1}{4\pi\varepsilon_0}.\frac{4\pi b^2(-\sigma)}{b} + \frac{1}{4\pi\varepsilon_0}.\frac{4\pi c^2\sigma}{c}$$

$(\because q = 4\pi r^2\sigma)$

or $V_A = \frac{\sigma}{\varepsilon_0}(a - b + c)$

3 **(d)**

Let potential difference between the plates of the capacitors C_1, C_2 and C_3 be V_1, V_2 and $V_3$and q be the charge.



V = 11 volt

Then, $V = \frac{q}{C_1}, V_2 = \frac{q}{C_2}, V_3 = \frac{q}{C_3}$

The total potential difference $V = 11$volt

$\therefore\quad V = V_1 + V_2 + V_3$

$\Rightarrow\quad V = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3} = 11$

Given, $C_1 = 1\mu F, C_2 = 2\mu F, C_3 = 3\mu F$

$\therefore\quad 11 = q\left(\frac{1}{1} + \frac{1}{2} + \frac{1}{3}\right)$

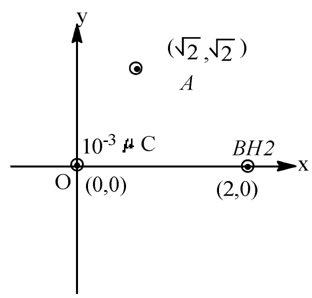
$\Rightarrow\quad 11 = \frac{11q}{6}$

$\Rightarrow\quad q = 6\mu c$

$\therefore\quad V_1 = \frac{q}{C_1} = \frac{6}{1} = 6$ V

4 **(b)**

Potential at A due to charge at O



$$V_A = \frac{1}{4\pi\varepsilon_0}\frac{(10^{-3})}{OA}$$

$$= \frac{1}{4\pi\varepsilon_0}.\frac{(10^{-3})}{\sqrt{(\sqrt{2})^2 + (\sqrt{2})^2}}$$

Potential at B due to charge at O

$$V_B = \frac{1}{4\pi\varepsilon_0}.\frac{(10^{-3})}{OB}$$

$$= \frac{1}{4\pi\varepsilon_0}.\frac{(10^{-3})}{2}$$

So,

$V_A - V_B = 0$

6 **(a)**

Since,C_1 and C_2 are parallel to their equivalent capacitance will be $(C_1 + C_2)$. Now, $(C_1 +$ $C2$ and $C3$ are in series, so the net equivalent capacitances of circuit.

$\frac{1}{C} = \frac{1}{C^3} + \frac{1}{C_1+C_2}$

$= \frac{C_1+C_2+C_3}{(C_1+C_2)C_3}$

$C = \frac{(C_1+C_2)C_3}{C_1+C_2+C_3}$

Since, V is the voltage of the battery, so charge on this system

$q = CV$

$q = \frac{(C_1+C_2)C_3 V}{C_1+C_2+C_3}$

If the capacitor C_3 breaks down then total equivalent capacitance

$C' = C_1 + C_2$

∴ New charge stored

$q' = C'V$

$q' = (C_1 + C_2)V$

Change in total charge

$\Delta q = q' - q \qquad (\because q' > q)$

$= (C_1 + C_2)V - \frac{(C_1+C_2)C_3 V}{C_1+C_2+C_3}$

$= (C_1 + C_2)V\left[1 - \frac{C_3}{C_1+C_2+C_3}\right]$

$$\Delta q = (C_1 + C_2)V\left[1 - \frac{C_3}{C_1 + C_2 + C_3}\right]$$

7 **(b)**

At equitorial point

$$E_e = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$$

(directed from +q to –q) and $V_e = 0$.

8 **(a)**

$$V_B - V_A = -\left[\int_1^2 2dx + \int_2^1 3dy\right]$$

$= -[2(2-1) + 3(1-2)]$

$= -[2-3] = 1$ V

Hence, $V_A - V_B = -1$ V

9 **(d)**

At each point on the surface of a conducting sphere the potential is equal.

So, $V_A = V_B = V_C$

10 **(b)**

$W_{\text{eq}} = q(V_A - V_B)$

$50 \times 10^{-6} = 2 \times 10^{-6}(V_A - V_B)$

$V_A - V_B = 25$ V

11 **(c)**

In series combination,

$$\frac{1}{C_1} = \frac{1}{1} + \frac{1}{2} + \frac{1}{4} = \frac{4+2+1}{4} = \frac{7}{4}$$

$\Rightarrow C_1 = \frac{4}{7}\mu\text{F}$

In parallel combination,

$C_2 = 1 + 2 + 4 = 7\mu\text{F}$

$\therefore \frac{C_1}{C_2} = \frac{4/7}{7} = \frac{4}{49}$

12 **(c)**

When a capacitor is charged, work is done by the charging battery. As the capacitor charges, the potential difference across its plates rises. The total amount of work in charging the capacitor is stored up in the capacitor, in the form of electric potential energy between the plates.

13 **(d)**

$W = q(V_f - V_i) = 0$, since $V_f = V_i$

14 **(b)**

Capacitance of two capacitors each of area $\frac{A}{2}$, plate separation d but dielectric constants K_1 and K_2 respectively joined in parallel

$$C_1 = \frac{K_1\varepsilon_0\left(\frac{A}{2}\right)}{d/2} + \frac{K_2\varepsilon_0\left(\frac{A}{2}\right)}{d/2} = \frac{(K_1+K_2)\varepsilon_0 A}{d}$$

It is in series with a capacitor of plate area A, plate separation $d/2$ and dielectric constant K_3 ie, $C_2 = \frac{K_3\varepsilon_0 A}{d/2}$.

If resultant capacitance be taken as $C = \frac{K\varepsilon_0 A}{d}$,

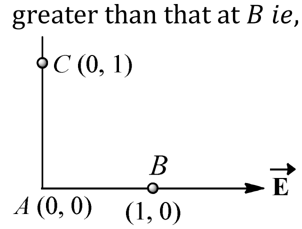
Then $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

$\therefore \frac{d}{K\varepsilon_0 A} = \frac{d}{(K_1+K_2)\varepsilon_0 A} + \frac{d/2}{K_3\varepsilon_0 A}$

$$\Rightarrow \frac{1}{K} = \frac{1}{K_1 + K_2} + \frac{1}{2K_3}$$

15 **(b)**

As electric field is along positive x-axis and $E = -\frac{dV}{dx}$, hence potential at A must be greater than that at B ie, $V_A > V_B$



16 **(b)**

The work done in charging the capacitor (C) is stored as potential energy (U) in the vicinity of capacitor, given by.

$$U = \frac{1}{2}CV^2$$

This produces the heat when its plates are joint through a resistance.

Given, $C = 4\mu\text{F} = 4 \times 10^{-6}\text{F}$, $V = 400$volt

$\therefore U = \frac{1}{2} \times 4 \times 10^{-6} \times (400)^2$

$U = 0.32$ J

17 **(b)**

$$\therefore \frac{1}{C_s} = \frac{1}{2} + \frac{1}{1} = \frac{3}{2}$$

$$C_s = \frac{2}{3}\text{F}$$

$$Q = C_s V = \frac{2}{3} \times 12 = 8\text{C}$$

$$V_1 = \frac{Q}{C_1} = \frac{8}{2} = 4\text{V}$$

18 **(c)**

If we take a charge from one point to another inside a charged spherical shell, then no work will be done. This means that inside a spherical charge the potential at all points is the same and its value is equal to that on the surface, that is

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R} \text{ volt}$$

Also outside the metallic sphere

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$

$$V \propto \frac{1}{r}$$

19 **(c)**

p and q are in parallel and then r in series

20 **(b)**

Given, the capacity of capacitor, $C = 10 \times 10^{-6}\mu\text{F}$

Potential $V = 400\text{volt}$

Stored energy =Heat generated

$U = \frac{1}{2}CV^2 = \frac{1}{2}(10 \times 10^{-6}) \times (400)^2 = 0.8\text{ J}$

21 **(d)**

$q_i = C_i V = 2V = q$ (say)

This charge will remain constant after switch is shifted from position 1 to position 2.

$$U_i = \frac{1}{2}\frac{q^2}{C_i} = \frac{q^2}{2 \times 2} = \frac{q^2}{4}$$

$$U_i = \frac{1}{2}\frac{q^2}{C_i} = \frac{q^2}{2 \times 10} = \frac{q^2}{20}$$

$\therefore$Energy dissipated $\left(\frac{q^2}{5}\right)$ is 80% of the initial stored energy $\left(= \frac{q^2}{4}\right)$.

22 **(b)**

The two charges form an electric dipole and for this dipole any point on y-axis is at the equatorial line. Hence, $\vec{E}$ at all point on y-axis will be in a direction opposite to $\vec{p}$ and $\vec{p}$ is along negative x-axis. So $\vec{E}$ is along positive x –axis , *ie*, along $\hat{i}$.

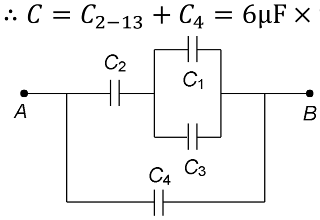
23 **(d)**

The arrangement can be redrawn as shown in the adjoining figure.

$$C_{13} = C_1 + C_3 = 9 + 9 = 18\mu\text{F}$$

$$C_{2-13} = \frac{C_2 \times C_{13}}{C_2 + C_{13}} = \frac{9\mu\text{F} \times 18\mu\text{F}}{(9 + 18)\mu\text{F}} = 6\mu\text{F}$$

$$\therefore C = C_{2-13} + C_4 = 6\mu\text{F} \times 9\mu\text{F} = 15\mu\text{F}.$$



24 **(d)**

The arrangement of n metal plates separated by dielectric acts as parallel combination of $(n-1)$ capacitors.

Therefore, $C = \frac{(n-1)K\varepsilon_0 A}{d}$

Here, $C = 100\text{ pF}$

$= 100 \times 10^{-12}\text{F}$

$K = 4, \varepsilon_0 = 8.85 \times 10^{-12}\text{C}^2\text{N}^{-1}\text{m}^{-2}$

$A = \pi r^2 = 3.14 \times (1 \times 10^{-2})^2$

$d = 1\text{ mm} = 1 \times 10^{-3}$

$$\therefore \quad 100 \times 10^{-12} = \frac{(n-1) \times 4 \times (8.85 \times 10^{-12}) \times 3.14 \times (1 \times 10^{-2})^2}{1 \times 10^{-3}}$$

or $\quad n = \frac{1111.156}{111.156} = 9.99 \approx 10$

25 **(c)**

$$\frac{kQ}{x} = \frac{1}{2}\left(\frac{3}{2}\frac{kQ}{R}\right) \Longrightarrow x = 4R/3$$

Distance from surface : $x - R = R/3$

26 **(d)**

When two conductors of capacities $C_1$and C_2 and potentials V_1 and V_2 are connected by a conducting wire, charge redistributes in these conductors till potential of both the conductors become equal, known as common potential.

Common potential $=\frac{\text{net charge}}{\text{total capacity}}$

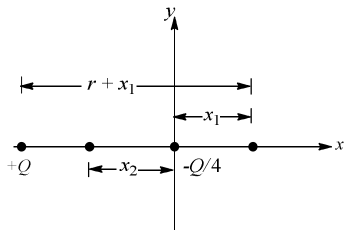
ie $V = \dfrac{q_1 + q_2}{C_1 + C_2}$

or $V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

27 **(c)**

$\dfrac{kQ}{4x_1} = \dfrac{kQ}{r + x_1} \Rightarrow r + x_1 = 4x_1 \Rightarrow x_1 = r/3$

$\dfrac{kQ}{4x_2} = \dfrac{kQ}{r - x_2} \Rightarrow x_2 = \dfrac{r}{5}$



28 **(a)**

Potential energy of the system

$$U = \frac{KQq}{l} + \frac{Kq^2}{l} + \frac{KqQ}{l} = 0$$

$$\Rightarrow \frac{Kq}{l}(Q + q + Q) = 0$$

$$\Rightarrow \quad Q = -\frac{q}{2}$$

29 **(a)**

Required work done,

$W = QV$

$= (2e) \times 25$

$= 50e = 50 \times 1.6 \times 10^{-19}$

$= 8 \times 10^{-18}\text{J}$

30 **(c)**

$\frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 A}{d' - t + \frac{t}{K}}$

$\Rightarrow \quad d = d' - t + \dfrac{1}{K}$

$\Rightarrow \quad d' - d = t\left(1 - \dfrac{1}{K}\right)$

Here, $d' - d = 3.2$ mm, $t = 4$mm

$\therefore \quad 3.2 = 4\left(1 - \frac{1}{K}\right) 1 - \frac{1}{K}$

$\Rightarrow \quad \dfrac{3.2}{4} = 1 - \dfrac{1}{K}$

$\Rightarrow \quad 1 - \dfrac{1}{K} = \dfrac{4}{5}$

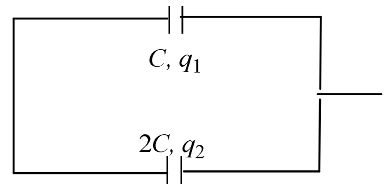
$\therefore \quad K = 5$

31 **(c)**

The charge $q_1 = CV_0$

or

$V_0 = \frac{q_1}{C}$ ...(i)



$\therefore$ Capacitors are in parallel, in parallel V_0 is same for all capacitors.

$\therefore$ For second capacitor $V_0 = \frac{q_2}{2C}$ ...(ii)

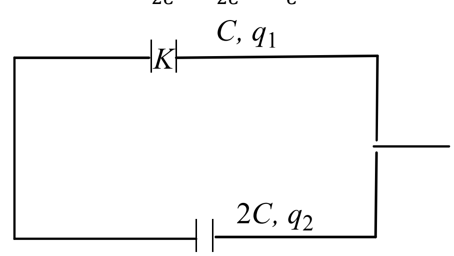
From Eqs. (i) and (ii),

$q_2 = 2q_1$ ...(iii)

After disconnecting the battery, the region between the plates of the capacitor C is completely filled with a material of dielectric constant ($K = 2$).

Then, $V_1 = \frac{q_1}{CK} = \frac{q_1}{2C}$

and $V_1 = \frac{q_2}{2C} = \frac{2q_1}{2C} = \frac{q_1}{C}$ [from Eq. (iii)]



Charge will flow from 2 to 1 till

$\dfrac{q_2'}{2C} = \dfrac{q'_1}{KC}$

$\dfrac{q_2'}{2C} = \dfrac{q_1'}{2C}$

ie, $q_1' = q_2'$

Earlier potential $V_0 = \frac{q_1}{C}$

Now it is $V_0 = \frac{q_1'}{2C}$

Now, $q_1 + q_2 = 3q_1$ [from Eq.(iii)]

and $q_1' + q_2' = 3q_1$

or $2q_1' = 3q_1$ or $q_1' = \frac{3q_1}{2}$

$\therefore$ Now potential $\frac{q_1'}{2C} = \frac{3q_1}{4C}$

$V = \frac{3V_0}{4}$

$[\because q_1 = V_0C]$

32 **(a)**

The potential V_1 of smaller sphere is given by

$$V_1 = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r} + \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} \quad \dots\dots \text{(i)}$$

The potential V_2 of bigger sphere is given by

$$V_2 = \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} + \frac{1}{4\pi\varepsilon_0}.\frac{q}{R}$$

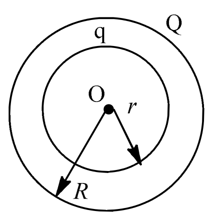
So, the potential difference between the plates

$V = V_1 - V_2$

Or

$$V = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r} + \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} - \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} - \frac{1}{4\pi\varepsilon_0}.\frac{q}{R}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{r} - \frac{1}{4\pi\varepsilon_0}.\frac{q}{R} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r} - \frac{q}{R}\right)$$



33 **(a)**

The energy which is stored in the condenser is given by

$E = \frac{1}{2}.\frac{q^2}{C}$ ...(i)

where q is charge and C the capacitance.

Also, $C = \frac{\varepsilon_0 A}{d}$ ...(ii)

From Eqs. (i) and (ii), we get

$E = \frac{1}{2}.\frac{q^2 d}{\varepsilon_0 A} \Rightarrow E \propto d$

When plate separation (d) is increased energy increases.

34 **(b)**

$V = 10r = 10\sqrt{x^2 + y^2 + z^2}$

$E_x = -\frac{dv}{dx} = -\frac{10(2x)}{2\sqrt{x^2 + y^2 + z^2}}$

$= \frac{-10}{\sqrt{x^2 + y^2 + z^2}} = \frac{-10 \times 3}{\sqrt{x^2 + 4^2 + 5^2}} = -3\sqrt{2}$

Similarly, $E_y = -4\sqrt{2}$

$E_z = 5\sqrt{2}$; $\vec{E} = E_x\hat{\imath} + E_y\hat{\jmath} + E_z\hat{k}$

35 **(a)**

Let R and r be the radii of bigger and each smaller drop respectively

$\therefore \quad \frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$

$\Rightarrow \quad R = 2r$ ...(i)

The capacitance of a smaller spherical drop is

$C = 4\pi\varepsilon_0 r$ ...(ii)

The capacitance of bigger drop is

$C' = 4\pi\varepsilon_0 R$

$= 2 \times 4\pi\varepsilon_0 r$ $(\because R = 2r)$

$= 2C$ [From Eq. (ii)]

$C = \frac{C'}{2}$

$= \frac{1}{2}\mu\text{F}$ $(\because C' = 1\mu\text{F})$

36 **(b)**

E is a vector quantity, V is a scalar quantity

37 **(b)**

$W_{BA} = q(V_A - V_B) = q\left[\frac{Q}{4\pi\varepsilon_0 a} - \frac{Q}{4\pi\varepsilon_0 b}\right]$

$= \frac{qQ}{4\pi\varepsilon_0}\left[\frac{1}{a} - \frac{1}{b}\right]$

38 **(a)**

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

$\therefore \quad V \propto d$

As the distance between the plates of the capacitor increases potential difference also increases.

39 **(a)**

By using $W = Q(\mathbf{E}.\Delta\mathbf{r})$

$\Rightarrow \text{W} = Q[e_1\hat{\boldsymbol{\imath}} + e_2\hat{\boldsymbol{\jmath}} + e_3\hat{\boldsymbol{k}}).(a\hat{\boldsymbol{\imath}} + b\hat{\boldsymbol{\jmath}})]$

$= Q(e_1 a + e_2 b)$

40 **(c)**

At junction A, Q_1 will divide into Q_2 and Q_3. Hence,

$Q_1 = Q_2 + Q_3$

C_2 and C_3 are in parallel, so potential on them will be the same, i.e., $V_2 = V_3$

V will divide into V_1 and V_2 (or V_3)

Hence, $V = V_1 + V_2$ or $V = V_1 + V_3$

41 **(a)**

As we add $-3Q$ charge on the surface, the potential on the surface changes by the same amount as that inside. Therefore, the potential difference remains the same

42 **(c)**

Net dipole moment $= \sqrt{3}qa$

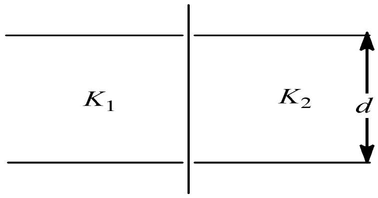
$\tau = -\sqrt{3}qa\frac{|\sigma_1 - \sigma_2|\theta}{2\varepsilon_0} = l\alpha$

$\frac{\sqrt{3}qa|\sigma_1 - \sigma_2|}{2\varepsilon_0} = l\left(\frac{2\pi}{T}\right)^2$

$$T = 2\pi\sqrt{\frac{2\varepsilon_0 l}{\sqrt{3}qa|\sigma_1 - \sigma_2|}}$$

43 **(b)**

Initially, the capacitance of capacitor



$$C = \frac{\varepsilon_0 A}{d}$$

$\therefore \quad \frac{\varepsilon_0 A}{d} = 1\mu F$

...(i)

When it is filled with dielectric of dielectric constant K_1 and K_2 as shown, then there are two capacitors connected is parallel. So,

$$C' = \frac{K_1\varepsilon_0\left(\frac{A}{2}\right)}{d} + \frac{K_2\varepsilon_0\left(\frac{A}{2}\right)}{d}$$

(as area becomes half)

$$C' = \frac{4\varepsilon_0 A}{2d} + \frac{6\varepsilon_0 A}{2d} = \frac{2\varepsilon_0 A}{d} + \frac{3\varepsilon_0 A}{d}$$

Using Eq. (i), we obtain

$$C' = 2 \times 1 + 3 \times 1 = 5\ \mu F$$

44 **(a)**

Here, $U_1 = \frac{Q(-q)}{4\pi\varepsilon_0 r}; U_2 = \frac{Q(-q)}{4\pi\varepsilon_0 (r/2)}$

$$U_1 - U_2 = \frac{Q(-q)}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{2}{r}\right]$$

$= \frac{Qq}{4\pi\varepsilon_0} = 9$ ...(i)

When negative charge travels first half of distance, *ie*, $r/4$, potential energy of the system

$$U_3 = \frac{Q(-q)}{4\pi\varepsilon_0(3r/4)} = -\frac{Qr}{4\pi\varepsilon_0 r} \times \frac{4}{3}$$

$\therefore$ work done $= U_1 - U_3$

$$= \frac{Q(-q)}{4\pi\varepsilon_0 r} + \frac{Qr}{4\pi\varepsilon_0 r} \times \frac{4}{3}$$

$$= \frac{Qq}{4\pi\varepsilon_0 r} \times \frac{1}{3} = \frac{9}{3} = 3J$$

45 **(d)**

Potential due to charge $-q$ at A

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

Potential due to charge $-q$ at B

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

Potential due to charge $-q$ at C

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

Total potential at centre.

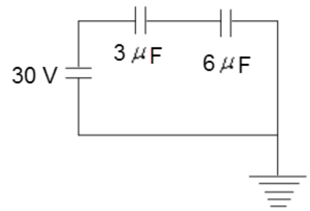
$$V = V_A + V_B + V_C$$

$$V = 0$$

From charge configuration at the centre electric field in non zero.

46 **(c)**

Circuit is redrawn as shown in Figure



Equivalent capacity of combination

$$C_{eq} = \frac{3 \times 6}{9} = 2\mu F$$

Hence, charge $q = C_{eq}V$

$q = 2\ \mu F \times 30\ V = 60\ \mu C$

47 **(b)**

$$\frac{1}{C_s} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12} = \frac{3+2+1}{12} = \frac{6}{12} = \frac{1}{2}$$

$C_s = 2\ \mu F$

$C_p = 4 + 6 + 12 = 22\ \mu F$

$$\frac{C_s}{C_p} = \frac{2}{22} = \frac{1}{11}$$

48 **(d)**

$$C_{eq} = \frac{\varepsilon_0}{\frac{d}{K_1} + \frac{d}{K_2} + \frac{d}{K_3}}$$

Here, $K_1 = K_3 = 1, K_2 = \varepsilon/\varepsilon_0$

49 **(d)**

With S_1 and S_3 closed, the capacitors C_1 and C_2 are in series arrangement. In series arrangement potential difference developed across capacitors are in the inverse radio of their capacities. Hence,

$\frac{V_1'}{V_2'} = \frac{C_2}{V_1} = \frac{3pF}{3pF} = \frac{3}{2}$ and

$V_1' + V_2' = V_1 + V_2 = 30 + 20 = 50V$

On simplification, we get $V_1' = V_1 = 30V$ and $V_2' = V_2 = 20\ V$

50 **(c)**

$Q = CV$. As V is constant, therefore, $Q \propto C$

Hence, C becomes $\frac{100}{40} = 2.5$ times

$\therefore\ K = 2.5$

51 **(d)**

The electric field of a hollow spherical capacitor is localised in between inner and outer surface of the spherical conductor.

Therefore, at point $r_1 < r < r_2$, the electric field will not be zero.

52 **(c)**

The charge on capacitor before dielectric is

$q_1 = CV = 50 \times 10^{-6} C$

Final charge on capacitor after dielectric is

$q_2 = (KC)V = 5 \times 50 \times 10^{-9}$

$= 250 \times 10^{-9}$C

Charge flow from battery, $\Delta q = q_2 - q_1 = 200$nC

53 **(c)**

$$\frac{kq_1}{a} + \frac{k\,q}{2d} = 0 \Rightarrow q_1 = \frac{-qa}{2d}$$

$$\frac{kq_2}{a} + \frac{kq}{2d} + \frac{kq_1}{d} = 0 \Rightarrow q_2 = \frac{-qa}{2d}\left(\frac{d-a}{d}\right)$$

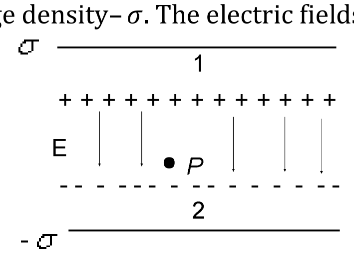
55 **(c)**

In steady state no current flows through the capacitor segment. The steady current in remaining loop $I = \frac{2V-V}{2R+R} = \frac{V}{3R}$ (anti-clockwise).

Now applying Kirchhoff's second law to loop containing $2V, 2R, C$ and V, we have $V_c = 2V - 1.2V - \frac{V}{3R}.2R - V = \frac{V}{3}$

56 **(c)**

The situation is shown in the figure. Plate 1 has surface charge density σ and plate 2 has surface charge density$-\sigma$. The electric fields



at point P due to two charged plates add up, giving

$$E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$

Given , $\sigma = 26.4 \times 10^{-12}\text{Cm}^{-2}$

$\varepsilon_0 = 8.85 \times 10^{-12}\text{C}^2\text{N}^{-1}\text{m}^{-2}$

Hence , $E = \frac{26.4\times10^{-12}}{8.85\times10^{-12}} \approx 3\text{NC}^{-1}$

positive to the negative plate.

57 **(d)**

V is a scalar quantity, E is a vector quantity

58 **(a)**

The points S and R are inside the uniform electric field, so these will be at equal potential.

59 **(a)**

$\vec{E} = E_1\hat{i} + E_2\hat{j}$

As $W = \vec{F}.\vec{r} = Q\vec{E}.\vec{r}$

$= Q(E_1\hat{i} + E_2\hat{j}).(a\hat{i} + b\hat{j})$

$= QE_1a + QE_2b = Q(E_1a + E_2b)$

60 **(b)**

Electric field will remain the same, because electric field due to surface charge distributed uniformly will be zero at any point inside the sphere

61 **(b)**

Potential inside the sphere will be same as that on its surface

$$ie,\ \ V = V_{\text{surface}} = \frac{q}{10}\text{stat} - \text{volt}$$

$$V_{\text{out}} = \frac{q}{15}\text{stat} - \text{volt}$$

$$\therefore \frac{V_{\text{out}}}{V} = \frac{2}{3}$$

$$\Rightarrow V_{\text{out}} = \frac{2}{3}V$$

62 **(b)**

As the electrostatic force are conservative, work done is independent of path .

$W = \vec{F}.\ \vec{ds} = q\,E\hat{i}.\left[(0-a)\hat{i} + (0-b)\hat{j}\right]$

$= -q\,E\,a$

63 **(a)**

$q_1 + q_2 = 2Q$

$V_{AB} = V_{AC} \Rightarrow \frac{q_1}{C_1} = \frac{q_2}{C_2}$

$\frac{q_1}{q_2} = \frac{C_1}{C_2} = 2 \Rightarrow q_1 = 2q_2$

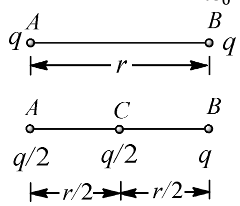
Solving, we get $q_1 = \frac{4Q}{3}, q_2 = \frac{2Q}{3}$

Charge flown through K:

$= -\frac{Q}{2} - (-q_1) = -\frac{Q}{2} + \frac{4Q}{3} = 5Q/6$

64 **(b)**

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



Finally, force on

$$F_C = F_{AB} - F_{CA} = \frac{1}{4\pi\varepsilon_0}.\frac{\left(\frac{q}{2}\right)(q)}{\left(\frac{r}{2}\right)^2} - \frac{1}{4\pi\varepsilon_0}.\frac{\left(\frac{q}{2}\right)\left(\frac{q}{2}\right)}{\left(\frac{r}{2}\right)^2}$$

$$= \frac{1}{4\pi\varepsilon_0}.\frac{q^2}{r^2}$$

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

65 **(a)**

The potential at the centre of the sphere is 80 V because it remains same at each point under the metallic hollow sphere.

66 **(b)**

In parallel, potential is same, say V

$\frac{Q_1}{Q_2} = \frac{C_1 V}{C_2 V} = \frac{C_1}{C_2}$

67 **(c)**

Here,

$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 =$

$\left(+\frac{\sigma}{2\varepsilon_0}\right)(-\hat{k}) + \left(\frac{2\sigma}{2\varepsilon_0}\right)(-\hat{k}) + \left(\frac{\sigma}{2\varepsilon_0}\right)(-\hat{k})$

$= -\left(\frac{2\sigma}{\varepsilon_0}\right).\hat{k}$

68 **(b)**

Potential decreases in the direction of electric field. Hence, electric field should be along PA

$E = \frac{\Delta V}{\Delta r} = \frac{5-2}{0.1 \times \sqrt{2}} = 15\sqrt{2}$ V/m

69 **(a)**

Inside the hollow sphere, $V =$ constant =potential on the surface of the sphere. Outside the sphere, $V \propto \frac{1}{r}$. Hence figure (a) represents the correct graph.

70 **(a)**

$u = \frac{q^2}{2C} = \frac{(8 \times 10^{-18})^2}{2 \times 100 \times 10^{-6}} = \frac{64 \times 10^{-36}}{2 \times 10^{-4}}$

$= 32 \times 10^{-32}$ J

71 **(b)**

Co-ordinates of the point are (x, y)

$\therefore$ Distance of point from origin,

$r = \sqrt{x^2 + y^2}$, $V = -kxy$

$E_x = -\frac{dV}{dx} = -\frac{d}{dx}(-kxy) = ky$

$E_y = -\frac{dV}{dy} = (-kxy) = kx$

$\therefore \; E = \sqrt{E_x^2 + E_y^2} = k\sqrt{y^2 + x^2} = kr$

$\therefore \; E \propto r$

72 **(a)**

$r_b - r_a = 1\text{mm} = 10^{-3}\text{m}$

From $\quad C = \frac{4\pi\varepsilon_0 r_a r_b}{r_b - r_a}$

$10^{-6} = \frac{1(r_b - 10^{-3})r_b}{9 \times 10^9 (10^{-3})}$

$r_b^2 = 9, r_b = 3\text{m}$

73 **(c)**

Charge resides only on the outer surfaces

74 **(c)**

$\int \vec{E}.\vec{dl} \to \text{NC}^{-1}\text{m} = \text{JC}^{-1}$

75 **(b)**

Potential energy of an electron at any point is$U = -eV$, where V is the potential at that point V is negative maximum at point B, hence U is maximum for this point

76 **(b)**

In capacitor, energy is stored in electric field between the plates.

Increase in energy

$\Delta U = U_f - U_i$

$= \frac{1}{2}CV_f^2 - \frac{1}{2}CV_i^2 = \frac{1}{2}C(V_f^2 - V_i^2)$

Given, $C = 6\mu\text{F} = 6 \times 10^{-6}, V_i =$10 volt,

$V_f \; = 20$volt

$\therefore \quad \Delta U = \frac{1}{2} \times 6 \times 10^{-6}[(20)^2 - (10)^2]$

$= 3 \times 10^{-6} \times 300 = 9 \times 10^{-4}$ J

77 **(c)**

Energy given to conductor $= \frac{1}{2}CV^2$

$$= \frac{1}{2} \times 5 \times 10^{-6} \times (800)^2$$

$$= 1.6 \text{ J}$$

78 **(d)**

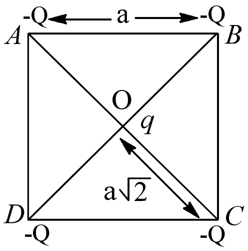
For equilibrium net electric force on any charge (say charge – Q at A) should be zero. Hence,

$\vec{F}_A = \vec{F}_{AB} + \vec{F}_{AD} + \vec{F}_{AC} + \vec{F}_{AO} = \vec{O}, \vec{F}_{AB} = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{a^2}$ along BA, $\vec{F}_{AD} = \frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{a^2}$ along DA, $\vec{F}_{AC} = \frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{a^2}$ along CA, and $\vec{F}_{OA} = -\frac{1}{4\pi\varepsilon_0}.\frac{2Qq}{a^2}$ along AO

Resultant of $\vec{F}_{AB}$ and $\vec{F}_{AD}=\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{a^2}\sqrt{2}$ along COA,

$\therefore\ \vec{F}_A=\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{a^2}\sqrt{2}+\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{2a^2}-\frac{1}{4\pi\varepsilon_0}.\frac{2Qq}{a^2}=\vec{0}$

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



79 **(a)**

Given plates can be rearranged as shown:

$C_1=\frac{\varepsilon_0 A}{d};C_2=\frac{\varepsilon_0 A}{2d}$

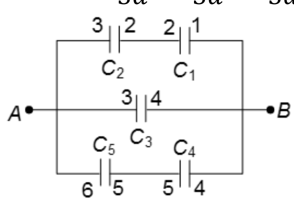
$C_3=\frac{\varepsilon_0 A}{3d};C_4=\frac{\varepsilon_0 A}{2d};C_5=\frac{\varepsilon_0 A}{d}$

C_1 and C_2 are in series and its effective capacity is

$\frac{\frac{\varepsilon_0 A}{d}\times\frac{\varepsilon_0 A}{2d}}{\frac{\varepsilon_0 A}{d}+\frac{\varepsilon_0 A}{2d}}=\frac{\varepsilon_0 A}{3d}$

Effective capacitance of C_4 and $C_5=\frac{\varepsilon_0 A}{3d}$

$\therefore\ C_{AB}=\frac{\varepsilon_0 A}{3d}+\frac{\varepsilon_0 A}{3d}+\frac{\varepsilon_0 A}{3d}=\frac{\varepsilon_0 A}{d}$



80 **(a)**

Net capacity of 5 capacitors joined in parallel= $5\times 2=10$ μF. now it is connected with two capacitors of 2 μF each in series, hence equivalent capacitance is $\frac{10}{11}$ μF.

81 **(b)**

Common potential of system

$$V=\frac{C_1V_1+C_2V_2}{C_1+C_2}$$

$$40=\frac{10\times 100+C_2\times 0}{10+C_2}$$

or $\quad 40(10+C_2)=1000$

$\Rightarrow\quad C_2=15$ μF

82 **(c)**

A positively charged particle free to move in electric field will move in the direction of electric field whereas a negatively charged particle will move in opposite direction of the field

83 **(b)**

$C_1=\frac{K_1\varepsilon_0 A}{d/2}=\frac{2K_1\varepsilon_0 A}{d}$

$C_2=\frac{2K_2\varepsilon_0 A}{d}$

$\frac{1}{C_s}=\frac{1}{C_1}+\frac{1}{C_2}=\frac{d}{2K_1\varepsilon_0 A}+\frac{d}{2K_2\varepsilon_0 A}$

$=\frac{d}{2\varepsilon_0 A}\left(\frac{K_1+K_2}{K_1K_2}\right)$

$C_s=\frac{2\varepsilon_0 A}{d}\left(\frac{K_1K_2}{K_1+K_2}\right)$

84 **(a)**

$\left(0-\frac{1}{2}mv^2\right)=q(V_P-V_Q)\qquad$ ...(i)

$\left(\frac{1}{2}mv_1^2-\frac{1}{2}mv^2\right)=-q\,(V_P-V_Q)$...(ii)

From Eqs. (i) and (ii), $v_1=\sqrt{2}v$

85 **(b)**

The given arrangement of nine plates is equivalent to the parallel combination of 8 capacitors.

The capacity of each capacitor,

$C=\frac{\varepsilon_0 A}{d}$

$=\frac{8.854\times 10^{-12}\times 5\times 10^{-4}}{0.885\times 10^{-2}}=0.5\text{pF}$

Hence, the capacity of 8 capacitors

$=8C=8\times 0.5=4$ pF

86 **(b)**

Charge on each plate of each capacitor

$Q=\pm CV=\pm 25\times 10^{-6}\times 200$

$=\pm 5\times 10^{-3}$C

87 **(a)**

Effective capacitance of C_2 and C_3

$\frac{1}{C}=\frac{1}{2}+\frac{1}{2}$

$\therefore\quad C=1\mu$ F

Now, C_1 and C are in parallel, therefore effective capacitance C'

$C'=1+1=2\mu$ F

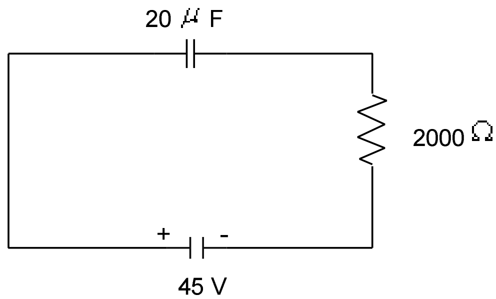
Now, C' and C_4 are in series, therefore, effective capacitance between points A and B

$\frac{1}{C''}=\frac{1}{2}+\frac{1}{4}=\frac{3}{4}$

$\Rightarrow\quad C''=\frac{4}{3}\mu$F

88 **(a)**

We know that in steady state the capacitor behaves like as an open circuit *ie*, capacitor will not pass the current.



So, the potential difference across the capacitor = 45 V

Hence , the final charge on the capacitor is

$$q = CV$$

Here , $C = 20\mu\text{F}$, $V = 45$ V

$\therefore$ $q = 20 \times 10^{-6} \times 45$

or $q = 900 \times 10^{-6}$

or $q = 9 \times 10^{-4}\text{C}$

89 **(d)**

$\frac{1}{C_s} = \frac{1}{1} + \frac{1}{1} + \frac{1}{1} = 3$

$C_s = \frac{1}{3}$

Capacitance between A and B

$C_p = \frac{1}{3} + 1$

$\frac{4}{3}\mu\text{F} = 1.33\mu\text{F}$

90 **(c)**

Potential at a point in a field is defined as the amount of work done in bringing a unit positive test charge, from infinity to that point along any arbitrary path, $i.e.$,

$V = \frac{W}{q_0}$

$\therefore \quad V = \phi = \frac{W}{Q} \qquad (\because X \ll \infty)$

91 **(a)**

$q_1 = 10 \times 50 = 500\ \mu\text{C}, \text{C}_1 = 10\ \mu\text{F}, \text{C}_2 = ?, \text{q}_2 = 0$

As $V = \frac{q_1+q_2}{C_1+C_2}$

$\therefore\ C_1 + C_2 = \frac{q_1+q_2}{V} = \frac{500+0}{20} = 25\mu\text{F}$

$C_2 = 25 - C_1 = 25 - 10 = 15\ \mu\text{F}$

92 **(b)**

From Gauss's law, $\phi = \frac{q}{\varepsilon_0}$

So, $\frac{\phi_{\max}}{\phi_{\min}} = \frac{Q_{\max}}{Q_{\min}} = \frac{\lambda(l^2+b^2+h^2)^{1/2}}{\lambda h}$

$= \frac{\sqrt{l^2+b^2+h^2}}{h}$

93 **(b)**

$\vec{\text{E}}_1 = \frac{1}{4\mu\pi\varepsilon_0}.\frac{2\vec{P}}{r^3}$ and

$\vec{\text{E}}_2 = -\frac{1}{4\pi\varepsilon_0}.\frac{\vec{P}}{(2r^3)} = -\frac{1}{4\pi\varepsilon_0}.\frac{\vec{P}}{8r^3}$

$\Rightarrow\ \vec{\text{E}}_2 = -\frac{\vec{\text{E}}_1}{16}$

(Here negative sign means direction)

94 **(b)**

Equal and opposite charges get induced on the inner surface of conductor, so the net charge enclosed by the surface is zero and hence flux crossing through the surface is zero

95 **(b)**

$C_p = 3 + 3 = 6\ \mu\text{F}$

$\frac{1}{C_s} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} = \frac{3}{6} = \frac{1}{2}$

$C_s = 2\mu\ \text{F}$

96 **(a)**

Due to additional charge of $-3Q$ given to external spherical shell, the potential difference between conducting sphere and the outer shell will not change because by presence of charge on outer shell, potential everywhere inside and on the surface of the shell will change by same amount. Therefore, the potential difference between sphere and shell remain unchanged.

97 **(d)**

Heat produced =energy stored in capacitor

$\frac{1}{2}CV^2 = \frac{1}{2}(10 \times 10^{-6})(500)^2$

$= 1.25$ J

98 **(d)**

Minimum capacity, $C_s = \frac{5}{10} = 0.5\ \mu\text{F}$

Maximum capacity, $C_p = 10 \times 5 = 50\ \mu\text{F}$

$\frac{C_p}{C_s} = \frac{50}{0.5} = 100$

99 **(a)**

By definition $\int_{l=\infty}^{l=0} -E.dl = V$, the potential at the centre of ring and $V = \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} = \frac{9\times10^9\times1.11\times10^{-10}}{0.5} =$ 2V

Hence value of given line integral is 2 V.

100 **(c)**

$0 - \frac{Q}{C} + 10 - \frac{Q}{2C} = 0$

$Q = \frac{20C}{3} = \frac{20 \times 6}{3} = 40\ \mu\text{C}$

101 **(c)**

$\phi = E(ds)\cos\theta = E(2\pi r^2)\cos 0^0 = 2\,\pi r^2 E$

102 **(d)**

radius of the sphere.

103 **(a)**

$$V_1 = \frac{C \times 100}{3C + C} = 25 \text{ V}, V_2 = 100 - 25 = 75 \text{ V}$$

104 **(d)**

Capacitance with air

$$C = \frac{A\varepsilon_0}{d}$$

When interspace between the plates is filled with wax, then

$$C' = \frac{KA\varepsilon_0}{2d}$$

or $$C' = \left(\frac{A\varepsilon_0}{d}\right)\frac{K}{2}$$

or $$C' = C\frac{K}{2}$$

$\therefore$ $$6 = 2.\frac{K}{2} \Rightarrow K = 6$$

105 **(d)**

$$V_C = \frac{Q_1 + Q_2}{C_1 + C_2} = \frac{CV + 2CV}{KC + 2C} = \frac{3V}{K + 2}$$

106 **(c)**

Here, magnetic force =electrostatic force

$$qvB = qE$$

$$v = \frac{E}{B} = \frac{\sigma}{\varepsilon_0 B}$$

The time taken by electron to travel a distance l in that space

$$t = \frac{1}{v} = \frac{l}{\frac{\sigma}{\varepsilon_0 B}} = \frac{\varepsilon_0 lB}{\sigma}$$

108 **(a)**

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{10} + \frac{1}{20} = \frac{3}{20};$$

$$C_s = \frac{20}{3} \text{ μF}$$

$\therefore$ charge on each capacitor

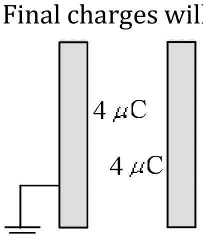
$$= C_s V = \frac{20}{3} \times 200 = \frac{4000}{3} \text{μC}$$

Common potential $= \frac{\text{total charge}}{\text{total capacity}}$

$$= \frac{2 \times 4000/3}{10 + 20} = \frac{800}{9} V$$

109 **(b)**

Final charges will be as shown in Figure.



So, charge flowing from earth to plate = final charge – initial charge = $-4 - 10 = -14$ μC

110 **(c)**

The arrangement shows a Wheatstone bridge.

As $\frac{C_1}{C_3} = \frac{C_4}{C_5} = 1$, therefore the bridge is balanced.

$$\frac{1}{C_{s_1}} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2}, C_{s_1} = 2\text{μ F}$$

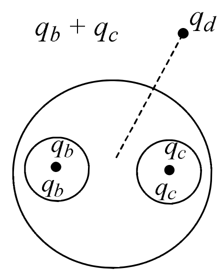
Similarly, $C_{s_2} = 2$μ F

$\therefore$ effective capacitance

$= C_p = C_{s_1} + C_{s_2} = 2 + 2 += 4$μ F

111 **(b)**

$$F_3 = \frac{k(a_b + q_d)}{r^2}$$



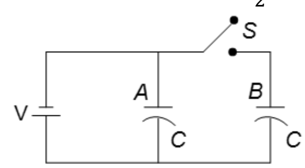
$F_1 = F_2 =$zero

112 **(c)**

Work done is zero because all the points on the circular path are at same potential.

113 **(d)**

Initial total energy $= \frac{1}{2}CV^2 + \frac{1}{2}CV^2 = CV^2$



When the switch is open, dielectric is introduced

Then capacitance $C = KC = 3C$

Energy stored in $C = \frac{1}{2}3CV^2 = \frac{3}{2}CV^2$

Since the switch is open, charge will be the same in B so

Energy $B = \frac{1}{2}\frac{C}{3}V^2$

So, total final energy $= \frac{3}{2}CV^2 + \frac{1}{6}CV^2$

$$= \frac{9CV^2 + 1CV^2}{6} = \frac{10}{6}CV^2$$

So, required ratio $= \frac{CV^2}{\frac{10}{6}CV^2} = \frac{3}{5} = 3:5$

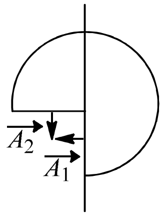
114 **(a)**

Electric field due to large metal plate $= \sigma/\varepsilon_0$

Since the electron has energy of 100 eV, so it can cross a potential difference of 100 V only. So

$100 = \frac{\sigma}{\varepsilon_0}d$, solve to get d

115 **(c)**



From Fig .we have

$\overrightarrow{A_1} = \frac{\pi R^2}{2}\hat{\imath}$

$\overrightarrow{A_2} = \frac{\pi R^2}{2}\hat{\jmath}$

$\vec{E} = E\cos45°\hat{\imath} + E\sin45°\hat{\jmath} = \frac{E}{\sqrt{2}}\hat{\imath} + \frac{E}{\sqrt{2}}\hat{\jmath}$

$\phi = \vec{E}\cdot\left(\overrightarrow{A_1} + \overrightarrow{A_2}\right) = \frac{-E}{\sqrt{2}}\frac{\pi R^2}{2} - \frac{E}{\sqrt{2}}\frac{\pi R^2}{2}$

$\frac{\pi R^2 E}{\sqrt{2}}$

This is the flux entering, so flux leaving $= \frac{\pi R^2 E}{\sqrt{2}}$

116 **(a)**

Let radius of big drop be $R$and of smaller be r. Then,

Volume of bigger drop = 8 ×volume of single drop

Also, since shape of drop is assumed spherical, volume of a sphere of radius a is$\frac{4}{3}\pi a^3$

$\therefore \frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$

$\Rightarrow = 2r$

Capacitance of sphere of radius a is

$C = 4\pi\varepsilon_0 a$

$\therefore$ Capacitance of big drop

$C = 4\pi\varepsilon_0 R$

Capacitance of small drop

$C' = 4\pi\varepsilon_0(2r)$

$\therefore \quad \frac{C'}{C} = \frac{4\pi\varepsilon_0(2r)}{4\pi\varepsilon_0 r} = \frac{2}{1}$

117 **(c)**

This work done by us is stored in the capacitor in the volume $A(d_2 - d_1)$ where new electric field is created. If you calculate the work done by using the expression

$W_{ext} - W_{el} = dU = \frac{\varepsilon_0 AV^2}{2}\left[\frac{1}{d_2} - \frac{1}{d_1}\right] < 0$, You may get confused. Here, battery is also doing work, do from energy conservation principle, we get

$W_{est} + W_{el} + W_{\text{battery}} = 0$

118 **(c)**

As potential at A and B is the same, $V_A = V_B = kQ/d$. So, work done in both the cases will be the same

119 **(b)**

Extra charge will flow through battery, so work is done by battery. External agent will do negative work

120 **(a)**

According to gauss's law, electric field at any point on Gaussian surface is due to all the charges present inside or outside

121 **(b)**

Here, $r_1 = 10$ cm, $r_2 = 15$ cm,

$V_1 = 150$ V, $V_2 = 100$ V

Common potential

$V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{4\pi\varepsilon_0(r_1V_1 + r_2V_2)}{4\pi\varepsilon_0(r_1 + r_2)}$

$= 120$ V

$q_1 = C_1 V = 4\pi\varepsilon_0 r_1 V = \frac{10^{-1}}{9\times10^9} \times 120\text{C}$

$= \frac{12}{9\times10^9} \times 3\times10^9$ esu $= 4$ esu

122 **(d)**

Common potential, $V = \frac{q_1+q_2}{C_1+C_2}$

$\therefore$ charge on smaller sphere after contact

$= C_1V = \frac{C_1(q_1+q_2)}{C_1+C_2}$

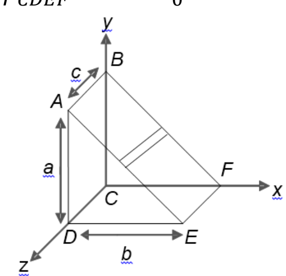
$= \frac{4\pi\varepsilon_0 r_1(10^{-2} + 5\times10^{-2})}{4\pi\varepsilon_0(r_1+r_2)}$

$= \frac{10^{-2}\times6\times10^{-2}}{3\times10^{-2}} = 2\times10^{-2}\text{C}$

123 **(a)**

$\phi_{ABCD} = -acd$ unit

$\phi_{CDEF} = -bcE_0$ unit



$\phi_{ABEF} = bcE_0 + c\int_0^a (d+x)dy$

$= +bcE_0 + acd + c\int_0^a xdy$

$= +bcE_0 + acd + \frac{ca}{b}\int_0^a xdx$

[since $\frac{x}{b} + \frac{y}{a} = 1 \Rightarrow \frac{dx}{b} = \frac{-dy}{a}$]

$= \left[+bcE_0 + acd + \frac{acd}{2}\right]$unit

Using Gauss's law, we get

$\phi_{net} = \frac{q_{in}}{\varepsilon_0} \Rightarrow q_{in} = \frac{abc\varepsilon_0}{2}$

124 **(c)**

$W = \frac{1}{2}C[(2V)^2 - V^2] = \frac{3}{2}CV^2$

$W' = \frac{1}{2}[(2V)^2 - (2V)^2] = 6CV^2$

$= \frac{6 \times 2W}{3} = 4W$

125 **(c)**

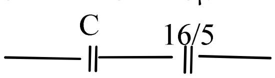
There are two capacitors in parallel

$U = \frac{1}{2}CV^2, C = \frac{2\varepsilon_0 A}{d}$

126 **(b)**

$$3 = \frac{\frac{16}{5}C}{\frac{16}{5} + C}$$

or $\quad C = 48\mu\text{F}$



127 **(b)**

Initially, when the switch is closed on position 1, the capacitor C is connected in series with batteries E_1andE_2. From KVL, we have

$\frac{Q_i}{C} = E_2 + E_1 = 0$

Or $\quad Q_i = (E_2 - E_1)C \qquad$ (i)

Depending upon the sing of $(E_2 - E_1)$, chargeQ_i, on the left plate may be positive (if$E_2 > E_1$), or negative (if $E_2 < E_1$); charge on right plate would be equal and opposite

When the switch is moved to position 2, the left plate (earlier having charge $+Q_i$) will now have charge

$Q_f = -E_1C \qquad$ (ii)

The net charge flow through the circuit is

$\Delta Q = Q_f - Q_i = [-E_1 - (E_2 - E_1)]C = -E_2C$

We can say that a net possible charge equal to E_2C is pulled by the battery of e.m.f. E_1 from the left plate of the capacitor, which flows through battery $E_1$and is transferred to the right plate of the capacitor. Work done by battery E_1 in the process of charge transfer is

$\Delta W = E_1E_2C \qquad$ (iii)

A part of this work changes the energy of the capacitor:

$\Delta W_c = \frac{Q_f^2}{2C} - \frac{Q_i^2}{2c} = \frac{1}{2}E_1^2C - \frac{1}{2}(E_2 - E_1)^2C$

$= \frac{1}{2}(2E_1E_2 - E_2^2)C$

And the remaining part is lost as joule heating:

$H = \Delta W - \Delta W_C = \frac{1}{2}E_2^2C$

128 **(b)**

Here, KE $= 100$ eV $= 100 \times 1.6 \times 10^{-19}$J

This is lost when electron moves through a distance (d) towards the negative plate.

KE $=$ work done $= F \times s \Rightarrow qE \times s = e\left(\frac{\sigma}{\varepsilon_0}\right)d = \left(\frac{(\text{KE})\varepsilon_0}{e\sigma}\right)$

$d = \frac{100 \times 1.6 \times 10^{-19} \times 8.86 \times 10^{-12}\text{J}}{1.6 \times 10^{-19} \times 2 \times 10^{-6}}$

$= 4.43 \times 10^{-4}$m

$= 0.443$ mm

129 **(a)**

When metal sphere is placed inside a charged parallel plate capacitor, the electric lines of force will not enter the metallic conductor as $E =$ 0inside a charged conductor. Moreover, the surface of a charged conductor is an equipotential surface and hence, electric lines of force are always perpendicular to equipotential surface.

130 **(b)**

Electric field will do the negative work, because the force of electric field is opposite to the displacement. So external agent has to do positive work. So its energy will be used

131 **(c)**

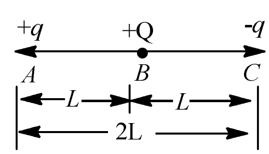
$E_1 = E_2 \Longrightarrow \frac{kQ_1}{r_1^2} = \frac{kQ_2}{r_2^2}$

$\frac{Q_1}{Q_2} = \left(\frac{r_1}{r_2}\right)^2$

$\frac{V_1}{V_2} = \frac{Q_1}{r_1} \times \frac{r_2}{Q_2} = \left(\frac{r_1}{r_2}\right)^2 \frac{r_2}{r_1} = \frac{r_1}{r_2}$

132 **(d)**

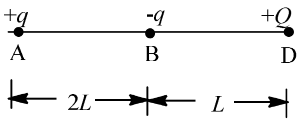
In Ist case, when charge $+Q$ is situated at C.



Electric potential energy of system

$U_1 = \frac{1}{4\pi\varepsilon_0}\frac{(q)(-q)}{2L} + \frac{1}{4\pi\varepsilon_0}\frac{(-q)Q}{L} + \frac{1}{4\pi\varepsilon_0}.\frac{qQ}{L}$

In IInd case, when charge $+Q$is moved from C to D.



Electric potential energy of system in that case

$$U_2 = \frac{1}{4\pi\varepsilon_0}.\frac{(q)(-q)}{2L} + \frac{1}{4\pi\varepsilon_0}.\frac{qQ}{3L} + \frac{1}{4\pi\varepsilon_0}\frac{(-q)(Q)}{L}$$

$\therefore$ Work done $= \Delta U = U_2 - U_1$

$$= \left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{2L} + \frac{1}{4\pi\varepsilon_0}\frac{qQ}{3L} - \frac{1}{4\pi\varepsilon_0}\frac{qQ}{L}\right)$$

$$-\left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{2L} + \frac{1}{4\pi\varepsilon_0}\frac{qQ}{L} + \frac{1}{4\pi\varepsilon_0}\frac{qQ}{L}\right)$$

$$= \frac{qQ}{4\pi\varepsilon_0}.\left[\frac{1}{3L} - \frac{1}{L}\right]$$

$$= \frac{qQ}{4\pi\varepsilon_0}\frac{(1-3)}{3L}$$

$$= \frac{-2qQ}{12\pi\varepsilon_0 L} = -\frac{qQ}{6\pi\varepsilon_0 L}$$

133 **(b)**

When a conductor of capacitance C is given a charge q, it acquires a potential given by

$$V = \frac{q}{C}$$

The work done in charging the conductor is stored as potential energy in the electric field in the vicinity of the conductor.

134 **(b)**

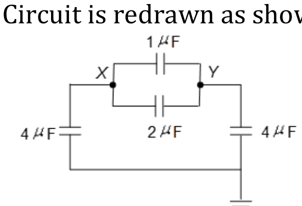
Work done =potential energy of configuration of charges

$$\frac{1}{4\pi\varepsilon_0 a}[q(-q) + (9-q)q + q(-q) + (-q)(q)] + \frac{(-q)(-q) + q^2}{4\pi\varepsilon_0 a\sqrt{2}}$$

$$= \frac{1}{4\pi\varepsilon_0}\left[-\frac{4q^2}{a} + \frac{2q^2}{a\sqrt{2}}\right] = -\frac{2.6}{4\pi\varepsilon_0}\frac{q^2}{a}$$

135 **(d)**

Circuit is redrawn as shown in Figure.



In the circuit, capacitors 4μF capacitors and 4μF are connected in series. Combination of this is in parallel with 1μF and 2μF capacitors

136 **(a)**

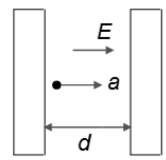
Negative charge itself goes from low to high potential

137 **(b)**

$$E = \frac{Q}{2A\varepsilon_0}$$

$$a = \frac{qE}{m} = \frac{qQ}{2A\varepsilon_0}$$

$$d = \frac{1}{2}at^2; t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2d2A\varepsilon_0}{qQ}}$$



138 **(c)**

$+q$ will not provide restoring torque

139 **(a)**

Total charge enclosed in surface A is

$Q = (q_1 + q_2 + q_3) = (-14 + 78.85 - 56)$nC

$$\phi = \frac{Q}{\varepsilon_0} = \frac{8.85 \times 10^{-9}}{8.85 \times 10^{-12}} = 10^3\ \mathrm{Nm^3C^{-1}}.$$

140 **(c)**

For a ring $E = \frac{1}{4\pi\varepsilon_0}.\frac{qx}{(x^2+R^2)}$ and E is maximum when

$$x = \frac{R}{\sqrt{2}}$$

$$\Rightarrow \quad E_{\max} = \frac{1}{4\pi\varepsilon_0}.\frac{2q}{3\sqrt{3}.R^2}$$

141 **(c)**

6 μF and 3 μF capacitors are in series

$$\frac{1}{C_1} = \frac{1}{6} + \frac{1}{3}$$

$$C_1 = 2$$

C_1 is parallel to 2 μF capacitor

$\therefore \quad C_{eq} = 2 + 2 = 4\mu$F

Total energy, $U = \frac{1}{2}CV^2$

$$= \frac{1}{2} \times 4 \times (2)^2 = 8\mu\text{J}$$

142 **(c)**

Potential energy

$$U = \frac{q_1 q_2}{4\pi\varepsilon_0 r}$$

Or $U \propto \frac{1}{r}$

When r decreases U increases and $vice - versa$. Moreover, potential energy as well as force is positive, if there is repulsion between the particles and negative if there is attraction.

143 **(c)**

Potential difference between two equipotential surfaces *A* and *B*.

$V_A - V_B = kq\left(\frac{1}{r_A} - \frac{1}{r_B}\right)$

$= kq\left(\frac{r_B - r_A}{r_A r_B}\right)$

$= \frac{kqt_1}{r_A r_B}$

Or

$t_1 = \frac{(V_A - V_B) r_A r_B}{kq}$

Or $t_1 \propto r_A r_B$

Similarly, $t_2 \propto r_B r_C$

Since,

$r_A < r_B < r_C$, therefore $r_A r_B < r_B r_C$

$\therefore\ t_1 < t_2$

144 **(a)**

Though effective value of g will change, as the time period of spring block system does not depend on g, so time period will remain the same, i. e. T

145 **(b)**

Here, $C_s = \frac{C_1 C_2}{C_1 + C_2} = 3\mu$ F

And $C_p = C_1 + C_2 = 16\mu$ F

Solve to get, $C_1 = 4\mu$ F and $C_2 = 12\mu$ F

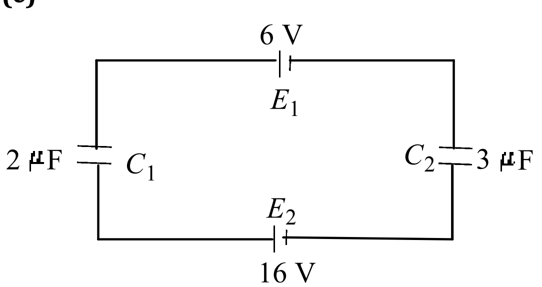
146 **(d)**

$\text{PE} = \frac{q_1 q_2}{4\pi\varepsilon_0 r} = \frac{9\times10^9 (2\times10^{-6})^2}{1} = 0.036$ J

147 **(c)**

$E \propto \frac{1}{r}$, where r is the distance from the axis.

148 **(c)**



Net emf in the circuit here

$E = E_2 - E_1 = 16 - 6 = 10$ volt

While the equivalent capacity

$C = \frac{C_1 C_2}{C_1 + C_2} = \frac{2\times3}{2+3} = \frac{6}{5}\mu\text{F}$

Charge on each capacitor

$q = CV = \frac{6}{5}\times 10 = 12\mu\text{C}$

$\therefore$ Potential difference across 2μF capacitor

$V_1 = \frac{q}{C_1} = \frac{12}{2} = 6$ volt

149 **(b)**

Dielectric strength, it is the maximum electric field which a material can be bear

150 **(c)**

From eq. (i) *A* and *C* both are charged, either positively or negatively. From eq. (ii), *B* is charged and *D* and *E* have no charge. From eq. (iii), *A* is positively charged.

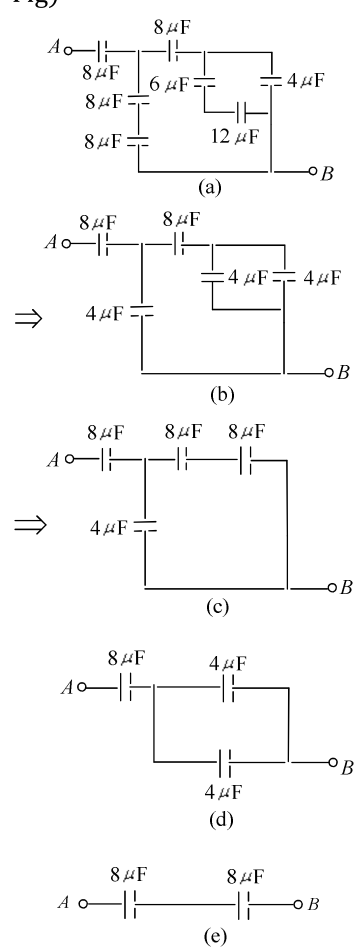
Therefore, from eq. (i), *B* is negatively charged

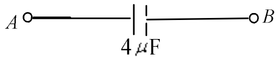
151 **(a)**

All the statements are general properties of electric lines of force

152 **(c)**

Using the method of successive reduction (see Fig)





(f)

153 **(b)**
Common potential,
$V = \dfrac{\text{total charge}}{\text{total capacity}} = \dfrac{Q + 0}{4\pi\varepsilon_0(r + r')}$
∴ charge on smaller sphere
$= 4\pi\varepsilon_0 r' \times V = \dfrac{Qr'}{r + r'}$

154 **(a)**
Here , $t = 2$ mm, $x = 1.6$ mm, $K = ?$
As potential difference remains the same, capacity must remain the same
∴ $x = t\left(1 - \dfrac{1}{K}\right)$
$1.6 = 2\left(1 - \frac{1}{K}\right)$, which gives $K = 5$

155 **(a)**
Change in energy $\Delta U = \frac{1}{2}\left[\frac{q_1^2 - q_2^2]}{C}\right]$
$= \dfrac{1}{2}\left[\dfrac{(0.5)^2 - (0.1)^2}{48 \times 10^{-6}}\right]$
$= \dfrac{1}{2}\left[\dfrac{0.25 - 0.01}{48 \times 10^{-6}}\right]$
$= \dfrac{1}{2}\left[\dfrac{0.24}{48 \times 10^{-6}}\right] = \dfrac{1}{2}\left[\dfrac{10^4}{2}\right]$
$= 2500$ J

156 **(a)**
Their potential will be same i.e.,$V_1 = V_2$
$\dfrac{kq_1}{R_1} = \dfrac{kq_2}{R_2} \Longrightarrow \dfrac{q_1}{q_2} = \dfrac{R_1}{R_2}$
$\dfrac{E_1}{E_2} = \dfrac{kq_1/R_1^2}{kq_2/R_2^2} = \dfrac{q_1}{q_2}\left(\dfrac{R_2}{R_1}\right)^2$
$= \dfrac{R_1}{R_2}\left(\dfrac{R_2}{R_1}\right)^2 = \dfrac{R_2}{R_1}$

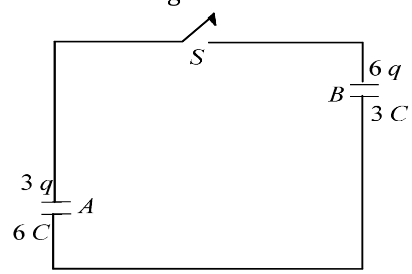
157 **(a)**
Since the two spheres are joined by a wire, their potential are equal *ie*,
$\dfrac{q_1}{4\pi\varepsilon_0 R_1} = \dfrac{q_2}{4\pi\varepsilon_0 R_2} \Rightarrow \dfrac{q_1}{q_2} = \dfrac{R_1}{R_2}$
Now, $\sigma_1 = \frac{q_1}{4\pi\varepsilon_0 R_1^2}$
And $\sigma_2 = \frac{q_2}{4\pi\varepsilon_0 R_2^2}$,
Hence $\frac{\boldsymbol{\sigma_2}}{\boldsymbol{\sigma_1}} = \frac{\boldsymbol{\sigma_2}}{\boldsymbol{\sigma_1}} \times \frac{R_1^2}{R_2^2} = \left(\frac{R_2}{R_1}\right)\left(\frac{R_1}{R_2}\right)^2$
$\Rightarrow \frac{\sigma_2}{\sigma_1} = \frac{R_1}{R_2}$

158 **(b)**
Find potential at A and C due to charge at B, then the required work done is $W = q(V_A - V_C)$

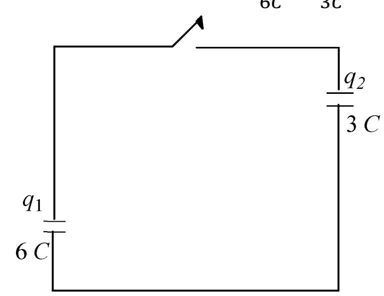
159 **(c)**
Refer concepts and formulate isolated sphere and non-isolated sphere

160 **(b)**
Potential V_1 due to a ring is given by:
$V_1 = \dfrac{1}{4\pi\varepsilon_0} \times \dfrac{q}{\sqrt{R^2 + r^2}}$
$= \dfrac{1}{4\pi\varepsilon_0} \times \dfrac{q}{\sqrt{R^2 + 3R^2}} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{2R}$
At the centre, $V_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$
$\text{K.E.} = q_0(V_2 - V_1) = \dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{qq_0}{2R}\right)$

161 **(b)**
The circuit is given as



Let q_1 and q_2 be the charge after switch S has been closed.
Then, $V = \frac{q_1}{6C} = \frac{q_2}{3C}$



$\Rightarrow \quad \dfrac{q_1}{2} = q_2$
$\Rightarrow \quad q_1 = 2q_2$ ...(i)
But we know that, charge is conserved
$q_1 + q_2 = 3q + 6q$
or $q_1 + q_2 = 9q$ ...(ii)
On putting the value of q_1Eq. (ii)
$2q_2 + q_2 = 9q$
$\Rightarrow \quad 3q_2 = 9q$
$q_2 = 3q$
Now, from Eq. (i)
$q_1 = 2 \times 3q$
$\Rightarrow \quad q_1 = 6q$
Hence, $q_1 = 6q, q_2 = 3q$

162 **(b)**
Linear momentum of electron, $p_e = \sqrt{2m_e eV}$

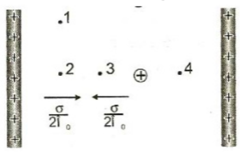
Linear momentum of photon, $p_p = \sqrt{2m_p eV}$

$$\frac{p_e}{p_p} = \frac{\sqrt{2m_e eV}}{\sqrt{2m_p eV}}$$

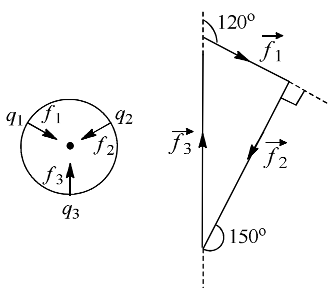
$$\frac{p_e}{p_p} = \sqrt{\frac{m_e}{m_p}}$$

163 **(c)**

Electric field due to both the plates will be cancelled out for all the points. So the net electric field at the points will be governed only by the sphere. The farther the point from the sphere, the lesser the magnitude of the electric field



Since the charges exert force on one another that are in action-reaction pair, sum of force $\vec{f_1}$, $\vec{f_2}$ and $\vec{f_3}$ is zero. So force vectors form a triangle, as shown in the figure



Applying since rule, we have

$$\frac{f_1}{\sin 30} = \frac{f_2}{\sin 60} = \frac{f_3}{\sin 90}$$

Or $2f_1 = \frac{2f_2}{\sqrt{3}} = f_3 = K$ (suppose)

$$f_1 = \frac{k}{2}, f_2 = \frac{\sqrt{3}}{2}K, f_3 = K$$

So $f_1 : f_2 : f_3 = \frac{1}{2} : \frac{\sqrt{3}}{2} : 1 = 1 : \sqrt{3} : 2$

164 **(d)**

(n-1) capacitors are made by n plates and all are connected in parallel because plates are connected alternately.

$\therefore$ Total capacitance $= (n-1)x$

165 **(c)**

$$E_x = \frac{dV}{dx} = \frac{120 - 80}{2} = 20 \text{ Vcm}^{-1}$$

There may be the y- and z- components of field also

166 **(b)**

On connecting, the entire amount of charge will shift to the outer sphere

Heat generated

$$U_i - U_f = \frac{q^2}{8\pi\varepsilon_0 R_1} - \frac{q^2}{8\pi\varepsilon_0 R_2}$$

$$= \frac{(20 \times 10^{-6}) \times 9 \times 10^9}{2}\left[\frac{1}{0.10} - \frac{1}{0.20}\right] = 9 \text{ J}$$

167 **(d)**

Work done $= U_2 - U_1 = \frac{q_1 q_2}{4\pi\varepsilon_0}\left[\frac{1}{r_2} - \frac{1}{r_1}\right]$

$$= 12 \times 10^{-6} \times 8 \times 10^{-6} \times 9 \times 10^9 \left[\frac{10^2}{6} - \frac{10^2}{10}\right]$$

$$W = 96 \times 9 \times 10^{-3} \times 10^2 \times \frac{4}{60} = 5.8\text{J}$$

168 **(a)**

Each plate is taking part in the formation of two capacitors except the plates at the ends.

These capacitors are in parallel and n plates form $(n-1)$ capaitors.

Thus, equivalent capacitance between points A and $B = (n-1)C$

169 **(b)**

$$C' = \frac{\varepsilon_0 A}{d - t} = \frac{\varepsilon_0 A}{d - d/2} = \frac{2\varepsilon_0 A}{d}$$

Hence, capacitance is doubled

170 **(d)**

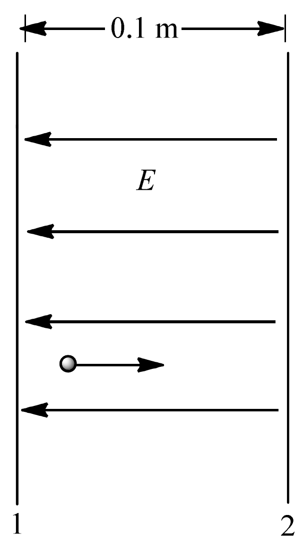
The net field at O.

$\text{E} = 2\vec{\text{E}}_\text{R}$, when $\vec{\text{E}}_\text{p} + \vec{\text{E}}_\text{s} = \vec{0}, \vec{\text{E}}_\text{Q} + \vec{\text{E}}_\text{T} = \vec{0}$ and $\vec{\text{E}}_\text{R} = \vec{\text{E}}_\text{U}$ along ROU diriction. It is possible in arrangement of (d) as shown in a joining figure.

171 **(a)**

Since $V_2 > V_1$, so electric field will point from plate 2 to plate 1.

The electron will experience an electric force, opposite to the direction of electric field, and hence move towards the plate 2.



Use work-energy theorem to find speed of electron when it strikes the plate 2.

$$\frac{m_e v^2}{2} - 0 = e(V_2 - V_1)$$

Where v is the required speed.

$\therefore \quad \frac{9.11\times10^{-31}}{2} v^2 = 1.6 \times 10^{-19} \times 20$

$\Rightarrow \quad v = \sqrt{\frac{1.6 \times 10^{-19} \times 40}{9.11 \times 10^{-31}}}$

$= 2.65 \times 10^6 \text{ms}^{-1}$

172 **(a)**

$\because \quad V = 4x^2$

Hence, $\vec{E} = -\frac{dV}{dr} = -8x\hat{i}$

Hence, value of $\vec{E}$ at (1m, 0, 2m) will be

$\vec{E} = -8 \times 1\hat{i} = -8\hat{i}\ \text{Vm}^{-1}$

173 **(a)**

In series combination, charge is constant.

$\therefore \quad V \propto \frac{1}{C}$

Now, $\quad \frac{V_2}{V_1} = \frac{KC}{C} = \frac{K}{1}$

But $\quad V_1 + V_2 = V$

or $\quad \frac{V_2}{K} + V_2 = V$ or $V_2 = \frac{K}{K+1} V$

174 **(a)**

When a positive charge is moved from one point to another in an electric of magnetic field, then under the influence of the field force acts on the particle and an external agent will have to do work against this force. But in the given case the charge moves under influence of no field, hence it does not experience any force therefore, no work is done.

$W_A = W_B = W_C = 0$

175 **(c)**

$F_e = mg \tan\theta$

$= (1.20 \times 10^{-3}\text{kg})(10\ \text{ms}^{-2}) \tan(37°)$

$= 0.0090$ N

$F_e = Eq = \frac{Vq}{d}$

$\therefore V = \frac{F_e d}{q} = \frac{(0.009\ \text{N})(0.0500\ \text{m})}{9.0 \times 10^{-6}\text{C}} = 50.0$ V

176 **(a)**

$a_x = \frac{qE}{m} = \frac{10^{-6} \times 2 \times 10^7}{2} = 10ms^{-2}$

Time of flight $T = \frac{2usin\theta}{g} = \frac{2\times10\times\frac{1}{\sqrt{2}}}{10}$

T$= \sqrt{2}$ sec

Hence, range $R = u_s T + \frac{1}{2} a_x, T^2$

$R = 10 \cos 45° \times T + \frac{1}{2} a_x, T^2$

$= \frac{10}{\sqrt{2}} \times \sqrt{2} + \frac{1}{2} \times 10 \times 2$

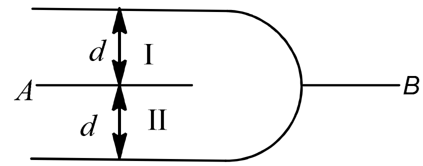
$\Rightarrow \quad R = 20$ m

177 **(d)**

In series, charge is the same on each capacitor

178 **(d)**

Here, we have two capacitors I and II connected in parallel order.



So, $\quad C = C_1 + C_2$

$= \frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d} = \frac{2\varepsilon_0 A}{d}$

179 **(a)**

The potential due to charge q at distance r is given by

$V = \frac{1}{4\pi\varepsilon_0} \frac{q}{r}$

If W be the work done in moving the charge from A to B then the potential difference (V) is given by

$V_A - V_B = \frac{W}{q}$

Both work (W) and charge (q) are scalar quantities hence potential difference ($V_A -$ VBwill also be a scalar quantity.

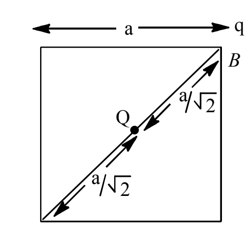
Here,

$V_A = V_B = \frac{1}{4\pi\varepsilon_0} \frac{Q}{a/\sqrt{2}}$

Since, $Q$is same for both,

$V_A - V_B = 0$

$W = 0$



180 **(d)**

The two capacitor the circuit are in parallel order, hence

$$C' = C + \frac{C}{2} = \frac{3C}{2}$$

The work done in charging the equivalent capacitor is stored in the form of potential energy.

Hence, $W = U = \frac{1}{2}C'V^2$

$$= \frac{1}{2}\left(\frac{3C}{2}\right)V^2$$

$$= \frac{3}{4}CV^2$$

181 **(a)**

Potential due to charge (q) at point (r) is given by

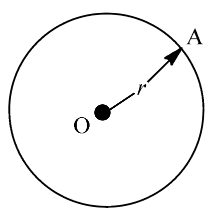
$$V = \frac{1}{4\pi e_0} \cdot \frac{q}{r}$$

Since, charge Q is rotated in a circle of radius r, hence its potential remains same at all points on the path, hence $\Delta V = 0$.

Also, work done $= q\Delta V$

Where q is charge and $\Delta V = 0$.

∴ Work done =0.



182 **(a)**

$V_C = V_1 = V_2$

$\frac{kq_1}{r_1} = \frac{kq_2}{r_2}$

$\frac{q_1}{q_2} = \frac{r_1}{r_2}$ ...(i)

$q_1 + q_2 = Q$ ...(ii)

Form Eqs. (i) and (ii), we get

$q_1 = \frac{Qr_1}{r_1 + r_2}$

Putting V_1, we get $V_C = \frac{kQ}{r_1+r_2}$

183 **(b)**

$\vec{E} = a(y\hat{i} + x\hat{j})$

$V_2 - V_1 = -\int (ayd\,x + axd\,y)$

Take $V_1 = C$ and $V_2 = V$

$V = -a\int (ydx + xdy) + C$

$= -a\int d(yx) + C = -axy + C$

184 **(a)**

$F = Kx$

$\frac{Q^2}{2A\varepsilon_0} = K(0.2d)$

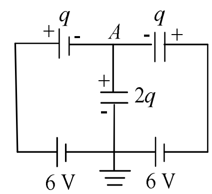
$\frac{\left(\frac{\varepsilon_0 A}{0.8d}E\right)^2}{2A\varepsilon_0} = 0.2\,Kd$

$K = 3.9\,\varepsilon_0 AE^2/d^3$

$K = 4\varepsilon_0 AE^2/d^3$

185 **(a)**

$6 = \frac{q}{2} + \frac{2q}{4} \Rightarrow q = 6\,\mu\text{C}$



186 **(a)**

Let q be charge on each small drop of radius r. If R is radius of big drop, then

$\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^3$

∴ $R = 10\,r$

$C' = 10\,C$

Initial energy $E_1 = 1000 \times \frac{q^2}{2C'}$

Final energy $E_2 = \frac{(1000q)^2}{C'}$

$\frac{E_2}{E_1} = \frac{1000 \times C}{C'}$

$= 1000 \times \frac{1}{10} = 100$

187 **(b)**

$W_{AB.} = W_{AC} + W_{CB}$

W_{CB} should be zero, because in moving from C to B, we always move perpendicular to field. Hence, force applied by field and displacement will be at 90°

$W_{AC} = -e(V_C - V_A)$

$V_C - V_A = -E \times AC$

$= -10 \times 4 = -40$

$W_{AC} = -e \times (-40) = 40e$

So $W_{AB} = 40e$ J $= 40$ eV

188 **(b)**

$E = \frac{\lambda}{2\pi\varepsilon_0 r}$

$\lambda = 2\pi\varepsilon_0 r\,E$

$= \frac{1}{2 \times 9 \times 10^9} \times 2 \times 10^{-2} \times 9 \times 0^4$

$= 10^{-7}\,\text{Cm}^{-1}$

189 **(a)**

$W = \vec{F} \cdot \vec{r} = q\vec{E} \cdot \vec{r}$

190 **(c)**

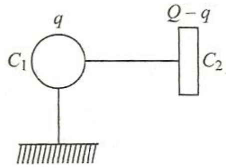
$\text{K.E.}_i + \text{P.E.}_i = \text{K.E.}_f + \text{P.E.}_f$

$0 + q \times 600 = \text{K.E.}_f + q \times 0$

$\text{K.E.}_f = 600 \times 10^{-8} = 6 \times 10^{-6}\text{J}$

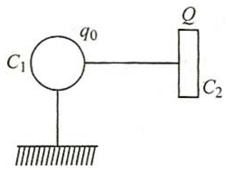
191 **(c)**

Let capacitance of the conductor be C_1 and that of plate be C_2(figure). After first operation, we get



$\frac{q}{C_1} = \frac{Q-q}{C_2}$ (i)

Let q_0 be the maximum charge that can be transferred to the conductor (figure) then,



$\frac{q_0}{C_1} = \frac{Q}{C_2}$ (ii)

From Eqs. (i) and (ii), $q_0 = \frac{Qq}{Q-q}$

192 **(c)**

Energy given by the cell

$$E = CV^2$$

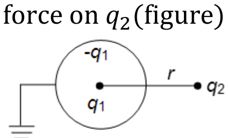
Here, C = capacitance of capacitor $= \frac{A\varepsilon_0}{d}$

V =potential difference across the plates = Ed

Therefore, $E = \left(\frac{A\varepsilon_0}{d}\right)(Ed)^2 = A\varepsilon_0 E^2 d$

193 **(a)**

There is no charge on the outer surface. Hence, no force on q_2(figure)



194 **(a)**

Work is required to set up the four charge configuration

$q_1 = +q, q_2 = -q, q_3 = +q$ and $q_4 = -q$

$$W = \frac{1}{4\pi\varepsilon_0}\left[\frac{(+q)(-q)}{AB} + \frac{(-q)(+q)}{BC} + \frac{(+q)(-q)}{CD} + \frac{(-q)(+q)}{DA} + \frac{(+q)(+q)}{AC} + \frac{(-q)(-q)}{BD}\right]$$

$$W = \frac{1}{4\pi\varepsilon_0}\left[-\frac{q^2}{a} - \frac{q^2}{a} - \frac{q^2}{a} - \frac{q^2}{a} + \frac{q^2}{a\sqrt{2}} + \frac{q^2}{a\sqrt{2}}\right]$$

$$W = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}[-4+\sqrt{2}] = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}[-4+1.414]$$

$$W = -0.21 \times \frac{q^2}{\varepsilon_0 a} \quad \text{(approx.)}$$

195 **(d)**

Ratio of energy stored in the capacitor and the work done by the battery

$$= \frac{\frac{1}{2}qV}{qV} = \frac{1}{2}$$

196 **(a)**

When S is open, spheres A and B have same, positive potential. When S is closed, potential of B will become zero. So, the potential of B will decrease. This decrease of potential takes place due to flow of electrons from earth to inner sphere$B$. But magnitude of charge acquired by inner sphere will be less than$Q$

197 **(b)**

$$\frac{E_A}{E_B} = \frac{\frac{1}{2}mv_A^2}{\frac{1}{2}mv_B^2} = \frac{W_A}{W_B} = \frac{(q)V}{(4q)V}$$

$$\frac{v_A}{v_B} = \frac{1}{2}$$

198 **(a)**

$$E = \frac{v}{d}, F = eE = eV/d$$

$$a = \frac{F}{m} = \frac{eV}{md}$$

$$d = \frac{1}{2}at^2 \Rightarrow t = \sqrt{\frac{2d}{a}}$$

$$t = \sqrt{\frac{2d\, md}{eV}} = \sqrt{\frac{2\, md^2}{eV}}$$

199 **(b)**

Energy of a charged capacitor,

$$E = \frac{1}{2}\frac{Q^2}{C}$$

$$C = \frac{2\pi\varepsilon_0 L}{\log_e\left(\frac{b}{a}\right)}$$

$$E' = \frac{1}{2}\frac{Q^2}{2\pi\varepsilon_0 L}\log_e\left(\frac{b}{a}\right)$$
...(i)

For a cylindrical capacitor.

where L= length of the cylinders

a and b = radii of two concentric cylinders

$$C' = \frac{2\pi\varepsilon_0(2L)}{\log_e\left(\frac{b}{a}\right)}$$

$$E' = \frac{1}{2}\frac{(2Q)^2}{C'}$$

$$= \frac{1}{2}\frac{(2Q)^2}{2\pi\varepsilon_0(2L)}\log_e\left(\frac{b}{a}\right)$$
...(ii)

From Eqs. (i) and (ii), we get

$$E' = 2E$$

200 **(b)**

The effective capacitance of three capacitor connected in parallel=$3C$

When $3C$is connected in series to C

$$C_{\text{resul}} = \frac{3C \times C}{3C + C} = 3.75$$

$\Rightarrow$ $C = 5\mu\text{F}$

201 **(d)**

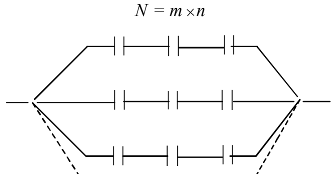
$$W = \frac{1}{2}\frac{q^2}{C}$$

$$= \frac{1}{2} \times \frac{(8 \times 10^{-18})^2}{100 \times 10^{-6}} = \frac{1}{2} \times \frac{64 \times 10^{-36}}{100 \times 10^{-6}}$$

$$= 32 \times 10^{-32}\text{J}$$

202 **(b)**

Let m rows of n series capacitor be taken then minimum number of capacitors required is



Also effective voltage is

$$V' = 1000 = n \times 250$$

$$\Rightarrow \quad n = \frac{1000}{250} = 4$$

Also these four capacitor are connected in series then effective capacitance is

$$\frac{1}{C'} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} = \frac{4}{8}$$

$\Rightarrow$ $C' = 2\mu\text{F}$

$\therefore$ $C'' = 16 = 2 \times m$

$$\Rightarrow \quad m = \frac{16}{2} = 8$$

Hence $N = m \times n = 8 \times 4 = 32$

203 **(d)**

For charge Q_1, electronic field is

$$E_1 = \frac{Q_1}{2\varepsilon_0 A}$$

where A is area.

For charge Q_2 electronic field is

$$E_2 = \frac{Q_2}{2\varepsilon_0 A}$$

Resultant electronic field

$$E = E_1 - E_2 = \frac{(Q_1 - Q_2)}{2\varepsilon_0 A}$$

Potential difference between plates when they are brought close together to form a parallel plate capacitor is

$$V = Ed = \frac{(Q_1 - Q_2)}{2\varepsilon_0 A}d$$

Since, $C = \frac{\varepsilon_0 A}{d}$ for parallel plate capacitor.

$$\therefore V = \frac{(Q_1 - Q_2)}{2C}$$

204 **(b)**

$$V - 0 = \frac{Q}{C} = \frac{Q(b-a)}{K4\pi\varepsilon_0 ab}$$

$$V = \frac{9 \times 10^9 \times 2.5 \times 10^{-6}(0.13 - 0.12)}{32 \times 0.13 \times 0.12}$$

$= 450$ V

205 **(c)**

Wheatstone bridge will be formed

207 **(c)**

When battery remains connected

$$C' = kC$$
$$Q' = kQ$$
$$V' = V$$
$$E' = E$$
$$U' = kU$$

U and Q Both increases.

208 **(d)**

$C_p = 1 + 1 + 1 = 3\mu$ F

$$\frac{1}{C_s} = \frac{1}{3} + \frac{1}{1} = \frac{4}{3}$$

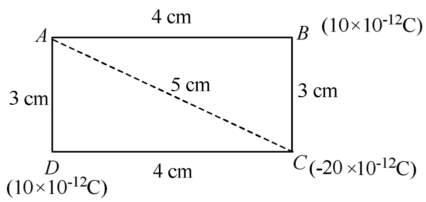
$$\therefore C_s = \frac{3}{4}\mu\text{ F}$$

209 **(a)**

The situation is summarised in figure.

$BC = AD = 3\text{cm}, \quad AB = DC = 4\text{cm},$

So, $\quad AC = 5\text{cm}.$



Now, potential at A

$$V_A = \frac{1}{4\pi\varepsilon_0}\frac{q_B}{AB} + \frac{1}{4\pi\varepsilon_0}.\frac{q_c}{AC} + \frac{1}{4\pi\varepsilon_0}.\frac{q_D}{AD}$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{10\times10^{-12}}{4\times10^{-2}} - \frac{20\times10^{-12}}{5\times10^{-2}} + \frac{10\times10^{-12}}{3\times10^{-2}}\right]$$

$$= 9\times10^9\times10^{-10}\left[\frac{10}{4} - \frac{20}{5} + \frac{10}{3}\right]$$

$$= \frac{9\times10^{-1}\times11}{6}$$

$$= 16.5\times10^{-1} = 1.65\text{V}$$

210 **(b)**

$\vec{E} = -\frac{\partial V}{\partial x}\hat{\imath} - \frac{\partial V}{\partial y}\hat{\jmath} - \frac{\partial V}{\partial z}\hat{k}$

$= (-6x+4)\hat{\imath}$

So, the equipotential surfaces would be planes parallel to YZ plane, as $\vec{E}$ is perpendicular to the equivalent surface

211 **(a)**

Electricity neutral means net charge zero. Potential of a neutral conductor may or may not be zero. It depends upon the other charges present in the surrounding

212 **(d)**

$\frac{\lambda q}{2\pi\varepsilon_0 r} = \frac{mv^2}{r}$ or $v = \sqrt{\frac{\lambda}{2\pi\varepsilon_0 mq}}$ independent of r

213 **(b)**

Presence of point charge $(+q)$ induces negative charge on inner surface of hollow conducting sphere and positive charge on outer of sphere. Hence, field lines will be directed radially outward from surface of sphere as shown in(b)

215 **(c)**

Capacitance $C = \frac{Q}{V}$

For a dielectric media $C = \frac{\varepsilon A}{d}$

$\therefore$ Capacitance C of a capacitor is independent of the geometrical configuration of the capacitor.

216 **(a)**

The energy stored is given by

$E = \frac{1}{2}CV^2$

When capacitors are connected in parallel, resultant capacitance is

$C' = C_1 + C_2$

$= 2\mu\text{F} + 2\mu\text{F} = 4\mu\text{F}$

$V = 100$ volt

$\therefore = \frac{1}{2}\times4\times10^{-6}\times(100)^2$

$E = 0.02\text{J}$

217 **(a)**

$V_A - 0 = \frac{2q}{4} = 3\text{ V}$

218 **(d)**

Here, battery is disconnected, so charge remains the same

219 **(d)**

As the capacitor is isolated, so charge will remain the same. Now, as the separation between the plates is increased, capacitance $(\varepsilon_0 A/d)$ will decrease

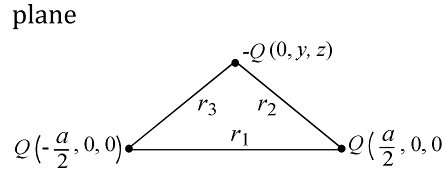
$V = \frac{Q}{C}$, if C decreases, V increases

220 **(c)**

For charge q placed at the centre of circle, the circular path is an equipotential surface and hence works done along all paths AB or AC or AD or AE is zero.

221 **(c)**

As in none of the options, the x-coordinate appears, so we have to find the locus in the $y-z$ plane



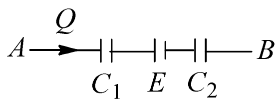
$$U = \frac{kQ^2}{r_1} - \frac{kQ^2}{r_2} - \frac{kQ^2}{r_3} = 0$$

$$kQ^2\left[\frac{1}{a} - \frac{1}{\sqrt{(a/2)^2+y^2+z^3}} - \frac{1}{\sqrt{(a/2)^2+y^2+z^2}}\right] = 0$$

$$\frac{1}{a} = \frac{2}{\sqrt{a^2/4+y^2+z^2}} \Rightarrow \quad y^2+z^2 = 15a^2/4$$

222 **(a)**

Let the charge following through section AB be Q(figure)



Applying kirchhoff's law, we get

$$V_A - \frac{Q}{C_1} + E - \frac{Q}{C_2} = V_B$$

$$V_A - V_B + E = Q\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$$

$$5 + 10 = Q\left(\frac{C_1 + C_2}{C_1 C_2}\right) = Q\left(\frac{1+2}{2}\right)$$

$$Q = \frac{15\times2}{3} = 10\mu\text{C}$$

So, potential difference across 2μF capacitor

$$V = \frac{Q}{C_2} = \frac{10\mu\text{C}}{2\mu\text{F}} = 5\text{V}$$

223 **(d)**

$E = \frac{\sigma}{\varepsilon_0}$ does not depend upon radius if σ is constant

224 **(d)**

Loss of energy $= \frac{1}{2}\frac{C_1C_2}{(C_1+C_2)}\ (V_1 - V_2)^2$

$$= \frac{1}{2}\frac{5\times10^{-6}\times5\times10^{-6}(2000-1000)^2}{(5+5)\times10^{-6}}$$

$$= \frac{5\times5}{2\times10} = 1.25\text{J}$$

225 **(c)**

Apply conservation of mechanical energy,

$$\frac{-9\times10^9\times10^{-12}}{2} = \frac{-9\times10^9\times10^{-12}}{1} + \frac{1}{2}(2m)v^2$$

$\Rightarrow v = 3/10$ m/s

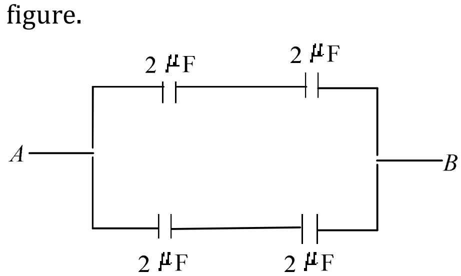
226 **(a)**

Potential of outer sphere $V = \frac{kq_1}{3r} + \frac{kq_2}{3r} + \frac{kq_3}{3r} = 0$

$\Rightarrow\ q_1 + q_3 = -q_2$

227 **(a)**

The figure is a balanced Wheatstone bridge, so diagonal capacitor will be ineffective.
So, the equivalent circuit will be as shown in the figure.



Equivalent capacitance of upper arms in series

$$C_1 = \frac{2\times2}{2+2} = 1\mu\text{F}$$

Similarly, for lower arm

$$C_2 = 1\mu\text{F}$$

$$\therefore\ C_{AB} = C_1 + C_2$$
$$= 1 + 1 = 2\mu\text{F}$$

228 **(c)**

$$\phi_E = \frac{\Sigma q}{\varepsilon_0} = \frac{(+5-5)\times10^{-6}}{\varepsilon_0} = \text{zero}$$

229 **(a)**

The potential of point B is +10 V, therefore no potential difference exists across 12 μF capacitor, hence $q_{12} = 0$. Charge on the 4μF capacitor is $q_4 = (4)(10) = 40\mu\text{C}$

230 **(d)**

Radius of big drop, $R = 3\,r$

$$\left[\because \frac{4}{3}\pi R^3 = 27\times\frac{4}{3}\pi r^3\right]$$

$$V = \frac{27q}{4\pi\varepsilon_0 R} = \frac{27q}{4\pi\varepsilon_0(3r)}$$

$$= 9\left(\frac{q}{4\pi\varepsilon_0 r}\right) = 9\times10 = 90\text{ V}$$

231 **(c)**

As work is done by the field, KE of the body increase by

$$\text{KE} = W = E = q(V_A - V_B)$$
$$= 10^{-8}(600-0) = 6\times10^{-6}\text{ J}$$

232 **(a)**

$$V = V_1 + V_2 + V_3$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{Q}{R} + \frac{1}{4\pi\varepsilon_0}\left(\frac{-2Q}{R}\right) + \frac{1}{4\pi\varepsilon_0}\left(\frac{3Q}{R}\right)$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{2Q}{R}\right) = \frac{Q}{2\pi\varepsilon_0 R}$$

233 **(b)**

Apply $V = \frac{kQ}{R}$, where $Q = Ze$

234 **(c)**

The capacitance of air capacitor

$$C = \frac{\varepsilon_0 A}{d}$$

When a dielectric slab of thickness $t = \frac{d}{2}$ is inserted between plates, the capacity becomes

$$C' = \frac{A\varepsilon_0}{d - \frac{d}{2}\left(1 - \frac{1}{K}\right)}$$

$$\frac{4}{3}\frac{A\varepsilon_0}{d} = \frac{\varepsilon_0 A}{d - \frac{d}{2}\left(1 - \frac{1}{K}\right)}$$

$$3d = 4d\left(1 - \frac{1}{2} + \frac{1}{2K}\right)$$

$$3 = 4\left(\frac{1}{2} + \frac{1}{2K}\right)$$

or $\ \frac{4}{2K} = 3 - 2$

or $\ K = 2$

235 **(d)**

Here, electric potential

$V = 3x^2$

Electric field,

$$E = -\frac{\partial V}{\partial x}$$

$$= -\frac{\partial}{\partial x}(3x^2) = -6x$$

$\therefore E_{(2,0,1)} = -12\text{Vm}^{-1}$

236 **(d)**
$V + Ed$. As d increases, V also increases. Note that E remains the same

237 **(c)**
$V_1 - V_2$ will be divided between C_1 and C_2 in series. Potential difference across C_1:

$$V_1 - V_D = \frac{C_2(V_1 - V_2)}{C_1 + C_2}$$

$$V_D = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

238 **(c)**
In a parallel plate capacitor, the capacity of capacitor,

$$C = \frac{k\varepsilon_0 A}{d}$$

$$\therefore \quad C \propto A$$

So, the capacity of capacitor increases if area of the plate is increased.

239 **(c)**
Inside a charged sphere, electric field intensity at all points is zero and electric potential is same at all the points.

Electrical potential,

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$$

Therefore, potential at the centre is equal to the potential at the surface.

240 **(c)**
Perpendicular distance between equipotential surfaces:

$d = 10 \sin 30° = 5$ cm

$$E = \frac{\Delta V}{d} = \frac{30 - 20}{5/100} = 200 \text{ Vm}^{-1}$$

Direction of electric field will be in the direction of decreasing potential

241 **(c)**
At P due to shell, potential

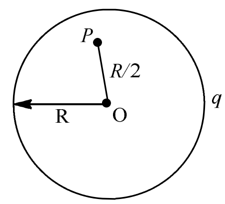
$$V_1 = \frac{q}{4\pi\varepsilon_0 R}$$

at P due to Q, potential

$$V_2 = \frac{Q}{4\pi\varepsilon_0 \frac{R}{2}} = \frac{2Q}{4\pi\varepsilon_0 R}$$

$\therefore$Net potential at P

$$V = V_1 + V_2 = \frac{q}{4\pi\varepsilon_0 R} + \frac{2Q}{4\pi\varepsilon_0 R}$$



242 **(b)**
$A = 90 \text{ cm}^2, d = 2 \text{ mm}$

$E = \frac{V}{d}, V = 400\ V$

$$u = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\varepsilon_0\left(\frac{V}{d}\right)^2$$

$$= \frac{1}{2}(8.85 \times 10^{-12})\left(\frac{400}{2 \times 10^{-3}}\right)^2 = 0.177 \text{ Jm}^{-3}$$

243 **(c)**
On connecting, potential becomes equal $q \propto C \propto r$ and $\sigma = \frac{q}{A} \propto \frac{r}{r^2} \rightarrow \frac{1}{r}$

$\therefore$ Surface charge density on 15 cm sphere will be greater than that on 20 cm sphere.

244 **(a)**
Capacitance of parallel plate capacitor

$$C_0 = \frac{\varepsilon_0 A}{d}$$

Where A =area of the plates,
d = separation between the plates,

Charge stored in the capacitor

$$Q = C_0 V_0$$

When battery is disconnected, then charge remains same.

So, energy $E_1 = \frac{1}{2}\frac{Q^2}{C}$

C = capacitance when plate separation is doubled.

So, $C_1 = \frac{C_0}{2}$

$$E_1 = \frac{1}{2}\frac{Q^2}{C_0/2} = \frac{Q^2}{C_0} = \frac{C_0^2 V_0^2}{C_0} = C_0 V_0^2$$

When battery is connected, then

Energy $E_2 = \frac{1}{2}CV_0^2$

where $E_2 = \frac{1}{2}\frac{C_0}{2}V_0^2 = \frac{1}{4}(C_0V_0^2)$

$\therefore \frac{E_1}{E_2} = \frac{C_0V_0^2}{\frac{1}{4}C_0V_0^2} = \frac{1}{4}$

$E_1 : E_2 = 4 : 1$

246 **(d)**

As $\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3 \therefore R = n^{1/3}r$

New potential $V' = \frac{nq}{4\pi\varepsilon_0 r} = n^{2/3}V$

247 **(a)**

Electrical force is balanced by the weight of the mass

$mg = qE$, where E =electric field

Or $mg = q\frac{V}{d}$(where d= separation at the plates

$= q.\frac{V}{2}\left(\because \frac{\varepsilon_0 A}{d} = C\frac{1}{d} = \frac{C}{\varepsilon_0 A}\right)$

Or $V = \frac{2mg\varepsilon_0 A}{qC}$

$= \frac{10^{-6} \times 10 \times 2.2 \times 10^{-12} \times 10^{-2}}{10^{-5} \times 4 \times 10^{-8}}$

$= \frac{10^{-6} \times 9.8 \times 8.88 \times 10^{-12} \times 100 \times 10^{-4}}{10^{-8} \times 0.04 \times 10^{-6}}$

$= 43$ mV

248 **(c)**

Here $V = \frac{q}{4\pi\varepsilon_0 . r} - \frac{q}{4\pi\varepsilon_0(3r)} = \frac{1}{4\pi\varepsilon_0}.\frac{2q}{3r}$ and

$E = \frac{1}{4\pi\varepsilon_0}.\frac{q}{(3r)^2} = \frac{1}{4\pi\varepsilon_0}.\frac{q}{9r^2}$

On simplification, we get $\frac{E}{V} = \frac{1}{6r}$ *or* $E = \frac{V}{6r}$

249 **(c)**

Let Q and q be the charges on the spheres. The potential at the common centre will be

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{R}\right) + \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r}\right)$$

$$= \frac{1}{\varepsilon_0}\left[\frac{Q}{4\pi R^2} \times R + \frac{q}{4\pi r^2} \times r\right]$$

But

$$\frac{Q}{4\pi R^2} = \frac{q}{4\pi r^2} = \sigma$$

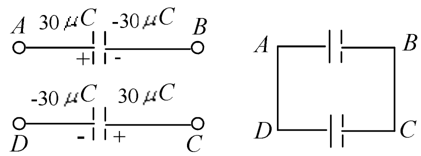
$$\therefore V = \frac{1}{\varepsilon_0}[\sigma R + \sigma r] = \frac{\sigma}{\varepsilon_0}(R + r)$$

250 **(a)**

The total charge on each plate will have to be same. They should also carry opposite charges

251 **(d)**

$V = \frac{Q_1 + Q_2}{C_1 + C_2} = 0$, where $Q_1 = 30$ μC, $Q_2 = -30$ μC



Final potential difference = zero

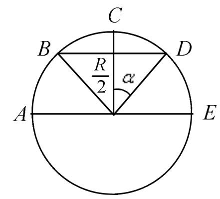
Finally energy = zero

Charge flow 30 μC from A to d

252 **(c)**

$\alpha = 60°$, solid angle subtended by BCD:

$\omega = 2\pi(1 - \cos\alpha) = \pi$



Solid angle subtended by $ABDE$ is

$\omega_{(ABDE)} - \omega_{(BCD)} = 2\pi - \pi = \pi$

Hence, flux through $ABDE$: $\phi = \frac{q}{\varepsilon_0}\frac{\pi}{4\pi} = \frac{q}{4\varepsilon_0}$

253 **(b)**

The potential at the surface of a hollow or conducting sphere is same as the potential at the centre of the sphere and any point inside the sphere

254 **(c)**

64 drops have formed a signal drop of radius R.

Volume of big drop = Volume of small' drops

$\therefore \frac{4}{3}\pi R^3 = 64 \times \frac{4}{3}\pi r^3$

$\Rightarrow \quad R = 4r$

So, the total current is

$Q_{\text{total}} = 64q$

As, $C' = \frac{Q}{V}$ and $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$; $C' = 4\pi\varepsilon_0 R$

$C' = (4\pi\varepsilon_0)4r$

$\Rightarrow \quad C' = 4C$

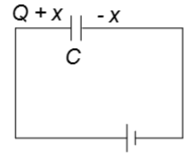
255 **(d)**

A conductor is an equipotential body. Potential on it or within it is the same everywhere

256 **(b)**

Electric field between the capacitor plates:

$E = \frac{Q + x}{2A\varepsilon_0} + \frac{x}{2A\varepsilon_0} = \frac{1}{2A\varepsilon_0}[Q + 2x]$



Potential difference $= Ed = \frac{d}{2A\varepsilon_0}[Q + 2x] = \varepsilon$

$\varepsilon = \frac{Q + 2x}{2C} - x = \frac{Q}{2} - C\varepsilon$

257 **(d)**
In a uniform electric field, field line should be straight but line of force cannot pass through the body of metal sphere and must end/start from the sphere normally. All these conditions are fulfilled only in plot (d).

258 **(b)**

Balancing torque about $-q$ is

$qE\ 2\ R\sin\theta = mg\sin\theta\ R \Rightarrow E = \frac{mg}{2q}$

259 **(b)**

$q_1 = CV_1 = 16 \times 5 = 80\mu\text{C}, q_f = CV_f = 16 \times 10 = 160\mu\text{C}$

Given $\frac{dq}{dt} = 40t \Rightarrow \int_{q_i}^{q_f} dq = \int_0^t 40t$

$\Rightarrow q_f - q_i = \frac{40t^2}{2}$

$\Rightarrow 160 - 80 = 20t^2 \Rightarrow T = 2\text{s}$

260 **(b)**
Knowledge based

261 **(d)**

$E_x = -\frac{dV}{dx} = -4x = -4 \times 2 = -8,$

$E_y = 0, E_z = 0$

Hence, $\vec{E} = -8\hat{\imath}\text{NC}^{-1}$

262 **(d)**
Option (a) is wrong, because force will be the same, but acceleration will be different because masses of electrons and protons are different
Option (b) is wrong, because at a point there can be only one potential
Option (c) is wrong, because charge always lies on the outer surface of a conductor
Option (d) is correct, because the whole conductor will be an equipotential body

263 **(a)**
Final charge on capacitor is

$$q = q_0 e^{-t/RC}$$

where q_0= charge on capacitor at $t = 0$,
RC=time constant of the circuit.

Putting $q_0 = CV_0$

$\therefore \quad q = CV_0^{-1/RC}$

Given, $C = 2\text{F}, V_0 = 5\text{ volt}, R = 6\ \Omega, t = 12\text{ s}$

Hence, $q = (2 \times 5)\, e^{-(12/6\times2)}$

$$= 10e^{-1} = \frac{10}{e}\text{C}$$

264 **(c)**
The potential due to charge q at a distance r is given by

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

Since, potential is a scalar quantity, it can be added to find the sum due to individual charges.

$\sum V = V_A + V_B + V_C$

$V_A = \frac{1}{4\pi\varepsilon_0}.\frac{2q}{x}$

$V_B = -\frac{1}{4\pi\varepsilon_0}.\frac{q}{x}$

$V_C = -\frac{1}{4\pi\varepsilon_0}.\frac{q}{x}$

$\therefore \quad V = \frac{1}{4\pi\varepsilon_0}\left(\frac{2q}{x} - \frac{q}{x} - \frac{q}{x}\right) = 0$

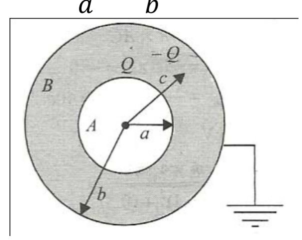
Electric field is a vector quantity, hence component along OD is taken

$$E = \frac{1}{4\pi\varepsilon_0}\left(\frac{2q}{x^2} + \frac{2q}{x^2}\cos\theta\right) \neq 0$$

265 **(b)**
Charge $+Q$ will flow into earth

$V_C = \frac{kQ}{r} - \frac{kQ}{b}$

$V_A = \frac{kQ}{a} - \frac{kQ}{b}$



Potential at B is zero

266 **(c)**
Apply conservation of mechanical energy between point a and b :

$(\text{K.E.} + \text{P.E.})_a = (\text{K.E.} + \text{P.E.})_a$

$\Rightarrow 0 + \frac{k(3 \times 10^{-9})q_0}{0.01} - \frac{k(3 \times 10^{-9})q_0}{0.02}$

$\Rightarrow \frac{1}{2}mv^2 + \frac{k(3 \times 10^{-9})q_0}{0.02} - \frac{k(3 \times 10^{-9})q_0}{0.01}$

Put the values and get: $v = 12\sqrt{15} = 46\text{ ms}^{-1}$

267 (c)

In equilibrium, $F = qE = (ne)\frac{v}{d} = mg$

$$n = \frac{mgd}{eV} = \frac{1.96 \times 10^{-15} \times 9.8 \times 0.02}{1.6 \times 10^{-19} \times 800} = 3$$

Therefore, $q = 3\,e$

269 **(d)**

The capacitance of parallel plate air capacitor

$C = \frac{\varepsilon_0 A}{d}$ ...(i)

where A is the area of each plate and d is the distance between the plates. In a medium of dielectric constant K and with given condition

$C' = \frac{K\varepsilon_0 A'}{d'}$

Given, $A' = A, d' = 2d, C' = 2C$

$\therefore\ 2C = \frac{K\varepsilon_0 A}{2d}$ ...(ii)

Equating Eqs. (i) and (ii), we get

$K = 4$

270 **(c)**

$$V = \frac{kQ}{r} \Longrightarrow u = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\frac{\varepsilon_0 k^2 Q^2}{r^4}$$

$V^4 \propto u$

271 **(a)**

Number of capacitors to be connected in series

$$V = \frac{\text{valtage rating required}}{\text{voltage rating of given capacitor}} = \frac{700}{200}$$

$$= 3.5 ie, 4$$

$$C_{\text{eq}} = \frac{10}{4} = 2.5\mu\text{F}$$

Number of rows required

$$= \frac{\text{capacitor required}}{\text{capacity of each row}} = \frac{10}{2.5} = 4$$

$\therefore$ total number of capacitors required

$= 4 \times 4 = 16$

272 **(b)**

Electric field due to one wire $= \frac{1}{4\pi\varepsilon_0}\frac{2\lambda_1}{R}$

Charge per unit length on other wire: $q_2 = \lambda_2 l$

$\Rightarrow \quad q_2 = \lambda_2 \times 1 = \lambda_2$

Force per metre length on other wire

$$F = q_2 E = \lambda_2 E = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda_1\lambda_2}{R} = K \times \frac{2\lambda_1\lambda_2}{R}$$

273 **(c)**

Using the formula for electric field produced by large

Sheet, $E = Q/2A\varepsilon_0$ and we get

$$E_A = \frac{4Q}{2A\varepsilon_0}(-\hat{\imath});\ E_B = \frac{2Q}{2A\varepsilon_0}(-\hat{\imath})$$

$$E_C = \frac{4Q}{2A\varepsilon_0}(+\hat{\imath})$$

274 **(a)**

Potential difference between two points in a electric fields is,

$$V_A - V_B = \frac{W}{q_0}$$

Where W is work done by moving charge q_0 from point A to B.

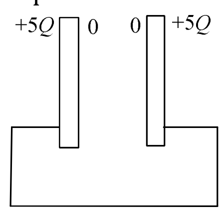
So,

$$V_A - V_B = \frac{2}{20}$$

(Here $W = 2, q_0 = 20C$)=0.1V

275 **(d)**

Final charges are as shown. Energy stored in the capacitor will be zero finally



Heat produced $= \Delta H \Rightarrow U_1 - U_f = \frac{1}{2}\frac{Q^2}{A/d} - 0$

276 **(b)**

$W_{\text{el}}. = q(V_i - V_f)$

$\Longrightarrow 6.4 \times 10^{-19} = -1.6 \times 10^{-19}(V_A - V_B)$

$\Longrightarrow V_A - V_B = -4\text{ V}$

$\Longrightarrow V_A - V_C = -4\text{ V}(\because V_B = V_C)$

$\Longrightarrow V_C - V_A = 4\text{ V}$

277 **(a)**

KE = PE of two protons

$$= \frac{e^2}{4\pi\varepsilon_0 r} = \frac{9 \times 10^9 \times (1.6 \times 10^{-19})^2}{10^{-10}}$$

$= 23 \times 10^{-19}$ J

$\therefore$ KE of each proton $= \frac{23}{2} \times 10^{-19}$ J

$= 11.5 \times 10^{-19}$ J

278 **(a)**

Given electric potential of spheres are same *ie*,

$$V_A = V_B$$

$$\frac{1}{4\pi\varepsilon_0}\frac{\theta_1}{a} = \frac{1}{4\pi\varepsilon_0}.\frac{\theta_2}{b}$$

$$\frac{\theta_1}{\theta^2} = \frac{a}{b} \quad \ldots\ldots\ldots.(i)$$

A surface charge density

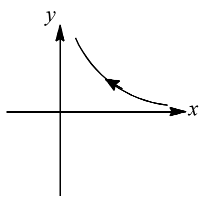
$$\sigma = \frac{a}{4\pi r^2}$$

$$\Rightarrow \frac{\sigma_1}{\sigma_2} = \frac{\theta_1}{\theta_2} \times \frac{b^2}{b^2}$$

$$= \frac{a}{b} \times \frac{b^2}{a^2} = \frac{b}{a}$$

279 **(a)**

$V = x^2 - y^2$



$$E_x = -\frac{dV}{dx} = -2x$$

$E_y = 2y$

280 **(a)**

This is the case of a balanced wheatstone bridge. The middle five capacitors will have no charge and will be useless

281 **(d)**

Net work done = final PE− initial PE

$= \frac{Qq}{4\pi\varepsilon_0 l} - \frac{Qq}{4\pi\varepsilon_0 l} =$ Zero.

282 **(b)**

Given:

$E = \frac{E_0}{l}\vec{i}, l = 2$ cm, $a = 1$ cm, $E_0 = 5 \times 10^3$N/c

We see that flux passes mainly through surface area $ABCD$ and $EFGH$. as the $AEFB$ and $CHGD$ are parallel to the flux again in $ABCD = 0$. Hence, the flux only passes through the surface area $EFGHE = 0$

Flux, $= E_0 \frac{a}{l} \times$ area $= 5 \times 10^3 \times \frac{a}{l} \times a^2$

$$= 5 \times 10^3 \times \frac{a^3}{l}$$

$$= 5 \times 10^3 \times \frac{(0.01)^3}{2 \times 10^{-2}} = 2.5 \times 10^{-1}$$

So, $q = \varepsilon_0$ flux

$= 8.85 \times 10^{-12} \times 2.5 \times 10^{-1}$

$= 22.125 \times 10^{-13} = 2.2125 \times 10^{-12}$C

283 **(c)**

Original capacity, with air

$$C = \frac{\varepsilon_0 A}{d}$$

When dielectric plate (medium) of thickness $t$is introduced between the plates, then capacity becomes

$$C' = \frac{\varepsilon_0 A}{d' - t\left(1 - \frac{1}{K}\right)}$$

but as given, $C' = C$

$$\therefore \quad \frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 A}{d' - t\left(1 - \frac{1}{K}\right)}$$

or $\quad d = d' - t + \frac{t}{K}$

or $\quad 8 = d' - 4 + \frac{4}{2}$

or $\quad 8 = d' - 2$

or $\quad d' = 10$ mm

284 **(c)**

$$U = 2kq^2\left[-\frac{1}{a} + \frac{1}{2a} - \frac{1}{3a} + \frac{1}{4a} + \cdots\right]$$

$$= -\frac{2q^2}{4\pi\varepsilon_0 a}\left[1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \cdots\right] = -\frac{2q^2 \log_e 2}{4\pi\varepsilon_0 a}$$

285 **(c)**

Combined capacity of 1 μF and 5μF = 1 + 5=6 μF

Now, 4μF and 6μF are in series.

$$\therefore \frac{1}{C_s} = \frac{1}{4} + \frac{1}{6} + \frac{3+2}{12} = \frac{5}{12}$$

$$C_s = \frac{12}{5}\,\mu\text{F}$$

Charge in the arm containing 4μF capacitor is

$q = C_s \times V = \frac{12}{5} \times 10 = 24\ \mu$C

286 **(a)**

We know that any extra charge resides on the outer surface. Finally, both will be at the same potential. It is because both are connected

287 **(b)**

For a charged sphere or shell of charge potential

$$V_S = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r}.$$

Hence, charge on both the spheres will be equal.

288 **(a)**

When charge $q_3$is at C, then its potential energy is

$$U_C = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_3}{0.4} + \frac{q_2 q_3}{0.5}\right)$$

Where charge $q_3$is at D, then

$$U_D = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_3}{0.4} + \frac{q_2 q_3}{0.1}\right)$$

Hence, change in potential energy

$$\Delta U = U_D - U_C$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_2 q_3}{0.1} - \frac{q_2 q_3}{0.5}\right)$$

but $\quad \Delta U = \frac{q_3}{4\pi\varepsilon_0}k$

$\therefore \frac{q_3}{4\pi\varepsilon_0}k = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_2q_3}{0.1} - \frac{q_2q_3}{0.5}\right)$

$\Rightarrow k = q_2(10-2) = 8q_2$

289 **(c)**

After combining, the volume remains same $i.e.$,

Volume of bigger drop= N $\times$ volume of smaller drop

Or

$\frac{4}{3}\pi R^3 = N \times \frac{4}{3}\pi r^3$

Or

$N = \left(\frac{R}{r}\right)^3$ ……………(i)

As charge is conserved, hence

$Q = Nq$ ………………. (ii)

Capacity of bigger drop $=4\pi\varepsilon_0 R$

Capacity of smaller drop$=4\pi\varepsilon_0 r$

From Eq. (ii), we have

$(4\pi\varepsilon_0 R)V_{big} = N(4\pi\varepsilon_0 r)V_{small}$

or $(4\pi\varepsilon_0 R) \times 40 = N(4\pi\varepsilon_0 r) \times 10$

or $4R = Nr$

or $\frac{R}{r} = \frac{N}{4}$ …………. (iii)

From Eqs. (i) and (iii), we have

$N = \left(\frac{N}{4}\right)^3$

or

$N = \frac{N^3}{64}$

or

$N^2 = 64$

OR N=8

290 **(c)**

Electrical potential energy of system

$U = -2\left[\frac{kq^2}{\sqrt{2}a}\right] = \frac{-\sqrt{2}kq^2}{a}$(four pairs will cancel each other)

If a decreases, U also decreases and if U decreases, the agent will do negative work

291 **(b)**

Potential at the centre of hollow metallic sphere

$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$

292 **(a)**

$E = -\frac{dV}{dr} = -\frac{d}{dx}(4x^2) = -8x$

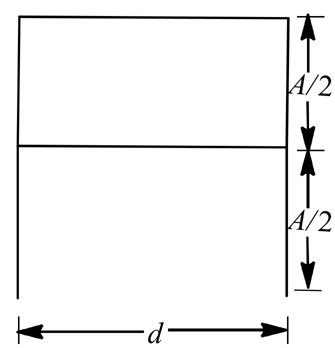
$= -8\,(1) = -8\text{ V m}^{-1}$

Negative sign indicates $\vec{E}$ is along negative direction of X-axis.

293 **(c)**

The dielectric is introduced such that, half of its area is occupied by

It.



In the given case the two capacitors are in parallel.

$\therefore \quad C' = C_1 + C_2$

$C_1 = \frac{A\varepsilon_0}{2d}$

And $\quad C_2 = \frac{KA\varepsilon_0}{2d}$

Thus, $\quad C' = \frac{A\varepsilon_0}{2d} + \frac{KA\varepsilon_0}{2d}$

$C' = \frac{C}{2}(1+K)$

294 **(a)**

If the plates of a parallel plate capacitor are not equal in area, then quantity of charge on the plates will be same but nature of charge will differ.

295 **(b)**

The electric field between the plates is

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

or $\quad V = Ed$ or $V \propto d$

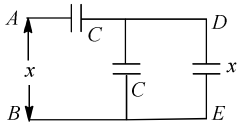
Hence, if the plates are pulled apart the potential difference increases.

296 **(a)**

In parallel, potential is same on each capacitor

297 **(b)**

Let capacitance between A and B be x. If we remove the first two capacitors, then capacitance across D and E will also be x. So the circuit can be redrawn as follows



$x = \frac{C(C+x)}{C+(C+x)}$, Solve to get $x = \frac{\sqrt{5}-1}{2}C$

299 **(a)**

$C_1 = C, V_1 = V_0, C_2 = KC, V_2 = 0$ and $V_{\text{common}} = V$

We know that $V_{\text{common}} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

$$V = \frac{CV_0 + KC \times O}{C + KC}$$

$$K = \frac{V_0}{V} - 1$$

300 **(b)**

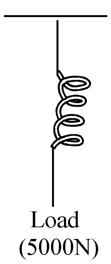
$$V_x - V_\infty = -\int_\infty^x E_x dx \Rightarrow V_x - 0 = -\int_\infty^x \frac{A}{x^3} dx$$

$$\Rightarrow V_x = \frac{A}{2x^2}$$

301 **(b)**

When a force of F Newton is applied the potential energy is given by

$$U = \frac{1}{2}Fx$$



Energy stored by capacitor is $\frac{1}{2}CV^2$

$\therefore$ Ratio is $\frac{\frac{1}{2}Fx}{\frac{1}{2}CV^2} = \frac{5000 \times 0.2}{10 \times 10^{-6} \times (10^4)^2} = 1$

302 **(b)**

The whole amount of energy stored in capacitor will convert into heat

Heat $= \frac{1}{2}CV^2 = \frac{1}{2} \times 2 \times 10^{-6} \times (100)^2 = 0.01$ J

303 **(c)**

$$V_A - \frac{q}{C_1} - E - \frac{q}{C_2} = V_B \Rightarrow V_A - V_B - E$$

$$= \left(\frac{1}{C_1} + \frac{1}{C_2}\right)$$

$$\Rightarrow q = -\frac{40}{3} \mu\text{C}$$

304 **(d)**

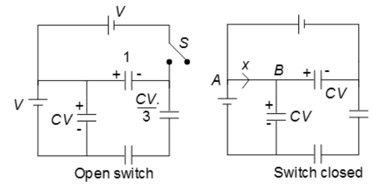
C_3, C_5 and C_6 are in parallel and C_4 is in series with it. Then C_2 is in parallel and C_1 is in series

305 **(a)**

$V = ER$; If R is doubled, V also gets doubled

306 **(d)**

Charge flown from A to B:

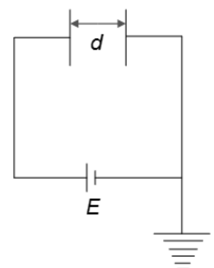


$x =$ change in charge on capacitor '1'

$$= CV - \frac{CV}{3} = \frac{2CV}{3}$$

307 **(b)**

The circuit can be redrawn as shown in Figure.



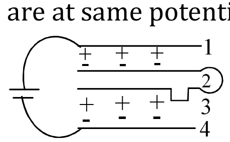
Charge on capacitor is

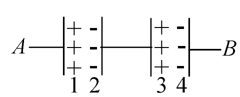
$$Q = CE = \frac{\varepsilon_0 AE}{d}$$

Option (a), (c) and (d) are incorrect

308 **(b)**

Plates can be rearranged as shown in Figure Plates 1 and 2 and plates 3 and 4 from two capacitors which are in series between A and B. Plates 2 and 3 do not form any capacitor as they are at same potential





So, $C_{eq} = \frac{C_1C_2}{C_1+C_2} = \frac{\left(\frac{\varepsilon_0 A}{d}\right) \times \left(\frac{\varepsilon_0 A}{3d}\right)}{\frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{3d}}$

$$= \frac{\varepsilon_0 A}{4d}$$

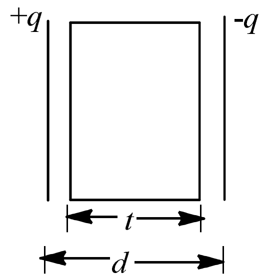
309 **(b)**

Electrical pressure (force/area)

$$\Rightarrow p = \frac{1}{2}\varepsilon_0 E^2 \text{ and } E = \frac{V}{r} \therefore p = \frac{1}{2}\varepsilon_0 \frac{V^2}{r^2}$$

310 **(b)**

The capacitance C of a capacitor of area A and distance between plates is d, then



$C = \frac{\varepsilon_0 A}{d}$

When a dielectric slab of thickness t is placed between the plates, we have

$$C' = \frac{\varepsilon_0 A}{d - t + \frac{t}{K}}$$

Given, $C = 20\mu F = 20 \times 10^{-6} F$,

$d = 2 \text{ mm} = 2 \times 10^{-3} m, t = 1 mm$

$= 1 \times 10^{-3} m, K = 2$

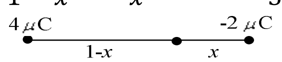
$\therefore \quad \frac{C'}{C} = \frac{d}{d - t\left(1 - \frac{1}{K}\right)}$

$= \frac{2 \times 10^{-3}}{2 \times 10^{-3} - 1 \times 10^{-3}\left(1 - \frac{1}{2}\right)} = 1.33$

$\Rightarrow \quad C' = 1.33 \times 20 \times 10^{-6} = 26.6 \ \mu F$

311 **(c)**

$\frac{k \times 4}{1 - x} = \frac{k \times 2}{x} \Rightarrow x = \frac{1}{3} m$



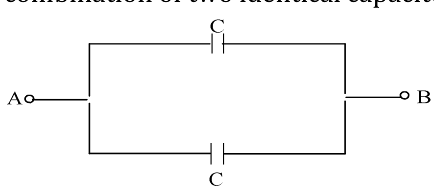
312 **(a)**

$\int \vec{E} . \overrightarrow{ds} = NC^{-1}(M^2)$

$= (Nm)C^{-1}(m) = JC^{-1}m = V - m$

313 **(a)**

The given circuit is equivalent to a parallel combination of two identical capacitors.

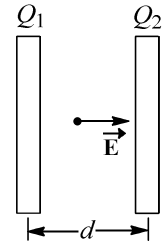


Hence, equivalent capacitance between points A and B is

$$C = \frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d} = \frac{2\varepsilon_0 A}{d}$$

314 **(d)**

On bringing the changed metal plates closer, electric field $\vec{E}$ in the intervening space is



$E = \frac{\sigma_1}{2\varepsilon_0} - \frac{\sigma_2}{2\varepsilon_0} = \frac{\sigma_1}{2A\varepsilon_0} - \frac{\sigma_2}{2A\varepsilon_0}$

Or $\quad E = \frac{Q_1 - Q_2}{2A\varepsilon_0} = \frac{V}{d} \text{ or } V = \frac{(Q_1 - Q_2)d}{2A\varepsilon_0}$

$\Rightarrow \quad V = \frac{Q_1 - Q_2}{2C} \qquad \left(\because C = \frac{\varepsilon_0 A}{d}\right)$

315 **(a)**

The capacitor with air as the dielectric has capacitance

$$C_1 = \frac{\varepsilon_0}{d}\left(\frac{3A}{4}\right) = \frac{3\varepsilon_0 A}{4d}$$

Similarly, the capacitor with K as the dielectric constant has capacitance $C_2 = \frac{\varepsilon_0 K}{d}\left(\frac{A}{4}\right) = \frac{\varepsilon_0 AK}{4d}$

Since, C_1 and C_2 are in parallel

$C_{\text{net}} = C_1 + C_2$

$= \frac{3\varepsilon_0 A}{4d} + \frac{\varepsilon_0 AK}{4d}$

$= \frac{\varepsilon_0 A}{d}\left[\frac{3}{4} + \frac{K}{4}\right]$

$= \frac{C}{4}(K + 3)$

316 **(d)**

The three capacitors are in parallel hence, their equivalent capacitance $= 3C$

317 **(b)**

Electric intensity inside is zero, whereas outside it is not zero

319 **(d)**

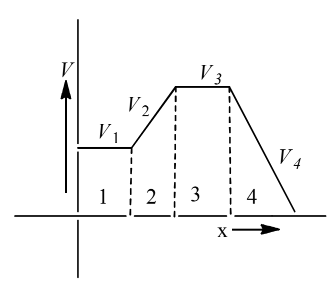
Equipotential surfaces are perpendicular to the electric lines of forces

320 **(b)**

Electric field

$$E = -\frac{dV}{dx}$$

For I region, $\quad V_1$=constant



$\therefore \dfrac{dV_1}{dx} = 0$

$\therefore \quad E_1 = 0$

For II region,

$V_2 = +\text{ve} = +f(x)$

$\therefore E_2 = -\dfrac{dV_2}{dx} = -\text{ve}$

For III region.

V_3=constant

$\therefore \dfrac{dV_3}{dx} = 0$

$\therefore \quad E_3 = 0$

For IV region, $V_1 = -f(x)$

$\therefore \quad E_4 = -\dfrac{dV_4}{dx} = +\text{ve}$

From these values, we have

$E_2 > E_4 > E_1 = E_3$

321 **(a)**

The 10μF and 6μF capacitors are connected in parallel, hence resultant capacitance is

$C' = 10\ \mu\text{F} + 6\ \mu\text{F} = 16\ \mu\text{F}$

This is connected in series with 4 μF capacitor, hence effective capacitance is

$$\frac{1}{C''} = \frac{1}{16} + \frac{1}{4} = \frac{20}{16 \times 4}$$

$$\Rightarrow C'' = \frac{64}{20} = 3.20\mu\text{F}$$

322 **(d)**

The capacitance of a parallel plate capacitor with dielectric (oil) between its plates is

$C = \frac{K\varepsilon_0 A}{d}$ ...(i)

where symbols have their usual meanings. when dielectric (oil) is removed, so capacitance

$C = \frac{\varepsilon_0 A}{d}$ ...(ii)

Comparing Eqs. (i) and (ii), we get

$C = KC_0$

$\Rightarrow C_0 = \frac{C}{K} = \frac{C}{2}$ $(\because K = 2)$

323 **(d)**

Start with C_3 and C_4 in parallel, then C_2 in series, then C_5 in parallel, then C_1 in series and finally C_6 in parallel

324 **(d)**

Variation of different variables (Q , C, V, E and U) of parallel plate capacitor when dielectric (K) is introduced when battery is removed is

$C' = KC\ E' = E/K$

$Q' = QU' \quad = U/K$

$V' = V/K$

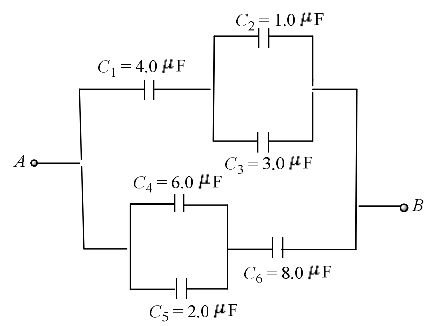
325 **(d)**

$$C = \frac{\varepsilon_0 A}{\frac{d_1}{K_1} + \frac{d_2}{K_2}}$$

$$= \frac{\varepsilon_0 A}{\frac{d}{2}\left(\frac{1}{1} + \frac{1}{2}\right)} = \frac{4\varepsilon_0 A}{3d}$$

326 **(a)**

In given figure C_2 and C_3 are in parallel,



$\therefore \quad C' = C_2 + C_3 = 4\mu\text{F}$

As C' and C_1 are in series,

$$\frac{1}{C''} = \frac{1}{C'} + \frac{1}{C_1} = \frac{1}{4} + \frac{1}{4}$$

$\Rightarrow \quad C'' = 2\ \mu\text{F}$

Similarly, C_4 and C_5 are in parallel

$C''' = 6 + 2 = 8\ \mu\text{F}$

C''' and C_6 are in series

$$\frac{1}{C'''} = \frac{1}{C'''} + \frac{1}{C_6} = \frac{1}{8} + \frac{1}{8}$$

$\Rightarrow \quad C''' = = 4\ \mu\text{F}$

Now, C''' and C'' are in parallel.

$\therefore \quad C = 4\mu\text{F} + 2\mu\text{F} = 6\mu\text{F}$

327 **(c)**

$P = 2 \times 10^{-8} \times 2 \times 10^{-3} = 4 \times 10^{-11}$ Cm

$$E = \frac{\lambda}{2\pi\varepsilon_0 x}, F = p\cos\theta \frac{dE}{dx}$$

$$F = -\frac{p\cos\theta\lambda}{2\pi\varepsilon_0 x^2} = \frac{-4 \times 10^{-11} \times \cos 60° \times 4 \times 10^{-4}}{\frac{1}{2\times 9 \times 10^9} \times \left(\frac{6}{100}\right)^2}$$

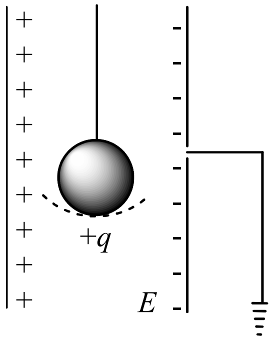
$= 0.04$ N

328 **(d)**

All the charges are placed in the x-y plane such that they form a square with origin as its centre. So, electric field at the origin will be zero but at other points on z-axis, field will be along z-axis

329 **(d)**

Time period of simple pendulum in air



when it is suspended between vertical plates of a charged parallel plate capacitor, then acceleration due to electric field,

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

This acceleration is acting horizontally and acceleration due to gravity is acting vertically.
So, effective acceleration

$$g' = \sqrt{g^2 + a^2} = \sqrt{g^2 + \left(\frac{qE}{m}\right)^2}$$

Hence, $T' = 2\pi \frac{\sqrt{l}}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}$

330 **(a)**

$$C_s = \frac{10 \times 20}{10 + 20} = \frac{200}{30} = \frac{20}{3}\ \mu\text{F}$$

$$Q = C_s V$$

$$Q = \frac{20}{3}\mu\text{F} \times 200\text{V}$$

$$Q = \frac{4000}{3}\mu\text{C}$$

Now, $V = \frac{4000\ \mu\text{C}}{3\times 30\ \mu\text{F}} = \frac{4000}{90}\text{V} = \frac{400}{9}\ \text{V}$

331 **(b)**

Common potential $= \frac{C_1V_0 + C_2 \times 0}{C_1 + C_2} = \frac{C_2V_0}{C_1+C_2}$

$$U_{\text{before}} = \frac{1}{2}C_1V_0^2$$

$$U_{\text{after}} = \frac{1}{2}C_1\left[\frac{C_1V_0}{C_1+C_2}\right]^2 + \frac{1}{2}C_2\left[\frac{C_1V_0}{C_1+C_2}\right]^2$$

$$= \frac{1}{2}\left[\frac{C_1V_0}{C_1+C_2}\right]^2 (C_1 + C_2)$$

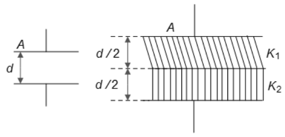
$\Rightarrow$ $\frac{U_{\text{before}}}{U_{\text{after}}} = \frac{C_1 + C_2}{C_1}$

Here, $C_1 = C_2 = C$

$\therefore$ $\frac{U_{\text{before}}}{U_{\text{after}}} = \frac{2C}{C}$

$\Rightarrow$ $U_{\text{after}} = \frac{U}{2}$

332 **(a)**



$$C_0 = \frac{\varepsilon_0 A}{d}$$

$$C_1 = \frac{k_1\varepsilon_0 A}{d/2} \quad \Rightarrow \quad C_2 = \frac{k_2\varepsilon_0 A}{d/2}$$

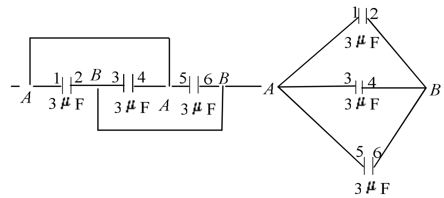
C_1 and C_2 are in series

Equivalent dielectric constant $K = \frac{2k_1k_2}{k_1+k_2}$ which is the ratio of capacitor

333 **(d)**

Check each option separately

334 **(a)**



Here, all the three capacitors are connected in parallel. Therefore, equivalent capacitance between points A and B is

$$C_{\text{eq}} = 3 + 3 + 3 = 9\mu\text{F}.$$

335 **(d)**

$E_1 = \frac{1}{2}C_1V^2$

$= \frac{1}{2} \times 2 \times 10^{-6} \times 100^2 = 0.01\text{J}$

$E_1 = \frac{1}{2}C_2V^2$

$\frac{1}{2} \times 10 \times 10^{-6} \times (100)^2 = 0.05\ \text{J}$

Energy change $= E_2 - E_2$

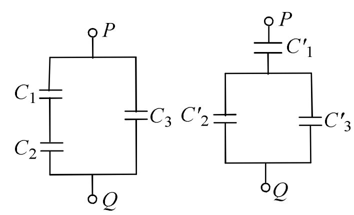
$= 0.05 - 0.01 = 0.04\text{J} = 4 \times 10^{-2}\text{J}$

336 **(a)**

We can make equivalent circuit of given system in two ways as in Fig (a) and (b). But (b) is wrong and (a) is correct

Hence $C_1 = \frac{\varepsilon_0 A/2}{t/2} = \frac{\varepsilon_0 A}{t}$

$C_2 = \frac{K\varepsilon_0 A/2}{t/2} = \frac{K\varepsilon_0 A}{t}$ and $C_3 = \frac{\varepsilon_0 A/2}{t} = \frac{\varepsilon_0 A}{2t}$,



(a) (Right) (b) (Wrong)

Now, $C_{\text{eq}} = \frac{C_1C_2}{C_1+C_2} + C_3$

$= \frac{\varepsilon_0 A}{t}\left[\frac{3K+1}{2(K+1)}\right]$

337 **(c)**

$\vec{\tau} = \vec{p} \times \vec{E}$

$\tau_{max} = pE$

$50 \times 10^{-28} = p40 \Rightarrow p = 1.25 \times 10^{-28}$ column

338 **(a)**

$C_1 = 40\ \mu\text{F}, C_2 = K \times 40 = 3 \times 40 = 120\ \mu\text{F}$

$$C_{\text{eq}} = \frac{C_1 C_2}{C_1 + C_2} = \frac{40 \times 120}{40 + 120} = 30\ \mu\text{F}$$

339 **(d)**

Potential decreases in the direction of electric field. So it depends whether the lines of forces are from A to B or from B to A

340 **(d)**

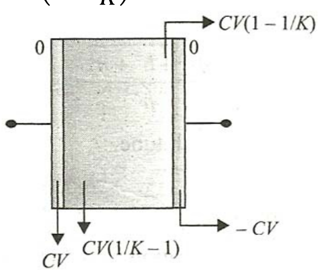
The capacity of an isolated spherical conductor of radius R is $4\pi\varepsilon_0 R$

$\therefore \qquad C \propto R$

341 **(b)**

Due to polarization, charge on dielectric slab would be

$$CV\left(1 - \frac{1}{K}\right)$$



So, charge on 1=0

Charge on 2= $CV - CV\left(1 - \frac{1}{K}\right) = \frac{CV}{K}$

Charge on 3 = $CV\left(1 - \frac{1}{K}\right) - CV = -\frac{CV}{K}$

Charge on 3 = 0

342 **(d)**

$$V = \frac{Q_1}{C_1} = \frac{Q_2}{C_2}$$

$Q_1 + Q_2 = Q$

Where $C_1 = \varepsilon_0 A/a$ and $C_2 = \varepsilon_0 A/b$

Solve to find $\quad Q_2 = \frac{Qa}{a+b}$

343 **(d)**

$F = qE, W = qE \times 2\cos 60°$

$$\Rightarrow 4 = 0.2\,E \times 2 \times \frac{1}{2} \Rightarrow E = 20\ \text{NC}^{-1}$$

344 **(d)**

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$V' = \frac{1}{4\pi\varepsilon_0}\frac{q'}{r'} = \frac{1}{4\pi\varepsilon_0}\frac{nq}{n^{\frac{1}{3}}r}$$

$(\because q' = nq, r' = n^{\frac{1}{3}}r)$

Or $V' = n^{2/3}V$

345 **(a)**

$$C = \frac{\varepsilon_0 A}{d} = 0.5$$

New capacitance

$$C' = \frac{\varepsilon_0 A}{\frac{d/2}{2} + \frac{d/2}{3}} = \frac{\varepsilon_0 A}{d}\left[\frac{1}{\frac{1}{4} + \frac{1}{6}}\right]$$

$= C \times 2.4 = 1.2\ \ \mu\text{F}$

346 **(d)**

The capacitors 2 μF and 2 μF of arm ACD are in series. So, their equivalent capacitance is 1 μF which is in parallel with capacitor of 1 μF of arm AD.

So, equivalent capacitance now is 2 μF.

This capacitance is now in series with 2 μF capacitance of arm BD which equivalents to 1 μF is in parallel with 1 μF capacitance of arm AB.

So, final effective capacitance=2 μF.

347 **(d)**

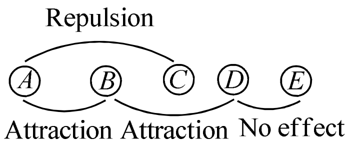
On introduction and removal and again on introduction, the capacity and potential remain same. So, net work done by the system in this process

$$W = U_f - U_i$$

$$= \frac{1}{2}CV^2 - \frac{1}{2}CV^2 = 0$$

348 **(d)**

Ball D has no effect on$E$, it means both D and E should be neutral



A Repels C, so both should have similar type of charge. Negatively charged rod attracts A, so A should have positive charge. So C should also have positive charge.

A attracts B, so B is either negatively charged or has no charge. But B attracts D which is uncharged, so B should have negative charge

349 **(b)**

$\frac{1}{2}CV^2 =$ mass× specific heat× change in temperature

$$V^2 = \frac{2 \times m \times s \times T}{C}; V = \sqrt{\frac{2msT}{C}}$$

350 **(b)**

Capacitors B and C are in parallel, then A is in series

$$C_{\text{eq}} = \frac{2 \times (3+4)}{2+(3+4)} = \frac{14}{9}\,\mu\text{F}$$

$$Q = C_{eq}V = \frac{14}{9}(7-6) = \frac{14}{9}\,\mu\text{C}$$

Q will be divided between B and C. So charge on B is

$$q = \frac{3 \times (14/9)}{3+4} = \frac{2}{3}\,\mu\text{C}$$

351 **(b)**

Potential on bubble,

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$\therefore \frac{V_1}{V_2} = \frac{r_2}{r_1}$$

$$\Rightarrow \frac{16}{V_2} = \frac{2}{1} \Rightarrow V_2 = 8\,V$$

352 **(a)**

$$V_C = \frac{C_1V_1}{C_1+C_2} = 100\text{ V}$$

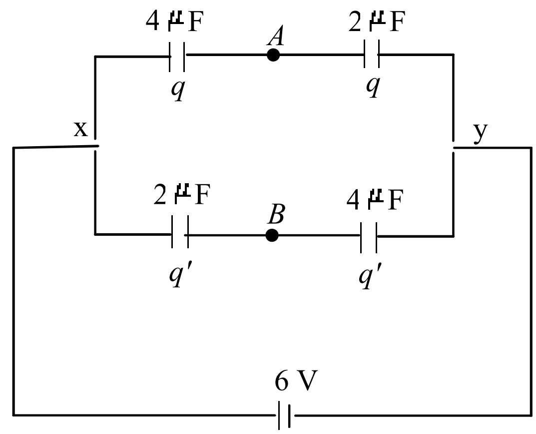
Energy lost $= U_i - U_f$

$$= \frac{1}{2}C_1V_1^2 - \frac{1}{2}(C_1+C_2)V_c^2$$

$= 6 \times 10^{-6}$ J

353 **(a)**

Consider the charge distribution as shown. Considering the branch on upper side, we have



$$\frac{q}{V_x - V_A} = 4 \times 10^{-6}$$

$$\frac{q}{V_A - V_y} = 2 \times 10^{-6}$$

Here, $V_x = 6$ volt, $V_y = 0$

$\therefore \quad \frac{q}{6-V_A} = 4 \times 10^{-6}$

...(i)

$\frac{q}{V_A - 0} = 2 \times 10^{-6}$

...(ii)

From Eqs. (i) and (ii), we get

$\frac{V_A}{6-V_A} = 2$

$\therefore \quad V_A = 4$volt

Similarly for the lower side branch

$\frac{q'}{6-V_B} = 2 \times 10^{-6}$

...(iii)

$\frac{q'}{V_B - 0} = 4 \times 10^{-6}$

...(iv)

From Eqs. (iii) and (iv)

$\frac{V_B}{6-V_B} = \frac{1}{2}$

$\therefore \; V_B = 2$ volt

$\therefore V_A - V_B = 4 - 2 = 2$ volt

354 **(d)**

Potential of big drop $V = n^{2/3}V'$

V'= potential of small drop

n=no. of drops=125

V=2.5

$\therefore \quad 2.5 = (125)^{2/3}\,V'$

2.5=25V'

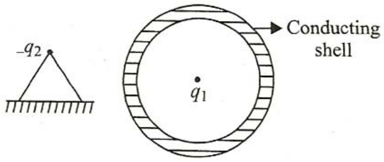
V'=0.1 volt

355 **(c)**

Trajectory will be tangent to the electric field

356 **(c)**

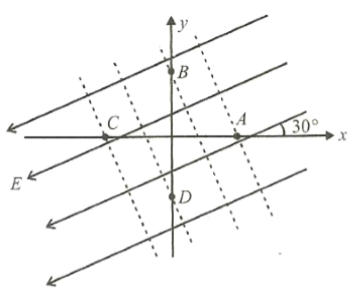
Net force on q_1 is zero, while that on the conducting sphere is towards the left due to attraction of $-q_2$ (figure)



357 **(a)**
Net flux leaving the surface
$\phi = 4 \times 10^5 - 5 \times 10^5 = -10^5$ MKS units
$\therefore$ charges must be negative
$q = \phi\varepsilon_0 = -10^5 \times 8.86 \times 10^{-12}$
$= -8.86 \times 10^{-7}$ C

358 **(b)**
Power $= \frac{\text{Energy}}{\text{Time}} = \frac{(12)CV^2}{\text{Time}}$
$= \dfrac{40 \times 10^{-6} \times (3000)^2}{2 \times 2 \times 10^{-3}} = \dfrac{40 \times 10^{-6} \times 9 \times 10^6}{4 \times 10^{-3}}$
$= 9 \times 10 = 90$ kW

359 **(b)**
Four lines perpendicular to lines of electric field and passing through A, B, C and D are drawn. These are equipotential lines. As potential decreases in the direction of electric field, $VA > VB > VD > VC$



360 **(c)**
Since magnitude of forces is proportional to m as $f = mv2/r, m_1 : m_2 : m_3 = 1 : \sqrt{3} : 2$

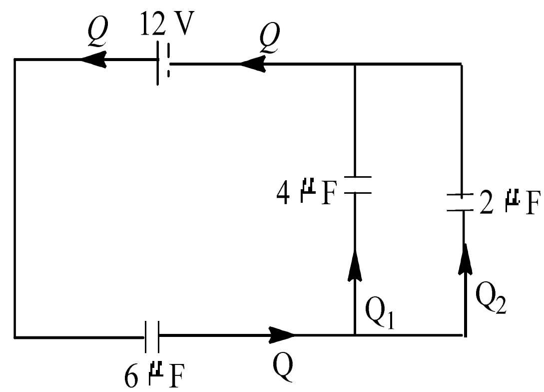
361 **(a)**
If a dielectric slab is inserted between the plates of a charged capacitor, the intensity of electric field potential difference of capacitor and the energy stored all reduce to $\frac{1}{K}$ times and capacity of the capacitor increases K times. But the charge on the capacitor remains unchanged.
Here, K is the dielectric constant of dielectric.

362 **(c)**
$E = -\dfrac{dV}{dr} = -\dfrac{(1-3)}{0.3 - 0.1}\text{Vm}^{-1} = 10 \text{ V m}^{-1}$

363 **(c)**
As battery is disconnected, total charge Q is shared equally by two capacitors. energy of each capacitor
$= \dfrac{(Q/2)^2}{2C} = \dfrac{1}{4}\dfrac{Q^2}{2C} = \dfrac{1}{4}U$

364 **(b)**
Charge on B will remain the same as it is not touched with any other body. Charge induced on A will decrease the potential of B (figure)

365 **(c)**



As the capacitors 4 µF and 2 µF are connected in parallel and are in series with 6 µF capacitor, their equivalent capacitance is
$\frac{(2+4)\times 6}{2+4+6} = 3$ µF
Charge in the circuit

$Q = 3\ \mu\text{F} \times 12\text{V} = 36\mu\text{C}$

Since, the capacitors 4µF and 2µF are connected in parallel, therefore potential difference across them is same.
$\Rightarrow \quad \frac{Q_1}{Q_2} = \frac{C_1}{C_2} = \frac{4}{2}$ or $Q_1 = 2Q_2$
Also $Q = Q_1 + Q_2$
$\therefore \quad 36\mu\text{C} = 2Q_2 + Q_2$ or $Q_2 = \frac{36\mu\text{C}}{3} = 12\mu\text{C}$

$Q_1 = Q - Q_2 = 36\mu\text{C} - 12\mu\text{C}$
$= 24\ \mu\text{C} = 24 \times 10^{-6}\text{C}$

366 **(d)**
(i) $Q/2, Q/2, 0$
(ii) $Q/2, Q/4, Q/4$

(iii) $3Q/8, Q/4, 3Q/8$
(iv) $5Q/16, 5Q/16, 3Q/8$
(v) $5Q/16, 11Q/32, 11Q/32$

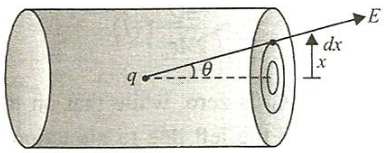
367 **(c)**

$\phi = \phi_{ps_1} + \phi_{cs} + \phi_{ps_2}$

$= 2\phi_{ps} + \phi_{cs} \quad [\because \phi_{ps_1} = \phi_{ps_2}]$

$\phi_{cs} = \phi - 2\phi_{ps} = \dfrac{q}{\varepsilon_0} - 2\phi_{ps}$

To find ϕ_{ps}, use integration technique.



$\vec{E} = \dfrac{q}{4\pi\varepsilon_0} \times \dfrac{1}{(x^2 + l^2/4)}$

$d\phi_{ps} = \vec{E} \cdot \vec{ds} = E \times 2\pi x dx \times cos\theta$

$= \dfrac{q}{2\varepsilon_0} \times \dfrac{xdx}{(x^2 + l^2/4)} \times \dfrac{l2}{\sqrt{x^2 + l^2/4}}$

$= \dfrac{ql}{4\varepsilon_0} \times \dfrac{xdx}{(x^2 + l^2/4)^{3/2}}$

$\phi_{ps} = \dfrac{ql}{4\varepsilon_0} \displaystyle\int_0^R \dfrac{xdx}{(x^2 + l^2/4)^{3/2}}$

$= \dfrac{q}{2\varepsilon_0} - \dfrac{ql}{4\varepsilon_0\sqrt{R^2 + l^2/4}}$

368 **(d)**

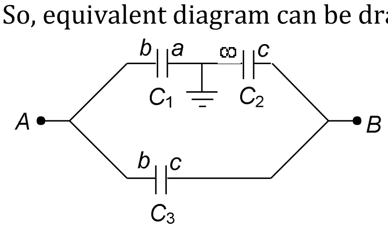
$V = K\left[\dfrac{q}{x_0} - \dfrac{q}{2x_0} + \dfrac{q}{3x_0} - \dfrac{q}{4x_0} + \cdots\right]$

$= \left(\dfrac{q}{x_0}\right) K \left[1 - \dfrac{1}{2} + \dfrac{1}{3} - \dfrac{1}{4} + \cdots\right]$

$= \dfrac{1}{4\pi \in_0} \dfrac{q}{x_0} \log 2$

369 **(c)**

The innermost conductor is at zero potential (the same potential as we assumed for infinity)
The conductors with radius a and b make one capacitor, between b and c; other conductor and c make a capacitor with its other plate at infinity.
So, equivalent diagram can be drawn as



Here, $C_1 = \frac{4\pi\varepsilon_0 ab}{b-a}$

$C_2 = 4\pi\varepsilon_0 c$

$C_3 = \dfrac{4\pi\varepsilon_0 bc}{c - b}$

$\therefore \; C_{eq} = C_3 + \dfrac{C_1 C_2}{C_1 + C_2}$

$= 4\pi\varepsilon_0 \left[\dfrac{bc}{c - b} + \dfrac{abc}{ab + c(b - a)}\right]$

370 **(a)**

The electric field strength in a parallel-plate capacitor with applied voltage of V and separation d is given by $E = V/d$

371 **(c)**

Electric potential inside the hollow conducting sphere is constant and equal to potential at the surface of the sphere $= \frac{Q}{4\pi\varepsilon_0 R}$.

372 **(c)**

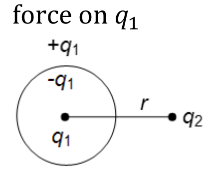
A positive charge, which is free to move, will always move from higher to lower potential

373 **(a)**

Bob will experience an additional force $F = q\,E$ in vertically upward direction and hence effective acceleration due to gravity is reduced from g to $(g - a) = \left(g - \frac{qE}{m}\right)$.
Consequently, time period of oscillation will become $T = 2\pi\sqrt{\frac{l}{(g-a)}}$ *ie*, time period will increase.

374 **(b)**

The charge on outer surface of shell will supply a force on q_1



$F = \dfrac{kq_1q_2}{r^2}$

375 **(c)**

Initial charge on C_1: $Q_1 = C_1 V = 110\ \mu C$
Let x charge flow through wires $\frac{Q_1 - x}{C_1} = \frac{x}{C_{eq}}$
Where $C_{eq} = \frac{C_2 \times C_3}{C_2 + C_3}$. Solve to get $x = 60\ \mu C$

376 **(d)**

If length of the foil is them

$C = \dfrac{K\varepsilon_0(l \times b)}{d}$

$\Rightarrow 2 \times 10^{-6} = \frac{2.5 \times 8.85 \times 10^{-12}(l \times 400 \times 10^{-3})}{0.15 \times 10^{-3}}$

$\Rightarrow \quad l = 33.9$ m.

377 **(d)**

$E = \dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{\frac{4}{3}\pi r^3 \rho}{r^2}\right) = \dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{4}{3}\pi r\,\rho\right)$ or $E \propto r$

378 **(c)**

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

$$\therefore U = \frac{9\times10^9\times(1.6\times10^{-19})(-1.6\times10^{-19})}{10^{-10}}$$

$$= -9\times10^9\times1.6\times10^{-19}\times10^{10}\text{eV}$$

$$= -14.4\text{eV}$$

379 **(c)**

The capacitance of air capacitor

$$C_0 = \frac{A\varepsilon_0}{d} = 3\mu\text{F} \qquad ...(i)$$

When a dielectric of permittivity ε_r and dielectric constant K is introduced between the plates of the capacitor, then its capacitance

$$C = \frac{KA\varepsilon_0}{d} = 15\ \mu\text{F} \qquad ...(ii)$$

Dividing Eq. (ii) by Eq. (i)

$$\frac{C}{C_0} = \frac{\frac{KA\varepsilon_0}{d}}{\frac{A\varepsilon_0}{d}} = \frac{15}{3}$$

$\therefore \quad K = 5$

Permittivity of the medium

$$\varepsilon_r = \varepsilon_0 K$$
$$= 8.854\times10^{-12}\times5$$
$$= 44.27\times10^{-12}$$
$$= 0.44\times10^{-10}\text{C}^2\text{N}^{-1}\text{m}^{-2}$$

380 **(d)**

It depends whether both charges are of the same or opposite sign

381 **(b)**

In series, all the potentials will be added

382 **(c)**

After closing S_1, charge on C_1; $q = 6\times20 = 120\ \mu\text{C}$. Now, S_1 is opened. On closing S_2, charge q will be distributed between C_1 and C_2 according to their capacitances.

So, charge on C_2: $q_2 = \frac{C_2 q}{C_1+C_2} = \frac{3\times120}{3+6} = 40\ \mu\text{C}$

383 **(b)**

Charge on the metal sphere: $V_1 = \frac{kq}{r_1} \Rightarrow q = \frac{V_1 r_1}{k}$

On connecting the sphere with shell, entire charge will be transferred to the shell. So, potential of sphere now is

$$V_2 = \frac{kq}{r_2} = \frac{V_1 r_1}{r_2}$$

384 **(d)**

Since, the proton is moving against the direction of electric field so, work is done by the proton against electric field. It implies that electric field does negative work on the proton.

Again, proton is moving in electric field from low potential region to high potential region hence, its potential energy increases.

385 **(a)**

The system will be equivalent to series combination of two capacitors of half thickness ie.,each of capacity 2 C

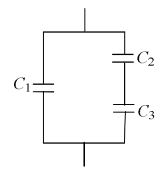
$$\therefore \frac{1}{C_s} = \frac{1}{2c} + \frac{1}{2c} = \frac{1}{c} \text{ or } C_s = c$$

$\therefore$capacity remains the same

386 **(a)**

$$C_1 = \frac{K_1\varepsilon_0 A/2}{t}$$
$$C_2 = \frac{K_2\varepsilon_0 A/2}{t/2}$$
$$C_3 = \frac{K_3\varepsilon_0 A/2}{t/2}$$

Now, $C_{\text{eq}} = C_1 + \frac{C_2 C_3}{C_2+C_3}$



387 **(b)**

Electrostatic potential energy of system of two electrons

$$U = \frac{1}{4\pi\varepsilon_0}\frac{(-e)(-e)}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

Thus, as r decreases, potential energy U increases.

388 **(d)**

$\Delta V = -\int_A^B \vec{E}\cdot dl = \text{zero}$

389 **(b)**

Initially at switch position Q, by conservation of charge, the voltage V across the two capacitors is thus given by

$q = q_1 + q_2 = C_1 V + C_2 V = (C_1 + C_2)\text{ V}$

$\Rightarrow \ 18 = (3+6)\text{V}$

$\Rightarrow \ V = (18/9) = 2\ \text{V}$

390 **(b)**

Given, $C_1 = 6\mu\text{F}, C_2 = 12\mu\text{F}, V = 150\text{volt}$.

Total capacity, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{6} + \frac{1}{12}$

$$= \frac{2+1}{12}\frac{1}{C} = \frac{3}{12}C = 4\mu\text{F}$$

Potential of 12μF capacitor

$$V = \frac{q}{C}$$
$$V = \frac{4\times150}{12}$$

$V = 50$ volt

391 **(c)**

$C_0 = \frac{\varepsilon_0 A}{d} = 18$

$C_0 = \frac{K\varepsilon_0 A}{3d} = 72$

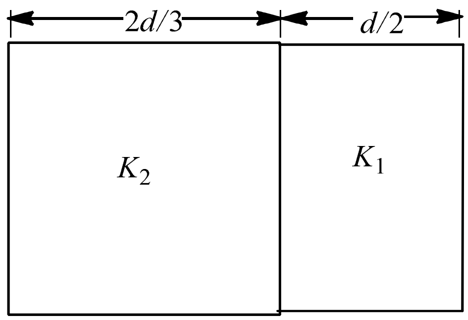
Dividing Eq. (ii) by Eq. (i)

$\frac{k}{3} = \frac{72}{18} = 4$

$K = 12$

392 **(c)**

$C = \frac{C_1 C_2}{C_1 + C_2}$ ...(i)



where $C_1 = \frac{K_1\varepsilon_0 A}{d/3}$ ...(ii)

And $C_2 = \frac{K_2\varepsilon_0 A}{2d/3}$ ...(iii)

It is given that $\frac{\varepsilon_0 A}{d} = 9\text{pF}$

On substituting Eqs. (ii)and (iii)in Eq. (i), we get the result

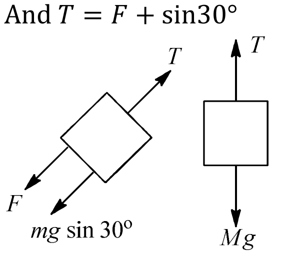
$C_{\text{eq}} = 40.5\mu\text{F}$

393 **(a)**

For equilibrium, we have

$T = Mg$

And $T = F + \sin 30°$

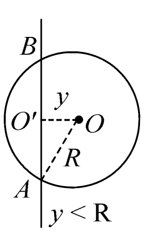


$\Rightarrow Mg = F + \frac{mg}{2}$

$\Rightarrow m = \frac{m}{2} + \frac{F}{g} = \frac{m}{2} + \frac{E^2\varepsilon_0 A(k-1)}{2lgd}$

394 **(c)**

Electric flux $\oint_S \vec{E} \cdot \overrightarrow{ds} = \frac{q_{\text{in}}}{\varepsilon_0}$



q_{in} is the charge enclosed by the Gaussian surface which, in the present case, is the surface of given sphere. As shown, length AB of the line lies inside the sphere.

In $\Delta OO'A, R^2 = y^2 + (O'A)^2$

$O'A = \sqrt{R^2 - y^2}$ and $AB = 2\sqrt{R^2 - y^2}$

Charge on length $AB = 2\sqrt{R^2 - y^2} \times \lambda$

Therefore, electric flux $\oint_S \vec{E} \cdot \overrightarrow{ds} = \frac{2\lambda\sqrt{R^2 - y^2}}{\varepsilon_0}$

395 **(d)**

Positive plate of all the three condensers is connected to one point (A) and negative plate of all the three condensers is connected to point (B) *ie*, they are joined in parallel.

$C_p = 3 + 3 + 3 = 9\mu\text{ F}$

396 **(a)**

When plates of capacitor are separated by a dielectric medium of dielectric constant K, its capacity

$C_m = \frac{K\varepsilon_0 A}{d} = KC_0$

ie, $C_m = KC_0$

Here, $C_0 = C$

$\therefore$ $C_m = KC$

Now, two capacitors of capacities KC and C are in series, their effective capacitance

$\frac{1}{C'} = \frac{1}{KC} + \frac{1}{C}$

or $\frac{1}{C'} = \frac{1+K}{KC}$

$\therefore C' = \frac{KC}{K+1}$

397 **(d)**

Let their potentials is be the same

$V_1 = V_2 \Rightarrow \frac{kQ_1}{R_1} = \frac{kQ_2}{R_2} \Rightarrow Q_1 R_2 = Q_2 R_1$

If potential are the same, then no flow of charge will occur, otherwise charge will flow and there will be loss of energy

398 **(a)**

$V = \frac{\sum q}{4\pi\varepsilon_0 r} = \frac{-10 + 10}{4\pi\varepsilon_0 r} = 0$

399 **(b)**

Potential on 5 μF capacitor is

$\frac{3 \times 6}{3 + (2 + 5)} = 1.8\text{ V}$

So, charge on this capacitor $= CV = 5 \times 1.8 =$ 9 μC

400 **(b)**

$C = \frac{A\varepsilon_0}{d}$

After inserting the slab

$$C' = \frac{A\varepsilon_0}{(d-b)} = \frac{A\varepsilon_0}{d-\frac{d}{2}}$$

$C' = \frac{2A\varepsilon_0}{d}$ $\therefore$ $\frac{C'}{C} = \frac{2}{1}$

401 **(c)**

Total electric flux, $\phi_1 = \phi = \frac{1}{\varepsilon_0}$(charge enclosed) and *ie*, charge of given body is body is constant.

402 **(b)**

Potential energy of charges q_1 and q_2, r distance apart

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

For $r = 0.1$m,

$$U_1 = \frac{1}{4\pi\varepsilon_0}\frac{12\times10^{-6}\times5\times10^{-6}}{0.1}$$

$$= \frac{9\times10^9\times60\times10^{-12}}{0.1} = 5.4\text{ J}$$

For $r = 0.06$m,

$$U_2 = \frac{9\times10^9\times60\times10^{-12}}{0.06} = 9\text{ J}$$

$\therefore$ Work done = (9 – 5.4) J = 3.6 J

403 **(a)**

$$C = \frac{K\varepsilon_0 2\pi l}{\text{In}\,(b/a)}$$

$$= \frac{3.5\times2\pi\times8.85\times10^{-12}\times8\times10^3}{\text{In}(15/10)}$$

$= 3.84\times10^{-6}$F

404 **(a)**

$E = -\frac{dV}{dr}$ = negative of the slope of $V-r$ graph

406 **(d)**

$E = \left(\frac{1}{2}\right)CV^2$ ...(i)

The energy stored in capacitor is lost in form of heat energy

$H = ms\,\Delta T$ ...(ii)

From Eqs. (i) and (ii), we have

$ms\,\Delta T = \left(\frac{1}{2}\right)CV^2$

$$V = \sqrt{\frac{2\,ms\Delta T}{C}}$$

407 **(a)**

Charge on nucleus

$Q = Ze = 47\times1.6\times10^{-19}$

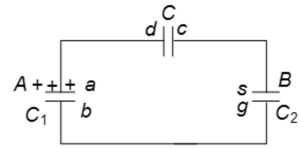
$= 7.52\times10^{-18}$C

Potential on the surface of nucleus is

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

$$= \frac{9\times10^9\times7.52\times10^{-18}}{3.4\times10^{-14}} = 1.99\times10^6\text{V}$$

408 **(d)**



Charge on positive plate of $A = C_1V_1$

Charge on negative plate of $B = -C_2V_2$

When d plate of capacitor C is connected with the plate of A, then the total charge of (d,a) plate system will be C_1V_1 (conservation of charge)

Similarly on (C,S) plates, total charge will be $-C_2V_2$

The total charge on (b,g) plate system will be$+C_2V_2 - C_1V_1$

409 **(b)**

Potential of larger capacitor after the first charging

$$V_1 = \frac{C_0V_0}{(C+C_0)}$$

After the second charging

$$V_2 = \frac{C_0V_1}{(C+C_0)} \Rightarrow V_2 = \left(\frac{C_0}{C+C_0}\right)^2 V_0$$

After the n^{th} charging,

$V_n = \left(\frac{C_0}{C+C_0}\right)^n V_0$, but $V_n = V$

$$\Rightarrow C = C_0\left[\left(\frac{V_0}{V}\right)^{1/n} - 1\right]$$

410 **(b)**

$$2000\times0.04 = \frac{1}{2}\times40\times10^{-6}V^2$$

$V^2 = 4\times10^6 \Longrightarrow V = 2000$ V

411 **(a)**

Because electric field intensity is zero inside a spherical conductor

412 **(d)**

$C_{\text{eq}} = C + 2C + 3C + \cdots + nC$

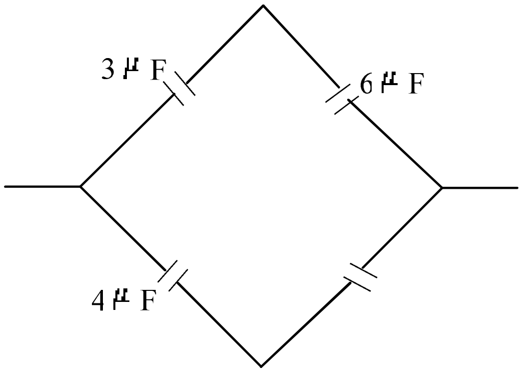
$$= \frac{(n+1)n}{2}C$$

413 **(b)**

The points C and D will be at same potentials since,$\frac{3}{6} = \frac{4}{8}$.

Therefore, capacitance of 2μF will be unaffected.

So, the equivalent circuit can be shown as.



The effective capacitance in upper arm in series, is given by

$$C_1 = \frac{3 \times 6}{3+6} = \frac{18}{9} = 2\ \mu\text{F}$$

The effective capacitance in lower arm in series is given by

$$C_2 = \frac{4 \times 8}{4+8} = \frac{32}{12} = \frac{8}{3}\mu\text{F}$$

Hence, the resultant capacitance in parallel is given by

$$C = C_1 + C_2 = 2 + \frac{8}{3} = \frac{14}{3}\mu\text{F}$$

414 **(b)**

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3}\right)$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{33 \times 10^{-9}}{93 \times 10^{-3}} - \frac{51 \times 10^{-9}}{\sqrt{2} \times 93 \times 10^{-3}} + \frac{47 \times 10^{-9}}{93 \times 10^{-3}}\right)$$

$$= \frac{1}{4\pi\varepsilon_0} \times \frac{10^{-9}}{93 \times 10^{-3}}\left(33 - \frac{51}{\sqrt{2}} + 47\right)$$

$$\approx 4 \times 1000\ \text{V} = 4\ \text{kV}$$

415 **(b)**

The electric field intensity of a point in an electric field in a given direction is equal to the negative potential gradient in that direction, *ie*,

$$E = -\frac{dV}{dx}$$

The negative sign signifies that the potential decreases in the direction of electric field, *ie*, electric lines of force flow from higher potential region to lower potential region.

Since, AB is perpendicular to field lines, so A and B are at same potential.

Hence, $V_A = V_B > V_C$

416 **(a)**

The material suitable for use as dielectric must have high dielectric strength X and large dielectric constant K.

417 **(c)**

On sharing of charges loss in electrical energy, $\Delta U = \frac{C_1C_2}{2(C_1+C_2)}(V_1 - V_2)$. In present case

$C_1 = C_2 = C$

$$\therefore\ \Delta U = \frac{C^2}{2(2C)}(V_1 - V_2)^2 = \frac{1}{4}C(V_1 - V_2)^2$$

418 **(b)**

Since electrical potential at any point of circle of radius R due to charge Q_2 at its centre is same $V = \frac{Q_2}{4\pi\varepsilon_0 R}$, hence work done in carrying a charge Q_1 round the circle is zero.

419 **(b)**

The arrangement behaves as a combination of 2 capacitors each of capacitance $C = \frac{\varepsilon_0 A}{d}$.

Thus, equivalent capacity $= 2C$

$\therefore$ total energy stored $U = \frac{1}{2} \times (2C)V^2 = CV^2 = \frac{\varepsilon_0 A}{d}V^2$

420 **(d)**

Electrostatic potential energy of the system of charges is

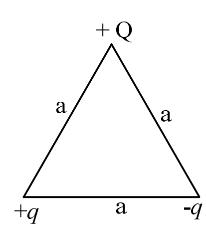
$$U = \frac{1}{4\pi\varepsilon_0}\left[\frac{Qq}{a} + \frac{Qq}{a} + \frac{q^2}{a}\right]$$

$$U = \frac{1}{4\pi\varepsilon_0 a}[2Qq + q^2]$$

Given, $U = 0$

$$\Rightarrow \quad 2Qq + q^2 = 0$$

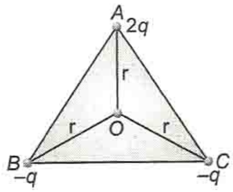
$$\Rightarrow \quad Q = -\frac{q}{2}$$



421 **(c)**

In an equilateral triangle distance of centroid from all the vertices is same (say r).

$$\therefore\ V = V_1 + V_2 + V_3 = \frac{1}{4\pi\varepsilon_0}\left[\frac{2q}{r} - \frac{q}{r} - \frac{q}{r}\right] = 0$$



But $\vec{E}_A = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2q}{1}$ along AO, $\vec{E}_B = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}$ along OB and

$\vec{E}_c = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$ along OC. obviously $\vec{E}_B + \vec{E}_B$ Will also be in the direction of AO extended and hence $\vec{E}_A\ and (\vec{E}_B + \vec{E}_C)$ being in same direction will not give zero resultant.

422 **(a)**

$$\phi_E = \frac{q}{K\varepsilon_0} = \frac{0.5}{10 \times 8.85 \times 10^{12}} = 5.65 \times 10^9$$

423 **(d)**

In the arrangement shown both plates of capacitors C_3 are joined to point B. Hence, it does not act as a capacitor and is superfluous. Now C_1 and C_2 are in parallel, hence $C_{AB} = C_1 + C_2 = C + C = 2C$

424 **(b)**

Minimum effective capacitance

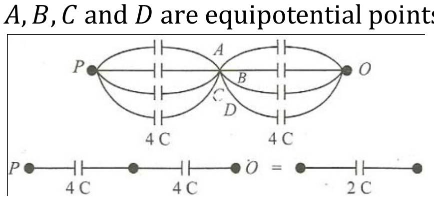
$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$= \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{3+2+1}{6} = 1$$

$C = 1\mu F$

425 **(a)**

A, B, C and D are equipotential points (see Fig)



426 **(b)**

Charge will induce on A but total charge on A will remain zero. Negative charge of A will be more closer to B than positive charge on A. So potential of B will decrease

427 **(b)**

From figure, we get

$dp = (\lambda a d\theta) 2a\cos\theta$

$$p = \int dp = 2\lambda a^2 \int_{-\pi/2}^{\pi/2} \cos\theta d\theta$$

$= 2\lambda a^2 [\sin\theta]_{-\pi/2}^{\pi/2}$

$|p| = 4\lambda a^2$

428 **(d)**

Given that,

$C = 500\mu F$

$\frac{dq}{dt} = 100\ \mu C s^{-1}$

$V = 10$ volt

Then the total charge on the capacitor

$q = CV$

$= 500 \times 10^{-6} \times 10$

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

Hence, time $= \frac{\text{total charge}}{\text{charge rate}}$

$E = \frac{5 \times 10^{-3} C}{100 \times 10^{-6} C} s$

$= 50s$

429 **(a)**

In free space, the electric field between plates of capacitor.

$$E_0 = \frac{q}{A\varepsilon_0}$$

...(i)

When plates of capacitor dipped in oil tank then, the electric field between the plates is

$$E_0 = \frac{q}{A\varepsilon}$$

...(ii)

(when ε is the permittivity of medium)

or $E = \frac{E_0}{AK\varepsilon_0}$ $[\because \varepsilon = K\varepsilon_0]$

From Eqs. (i) and (ii),

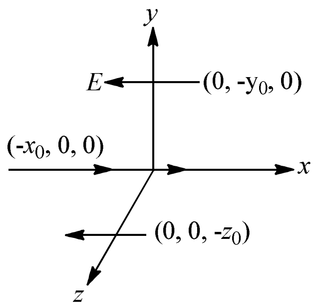
$$E = \frac{E_0}{K}$$

(where K is the dielectric constant)

Hence, the electric field between the plates is increase.

430 **(d)**

Field on the axis of the dipole lies in the direction of dipole



Field on the bisector of the dipole lies opposite to the direction of dipole

431 **(d)**

Frequency n =50Hz

Time period $T = \frac{1}{50}$ s

Time taken for voltage to change from its peak value to zero

$= \frac{T}{4} = \frac{1}{4 \times 50} = \frac{1}{200} = 5 \times 10^{-3}$s

432 **(a)**

Potential gradient relates with electric field according to the relation,$E = -\frac{dV}{dr}$

$= -\frac{10}{20 \times 10^{-2}} = 50\ \text{Vm}^{-1}$

433 **(c)**

The four plates are alternately connected. They form three capacitors in parallel. Capacity of each capacitor is $\varepsilon_0 A/d$. So, the net capacity is $3\varepsilon_0 A/d$

434 **(c)**

Electric potential inside a conductor is constant and it is equal to that on the surface of conductor.

435 **(b)**

As $E = -\frac{dV}{dr}$

$\therefore\ +E_0 = -\frac{[V(x) - 0]}{x}$

or $V_x = -E_0 x$

436 **(a)**

5 μF, 10 μF, 15 μF will be in parallel, then 30 μF will be in series

437 **(a)**

Energy $E_1 = \frac{1}{2} C_1 V_1^2$

$= \frac{1}{2} \times 1 \times 10^{-6} \times (30)^2 = 450 \times 10^{-6}$ J

Common potential

$V = \frac{q_1 + q_2}{C_1 + C_2}$

$= \frac{1 \times 30 + 0}{1+2} = 10$ volt

$E_2 = \frac{1}{2}(C_1 + C_2)V^2$

$= \frac{1}{2}(1 + 2) \times 10^{-6} \times (10)^2$

$= 1.5 \times 100 \times 10^{-6} = 150 \times 10^{-6}$ J

Loss of energy $= E_2 - E_1 = 300$μJ

438 **(d)**

$W = U_2 - U_1 = \frac{q^2}{2}\left[\frac{1}{C_2} - \frac{1}{C_1}\right]$

$C_1 = \frac{\varepsilon_0 A}{d}, C_2 = \frac{C_1}{2} = \frac{\varepsilon_0 A}{2d}$

$q = C_1 V = \frac{\varepsilon_0 AV}{d}$

Solve to get, $W = \frac{1}{2}\frac{\varepsilon_0 AV^2}{d}$

Alternatively: $W = Fd = \frac{Q^2}{2A\varepsilon_0} d = \frac{C_1^2 V^2}{2\varepsilon_0 A} d = \frac{1}{2}\frac{\varepsilon_0 AV^2}{d}$

439 **(b)**

Given, $C = 2$μF, $C_2 = 4$μF, and $V = 10$volt

Capacitors are connected in series

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

$\therefore\ C = \frac{4 \times 2}{4 + 2} = \frac{4}{3}$

The charge of combination

$q = CV = \frac{4}{3} \times 10 = \frac{40}{3}$

The energy of 2μF capacitor

$E = \frac{1}{2} \times \frac{q^2}{C_1} = \frac{1}{2} \times \frac{1600}{9 \times 2} = \frac{400}{9}$

The energy of 4μF capacitor

$E_2 = \frac{1}{2} \times \frac{q^2}{C_2} = \frac{1}{2} \times \frac{1600}{9 \times 4} = \frac{200}{9}$

The ratio of energies is

$\frac{E_1}{E_2} = \frac{\frac{400}{9}}{\frac{200}{9}} = \frac{2}{1}$

440 **(b)**

Energy of second proton = PE of the system

$= \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$

$= 9 \times 10^9 \times \frac{1.6 \times 10^{-19} \times 1.6 \times 10^{-19}}{1 \times 10^{-10}}$

$= 23.0 \times 10^{-19}$ J

441 **(a)**

$$V_1 = \frac{kQ}{a} - \frac{kQ}{d}, V_2 = \frac{-kQ}{b} + \frac{kQ}{d}$$

$$C = \frac{Q}{V_1 - V_2} = \frac{4\pi\varepsilon_0}{\frac{1}{a} + \frac{1}{b} - \frac{2}{d}}$$

442 **(b)**

Let R and r be the radii of bigger and each smaller drop. Charge remains conserved.

Hence, charge on bigger drop

$= 27 \times$charge on smaller drop

ie, $q' = 27q$

Now, before and after coaleseing, volume remains same.

That is,

$\frac{4}{3}\pi R^3 = 27 \times \frac{4}{3}\pi r^3$

$\therefore \; R = 3r$

Hence, capacitance of bigger drop

$C' = 4\pi\varepsilon_0 R = 4\pi\varepsilon_0(3r)$

$= 3(4\pi\varepsilon_0 r) = 3C$

443 **(a)**

Potential decreases in the direction of electric field

444 **(b)**

$$V_1 = \frac{k \times 2 \times 10^{-6}}{0.1} + \frac{k \times 4 \times 10^{-6}}{\sqrt{(0.1)^2 + (0.5)^2}}$$

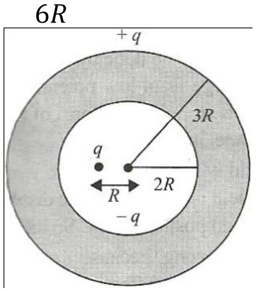
$$V_2 = \frac{k \times 4 \times 10^{-6}}{0.1} + \frac{k \times 2 \times 10^{-6}}{\sqrt{(0.1)^2 + (0.5)^2}}$$

Work done $= q(V_2 - V_1) = 0.72$ J

445 **(c)**

$$V = k\frac{q}{R} - \frac{kq}{2R} + \frac{kq}{3R} = \frac{kq}{R}\left[1 - \frac{1}{2} + \frac{1}{3}\right]$$

$$= \frac{k5q}{6R}$$



446 **(d)**

$R = \sqrt{8^2 + 8^2 + 2 \times 8 \times 8\cos 120°} = 8$N

447 **(a)**

$dV = -E \, dr \cos\theta$

Along the line of force, θis 0°, hence dV is maximum. So, the variation of potential is maximum along the line of force

448 **(a)**

$C = \frac{K\varepsilon_0 A}{d}$, find K/d for each sheet. Capacitance will be largest for which K/d is largest

449 **(c)**

Electric flux may be due to the charges present inside the Gaussian surface, but for the purpose of calculation of electric field E at any point we shall have to consider contribution of all the charges.

450 **(c)**

$$U = \frac{1}{2}CV^2$$

Potential of each capacitor now $= V/2$

$$U' = \frac{1}{2}C\left(\frac{V}{2}\right)^2 = \frac{U}{4}$$

451 **(d)**

Electric potential of charged spherical shell

$$V = \frac{q}{4\pi\varepsilon_0 R} \qquad (0 \le r \le R)$$

∴ Electric potential at centre=Electric potential on the surface.

452 **(d)**

$$V = \frac{kQ}{c} - \frac{kQ}{b}$$

453 **(a)**

Here, $E = \frac{\sigma}{\varepsilon_0}$ *and* $t = \frac{1}{u}$

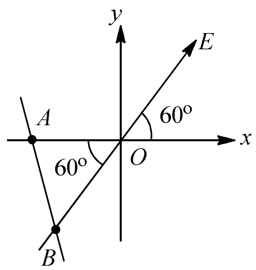
Along *Y*-axis, $u = 0, a = \frac{f}{m} = \frac{eE}{m}$

$$s = d = \frac{1}{2}at^2 = \frac{1}{2}\frac{eE}{m}t^2 = \frac{1}{2}\frac{e\sigma}{m\varepsilon_0}\frac{l^2}{u^2}$$

$$\sigma = \frac{2d\varepsilon_0 mu^2}{el^2}$$

454 **(d)**

$OB = OA\cos 60° = 2 \times \frac{1}{2} = 1$ m

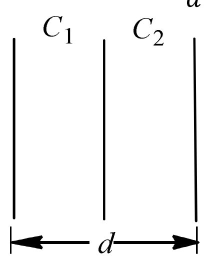


$V_B - V_O = E(OB) = 100 \times 1 = 100\text{V}$
$V_A - V_O = 100\text{V}\ [\because V_B = V_A]$
$V_O - V_A = -100\text{V}$

455 **(d)**
There will be $n-1$ capacitors, all connected in parallel

456 **(b)**
Initial capacitance

$$C = \frac{\varepsilon_0 A}{d}$$



When it is half filled by a dielectric of dielectric constant K, then

$$C_1 = \frac{K\varepsilon_0 A}{d/2} = 2K\frac{\varepsilon_0 A}{d}$$

and $$C_2 = \frac{\varepsilon_0 A}{d/2} = \frac{2\varepsilon_0 A}{d}$$

$\therefore$ $$\frac{1}{C\prime} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{d}{2\varepsilon_0 A}\left(\frac{1}{K} + 1\right) = \frac{d}{2\varepsilon_0 A}\left(\frac{1}{5} + 1\right)$$

$$= \frac{6}{10}\frac{d}{\varepsilon_0 A}$$

$\therefore$ $$C' = \frac{5\varepsilon_0 A}{3d}$$

Hence, increase in capacitance

$$= \frac{\frac{5}{3}\frac{\varepsilon_0 A}{d} - \frac{\varepsilon_0 A}{d}}{\frac{\varepsilon_0 A}{d}} = \frac{5}{3} - 1 = \frac{2}{3}$$

$$= 66.6\%$$

457 **(b)**
For neutral point $\vec{E}_A + \vec{E}_B = \vec{0}$ *or* $\vec{E}_A = -\vec{E}_B$. It is possible, in present problem, only at a point somewhere on the left of $-Q$

458 **(c)**
After covering with a hemispherical shell;
$\phi_{\text{shell}} + \phi_{\text{disc}} = 0$(from gauss's law)
$\phi_{\text{shell}} = -\phi_{\text{disc}} = -\phi$

459 **(b)**
Electric field is the −ve of slope of $V - x$ graph. Inside the conductor, electric field is zero, so slope of $V - x$ graph is zero. Inside dielectric, field decreases, so slope also decreases

460 **(d)**
l =length of the each tube
$u_x = u$ =constant
Time of travel between the plates $t = l/u$
Let a =constant acceleration in y-direction
So, $v_y = at$ when the particle emerges from the plates
So, $v^2 = u_x^2 + v_y^2 = u^2 + a^2t^2$
$= u^2 + a^2\frac{l^2}{u^2} = u^2 + \frac{C}{u^2}$(where $a^2l^2 = C$)
So, $v = \sqrt{u^2 + \frac{C}{u^2}}$

461 **(d)**
Consider the Gaussian surface where the induced charge is as shown in the figure
The net field at P due to all the charges is zero, e i.e.,

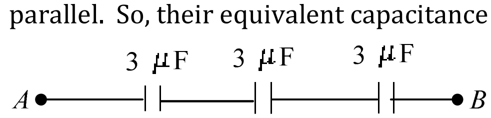
$$-2Q + \frac{q}{2A\varepsilon_0}(\text{left}) + \frac{q}{2A\varepsilon_0}(\text{right}) + q - \frac{q}{2A\varepsilon_0}(\text{right}) = 0$$

$\Rightarrow\ -2q + q - Q + q = 0$
$\Rightarrow\ q = \frac{3}{2}Q$
Charge on the right side of the rightmost plate is
$-2Q + Q = -2Q + \frac{3}{2}Q = -\frac{Q}{2}$

462 **(c)**
In series, potential is divided

463 **(d)**
The capacitance of capacitor $C = \frac{\varepsilon_0 A}{x}$
Charge on capacitor
$q = CV = \frac{\varepsilon_0 AV}{x};\ U = \frac{1}{2}qV = \frac{1}{2}\frac{\varepsilon_0 AV^2}{x}$
So, $\frac{dU}{dt} = \frac{1}{2}\varepsilon_0 AV^2\left(-\frac{1}{x^2}\right)\frac{dU}{dt}$
$= \frac{1}{2}\varepsilon_0 AV^2 v\left(-\frac{1}{x^2}\right)$
From the earlier expression, $\frac{dU}{dt} \propto \frac{1}{x^2}$

464 **(a)**
The two capacitors each of value 1.5μF are in parallel. So, their equivalent capacitance



$= 1.5 + 1.5 = 3$ μF
Now, three capacitors each of value 3μF are in series. Hence, their equivalent capacitance is

given by

$$\frac{1}{C}=\frac{1}{3}+\frac{1}{3}+\frac{1}{3}$$

or $\frac{1}{C}=\frac{3}{3}$

or $c = 1\mu F$

465 **(d)**

$W = Q\,dV = Q(V_q - V_p)$

$= -100 \times (1.6 \times 10^{-19}) \times (-4 - 10)$

$= +100 \times 1.6 \times 10^{-19} \times 14$

$= +2.24 \times 10^{-16} J$

466 **(b)**

Here, $\vec{E} = 8\hat{i} + 4\hat{j} + 3\hat{k}$

$\vec{S} = 100\hat{k}$

(direction of area is perpendicular to x-y plane)

$\phi = \vec{E}.\vec{s} = (8\hat{i} + 4\hat{j} + 3\hat{k}).100\hat{k}$

$= 300$ unit

467 **(d)**

External applied field's effect is neutralized by charge induced on outer surface, i.e. their combined effect is zero. Hence, force applied by induced charges on outer surface should be equal and opposite to that applied by electric field. This is equal to $qE = 1 \times 20 = 20$N towards left. 15 N force is only due to induced charge on the inside surface of the hollow sphere. Hence, net force by induced charges is $15 + 20 = 35$ N

468 **(b)**

Equipotential lines are concentric circles,

These pattern of equipotential lines should be due to point charge at the centre of circles

Let us consider few equipotential lines,

$$20 = \frac{1}{4\pi\varepsilon_0}\frac{q}{30 \times 10^{-2}} \Longrightarrow \frac{q}{4\pi\varepsilon_0} = 6$$

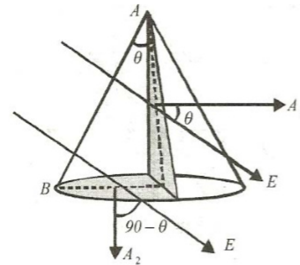
$$60 = \frac{1}{4\pi\varepsilon_0}\frac{q}{10 \times 10^{-2}} \Longrightarrow \frac{q}{4\pi\varepsilon_0} = 6$$

For point charge, electric field should be in radial direction

The value is $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} = \frac{6}{r^2}(\text{Vm}^{-1})$

469 **(a)**

Flux entering the cone from side AB will ultimately also pass through area A_1 and A_2.



Hence, $\phi = EA_1 \cos\theta + EA_2 \cos(90-\theta)$

$$= E\left(\frac{1}{2}2Rh\cos\theta + \frac{\pi}{2}R^2\sin\theta\right)$$

$= ER(h\cos\theta + \pi(R/2)\sin\theta)$

470 **(c)**

If C is capacity of each condenser, then charge on each capacitor = 10 C

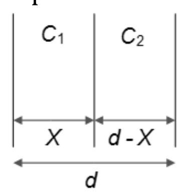
($\because V = 10V$)

When connected in series, potential difference between free plates $= \frac{\text{total charge}}{\text{total capacity}}$

$$= \frac{10\,C}{C/6} = 60 \text{ V}$$

471 **(c)**

On placing this aluminium sheet, it will form two capacitors in series, say initial separation is d



$$C_1 = \frac{\varepsilon_0 A}{x}, C_2 = \frac{\varepsilon_0 A}{d-x}$$

$$C_{eq} = \frac{C_1C_2}{C_1 + C_2} = \frac{\frac{\varepsilon_0 A}{x}\cdot\frac{\varepsilon_0 A}{d-x}}{\frac{\varepsilon_0 A}{x} + \frac{\varepsilon_0 A}{d-x}}$$

$$= \frac{\varepsilon_0 A}{x(d-x)\left[\frac{1}{x} + \frac{1}{d-x}\right]} = \frac{\varepsilon_0 A}{x + d - x}$$

$$= \frac{\varepsilon_0 A}{d}$$

Hence, capacitance remains unchanged

472 **(a)**

Electric field produced due to charge Q will be zero at P, but potential produced by Q at P will not be zero

473 **(c)**

Here $\frac{r_1}{r_2} = \frac{1\text{mm}}{2\text{mm}} = \frac{1}{2}$. when the spheres are connected by a conducting wire $V_1 = V_2$

Or $\frac{q_1}{4\pi\varepsilon_0 r_1} = \frac{q_2}{4\pi\varepsilon_0 r_2} \Rightarrow \frac{q_1}{q_2} = \frac{r_1}{r_2} = \frac{1}{2}$

Now, $\frac{E_1}{E_2} = \frac{q_1}{q_2}.\left(\frac{r_2}{r_1}\right)^2 = \frac{1}{2} \times \left(\frac{2}{1}\right)^2 = 2:1$

474 **(a)**

Given $\frac{\varepsilon_0 A}{d} = 10$

$C' = \frac{\varepsilon_0 A/2}{d} + \frac{4\varepsilon_0 (A/2)}{d} = 10\left[\frac{1}{2} + 2\right] = 25\ \mu F$

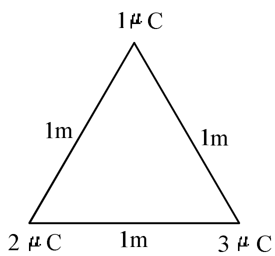
475 **(c)**

There will be two dipoles inclined to each other at an angle of 60°. The dipole moment of each dipole will be$q\lambda$. The resultant dipole moment is

$\sqrt{(ql)^2 + (ql)^2 + 2(ql)(ql)\cos 60°} = \sqrt{3}ql$

476 **(c)**

When charges are placed at vertices of an equilateral triangle of side 1m, then potential energy of combination is

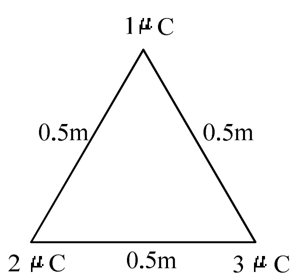


$U_1 = \frac{1}{4\pi\varepsilon_0}.\frac{1 \times 2 \times 10^{-12}}{(1)} + \frac{1}{4\pi\varepsilon_0}.\frac{2 \times 3 \times 10^{-12}}{(1)}$

$+\frac{1}{4\pi\varepsilon_0}.\frac{3 \times 1 \times 10^{-12}}{(1)}$

$= 11 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12} J$

When charges are placed at vertices of an equilateral triangle of side 0.5m, then potential energy of combination is



$U_1 = \frac{1}{4\pi\varepsilon_0}.\frac{1 \times 2 \times 10^{-12}}{(0.5)} + \frac{1}{4\pi\varepsilon_0}.\frac{2 \times 3 \times 10^{-12}}{(0.5)}$

$+\frac{1}{4\pi\varepsilon_0}.\frac{3 \times 1 \times 10^{-12}}{(0.5)}$

$= 22 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12} J$

$\therefore$ Work done $= \Delta U = U_2 - U_1$

$= 22 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12} - 11 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12}$

$= 11 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12}$

$= 11 \times 9 \times 10^9 \times 10^{-12} = 99 \times 10^{-3}$

$= 0.099 J \approx 0.01 J$

477 **(a)**

As battery is disconnected, so charge will remain the same. It is given that final potential is the same. So, final capacitance should be equal to initial capacitance

$\frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 A}{(1.6 + d) - t(1 - 1/k)}$

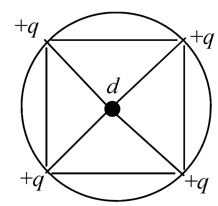
$\Rightarrow K = 5$

478 **(b)**

Potential at centre due to all charges are

$= \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{d} + \frac{q}{d} + \frac{q}{d} + \frac{q}{d}\right]$

$= \frac{1}{4\pi\varepsilon_0}\frac{4q}{d}$ in SI units



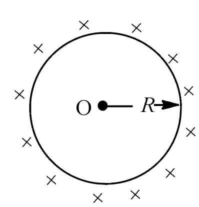
$= \frac{4q}{d}$ in CGS units

479 **(b)**

Electric field inside a spherical charge is everywhere zero, hence, inside a spherical charge the potential at all points is the same and its value is equal

to that on the surface.

$\therefore$ Potential at surface=10V.



480 **(a)**

Work done in delivering q coulomb of charge from clouds to ground.

$W = Vq$

$= 4 \times 10^6 \times 4 = 16 \times 10^6$J

The power of lightning strike is

$P = \frac{W}{t}$

$= \frac{16 \times 10^6}{0.1} = 160 \times 10^6 W$

$= 160\ MW$

481 **(d)**

$E = \frac{\lambda}{2\pi\varepsilon_0 r} = -\frac{\partial V}{\partial r}$ or $\int_{V_a}^{V_b} dV = -\int_a^b \frac{\lambda}{2\pi\varepsilon_0}\frac{dr}{r}$

$V_a - V_b = \frac{\lambda}{2\pi\varepsilon_0}\log\left(\frac{b}{a}\right)$

Hence, $V_a - V_b \propto \log\frac{b}{a}$

482 **(b)**

$C = \frac{K\varepsilon_0 vtb}{d} + \frac{\varepsilon_0(l - vt)b}{d}; q = CV$

$I = \frac{dq}{dt} = V\frac{dC}{dt} = V\left[\frac{K\varepsilon_0 bv}{d} - \frac{\varepsilon_0 bv}{d}\right]$ =constant

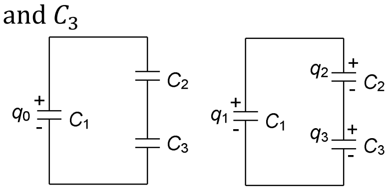
So, till the dielectric is fully inserted, a constant current will flow. When the dielectric is fully inside, C will be constant, so $I = 0$. And when dielectric starts coming out, again a constant current will flow but in opposite direction

483 **(d)**

Initial situation after the reconnection is shown in Figure and the final situation in figure

The charge transferred by C_1 is $q_0 - q_1$ and the capacitors C_2 and C_3 are in series, so$q_2 = q_3$

Other way to solve the questions is to equalize the potentials across C_1 and series combination of C_2 and C_3



484 **(d)**

$Q = nq, R = n^{1/3} r$

$E_{\text{small}} = \frac{kq}{r^2}, E_{\text{big}} = \frac{kQ}{R^2}$

$E_{\text{big}} = \frac{k\ n\ q}{n^{2/3}r^2} = (n^{1/3})\frac{kq}{r^2} = n^{1/3}E_{\text{small}}$

$V_{\text{small}} = \frac{kq}{r}, V_{\text{big}} = \frac{kQ}{R}$

$V_{\text{big}} = \frac{k\ n\ q}{n^{1/3}r} = n^{2/3}\frac{kq}{r} = n^{2/3}V_{\text{small}}$

485 **(c)**

Work done= $Fs\cos\theta = F(2\pi r)\cos 90^0 = 0$.

486 **(d)**

In series arrangement potential difference is the sum of the individual potential difference of each capacitor.

ie, $V = V_1 + V_2 + V_3 + \ldots$

$\therefore$ $600 = x \times 200$

$x = 3$

So, there should be 3 capacitors in series to obtain the required potential difference.

The equivalent capacitance of the 3 capacitors in series is

$\frac{1}{C_{\text{eq}}} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6}$

$C_{\text{eq}} = 2$

Now, we require 18 μF capacitance, for this we need 9 such combinations is parallel.

Hence, $9 \times 3 = 27$

487 **(a)**

Potential energy of electric dipole, $U = -\vec{p} \cdot \vec{E} = -pE\cos\theta$.

In Fig. (a), $\theta = \pi$ rad hence $U = -pE\cos\pi = +pE =$ maximum.

488 **(b)**

Plate 2 and 3 will be at the same potential. So, there will be two capacitors in parallel

489 **(a)**

In the given circuit capacitor's (1) (2) and (3) are connected in series, hence equivalent capacitance is

$\frac{1}{C'} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C}$

$\Rightarrow C' = \frac{C}{3}$

This is connected in parallel with (4).

$\therefore\ C'' = C' + C = \frac{C}{3} + C = \frac{4C}{3}$

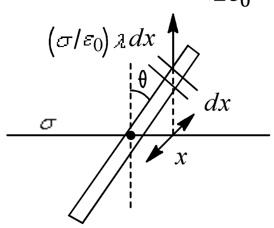
The three capacitor's (5), $\frac{4C}{3}$, (6) are now

∴ Equivalent capacitance is

$$\frac{1}{C'''} = \frac{1}{C} + \frac{3}{4C} + \frac{1}{C}$$
$$\frac{1}{C'''} = \frac{11}{4C}$$
$$\Rightarrow \ C''' = \frac{4C}{11}$$

490 **(b)**

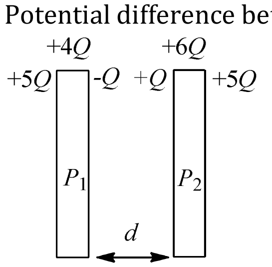
$$\tau = 2\left(\frac{\sigma}{2\varepsilon_0}\lambda dx\right) x \sin\theta$$
$$= \frac{\sigma}{\varepsilon_0}\lambda \int_0^{l/2} x.dx \sin\theta$$
$$= \frac{\sigma}{2\varepsilon_0}\lambda \frac{l^2}{4}\sin\theta$$



$$\tau = -I\alpha \Rightarrow \alpha = -\tau I = \frac{\sigma}{2\varepsilon_0}\lambda \frac{l^2}{4}\frac{12}{ml^2}\sin\theta$$
$\alpha = -\left(\frac{3\sigma\lambda}{2m\varepsilon_0}\theta\right)$(for small angle)
$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{2m\varepsilon_0}{3\sigma\lambda}}$$

491 **(b)**

Potential difference between the plates



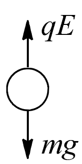
492 **(a)**

$$T = 2\pi\sqrt{\frac{l}{g_{eff}}}$$

Here, $g_{eff} = g - \frac{qE}{m}$

$\Rightarrow$ g_{eff} will decrease

Hence, T will increase



493 **(c)**

$C = 4\varepsilon_0 R$, where $R = 6.4 \times 10^6$ m

$$= \frac{6.4 \times 10^6}{9 \times 10^9} = 711\mu F$$

494 **(a)**

Because work is to be done by an external agent in moving a positive charge from low potential to high potential and this work gets stored in the form of potential energy of the system. Hence, it increases

495 **(a)**

The potential

$$V = \frac{1}{4\pi\varepsilon_0}\frac{1}{r}(q_1 + q_2 + q_3 + q_4)$$
$$V = (9 \times 10^9)\left(\frac{1}{1\text{m}}\right)\{(3 - 3 - 4 + 7) \times 10^{-6}\text{C}\}$$
$$= 2.7 \times 10^4 \frac{\text{N} - \text{m}}{\text{C}}$$
$$= 2.7 \times 10^4 \text{JC}^{-1}$$
$$= 2.7 \times 10^4 \text{V}$$

496 **(a)**

Here, $C_{13} = 30 + 30 = 60$ pF. total equivalent capacitance is given by

$$\frac{C}{1} = \frac{1}{C_1} + \frac{1}{C_{23}} + \frac{1}{C_4} = \frac{1}{30} + \frac{1}{60} + \frac{1}{120} = \frac{1}{170} \Rightarrow C = \frac{120}{7}\text{pF}$$

∴ Total charge $Q = CV = \frac{120}{7} \times 140\text{pC} = 2400\text{pC}$

$$\therefore \ V_1 = \frac{Q}{C_1} = \frac{2400\text{pC}}{30\text{pF}} = 80\text{V}$$
$$V_2 = V_3 = V_{23} = \frac{Q}{C_{23}} = \frac{2400\text{pC}}{60\text{pF}} = 40\text{V and}$$
$$V_4 = \frac{Q}{C_4} = \frac{2400\text{pC}}{120\text{pF}} = 20\text{V}$$

497 **(c)**

As $V_1 = V_2$

$$\frac{q_1}{4\pi\varepsilon_0 r_1} = \frac{q_2}{4\pi\varepsilon_0 r_2}$$
$$\therefore \ \frac{q_1}{q_2} = \frac{r_1}{r_2}$$

498 **(b)**

$$U = -\frac{kqQ}{r} - \frac{kqQ}{r} + \frac{kq^2}{2r} = 0 \Longrightarrow Q/q = 1/4$$

499 **(b)**

$U = \sum \frac{kq_1q_2}{r}$. There will be six pairs, four on a side of square and two as diagonal

500 **(d)**

Let the charge on the smaller sphere be q. As the potential of both will be the same finally, i.e.,

$$\frac{q}{r'} = \frac{Q - q}{r} \Longrightarrow q = \frac{Qr'}{r + r'}$$

501 **(b)**

Potential across 6 μF capacitor:

$$V_A - V_B = \frac{12 \times 24}{12+6} = 16$$

$\Rightarrow V_A - 0 = 16$

$\Rightarrow V_A = 16\text{ V}$

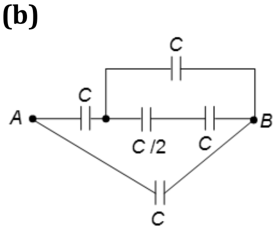
502 **(b)**

$V = \frac{kQ}{R}, E = \frac{kQ}{R^2}$

$\frac{V}{E} = R \quad \Rightarrow E = \frac{V}{R}$

If R increases, E decreases

503 **(b)**



$$C_{\text{eq}} = \frac{\frac{4C}{3} \times C}{\frac{7C}{3}} + C = \frac{11C}{7}$$

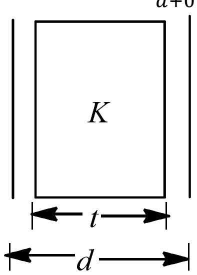
504 **(b)**

From the formula ,

$$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{K}}$$

$\Rightarrow$ Here, $K = \infty$ and $t \to 0$

So, $C = \frac{\varepsilon_0 A}{d+0} = \frac{\varepsilon_0 A}{d} = C_0$



505 **(c)**

Stored charge on capacitor becomes zero only when it is discharged through resistance or when two capacitors of equal capacitances are charged and then connected to opposite terminals. Here the capacitances are different.

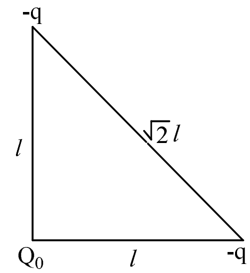
506 **(b)**

Here total electrostatic potential energy is zero

$$ie, \quad \frac{-Q_0 q}{l} - \frac{qQ_0}{l} + \frac{q^2}{\sqrt{2}l} = 0$$

On solving,

$$Q_0 = \frac{q}{2\sqrt{2}} = \frac{2q}{\sqrt{32}}$$

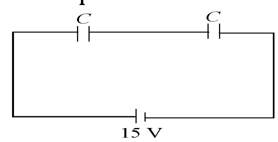


507 **(a)**

22 V get will divide into series combination of C_3 and C_4

508 **(c)**

Let capacitance of each capacitor is C.



Then equivalent capacitance in series is

$$\frac{1}{C'} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C}$$

$\Rightarrow \quad C' = \frac{C}{2}$

Charge $\quad Q = C'V = \frac{C}{2}.15 \quad$ ...(i)

When filled with dielectric

$$C_1 = 4C, \; C_2 = C$$

$$\frac{1}{C'} = \frac{1}{4C} + \frac{1}{C} = \frac{5}{4C}$$

$\Rightarrow \quad C' = \frac{4C}{5}$

Since, charge is conserved

$$Q = C'V' = \frac{4C}{5}V' \quad \text{...(ii)}$$

From Eqs. (i) and (ii), we get

$$\frac{C}{2} \times 15 = \frac{4C}{5} \times V'$$

$\Rightarrow \quad V' = \frac{15 \times 5}{4 \times 2} = 9.4\text{V}$

≈ 10 V

509 **(d)**

Net electric flux of surface

$$(\phi_2 - \phi_1) = \frac{1}{\varepsilon_0}(q) \Rightarrow q = \varepsilon_0(\phi_2 - \phi_1)$$

510 **(b)**

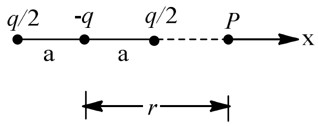
$$C' = \frac{2\varepsilon_0 A/2}{d} + \frac{3\,\varepsilon_0 A/2}{d}$$

$$C\left[1 + \frac{3}{2}\right] = \frac{5}{2} \times 0.5 = 1.25\text{ μF}$$

511 **(b)**

As $r \gg a$, so $r > 2a$

So, potential at point p



$$V=\frac{1}{4\pi\varepsilon_0}\left[\frac{\frac{q}{2}}{r+a}-\frac{q}{r}+\frac{\frac{q}{2}}{r-a}\right]$$

$$=\frac{1}{4\pi\varepsilon_0}\frac{q}{2}\left[\frac{1}{r+a}-\frac{2}{r}+\frac{1}{r-a}\right]$$

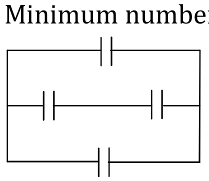
$$=\frac{q}{8\pi\varepsilon_0}\left[\frac{r(r-a)-2(r^2-a^2)+r(r+a)}{r(r^2-a^2)}\right]$$

$$=\frac{q}{8\pi\varepsilon_0}.\frac{2a^2}{r(r^2-a^2)}$$

$$=\frac{qa^2}{4\pi\varepsilon_0 r^3} \qquad (\text{as } r\gg a)$$

512 **(b)**

Minimum number of capacitors is 4



513 **(d)**

$V_B-V_A=-\int E_X dx=-[\text{Area under } E_x-x\text{curve}]$

$V_B-10=-\frac{1}{2}\times 2\times(-20)=20$

$V_B=30\text{V}$

514 **(b)**

Equivalent capacitance between points B and C is

$$C'=\frac{10\times 10}{10+10}+10=15\mu\text{F}$$

Now equivalent capacitance between points A and C is

$$C''=\frac{5\times 15}{15+5}=\frac{75}{20}\mu\text{F}$$

Charge on capacitor of capacity 5μF is

$$Q=CV=\frac{75}{20}\times 2000=7500\mu\text{C}$$

(Since, potential at the point C will be zero)

Now, potential difference across capacitor of 5μF is

$$V_A-V_B=\frac{Q}{5\mu\text{F}}=\frac{7500\mu\text{C}}{5\mu\text{C}}=1500\text{volt}$$

As, $V_A=2000\text{volt}$

Hence, $V_B=2000-1500=500$ volt.

515 **(a,b,c)**

Time of flight $(t)=\frac{2u}{g}=\frac{2\times 10}{10}=2$ sec

$$H=\frac{u^2}{2g}=\frac{10^2}{2\times 10}=5\text{m}$$

$$R=0+\frac{1}{2}\left(\frac{qE}{m}\right)t^2=\frac{1}{2}\times\frac{10^{-3}\times 10^4\times 2\times 2}{2}$$
$$=10\text{ m}$$

516 **(a,d)**

As no charge is present inside the conductor, potential at any point inside the conductor is same as that of the potential of conductor

So, potential of the conductor = Potential at the centre

$=V_q+V_{\text{induced charges}}$

i.e., $V_{\text{conductor}}=\frac{q}{4\pi\varepsilon_0(d+R)}+0$

As the total induced charge at conductor's surface is equal to zero, hence the potential at centre due to the induced charges is zero

For point B

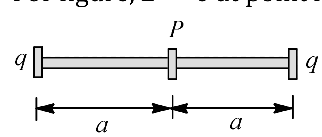
$V_{\text{conductor}}=V_{\text{at point B}}=V_q+V_{\text{induced charges}}$

$$V_{\text{induced charges}}=\frac{q}{4\pi\varepsilon_0(d+R)}-\frac{q}{4\pi\varepsilon_0 d}$$
$$=\frac{-qR}{4\pi\varepsilon_0 d(d+R)}$$

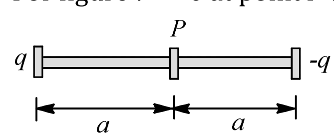
517 **(a,b,c,d)**

Positive charge moves from a region of high electric potential to a region of low electric potential, while for negative charge it reverses. If some charge is present near the conductor, then its potential gets affected

For figure, $\vec{E}=0$ at point P but V is not



For figure $V=0$ at point P but E is not



518 **(b,c)**

$V=\frac{1}{4\pi\varepsilon_0}\frac{q}{x}=600$ (i)

$E=\frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}=200$ (ii)

From Eq. (i) and Eq. (ii), $x=3$ m

From Eq.(i), $q=\frac{600\times 3}{9\times 10^9}=2\times 10^{-7}\text{C}$

$$V'=\frac{1}{4\pi\varepsilon_0}\frac{q}{x'}=9\times 10^9\times\frac{2\times 10^{-7}}{9}=200\text{ V}$$

$W=q(V'-V)=10^{-6}(200-600)=-4\times 10^{-4}$ J

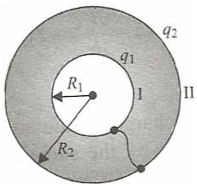
519 **(a,b,c,d)**

Points A and B lie within the same metal hence$V_A=V_B$. The potential inside a hollow sphere is same as potential at the surface, hence$V_A = V_B = V_C = V_0$

520 **(a,b,c)**

This question is based on the working principle of a generator

$$V_{\text{I}} - V_{\text{II}} = \left(\frac{q_1}{4\pi\varepsilon_0 R_1} + \frac{q_2}{4\pi\varepsilon_0 R_2}\right) - \left(\frac{q_1 + q_2}{4\pi\varepsilon_0 R_2}\right)$$



As two conductors are connected, transfer of charge takes place from one conductor to other till both acquire same potential, i.e., here

$V_{\text{I}} - V_{\text{II}} = 0$

Potential difference depends only on q_1(charge of inner conductor), so $V_{\text{I}} - V_{\text{II}} = 0$, where $q_1 = 0$, i.e., total charge is transferred to the outer conductor

521 **(a,b,c,d)**

Inside a conducting shell electric field is always zero. Therefore, option (a) is correct. When the two are connected, their potentials become the same

$\therefore \quad V_A = V_B$

Or

$$\frac{Q_A}{R_A} = \frac{Q_B}{R_B} \qquad \left(V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}\right)$$

Since, $R_A > R_B$

$\therefore \quad Q_A > Q_B$

Potential is also equal to,

$$V = \frac{\sigma R}{\varepsilon_0}$$

$V_A = V_B$

$\therefore \quad \sigma_A R_A = \sigma_B R_B$

or $\quad \dfrac{\sigma_A}{\sigma_B} = \dfrac{R_B}{R_A}$

or $\sigma_A < \sigma_B$

Electric field on surface,

$$E = \frac{\sigma}{\varepsilon_0}$$

Or $E \propto \sigma$

Since,

$\sigma_A < \sigma_B$

$\therefore E_A < E_B$

$\therefore$Correct options are (a), (b), (c) and (d).

522 **(a,b,d)**

At a centre, the force experienced by the charge particle is zero, so it is a position of equilibrium. As we displace the charge from the equilibrium position. Electric force starts acting on it towards equilibrium position and hence equilibrium is a stable one

At a distance x from the centre of sphere (equilibrium position), force experienced by the charge particle is

$F = \frac{qQx}{4\pi\varepsilon_0 R^2}$[for $x < R$]

As $\ F \propto x$, it performs S.H.M. about the centre

Time period can be calculated by using$F = m\omega^2 x$

523 **(a,c,d)**

On inserting the dielectric slab electric charge on plates remains unchanged at $Q = \frac{\varepsilon_0 AV}{d}$ in accordance with conservation of charge principle. But new electric field is $\frac{1}{K}$ times of original value. Hence, $E = \frac{V}{Kd}$. As now potential different $V' = \frac{V}{K}$, hence work done $W = \frac{1}{2}QV - \frac{1}{2}QV' =$

$\frac{QV}{2}\left[1 - \frac{1}{K}\right]$ or $W = \frac{\varepsilon_0 AV}{d}.\frac{V}{2}\left[1 - \frac{1}{K}\right] = \frac{\varepsilon_0 AV^2}{2d}\left[1 - \frac{1}{K}\right]$

524 **(a,b,d)**

$$C = \frac{\varepsilon_0 A}{d_1}, C' = \frac{\varepsilon_0 A}{d_2}$$

Extra charge flown $= Q' - Q = (C' - C)V$

$$= \varepsilon_0 AV\left[\frac{1}{d_2} - \frac{1}{d_1}\right]$$

Work done by battery:

$$W_b = V \times \text{charge flown} = \varepsilon_0 AV^2\left[\frac{1}{d_2} - \frac{1}{d_1}\right]$$

Charge in P.E. of capacitor $= \Delta U = \frac{1}{2}(C' - C)V^2$

$$= \frac{1}{2}\varepsilon_0 AV^2\left[\frac{1}{d_2} - \frac{1}{d_1}\right]$$

525 **(a,d)**

$E = at(a = \text{constant})F = QE$

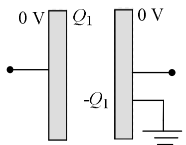
$a = F/m = QE/m = Es = ast$

$$= \frac{dv}{dt} = ast$$

Or $\ v = \frac{1}{2}ast^2 \Rightarrow v \propto s$ and t^2

526 **(a,d)**
E is a vector quantity; V is a scalar quantity

527 **(b,c,d)**
As the switch is closed, the charge on the outer surface of the second plate becomes zero. From the concept in electrostatics that electric field inside the bulk of the material of conductor is zero, we can find the charges on various faces
So, it is clear that $Q_1 + Q_2$ charge goes from the second plate to the earth. Charge on capacitor is Q_1 and hence its potential is Q_1/C



528 **(a,b,c)**
i. $E = \frac{2Q}{2A\varepsilon_0} + \frac{Q}{2A\varepsilon_0} \Rightarrow E = \frac{3Q}{2A\varepsilon_0}$

$$E = \frac{3}{2}\frac{Q}{Cd} \Rightarrow Ed = \frac{3Q}{2C} = V$$

ii. $F = E(-Q); F = \left(\frac{2Q}{2A\varepsilon_0}\right) \times \frac{(-Q)}{1} = \frac{Q^2}{A\varepsilon_0}$

$$\Rightarrow F = \frac{Q^2}{A\varepsilon_0}$$

iii. Energy $= \frac{1}{2}\varepsilon_0 E^2 Ad = \frac{1}{2}\varepsilon_0\left(\frac{3Q}{2Cd}\right)Ad = \frac{9}{8}\frac{Q^2}{C}$

529 **(b,c)**
At any point outside the shell $V = \frac{Q}{4\pi\varepsilon_0 r}$, where r is the radius of spherical shell.
The outer surface of the spherical shell is an equipotential surface.

530 **(a,b,c)**
$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r} = 600\text{V}$
And $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} = 200\ \text{NC}^{-1}$
Hence, $\frac{V}{E} = r = \frac{600}{200} = 3\text{m}$
Now, $\frac{q}{4\pi\varepsilon_0 r} = 600; \frac{q}{4\pi\varepsilon_0 r'} = V'$
$\therefore \frac{V'}{600} = \frac{r}{r'} = \frac{3}{9}$
Or $V' = 200\text{V}$
$W = q(V - V') = 10^{-6}(600 - 200)$
$= 4 \times 10^{-4}$ J

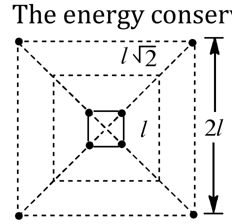
531 **(a,c)**
$\vec{E}_A$ is along $\overrightarrow{OA}$ and $\overrightarrow{OA} = \hat{\imath} + 2\hat{\jmath} + 3\hat{k}$
$\vec{E}_B$ is along $\rightarrow \overrightarrow{OB} = \hat{\imath} + \hat{\jmath} - \hat{k}$
Since $\overrightarrow{OA} \cdot \overrightarrow{OB} = (\hat{\imath} + 2\hat{\jmath} + 3\hat{k}) \cdot (\hat{\imath} + \hat{\jmath} - \hat{k}) = 0$
So $\overrightarrow{OA} \perp \overrightarrow{OB} \Rightarrow \vec{E}_A \perp \vec{E}_B$
So, option (a) is correct.
Since $\vec{E}_B = \frac{kq}{|OC|^2} = \frac{kq}{3}$
$\vec{E}_C = \frac{kq}{|OC|^2} = \frac{kq}{12}$
So $\frac{E_B}{E_C} = 4$ or $|\vec{E}_B| = 4|\vec{E}_C|$
So option (c) is correct
Option (b) and (d) are wrong from the explanation

532 **(b,d)**
The electric field inside any point of the sphere is zero

533 **(a,c,d)**
This system can be considered as two capacitor in parallel, with $C_1 = \frac{\varepsilon_0 A}{2d}$ and $C_2 = \frac{K\varepsilon_0 A}{2d}$
C_1 is due to upper half of two plates while C_2 is due to lower half
As potential difference across two capacitors is the same, charge would be difference as capacitors are different

534 **(a,b,c,d)**
As for $r \leq R_0$, electric potential is constant, hence E inside the sphere is zero and consequently electrostatic energy is not stored at all inside the sphere. This indicates that the sphere is a thin spherical shell and charge lies only on its surface ie, at $r = R_0$. No charge is outside. moreover, as for $r < R_0$, $E = 0$ and at $r = R_0$ electric field suddenly appears, it shows that E is discontinuous at $r = R_0$.

535 **(a,c)**
Since the situation is having symmetry, the particles move symmetrically along the diagonal as shown in figure
The energy conservation law is to be used



$$U_i = \frac{1}{4\pi\varepsilon_0}\left[\frac{4q^2}{l} + \frac{2q^2}{\sqrt{2}l}\right]$$
$$U_f = \frac{1}{4\pi\varepsilon_0}\left[\frac{4q^2}{2l} + \frac{2q^2}{\sqrt{2} \times \sqrt{2}l}\right]$$
$$U_i = U_f + \frac{4mv^2}{2}$$
$$2mv^2 = \frac{1}{4\pi\varepsilon_0}\left[\frac{2q^2}{l} + \frac{q^2}{l\sqrt{2}}\right]$$

$$v=\left[\frac{q^2}{8\pi\varepsilon_0 ml}\left(2+\frac{1}{\sqrt{2}}\right)\right]^{1/2}$$

536 **(c,d)**

As points A and B are at different distances from charge q, hence electric field at A and B is different. Induced charge is present on the inner surface of cavity but surface density of charge at A and B are different due to different curvatures at these points.

Potentials at A and B are equal because A and B lie on a metallic conductor and a metallic surface is an equipotential surface.

As per gauss theorem total flux $\phi_E=\frac{q}{\varepsilon_0}$.

537 **(a,c)**

As A and C are earthed, they are connected to each other. Hence, $'A+B'$ and $'B+C'$ are two capacitors with the same potential difference. If B is closer to A than to C; then the capacitance $C_{AB}>C_{BC}$. The upper surface of B will have greater charge than the lower surface. As the force of attraction between the plates of a capacitor is proportional toQ^2, there will be a net upward force on B. This can balance its weight.

538 **(a,d)**

Suppose a positively charged sphere is brought near an uncharged metallic sphere, Then on nearer surface of the uncharged sphere, negative charge is induced and on farther surface, positive charge is induced. Hence, a force of attraction will be observed between these two spheres.

Therefore, if a force of attraction is observed between a positively charged sphere and a metallic sphere, it cannot be concluded that the metallic sphere is necessarily negatively charged. Therefore, option (b) is wrong and options (a) and (d) are correct

539 **(c,d)**

A close loop shaped line of force can never represent an electrostatic field as well as gravitational field of a mass at rest. However, magnetostatic field line is always a closed loop and field line due to induced electric field (being non-conservative) may also on a closed loop.

540 **(b,c,d)**

As the dielectric slab is pulled out, the equivalent capacity of the system decreases and hence charge supplied by the battery decrease as potential of the system remains constant. It means charging of battery takes place and a positive charge flows a to b. As the two capacitors are connected in series, so charge on both capacitors remains the same at all instants

From energy conservation law,

$U_i+W_{\text{ext}}=U_f+$ work done on battery $+\Delta H$

As dielectric slab is attracted by the plates of capacitors, to pull it out F has to perform some work, i.e., $W_{\text{ext}}(F)>0$

541 **(a,b,c,d)**

Charge on $a_1=(r_1\theta)\lambda$

Charge on $a_2=(r_2\theta)\lambda$

Ration of the charges $=\frac{r_1}{r_2}$

E_1(Field produced by a_1)$=\frac{K[(r_1\theta)\lambda]}{r_1^2}=\frac{K\theta\lambda}{r_1}$

E_2(Field produced by a_1)$=\frac{K\theta\lambda}{r_2}$

As $r_2>r_1$, therefore $E_1>E_2$

i.e., Net field at A is towards a_2

$$V_1=\frac{K(r_1\theta)}{r_1}=K\theta\lambda$$

$$V_2=\frac{K(r_2\theta)}{r_2}=K\theta\lambda$$

$V_1=V_2$

542 **(a,c,d)**

$$0\le x\le a;V_x=\left[-\int_0^x E_x dx\right]+V_{(0)}=0$$

(as $E_x=0$)

$$x\ge a;V=-\int_a^x E_x dx+V_{(a)}$$

$$V=\left[-\int_a^x\frac{\sigma}{\varepsilon_0}dx\right]+V_{(a)}=-\frac{\sigma}{\varepsilon_0}(x-a)$$

$$=\frac{-\sigma}{\varepsilon_0}(x-a)$$

$$x\le 0;V=-\int_a^x E_x dx+V_{(0)}\left[\because E_x=\frac{-\sigma}{\varepsilon_0}\right]$$

$$=-\left(-\frac{\sigma}{\varepsilon_0}x\right)+V_{(0)}=\frac{\sigma}{\varepsilon_0}x$$

543 **(b,c,d)**

Charge on inner sphere can be supposed to be concentrated as a point charge at the centre, hence electric field at a point in the region between the spheres at a distance r from the centre $=(q/4\pi\varepsilon_0 r^2)$.Due to induction, equal and opposite charges will appear on the inner and outer surfaces of the outer sphere.Hence, net charge which can be supposed to be placed at the centre=q and electric field due to it at a point outside the hollow sphere at a distance r from centre $=(\frac{q}{4\pi}\in_0 r^2)$

Potential of inner sphere= $\frac{q}{4\pi\varepsilon_0}\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}\right)$

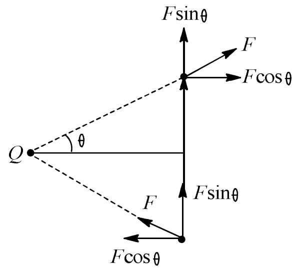
And potential of outer sphere $=\frac{q}{4\pi\varepsilon_0 c}$

Potential of inner sphere with respect to the outer sphere

$\frac{q}{4\pi\varepsilon_0}\left(\frac{1}{a}-\frac{1}{b}\right)$

544 **(b,c)**

The situation is shown in Figure



$\vec{F}_{net} = 2F\sin\theta \uparrow = \frac{PQ}{4\pi\varepsilon_0 r^3}$

$\vec{\tau} = F\cos\theta \times 2a$ in clockwise direction

$= \frac{PQ}{4\pi\varepsilon_0 r^2}$

545 **(c,d)**

$\vec{r}_P = \hat{\imath} + 2\hat{\jmath} + 4\hat{k}; \vec{r}_q = 3\hat{\imath} + 2\hat{\jmath} + \hat{k}$

$|\vec{r}_q - \vec{r}_P| = \sqrt{[(2)^2 + (-3)^2]} = \sqrt{13}$

As $q = 2 \times 10^{-8}$C, hence

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{|\vec{r}_q} - \vec{r}_P|$

$= \frac{9\times10^9 \times 2\times10^{-8}}{\sqrt{13}} = 49.9$ V

$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{|\vec{r}_q - \vec{r}_P|^2}\frac{(\vec{r}_q - \vec{r}_P)}{|\vec{r}_q - \vec{r}_P|}$

$= \frac{1}{4\pi\varepsilon_0}\frac{q}{|\vec{r}_q - \vec{r}_P|^3}(2\hat{\imath} - 3\hat{k})$

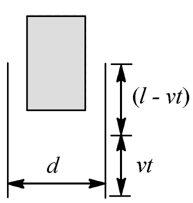
(By filling a dielectric of dielectric constant K, electric field gets decreased as $E = E_0/K$ and $K > 1$)

546 **(b,c,d)**

$V_P = \frac{kq}{r}$(independent of x)

547 **(a,c)**

Let the length, width and thickness of slab be l, b and d respectively. K be the dielectric constant of dielectric



At time t length t of the slab has been pulled out, so at this instant the capacitor may be considered as a parallel combination of two capacitors as shown. The capacitance of combination is

$C = \frac{\varepsilon_0 vtb}{d} + \frac{\varepsilon_0 Kb(l-vt)}{d}$;

$C = \frac{\varepsilon_0 b}{d}[vt + K(l - vt)$

$\Rightarrow \quad C = \frac{\varepsilon_0 b}{d}[Kl - (K-1)vt]$

This equation is of straight line, having positive intercept and negative slope. Hence, option (a) is correct and option (b) is incorrect

Since battery is disconnected, so charge on capacitor remains constant

$V = \frac{q}{C}$ or $V \propto \frac{1}{C}$

Hence, current between V and C will be rectangular hyperbola

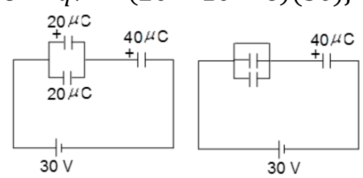
So, option (c) is correct and option (d) is incorrect

548 **(a,c,d)**

The amount of charge flown through the battery is $q = 20\mu$C. Because charge on the right capacitor changes by 20μC. Charge flown through the switch is $60m$C. It is because the sum of charge of both the left capacitors and the charge which flows through the battery will pass through the switch

Therefore, energy supplied by the battery is

$U = qV = (20 \times 10 - 6)(30)\text{J} = 0.6$ mJ



Energy stored in all the capacitors before closing the switch S is

$U_i = \frac{1}{2}C_{\text{net}}V^2 = \frac{1}{2}\left(\frac{4}{3}\times10^{-6}\right)(30)^2 = 0.6$ mJ

And after closing the switch

$U_f = \frac{1}{2}C_{\text{net}}V^2 = \frac{1}{2}(2\times10^{-6})(30)^2 = 0.3$ mJ

Therefore, heat generated $H = U(U_f - U_i) =$ 0.3 mJ

549 **(a,c)**

$\vec{E} = 54\hat{\imath} + 74\hat{\jmath}, E = 90\text{NC}^{-1}$

$90 = \frac{9\times10^9 Q}{r^2}$ (i)

$V = 1800 = \frac{9\times10^9 Q}{r}$ (ii)

From Eqs. (i) and (ii), we get

$r = 20M, q = 4\mu$C

Now, $\frac{(9-x_0)\hat{\imath}+(4-y_0)\hat{\jmath}}{20} = \frac{54\hat{\imath}+72\hat{\jmath}}{90}$

$\Rightarrow x_0 = -3, y_0 = -12$

550 **(b,c)**

$C = \frac{Q}{V}$ also, $C = \frac{\varepsilon_0 A}{d}$

As d increases, C will decrease

Therefore, V should increase, as Q remains the same $E = \frac{V}{d} = \frac{Q}{A\varepsilon_0}$ will be constant

Energy, $U = \frac{Q^2}{2C}$. As C decreases, U will increase

551 **(b,c)**

Energy density, $u = \frac{1}{2}\varepsilon_0 E^2$

552 **(a,b)**

If the charge is given to a conducting sphere, then an electric field is established in the surrounding space. Magnitude of electric field is maximum just outside the sphere. This maximum electric field may be increased to the dielectric strength of the surrounding medium. Therefore, three is a limiting value of maximum charge which can be given to the conducting sphere. Hence, option (c) is wrong. Obviously, the conducting sphere cannot be charged to a potential greater than a certain value. Hence, option (a) is correct. It can be easily said that option (b) is also correct

553 **(a,d)**

Let q_1 and q_2 be the instantaneous charges on capacitors. Since they are in parallel, then

$\frac{q_1}{C_1} = \frac{q_2}{C_2}$ and $q_1 + q_2 = Q$

$$C_1 = \frac{\varepsilon_0 A}{d_0 + vt}, C_2 = \frac{\varepsilon_0 A}{d_0 - vt}$$

So $\frac{q_1}{q_2} = \frac{C_1}{C_2} = \frac{d_0 - vt}{d_0 + vt} \Rightarrow q_2\left(\frac{d_0 - vt}{d_0 + vt}\right) + q_2 = 0$

So $q_2 = \frac{Q(d_0 + vt)}{2d_0}$ and $q_1 = \frac{Q(d_0 - vt)}{2d_0}$

Hence, option (a) is correct and option (b) is incorrect

$i = \frac{-dq_1}{dt}$ or $\frac{dq_2}{dt}$ or $i = \frac{Qv}{2d_0}$

Which does not depend on time. So option (d) is correct and option (c) is incorrect

554 **(a,c)**

For a non-conducting solid charged sphere

(i) For $0 < r < R$, magnitude of electric field $E \propto r$ and hence increases with increase in r.

(ii) For $R < r < \propto$, magnitude of electric field $E \propto \frac{1}{r^2}$ and hence decreases with increases in r.

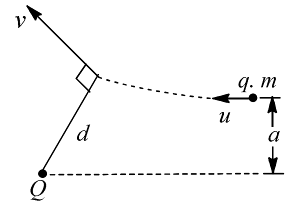
555 **(b,c,d)**

The path traced by q is shown in Figure, the path is curvilinear and acceleration is due to the force exerted by Q on q

The separation between them is minimum if relative velocity of the particle along the line joining them is zero. Let d be the minimum separation between them. As torque about Q is zero, angular momentum remains conserved

$$mua = mvd \Rightarrow v = \frac{ua}{d}$$

From energy conservation law, $\frac{mu^2}{2} = \frac{mv^2}{2} + \frac{1}{4\pi\varepsilon_0}\frac{qQ}{d}$



556 **(a,d)**

When capacitors are connected in parallel, initial capacitance is $C = 2\varepsilon_0 A/d$. After the distance between the plates is changed, the capacitance becomes

$C = \frac{\varepsilon_0 A}{d+a} + \frac{\varepsilon_0 A}{d-a}$ or

$$C = \frac{2\varepsilon_0 A}{d - (a^2/d)}$$

Which is greater than initial one. Hence, option (a) is correct and option (b) is incorrect

When capacitors are connected in series, then

$$\frac{1}{C} = \frac{2d}{\varepsilon_0 A}$$

After the distance between the plates is changed,

$$\frac{1}{C} = \frac{d+a}{\varepsilon_0 A} + \frac{d-a}{\varepsilon_0 A} = \frac{2d}{\varepsilon_0 A}$$

That is, the capacitance remains unchanged. Hence, option (d) is correct and option (c) is incorrect

557 **(a,c)**

Initial stored energy $U_i = \frac{1}{2}\frac{\varepsilon_0 A V_1^2}{x}$

Final stored energy $U_f = \frac{1}{2}\frac{\varepsilon_0 A V_0^2}{2(x+dx)}$

So $\Delta U = U_f - U_i = \frac{1}{2}\varepsilon_0 A V_0^2\left[\frac{1}{x+dx} - \frac{1}{x}\right]$

$$= \frac{1}{2}\varepsilon_0 A V_0^2\left[\frac{x - x - dx}{x(x+dx)}\right]$$

$$= \frac{1}{2}\frac{\varepsilon_0 A V_0^2}{x^2}dx = -\frac{1}{2}\frac{\varepsilon_0 A V_0^2}{x}\cdot\frac{dx}{x} = \frac{U dx}{x}$$

So, option (a) is correct and option (b) is incorrect

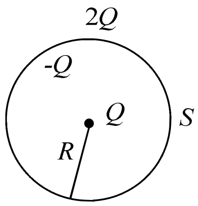
$$F = -\frac{dU}{dx} = -\frac{U}{x}$$

$$= -\frac{1}{2}\frac{\varepsilon_0 A}{x}\cdot\frac{V_0^2}{x} = -\frac{1}{2}\left(\frac{\varepsilon_0 A}{x}V_0\right)\frac{V_0}{x} = -\frac{1}{2}qE$$

So magnitude of attractive force is $\frac{1}{2}qE$

So option (c) is correct and option (d) is incorrect

558 **(a,c,d)**



Charge density at the outer surface (figure)is

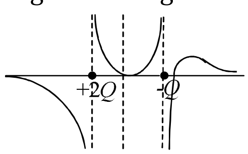
$$\frac{2Q}{4\pi R^2}=\frac{Q}{2\pi R^2}$$

$$E_{\text{inside}}=\frac{2Q}{4\pi\varepsilon_0 R^2}, E_{\text{outside}}=\frac{2Q}{4\pi\varepsilon_0 R^2}$$

$$\therefore E_{\text{outside}}=2E_{\text{inside}}$$

559 **(a,d)**

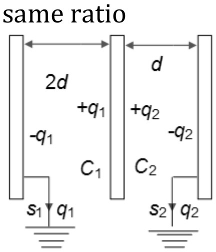
Electric field is zero only at a point in region III. Equilibrium at this point will be stable for a negative charge



560 **(a,b,c)**

When either A or C is earthed (but not both together), a parallel-plate capacitor is formed with$B$, with $\pm Q$ charges on the inner surfaces. (The other plate, which is not earthed, plays no role.) Hence, charge of amount $+Q$ flows to the earth.

When both area earthed together, A and C effectively become connected. The plates now form two capacitors in parallel, with capacitances in the ratio 1:2, and hence share charge Q in the same ratio



Now we can write $\frac{q_1}{q_2}=\frac{C_1}{C_2}=\frac{1}{2}$, because potential difference of both the capacitors is same. And $q_1+q_2=Q$. solving these, we get

$$q_1=\frac{Q}{3}, q_2=\frac{2Q}{3}$$

561 **(a,b)**

Electric field lines will be from M to N, so potential of N will be less than that of M

562 **(a,b,c)**

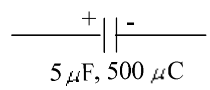
If there is no external electric field, then the charge given to a conducting sphere gets uniformly distributed over its surface. Therefore, option (a) is correct. If an external electric field exists, then the charge gets distributed over the surface of the sphere in such a way that the electric field inside the sphere can become equal to zero. Hence, distribution of the charge on the surface of sphere will be non-uniform.

Therefore, option (b) is correct. Obviously, option (d) is wrong.

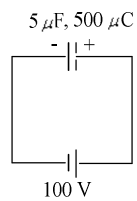
Since electric field inside the conducting sphere is equal to zero, therefore, potential difference between two points in the sphere is equal to zero. It means, the potential is same at every point of the sphere. Therefore, option (c) is correct

563 **(b,c)**

Initial condition just after the connection of battery



Condition after a long time:



It means battery supplies 1000 μC charge from its positive terminal and an equal and opposite charge enters from its negative terminal, i.e., charge flow through battery is 1000 μC

Work done by the battery, $W_{\text{battery}}=100\text{ V}\times 10^3\,\mu\text{C}=0.1\text{ J}$

From energy conservation law, $U_i+W_{\text{battery}}=U_f+\Delta H$

$U_i=U_f$ so $\Delta H=0.1$ J

564 **(c,d)**

Torque will be perpendicular to the line $y=2x$ and it should be in $x-y$ plane, because electric field is in z-direction. The lines in options (c) and (d) are perpendicular to $y=2x$

565 **(a,c)**

After disconnecting battery if plates of a parallel plate capacitor are moved apart then capacity C decreases, V and E increase, Qremains unchanged and electrical energy U increases.

566 **(a,d)**

When a negative charge moves from high potential to low potential, its potential energy increases

$W_{\text{el}}=q(V_1-V_2)$

As $V_1>V_2$ and q is negative, hence

W_{el}= negative

567 **(a,c)**

Force on a negative charge $\vec{F} = -q_0\vec{E}$ is always directed towards the centre of ring and is variable as $E = \frac{1}{4\pi\varepsilon_0}\frac{dx}{(x^2+R^2)^{3/2}}$. consequently, motion of charged particle will definitely be periodic. Moreover, if $x << R$, then $E = \frac{1}{4\pi\varepsilon_0 R^2}.x$ and $F = -\frac{qq_0}{4\pi\varepsilon_0 R^2}.x$ $ie, F \propto -x$. It shows that motion will be simple harmonic.

568 **(a,c,d)**

$V(x) = 4 + 5x^2$

$V(x = 1) = 9\text{V}$

And $V(X = -2) = 24\text{V}$

Hence, $\Delta V = 15\text{V}$

$E = -(\Delta V/\Delta x) = -10x$

$\therefore$ $E(\text{at } x = -1\text{m}) = 10 \text{ NC}^{-1}$

So, $F = qE = +10$ N (along +ve x-axis)

569 **(a,c)**

$$\frac{1}{4\pi\varepsilon_0}\frac{Q}{R} + \frac{1}{4\pi\varepsilon_0}\frac{q}{(R_0 - vt)} = 0$$

Where R_0 is the initial distance of the charged particle

$$Q = \frac{Rq}{R_0 - vt} \Rightarrow \frac{dQ}{dt} = i = \frac{Rqv}{(R_0 - vt)^2}$$

570 **(b,c)**

For a uniformly charged circular ring the electric field intensity is maximum at its axial line at a distance $x = \pm\frac{R}{\sqrt{2}}$ from the centre of ring and $|E_{\text{max}}| = \frac{1}{4\pi\varepsilon_0}.\frac{2q}{3\sqrt{3}R^2} = \frac{q}{6\sqrt{3}\pi\varepsilon_0 R^2}$.

571 **(a,b,c,d)**

Here all the four statement are false. If $E = 0$, V may or may not be zero. Similarly, if $V = 0$ the E may not be zero. Again $E \neq 0$ does not necessarily mean that $V \neq 0$ and $vice - versa$

572 **(a,c)**

If positive test charge is displaced along x-axis, then net force will always act in a direction opposite to that of displacement and the test charge will always come back to its original position. But if test charge is displaced along y-axis, it will never come back to its original position and will fly away along y-axis