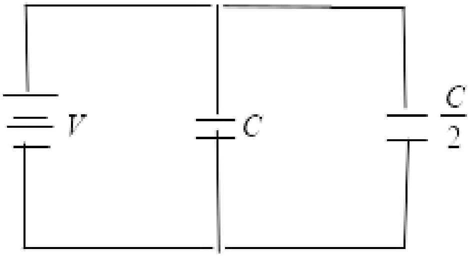
Single Correct Answer Type

1. 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)

2. 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

3. The capacitance of a parallel plate capacitor with air as medium is $3\mu F$. With the introduction of a dielectric medium between the plates, the capacitance becomes $15\mu F$. The permittivity of the medium is
a) $5C^2N^{-1}m^{-2}$ b) $15C^2N^{-1}m^{-2}$
c) $0.44\times10^{-10}C^2N^{-1}m^{-2}$ d) $8.854\times10^{-11}C^2N^{-1}m^{-2}$

4. The SI unit of surface integral of electric field is
a) V-m b) V c) NC^{-1}m d) Cm^{-3}

5. 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) $3U/2$ b) U c) $U/4$ d) $U/2$

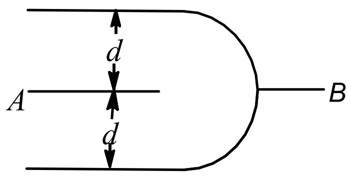
6. The plates of a parallel plate capacitor are charged up to 100 V. A 2 mm thick plate is inserted between the plates, then to maintain the same potential difference, the distance between the capacitor plated is increase by 1.6 mm. the dielectric constant of the plate, is
a) 5 b) 1.25 c) 4 d) 2.5

7. 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

8. 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) $\frac{Qq}{2\pi\varepsilon_0 a}$

9. The capacitance of an isolated conducting sphere of radius $R$is proportional to
a) R^{-1} b) R^2 c) R^{-2} d) R

10. 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) $\frac{2\varepsilon_0 A}{d}$

11. 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

12. 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

13. 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) $\frac{Q}{r'+r}$

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

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

15. 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

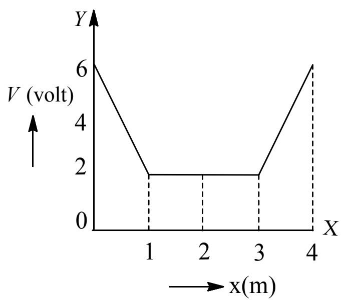
16. The electric flux from a cube of edge l is ϕ. What will be its value if edge of cube is made $2l$and charge enclosed is halved

a) $\phi/2$ b) 2ϕ c) 4ϕ d) 5ϕ

17. The displacement of a charge Qin the electric field $E=e_1\hat{i}+e_2\hat{j}+e_3\hat{k}\, is\, r=a\hat{i}+b\hat{j}$. 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) $Q(\sqrt{e_1^2-e_2^2})(a+b)$

18. 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

19. 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) 2 E c) E/4 d) E

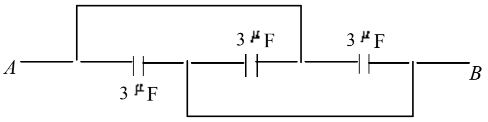
20. A 100 eV electron is fired directly towards a large metal plate having surface charge density $-2\times10^{-6} c\,m^{-2}$. The distance from where the electrons be projected so that it just fails to strike the plate is

a) 0.22mm b) 0.44mm c) 0.66mm d) 0.88mm

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

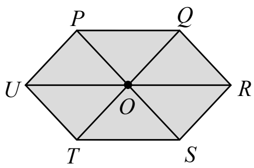
a) Vn b) V/n c) $V n^{1/3}$ d) $V n^{2/3}$

22. The effective capacitance between points $A \wedge B$ is



a) $9\ \mu F$ b) $3\ \mu F$ c) $6\ \mu F$ d) $1\ \mu F$

23. 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) $-,+,+,-,+,-¿$

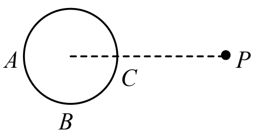
24. The plates of a parallel plate capacitor are charged upto 200 V. A dielectric slab of thickness 4 mm is inserted between its plates. Then, to maintain the same potential difference between the plates of the capacitor, the distance between the plates is increased by 3.2 mm. The dielectric constant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

a) 1 b) 4 c) 5 d) 6

25. 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

26. 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) $V_A = V_C$

27. 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

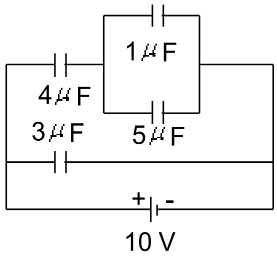
28. There are 10 condensers each of capacity 5 μF. The radio between maximum and minimum capacities obtained from these condenses will be

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

29. Taking earth to be a metallic spheres, its capacity will approximately be

a) 6.4×10^{6}F b) 700 F c) 711 μF d) 700 pF

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

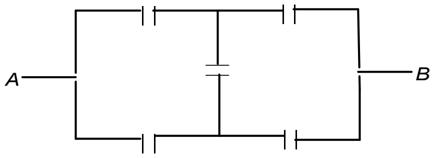


a) 40 μC b) 30 μC c) 24 μC d) 54 μC

31. 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

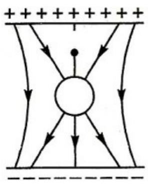
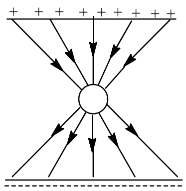
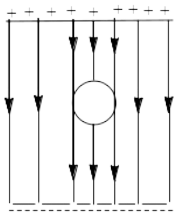
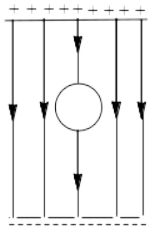
a) V b) $2V$ c) $4V$ d) $-2V$

32. Each capacitor shown in figure is $2\mu F$ .Then the equivalent capacitance between points $A \wedge B$ is



a) $2\ \mu F$ b) $4\ \mu F$ c) $6\ \mu F$ d) $8\ \mu F$

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

a) 
b) 
c) 
d) 

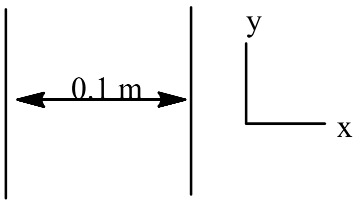
34. Along the x-axis, three charges $\frac{q}{2}, -\frac{q \wedge q}{2}$ are placed at $x=0, x=a \wedge x=2a$ respectively. The resultant electric potential at a point P located at a distance r from the charge $-q(a \ll r)$ is (ε_0 is the permittivity of free space)

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) $\frac{q}{4\pi\varepsilon_0 r}$

35. A parallel plate capacitor is charged. If the plates are pulled apart

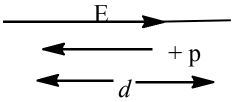
a) The capacitance increases
b) The potential difference increases
c) The total charge increases
d) The charge and potential difference remain the same

36. Two insulating plates are both uniformly charged in such a way that the potential difference between them is $V_2 - V_1 = 20$V. (*ie*, plate 2 is at a higher potential). The plates are separated by $d = 0.1$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) $2.65\times10^{6} ms^{-1}$ b) $7.02\times10^{12} ms^{-1}$ c) $1.87\times10^{6} ms^{-1}$ d) $32\times10^{-19} ms^{-1}$

37. In the figure, a proton moves a distance d in a uniform electric field **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?

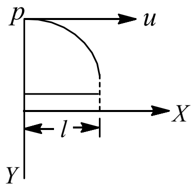


a) Negative, increase b) Positive, decrease c) Negative, decrease d) Positive, increase

38. 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

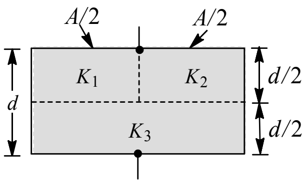
39. A parallel plate condenser with oil (dielectric constant 2) between the plates has capacitance C. If oil is removed, the capacitance of capacitor becomes
a) $\sqrt{2C}$ b) $2C$ c) $\frac{C}{\sqrt{2}}$ d) $\frac{C}{2}$

40. 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) $\frac{d\varepsilon_0 mu}{el}$

41. A parallel plate capacitor of area A, plate separation d and capacitance C is filled with three different dielectric materials having dielectric constants $K_1, K_2 \wedge K_3$ 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) $\frac{1}{K}=\frac{1}{K_1}+\frac{1}{K_2}+\frac{1}{2K_3}$ b) $\frac{1}{K}=\frac{1}{K_1+K_2}+\frac{1}{2K_3}$ c) $K=\frac{K_1K_2}{K_1+K_2}+2K_3$ d) $K=K_1+K_2+2K_3$

42. 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

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

44. 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

45. 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) 4μF b) $(4/3)\mu$F c) 2μF d) $(3/4)\mu$F

46. 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}

47. 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) $12\mu F$ b) $15\ \mu F$ c) $25\ \mu F$ d) $30\ \mu F$

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

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

49. 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) $V_A ¿ V_C$

50. 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) $1.6\times10^{-2} J$ b) 3.2 J c) 1.6 J d) 4.2 J

51. 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) $2C(1+K)$

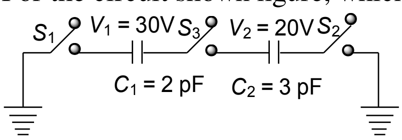
52. If dielectric constant and dielectric strength be denoted by K and X respectively, then a material suitable for use as a dielectric in a capacitor must have

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

53. 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

54. 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, $V_1=V_2=20V$

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

55. An infinite line charge produces a field of $9\times10^4 N C^{-1}$ at a distance of 2 cm. the linear density is

a) $2\times10^{-7} C m^{-1}$ b) $10^{-7} C m^{-1}$ c) $9\times10^{4} C m^{-1}$ d) None of these

56. Three capacitors of capacitance $1\mu F, 2\mu F \wedge 3\mu F$ are connected in series and a potential difference of 11 V is applied across the combination. Then, the potential difference across the plate of $1\mu F$ capacitor is

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

57. 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) $4F$

58. 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) $22\ \mu$F b) $26.6\ \mu$F c) $52.2\ \mu$F d) $13\ \mu$F

59. 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) $\vec{E}_2 = \frac{\vec{E}_1}{8}$

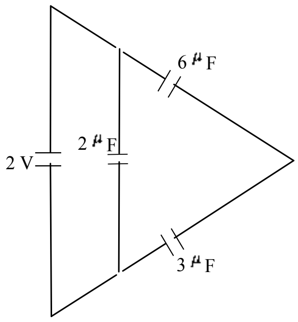
60. Two identical air core capacitors are connected in series to a voltage source of 15 V. If one of the capacitors is filled with a medium of dielectric constant 4, the new potential across this capacitor is

a) 5 V b) 8 V c) 10 V d) 12 V

61. 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

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



a) $2\ \mu J$ b) $4\ \mu J$ c) $8\ \mu J$ d) $16\ \mu J$

63. Two free protons are separated by a distance of 1 $\mathring{A}$. 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

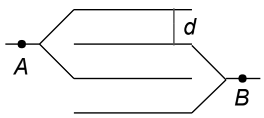
64. The work done in bringing a unit positive charge from infinity distance to a point at distance X from a positive charge Q is W. Then, the potential ϕ at the point is

a) $\frac{WQ}{X}$ b) W c) $\frac{W}{Q}$ d) WQ

65. 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

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



a) 2μF b) 4μF c) $7\ \mu$F d) $9\ \mu$F

67. 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

68. 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

69. 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

70. 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) $\frac{QQ'}{2r}$

71. 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

72. 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

73. Two capacitor of capacity $6\,\mu F$ and $12\,\mu F$ in series are connected by potential of 150 V. the potential of capacitor of capacity $12\,\mu F$ will be

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

74. 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) $\frac{1}{2}$

75. The potential at a point P which 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

76. 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

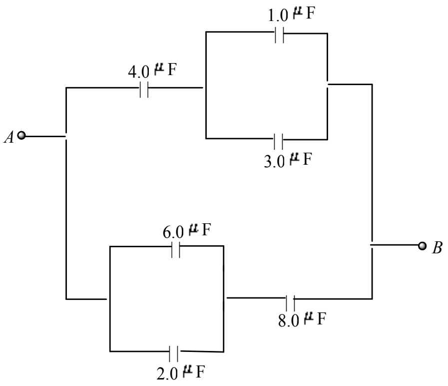
77. Two capacitors of capacitance $2\,\mu F \wedge 4\,\mu F$ respectively are connected in series. The combination is connected across a potential difference of 10 V. The ratio of energies stored by capacitors will be

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

78. A $20\mu F$ capacitor is connected to 45 V battery through a circuit whose resistance is 2000Ω. What is the final charge on the capacitor?

a) $9\times10^{-4}C$ b) $9.154\times10^{-4}C$ c) $9.8\times10^{-4}C$ d) None of these

79. The equivalent capacitance between points $A \wedge B$ for the combination of capacitors shown in figure, where all capacitances are in microfarad is



a) $6.0\ \mu F$ b) $4.0\ \mu F$ c) $2.0\ \mu F$ d) $3.0\ \mu F$

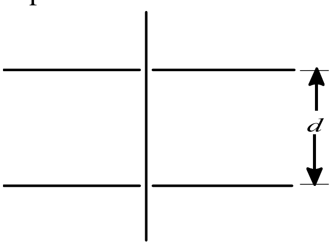
80. An air filled parallel plate capacitor has a capacity of 2pF. The separation of the plates is doubled and the interspace between the plates is filled with wax. If the capacity is increased to 6 pF, the dielectric constant of wax is

a) 2 b) 3 c) 4 d) 6

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

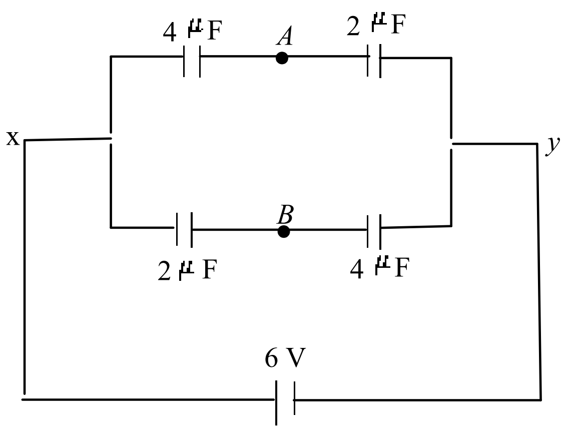
a) $50\ Vm^{-1}$ b) $500\ Vm^{-1}$ c) $0.5\ Vm^{-1}$ d) $20\ Vm^{-1}$

82. A capacitor of capacitance $1\mu F$ is filled with two dielectrics of dielectric constant 4 and 6. What is the new capacitance?



a) $10\ \mu F$ b) $5\ \mu F$ c) $4\ \mu F$ d) $7\ \mu F$

83. What is the potential difference between points $A \wedge B$ in the circuit shown?



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

84. 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

85. 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

86. Two capacitors of capacitances C_1 and C_2 are connected in parallel across a battery. If Q_1 and Q_2 respectively be

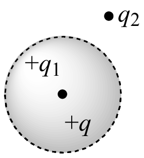
the charges on the capacitors, then $\frac{Q_1}{Q_2}$ will be equal to

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

87. Two parallel plate capacitors of capacitance $C \wedge 2C$ 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

88. 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) $+q_1 \wedge -q_1$

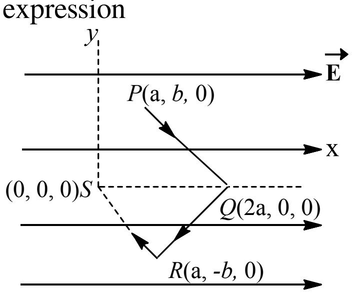
89. An AC source is rated at 220 V, 50 Hz. The time taken for voltage to change from its peak value to zero is

a) 50 s b) 0.02 s c) 5 s d) $5 \times 10^{-3} s$

90. 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) $\sqrt{\frac{2ms\Delta T}{C}}$

91. A point charge q moves from point $\underset{\rightarrow}{P}$ to point S along the path *PQRS* in a uniform electric field $\vec{E}$ 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

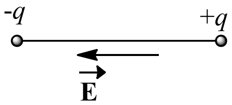


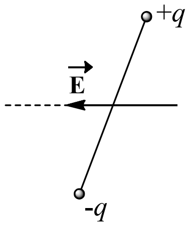
a) qE b) $-qaE$ c) $q¿$ d) $3qE\sqrt{a^2+b^2}$

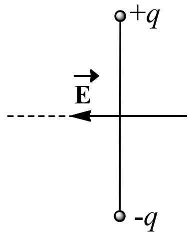
92. A variable condenser is permanently connected to a 100 V battery. If capacity is changed from 2 μF and 10 μF, then energy change is equal to

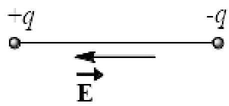
a) 2×10^{-2}J b) 2.5×10^{-2}J c) 6.5×10^{-2}J d) 4×10^{-2}J

93. In which of the states shown in figure is the potential energy of a electric dipole maximum?

a) 

b) 

c) 

d) 

94. A 10 μF 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) $200\,V$

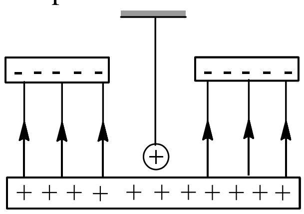
95. In bringing an electron towards another electron, the electrostatic potential energy of the system

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

96. 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) $\frac{\varepsilon_0 V^2}{4r^2}$

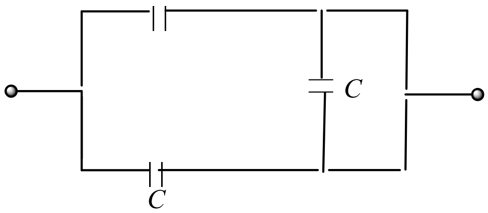
97. If a positively charged pendulum is oscillating in a uniform electric field as shown in figure. Its time period as compared to that when it was uncharged will



a) Increase b) Decrease

c) Not change d) First increase and then decrease

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

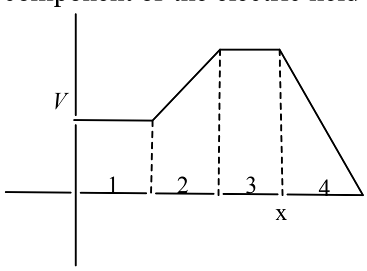


a) $2C$ b) C c) $\frac{1}{2}C$ d) None of these

99. 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

100. 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) $E_1 > E_3 > E_2 > E_4$

101. 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

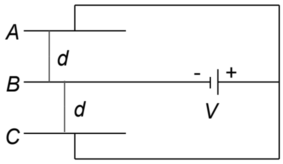
a) $\frac{qR}{4\pi\varepsilon_0 d^2}$

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

c) Zero

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

102. 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

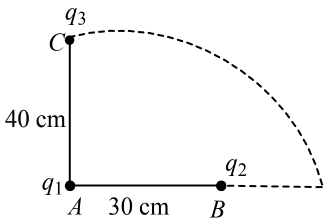


a) $\frac{\varepsilon_0 A V^2}{2d}$ b) $\frac{\varepsilon_0 A V^2}{d}$ c) $\frac{2\varepsilon_0 A V^2}{d}$ d) $\frac{3\varepsilon_0 A V^2}{2d}$

103. 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 B also 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

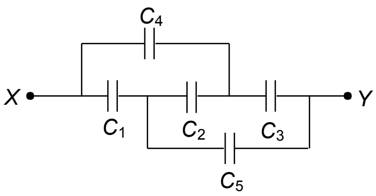
a) $\frac{\sigma l}{\varepsilon_0 B}$ b) $\frac{\sigma B}{\varepsilon_0 l}$ c) $\frac{\varepsilon_0 lB}{\sigma}$ d) $\frac{\varepsilon_0 l}{\sigma B}$

104. 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



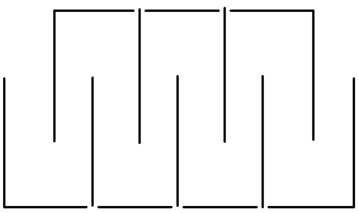
a) $8q_2$ b) $8q_1$ c) $6q_2$ d) $6q_1$

105. The effective capacitance between points X and Y shown in figure. Assuming $C_2=10\,\mu$F and that outer capacitors are all $4\,\mu$F is



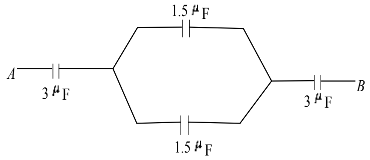
a) $1\,\mu$F b) $3\,\mu$F c) $4\,\mu$F d) $5\,\mu$F

106. 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

107. The equivalent capacitance between the points $A \wedge B$ in the following circuit is



a) $1\ \mu F$ b) $2\ \mu F$ c) $4\ \mu F$ d) $8\ \mu F$

108. 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) $300\ \mu J$ b) $450\ \mu J$ c) $225\ \mu J$ d) $150\ \mu J$

109. 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

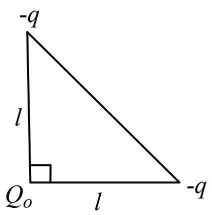
110. A uniform electric field having a magnitude $E_0$and direction along the positive X–axis, exists. If the potential V is zero at $x=0$, then its value at $x=+x$ will be

a) $V(x)=+xE_0$ b) $V(x)=-xE_0$ c) $V(x)=+x^2E_0$ d) $V(x)=-x^2E_0$

111. 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 $\vec{j}$
c) Work has to be done in bringing a test charge from infinity to the origin.
d) The dipole moment is $2qd$ directed along $\hat{j}$.

112. 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

113. 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

114. 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) $12\ V m^{-1}$ b) $-6\ V m^{-1}$ c) $6\ V m^{-1}$ d) $-12\ V m^{-1}$

115. $C, V, U \wedge Q$ 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) $V \wedge C$ b) $V \wedge U$ c) $U \wedge Q$ d) $V \wedge Q$

116. 27 small drops each having charge $q \wedge radius\, r$ 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

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

a) $N C^{-1}$ b) $Nm^2 C^1$ c) $J C^{-1}$ d) $V m^{-1}$

118. 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.

119. 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

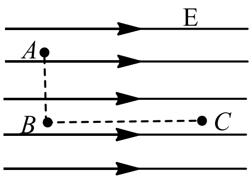
120. A small conducting sphere of radius r is lying concentrically inside a bigger hollow conducting sphere of radius R. The bigger and smaller spheres are charged with Q and q $(Q>q)$ and are insulated from each other. The potential difference between the spheres will be

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) $\frac{1}{4\pi\varepsilon_0}\left(\frac{Q}{R}-\frac{q}{r}\right)$

121. Minimum number of $8\,\mu F$ and 250 V capacitors are used to make a combination $16\mu F$ and 1000 V are

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

122. Figure shows three points A, B and C in 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?



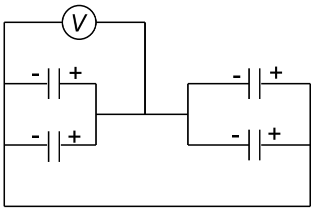
Where $V_A, V_B \wedge V_C$ represent the electric potential at the points A, B and C respectively.

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

123. 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

124. 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) $\pm 2\times 10^{-3}$C b) $\pm 5\times 10^{-3}$C c) $\pm 2\times 10^{-2}$C d) $\pm 5\times 10^{-2}$C

125. 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) $\frac{2U}{4}$

126. 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

127. 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) $Vn^{2/3}$

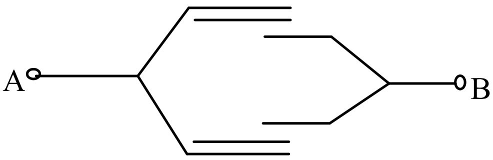
128. If a charged spherical conductor of radius 10 cm has potential V at a point distant 5cm from its centre, then the potential at a point distant 15 cm from the centre will be

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

129. 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

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

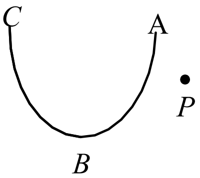


a) $\frac{2\varepsilon_0 A}{d}$ b) $\frac{3\varepsilon_0 A}{d}$ c) $\frac{3\varepsilon_0 A}{2d}$ d) $\frac{\varepsilon_0 A}{d}$

131. 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

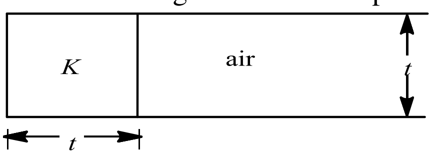
a) $\frac{1}{2}\frac{\varepsilon_0 E^2}{Ad}$ b) $\frac{\varepsilon_0 E^2}{Ad}$ c) $\varepsilon_0 E^2 Ad$ d) $\frac{1}{2}\varepsilon_0 E^2 Ad$

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



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

133. 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) $\frac{KC}{4}$

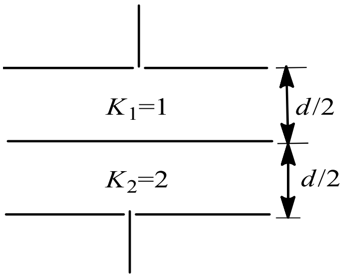
134. Two identical capacitors have the same capacitance C. One of them is charged to potential V_1 and the other to V_2. The negative ends of the capacitors are connected together. When the positive ends are also connected, the decrease in energy of the system is

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

135. 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

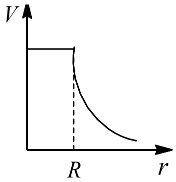
a) Remains same b) Increases two times c) Decreases two times d) Increase four time

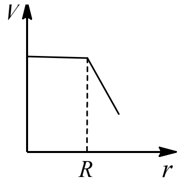
136. Two parallel plates of area A are separated by two different dielectric as shown in figure. The net capacitance is

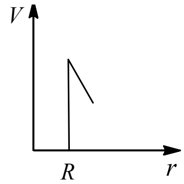


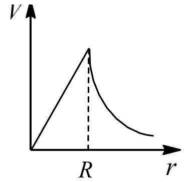
a) $\frac{\varepsilon_0 A}{2d}$ b) $\frac{\varepsilon_0 A}{d}$ c) $\frac{3\varepsilon_0 A}{d}$ d) $\frac{4\varepsilon_0 A}{3d}$

137. 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

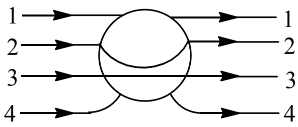
a) 

b) 

c) 

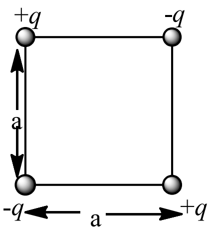
d) 

138. 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

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



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

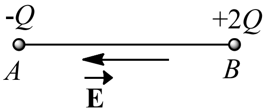
140. How many $6\,\mu F, 200\,V$ condensers are needed to make a condenser of $18\,\mu F, 600\,V$?

a) 9 b) 18 c) 3 d) 27

141. Three capacitors of capacitances 4 μF, 6μF 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

142. Charges $+2Q$ and $-Q$ are placed as shown is figure. The point at which electric filed intensity is zero will be



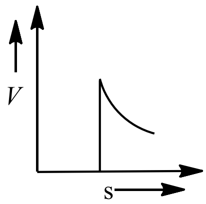
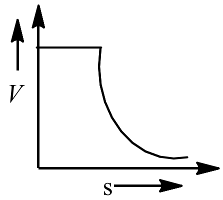
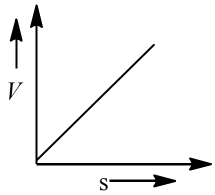
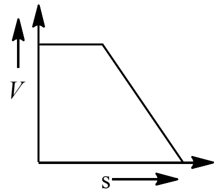
a) Somewhere between $-Q$and $+2Q$

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 $+2Q$.

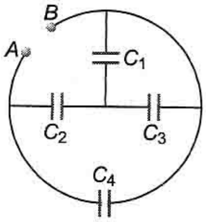
143. In the case of a charged metallic sphere, potential (V) changes with respect to distance(S) from the centre as

a)  b)  c)  d) 

144. 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

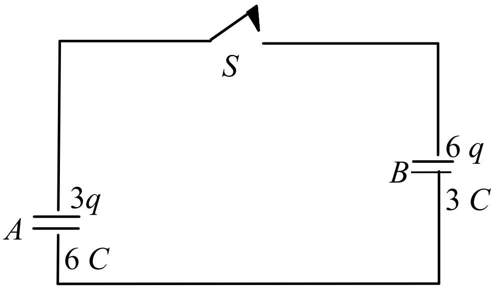
a) $E \neq 0 \wedge V \neq 0$ b) $E = 0 \wedge V = 0$ c) $E \neq 0 \wedge V = 0$ d) $E = 0 \wedge V \neq 0$

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



a) 9μF b) 18μF c) 4.5μF d) 15μF

146. 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) $4.5q, 4.5q$ d) $5q, 4q$

147. A parallel plate capacitor has the space between its plates filled by two slabs of thickness $\frac{d}{2}$ each and dielectric constant K_1 and K_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) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1+K_2}{K_1 K_2}\right)$

148. 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

149. 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

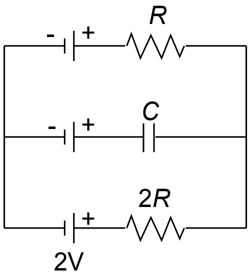
150. Two positive point charges of $12\mu C \wedge 5\mu C$ are placed 10 cm apart in air. The work needed to bring them 4 cm closer is

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

151. 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

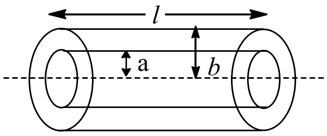
a) 160 J b) Zero c) 5 J d) 1.25 J

152. 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) $\frac{2V}{3}$

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



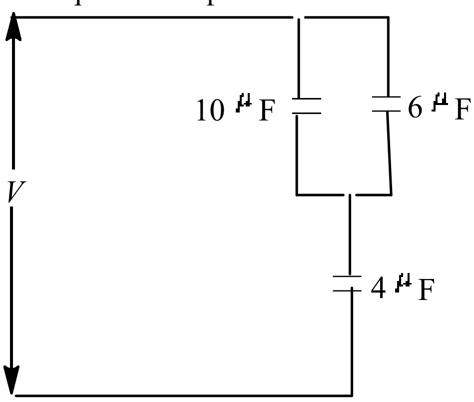
a) Is same throughout
b) Is higher near the outer cylinder than near the inner cylinder
c) Varies as $\frac{1}{r}$, where r is the distance from the axis
d) Varies as $\frac{1}{r^2}$, where r is the distance from the axis

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

155. Three charges $1\,\mu C$, $2\,\mu C$, $3\,\mu C$ 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

156. A ball of mass 1 carrying a charge 10^{-8} Cmoves from a point A at potential 600 V to a point B at 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

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



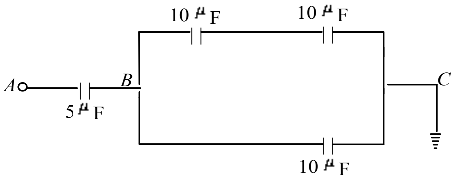
a) $3.20\,\mu F$
b) $7.80\,\mu F$
c) $3.90\,\mu F$
d) $2.16\,\mu F$

158. 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) $2\pi\sqrt{\frac{l}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$

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

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

160. 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

161. 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) $\frac{V}{4r}$

162. 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) $\frac{10}{6}V$

163. The potential energy of system of two equal negative point charges of 2μC each held 1m apart in air is $(k=9\times10^9\, SI\, unit)$

a) 36J b) $3.6\times10^{-3}J$ c) 3.6J d) $3.6\times10^{-2}J$

164. 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

165. 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

166. 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

167. 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) $\frac{Q_1Q_2}{4\pi\varepsilon_0R^2}$ b) Zero c) $\frac{Q_1Q_2}{4\pi\varepsilon_0R}$ d) Infinite

168. 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) $2r^2$

169. The work done in moving an alpha particle between two points having potential difference 25 V is

a) $8\times10^{-18}J$ b) $8\times10^{-19}J$ c) $8\times10^{-20}J$ d) $8\times10^{-16}J$

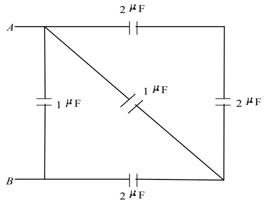
170. Two parallel large thin metal sheets have equal surface charge densities $(\sigma=26.4\times10^{-12}Cm^{-2})$ of opposite signs. The electric field between these sheets is

a) $1.5\,NC^{-1}$ b) $1.5\times10^{-10}NC^{-1}$ c) $3\,NC^{-1}$ d) $3\times10^{-10}NC^{-1}$

171. The electrostatic potential energy between proton and electron separated by a distance 1Å is

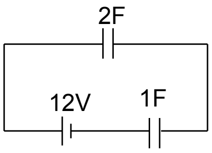
a) 13.6eV b) 27.2eV c) 14.4eV d) 1.44eV

172. Equivalent capacitance between $A \wedge B$ is



a) $14\ \mu F$ b) $4\ \mu F$ c) $6\ \mu F$ d) $2\ \mu F$

173. 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

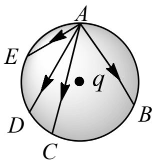
174. A 10μC capacitor is charged to a potential difference of 50 V and is connected to another uncharged capacitor in parallel. Now the common potential difference becomes 20 V. The capacitance of second capacitor is

a) $15\ \mu F$ b) $30\ \mu F$ c) $20\ \mu F$ d) $10\ \mu F$

175. 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

176. 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

177. 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 $V \neq 0$

178. 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) $\phi_1 > \phi$

179. 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

180. 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

181. 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) $\left(\frac{R_2}{R_1}\right)^2$

182. 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) $(n-1)x$

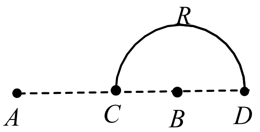
183. Capacitance of a parallel plate capacitor becomes $\frac{4}{3}$ times its original value, if a dielectric slab of thickness $t=\frac{d}{2}$ is inserted between the plates [d is the separation between the plates]. The dielectric constant of the slab is

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

184. 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

185. 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

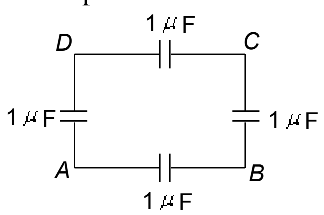


a) $\frac{qQ}{4\pi\varepsilon_0 L}$ b) $\frac{qQ}{2\pi\varepsilon_0 L}$ c) $\frac{qQ}{6\pi\varepsilon_0 L}$ d) $\frac{-qQ}{6\pi\varepsilon_0 L}$

186. 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

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

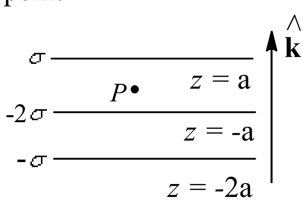


a) 4 μF b) 0.25 μF c) 0.75 μF d) 1.33 μF

188. 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

189. 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) $\frac{2\sigma}{\varepsilon_0}\hat{k}$

190. 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

191. 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) $\sqrt{\frac{m_p}{m_e}}$

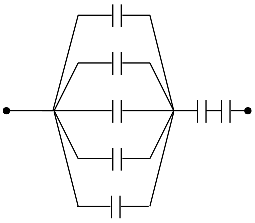
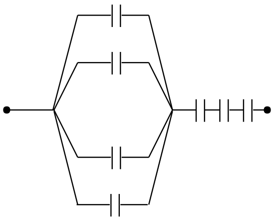
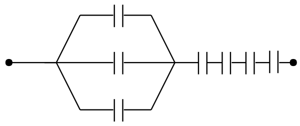
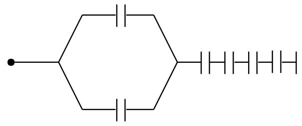
192. Large number of capacitors of rating 10 μF/200 V are available. The minimum number of capacitors required to design a 10 μF/700 capacitor is

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

193. 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) $\left(\frac{R_2}{R_1}\right)^1$

194. Seven capacitors each of the capacitance $2\mu F$ are be connected in a configuration to obtain an effective capacitance of $\frac{10}{11}\mu F$. Which of the combination (S) shown in figure will achieve the desired result?

a)  b)  c)  d) 

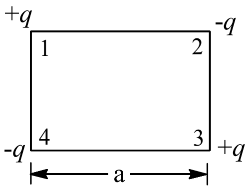
195. Two identical metal plates are given positive charges Q_1 and Q_2 (¿Q_1) respectively. If they are now brought close together to form a parallel plate capacitor with capacitance C,the potential difference between them is

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

196. 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.

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

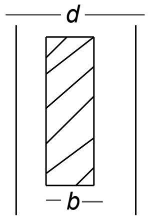


a) $\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}$ b) $\frac{-2.6}{4\pi\varepsilon_0}\frac{q^2}{a}$ c) $\frac{+2.6}{4\pi\varepsilon_0}\frac{q^2}{a}$ d) None of these

198. 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

199. 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

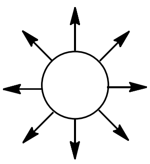


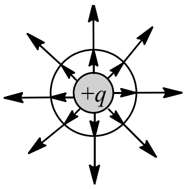
a) $\sqrt{2}:1$ b) 2 : 1 c) 1 : 1 d) $1:\sqrt{2}$

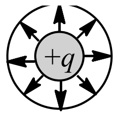
200. If the electric flux entering and leaving an enclosed surface respectively is ϕ_1 and ϕ_1, then, charge enclosed in closed surface is

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) $\varepsilon_0(\phi_2-\phi_1)$

201. 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

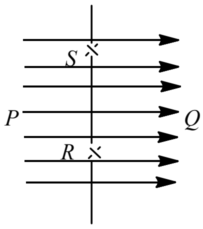
202. Two tree protons are separated by a distance of $1\,Å$. If they are released, the kinetic energy of each proton when at infinite separation is

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

203. When two conductors of charges and potentials $C_1, V_1 \wedge C_2, V_2$ respectively are joined, the common potential will be

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) $\frac{C_1V_1+C_2V_2}{C_1+C_2}$

204. The points resembling equal potentials are



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

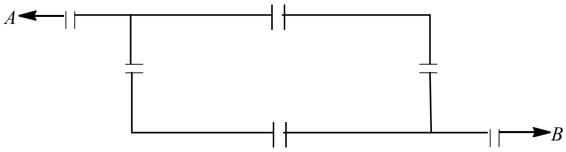
205. The electric potential V at any point x, y, z ¿all the metre¿ in space is given by $V=4x^2$ volt. The electric field at the point (1m, 0, 2m) in $V\,m^{-1}$ is

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

206. 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

207. A network of six identical capacitors, each of value C, is made as shown in the figure.



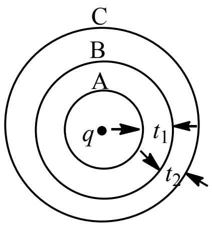
The equivalent capacitance between the points $A \wedge B$ is

a) $\frac{4C}{11}$ b) $\frac{3C}{4}$ c) $\frac{3C}{2}$ d) $3C$

208. In a region of space, the electric field is given by $\vec{E}=8\hat{i}+4\hat{j}+3\hat{k}$. 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

209. 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) $t_1\leq t_2$

210. 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

211. Three capacitors of capacitance $C(\mu F)$ 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) $4\ \mu F$ b) $5\ \mu F$ c) $6\ \mu F$ d) $8\ \mu F$

212. 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) $\frac{K+1}{2K}V$

213. Across each of two capacitors $1\,\mu$F and $4\ \mu F$, 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

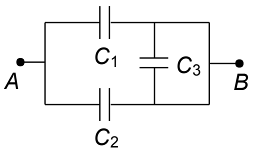
214. On increasing the plate separation of a charged capacitor, the energy

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

215. 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

216. 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

217. 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) $\frac{(q+Q)}{4\pi\varepsilon_0}\frac{2}{R}$

218. 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

219. 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

220. 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

221. 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) $\frac{b^2}{a^2}$

222. 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

223. 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

224. 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

225. 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) $-19\times10^{-17}J$ b) $9.60\times10^{-17}J$ c) $-2.24\times10^{-16}J$ d) $2.24\times10^{-16}J$

226. 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) $\frac{Q}{4}(1+2\sqrt{2})$

227. The electric flux for Gaussian surface A that encloses the charged particles in free space. (Given, $q_1=-14nC, q_2=78.85nC, q_3=-56\,nC$)

a) $10^3\,N\,m^2\,C^{-1}$ b) $10^3\,C\,N^{-1}\,m^{-2}$

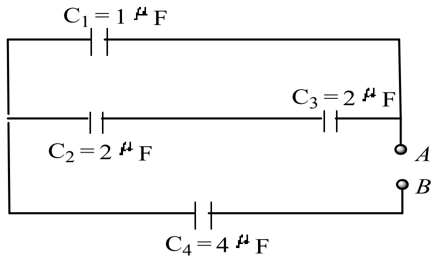
c) $6.32\times10^3\,N\,m^2\,C^{-1}$ d) $6.32\times10^3\,CN^{-1}\,m^{-2}$

228. 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

229. Four capacitors are connected in a circuit as shown in the following figure. Calculate the effective capacitance between the points $A \wedge B$.



a) $\frac{4}{3}\mu F$ b) $\frac{24}{5}\mu F$ c) $9\,\mu F$ d) $5\,\mu F$

230. 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

231. 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

232. 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)

233. 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) $\frac{Q_1-Q_2}{2C}$

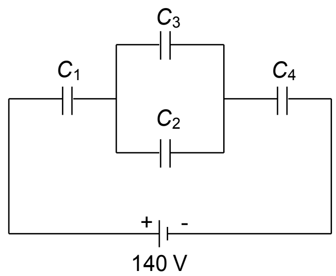
234. Two spherical conductors A and B of radii 1 mm and 2 mm are separated by a distance of 5 cm and are uniformly charged. If the spheres are connected by a conducting wire, then in equilibrium condition, the radio of the magnitude of the electric fields at the surfaces of spheres A and B is

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

235. Capacitor of a capacitor is $48\mu F$. When it is charged from 0.1 C to 0.5 C , change in the energy stored is

a) 2500 J b) $2.5 \times 10^{-3}\,J$ c) $2.5 \times 10^6\,J$ d) $2.42 \times 10^{-2}\,J$

236. 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

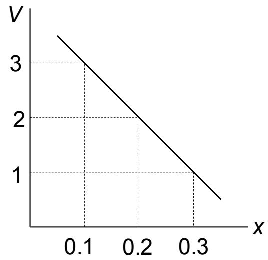


a) 80, 40, 40 and 20 V b) 20, 40, 40 and 80 V c) 35, 35, 35 and 35 V d) 80, 20, 20 and 20 V

237. 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 %

238. 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



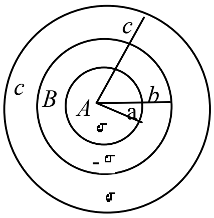
a) $+0.4\,V\,m^{-1}$ b) $-0.4\,V\,m^{-1}$ c) $+10\,V\,m^{-1}$ d) $-10\,V\,m^{-1}$

239. 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

240. Three capacitors 2, 3 and 6 μF are joined with each other. What is the minimum effective capacitance?
a) $\frac{1}{2}\mu F$ b) $1\ \mu F$ c) $2\ \mu F$ d) $3\ \mu F$

241. The work done in placing a charge of $8\times10^{-18}C$ 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

242. 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 $\sigma, -\sigma \wedge \sigma$ respectively. Calculate the electric potential on the surface of shell A



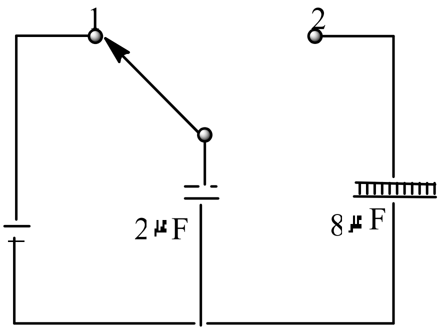
a) $\frac{\sigma}{\varepsilon_0}(a-b+c)$ b) $\frac{\sigma}{\varepsilon_0}(a-b-c)$ c) $\frac{\sigma}{\varepsilon_0}(a^2+b^2+c^2)$ d) $\frac{\sigma}{\varepsilon_0}(a+b-c)$

243. Find the potential at the centre of a square of side $\sqrt{2}$m. Which carries at its four corners charges $q_1=3\times10^{-6}C$, $q_2=-3\times10^{-6}C, q_3=-4\times10^{-6}C, q_4=7\times10^{-6}C$
a) $2.7\times10^4\,V$ b) $1.5\times10^3\,V$ c) $3\times10^2\,V$ d) $5\times10^3\,V$

244. 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) $16\,q, 4\,C$ c) $64\,q, 4\,C$ d) $16\,q, 64\,C$

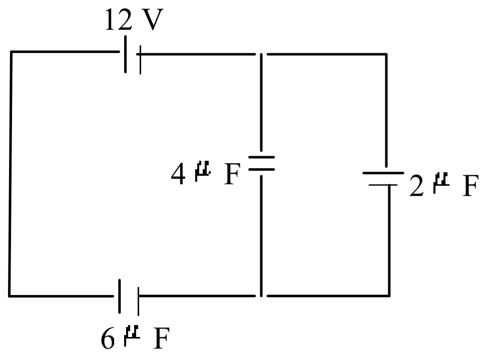
245. A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor
a) Decreases b) Remain unchanged c) Becomes infinite d) Increases

246. 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%

247. The charge deposited on $4\,\mu F$ capacitor the circuit is



a) $6\times10^{-6}C$ b) $12\times10^{-6}C$ c) $24\times10^{-6}C$ d) $36\times10^{-6}C$

248. Three capacitors of capacitance $1\,\mu F$, $2\,\mu F \wedge 4\,\mu F$ 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

249. The energy stored in a capacitor is in the form of

a) Kinetic energy b) Potential energy c) Elastic energy d) Magnetic energy

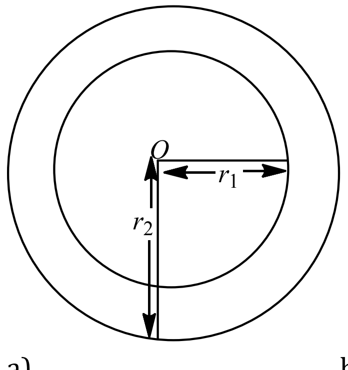
250. $ABCD$ is a rectangle. At corners B, C and D of the rectangle are placed charges $+10\times10^{-10}C$, $-20\times10^{-12}C, \wedge 10\times10^{-12}C$, respectively. Calculate the potential at the fourth corner. (The side AB=4cm and BC=3cm)

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

251. 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

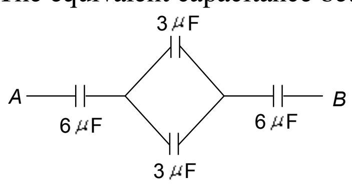
a) $\frac{1}{2}(K-1)CV^2$ b) $CV^2(K-1)/K$ c) $(K-1)CV^2$ d) Zero

252. 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) $r_1<r<r_2$

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



a) 4 μF b) 2 μF c) 10.5 μF d) 3 μF

254. The radius of nucleus of silver (atomic number Z=47) is $3.4\times10^{-14}\,m$. The electric potential on the surface of nucleus will be

a) $1.99\times10^6\,V$ b) $2.99\times10^6\,V$ c) $3.99\times10^6\,V$ d) None of these

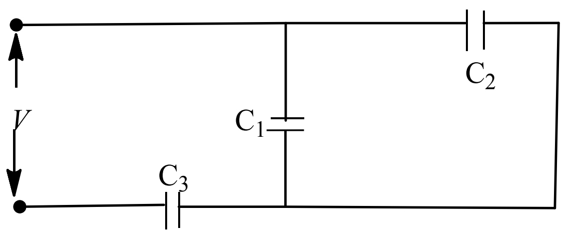
255. Charge Q is given a displacement $\vec{r}=a\hat{i}+b\hat{j}$ in an electric field $\vec{E}=E_1\hat{i}+E_2 b\hat{j}$. The work done is

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

256. 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) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{3q}{3\sqrt{3}R^2}$

257. Three capacitors $C_1, C_2 \wedge C_3$ are connected as shown in the figure to a battery of V volt. If the capacitor C_3breaks 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) $(C_1+C_2)V\left[1+\left(\frac{C_2}{C_1+C_2+C_3}\right)\right]$

258. 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) $\frac{q}{4d}$

259. 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) $\pi r^2 E$

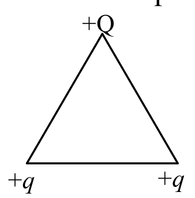
260. A hollow metal sphere of radius 5 cm is charged such that potential at its surface is 10V. The potential at the centre of the sphere is

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

261. 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

262. 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) $\frac{-q}{2}$

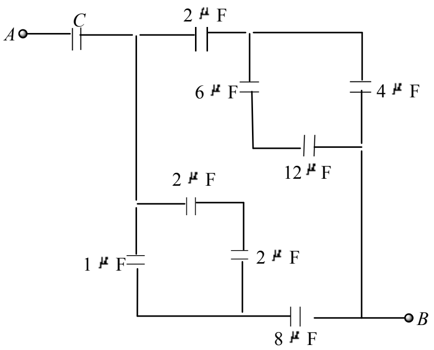
263. The electric potential V at any point (x, y, z) in space is given by $V=4x^2$V. the electric field at (1,0,2) m inVm^{-1} is

a) 8, along negative X-axis
b) 8, along positive X-axis
c) 16,along negative X-axis
d) 16, along positive X-axis

264. 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

265. In the given network, the value of C, so that an equivalent capacitance between A and B is $3\ \mu F$, is



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

266. A capacitor of capacity $10\mu F$ 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) $8\times10^{-3}J$
d) $8\times10^{-6}J$

267. 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.**

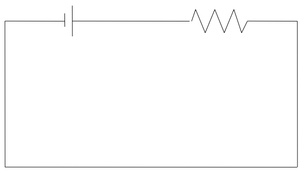
c) Electric field at the surface of a charged conductor is always normal to the surface.

d) The electric potential decrease along a line of force in an electric field.

268. A spherical drop of capacitance 1 μF is broken into eight drops of equal radius. Then, the capacitance of each small drop is

a) $\frac{1}{2}\mu F$
b) $\frac{1}{4}\mu F$
c) $\frac{1}{8}\mu F$
d) $8\ \mu F$

269. 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) $\frac{e^2}{10}C$

270. 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

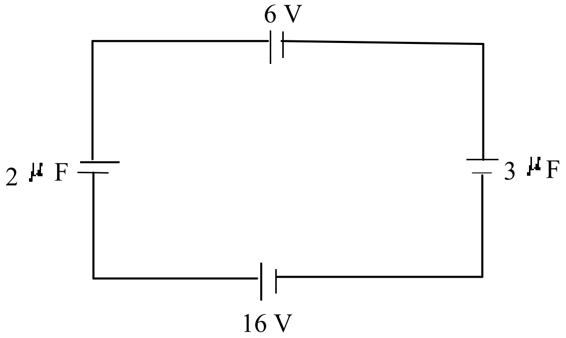
271. A 500 μF capacitor is charged at a steady rate of $100\mu Cs^{-1}$. The potential difference across the capacitor will be 10 V after in interval of

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

272. 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

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



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

274. 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

275. 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.

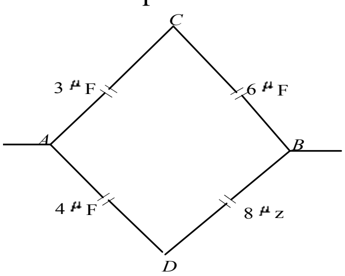
The value of the line integral $\int_{l=\infty}^{l=0} -E.dl$ ¿¿ being centre of ring) in volt is

a) +2
b) −1
c) −2
d) Zero

276. 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 $b=$¿)

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) $\frac{qQ}{4\pi\varepsilon_0}\left(\frac{1}{a^2}+\frac{1}{b^2}\right)$

277. Effective capacitance between points $A\wedge B$ in the figure, shown is



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

: ANSWER KEY :

1)	d	2)	d	3)	c	4)	a
5)	c	6)	a	7)	c	8)	a
9)	d	10)	d	11)	c	12)	b
13)	b	14)	b	15)	a	16)	a
17)	a	18)	a	19)	d	20)	b
21)	d	22)	a	23)	d	24)	c
25)	b	26)	d	27)	a	28)	d
29)	c	30)	c	31)	a	32)	a
33)	a	34)	b	35)	b	36)	a
37)	d	38)	a	39)	d	40)	a
41)	b	42)	b	43)	b	44)	a
45)	d	46)	a	47)	b	48)	d
49)	b	50)	c	51)	c	52)	a
53)	a	54)	d	55)	b	56)	d
57)	b	58)	b	59)	b	60)	c
61)	b	62)	c	63)	b	64)	c
65)	c	66)	d	67)	d	68)	b
69)	d	70)	c	71)	b	72)	d
73)	b	74)	a	75)	b	76)	a
77)	b	78)	a	79)	a	80)	d
81)	a	82)	b	83)	a	84)	a
85)	d	86)	b	87)	c	88)	c
89)	d	90)	d	91)	b	92)	d
93)	a	94)	a	95)	b	96)	b
97)	a	98)	d	99)	c	100)	b
101)	b	102)	b	103)	c	104)	a
105)	c	106)	b	107)	a	108)	a
109)	a	110)	b	111)	b	112)	b
113)	d	114)	d	115)	c	116)	b
117)	c	118)	b	119)	c	120)	a
121)	b	122)	b	123)	c	124)	b
125)	b	126)	a	127)	d	128)	b
129)	a	130)	a	131)	c	132)	a
133)	a	134)	c	135)	b	136)	d
137)	a	138)	d	139)	a	140)	d
141)	b	142)	b	143)	c	144)	c
145)	d	146)	b	147)	b	148)	c
149)	a	150)	b	151)	d	152)	c
153)	c	154)	b	155)	c	156)	c
157)	a	158)	d	159)	a	160)	b
161)	c	162)	c	163)	d	164)	a
165)	d	166)	d	167)	b	168)	b

169)	a	170)	c	171)	c	172)	d
173)	b	174)	a	175)	d	176)	c
177)	c	178)	c	179)	b	180)	c
181)	a	182)	d	183)	c	184)	a
185)	d	186)	c	187)	d	188)	c
189)	c	190)	a	191)	b	192)	a
193)	b	194)	a	195)	d	196)	c
197)	b	198)	c	199)	b	200)	d
201)	b	202)	a	203)	d	204)	a
205)	a	206)	a	207)	a	208)	b
209)	c	210)	a	211)	b	212)	a
213)	c	214)	a	215)	a	216)	d
217)	c	218)	c	219)	c	220)	d
221)	a	222)	c	223)	a	224)	c
225)	d	226)	d	227)	a	228)	d
229)	a	230)	d	231)	a	232)	c
233)	d	234)	c	235)	a	236)	a
237)	b	238)	c	239)	a	240)	b
241)	d	242)	a	243)	a	244)	c
245)	b	246)	d	247)	c	248)	c
249)	b	250)	a	251)	d	252)	d
253)	b	254)	a	255)	a	256)	c
257)	a	258)	b	259)	c	260)	b
261)	d	262)	d	263)	a	264)	c
265)	b	266)	b	267)	c	268)	a
269)	a	270)	c	271)	d	272)	d
273)	c	274)	c	275)	a	276)	b
277)	b						

: HINTS AND SOLUTIONS :

1 **(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, $W = U = \frac{1}{2} C' V^2$

¿ $\frac{1}{2}\left(\frac{3C}{2}\right)V^2$

¿ $\frac{3}{4} C V^2$

2 **(d)**

If length of the foil is them

$C = \frac{K \varepsilon_0 (l \times b)}{d}$

$\Rightarrow 2 \times 10^{-6} = \frac{2.5 \times 8.85 \times 10^{-12} (l \times 400 \times 10^{-3})}{0.15 \times 10^{-3}}$

$\Rightarrow l = 33.9 m.$

3 **(c)**

The capacitance of air capacitor

$C_0 = \frac{A \varepsilon_0}{d} = 3 \mu F$ …(i)

When a dielectric of permittivity ε_r and dielectric constant K is introduced between the plates of the capacitor, then its capacitance

$C = \frac{KA \varepsilon_0}{d} = 15 \mu F$ …(ii)

Dividing Eq. (ii) by Eq. (i)

$\frac{C}{C_0} = \frac{\frac{KA\varepsilon_0}{d}}{\frac{A\varepsilon_0}{d}} = \frac{15}{3}$

$\therefore$ $K = 5$

Permittivity of the medium

$\varepsilon_r = \varepsilon_0 K$

¿ $8.854 \times 10^{-12} \times 5$

¿ 44.27×10^{-12}

¿ $0.44 \times 10^{-10} C^2 N^{-1} m^{-2}$

4 **(a)**

$\int \vec{E} . \vec{ds} = N C^{-1} (M^2)$

¿ $(Nm) C^{-1} (m) = J C^{-1} m = V - m$

5 **(c)**

As battery is disconnected, total charge Q is shared equally by two capacitors. energy of each capacitor

¿ $\frac{(Q/2)^2}{2C} = \frac{1}{4}\frac{Q^2}{2C} = \frac{1}{4} U$

6 **(a)**

Here , $t = 2 mm, x = 1.6 mm, K = ?$

As potential difference remains the same, capacity must remain the same

$\therefore x = t\left(1 - \frac{1}{K}\right)$

$1.6 = 2\left(1 - \frac{1}{K}\right)$,which gives $K = 5$

7 **(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.

8 **(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 ¿ 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 $(V_A - V_B)$will also be a scalar quantity.

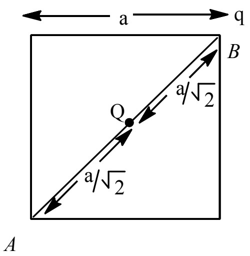
Here,

$$V_A = V_B = \frac{1}{4\pi\varepsilon_0}\frac{Q}{a/\sqrt{2}}$$

Since, $Q$is same for both,

$$V_A - V_B = 0$$

$$W = 0$$



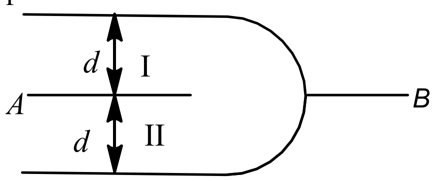
9 **(d)**

The capacity of an isolated spherical conductor of radius R is $4\pi\varepsilon_0 R$

$\therefore C \propto R$

10 **(d)**

Here, we have two capacitors I and II connected in parallel order.



So, $C = C_1 + C_2$

¿ $\frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d} = \frac{2\varepsilon_0 A}{d}$

11 **(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.

12 **(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

$$q_1 = C_1V = 4\pi\varepsilon_0 r_1 V = \frac{10^{-1}}{9\times10^9}\times 120\, C$$

¿ $\frac{12}{9\times10^9}\times 3\times10^9\, esu = 4$esu

13 **(b)**

Common potential,

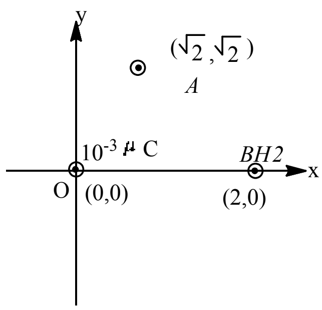
$$V = \frac{total\, charge}{total\, capacity} = \frac{Q+0}{4\pi\varepsilon_0(r+r')}$$

$\therefore$ charge on smaller sphere

¿ $4\pi\varepsilon_0 r' \times V = \frac{Qr'}{r+r'}$

14 **(b)**

Potential at A due to charge at O



$$V_A = \frac{1}{4\pi\varepsilon_0}\frac{(10^{-3})}{OA}$$

¿ $\frac{1}{4\pi\varepsilon_0}\cdot\frac{(10^{-3})}{\sqrt{(\sqrt{2})^2 + (\sqrt{2})^2}}$

Potential at B due to charge at O

$$V_B = \frac{1}{4\pi\varepsilon_0}\cdot\frac{(10^{-3})}{OB}$$

¿ $\frac{1}{4\pi\varepsilon_0}\cdot\frac{(10^{-3})}{2}$

So,

$$V_A - V_B = 0$$

15 **(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 ¿ $U_1 - U_3$

¿ $\frac{Q(-q)}{4\pi\varepsilon_0 r} + \frac{Qr}{4\pi\varepsilon_0 r} \times \frac{4}{3}$

¿ $\frac{Qq}{4\pi\varepsilon_0 r} \times \frac{1}{3} = \frac{9}{3} = 3\,J$

17 **(a)**

By using $W = Q(E.\Delta r)$

$\Longrightarrow W = Q[e_1\hat{i} + e_2\hat{j} + e_3\hat{k}).(a\hat{i} + b\hat{j})$ ¿

¿ $Q(e_1 a + e_2 b)$

19 **(d)**

$E = \sigma/\varepsilon_0$, The value of E does not depend upon radius of the sphere.

20 **(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.

$KE = work\ done = F \times s \Rightarrow qE \times s = e\left(\frac{\sigma}{\varepsilon_0}\right) d = \left(\frac{(KE)}{e\sigma}\right.$

$d = \frac{100 \times 1.6 \times 10^{-19} \times 8.86 \times 10^{-12} J}{1.6 \times 10^{-19} \times 2 \times 10^{-6}} = 4.43 \times 10^{-4}$

= 0.443 mm

21 **(d)**

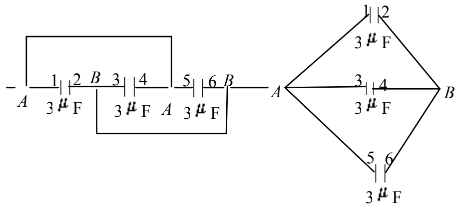
$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

$V' = \frac{1}{4\pi\varepsilon_0}\frac{q'}{r'} = \frac{1}{4\pi\varepsilon_0}\frac{nq}{n^{\frac{1}{3}} r}$

$(\because q' = nq, r' = n^{\frac{1}{3}} r)$

Or $V' = n^{2/3} V$

22 **(a)**



Here, all the three capacitors are connected in parallel. Therefore, equivalent capacitance between points $A \wedge B$ is

$C_{eq} = 3 + 3 + 3 = 9\,\mu F$.

23 **(d)**

The net field at O.

$E = 2\vec{E}_R, when\ \vec{E}_p + \vec{E}_s = \vec{0}, \vec{E}_Q + \vec{E}_T = \vec{0} \wedge \vec{E}_R = \vec{E}_U\ along\ ROU$ diriction. It is possible in arrangement of (d) as shown in a joining figure.

24 **(c)**

$\frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 A}{d' - t + \frac{t}{K}}$

$\Rightarrow d = d' - t + \frac{1}{K}$

$\Rightarrow d' - d = t\left(1 - \frac{1}{K}\right)$

Here, $d' - d = 3.2\,mm, t = 4\,mm$

$\therefore 3.2 = 4\left(1 - \frac{1}{K}\right) 1 - \frac{1}{K}$

$\Rightarrow \frac{3.2}{4} = 1 - \frac{1}{K}$

$\Rightarrow 1 - \frac{1}{K} = \frac{4}{5}$

$\therefore K = 5$

25 **(b)**

The work done in charging the capacitor (C) is stored as potential energy (U) in the vicinity of capacitor, given by.

$U = \frac{1}{2} C V^2$

This produces the heat when its plates are joint through a resistance.

Given, $C = 4\,\mu F = 4 \times 10^{-6} F, V = 400$volt

$\therefore U = \frac{1}{2} \times 4 \times 10^{-6} \times (400)^2$

$U = 0.32\,J$

26 **(d)**

At each point on the surface of a conducting sphere the potential is equal.

So, $V_A = V_B = V_C$

27 **(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 $A \wedge B = (n-1)C$

28 **(d)**

Minimum capacity, $C_s = \frac{5}{10} = 0.5\,\mu F$

Maximum capacity, $C_p = 10 \times 5 = 50\,\mu F$

$\frac{C_p}{C_s} = \frac{50}{0.5} = 100$

29 **(c)**

$C = 4\varepsilon_0 R$, where $R = 6.4 \times 10^6$ m

¿ $\frac{6.4 \times 10^6}{9 \times 10^9} = 711\,\mu F$

30 **(c)**

Combined capacity of $1\,\mu F$ and $5\,\mu F$ = 1 + 5=6 μF
Now, $4\,\mu F$ and $6\,\mu F$ are in series.

$\therefore \frac{1}{C_s} = \frac{1}{4} + \frac{1}{6} + \frac{3+2}{12} = \frac{5}{12}$

$C_s = \frac{12}{5}\,\mu F$

Charge in the arm containing $4\,\mu F$ capacitor is

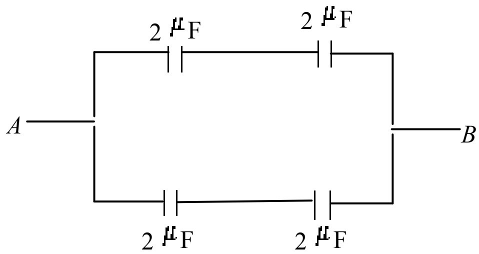
$q = C_s \times V = \frac{12}{5} \times 10 = 24\,\mu C$

31 **(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.

32 **(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

$C_1 = \frac{2 \times 2}{2+2} = 1\,\mu F$

Similarly, for lower arm

$C_2 = 1\,\mu F$

$\therefore C_{AB} = C_1 + C_2$

¿ $1 + 1 = 2\,\mu F$

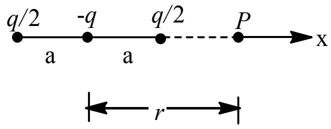
33 **(a)**

When metal sphere is placed inside a charged parallel plate capacitor, the electric lines of force will not enter the metallic conductor as $E = 0$ inside 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.

34 **(b)**

$As\, r \gg a, so\, r > 2a$

So, potential at point p



$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{\frac{q}{2}}{r+a} - \frac{q}{r} + \frac{\frac{q}{2}}{r-a}\right]$

¿ $\frac{1}{4\pi\varepsilon_0}\frac{q}{2}\left[\frac{1}{r+a} - \frac{2}{r} + \frac{1}{r-a}\right]$

¿ $\frac{q}{8\pi\varepsilon_0}\left[\frac{r(r-a) - 2(r^2 - a^2) + r(r+a)}{r(r^2 - a^2)}\right]$

¿ $\frac{q}{8\pi\varepsilon_0} \cdot \frac{2a^2}{r(r^2 - a^2)}$

¿ $\frac{qa^2}{4\pi\varepsilon_0 r^3}(as\, r \gg a)$

35 **(b)**

The electric field between the plates is

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

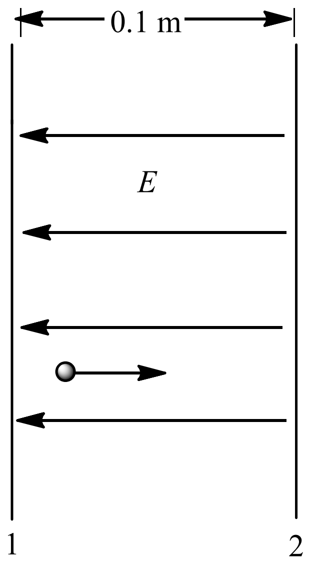
or $V = Ed \vee V \propto d$

Hence, if the plates are pulled apart the potential difference increases.

36 **(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.

$$\frac{m_e v^2}{2} - 0 = e\left(V_2 - V_1\right)$$

Where v is the required speed.

$$\therefore \frac{9.11 \times 10^{-31}}{2} v^2 = 1.6 \times 10^{-19} \times 20$$

$$\Rightarrow v = \sqrt{\frac{1.6 \times 10^{-19} \times 40}{9.11 \times 10^{-31}}} = 2.65 \times 10^6 ms^{-1}$$

37 **(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.

38 **(a)**

The potential at the centre of the sphere is 80 V because it remains same at each point under the metallic hollow sphere.

39 **(d)**

The capacitance of a parallel plate capacitor with dielectric (oil) between its plates is

$$C = \frac{K\varepsilon_0 A}{d} \qquad \ldots\text{(i)}$$

where symbols have their usual meanings. when dielectric (oil) is removed, so capacitance

$$C = \frac{\varepsilon_0 A}{d} \qquad \ldots\text{(ii)}$$

Comparing Eqs. (i) and (ii), we get

$$C = KC_0$$

$$\Rightarrow C_0 = \frac{C}{K} = \frac{C}{2} \left(\therefore K = 2\right)$$

40 **(a)**

Here, $E = \frac{\sigma}{\varepsilon_0} \wedge t = \frac{1}{u}$

Along Y-axis, $u = 0, a = \frac{f}{m} = \frac{eE}{m}$

$$s = d = \frac{1}{2} a t^2 = \frac{1}{2} \frac{eE}{m} t^2 = \frac{1}{2} \frac{e\sigma}{m\varepsilon_0} \frac{l^2}{u^2}$$

$$\sigma = \frac{2d\varepsilon_0 m u^2}{e l^2}$$

41 **(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

$$C_1 = \frac{K_1 \varepsilon_0 \left(\frac{A}{2}\right)}{d/2} + \frac{K_2 \varepsilon_0 \left(\frac{A}{2}\right)}{d/2} = \frac{\left(K_1 + K_2\right)\varepsilon_0 A}{d}$$

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 $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

$$\therefore \frac{d}{K\varepsilon_0 A} = \frac{d}{\left(K_1 + K_2\right)\varepsilon_0 A} + \frac{d/2}{K_3 \varepsilon_0 A ¿}$$

¿

$$\Rightarrow \frac{1}{K} = \frac{1}{K_1 + K_2} + \frac{1}{2K_3}$$

42 **(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.

43 **(b)**

Potential at the centre of hollow metallic sphere

$$V=\frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$$

44 **(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 $A¿B$.

So,

$$V_A-V_B=\frac{2}{20}$$

(Here $W=2, q_0=20C$)=0.1V

45 **(d)**

$C_p=1+1+1=3\mu F$

$\frac{1}{C_s}=\frac{1}{3}+\frac{1}{1}=\frac{4}{3}$

$\therefore C_s=\frac{3}{4}\mu F$

46 **(a)**

$$\phi_E=\frac{q}{K\varepsilon_0}=\frac{0.5}{10\times 8.85\times 10^{12}}=5.65\times 10^9$$

47 **(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 $40(10+C_2)=1000$

$\Rightarrow$ $C_2=15\mu F$

48 **(d)**

Variation of different variables $(Q, C, V, E\wedge U)$ of parallel plate capacitor when dielectric (K) is introduced when battery is removed is

$C'=KC\,E'=E/K$

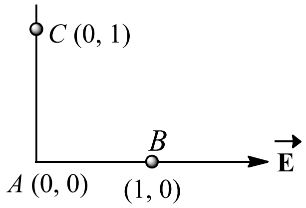
$Q'=Q\,U'=U/K$

$V'=V/K$

49 **(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, $V_A>V_B$



50 **(c)**

Energy given to conductor $¿\frac{1}{2}CV^2$

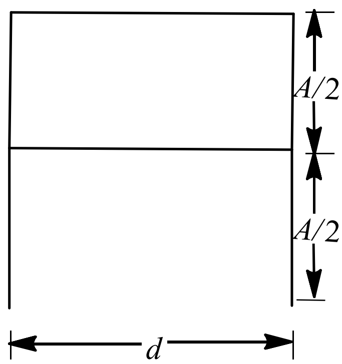
$¿\frac{1}{2}\times 5\times 10^{-6}\times(800)^2$

= 1.6 J

51 **(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.

$\therefore C'=C_1+C_2$

$C_1=\frac{A\varepsilon_0}{2d}$

And $C_2=\frac{KA\varepsilon_0}{2d}$

Thus, $C'=\frac{A\varepsilon_0}{2d}+\frac{KA\varepsilon_0}{2d}$

$C'=\frac{C}{2}(1+K)$

52 **(a)**

The material suitable for use as dielectric must have high dielectric strength X and large dielectric constant K.

53 **(a)**

The energy stored is given by

$E=\frac{1}{2}CV^2$

When capacitors are connected in parallel, resultant capacitance is

$C^{'}=C_1+C_2$

¿ $2\,\mu F+2\,\mu F=4\,\mu F$

$V=100$ volt

$\therefore=\frac{1}{2}\times 4\times 10^{-6}\times(100)^2$

$E=0.02\text{J}$

54 **(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,

$\frac{V_1^{'}}{V_2^{'}}=\frac{C_2}{V_1}=\frac{3\,pF}{3\,pF}=\frac{3}{2}$ and

$V_1^{'}+V_2^{'}=V_1+V_2=30+20=50\,V$

On simplification, we get

$V_1^{'}=V_1=30\,V\wedge V_2^{'}=V_2=20\,V$

55 **(b)**

$E=\frac{\lambda}{2\pi\varepsilon_0 r}$

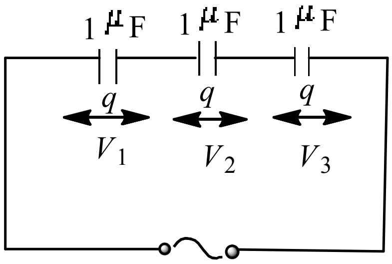
$\lambda=2\pi\varepsilon_0 r\,E$

¿ $\frac{1}{2\times 9\times 10^9}\times 2\times 10^{-2}\times 9\times 0^4$

¿ $10^{-7}\,C\,m^{-1}$

56 **(d)**

Let potential difference between the plates of the capacitors $C_1, C_2\wedge C_3\,be\,V_1, V_2\wedge V_3\wedge q$ 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

$\therefore V=V_1+V_2+V_3$

$\Rightarrow V=\frac{q}{C_1}+\frac{q}{C_2}+\frac{q}{C_3}=11$

Given, $C_1=1\,\mu F, C_2=2\,\mu F, C_3=3\,\mu F$

$\therefore 11=q\left(\frac{1}{1}+\frac{1}{2}+\frac{1}{3}\right)$

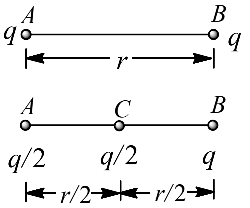
$\Rightarrow 11=\frac{11q}{6}$

$\Rightarrow q=6\,\mu c$

$\therefore V_1=\frac{q}{C_1}=\frac{6}{1}=6$ V

57 **(b)**

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



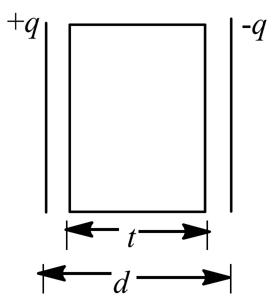
Finally, force on

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

$\Rightarrow F_C=F_{AB}$

58 **(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, $C=20\,\mu F=20\times10^{-6}\,F$,
$d=2mm=2\times10^{-3}m, t=1\,mm$
¿ $1\times10^{-3}m, K=2$

$$\therefore \frac{C'}{C}=\frac{d}{d-t\left(1-\frac{1}{K}\right)}$$

¿ $$\frac{2\times10^{-3}}{2\times10^{-3}-1\times10^{-3}\left(1-\frac{1}{2}\right)}=1.33$$

$$\Rightarrow C'=1.33\times20\times10^{-6}=26.6\,\mu F$$

59 **(b)**

$$\vec{E}_1=\frac{1}{4\mu\pi\varepsilon_0}\cdot\frac{2\vec{P}}{r^3}$$ and

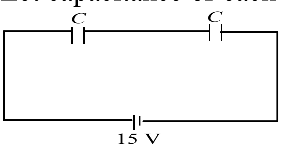
$$\vec{E}_2=\frac{-1}{4\pi\varepsilon_0}\cdot\frac{\vec{P}}{(2r¿¿3)=\frac{-1}{4\pi\varepsilon_0}\cdot\frac{\vec{P}}{8r^3}¿}$$

$$\Rightarrow \vec{E}_2=\frac{-\vec{E}_1}{16}$$

(Here negative sign means direction)

60 **(c)**

Let capacitance of each capacitor is C.



Then equivalent capacitance in series is

$$\frac{1}{C'}=\frac{1}{C}+\frac{1}{C}=\frac{2}{C}$$

$$\Rightarrow C'=\frac{C}{2}$$

Charge $\quad Q=C'V=\frac{C}{2}.15 \quad$ ...(i)

When filled with dielectric

$C_1=4C, C_2=C$

$$\frac{1}{C'}=\frac{1}{4C}+\frac{1}{C}=\frac{5}{4C}$$

$$\Rightarrow C'=\frac{4C}{5}$$

Since, charge is conserved

$Q=C'V'=\frac{4C}{5}V' \quad$ ...(ii)

From Eqs. (i) and (ii), we get

$$\frac{C}{2}\times15=\frac{4C}{5}\times V'$$

$$\Rightarrow V'=\frac{15\times5}{4\times2}=9.4\,V$$

$$\approx 10\,V$$

61 **(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, $C=6\,\mu F=6\times10^{-6}, V_i=$¿10 volt,
$V_f=20$volt

$$\therefore \Delta U=\frac{1}{2}\times6\times10^{-6}[(20)^2-(10)^2]$$

¿ $3\times10^{-6}\times300=9\times10^{-4}J$

62 **(c)**

$6\mu F$ and $3\mu F$ capacitors are in series

$$\frac{1}{C_1}=\frac{1}{6}+\frac{1}{3}$$

$C_1=2$

$C_1 is||$¿$2\,\mu F\,capacitor$

$\therefore C_{eq}=2+2=4\,\mu F$

Total energy, $U=\frac{1}{2}CV^2$

¿ $\frac{1}{2}\times4\times(2)^2=8\,\mu J$

63 **(b)**

Energy of second proton = PE of the system

¿ $\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$

¿ $9\times10^9\times\frac{1.6\times10^{-19}\times1.6\times10^{-19}}{1\times10^{-10}}$

¿ 23.0×10^{-19}J

64 **(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, $i.e.,$

$$V=\frac{W}{q_0}$$

$$\therefore V=\phi=\frac{W}{Q}(\because X\ll\infty)$$

65 **(c)**

Work done¿ $Fs\cos\theta=F(2\pi r)\cos90^0=0$.

66 **(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.
$C_p=3+3+3=9\,\mu F$

67 **(d)**
Radius of big drop, $R=3r$
$\left[\because \frac{4}{3}\pi R^3=27\times\frac{4}{3}\pi r^3\right]$
$V=\frac{27q}{4\pi\varepsilon_0 R}=\frac{27q}{4\pi\varepsilon_0 ¿¿}$
$¿9\left(\frac{q}{4\pi\varepsilon_0 r}\right)=9\times10=90\text{V}$

68 **(b)**

Potential on bubble,

$V=\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

$\therefore \frac{V_1}{V_2}=\frac{r_2}{r_1}$

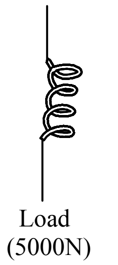
$\Longrightarrow \frac{16}{V_2}=\frac{2}{1}\Longrightarrow V_2=8V$

69 **(d)**
Heat produced =energy stored in capacitor
$\frac{1}{2}CV^2=\frac{1}{2}(10\times10^{-6})(500)^2$
$¿1.25$ J

70 **(c)**

Work done is zero because all the points on the circular path are at same potential.

71 **(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 $\frac{\frac{1}{2}Fx}{\frac{1}{2}CV^2}=\frac{5000\times0.2}{10\times10^{-6}\times(10^4)^2}=1$

72 **(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, $C=100\,pF$
$¿100\times10^{-12}\,F$
$K=4,\varepsilon_0=8.85\times10^{-12}C^2N^{-1}m^{-2}$
$A=\pi r^2=3.14\times(1\times10^{-2})^2$
$d=1mm=1\times10^{-3}$
$\therefore 100\times10^{-12}=¿$
$\frac{(n-1)\times4\times(8.85\times10^{-12})\times3.14\times(1\times10^{-2})^2}{1\times10^{-3}}$
or $n=\frac{1111.156}{111.156}=9.99\approx10$

73 **(b)**
Given, $C_1=6\,\mu F, C_2=12\,\mu F, V=150\,volt$.
Total capacity, $\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}=\frac{1}{6}+\frac{1}{12}$
$¿\frac{2+1}{12}\frac{1}{C}=\frac{3}{12}C=4\,\mu F$
Potential of $12\,\mu F$ capacitor
$V=\frac{q}{C}$
$V=\frac{4\times150}{12}$
$V=¿50$ volt

74 **(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
$Q=C_0V_0$
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, $C_1=\frac{C_0}{2}$

$$E_1=\frac{1}{2}\frac{Q^2}{C_0/2}=\frac{Q^2}{C_0}=\frac{C_0^2V_0^2}{C_0}=C_0V_0^2$$

When battery is connected, then

Energy $E_2=\frac{1}{2}CV_0^2$

where $E_2=\frac{1}{2}\frac{C_0}{2}V_0^2=\frac{1}{4}(C_0V_0^2)$

$$\therefore \frac{E_1}{E_2}=\frac{C_0V_0^2}{\frac{1}{4}C_0V_0^2}=\frac{1}{4}$$

$E_1:E_2=4:1$

75 **(b)**

$$V=\frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1}{r_1}+\frac{Q_2}{r_2}+\frac{Q_3}{r_3}\right)$$

$$¿\frac{1}{4\pi\varepsilon_0}\left(\frac{33\times10^{-9}}{93\times10^{-3}}-\frac{51\times10^{-9}}{\sqrt{2}\times93\times10^{-3}}+\frac{47\times10^{-9}}{93\times10^{-3}}\right)$$

$$¿\frac{1}{4\pi\varepsilon_0}\times\frac{10^{-9}}{93\times10^{-3}}\left(33-\frac{51}{\sqrt{2}}+47\right)$$

$$\approx 4\times1000\,V=4\,kV$$

76 **(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.

77 **(b)**

Given, $C=2\,\mu F, C_2=4\,\mu F, \wedge V=10$volt

Capacitors are connected in series

$$\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}$$

$$\therefore C=\frac{4\times2}{4+2}=\frac{4}{3}$$

The charge of combination

$$q=CV=\frac{4}{3}\times10=\frac{40}{3}$$

The energy of $2\,\mu F$ capacitor

$$E=\frac{1}{2}\times\frac{q^2}{C_1}=\frac{1}{2}\times\frac{1600}{9\times2}=\frac{400}{9}$$

The energy of $4\,\mu F$ capacitor

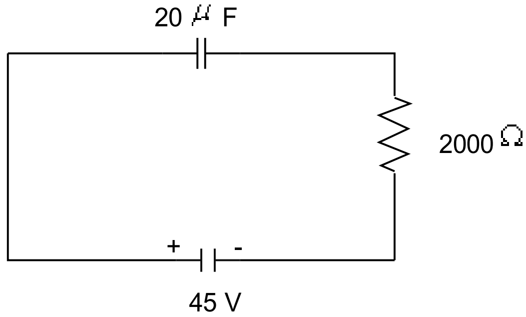
$$E_2=\frac{1}{2}\times\frac{q^2}{C_2}=\frac{1}{2}\times\frac{1600}{9\times4}=\frac{200}{9}$$

The ratio of energies is

$$\frac{E_1}{E_2}=\frac{\frac{400}{9}}{\frac{200}{9}}=\frac{2}{1}$$

78 **(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 , $C=20\,\mu F, V=45\,V$

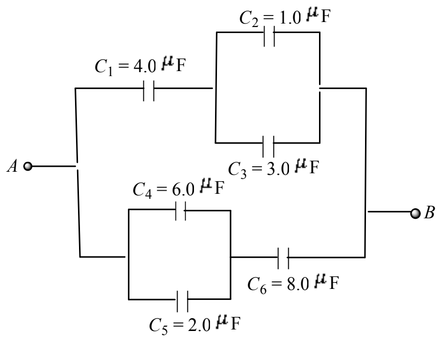
$\therefore q=20\times10^{-6}\times45$

or $q=900\times10^{-6}$

or $q=9\times10^{-4}\,C$

79 **(a)**

In given figure $C_2 \wedge C_3$ are in parallel,



$\therefore C'=C_2+C_3=4\,\mu F$

As $C' \wedge C_1$are in series,

$$\frac{1}{C''}=\frac{1}{C'}+\frac{1}{C_1}=\frac{1}{4}+\frac{1}{4}$$

$\Rightarrow C''=2\,\mu F$

Similarly, $C_4 \wedge C_5$ are in parallel

$C'''=6+2=8\,\mu F$

$C''' \wedge C_6$ are in series

$$\frac{1}{C'''}=\frac{1}{C'''}+\frac{1}{C_6}=\frac{1}{8}+\frac{1}{8}$$

$\Rightarrow C'''=¿ 4\,\mu F$

Now, $C''' \wedge C''$ are in parallel.

$\therefore C=4\,\mu F+2\,\mu F=6\,\mu F$

80 **(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 $C'=C\frac{K}{2}$

$\therefore 6=2.\frac{K}{2}\Rightarrow K=6$

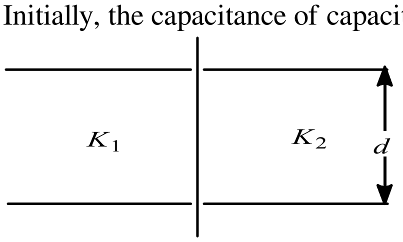
81 **(a)**

Potential gradient relates with electric field according to the relation, $E=\frac{-dV}{dr}$

$¿-\frac{10}{20\times10^{-2}}=50\,Vm^{-1}$

82 **(b)**

Initially, the capacitance of capacitor



$$C=\frac{\varepsilon_0 A}{d}$$

$\therefore \frac{\varepsilon_0 A}{d}=1\,\mu F$

…(i)

When it is filled with dielectric of dielectric constant $K_1 \wedge K_2$ 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)

$$C'=\frac{4\varepsilon_0 A}{2d}+\frac{6\varepsilon_0 A}{2d}=\frac{2\varepsilon_0 A}{d}+\frac{3\varepsilon_0 A}{d}$$

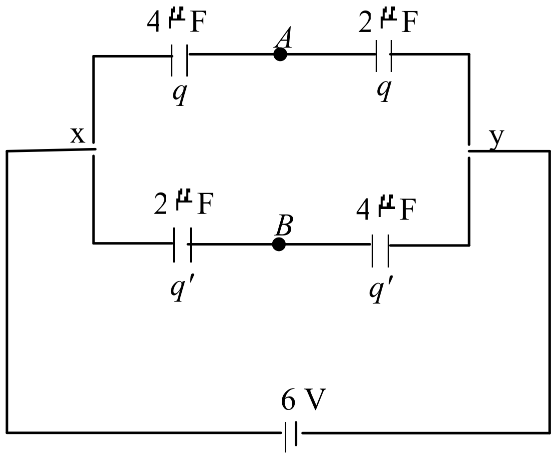
Using Eq. (i), we obtain

$C'=2\times1+3\times1=5\,\mu F$

83 **(a)**

Consider the charge distribution as shown.

Considering the branch on upper side, we have



$$\frac{q}{V_x-V_A}=4\times10^{-6}$$

$$\frac{q}{V_A-V_y}=2\times10^{-6}$$

Here, $V_x=6\,volt, V_y=0$

$\therefore \frac{q}{6-V_A}=4\times10^{-6}$

…(i)

$$\frac{q}{V_A-0}=2\times10^{-6}$$

…(ii)

From Eqs. (i) and (ii), we get

$$\frac{V_A}{6-V_A}=2$$

$\therefore V_A=4\,volt$

Similarly for the lower side branch

$$\frac{q'}{6-V_B}=2\times10^{-6}$$

…(iii)

$$\frac{q'}{V_B-0}=4\times10^{-6}$$

...(iv)

From Eqs. (iii) and (iv)

$$\frac{V_B}{6-V_B}=\frac{1}{2}$$

$\therefore V_B=2\,volt$

$\therefore V_A-V_B=4-2=2\,volt$

84 **(a)**

The system will be equivalent to series combination of two capacitors of half thickness ie.,each of capacity 2 C

$\therefore \frac{1}{C_s} = \frac{1}{2c} + \frac{1}{2c} = \frac{1}{c} \vee C_s = c$

∴capacity remains the same

86 **(b)**

In parallel, potential is same, say V

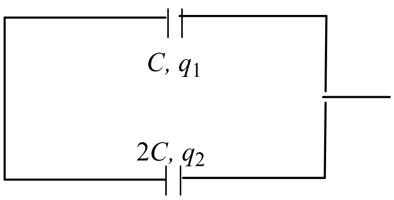
$\frac{Q_1}{Q_2} = \frac{C_1 V}{C_2 V} = \frac{C_1}{C_2}$

87 **(c)**

The charge $q_1 = C V_0$

or

$V_0 = \frac{q_1}{C}$ …(i)



∴Capacitors are in parallel, in parallel V_0 is same for all capacitors.

∴ For second capacitor $V_0 = \frac{q_2}{2C}$ …(ii)

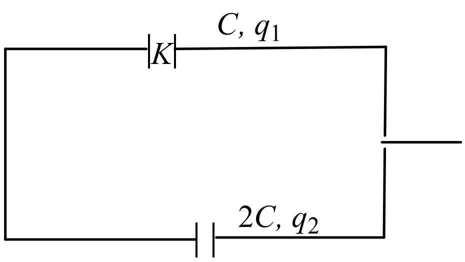
From Eqs. (i) and (ii),

$q_2 = 2q_1$ …(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

$\frac{q_2'}{2C} = \frac{q'_1}{KC}$

$\frac{q_2'}{2C} = \frac{q_1'}{2C}$

$ie, q_1' = q_2'$

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 $2q_1' = 3q_1 \vee q_1' = \frac{3q_1}{2}$

∴ Now potential $\frac{q_1'}{2C} = \frac{3q_1}{4C}$

$V = \frac{3V_0}{4}$

$[\because q_1 = V_0 C]$

88 **(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.

89 **(d)**

Frequency $n =$ ¿50Hz

Time period $T = \frac{1}{50}$ s

Time taken for voltage to change from its peak value to zero

¿ $\frac{T}{4} = \frac{1}{4 \times 50} = \frac{1}{200} = 5 \times 10^{-3} s$

90 **(d)**

$E = \left(\frac{1}{2}\right) C V^2$ ...(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

$ms\Delta T = \left(\frac{1}{2}\right) C V^2$

$V = \sqrt{\frac{2ms\Delta T}{C}}$

91 **(b)**

As the electrostatic force are conservative, work done is independent of path .

$W = \vec{F} . \vec{ds} = qE\hat{i} . \left[(0-a)\hat{i} + (0-b)\hat{j} \right]$

$¿-qEa$

92 **(d)**

$E_1=\frac{1}{2}C_1V^{2¿}$

$¿\frac{1}{2}\times 2\times 10^{-6}\times 100^2=0.01\,J$

$E_1=\frac{1}{2}C_2V^{2¿}$

$\frac{1}{2}\times 10\times 10^{-6}\times (100)^2=0.05$ J

Energy change $¿E_2-E_2$

$¿0.05-0.01=0.04\,J=4\times 10^{-2}\,J$

93 **(a)**

Potential energy of electric dipole, $U=-\vec{p}\,.\vec{E}=-pE\cos\theta$.

In Fig. (a), $\theta=\pi$ rad hence

$U=-pE\cos\pi=+pE=maximum$.

94 **(a)**

$C_s=\frac{10\times 20}{10+20}=\frac{200}{30}=\frac{20}{3}\,\mu F$

$Q=C_sV$

$Q=\frac{20}{3}\,\mu F\times 200\,V$

$Q=\frac{4000}{3}\,\mu C$

Now, $V=\frac{4000\,\mu C}{3\times 30\,\mu F}=\frac{4000}{90}V=\frac{400}{9}V$

95 **(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.

96 **(b)**

Electrical pressure (force/area)

$\Rightarrow p=\frac{1}{2}\varepsilon_0E^2\wedge E=\frac{V}{r}\therefore p=\frac{1}{2}\varepsilon_0\frac{V^2}{r^2}$

97 **(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.

98 **(d)**

The three capacitors are in parallel hence, their equivalent capacitance ¿$3C$

99 **(c)**

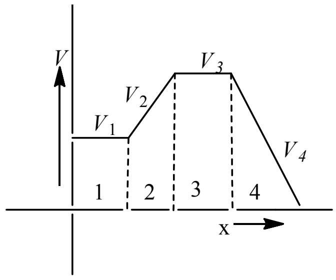
Electric potential inside the hollow conducting sphere is constant and equal to potential at the surface of the sphere¿ $\frac{Q}{4\pi\varepsilon_0 R}$.

100 **(b)**

Electric field

$E=\frac{-dV}{dx}$

For I region, V_1=constant



$\therefore \frac{dV_1}{dx}=0$

$\therefore E_1=0$

For II region,

$V_2=+ve=+f(x)$

$\therefore E_2=\frac{-dV_2}{dx}=-ve$

For III region.

V_3=constant

$\therefore \frac{dV_3}{dx}=0$

$\therefore E_3=0$

For IV region, $V_1=-f(x)$

$\therefore E_4=\frac{-dV_4}{dx}=+ve$

From these values, we have

$E_2>E_4>E_1=E_3$

102 **(b)**

The arrangement behaves as a combination of 2 capacitors each of capacitance $C=\frac{\varepsilon_0 A}{d}$.

Thus, equivalent capacity¿ $2C$

∴total energy stored

$$U=\frac{1}{2}\times(2C)V^2=CV^2=\frac{\varepsilon_0 A}{d}V^2$$

103 **(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

$t=\frac{1}{v}=\frac{l}{\frac{\sigma}{\varepsilon_0 B}}=\frac{\varepsilon_0 lB}{\sigma}$

104 **(a)**

When charge $q_3$is at C, then its potential energy is

$U_C=\frac{1}{4\pi\varepsilon_0}\left(\frac{q_1q_3}{0.4}+\frac{q_2q_3}{0.5}\right)$

Where charge $q_3$is at D, then

$U_D=\frac{1}{4\pi\varepsilon_0}\left(\frac{q_1q_3}{0.4}+\frac{q_2q_3}{0.1}\right)$

Hence, change in potential energy

$\Delta U=U_D-U_C$

¿ $\frac{1}{4\pi\varepsilon_0}\left(\frac{q_2q_3}{0.1}-\frac{q_2q_3}{0.5}\right)$

$but\,\Delta U=\frac{q_3}{4\pi\varepsilon_0}k$

$\therefore\frac{q_3}{4\pi\varepsilon_0}k=\frac{1}{4\pi\varepsilon_0}\left(\frac{q_2q_3}{0.1}-\frac{q_2q_3}{0.5}\right)$

$\Longrightarrow k=q_2(10-2)=8q_2$

105 **(c)**

The arrangement shows a Wheatstone bridge.

As $\frac{C_1}{C_3}=\frac{C_4}{C_5}=1$,therefore the bridge is balanced.

$\frac{1}{C_{s_1}}=\frac{1}{4}+\frac{1}{4}=\frac{2}{4}=\frac{1}{2}, C_{s_1}=2\mu F$

Similarly, $C_{s2}=2\mu F$

$\therefore$ effective capacitance

¿ $C_p=C_{s1}+C_{s2}=2+2+$¿ $4\mu F$

106 **(b)**

The given arrangement of nine plates is equivalent to the parallel combination of 8 capacitors.

The capacity of each capacitor,

$C=\frac{\varepsilon_0 A}{d}$

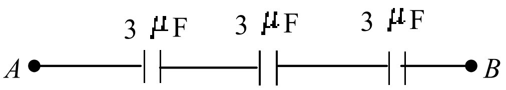
¿ $\frac{8.854\times10^{-12}\times5\times10^{-4}}{0.885\times10^{-2}}=0.5\,pF$

Hence, the capacity of 8 capacitors

¿ $8C=8\times0.5=4\,pF$

107 **(a)**

The two capacitors each of value $1.5\mu F$ are in parallel. So, their equivalent capacitance



¿ $1.5+1.5=3\mu F$

Now, three capacitors each of value $3\,\mu F$ 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 $c=1\,\mu F$

108 **(a)**

Energy $E_1=\frac{1}{2}C_1V_1^2$

¿ $\frac{1}{2}\times1\times10^{-6}\times(30)^2=450\times10^{-6}\,J$

Common potential

$V=\frac{q_1+q_2}{C_1+C_2}$

¿ $\frac{1\times30+0}{1+2}=10\,volt$

$E_2=\frac{1}{2}(C_1+C_2)V^2$

¿ $\frac{1}{2}(1+2)\times10^{-6}\times(10)^2$

¿ $1.5\times100\times10^{-6}=150\times10^{-6}\,J$

Loss of energy $=E_2-E_1=300\,\mu J$

109 **(a)**

$\frac{1}{C_s}=\frac{1}{C_1}+\frac{1}{C_2}=\frac{1}{10}+\frac{1}{20}=\frac{3}{20}$;

$C_s=\frac{20}{3}\,\mu F$

∴ charge on each capacitor

¿ $C_sV=\frac{20}{3}\times200=\frac{4000}{3}\,\mu C$

Common potential ¿ $\frac{total\ charge}{total\ capacity}$

¿ $\frac{2\times4000/3}{10+20}=\frac{800}{9}V$

110 **(b)**

As $E=\frac{-dV}{dr}$

$\therefore +E_0=\frac{-[V(x)-0]}{x}$

or $V_x=-E_0x$

111 **(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 $\hat{i}$.

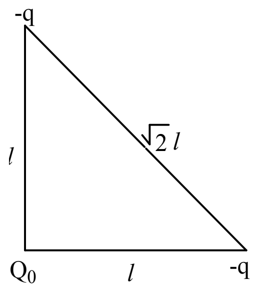
112 **(b)**

Here total electrostatic potential energy is zero

$ie,\frac{-Q_0q}{l}-\frac{qQ_0}{l}+\frac{q^2}{\sqrt{2}l}=0$

On solving,

$Q_0=\frac{q}{2\sqrt{2}}=\frac{2q}{\sqrt{32}}$



113 **(d)**

Potential due to charge $-q$ at A

$V_A=\frac{1}{4\pi\varepsilon_0k}\frac{-q}{(r^2)^{1/2}}$

Potential due to charge $-q$ at B

$V_B=\frac{1}{4\pi\varepsilon_0k}\frac{-q}{(r^2)^{1/2}}$

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.

114 **(d)**

Here, electric potential

$V = 3x^2$

Electric field,

$E = \frac{-\partial V}{\partial x}$

$¿ -\frac{\partial}{\partial x}(3x^2) = -6x$

$\therefore E_{(2,0,1)} = -12\, V\, m^{-1}$

115 **(c)**

When battery remains connected

$C' = kC$

$Q' = kQ$

$V' = V$

$E' = E$

$U' = kU$

$U \wedge Q$ Both increases.

116 **(b)**

Let $R \wedge r$ be the radii of bigger and each smaller drop. Charge remains conserved.

Hence, charge on bigger drop

$¿ 27 \times$ charge on smaller drop

$ie,\quad q' = 27q$

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

$C' = 4\pi\varepsilon_0 R = 4\pi\varepsilon_0(3r)$

$¿ 3(4\pi\varepsilon_0 r) = 3C$

117 **(c)**

$\int \vec{E}.\vec{dl} \rightarrow N C^{-1} m = J C^{-1}$

118 **(b)**

At equitorial point

$E_e = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$

(directed from +q to –q) and $V_e = 0$.

119 **(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

$\frac{Q}{4\pi R^2} = \frac{q}{4\pi r^2} = \sigma$

$\therefore V = \frac{1}{\varepsilon_0}[\sigma R + \sigma r] = \frac{\sigma}{\varepsilon_0}(R + r)$

120 **(a)**

The potential V_1 of smaller sphere is given by

$V_1 = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r} + \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} \ldots\ldots (i)$

The potential V_2 of bigger sphere is given by

$V_2 = \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} + \frac{1}{4\pi\varepsilon_0}.\frac{q}{R}$

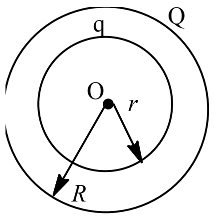
So, the potential difference between the plates

$V = V_1 - V_2$

Or

$V = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r} + \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} - \frac{1}{4\pi\varepsilon_0}.\frac{Q}{R} - \frac{1}{4\pi\varepsilon_0}.\frac{q}{R}$

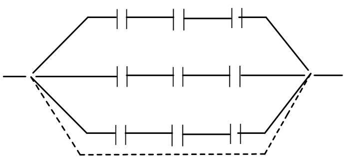
$¿ \frac{1}{4\pi\varepsilon_0}\frac{q}{r} - \frac{1}{4\pi\varepsilon_0}.\frac{q}{R} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r} - \frac{q}{R}\right)$



121 **(b)**

Let m rows of n series capacitor be taken then minimum number of capacitors required is

$N = m \times n$



Also effective voltage is

$V^{'} = 1000 = n \times 250$

$\Rightarrow n = \frac{1000}{250} = 4$

Also these four capacitor are connected in series then effective capacitance is

$\frac{1}{C'} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} = \frac{4}{8}$

$\Rightarrow C^{'} = 2\mu F$

$\therefore C^{''} = 16 = 2 \times m$

$\Rightarrow m = \frac{16}{2} = 8$

Hence $N = m \times n = 8 \times 4 = 32$

122 **(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 $A \wedge B$ are at same potential.

Hence, $V_A = V_B > V_C$

123 **(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, $C^{'} = C$

$\therefore \frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 A}{d^{'} - t\left(1 - \frac{1}{K}\right)}$

or $d = d^{'} - t + \frac{t}{K}$

or $8 = d^{'} - 4 + \frac{4}{2}$

or $8 = d^{'} - 2$

or $d^{'} = 10\, mm$

124 **(b)**

Charge on each plate of each capacitor

$Q = \pm CV = \pm 25 \times 10^{-6} \times 200$

¿ $\pm 5 \times 10^{-3} C$

125 **(b)**

Common potential $= \frac{C_1 V_0 + C_2 \times 0}{C_1 + C_2} = \frac{C_2 V_0}{C_1 + C_2}$

$U_{before} = \frac{1}{2} C_1 V_0^2$

$U_{after} = \frac{1}{2} C_1 \left[\frac{C_1 V_0}{C_1 + C_2}\right]^2 + \frac{1}{2} C_2 \left[\frac{C_1 V_0}{C_1 + C_2}\right]^2$

¿ $\frac{1}{2}\left[\frac{C_1 V_0}{C_1 + C_2}\right]^2 (C_1 + C_2)$

$\Rightarrow \frac{U_{before}}{U_{after}} = \frac{C_1 + C_2}{C_1}$

Here, $C_1 = C_2 = C$

$\therefore \frac{U_{before}}{U_{after}} = \frac{2C}{C}$

$\Rightarrow U_{after} = \frac{U}{2}$

126 **(a)**

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

$\therefore V \propto d$

As the distance between the plates of the capacitor increases potential difference also increases.

127 **(d)**

As $\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3 \therefore R = n^{1/3} r$

New potential $V^{'}=\frac{nq}{4\pi\varepsilon_0 r}=n^{2/3}V$

128 **(b)**

Potential inside the sphere will be same as that on its surface

$ie, V=V_{surface}=\frac{q}{10}stat-volt$

$V_{out}=\frac{q}{15}stat-volt$

$\therefore\frac{V_{out}}{V}=\frac{2}{3}$

$\Longrightarrow V_{out}=\frac{2}{3}V$

129 **(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

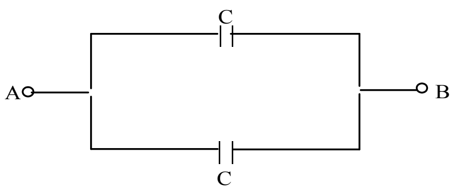
$\frac{1}{C^{'}}=\frac{1}{KC}+\frac{1}{C}$

or $\frac{1}{C^{'}}=\frac{1+K}{KC}$

$\therefore C^{'}=\frac{KC}{K+1}$

130 **(a)**

The given circuit is equivalent to a parallel combination of two identical capacitors.



Hence, equivalent capacitance between points $A\wedge B$ is

$C=\frac{\varepsilon_0 A}{d}+\frac{\varepsilon_0 A}{d}=\frac{2\varepsilon_0 A}{d}$

131 **(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, $E=\left(\frac{A\varepsilon_0}{d}\right)(Ed)^2=A\varepsilon_0 E^2 d$

132 **(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.

$W_A=W_B=W_C=0$

133 **(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, $C_1\wedge C_2$ are in parallel

$C_{net}=C_1+C_2$

¿ $\frac{3\varepsilon_0 A}{4d}+\frac{\varepsilon_0 AK}{4d}$

¿ $\frac{\varepsilon_0 A}{d}\left[\frac{3}{4}+\frac{K}{4}\right]$

¿ $\frac{C}{4}(K+3)$

134 **(c)**

On sharing of charges loss in electrical energy,

$\Delta U=\frac{C_1 C_2}{2(C_1+C_2)}(V_1-V_2)$. In present case

$C_1=C_2=C$

$\therefore\Delta U=\frac{C^2}{2(2C)}(V_1-V_2)^2=\frac{1}{4}C(V_1-V_2)^2$

135 **(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

$a\wedge b$ = 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

$$E'=2E$$

136 **(d)**

$$C=\frac{\varepsilon_0 A}{\frac{d_1}{K_1}+\frac{d_2}{K_2}}$$

¿ $\frac{\varepsilon_0 A}{\frac{d}{2}\left(\frac{1}{1}+\frac{1}{2}\right)}=\frac{4\varepsilon_0 A}{3d}$

137 **(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.

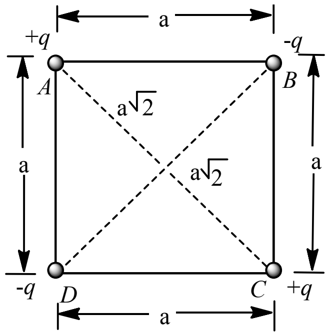
138 **(d)**

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).

139 **(a)**

Work is required to set up the four charge configuration

$$q_1=+q, q_2=-q, q_3=+q\wedge q_4=-q$$



$$W=\frac{1}{4\pi\varepsilon_0}\left[\frac{(+q)(-q)}{AB}+\frac{(-q)(+q)}{BC}+\frac{(+q)(-q)}{CD}+\frac{(-q}{L}\right.$$

$$W=\frac{1}{4\pi\varepsilon_0}\left[\frac{-q^2}{a}-\frac{q^2}{a}-\frac{q^2}{a}-\frac{q^2}{a}+\frac{q^2}{a\sqrt{2}}+\frac{q^2}{a\sqrt{2}}\right]$$

$$W=\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}\left[-4+\sqrt{2}\right]=\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}\left[-4+1.414\right]$$

$W=-0.21\times\frac{q^2}{\varepsilon_0 a}$(¿.)

140 **(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

$\frac{1}{C_{eq}}=\frac{1}{6}+\frac{1}{6}+\frac{1}{6}$

$C_{eq}=2$

Now, we require $18\mu F$ capacitance, for this we need 9 such combinations is parallel.

Hence, $9\times 3=27$

141 **(b)**

$\frac{1}{C_s}=\frac{1}{4}+\frac{1}{6}+\frac{1}{12}=\frac{3+2+1}{12}=\frac{6}{12}=\frac{1}{2}$

$C_s=2\mu F$

$C_p=4+6+12=22\mu F$

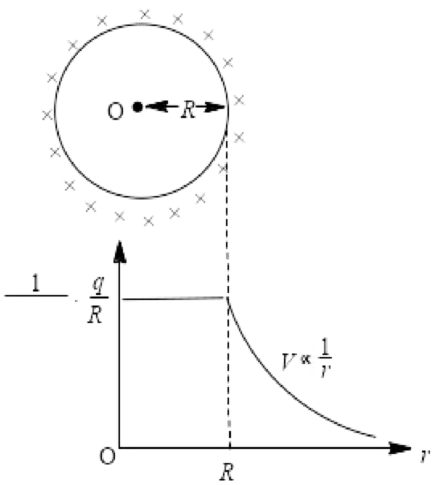
$\frac{C_s}{C_p}=\frac{2}{22}=\frac{1}{11}$

142 **(b)**

For neutral point $\vec{E}_A+\vec{E}_B=\vec{0} \vee \vec{E}_A=-\vec{E}_B$. It is possible, in present problem, only at a point somewhere on the left of $-Q$

143 **(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



$V=\frac{1}{4\pi\varepsilon_0}\frac{q}{R} volt$

Also outside the metallic sphere

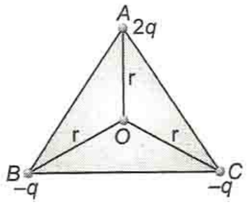
$V=\frac{1}{4\pi\varepsilon_0}.\frac{q}{r}$

$V\propto\frac{1}{r}$

144 **(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 $\vec{E}_A=\frac{1}{4\pi\varepsilon_0}.\frac{2q}{1} along AO, \vec{E}_B=\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ along OB and

$\vec{E}_c=\frac{1}{4\pi\varepsilon_0}.\frac{q}{r^2} along OC. obviously \vec{E}_B+\vec{E}_B$ Will also be in the direction of AO extended and hence $\vec{E}_A \wedge \left(\vec{E}_B+\vec{E}_C\right)$ being in same direction will not give zero resultant.

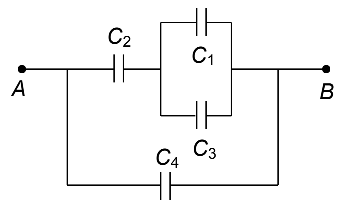
145 **(d)**

The arrangement can be redrawn as shown in the adjoining figure.

$C_{13}=C_1+C_3=9+9=18\mu F$

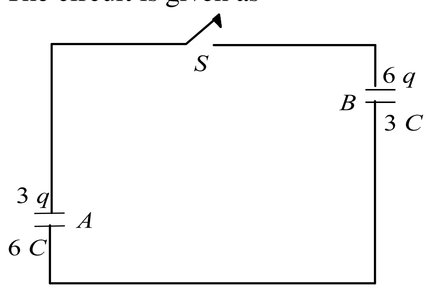
$C_{2-13}=\frac{C_2\times C_{13}}{C_2+C_{13}}=\frac{9\mu F\times 18\mu F}{(9+18)\mu F}=6\mu F$

$\therefore C=C_{2-13}+C_4=6\mu F\times 9\mu F=15\mu F.$



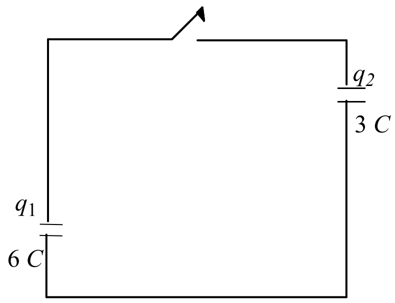
146 **(b)**

The circuit is given as



Let $q_1 \wedge q_2$ be the charge after switch S has been closed.

Then, $V=\frac{q_1}{6C}=\frac{q_2}{3C}$



$\Rightarrow\frac{q_1}{2}=q_2$

$\Rightarrow q_1=2q_2$ …(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)

$2q_2+q_2=9q$

$\Rightarrow 3q_2=9q$

$q_2=3q$

Now, from Eq. (i)

$q_1=2\times 3q$

$\Rightarrow q_1=6q$

Hence,$q_1=6q, q_2=3q$

147 **(b)**

$C_1=\frac{K_1\varepsilon_0 A}{d/2}=\frac{2K_1\varepsilon_0 A}{d}$

$C_2=\frac{2K_2\varepsilon_0 A}{d}$

$\frac{1}{C_s}=\frac{1}{C_1}+\frac{1}{C_2}=\frac{d}{2K_1\varepsilon_0 A}+\frac{d}{2K_2\varepsilon_0 A}$

¿ $\frac{d}{2\varepsilon_0 A}\left(\frac{K_1+K_2}{K_1K_2}\right)$

$C_s=\frac{2\varepsilon_0 A}{d}\left(\frac{K_1K_2}{K_1+K_2}\right)$

148 **(c)**

Electric potential inside a conductor is constant and it is equal to that on the surface of conductor.

149 **(a)**

Potential energy of the system

$U=\frac{KQq}{l}+\frac{Kq^2}{l}+\frac{KqQ}{l}=0$

$\Longrightarrow \frac{Kq}{l}(Q+q+Q)=0$

$\Longrightarrow Q=\frac{-q}{2}$

150 **(b)**

Potential energy of charges $q_1 \wedge q_2, r$ distance apart

$U=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$

For $r=0.1$m,

$U_1=\frac{1}{4\pi\varepsilon_0}\frac{12\times10^{-6}\times5\times10^{-6}}{0.1}$

¿ $\frac{9\times10^9\times60\times10^{-12}}{0.1}=5.4J$

For $r=0.06m$,

$U_2=\frac{9\times10^9\times60\times10^{-12}}{0.06}=9J$

∴ Work done = (9 – 5.4) J = 3.6 J

151 **(d)**

Loss of energy ¿ $\frac{1}{2}\frac{C_1C_2}{(C_1+C_2)}(V_1-V_2)^2$

¿ $\frac{1}{2}\frac{5\times10^{-6}\times5\times10^{-6}(2000-1000)^2}{(5+5)\times10^{-6}}$

¿ $\frac{5\times5}{2\times10}=1.25J$

152 **(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 $V_c=2V-1.2V-\frac{V}{3R}.2R-V=\frac{V}{3}$

153 **(c)**

$E\propto\frac{1}{r}$, *where r is the distance ¿ the axis.*

154 **(b)**

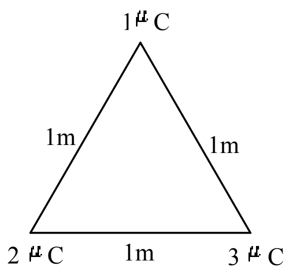
Here, $C_s=\frac{C_1C_2}{C_1+C_2}=3\mu F$

And $C_p=C_1+C_2=16\mu F$

Solve to get, $C_1=4\mu F \wedge C_2=12\mu F$

155 **(c)**

When charges are placed at vertices of an equilateral triangle of side 1m, then potential energy of combination is

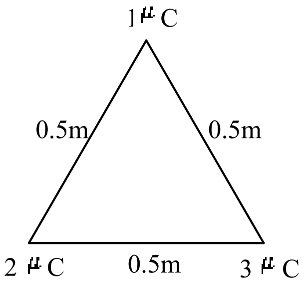


$U_1=\frac{1}{4\pi\varepsilon_0}.\frac{1\times2\times10^{-12}}{(1)}+\frac{1}{4\pi\varepsilon_0}.\frac{2\times3\times10^{-12}}{(1)}$

$\frac{+1}{4\pi\varepsilon_0}.\frac{3\times1\times10^{-12}}{(1)}$

$¿11 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12} J$

When charges are placed at vertices of an equilateral triangle of side 0.5m, then potential energy of combination is



$$U_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{1 \times 2 \times 10^{-12}}{(0.5)} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{2 \times 3 \times 10^{-12}}{(0.5)}$$

$$+ \frac{1}{4\pi\varepsilon_0} \cdot \frac{3 \times 1 \times 10^{-12}}{(0.5)}$$

$$¿22 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12} J$$

$$\therefore Work\ done = \Delta U = U_2 - U_1$$

$$¿22 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12} - 11 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12}$$

$$¿11 \times \frac{1}{4\pi\varepsilon_0} \times 10^{-12}$$

$$¿11 \times 9 \times 10^9 \times 10^{-12} = 99 \times 10^{-3}$$

$$¿0.099 J \approx 0.01 J$$

156 **(c)**

As work is done by the field, KE of the body increase by

KE $= W = E = q(V_A - V_B)$

$¿10^{-8}(600 - 0) = 6 \times 10^{-6} J$

157 **(a)**

The $10\mu F$ and $6\mu F$ capacitors are connected in parallel, hence resultant capacitance is

$C' = 10\mu F + 6\mu F = 16\mu F$

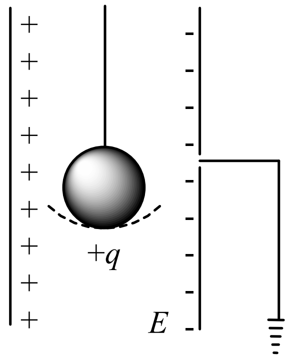
This is connected in series with $4\mu F$ capacitor, hence effective capacitance is

$$\frac{1}{C''} = \frac{1}{16} + \frac{1}{4} = \frac{20}{16 \times 4}$$

$$\Rightarrow C'' = \frac{64}{20} = 3.20\mu F$$

158 **(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, $$T' = 2\pi \frac{\sqrt{l}}{\sqrt{g^2 + \left(\frac{qE}{m}\right)^2}}$$

160 **(b)**

Equivalent capacitance between points $B \wedge C$ is

$$C' = \frac{10 \times 10}{10 + 10} + 10 = 15\mu F$$

Now equivalent capacitance between points $A \wedge C$ is

$$C'' = \frac{5 \times 15}{15 + 5} = \frac{75}{20}\mu F$$

Charge on capacitor of capacity $5\mu F$ is

$$Q = CV = \frac{75}{20} \times 2000 = 7500\mu C$$

(Since, potential at the point C will be zero)

Now, potential difference across capacitor of $5\mu F$ is

$$V_A - V_B = \frac{Q}{5\mu F} = \frac{7500\mu C}{5\mu C} = 1500\text{volt}$$

As, $V_A = 2000$ volt

Hence, $V_B = 2000 - 1500 = 500$ volt.

161 **(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 $\frac{E}{V}=\frac{1}{6r}\vee E=\frac{V}{6r}$

162 **(c)**

If C is capacity of each condenser, then charge on each capacitor¿ $10C$

$(\because V=10V)$

When connected in series, potential difference

between free plates = $\frac{total\ charge}{total\ capacity}$ ¿ ¿

¿ $\frac{10C}{C/6}=60V$

164 **(a)**

Net flux leaving the surface

$\phi=4\times10^5-5\times10^5=-10^5$ MKS units

∴charges must be negative

$q=\phi\varepsilon_0=-10^5\times8.86\times10^{-12}$

¿ $-8.86\times10^{-7}C$

165 **(d)**

Net work done = final PE $-$ ¿ initial PE

¿ $\frac{Qq}{4\pi\varepsilon_0 l}-\frac{Qq}{4\pi\varepsilon_0 l}=$ ¿ Zero.

166 **(d)**

PE¿ $\frac{q_1q_2}{4\pi\varepsilon_0 r}=\frac{9\times10^9(2\times10^{-6})^2}{1}=0.036J$

167 **(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_1round the circle is zero.

168 **(b)**

Co-ordinates of the point are (x, y)

∴Distance of point from origin,

$r=\sqrt{x^2+y^2}, V=-kxy$

$$E_x=\frac{-dV}{dx}=\frac{-d}{dx}(-kxy)=ky$$

$$E_y=\frac{-dV}{dy}=(-kxy)=kx$$

$\therefore E=\sqrt{E_x^2+E_y^2}=k\sqrt{y^2+x^2}=kr$

$\therefore E\propto r$

169 **(a)**

Required work done,

$W=QV$

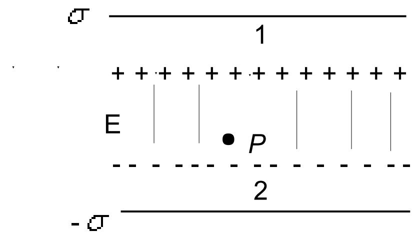
¿ $(2e)\times25$

¿ $50e=50\times1.6\times10^{-19}$

¿ $8\times10^{-18}J$

170 **(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 , $\sigma=26.4\times10^{-12}Cm^{-2}$

$\varepsilon_0=8.85\times10^{-12}C^2N^{-1}m^{-2}$

Hence , $E=\frac{26.4\times10^{-12}}{8.85\times10^{-12}}\approx3NC^{-1}$

Note the direction of electric field is from the positive to the negative plate.

171 **(c)**

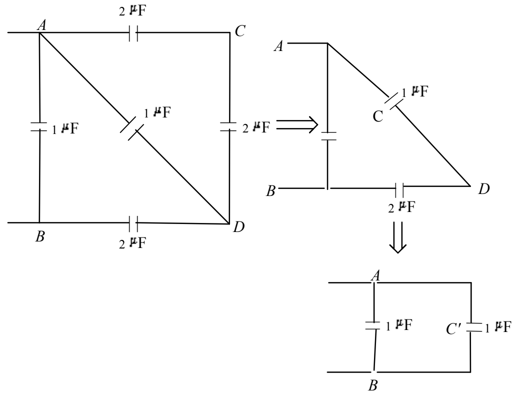
$$U=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$$

$$\therefore U=\frac{9\times10^9\times(1.6\times10^{-19})(-1.6\times10^{-19})}{10^{-10}}$$

¿ $-9\times10^9\times1.6\times10^{-19}\times10^{10}eV$

¿ $-14.4eV$

172 **(d)**



The capacitors $2\mu F$ and $2\mu F$ of arm ACD are in series. So, their equivalent capacitance is $1\mu F$ which is in parallel with capacitor of $1\mu F$ of arm AD.
So, equivalent capacitance now is $2\mu F$.
This capacitance is now in series with $2\mu F$ capacitance of arm BD which equivalents to $1\mu F$ is in parallel with $1\mu F$ capacitance of arm AB.
So, final effective capacitance=$2\mu F$.

173 **(b)**

$$\therefore \frac{1}{C_s}=\frac{1}{2}+\frac{1}{1}=\frac{3}{2}$$

$$C_s=\frac{2}{3}F$$

$$Q=C_s V=\frac{2}{3}\times 12=8C$$

$$V_1=\frac{Q}{C_1}=\frac{8}{2}=4V$$

174 **(a)**

$q_1=10\times 50=500\mu C, C_1=10\mu F, C_2=?, q_2=0$

As $\qquad V=\frac{q_1+q_2}{C_1+C_2¿}$
¿

$$\therefore C_1+C_2=\frac{q_1+q_2}{V}=\frac{500+0}{20}=25\mu F$$

$C_2=25-C_1=25-10=15\mu F$

175 **(d)**

The capacitance of parallel plate air capacitor

$$C=\frac{\varepsilon_0 A}{d} \qquad \ldots\text{(i)}$$

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, $A'=A, d'=2d, C'=2C$

$$\therefore 2C=\frac{K\varepsilon_0 A}{2d} \qquad \ldots\text{(ii)}$$

Equating Eqs. (i) and (ii), we get
$K=4$

176 **(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.

177 **(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.

$$\sum V=V_A+V_B+V_C$$

$$V_A=\frac{1}{4\pi\varepsilon_0}.\frac{2q}{x}$$

$$V_B=\frac{-1}{4\pi\varepsilon_0}.\frac{q}{x}$$

$$V_C=\frac{-1}{4\pi\varepsilon_0}.\frac{q}{x}$$

$$\therefore V=\frac{1}{4\pi\varepsilon_0}\left(\frac{2q}{x}-\frac{q}{x}-\frac{q}{x}\right)=0$$

Electric field is a vector quantity, hence component along OD is taken

$$E=\frac{1}{4\pi\varepsilon_0}\left(\frac{2q}{x^2}+\frac{2q}{x^2}\cos\theta\right)\neq 0$$

178 **(c)**

Total electric flux, $\phi_1=\phi=\frac{1}{\varepsilon_0}¿$charge enclosed¿ and

ie, charge of given body is body is constant.

179 **(b)**

$$\frac{E_A}{E_B}=\frac{\frac{1}{2}mv_A^2}{\frac{1}{2}mv_B^2}=\frac{W_A}{W_B}=\frac{(q)V}{(4q)V}$$

$$\frac{v_A}{v_B}=\frac{1}{2}$$

180 **(c)**

$$\phi_E = \frac{\sum q}{\varepsilon_0} = \frac{(+5-5)\times 10^{-6}}{\varepsilon_0} = ¿\text{zero}$$

181 **(a)**

Since the two spheres are joined by a wire, their potential are equal *ie*,

$$\frac{q_1}{4\pi\varepsilon_0 R_1} = \frac{q_2}{4\pi\varepsilon_0 R_2} \Rightarrow \frac{q_1}{q_2} = \frac{R_1}{R_2}$$

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 $\frac{\sigma_2}{\sigma_1} = \frac{\sigma_2}{\sigma_1} \times \frac{R_1^2}{R_2^2} = \left(\frac{R_2}{R_1}\right)\left(\frac{R_1}{R_2}\right)^2$

$$\Rightarrow \frac{\sigma_2}{\sigma_1} = \frac{R_1}{R_2}$$

182 **(d)**

(n-1) capacitors are made by n plates and all are connected in parallel because plates are connected alternately.

$\therefore$ Total capacitance$¿(n-1)x$

183 **(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 $K = 2$

184 **(a)**

$$r_b - r_a = 1\,mm = 10^{-3}\,m$$

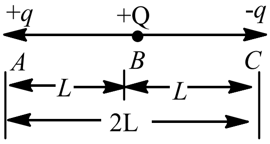
From $C = 4\pi\varepsilon_0 r_a \frac{r_b ¿}{r_b - r_a} ¿$

$$10^{-6}=\frac{1\left(r_b-10^{-3}\right)r_b}{9\times 10^{9}\left(10^{-3}\right)}$$

$r_b^2=9, r_b=3m$

185 **(d)**

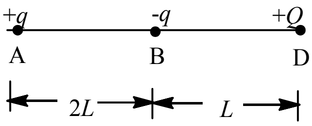
In Ist case, when charge $+Q$ is situated at C.



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

$$U_2=\frac{1}{4\pi\varepsilon_0}.\frac{(q)(-q)}{2L}+\frac{1}{4\pi\varepsilon_0}.\frac{qQ}{3L}+\frac{1}{4\pi\varepsilon_0}\frac{(-q)(Q)}{L}$$

$\therefore Work\,done=\Delta U=U_2-U_1$

¿ $\left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{2L}+\frac{1}{4\pi\varepsilon_0}\frac{qQ}{3L}-\frac{1}{4\pi\varepsilon_0}\frac{qQ}{L}\right)$

$-\left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{2L}+\frac{1}{4\pi\varepsilon_0}\frac{qQ}{L}+\frac{1}{4\pi\varepsilon_0}\frac{qQ}{L}\right)$

¿ $\frac{qQ}{4\pi\varepsilon_0}.\left[\frac{1}{3L}-\frac{1}{L}\right]$

¿ $\frac{qQ}{4\pi\varepsilon_0}\frac{(1-3)}{3L}$

¿ $\frac{-2qQ}{12\pi\varepsilon_0 L}=\frac{-qQ}{6\pi\varepsilon_0 L}$

186 **(c)**

$C_0=\frac{\varepsilon_0 A}{d}=18$

$C_0=\frac{K\varepsilon_0 A}{3d}=72$

Dividing $Eq.(ii)\,by\,Eq.$ (i)

$\frac{k}{3}=\frac{72}{18}=4$

$K=12$

187 **(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

$C_p=\frac{1}{3}+1$

$\frac{4}{3}\mu F=1.33\mu F$

189 **(c)**

Here,

$\vec{E}=\vec{E}_1+\vec{E}_2+\vec{E}_3=\left(\frac{+\sigma}{2\varepsilon_0}\right)(-\hat{k})+\left(\frac{2\sigma}{2\varepsilon_0}\right)(-\hat{k})+$

$\left(\frac{\sigma}{2\varepsilon_0}\right)(-\hat{k})$

¿ $-\left(\frac{2\sigma}{\varepsilon_0}\right).\hat{k}$

190 **(a)**

$$V=\frac{\sum q}{4\pi\varepsilon_0 r}=\frac{-10+10}{4\pi\varepsilon_0 r}=0$$

191 **(b)**

Linear momentum of electron, $p_e=\sqrt{2m_e eV}$

Linear momentum of photon, $p_p=\sqrt{2m_p eV}$

$\frac{p_e}{p_p}=\frac{\sqrt{2m_e eV}}{\sqrt{2m_p eV}}$

$\frac{p_e}{p_p}=\sqrt{\frac{m_e}{m_p}}$

192 **(a)**

Number of capacitors to be connected in series

$V=\frac{valtage\,rating\,required}{voltage\,rating\,of\,given\,capacitor}=\frac{700}{200}=3.5\,i$

$C_{eq}=\frac{10}{4}=2.5\,\mu F$

Number of rows required

¿ $\frac{capacitor\,required}{capacity\,of\,each\,row}=\frac{10}{2.5}=4$

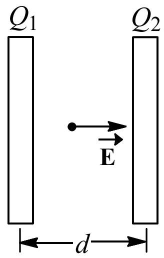
$\therefore$ total number of capacitors required ¿ $4\times 4=16$

194 **(a)**

Net capacity of 5 capacitors joined in parallel ¿ $5\times 2=10\,\mu F$. now it is connected with two capacitors of 2 μF each in series, hence equivalent capacitance is $\frac{10}{11}\mu F$.

195 **(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 $E=\frac{Q_1-Q_2}{2A\varepsilon_0}=\frac{V}{d}\vee V=\frac{(Q_1-Q_2)d}{2A\varepsilon_0}$

$$\Rightarrow V=\frac{Q_1-Q_2}{2C} \qquad \left(\therefore C=\frac{\varepsilon_0 A}{d}\right)$$

196 **(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.

197 **(b)**

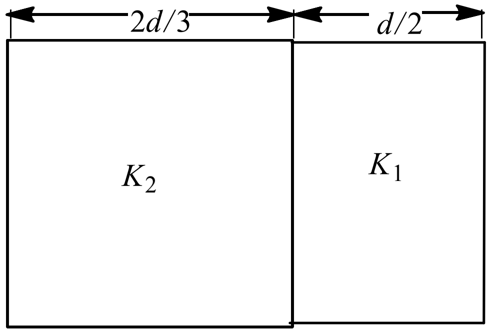
Work done =potential energy of configuration of charges

$\frac{1}{4\pi\varepsilon_0 a}$ ¿

¿ $\frac{1}{4\pi\varepsilon_0}\left[\frac{-4q^2}{a}+\frac{2q^2}{a\sqrt{2}}\right]=\frac{-2.6}{4\pi\varepsilon_0}\frac{q^2}{a}$

198 **(c)**

$$C=\frac{C_1C_2}{C_1+C_2} \qquad \ldots\text{(i)}$$



where $C_1 = \dfrac{K_1 \varepsilon_0 A}{d/3}$ …(ii)

And $C_2 = \dfrac{K_2 \varepsilon_0 A}{2d/3}$ …(iii)

It is given that $\dfrac{\varepsilon_0 A}{d} = 9\text{pF}$

On substituting Eqs. (ii)and (iii)in Eq. (i), we get the result

$C_{eq} = 40.5\,\mu F$

199 **(b)**

$C = \dfrac{A\varepsilon_0}{d}$

After inserting the slab

$C' = \dfrac{A\varepsilon_0}{(d-b)} = \dfrac{A\varepsilon_0}{d - \dfrac{d}{2}}$

$C' = \dfrac{2A\varepsilon_0}{d} \quad \therefore \dfrac{C'}{C} = \dfrac{2}{1}$

200 **(d)**

Net electric flux of surface

$(\phi_2 - \phi_1) = \dfrac{1}{\varepsilon_0}(q) \Rightarrow q = \varepsilon_0(\phi_2 - \phi_1)$

201 **(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)

202 **(a)**

KE = PE of two protons

¿ $\dfrac{e^2}{4\pi\varepsilon_0 r} = \dfrac{9 \times 10^9 \times (1.6 \times 10^{-19})^2}{10^{-10}}$

¿ 23×10^{-19} J

∴KE of each proton ¿ $\dfrac{23}{2} \times 10^{-19} J$

¿ $11.5 \times 10^{-19} J$

203 **(d)**

When two conductors of capacities $C_1 \wedge C_2$ and potentials $V_1 \wedge V_2$ 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 $= \dfrac{net\, charge}{total\, capacity}$

$ie\, V = \dfrac{q_1 + q_2}{C_1 + C_2}$

or $V = \dfrac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$

204 **(a)**

The points S and R are inside the uniform electric field, so these will be at equal potential.

205 **(a)**

$\because V = 4x^{2}$¿

Hence,$\vec{E}$ ¿ $-\dfrac{dV}{dr} = -8x\hat{i}$

Hence, value of $\vec{E}$ at (1m, 0, 2m) will be

$\vec{E}$ ¿ $-8 \times 1\hat{i} = -8\hat{i}\, V m^{-1}$

206 **(a)**

In free space, the electric field between plates of capacitor.

$E_0 = \dfrac{q}{A\varepsilon_0}$

...(i)

When plates of capacitor dipped in oil tank then, the electric field between the plates is

$E_0 = \dfrac{q}{A\varepsilon}$

…(ii)

(when ε is the permittivity of medium)

or $E = \dfrac{E_0}{AK\varepsilon_0}$ $[\therefore \varepsilon = K\varepsilon_0]$

From Eqs. (i) and (ii),

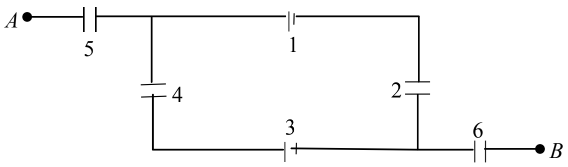
$E = \dfrac{E_0}{K}$

(where K is the dielectric constant)

Hence, the electric field between the plates is increase.

207 **(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 connected in series.

$\therefore$ Equivalent capacitance is

$\frac{1}{C'''}=\frac{1}{C}+\frac{3}{4C}+\frac{1}{C}$

$\frac{1}{C'''}=\frac{11}{4C}$

$\Rightarrow C'''=\frac{4C}{11}$

208 **(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)

$\phi=\vec{E}.\vec{s}=¿+4\hat{j}+3\hat{k}¿.100\hat{k}$

= 300 unit

209 **(c)**

Potential difference between two equipotential surfaces A and B.

$V_A-V_B=kq\left(\frac{1}{r_A}-\frac{1}{r_B}\right)$

$¿kq\left(\frac{r_B-r_A}{r_A r_B}\right)$

$¿\frac{kq t_1}{r_A r_B}$

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 $r_A r_B<r_B r_C$

$\therefore t_1<t_2$

210 **(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.

211 **(b)**

The effective capacitance of three capacitor connected in parallel=$3C$

When $3C$ is connected in series to C

$C_{resul}=\frac{3C\times C}{3C+C}=3.75$

$\Rightarrow C=5\,\mu F$

212 **(a)**

In series combination, charge is constant.

$\therefore V \propto \frac{1}{C}$

Now, $\frac{V_2}{V_1}=\frac{KC}{C}=\frac{K}{1}$

But $V_1+V_2=V$

or $\frac{V_2}{K}+V_2=V \vee V_2=\frac{K}{K+1}V$

213 **(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.

214 **(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

$E=\frac{1}{2}\cdot\frac{q^2 d}{\varepsilon_0 A}\Rightarrow E\propto d$

When plate separation (d) is increased energy increases.

215 **(a)**

Potential due to charge (q) at point (r) is given by

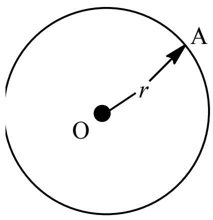
$V=\frac{1}{4\pi e_0}\cdot\frac{q}{r}$

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.



216 **(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 $C_{AB}=C_1+C_2=C+C=2C$

217 **(c)**

At P due to shell, potential

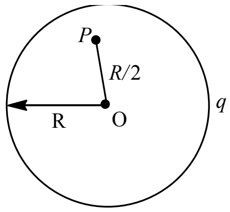
$V_1=\frac{q}{4\pi\varepsilon_0 R}$

at P due to Q, potential

$V_2=\frac{Q}{4\pi\varepsilon_0\frac{R}{2}}=\frac{2Q}{4\pi\varepsilon_0 R}$

∴Net potential at P

$V=V_1+V_2=\frac{q}{4\pi\varepsilon_0 R}+\frac{2Q}{4\pi\varepsilon_0 R}$



218 **(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.

219 **(c)**

In a parallel plate capacitor, the capacity of capacitor,

$C=\frac{k\varepsilon_0 A}{d}$

$\therefore C\propto A$

So, the capacity of capacitor increases if area of the plate is increased.

220 **(d)**

Potential of big drop $V=n^{2/3}V'$

V'= potential of small drop

n=no. of drops=125

V=2.5

$\therefore 2.5=(125)^{2/3}V'$

2.5=25V'

V'=0.1 volt

221 **(a)**

Given electric potential of spheres are same ie,

$V_A=V_B$

$\frac{1}{4\pi\varepsilon_0}\frac{\theta_1}{a}=\frac{1}{4\pi\varepsilon_0}\cdot\frac{\theta_2}{b}$

$\frac{\theta_1}{\theta^2}=\frac{a}{b}\ldots\ldots\ldots(i)$

A surface charge density

$\sigma=\frac{a}{4\pi r^2}$

$\Longrightarrow \frac{\sigma_1}{\sigma_2}=\frac{\theta_1}{\theta_2}\times\frac{b^2}{b^2}$

$¿\frac{a}{b}\times\frac{b^2}{a^2}=\frac{b}{a}$

222 **(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

$N=\left(\frac{R}{r}\right)^3 \ldots\ldots\ldots\ldots\ldots(i)$

As charge is conserved, hence

$Q=Nq\ldots\ldots\ldots\ldots\ldots\ldots(ii)$

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$(4\pi\varepsilon_0 R)\times 40=N(4\pi\varepsilon_0 r)\times 10$

$¿4R=Nr$

$¿\frac{R}{r}=\frac{N}{4}\ldots\ldots\ldots\ldots(iii)$

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

223 **(a)**

Let q be charge on each small drop of radius r. If R is radius of big drop, then

$\frac{4}{3}\pi R^3=1000\times\frac{4}{3}\pi r^3$

$\therefore R=10r$

$C‘=10\,C$

Initial energy$E_1=1000\times\frac{q^2}{2C'}$

Final energy $E_2=\frac{(1000q)^2}{C'}$

$\frac{E_2}{E_1}=\frac{1000\times C}{C'}$

$¿1000\times\frac{1}{10}=100$

224 **(c)**

$Q=CV.\,As\,V\,is\,constant,therefore,Q\propto C$

Hence, Cbecomes $\frac{100}{40}=2.5\times¿$

$\therefore K=2.5$

225 **(d)**

$W=Q\,dV=Q(V_q-V_p)$

$¿-100\times(1.6\times10^{-19})\times(-4-10)$

$¿+100\times1.6\times10^{-19}\times14$

$¿+2.24\times10^{-16}\,J$

226 **(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

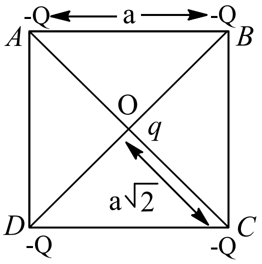
CA,and $\vec{F}_{OA}=\frac{-1}{4\pi\varepsilon_0}.\frac{2Qq}{a^2}$ along AO

Resultant of $\vec{F}_{AB}$ and $\vec{F}_{AD}=\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{a^2}\sqrt{2}$ along COA,

$\therefore \vec{F}_A=\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{a^2}\sqrt{2}+\frac{1}{4\pi\varepsilon_0}.\frac{Q^2}{2a^2}-\frac{1}{4\pi\varepsilon_0}.\frac{2Qq}{a^2}$

$= \vec{O}$

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



227 **(a)**

Total charge enclosed in surface A is

$Q = (q_1 + q_2 + q_3) = (-14 + 78.85 - 56)\, nC$

$\phi = \frac{Q}{\varepsilon_0} = \frac{8.85 \times 10^{-9}}{8.85 \times 10^{-12}} = 10^3\, N\, m^3 C^{-1}$.

228 **(d)**

Electric potential of charged spherical shell

$V = \frac{q}{4\pi \varepsilon_0 R}\,(0 \le r \le R)$

∴ Electric potential at centre=Electric potential on the surface.

229 **(a)**

Effective capacitance of $C_2 \wedge C_3$

$\frac{1}{C} = \frac{1}{2} + \frac{1}{2}$

$\therefore C = 1\,\mu F$

Now, $C_1 \wedge C$ are in parallel, therefore effective capacitance C'

$C' = 1 + 1 = 2\,\mu F$

Now, $C' \wedge C_4$ are in series, therefore,

effective capacitance between points $A \wedge B$

$\frac{1}{C''} = \frac{1}{2} + \frac{1}{4} = \frac{3}{4}$

$\Rightarrow C'' = \frac{4}{3}\mu F$

230 **(d)**

Work done ¿ $U_2 - U_1 = \frac{q_1 q_2}{4\pi \varepsilon_0}\left[\frac{1}{r_2} - \frac{1}{r_1}\right]$

¿ $12 \times 10^{-6} \times 8 \times 10^{-6} \times 9 \times 10^9$ ¿

$W = 96 \times 9 \times 10^{-3} \times 10^2 \times \frac{4}{60} = 5.8\,J$

231 **(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

$P = \frac{W}{t}$

¿ $\frac{16 \times 10^6}{0.1} = 160 \times 10^6\, W$

¿ $160\, MW$

233 **(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.

$\therefore V = \frac{(Q_1 - Q_2)}{2C}$

234 **(c)**

Here $\frac{r_1}{r_2} = \frac{1\,mm}{2\,mm} = \frac{1}{2}$. 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, $\frac{E_1}{E_2} = \frac{q_1}{q_2} \cdot \left(\frac{r_2}{r_1}\right)^2 = \frac{1}{2} \times \left(\frac{2}{1}\right)^2 = 2:1$

235 **(a)**

Change in energy $\Delta U = \frac{1}{2}[q_1^2 - q_2^2$ ¿¿¿ $C]$

$¿ \frac{1}{2}\left[\frac{(0.5)^2-(0.1)^2}{48\times10^{-6}}\right]$

$¿ \frac{1}{2}\left[\frac{0.25-0.01}{48\times10^{-6}}\right]$

$¿ \frac{1}{2}\left[\frac{0.24}{48\times10^{-6}}\right]=\frac{1}{2}\left[\frac{10^4}{2}\right]=2500\,J$

236 **(a)**

Here, $C_{13}=30+30=60\,pF$. total equivalent capacitance is given by

$\frac{C}{1}=\frac{1}{C_1}+\frac{1}{C_{23}}+\frac{1}{C_4}=\frac{1}{30}+\frac{1}{60}+\frac{1}{120}=\frac{1}{170}\Rightarrow C=\frac{12}{7}$

$\therefore$ Total charge $Q=CV=\frac{120}{7}\times140\,pC=2400\text{pC}$

$\therefore V_1=\frac{Q}{C_1}=\frac{2400\,pC}{30\,pF}=80\,V$

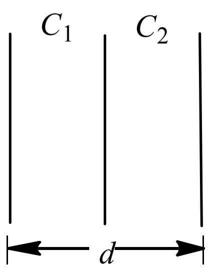
$V_2=V_3=V_{23}=\frac{Q}{C_{23}}=\frac{2400\,pC}{60\,pF}=40\,V\wedge¿$

$V_4=\frac{Q}{C_4}=\frac{2400\,pC}{120\,pF}=20\,V$

237 **(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 $C_2=\frac{\varepsilon_0 A}{d/2}=\frac{2\varepsilon_0 A}{d}$

$\therefore \frac{1}{C'}=\frac{1}{C_1}+\frac{1}{C_2}$

$¿ \frac{d}{2\varepsilon_0 A}\left(\frac{1}{K}+1\right)=\frac{d}{2\varepsilon_0 A}\left(\frac{1}{5}+1\right)$

$¿ \frac{6}{10}\frac{d}{\varepsilon_0 A}$

$\therefore C'=\frac{5\varepsilon_0 A}{3d}$

Hence, increase in capacitance

$¿ \frac{\frac{5}{3}\frac{\varepsilon_0 A}{d}-\frac{\varepsilon_0 A}{d}}{\frac{\varepsilon_0 A}{d}}=\frac{5}{3}-1=\frac{2}{3}=66.6\%$

238 **(c)**

$E=\frac{-dV}{dr}=\frac{-(1-3)}{0.3-0.1}V\,m^{-1}=10\,V\,m^{-1}$

239 **(a)**

Let radius of big drop be $R$and of smaller be r. Then,
Volume of bigger drop $¿8\times$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

$C'=4\pi\varepsilon_0(2r)$

$\therefore \frac{C'}{C}=\frac{4\pi\varepsilon_0(2r)}{4\pi\varepsilon_0 r}=\frac{2}{1}$

240 **(b)**

Minimum effective capacitance

$\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$

$¿ \frac{1}{2}+\frac{1}{3}+\frac{1}{6}=\frac{3+2+1}{6}=1$

$C=1\,\mu F$

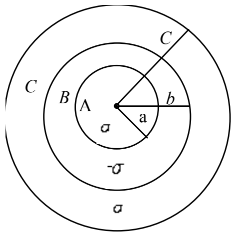
241 **(d)**

$W=\frac{1}{2}\frac{q^2}{C}$

$¿ \frac{1}{2}\times\frac{(8\times10^{-18})^2}{100\times10^{-6}}=\frac{1}{2}\times\frac{64\times10^{-36}}{100\times10^{-6}}=32\times10^{-32}\,J$

242 **(a)**

The electric potential on the surface of shell A



$V_A = V_a + V_b + V_c$

$V_A = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_a}{a} + \frac{1}{4\pi\varepsilon_0} + \frac{q_b}{b} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_c}{c}$

Or

$V_A = \frac{1}{4\pi\varepsilon_0} \cdot \frac{4\pi a^2 \sigma}{a} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{4\pi b^2(-\sigma)}{b} + \frac{1}{4\pi\varepsilon_0} \cdot$

$(\because q = 4\pi r^2 \sigma)$

¿ $V_A = \frac{\sigma}{\varepsilon_0}(a - b + c)$

243 **(a)**

The potential

$V = \frac{1}{4\pi\varepsilon_0} \frac{1}{r}(q_1 + q_2 + q_3 + q_4)$

$V = (9 \times 10^9)\left(\frac{1}{1m}\right)\{(3 - 3 - 4 + 7) \times 10^{-6} C\}$

¿ $2.7 \times 10^4 \frac{N-m}{C}$

¿ $2.7 \times 10^4 J C^{-1}$

¿ $2.7 \times 10^4 V$

244 **(c)**

64 drops have formed a signal drop of radius R.
Volume of big drop = Volume of small' drops

$\therefore \frac{4}{3}\pi R^3 = 64 \times \frac{4}{3}\pi r^3$

$\Rightarrow R = 4r$

So, the total current is

$Q_{total} = 64q$

As, $C' = \frac{Q}{V} \wedge V = \frac{1}{4\pi\varepsilon_0} \frac{Q}{R}; C' = 4\pi\varepsilon_0 R$

$C' = (4\pi\varepsilon_0) 4r$

$\Rightarrow C' = 4C$

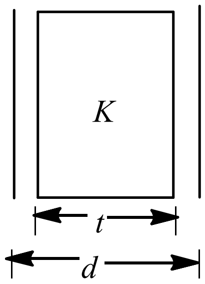
245 **(b)**

From the formula ,

$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{K}}$

$\Rightarrow$ Here, $K = \infty \wedge t \to 0$

So, $C = \frac{\varepsilon_0 A}{d + 0} = \frac{\varepsilon_0 A}{d} = C_0$



246 **(d)**

$q_i = C_i V = 2V = q$

(say)

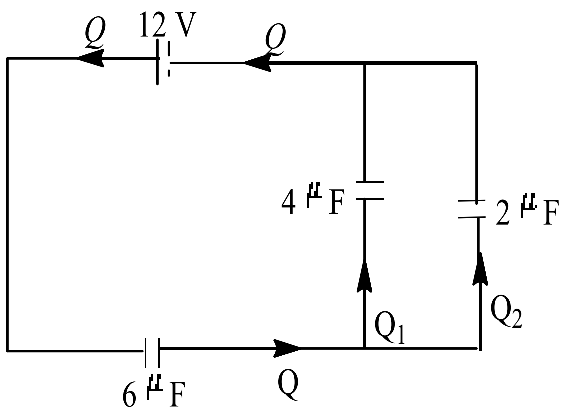
This charge will remain constant after switch is shifted from position 1 to position 2.

$U_i = \frac{1}{2} \frac{q^2}{C_i} = \frac{q^2}{2 \times 2} = \frac{q^2}{4}$

$U_i = \frac{1}{2} \frac{q^2}{C_i} = \frac{q^2}{2 \times 10} = \frac{q^2}{20}$

$\therefore$Energy dissipated $\left(\frac{q^2}{5}\right)$ is 80% of the initial stored energy $\left(¿ \frac{q^2}{4}\right)$.

247 **(c)**

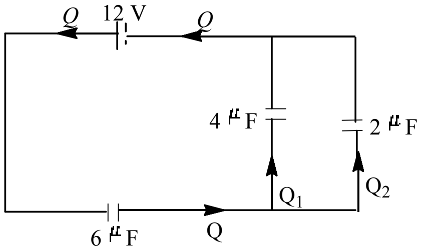


As the capacitors 4 μF and 2 μF are connected in parallel and are in series with 6μF capacitor, their equivalent capacitance is

$\frac{(2+4) \times 6}{2+4+6} = 3\,\mu F$

Charge in the circuit

$Q=$¿ $3\,\mu F\times 12\,V=36\,\mu C$



Since, the capacitors $4\,\mu F$ and $2\mu F$ are connected in parallel, therefore potential difference across them is same.

$\Rightarrow \quad \frac{Q_1}{Q_2}=\frac{C_1}{C_2}=\frac{4}{2}\vee Q_1=2Q_2$

Also $Q=Q_1+Q_2$

$\therefore 36\,\mu C=2Q_2+Q_2$ or $Q_2=\frac{36\,\mu C}{3}=12\,\mu C$

$Q_1=Q-Q_2=36\,\mu C-12\,\mu C$

¿ $24\,\mu C=24\times 10^{-6}\,C$

248 **(c)**

In series combination,

$\frac{1}{C_1}=\frac{1}{1}+\frac{1}{2}+\frac{1}{4}=\frac{4+2+1}{4}=\frac{7}{4}$

$\Rightarrow C_1=\frac{4}{7}\mu F$

In parallel combination,

$C_2=1+2+4=7\,\mu F$

$\therefore \frac{C_1}{C_2}=\frac{4/7}{7}=\frac{4}{49}$

249 **(b)**

When a conductor of capacitance C is given a charge q, it acquires a potential given by

$V=\frac{q}{C}$

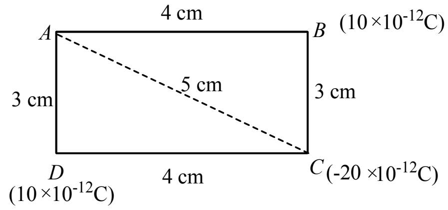
The work done in charging the conductor is stored as potential energy in the electric field in the vicinity of the conductor.

250 **(a)**

The situation is summarised in figure.

$BC=AD=3\,cm\,,AB=DC=4\,cm\,,$

So, $\quad AC=5\,cm\,.$



Now, potential at A

$V_A=\frac{1}{4\pi\varepsilon_0}\frac{q_B}{AB}+\frac{1}{4\pi\varepsilon_0}\cdot\frac{q_c}{AC}+\frac{1}{4\pi\varepsilon_0}\cdot\frac{q_D}{AD}$

¿ $\frac{1}{4\pi\varepsilon_0}\left[\frac{10\times 10^{-12}}{4\times 10^{-2}}-\frac{20\times 10^{-12}}{5\times 10^{-2}}+\frac{10\times 10^{-12}}{3\times 10^{-2}}\right]$

¿ $9\times 10^{9}\times 10^{-10}\left[\frac{10}{4}-\frac{20}{5}+\frac{10}{3}\right]$

¿ $\frac{9\times 10^{-1}\times 11}{6}$

¿ $16.5\times 10^{-1}=1.65\,V$

251 **(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

$W=U_f-U_i$

¿ $\frac{1}{2}CV^2-\frac{1}{2}CV^2=0$

252 **(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.

253 **(b)**

$C_p=3+3=6\,\mu F$

$\frac{1}{C_s}=\frac{1}{6}+\frac{1}{6}+\frac{1}{6}=\frac{3}{6}=\frac{1}{2}$

$C_s=2\,\mu F$

254 **(a)**

Charge on nucleus

$Q=Ze=47\times 1.6\times 10^{-19}$

¿ $7.52\times 10^{-18}\,C$

Potential on the surface of nucleus is

$V=\frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

¿ $\frac{9\times10^{9}\times7.52\times10^{-18}}{3.4\times10^{-14}}=1.99\times10^{6}V$

255 **(a)**

$\vec{E}=E_1\hat{i}+E_2\hat{j}$

As $W=\vec{F}.\vec{r}=Q\vec{E}.\vec{r}$

¿ Q ¿ $+E_2\hat{j}$ ¿ . ¿ $+b\,\hat{j})$

¿ QE_1a+QE_2b ¿ Q ¿ ¿ $+E_2b)$

256 **(c)**

For a ring $E=\frac{1}{4\pi\varepsilon_0}.\frac{qx}{(x¿¿2+R^2)¿}$ and E is maximum when

$x=\frac{R}{\sqrt{2}}$

$\Rightarrow E_{max}=\frac{1}{4\pi\varepsilon_0}.\frac{2q}{3\sqrt{3}.R^2}$

257 **(a)**

Since, $C_1\wedge C_2$ are parallel to their equivalent capacitance will be (C_1+C_2). Now, $(C_1+C_2)\wedge C_3$ 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

$q=CV$

$q=\frac{(C_1+C_2)C_3V}{C_1+C_2+C_3}$

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

$\Delta q=q^{'}-q \qquad (\because q^{'}>q)$

¿ $(C_1+C_2)V-\frac{(C_1+C_2)C_3V}{C_1+C_2+C_3}$

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

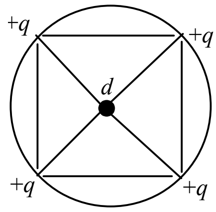
$\Delta q=(C_1+C_2)V\left[1-\frac{C_3}{C_1+C_2+C_3}\right]$

258 **(b)**

Potential at centre due to all charges are

¿ $\frac{1}{4\pi\varepsilon_0}\left[\frac{q}{d}+\frac{q}{d}+\frac{q}{d}+\frac{q}{d}\right]$

¿ $\frac{1}{4\pi\varepsilon_0}\frac{4q}{d}\in SI\,units$



¿ $\frac{4q}{d}\in CGS\,units$

259 **(c)**

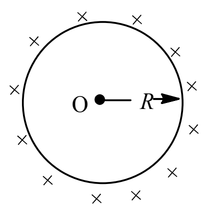
$\phi=E(ds)\cos\theta=E(2\pi r^2)\cos0^0=2\pi r^2E$

260 **(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.

∴ Potential at surface=10V.



261 **(d)**

Ratio of energy stored in the capacitor and the work done by the battery

¿ $\frac{\frac{1}{2}qV}{qV}=\frac{1}{2}$

262 **(d)**

Electrostatic potential energy of the system of charges is

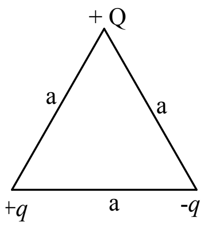
$$U=\frac{1}{4\pi\varepsilon_0}\left[\frac{Qq}{a}+\frac{Qq}{a}+\frac{q^2}{a}\right]$$

$$U=\frac{1}{4\pi\varepsilon_0 a}\left[2Qq+q^2\right]$$

Given, $U=0$

$$\Longrightarrow 2Qq+q^2=0$$

$$\Longrightarrow Q=\frac{-q}{2}$$



263 **(a)**

$$E=\frac{-dV}{dr}=\frac{-d}{dx}\left(4x^2\right)=-8x$$

$¿-8(1)=-8\,V\,m^{-1}$

Negative sign indicates $\vec{E}$ is along negative direction of X-axis.

264 **(c)**

In equilibrium, $F=qE=(ne)\frac{V}{d}=mg$

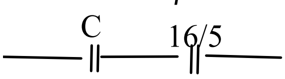
$$n=\frac{mgd}{eV}=\frac{1.96\times10^{-15}\times9.8\times0.02}{1.6\times10^{-19}\times800}=3$$

Therefore, $q=3e$

265 **(b)**

$$3=\frac{\frac{16}{5}C}{\frac{16}{5}+C}$$

or $\quad C=48\,\mu F$



266 **(b)**

Given, the capacity of capacitor, $C=10\times10^{-6}\,\mu F$

Potential $V=400$volt

Stored energy =Heat generated

$$U=\frac{1}{2}CV^2=\frac{1}{2}\left(10\times10^{-6}\right)\times(400)^2=0.8\,J$$

267 **(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

268 **(a)**

Let $R\wedge r$ be the radii of bigger and each smaller drop respectively

$$\therefore \frac{4}{3}\pi R^3=8\times\frac{4}{3}\pi r^3$$

$\Rightarrow R=2r \qquad \ldots$(i)

The capacitance of a smaller spherical drop is

$C=4\pi\varepsilon_0 r \qquad \ldots$(ii)

The capacitance of bigger drop is

$C'=4\pi\varepsilon_0 R$

$=2\times4\pi\varepsilon_0 r \qquad (\because R=2r)$

$¿2C[¿Eq.(ii)]$

$$C=\frac{C'}{2}$$

$¿\frac{1}{2}\mu F(\because C'=1\,\mu F)$

269 **(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 $q_0=CV_0$

$\therefore q=CV_0^{-1/RC}$

Given, $C=2F, V_0=5\,volt, R=6\,\Omega, t=12\,s$

Hence, $\quad q=(2\times5)e^{-(12/6\times2)}$

$¿10e^{-1}=\frac{10}{e}C$

270 **(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.

271 **(d)**

Given that,

$C=500\,\mu F$

$$\frac{dq}{dt}=100\,\mu Cs^{-1}$$

$V=10$ volt

Then the total charge on the capacitor

$q=CV$

¿$500\times10^{-6}\times10$

¿$5\times10^{-3}C$

Hence, time = $\frac{total\,charge}{charge\,rate}$

$$E=\frac{5\times10^{-3}C}{100\times10^{-6}C}s$$

= 50s

272 **(d)**

Common potential, $V=\frac{q_1+q_2}{C_1+C_2}$

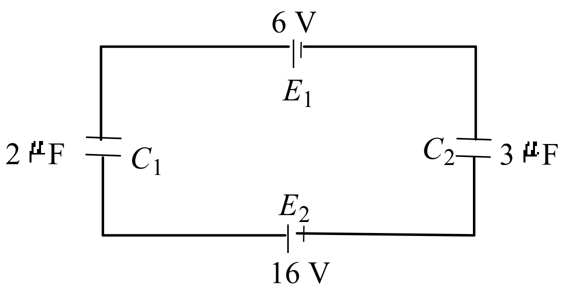
∴charge on smaller sphere after contact

¿$C_1V=C_1\frac{(q¿¿1+q_2)}{C_1+C_2}$¿

¿$\frac{4\pi\varepsilon_0 r_1(10^{-2}+5\times10^{-2})}{4\pi\varepsilon_0(r_1+r_2)}$

¿$\frac{10^{-2}\times6\times10^{-2}}{3\times10^{-2}}=2\times10^{-2}C$

273 **(c)**



Net emf in the circuit here

$E=E_2-E_1=16-6=10$ volt

While the equivalent capacity

$$C=\frac{C_1C_2}{C_1+C_2}=\frac{2\times3}{2+3}=\frac{6}{5}\mu F$$

Charge on each capacitor

$$q=CV=\frac{6}{5}\times10=12\,\mu C$$

∴ Potential difference across $2\,\mu F$ capacitor

$$V_1=\frac{q}{C_1}=\frac{12}{2}=6\,volt$$

274 **(c)**

As $V_1=V_2$

$$\frac{q_1}{4\pi\varepsilon_0 r_1}=\frac{q_2}{4\pi\varepsilon_0 r_2}$$

$$\therefore\frac{q_1}{q_2}=\frac{r_1}{r_2}$$

275 **(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.

276 **(b)**

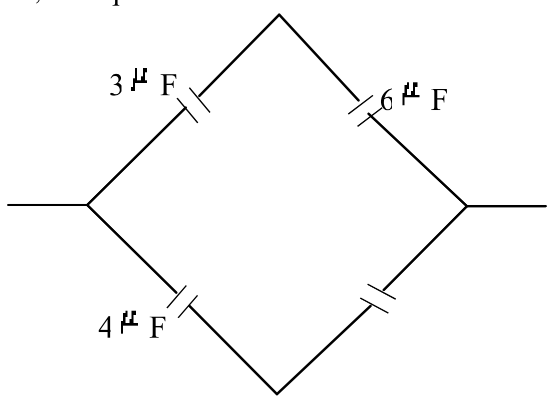
$$W_{BA}=q(V_A-V_B)=q\left[\frac{Q}{4\pi\varepsilon_0 a}-\frac{Q}{4\pi\varepsilon_0 b}\right]$$

¿$\frac{qQ}{4\pi\varepsilon_0}\left[\frac{1}{a}-\frac{1}{b}\right]$

277 **(b)**

The points $C\wedge D$ will be at same potentials since, $\frac{3}{6}=\frac{4}{8}$.

Therefore, capacitance of $2\mu F$ will be unaffected. So, the equivalent circuit can be shown as.



The effective capacitance in upper arm in series, is given by

$$C_1=\frac{3\times6}{3+6}=\frac{18}{9}=2\,\mu F$$

The effective capacitance in lower arm in series is given by

$$C_2=\frac{4\times8}{4+8}=\frac{32}{12}=\frac{8}{3}\mu F$$

Hence, the resultant capacitance in parallel is given by

$$C=C_1+C_2=2+\frac{8}{3}=\frac{14}{3}\mu F$$