

**Physics (Class 12)**

**Chapter 2: ELECTROSTATIC POTENTIAL AND CAPACITANCE**

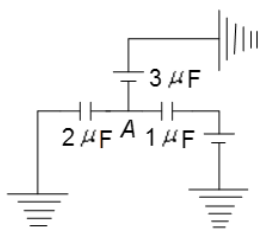
**SKYLIMIT EDUCATION**

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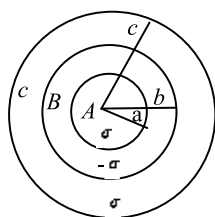
## 2. ELECTROSTATIC POTENTIAL AND CAPACITANCE

### Single Correct Answer Type

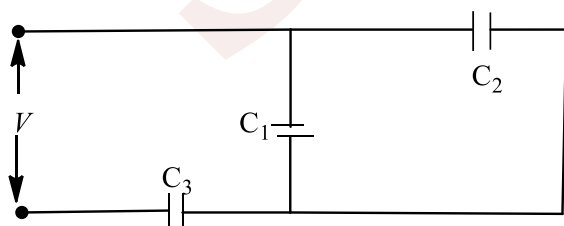
1. In the given arrangement of capacitors,  $6 \mu\text{C}$  charge is added to point  $a$ . Find the charge on upper capacitor



- a)  $3 \mu\text{C}$                       b)  $1 \mu\text{C}$                       c)  $2 \mu\text{C}$                       d)  $6 \mu\text{C}$
2. Consider three concentric shells of metal  $A$ ,  $B$  and  $C$  are having radii  $a$ ,  $b$  and  $c$  respectively as shown in the figure ( $a < b < c$ ). Their surface charge densities are  $\sigma$ ,  $-\sigma$  and  $\sigma$  respectively. Calculate the electric potential on the surface of shell  $A$



- a)  $\frac{\sigma}{\epsilon_0}(a - b + c)$                       b)  $\frac{\sigma}{\epsilon_0}(a - b - c)$                       c)  $\frac{\sigma}{\epsilon_0}(a^2 + b^2 + c^2)$                       d)  $\frac{\sigma}{\epsilon_0}(a + b - c)$
3. Three capacitors of capacitance  $1 \mu\text{F}$ ,  $2 \mu\text{F}$  and  $3 \mu\text{F}$  are connected in series and a potential difference of  $11 \text{ V}$  is applied across the combination. Then, the potential difference across the plate of  $1 \mu\text{F}$  capacitor is
- a)  $2 \text{ V}$                       b)  $4 \text{ V}$                       c)  $1 \text{ V}$                       d)  $6 \text{ V}$
4. An electric charge  $10^{-3} \mu\text{C}$  is placed at the origin  $(0, 0)$  of  $X$ - $Y$  coordinate system. Two points  $A$  and  $B$  are situated at  $(\sqrt{2}, \sqrt{2})$  and  $(2, 0)$  respectively. The potential difference between the points  $A$  and  $B$  will be
- a)  $9 \text{ V}$                       b) Zero                      c)  $2 \text{ V}$                       d)  $4.5 \text{ V}$
5. The potential to which a conductor is raised, depends on
- a) The amount of charge                      b) Geometry and size of the conductor  
c) Both (a) and (b)                      d) Only on (a)
6. Three capacitors  $C_1$ ,  $C_2$  and  $C_3$  are connected as shown in the figure to a battery of  $V$  volt. If the capacitor  $C_3$  breaks down electrically the change in total charge on the combination of capacitors is



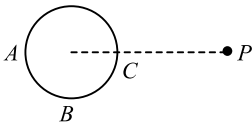
- a)  $(C_1 + C_2)V \left[ 1 - \left( \frac{C_3}{C_1 + C_2 + C_3} \right) \right]$                       b)  $(C_1 + C_2)V \left[ 1 - \left( \frac{(C_1 + C_2)}{C_1 + C_2 + C_3} \right) \right]$



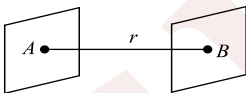
$$c) (C_1 + C_2)V \left[ 1 + \left( \frac{C_3}{C_1 + C_2 + C_3} \right) \right]$$

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

7. Two charges  $+q$  and  $-q$  are kept apart. Then at any point on the right bisector of line joining the two charges
- The electric field strength is zero
  - The electric potential is zero
  - Both electric potential and electric field strength are zero.
  - Both electric potential and electric field strength are non-zero.
8. An electric field is expressed as  $\vec{E} = 2\hat{i} + 3\hat{j}$ . Find the potential difference ( $V_A - V_B$ ) between two points  $A$  and  $B$  whose position vectors are given by  $r_A = \hat{i} + 2\hat{j}$  and  $r_B = 2\hat{i} + \hat{j} + 3\hat{k}$
- $-1$  V
  - $1$  V
  - $2$  V
  - $3$  V
9. A hollow conducting sphere is placed in an electric field produced by a point charge placed at  $P$  as shown in figure.  $V_A, V_B, V_C$  be the potentials at points  $A, B$  and  $C$  respectively. Then

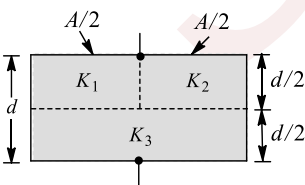


- $V_C > V_B$
  - $V_B > V_C$
  - $V_A > V_B$
  - $V_A = V_C$
10. When a  $2 \mu\text{C}$  of charge is carried from point  $A$  to point  $B$ , the amount of work done by electric field is  $50 \mu\text{J}$ . What is the potential difference and which point is at a higher potential?
- $25$  V,  $B$
  - $25$  V,  $A$
  - $20$  V,  $B$
  - Both are at same potential
11. Three capacitors of capacitance  $1 \mu\text{F}$ ,  $2 \mu\text{F}$  and  $4 \mu\text{F}$  are connected first in a series combination, and then in a parallel combination. The ratio of their equivalent capacitance will be
- $2 : 49$
  - $49 : 2$
  - $4 : 49$
  - $49 : 4$
12. In a charged capacitor the energy stored in
- The positive charges
  - The negative charges
  - The field between the plates
  - None of the above
13. Figure shows two parallel surfaces  $A$  and  $B$  at the same potential, kept at a small distance  $r$  from each other. A point charge  $q$  is taken from the surface  $A$  to  $B$



The amount of work done is

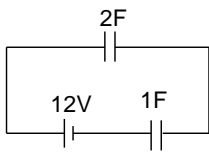
- $\frac{q^2}{2\pi\epsilon_0 r}$
  - $\frac{q^2}{8\pi\epsilon_0 r}$
  - $\frac{q^2}{4\pi\epsilon_0 r}$
  - Zero
14. A parallel plate capacitor of area  $A$ , plate separation  $d$  and capacitance  $C$  is filled with three different dielectric materials having dielectric constants  $K_1, K_2$  and  $K_3$  as shown. If a single dielectric material is to be used to have the same capacitance  $C$  is this capacitors, then its dielectric constant  $K$  is given by



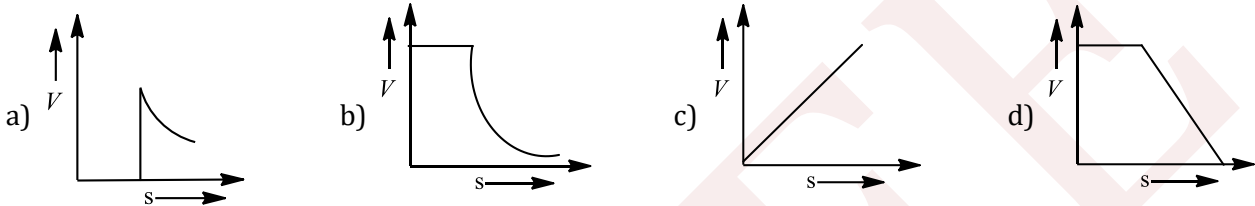
- $\frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{2K_3}$
  - $\frac{1}{K} = \frac{1}{K_1 + K_2} + \frac{1}{2K_3}$
  - $K = \frac{K_1 K_2}{K_1 + K_2} + 2K_3$
  - $K = K_1 + K_2 + 2K_3$
15. A uniform electric field pointing in positive  $x$ -direction exists in a region. Let  $A$  be the origin,  $B$  be the point on the  $x$ -axis at  $x=+1$  cm and  $C$  be the point on the  $y$ -axis at  $y=+1$  cm. then the potentials at the points  $A, B$  and  $C$  satisfy the condition



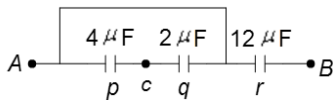
- a)  $V_A < V_B$                       b)  $V_A > V_B$                       c)  $V_A < V_C$                       d)  $V_A > V_C$   
 16. A  $4\mu\text{F}$  capacitor is charged to  $400\text{V}$  and then its plates are joined through a resistance. The heat produced in the resistance is  
 a)  $0.16\text{ J}$                       b)  $0.32\text{ J}$                       c)  $0.64\text{ J}$                       d)  $1.28\text{ J}$   
 17. In a circuit shown in figure, the potential difference across the capacitor of  $2\text{ F}$  is



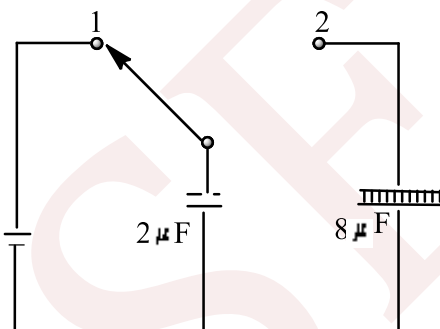
- a)  $8\text{ V}$                       b)  $4\text{ V}$                       c)  $12$                       d)  $6\text{ V}$   
 18. In the case of a charged metallic sphere, potential ( $V$ ) changes with respect to distance ( $S$ ) from the centre as



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

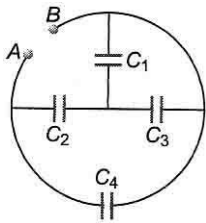


- a)  $6/5\ \mu\text{F}$                       b)  $5/6\ \mu\text{F}$                       c)  $4\ \mu\text{F}$                       d) None of these  
 20. A capacitor of capacity  $10\mu\text{F}$  is charged to a potential of  $400\text{V}$ . When its both plates are connected by a conducting wire, then heat generated will be  
 a)  $80\text{ J}$                       b)  $0.8\text{ J}$                       c)  $8 \times 10^{-3}\text{ J}$                       d)  $8 \times 10^{-6}\text{ J}$   
 21. A  $2\mu\text{F}$  capacitor is charged as shown in the figure. The percentage of its stored energy dissipated after the switch  $s$  is turned to positions 2 is



- a)  $0\%$                       b)  $20\%$                       c)  $75\%$                       d)  $80\%$   
 22. Two point charges  $+q$  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  $\hat{j}$ .  
 c) Work has to be done in bringing a test charge from infinity to the origin.                      d) The dipole moment is  $2qd$  directed along  $\hat{j}$ .  
 23. In the arrangement of capacitors shown in figure, each capacitor is of  $9\ \mu\text{F}$ , Then the equivalent capacitance between in points  $A$  and  $B$  is

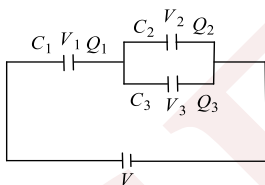




- a)  $9 \mu\text{F}$                       b)  $18 \mu\text{F}$                       c)  $4.5 \mu\text{F}$                       d)  $15 \mu\text{F}$
24. A parallel plate capacitor of capacitance  $100 \text{ pF}$  is to be constructed by using paper sheets of  $1 \text{ mm}$  thickness as dielectric. If the dielectric constant of paper is  $4$ , the number of circular metal foils of diameter  $2 \text{ cm}$  each required for the purpose is
- a)  $40$                       b)  $20$                       c)  $30$                       d)  $10$
25. A solid sphere of radius  $R$  is charged uniformly. At what distance from its surface is the electrostatic potential half of the potential at the centre?
- a)  $R$                       b)  $R/2$                       c)  $R/3$                       d)  $2R$
26. When two conductors of charges and potentials  $C_1, V_1$  and  $C_2, V_2$  respectively are joined, the common 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)  $\frac{C_1V_1 + C_2V_2}{C_1 + C_2}$
27. Two point charges  $Q$  and  $-Q/4$  placed along the  $x$ -axis are separated by a distance  $r$ . Take  $-Q/4$  as origin and it is placed on right of  $Q$ . Then, the potential is zero
- a) at  $x = r/3$  only  
b) at  $x = -r/5$  only  
c) Both at  $x = r/3$  and at  $x = -r/5$   
d) There exist two points on the axis where the electric field is zero
28. The charges  $Q, +q$  and  $+q$  are placed at the vertices of an equilateral triangle of side  $l$ . If the net electrostatic potential energy of the system is zero, then  $Q$  is equal to
- a)  $-\frac{q}{2}$                       b)  $-q$                       c)  $\frac{+q}{2}$                       d) Zero
29. The work done in moving an alpha particle between two points having potential difference  $25 \text{ V}$  is
- a)  $8 \times 10^{-18} \text{ J}$                       b)  $8 \times 10^{-19} \text{ J}$                       c)  $8 \times 10^{-20} \text{ J}$                       d)  $8 \times 10^{-16} \text{ J}$
30. The plates of a parallel plate capacitor are charged upto  $200 \text{ V}$ . A dielectric slab of thickness  $4 \text{ mm}$  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  $3.2 \text{ mm}$ . The dielectric constant of the dielectric slab is
- a)  $1$                       b)  $4$                       c)  $5$                       d)  $6$
31. Two parallel plate capacitors of capacitance  $C$  and  $2C$  are connected in parallel and charged to a potential difference  $V_0$ . The battery is then disconnected and the region between the plates of the capacitor  $C$  is completely filled with a material of dielectric constant  $2$ . The potential difference across the capacitors now becomes
- a)  $\frac{F_0}{4}$                       b)  $\frac{V_0}{2}$                       c)  $\frac{3V_0}{4}$                       d)  $V_0$
32. A small conducting sphere of radius  $r$  is lying concentrically inside a bigger hollow conducting sphere of radius  $R$ . The bigger and smaller spheres are charged with  $Q$  and  $q$  ( $Q > q$ ) and are insulated from each other. The potential difference between the spheres will be
- a)  $\frac{1}{4\pi\epsilon_0} \left( \frac{q}{r} - \frac{q}{R} \right)$                       b)  $\frac{1}{4\pi\epsilon_0} \left( \frac{q}{R} - \frac{Q}{r} \right)$                       c)  $\frac{1}{4\pi\epsilon_0} \left( \frac{q}{r} - \frac{Q}{R} \right)$                       d)  $\frac{1}{4\pi\epsilon_0} \left( \frac{Q}{R} - \frac{q}{r} \right)$
33. On increasing the plate separation of a charged capacitor, the energy
- a) Increases                      b) Decreases                      c) Remains unchanged                      d) Becomes zero

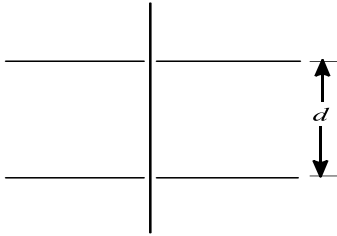


34. At a distance  $r$  from a point located at origin in space, the electric potential varies as  $V = 10r$ . Find the electric field at  $\vec{r} = 3\hat{i} + 4\hat{j} - 5\hat{k}$
- a)  $\sqrt{2}(3\hat{i} + 4\hat{j} - 5\hat{k})$       b)  $-\sqrt{2}(3\hat{i} + 4\hat{j} - 5\hat{k})$       c)  $-\sqrt{3}(3\hat{i} + 4\hat{j} - 5\hat{k})$       d) None of the above
35. A spherical drop of capacitance  $1 \mu\text{F}$  is broken into eight drops of equal radius. Then, the capacitance of each small drop is
- a)  $\frac{1}{2} \mu\text{F}$       b)  $\frac{1}{4} \mu\text{F}$       c)  $\frac{1}{8} \mu\text{F}$       d)  $8 \mu\text{F}$
36. Three charges  $2q, -q$  and  $-q$  are located at the vertices of an equilateral triangle. At the centre of the triangle
- a) The field is zero but potential is non-zero      b) The field is non-zero but potential is zero  
c) Both field and potential are zero      d) Both field and potential are non-zero
37. A positive point charge  $q$  is carried from a point  $B$  to a point  $A$  in the electric field of a point charge  $+Q$  at  $O$ . If the permittivity of free space is  $\epsilon_0$ , the work done in the process is given by (where  $a = OA$  and  $b = OB$ )
- a)  $\frac{qQ}{4\pi\epsilon_0} \left( \frac{1}{a} + \frac{1}{b} \right)$       b)  $\frac{qQ}{4\pi\epsilon_0} \left( \frac{1}{a} - \frac{1}{b} \right)$       c)  $\frac{qQ}{4\pi\epsilon_0} \left( \frac{1}{a^2} - \frac{1}{b^2} \right)$       d)  $\frac{qQ}{4\pi\epsilon_0} \left( \frac{1}{a^2} + \frac{1}{b^2} \right)$
38. A parallel plate capacitor having air as dielectric medium is charged by a potential difference of  $V$  volt. After disconnecting the battery, the distance between the plates of the capacitor is increased using an insulated handle. As a result, potential difference between the plates
- a) Increases      b) Does not change      c) Becomes zero      d) Decreases
39. The displacement of a charge  $Q$  in the electric field  $\vec{E} = e_1\hat{i} + e_2\hat{j} + e_3\hat{k}$  is  $\vec{r} = a\hat{i} + b\hat{j}$ . 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)  $Q\left(\sqrt{e_1^2 - e_2^2}\right)(a + b)$
40. In Fig, three capacitors  $C_1, C_2$  and  $C_3$  are joined to a battery. With symbols having their usual meaning, the correct conditions will be

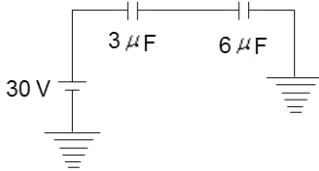


- a)  $Q_1 = Q_2 = Q_3$  and  $V_1 = V_2 = V_3 + V$       b)  $Q_1 = Q_2 + Q_3$  and  $V = V_1 + V_2 + V_3$   
c)  $Q_1 = Q_2 + Q_3$  and  $V = V_1 + V_2$       d)  $Q_2 = Q_3$  and  $V_2 = V_3$
41. A solid conducting sphere having a charge  $Q$  is surrounded by an uncharged concentric conducting hollow spherical shell. The potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell is  $V$ . If the shell is now given a charge of  $-3Q$ , the new potential difference between the same two surface is
- a)  $V$       b)  $2V$       c)  $4V$       d)  $-2V$
42. Three charges  $q, q$  and  $-2q$  are fixed on the vertices of an equilateral triangular plate of edge length  $a$ . This plate is in equilibrium between two very large plates having surface charge density  $\sigma_1$  and  $\sigma_2$ , respectively. Find the time period of small angular oscillation about an axis passing through its centroid and perpendicular to the plane. Moment of inertia of the system about this axis is  $I$
- a)  $2\pi \sqrt{\frac{\epsilon_0 l}{qa|\sigma_1 - \sigma_2|}}$       b)  $2\pi \sqrt{\frac{\epsilon_0 l}{2qa|\sigma_1 - \sigma_2|}}$       c)  $2\pi \sqrt{\frac{2\epsilon_0 l}{\sqrt{3}qa|\sigma_1 - \sigma_2|}}$       d)  $2\pi \sqrt{\frac{2\epsilon_0 l}{qa|\sigma_1 - \sigma_2|}}$
43. A capacitor of capacitance  $1 \mu\text{F}$  is filled with two dielectrics of dielectric constant 4 and 6. What is the new capacitance?

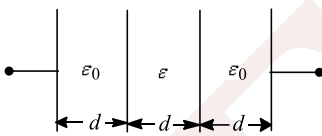




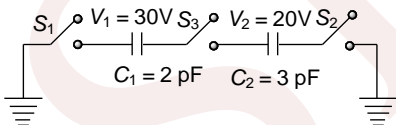
- a)  $10 \mu\text{F}$                       b)  $5 \mu\text{F}$                       c)  $4 \mu\text{F}$                       d)  $7 \mu\text{F}$
44. The work of electric field done during the displacement of a negatively charged particle towards a fixed positively charged particle is 9 J. As a result the distance between the charges has been decreased by half. What work is done by the electric field over the first half of this distance?
- a) 3 J                      b) 6 J                      c) 1.5 J                      d) 9 J
45. Three charges  $2q, -q, -q$  are located at the vertices of an equilateral triangle. At the circumcentre of the triangle
- a) The field is zero but potential is non-zero                      b) Potential is zero and the field is infinity  
c) Both the field and potential are zero                      d) The field is non-zero but potential is zero
46. In the circuit shown in Figure, the charge stored on a – capacitor of capacitance  $3 \mu\text{F}$  is



- a) Zero                      b)  $40 \mu\text{C}$                       c)  $60 \mu\text{C}$                       d)  $90 \mu\text{C}$
47. Three capacitors of capacitances  $4 \mu\text{F}, 6 \mu\text{F}$  and  $12 \mu\text{F}$  are connected first in series and then in parallel. What is the ratio of equivalent capacitance in the two cases?
- a) 2 : 3                      b) 1 : 11                      c) 11 : 1                      d) 1 : 3
48. For configuration of media of permittivity  $\epsilon_0, \epsilon, \epsilon_0$  between parallel plates each of area  $A$ , as shown in Fig, the equivalent capacitance is

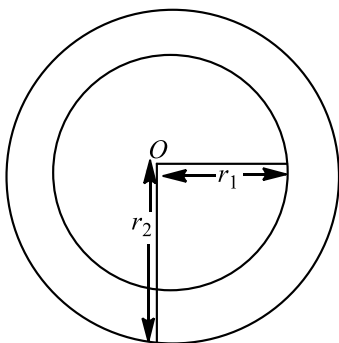


- a)  $\epsilon_0 A/d$                       b)  $\epsilon \epsilon_0 A/d$                       c)  $\frac{\epsilon \epsilon_0 A}{d(\epsilon + \epsilon_0)}$                       d)  $\frac{\epsilon \epsilon_0 A}{(2\epsilon + \epsilon_0)d}$
49. For the circuit shown figure, which of the following statements is true?

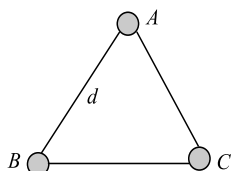


- a) With  $S_1$  closed,  $V_1 = 15 \text{ V}, V_2 = 20 \text{ V}$                       b) With  $S_3$  closed,  $V_1 = V_2 = 20 \text{ V}$   
c) With  $S_1$  and  $S_3$  closed,  $V_1 = V_2 = 0$                       d) With  $S_1$  and  $S_3$  closed,  $V_1 = 30 \text{ V}, V_2 = 20 \text{ V}$
50. A capacitor connected to a 10 V battery collects a charge of  $40 \mu\text{C}$  with air as dielectric and  $100 \mu\text{C}$  with a given oil as dielectric. The dielectric constant of the oil is
- a) 1.5                      b) 2.0                      c) 2.5                      d) 3.0
51. In the given figure, a hollow spherical capacitor is shown. The electric field will not be zero at

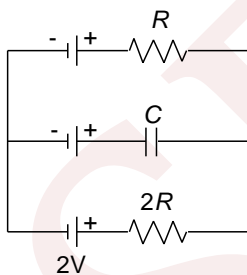




- a)  $r < r_1$                       b)  $r_1 < r_2$                       c)  $r < r_2$                       d)  $r_1 < r < r_2$
52. A parallel plate capacitor of capacitance  $10\mu\text{F}$  is connected across a battery of e.m.f.  $5\text{ mV}$ . Now, the space between the plates of the capacitor is filled with a dielectric material of dielectric constant  $K = 5$ . Then, the charge that will flow through the battery till equilibrium is reached is
- a)  $250\ \mu\text{C}$                       b)  $250\ \text{nC}$                       c)  $200\ \text{nC}$                       d)  $200\ \mu\text{C}$
53. Three identical metallic uncharged spheres  $A, B$  and  $C$  each of radius  $a$ , are kept at the corners of an equilateral triangle of side  $d$  ( $d \gg a$ ) as shown in Fig. The fourth sphere (of radius  $a$ ), which has a charge  $q$ , touches  $A$  and is then removed to a position far away.  $B$  is earthed and then the earth connection is removed.  $C$  is then earthed. The charge on  $C$  is

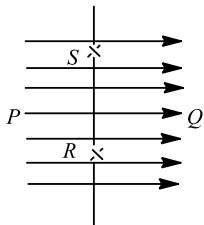


- a)  $\frac{qa}{2d} \left( \frac{2d-a}{2d} \right)$                       b)  $\frac{qa}{2d} \left( \frac{2d-a}{d} \right)$                       c)  $-\frac{qa}{2d} \left( \frac{d-a}{d} \right)$                       d)  $\frac{2qa}{d} \left( \frac{d-a}{2d} \right)$
54. The electric flux from a cube of edge  $l$  is  $\phi$ . What will be its value if edge of cube is made  $2l$  and charge enclosed is halved
- a)  $\phi/2$                       b)  $2\phi$                       c)  $4\phi$                       d)  $5\phi$
55. In the given circuit of figure with steady current, the potential drop across the capacitor must be

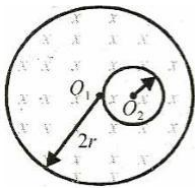


- a)  $V$                       b)  $\frac{V}{2}$                       c)  $\frac{V}{3}$                       d)  $\frac{2V}{3}$
56. Two parallel large thin metal sheets have equal surface charge densities ( $\sigma = 26.4 \times 10^{-12}\text{Cm}^{-2}$ ) of opposite signs. The electric field between these sheets is
- a)  $1.5\ \text{NC}^{-1}$                       b)  $1.5 \times 10^{-10}\text{NC}^{-1}$                       c)  $3\ \text{NC}^{-1}$                       d)  $3 \times 10^{-10}\ \text{NC}^{-1}$
57. Mark the correct statements:
- a) If  $E$  is zero at certain point, then  $V$  should be zero at that point  
 b) If  $E$  is not zero at certain point, then  $V$  should not be zero at that point  
 c) If  $V$  is zero at certain point, then  $E$  should be zero at that point  
 d) If  $V$  is zero at certain point, then  $E$  may or may not be zero
58. The points resembling equal potentials are

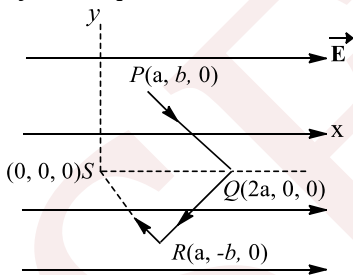




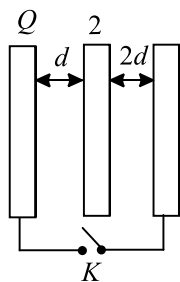
- a) P and Q                      b) S and Q                      c) S and R                      d) P and R
59. Charge  $Q$  is given a displacement  $\vec{r} = a\hat{i} + b\hat{j}$  in an electric field  $\vec{E} = E_1\hat{i} + E_2\hat{j}$ . The work done is
- a)  $Q(E_1a + E_2b)$                       b)  $Q\sqrt{(E_1a)^2 + (E_2b)^2}$
- c)  $Q(E_1 + E_2)\sqrt{a^2 + b^2}$                       d)  $Q(\sqrt{E_1^2 + E_2^2})\sqrt{a^2 + b^2}$
60. A non-conducting sphere with a cavity has volume charge density  $\rho$ .  $O_1$  and  $O_2$  represent the two centres as shown. The electric field inside the cavity is  $E_0$ . Now, an equal and opposite charge is given uniformly to the sphere on its outer surface. The magnitude of electric field inside the cavity becomes



- a) Zero                      b)  $E_0$                       c)  $2E_0$                       d)  $3E_0$
61. If a charged spherical conductor of radius 10 cm has potential  $V$  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)  $3V$
62. A point charge  $q$  moves from point  $P$  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)  $q(\sqrt{a^2 + b^2})E$                       d)  $3qE\sqrt{a^2 + b^2}$
63. Three large plates are arranged as shown. How much charge will flow through the key  $k$  if it closed?

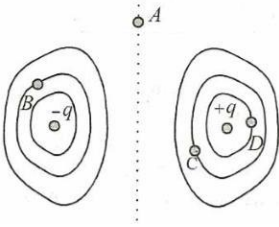


- a)  $\frac{5Q}{6}$                       b)  $\frac{4Q}{3}$                       c)  $\frac{3Q}{2}$                       d) None

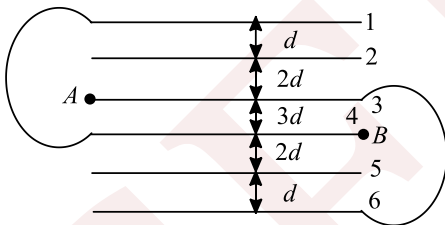




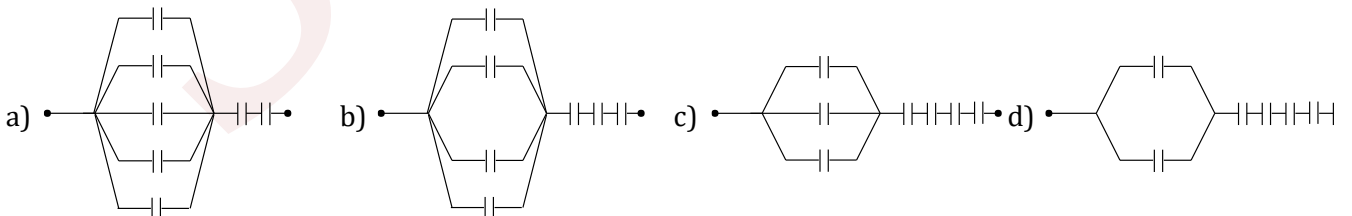
73. Two copper spheres of same radii, one hollow and the other solid, are charged to same potential. Then, which, if any, of the two will have more charge?  
 a) Hollow  
 b) Solid  
 c) Both will have the same charge  
 d) Nothing can be predicted
74. The SI unit of the line integral of electrical field  $\int \mathbf{E} \cdot d\mathbf{l}$  is  
 a)  $\text{NC}^{-1}$   
 b)  $\text{Nm}^2\text{C}^{-1}$   
 c)  $\text{JC}^{-1}$   
 d)  $\text{Vm}^{-1}$
75. Figure shows equipotential surfaces for a two charges system. At which of the labelled points will an electron have the highest potential energy?



- a) Point A  
 b) Point B  
 c) Point C  
 d) Point D
76. If the potential of a capacitor having capacity  $6\mu\text{F}$  is increased from 10 V to 20 V, then increase in its energy is  
 a)  $12 \times 10^{-6} \text{ J}$   
 b)  $9 \times 10^{-4} \text{ J}$   
 c)  $4.5 \times 10^{-6} \text{ J}$   
 d)  $2.25 \times 10^{-6} \text{ J}$
77. A  $5\mu\text{F}$  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)  $1.6 \times 10^{-2} \text{ J}$   
 b) 3.2 J  
 c) 1.6 J  
 d) 4.2 J
78. Four charges equal to  $-Q$  are placed at the four corners of a square and a charge  $q$  is at its centre. If the system is in equilibrium, the value of  $q$  is  
 a)  $-\frac{Q}{4}(1+2\sqrt{2})$   
 b)  $\frac{Q}{2}(1+2\sqrt{2})$   
 c)  $-\frac{Q}{2}(1+2\sqrt{2})$   
 d)  $\frac{Q}{4}(1+2\sqrt{2})$
79. Six plates of equal area  $A$  and plate separation as shown (figure) are arranged. The equivalent capacitance between A and B is



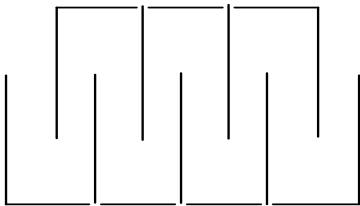
- a)  $\frac{\epsilon_0 A}{d}$   
 b)  $\frac{2\epsilon_0 A}{d}$   
 c)  $\frac{3\epsilon_0 A}{d}$   
 d)  $\frac{\epsilon_0 A}{3d}$
80. Seven capacitors each of the capacitance  $2\mu\text{F}$  are connected in a configuration to obtain an effective capacitance of  $\frac{10}{11}\mu\text{F}$ . Which of the combination (S) shown in figure will achieve the desired result?



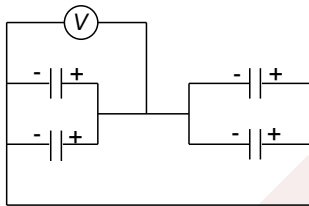
81. A capacitor of capacitance  $10\mu\text{F}$  charged to 100V is connected to an uncharged capacitor. The effective potential now is 40 V. The capacitance of uncharged capacitor is  
 a)  $12\mu\text{F}$   
 b)  $15\mu\text{F}$   
 c)  $25\mu\text{F}$   
 d)  $30\mu\text{F}$
82. Identify the wrong statement.  
 a) In an electric field two equipotential surfaces can never intersect.  
 b) A charged particle free to move in an electric field shall always move in the direction of  $\mathbf{E}$ .



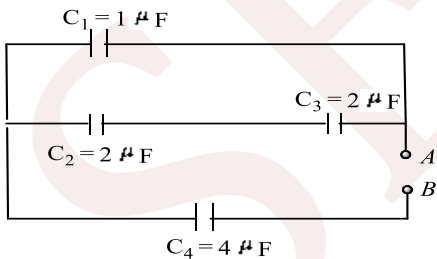
- c) Electric field at the surface of a charged conductor is always normal to the surface.  
 d) The electric potential decrease along a line of force in an electric field.
83. A parallel plate capacitor has the space between its plates filled by two slabs of thickness  $\frac{d}{2}$  each and dielectric constant  $K_1$  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)  $\frac{2\varepsilon_0 A}{d} \left( \frac{K_1 + K_2}{K_1 K_2} \right)$
84. A particle of mass  $m$  carrying charge ' $q$ ' is projected with velocity ' $v$ ' from point ' $P$ ' towards an infinite line of charge from a distance ' $a$ '. Its speed reduces to zero momentarily at point  $Q$  which is at a distance  $a/2$  from the line of charge. If another particle with mass  $m$  and charge ' $-q$ ' is projected with the same velocity ' $v$ ' from  $P$  towards the line of charge, what will be its speed at  $Q$ ?
- a)  $v_1 = \sqrt{2}v$       b)  $v_1 = 2v$       c)  $v_1 = \sqrt{v}$       d)  $v_1 = \sqrt{2}$
85. A gang capacitor is formed by interlocking a number of plates as shown in figure. The distance between the consecutive plates is 0.885 cm and the overlapping area of the plates is 5 cm<sup>2</sup>. The capacity of the unit is



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

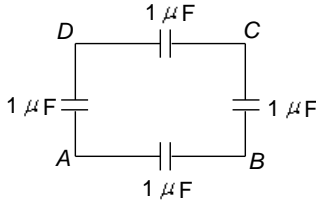


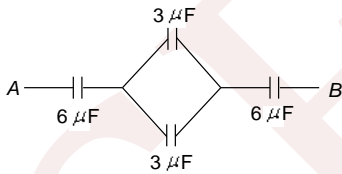
- a)  $\pm 2 \times 10^{-3} \text{C}$       b)  $\pm 5 \times 10^{-3} \text{C}$       c)  $\pm 2 \times 10^{-2} \text{C}$       d)  $\pm 5 \times 10^{-2} \text{C}$
87. Four capacitors are connected in a circuit as shown in the following figure. Calculate the effective capacitance between the points  $A$  and  $B$ .



- a)  $\frac{4}{3} \mu\text{F}$       b)  $\frac{24}{5} \mu\text{F}$       c) 9  $\mu\text{F}$       d) 5  $\mu\text{F}$
88. A 20  $\mu\text{F}$  capacitor is connected to 45 V battery through a circuit whose resistance is 2000  $\Omega$ . What is the final charge on the capacitor?
- a)  $9 \times 10^{-4} \text{C}$       b)  $9.154 \times 10^{-4} \text{C}$       c)  $9.8 \times 10^{-4} \text{C}$       d) None of these
89. Four capacitors are connected as shown in figure. The equivalent capacitance between  $A$  and  $B$  is





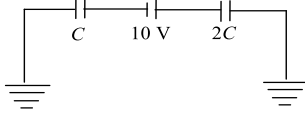
- a)  $4 \mu\text{F}$                       b)  $0.25 \mu\text{F}$                       c)  $0.75 \mu\text{F}$                       d)  $1.33 \mu\text{F}$
90. The work done in bringing a unit positive charge from infinity distance to a point at distance  $X$  from a positive charge  $Q$  is  $W$ . Then, the potential  $\phi$  at the point is  
 a)  $\frac{WQ}{X}$                       b)  $W$                       c)  $\frac{W}{Q}$                       d)  $WQ$
91. A  $10 \mu\text{C}$  capacitor is charged to a potential difference of  $50 \text{ V}$  and is connected to another uncharged capacitor in parallel. Now the common potential difference becomes  $20 \text{ V}$ . The capacitance of second capacitor is  
 a)  $15 \mu\text{F}$                       b)  $30 \mu\text{F}$                       c)  $20 \mu\text{F}$                       d)  $10 \mu\text{F}$
92. A wire of linear charge density  $\lambda$  passes through a cuboid of length  $l$ , breadth  $b$  and height  $h$  ( $l > b > h$ ). In such a manner that the flux through the cuboid is maximum. The position of the wire is now changed, so that the flux through the cuboid is minimum. The ratio of maximum flux to minimum flux will be  
 a)  $\sqrt{\frac{l^2 + b^2}{h}}$                       b)  $\sqrt{\frac{l^2 + b^2 + h^2}{h}}$                       c)  $\frac{h}{\sqrt{l^2 + b^2}}$                       d)  $\frac{h}{\sqrt{l^2 + b^2 + h^2}}$
93. Electric field on the axis of a small electric dipole at a distance  $r$  is  $\vec{E}_1$  and  $\vec{E}_2$  at a distance of  $2r$  on a line of perpendicular bisector. Then  
 a)  $\vec{E}_2 = -\frac{\vec{E}_1}{8}$                       b)  $\vec{E}_2 = -\frac{\vec{E}_1}{16}$                       c)  $\vec{E}_2 = -\frac{\vec{E}_1}{4}$                       d)  $\vec{E}_2 = \frac{\vec{E}_1}{8}$
94. A point charge  $q$  is placed at the centre of a closed cylindrical conductor of length  $l$  and radius  $R$ . The flux crossing through the conducting cylinder would be  
 a)  $\frac{ql}{2\epsilon_0[R^2 + l^2/4]^{1/2}}$                       b) Zero                      c)  $\frac{ql}{\epsilon_0[R^2 + l^2/4]^{1/2}}$                       d)  $\frac{q}{\epsilon_0}$
95. The equivalent capacitance between  $A$  and  $B$  in figure is  
  
 a)  $4 \mu\text{F}$                       b)  $2 \mu\text{F}$                       c)  $10.5 \mu\text{F}$                       d)  $3 \mu\text{F}$
96. A solid conducting sphere having a charge  $Q$  is surrounded by an uncharged concentric conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be  $V$ . If the shell is now given a charge  $-3Q$ , the new potential difference between the same two surfaces is  
 a)  $V$                       b)  $2V$                       c)  $4V$                       d)  $-2V$
97. A  $10 \mu\text{F}$  capacitor is charged to  $500 \text{ V}$  and its plates are joined together through a resistance of  $10 \Omega$ . The heat produced in the resistance is  
 a)  $500 \text{ J}$                       b)  $125 \text{ J}$                       c)  $250 \text{ J}$                       d)  $1.25 \text{ J}$
98. There are 10 condensers each of capacity  $5 \mu\text{F}$ . The ratio between maximum and minimum capacities obtained from these condensers will be  
 a)  $25 : 5$                       b)  $40 : 1$                       c)  $60 : 3$                       d)  $100 : 1$
99. A non-conducting ring of radius  $0.5 \text{ m}$  carries total charge of  $1.11 \times 10^{-10} \text{ C}$  distributed non-uniformly on its circumference producing an electric field everywhere in space.



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

- a) +2
- b) -1
- c) -2
- d) Zero

100. In the circuit shown Fig,  $C = 6 \mu\text{F}$ . The charge stored in the capacitor of capacity  $C$  is



- a) Zero
- b)  $90 \mu\text{C}$
- c)  $40 \mu\text{C}$
- d)  $60 \mu\text{C}$

101. In a region of space having a uniform electric field  $E$ , a hemispherical bowl of radius  $r$  is placed. The electric flux  $\phi$  through the bowl is

- a)  $2\pi r E$
- b)  $4\pi r^2 E$
- c)  $2\pi r^2 E$
- d)  $\pi r^2 E$

102. A spherical charged conductor has surface density of charge  $= \sigma$ , and electric field intensity on its surface is  $E$ . If radius of surface is doubled, point  $\sigma$  unchanged, what will be electric field intensity on the new sphere?

- a)  $E/2$
- b)  $2 E$
- c)  $E/4$
- d)  $E$

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

- a) 25 V, 75 V
- b) 75 V, 25 V
- c) 20 V, 80 V
- d) 50 V, 50 V

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

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

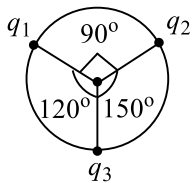
105. Two parallel-plate capacitors of capacitance  $C$  and  $2C$  are connected in parallel and charged to potential difference  $V$ . The battery is then disconnected and the region between the plates of  $C$  is filled completely with a material of dielectric constant  $K$ . The common potential difference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

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

106. An electron enters the space between the plates of a charged capacitor as shown. The charge density on the plate is  $\sigma$ . 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  $\mathbf{E}$  and  $\mathbf{B}$  without any change in direction. The time taken by the electron to travel a distance  $l$  in the space is

- a)  $\frac{\sigma l}{\epsilon_0 B}$
- b)  $\frac{\sigma B}{\epsilon_0 l}$
- c)  $\frac{\epsilon_0 l B}{\sigma}$
- d)  $\frac{\epsilon_0 l}{\sigma B}$

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



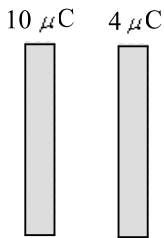
- a) 1:1:1
- b)  $q_1 : q_2 : q_3$
- c)  $1 : \sqrt{3} : 2$
- d) This ratio cannot be calculated



108. A  $10\ \mu\text{F}$  capacitor and a  $20\ \mu\text{F}$  capacitor are connected in series across  $200\ \text{V}$  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?

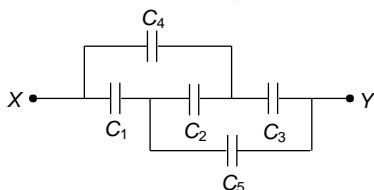
- a)  $\frac{800}{9}\ \text{V}$                       b)  $\frac{800}{3}\ \text{V}$                       c)  $400\ \text{V}$                       d)  $200\ \text{V}$

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



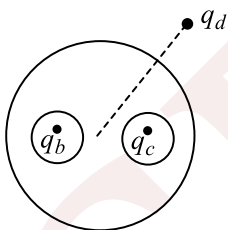
- a)  $14\ \mu\text{C}$                       b)  $-14\ \mu\text{C}$                       c)  $7\ \mu\text{C}$                       d)  $-7\ \mu\text{C}$

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



- a)  $1\ \mu\text{F}$                       b)  $3\ \mu\text{F}$                       c)  $4\ \mu\text{F}$                       d)  $5\ \mu\text{F}$

111. A spherical conductor  $A$  contains two spherical cavities. The total charge on the conductor itself is zero. However, there is a point charge  $q_b$  at the centre of one cavity and  $q_c$  at the Centre of the other. At considerable distance  $r$  away from the centre of the spherical conductor, there is another charge  $q_d$ . Forces acting on  $q_b$ ,  $q_c$  and  $q_d$  are  $F_1$ ,  $F_2$  and  $F_3$ , respectively. [Assume all charges are positive]

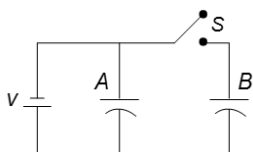


- a)  $F_1 < F_2 < F_3$                       b)  $F_1 = F_2 < F_3$                       c)  $F_1 = F_2 > F_3$                       d)  $F_1 > F_2 > F_3$

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

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

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



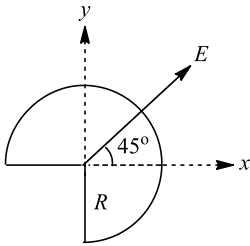
- a) 9:16                      b) 5:9                      c) 2:3                      d) 3:5



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

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

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

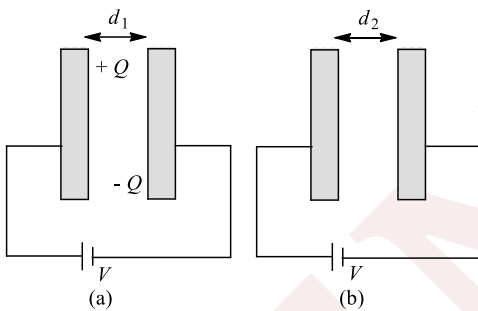


- a)  $\pi R^2 E$                       b)  $\sqrt{2}\pi R^2 E$                       c)  $\pi R^2 E\sqrt{2}$                       d) None of these

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

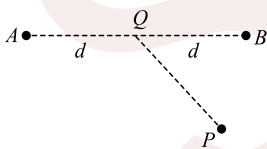
- a) 2:1                      b) 8:1                      c) 4:1                      d) 16:1

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



- a) Work done is  $\frac{Q^2}{2\epsilon_0 A} (d_2 - d_1)$  and is stored in volume  $A(d_2 - d_1)$   
 b) Work done is  $+\frac{Q^2}{2\epsilon_0 A} (d_2 - d_1)$  and is stored in volume  $Ad_2$   
 c) Work done is  $+\frac{\epsilon_0 AV^2 (d_2 - d_1)}{2 d_1 d_2}$  and is stored in volume  $A(d_2 - d_1)$   
 d) Work done is  $\frac{\epsilon_0 AV^2 (d_2 - d_1)}{2 d_1 d_2}$  and is stored in volume  $Ad_2$

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



Then

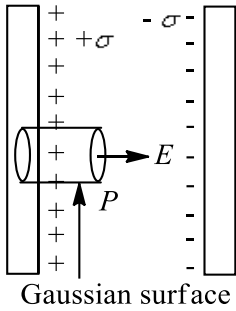
- a)  $W_A > W_B$                       b)  $W_A < W_B$                       c)  $W_A = W_B$                       d)  $W_A + W_B = 0$

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

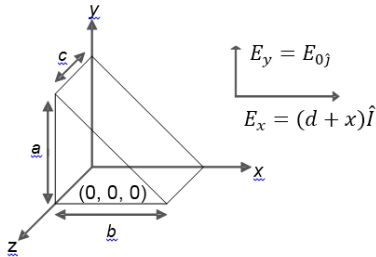
- a) No work is done  
 b) Work is done by the battery and the stored energy increases  
 c) Work is done by the external agent and the stored energy decreases  
 d) Work is done by the battery as well as external agent but the stored energy does not change



120. Consider the situation shown in Figure. We find electric field  $E$  at point  $P$  using Gauss's law and it comes out to be  $E = \sigma/\epsilon_0$ . This electric field is due to



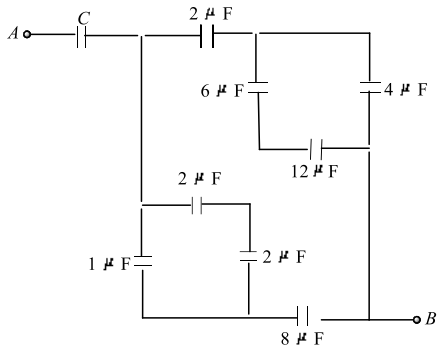
- a) All the amount of charges present on both the plates  
 b) All the charges present on positive plate only  
 c) Positive charge present only inside the Gaussian surface  
 d) Positive charge present inside the Gaussian surface plus equal magnitude of negative charge present on negative plate in front of Gaussian surface
121. Two insulated metal spheres of radii 10 cm and 15 cm charged to a potential of 150V and 100 V respectively are connected by means of a metallic wire. What is the charge on the first sphere?  
 a) 2 esu                                      b) 4 esu                                      c) 6 esu                                      d) 8 esu
122. Two metallic spheres of radii 1 cm and 2 cm are given charges of  $10^{-2}$  C and  $5 \times 10^{-2}$  C respectively. If these are connected by a conducting wire, the final charge on the smaller sphere is  
 a)  $3 \times 10^{-2}$  C                              b)  $1 \times 10^{-2}$  C                              c)  $4 \times 10^{-2}$  C                              d)  $2 \times 10^{-2}$  C
123. In the given electric field  $\vec{E} = [a(d+x)\hat{i} + E_a\hat{j}]$  N/C; where  $a = 1$  N/C hypothetical closed surface is taken as shown in Figure.



The total charge enclosed within the close surface is

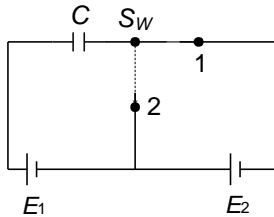
- a)  $\frac{abc\epsilon_0}{2}$                                       b)  $\frac{acd\epsilon_0}{2}$                                       c)  $\frac{abd\epsilon_0}{2}$                                       d) None of above
124. The work done in increasing the potential of a capacitor from  $V$  volt to  $2V$  volt is  $W$ . Then, the work done in increasing the potential of the same capacitor from  $2V$  volt to  $4V$  volt will be  
 a)  $W$     b)  $2W$     c)  $4W$     d)  $8W$
125. Three plates  $A, B, C$  each of area  $50 \text{ cm}^2$  have separation 3 mm between  $A$  and  $B$  and 3 mm between  $B$  and  $C$ . The energy stored when the plates are fully charges is
- 
- a)  $6 \times 10^{-9}$  J                                      b)  $3.12 \times 10^{-9}$  J                                      c)  $2.12 \times 10^{-9}$  J                                      d) None of these
126. In the given network, the value of  $C$ , so that an equivalent capacitance between  $A$  and  $B$  is  $3\mu\text{F}$ , is





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

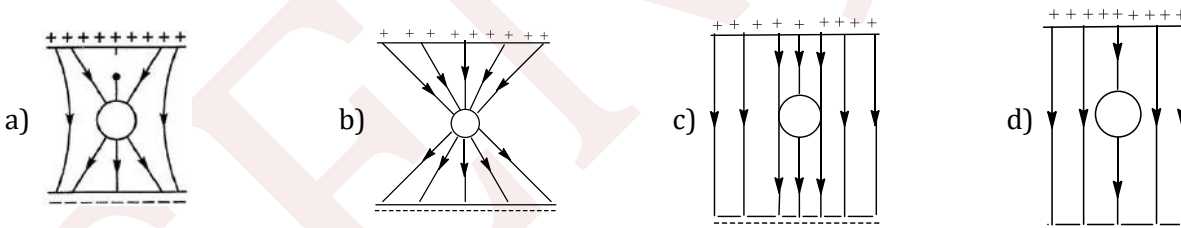
127. In the given circuit diagram (figure), switch  $S_W$  is shifted from position 1 to position 2. Then



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

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

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



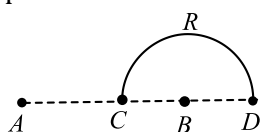
130. If a charge is moved against the coulomb force of an electric field, then the

- a) Positive work is done by the electric field  
 b) Energy is used from some outside source which does positive work  
 c) Strength of the field is decreased  
 d) Energy of the system is decreased

131. Two conducting spheres of radii  $r_1$  and  $r_2$  have same electric field near their surfaces. The ratio of their electrical potential is

- a)  $r_1^2/r_2^2$                       b)  $r_2^2/r_1^2$                       c)  $r_1/r_2$                       d)  $r_2/r_1$

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



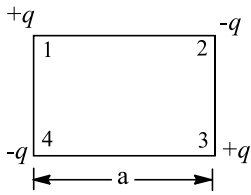
- a)  $\frac{qQ}{4\pi\epsilon_0 L}$                       b)  $\frac{qQ}{2\pi\epsilon_0 L}$                       c)  $\frac{qQ}{6\pi\epsilon_0 L}$                       d)  $-\frac{qQ}{6\pi\epsilon_0 L}$



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

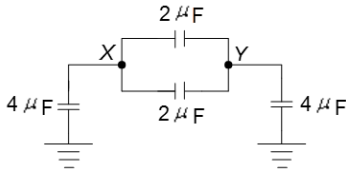
- a) Kinetic energy      b) Potential energy      c) Elastic energy      d) Magnetic energy

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



- a)  $\frac{1}{4\pi\epsilon_0} \frac{q^2}{a}$       b)  $-\frac{2.6}{4\pi\epsilon_0} \frac{q^2}{a}$       c)  $+\frac{2.6}{4\pi\epsilon_0} \frac{q^2}{a}$       d) None of these

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

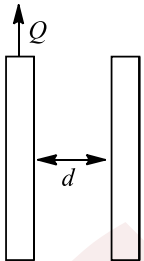


- a)  $2 \mu\text{F}$       b)  $3 \mu\text{F}$       c)  $4 \mu\text{F}$       d)  $5 \mu\text{F}$

136. An electron is released from rest in a region of space with a non-zero electric field. Which of the following statements is true?

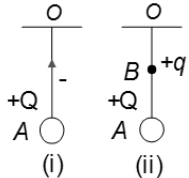
- a) The electron will begin moving towards a region of higher potential  
 b) The electron will begin moving towards a region of lower potential  
 c) The electron will begin moving along a line of constant potential  
 d) Nothing can be concluded unless the direction of the electric field is known

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



- a)  $\sqrt{\frac{3dm\epsilon_0 A}{qQ}}$       b)  $\sqrt{\frac{4dm\epsilon_0 A}{qQ}}$       c)  $\sqrt{\frac{2dm\epsilon_0 A}{qQ}}$       d) None of these

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



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

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

- a)  $10^3 \text{ Nm}^2 \text{ C}^{-1}$       b)  $10^3 \text{ CN}^{-1} \text{ m}^{-2}$   
 c)  $6.32 \times 10^3 \text{ Nm}^2 \text{ C}^{-1}$       d)  $6.32 \times 10^3 \text{ CN}^{-1} \text{ m}^{-2}$

140. The maximum field intensity on the axis of a uniformly charged ring of charge  $q$  and radius  $R$  will be



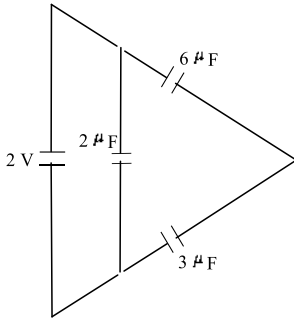
$$a) \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{3\sqrt{3}R^2}$$

$$b) \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{3R^2}$$

$$c) \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{3\sqrt{3}R^2}$$

$$d) \frac{1}{4\pi\epsilon_0} \cdot \frac{3q}{3\sqrt{3}R^2}$$

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



$$a) 2 \mu\text{J}$$

$$b) 4 \mu\text{J}$$

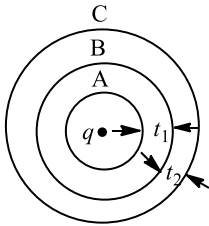
$$c) 8 \mu\text{J}$$

$$d) 16 \mu\text{J}$$

142. Identify the wrong statement.

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

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



$$a) t_1 = t_2$$

$$b) t_1 > t_2$$

$$c) t_1 < t_2$$

$$d) t_1 \leq t_2$$

144. A spring block system undergoes vertical oscillations above a large horizontal metal sheet with uniform positive charge the time period of the oscillation is  $T$ . If the block is given a charge  $Q$ . Its time period of oscillation will be

$$a) T$$

$$b) > T$$

$$c) < T$$

$$d) > T \text{ if } Q \text{ is } +ve \text{ and } < T \text{ if } Q \text{ is } -ve$$

145. A technician has only two capacitors. By using these singly, in series or in parallel he can obtain capacitances of  $3 \mu\text{F}$ ,  $4 \mu\text{F}$ ,  $12 \mu\text{F}$  and  $16 \mu\text{F}$ . The capacitances of these capacitors are

$$a) 6 \mu\text{F} \text{ and } 10 \mu\text{F}$$

$$b) 4 \mu\text{F} \text{ and } 12 \mu\text{F}$$

$$c) 7 \mu\text{F} \text{ and } 9 \mu\text{F}$$

$$d) 4 \mu\text{F} \text{ and } 16 \mu\text{F}$$

146. Potential energy of two equal negative point charges  $2 \mu\text{C}$  each held  $1 \text{ m}$  apart in air is

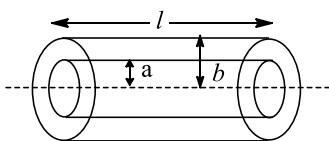
$$a) 2 \text{ J}$$

$$b) 2 \text{ eV}$$

$$c) 4 \text{ J}$$

$$d) 0.036 \text{ J}$$

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



a) Is same throughout

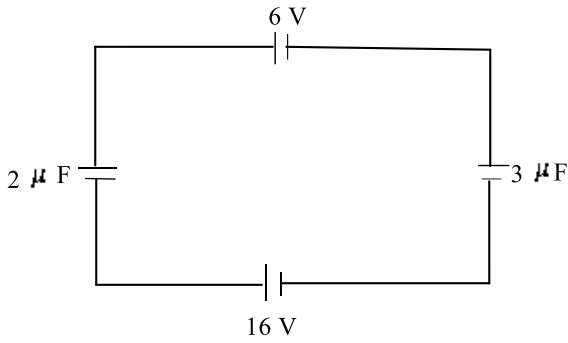
b) Is higher near the outer cylinder than near the inner cylinder

c) Varies as  $\frac{1}{r}$ , where  $r$  is the distance from the axis

d) Varies as  $\frac{1}{r^2}$ , where  $r$  is the distance from the axis



148. What is the potential difference across  $2\mu\text{F}$  capacitor in the circuit shown?



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

149. The potential gradient at which dielectric of the condenser just gets punctured is called

- a) Dielectric constant      b) Dielectric strength      c) Dielectric resistance      d) Dielectric number

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

- (i) Ball *A* repels *C* and attracts *B*
- (ii) Ball *D* attracts *B* and has no effect on *E*
- (iii) A negatively charged rod attracts both *A* and *E*

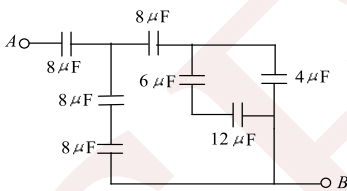
An electrically neutral Styrofoam ball gets attracted if placed nearby a charged body due to induced charge. What are the charges, if any, on each ball *A, B, C, D* and *E*?

- a) + + - + 0 +              b) - - + + 0              c) + - + 0 0              d) - + - 0 0

151. Mark out the correct statement about the electric lines of force

- a) The number of lines of force leaving a +ve charge or entering a -ve charge is proportional to the magnitude of charge
- b) The path of a charge particle in an electric field is not always along the field lines
- c) The direction of electric lines of force is along the normal to the equipotential surface
- d) All of the above

152. The equivalent capacitance across *AB* Fig is



- a)  $8\mu\text{F}$                       b)  $12\mu\text{F}$                       c)  $4\mu\text{F}$                       d)  $24\mu\text{F}$

153. A large insulated sphere of radius  $r$  charged with  $Q$  units of electricity is placed in contact with a small insulated uncharged sphere of radius  $r'$  and in then separated. The charge on smaller sphere will now be

- a)  $Q(r + r')$               b)  $\frac{Qr'}{r' + r}$               c)  $Q(r - r')$               d)  $\frac{Q}{r' + r}$

154. The plates of a parallel plate capacitor are charged up to 100 V. A 2 mm thick plate is inserted between the plates, then to maintain the same potential difference, the distance between the capacitor plates is increase by 1.6 mm. the dielectric constant of the plate, is

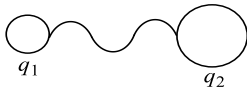
- a) 5                              b) 1.25                              c) 4                              d) 2.5

155. Capacitor of a capacitor is  $48\mu\text{F}$ . 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

156. Two spherical conductors of radii  $R_1$  and  $R_2$  are separated by a distance much larger than the radius of the either sphere. The spheres are connected by a conducting wire as shown in Fig. If the charges on the spheres in equilibrium are  $q_1$  and  $q_2$ , respectively, what is the ratio of the field strength at the surfaces of the spheres?

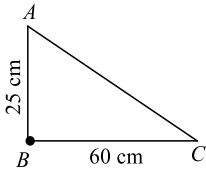




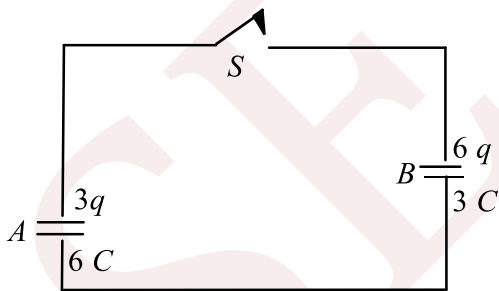
157. Two spheres of radii  $R_1$  and  $R_2$  joined by a fine wire are raised to a potential  $V$ . Let the surface charge densities at these two spheres be  $\sigma_1$  and  $\sigma_2$  respectively. Then the ratio  $\frac{\sigma_2}{\sigma_1}$  has a value

a)  $R_2/R_1$                       b)  $R_2^2/R_1^2$                       c)  $R_1/R_2$                       d)  $R_1^2/R_2^2$

158.  $ABC$  is a right-angled triangle, where  $AB$  and  $BC$  are 25 and 60 cm, respectively. A metal sphere of 2 cm radius charged to a potential of  $9 \times 10^5$  volt is placed at  $B$  as in Fig. Find the amount of work done in carrying a positive charge of 1 coulomb from  $C$  to  $A$



- a) 21 kJ                      b) 42 kJ                      c) 14 kJ                      d) 52 kJ
159. Mark out the correct statement(s).
- a) Capacitance of an isolated sphere depends on its charge  
 b) Capacitance of a non-isolated sphere depends only on its shape and size  
 c) Capacitance of a non-isolated sphere is increased because of the presence of other conducting bodies nearby it  
 d) Capacitance of a conductor cannot be affected because of the presence of other conducting bodies nearby it
160. A ring of radius  $R$  carries a charge  $+q$ . A test charge  $-q_0$  is released on its axis at a distance from its centre. How much kinetic energy will be acquired by the test charge when it reaches the centre of the ring?
- a)  $\frac{1}{4\pi\epsilon_0} \frac{qq_0}{R}$                       b)  $\frac{1}{4\pi\epsilon_0} \frac{qq_0}{2R}$                       c)  $\frac{1}{4\pi\epsilon_0} \frac{qq_0}{\sqrt{3}R}$                       d)  $\frac{1}{4\pi\epsilon_0} \frac{qq_0}{3R}$
161. In given circuit when switch  $S$  has been closed then charge on capacitor  $A$  and  $B$  respectively are

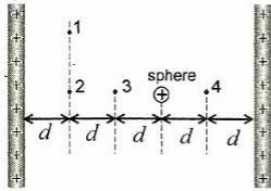


- a)  $3q, 6q$                       b)  $6q, 3q$                       c)  $4.5q, 4.5q$                       d)  $5q, 4q$
162. The ratio of momenta of an electron and proton which are accelerated from rest by a potential difference 50 V is

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

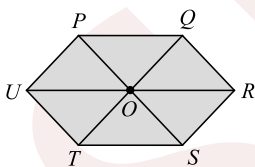
163. The figure shows two large, closely placed, parallel, non-conducting sheets with identical (positive) uniform surface charge densities, and a sphere with a uniform (positive) volume charge density. Four points marked as 1, 2, 3 and 4 are shown in the space in between. If  $E_1, E_2, E_3$  and  $E_4$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





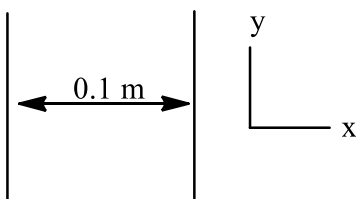
- a)  $E_1 > E_2 > E_3 > E_4$       b)  $E_1 > E_2 > E_3 = E_4$       c)  $E_3 = E_4 > E_2 > E_1$       d)  $E_1 = E_2 = E_3 = E_4$

164. A parallel plate capacitor is made by stocking  $n$  equally spaced plates connected alternately. If the capacitance between any two plates is  $x$ , then the total capacitance is,  
 a)  $nx$       b)  $n/x$       c)  $nx^2$       d)  $(n - 1)x$
165. The electric potential decreases uniformly from 120 V to 80 V as one moves on the  $X$ -axis from  $x = -1$  cm to  $x = +1$  cm. The electric field at the origin  
 a) Must be equal to  $20 \text{ Vcm}^{-1}$       b) Must be equal to  $20 \text{ Vm}^{-1}$   
 c) May be greater than  $20 \text{ Vcm}^{-1}$       d) May be less than  $20 \text{ Vcm}^{-1}$
166. A solid conducting sphere of radius 10 cm is enclosed by a thin metallic shell of radius 20 cm. A charge  $q = 20 \mu\text{C}$  is given to the inner sphere. Find the heat generated in the process when the inner sphere is connected to the shell by a conducting wire  
 a) 12 J      b) 9 J      c) 24 J      d) Zero
167. Two positive point charges of  $12 \mu\text{C}$  and  $8 \mu\text{C}$  are placed 10 cm, apart in air. The work done to bring them 4 cm closer is  
 a) Zero      b) 3.5 J      c) 4.8 J      d) 5.8 J
168. A parallel plate capacitor is made by stacking  $n$  equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is  $C$ , then the resultant capacitance is  
 a)  $(n - 1)C$       b)  $(n + 1)C$       c)  $C$       d)  $nC$
169. The distance between the plates of a parallel-plate capacitor is  $d$ . A metal plate of thickness  $d/2$  is placed between the plates. What will be its effect on the capacitance?  
 a) Capacitance will be halved      b) Capacitance will be doubled  
 c) Capacitance will not change      d) Capacitance will be become 1.5 times original
170. Six charges, three positive and three negative of equal magnitude are to be placed at the vertices of a regular hexagon such that the electric field at  $O$  is double the electric field when only one positive charge of same magnitude is placed at  $R$ . which of the following arrangements of charges is possible for  $P, Q, R, S, T$  and  $U$  respectively?



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

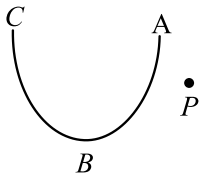
171. Two insulating plates are both uniformly charged in such a way that the potential difference between them is  $V_2 - V_1 = 20\text{V}$ . (ie, plate 2 is at a higher potential). The plates are separated by  $d = 0.1\text{m}$  and can be treated as infinitely large. An electron is released from rest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



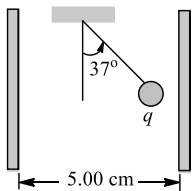
- a)  $2.65 \times 10^6 \text{ ms}^{-1}$       b)  $7.02 \times 10^{12} \text{ ms}^{-1}$       c)  $1.87 \times 10^6 \text{ ms}^{-1}$       d)  $32 \times 10^{-19} \text{ ms}^{-1}$



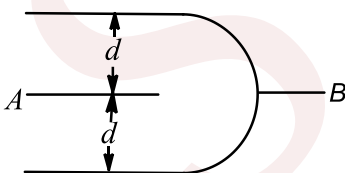
172. The electric potential  $V$  at any point  $x, y, z$  (all the metre) in space is given by  $V = 4x^2$  volt. The electric field at the point  $(1\text{m}, 0, 2\text{m})$  in  $\text{Vm}^{-1}$  is  
 a)  $-8\hat{i}$                       b)  $+8\hat{i}$                       c)  $-16\hat{i}$                       d)  $16\hat{k}$
173. Two identical parallel plate capacitors are placed in series and connected to a constant voltage source of  $V$  volt. If one of the capacitor is completely immersed in a liquid of dielectric constant  $K$ , then the potential difference between the plates of the other capacitor will change to  
 a)  $\frac{K}{K+1}V$                       b)  $\frac{K+1}{K}V$                       c)  $\frac{2K}{K+1}V$                       d)  $\frac{K+1}{2K}V$
174. In the following diagram the work done in moving a point charge from point  $P$  to point  $A, B$  and  $C$  is respectively as  $W_A, W_B$  and  $W_C$  then



- a)  $W_A = W_B = W_C$                       b)  $W_A = W_B = W_C = 0$                       c)  $W_A > W_B > W_C$                       d)  $W_A < W_B < W_C$
175. A small sphere with mass  $1.2\text{ g}$  hangs by a thread between two parallel vertical plates  $5.00\text{ cm}$  apart. The plates are insulating and have uniform surface charge densities  $+\sigma$  and  $-\sigma$ . The charge on the sphere is  $q = 9 \times 10^{-6}\text{ C}$ . What potential difference between the plates will cause the thread to assume an angle of  $37^\circ$  with the vertical as shown in Fig?

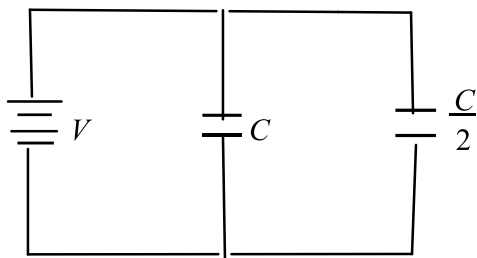


- a)  $30\text{ V}$                       b)  $12\text{ V}$                       c)  $50\text{ V}$                       d)  $25\text{ V}$
176. A charged particle of mass  $m = 2\text{ kg}$  and charge  $1\mu\text{C}$  is projected from a horizontal ground at an angle  $\theta = 45^\circ$  with speed  $10\text{ ms}^{-1}$ . In space, a horizontal electric field towards the direction of projection  $E = 2 \times 10^7\text{ NC}^{-1}$  exists. The range of the projection is  
 a)  $20\text{ m}$                       b)  $60\text{ m}$                       c)  $200\text{ m}$                       d)  $180\text{ m}$
177. In the above question, if the capacitors were connected in series, find the potential difference (in V) across each capacitor  
 a)  $\frac{300}{13}, \frac{600}{13}, \frac{400}{13}$                       b)  $\frac{600}{13}, \frac{300}{13}, \frac{400}{13}$                       c)  $\frac{300}{13}, \frac{400}{13}, \frac{600}{13}$                       d)  $\frac{600}{13}, \frac{400}{13}, \frac{300}{13}$
178. Three plates of common surface area  $A$  are connected as shown. The effective capacitance will be



- a)  $\frac{\epsilon_0 A}{d}$                       b)  $\frac{3\epsilon_0 A}{d}$                       c)  $\frac{3\epsilon_0 A}{2d}$                       d)  $\frac{2\epsilon_0 A}{d}$
179. A square of side  $a$  has charge  $Q$  at 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)  $\frac{Qq}{4\pi\epsilon_0 a}$                       c)  $\frac{Qq\sqrt{2}}{4\pi\epsilon_0 a}$                       d)  $\frac{Qq}{2\pi\epsilon_0 a}$
180. Two condensers, one of capacity  $C$  and the other of capacity  $\frac{C}{2}$ , are connected to a  $V$  volt battery, as shown. The work done in charging fully both the condensers is





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

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

- a) Zero                      b)  $\frac{Qq}{4\pi\epsilon_0 r}$                       c)  $\frac{Qq}{2\pi\epsilon_0 r}$                       d) None of these

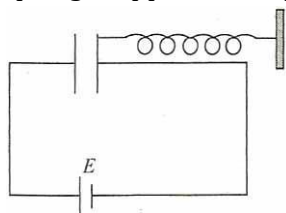
182. Two metal spheres (radii  $r_1, r_2$  with  $r_1 < r_2$ ) are very far apart but are connected by a thin wire. If their combined charge is  $Q$ , then what is their common potential?

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

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

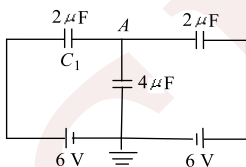
- a)  $axy + C$                       b)  $-axy + C$                       c)  $axy$                       d)  $-axy$

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



- a)  $\frac{125}{32} \frac{\epsilon_0 AE^2}{d^3}$                       b)  $\frac{2\epsilon_0 AE^2}{d^3}$                       c)  $\frac{6\epsilon_0 E^2}{Ad^2}$                       d)  $\frac{\epsilon_0 AE^3}{2d^3}$

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

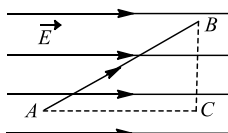


- a)  $6 \mu\text{C}$                       b)  $12 \mu\text{C}$                       c)  $18 \mu\text{C}$                       d)  $24 \mu\text{C}$

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

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

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



- a) 50 eV                      b) 40 eV                      c)  $-50 \text{ eV}$                       d)  $-40 \text{ eV}$

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

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

189. Charge  $Q$  is given a displacement  $\vec{r} = a\hat{i} + b\hat{j}$  in an electric field  $\vec{E} = E_1\hat{i} + E_2\hat{j}$ . 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)  $Q\sqrt{(E_1^2 + E_2^2)^2\sqrt{a^2 + b^2}}$

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

a)  $-6 \times 10^{-6}\text{erg}$

b)  $-6 \times 10^{-6}\text{J}$

c)  $6 \times 10^{-6}\text{J}$

d)  $6 \times 10^{-6}\text{erg}$

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

a)  $\frac{Qq}{Q + q}$

b)  $\frac{3Qq}{2Q + q}$

c)  $\frac{Qq}{Q - q}$

d)  $\frac{2Qq}{Q + q}$

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

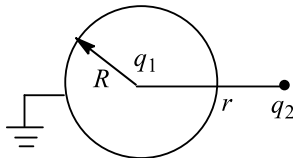
a)  $\frac{1}{2} \frac{\epsilon_0 E^2}{Ad}$

b)  $\frac{\epsilon_0 E^2}{Ad}$

c)  $\epsilon_0 E^2 Ad$

d)  $\frac{1}{2} \epsilon_0 E^2 Ad$

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



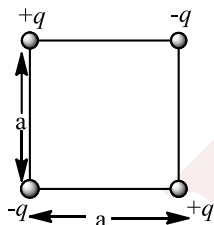
a) Zero

b)  $\frac{q_1 q_2}{4\pi\epsilon_0 r^2}$

c)  $\frac{q_1 q_2}{4\pi\epsilon_0 (r - R^2)}$

d)  $\frac{q_1 q_2}{4\pi\epsilon_0 (r^2 - R^2)}$

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



a)  $-0.21q^2/\epsilon_0 a$

b)  $-1.29q^2/\epsilon_0 a$

c)  $-1.41q^2/\epsilon_0 a$

d)  $+2.82q^2/\epsilon_0 a$

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

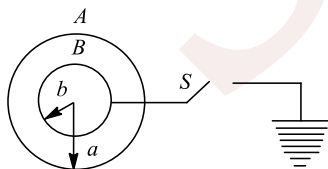
a) 1

b) 2

c)  $\frac{1}{4}$

d)  $\frac{1}{2}$

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



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

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

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

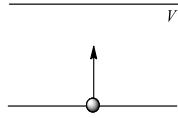
d) None of the above



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

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

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



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

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

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

200. Three capacitors of capacitance  $C$  ( $\mu\text{F}$ ) 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)  $4 \mu\text{F}$                       b)  $5 \mu\text{F}$                       c)  $6 \mu\text{F}$                       d)  $8 \mu\text{F}$

201. The work done in placing a charge of  $8 \times 10^{-18}\text{C}$  on a condenser of capacity  $100\mu\text{F}$  is

- a)  $16 \times 10^{-32} \text{ J}$                       b)  $3.1 \times 10^{-26} \text{ J}$                       c)  $4 \times 10^{-10} \text{ J}$                       d)  $32 \times 10^{-32} \text{ J}$

202. Minimum number of  $8\mu\text{F}$  and  $250 \text{ V}$  capacitors are used to make a combination  $16\mu\text{F}$  and  $1000 \text{ V}$  are

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

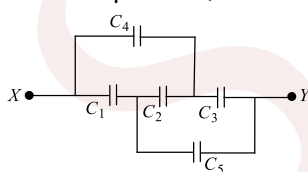
203. Two identical metal plates are given positive charges  $Q_1$  and  $Q_2 (< Q_1)$  respectively. If they are now brought close together to form a parallel plates capacitor with capacitance  $C$ , the potential difference between them is

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

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

- a)  $400 \text{ V}$                       b)  $450 \text{ V}$                       c)  $500 \text{ V}$                       d)  $300 \text{ V}$

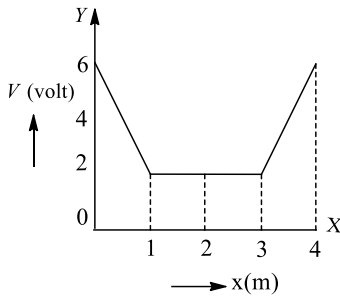
205. The effective capacitance between points  $X$  and  $Y$  in Fig, assuming  $C_2 = 10 \mu\text{F}$  and that outer capacitors are all  $4 \mu\text{F}$  each, is

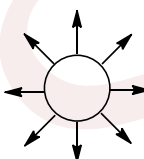
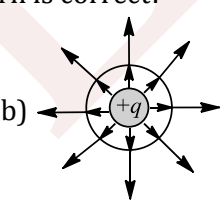
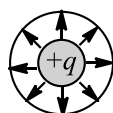


- a)  $1 \mu\text{F}$                       b)  $3 \mu\text{F}$                       c)  $4 \mu\text{F}$                       d)  $5 \mu\text{F}$

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

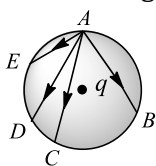




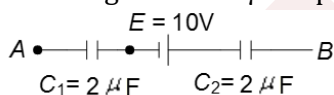
- a) Zero                                      b) 6/2                                      c) 6/1                                      d) 6/3
207.  $C, V, U$  and  $Q$  are capacitance, potential difference, energy stored and charge of a parallel plate capacitor respectively. The quantities that increase when a dielectric slab is introduced between the plates without disconnecting the battery are  
a)  $V$  and  $C$                                       b)  $V$  and  $U$                                       c)  $U$  and  $Q$                                       d)  $V$  and  $Q$
208. Three capacitors each of capacitance  $1 \mu\text{F}$  are connected in parallel. To the combination, a fourth capacitor of capacitance  $1 \mu\text{F}$  is connected in series. The resultant capacitance of the system is  
a)  $4 \mu\text{F}$                                       b)  $(4/3)\mu\text{F}$                                       c)  $2 \mu\text{F}$                                       d)  $(3/4)\mu\text{F}$
209.  $ABCD$  is a rectangle. At corners  $B, C$  and  $D$  of the rectangle are placed charges  $+10 \times 10^{-10}\text{C}$ ,  $-20 \times 10^{-12}\text{C}$ , and  $10 \times 10^{-12}\text{C}$ , respectively. Calculate the potential at the fourth corner. (The side  $AB=4\text{cm}$  and  $BC=3\text{cm}$ )  
a) 1.65 V                                      b) 0.165V                                      c) 16.5V                                      d) 2.65V
210. The electric potential in a certain region of space is given by  $V = -3x^2 + 4x$ , where  $x$  is in metres and  $V$  is in volts. In this region, the equipotential surfaces are  
a) Planes parallel to  $XY$  plane                                      b) Planes parallel to  $YZ$  plane  
c) Concentric cylinders with axis as  $x$ -axis                                      d) Concentric spheres centered at origin
211. If a conductor is electrically neutrally, then  
a) Net charge on it should be zero                                      b) Potential on it should be zero  
c) Both charge and potential should be zero                                      d) None of them may not be zero
212. A charge particle moves in a circle around an infinite line charge with the centre of circle at the line and line being perpendicular to the plane of circle. Let  $r$  be the radius of circle. The velocity of the particle depends upon which power of  $r$   
a) 1                                      b) 2                                      c)  $-1$                                       d) None of these
213. If a point charge  $q$  is placed at a point inside a hollow conducting sphere, then which of the following electric lines of force pattern is correct?  
a)                                       b)                                       c)                                       d) None of these
214. Two charged spheres of radii  $R_1$  and  $R_2$  having equal surface charge density. The ratio of their potential is  
a)  $R_1/R_2$                                       b)  $R_2/R_1$                                       c)  $\left(\frac{R_1}{R_2}\right)^2$                                       d)  $\left(\frac{R_2}{R_1}\right)^1$
215. The capacitance  $C$  of a capacitor is  
a) Independent of the charge and potential of the capacitor  
b) Dependent on the charge and independent of potential  
c) Independent of the geometrical configuration of the capacitor  
d) Independent of the dielectric medium between the two conducting surface of the capacitor
216. Two capacitors each of capacity  $2\mu\text{F}$  are connected in parallel. If they are connected to 100 V battery, then energy stored in them is



- a) 0.02 J                      b) 0.04 J                      c) 0.01 J                      d) 200 J
217. In the above question, the potential of point  $A$  is  
 a) 3 V                      b) 6 V                      c) 9 V                      d) Zero
218. When a dielectric slab is introduced between the plates of an isolated charged capacitor, it  
 a) Increases the capacitance of the capacitor  
 b) Decreases the electric field between the plates  
 c) Decreases the amount of energy stored in the capacitor  
 d) All of the above
219. A parallel-plate capacitor is charged and then isolated. What is the effect of increasing the plate separation on charge, potential and capacitance, respectively?  
 a) Constant, decreases, decreases                      b) Increases, decreases, decreases  
 c) Constant, decreases, increase                      d) Constant, increases, decreases
220. In the electric field of a point charge  $q$ , a certain point charges is carried from point  $A$  to  $B$ ,  $C$ ,  $D$  and  $E$  as shown in figure. The work done is

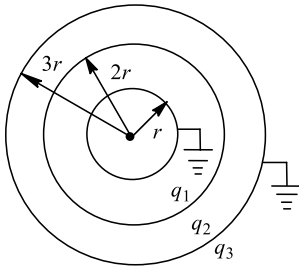


- a) Least along the path  $AE$                       b) Least along the path  $AC$   
 c) Zero along any one of the paths                      d) Least along  $AB$
221. Two point charges of  $+Q$  each have been placed at the positions  $(-a/2, 0, 0)$  and  $(a/2, 0, 0)$ . The locus of the points where  $-Q$  charge can be placed such that total electrostatic potential energy of the system can become equal to zero, can be represented by which of the following equations?  
 a)  $z^2 + (y - a)^2 = 2a$                       b)  $z^2 + (y - a)^2 = 27a^2/4$   
 c)  $z^2 + y^2 = 15a^2/4$                       d) None
222. A circuit has a section  $AB$  (figure). Potential difference between points  $A$  and  $B$  (i.e.  $V_A - V_B$ ) equals 5 V. the voltage across  $2 \mu\text{F}$  capacitor is



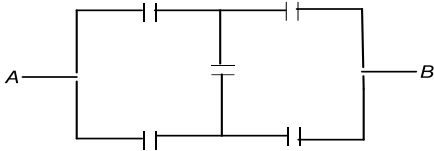
- a) 5 V                      b) 10 V                      c) 15 V                      d) Zero
223. A spherical charged conductor has surface density of charge as  $\sigma$ . The electric field intensity on its surface is  $E$ . If the radius of surface is doubled, keeping  $\sigma$  unchanged, what will be the electric field intensity on the new sphere?  
 a)  $E/2$                       b)  $E/4$                       c)  $2E$                       d)  $E$
224. Two identical capacitors each of capacitance  $5 \mu\text{F}$  are charged to potentials 2kV and 1kV respectively. Their  $-ve$  ends are connected together. When the  $+ve$  ends are also connected together, the loss of energy of the system is  
 a) 160 J                      b) Zero                      c) 5 J                      d) 1.25 J
225. Two charged particles having charges 1 and  $-1 \mu\text{C}$  and of mass 50 g each are held at rest while their separation is 2 m. Now the charges are released. Find the speed of the particles when their separation is 1 m  
 a)  $\frac{1}{5} \text{ m/s}$                       b)  $\frac{3}{5} \text{ m/s}$                       c)  $\frac{3}{10} \text{ m/s}$                       d)  $\frac{2}{7} \text{ m/s}$
226. Three concentric conducting spherical shells have radii  $r$ ,  $2r$  and  $3r$  and charges  $q_1$ ,  $q_2$  and  $q_3$  respectively. Innermost and outermost shells are earthed as shown In figure. The charges shown are after earthing. Select the correct alternative





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

227. Each capacitor shown in figure is  $2 \mu\text{F}$ . Then the equivalent capacitance between points  $A$  and  $B$  is

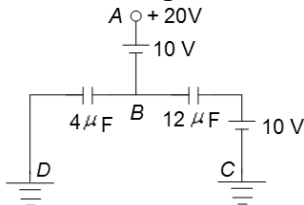


- a)  $2 \mu\text{F}$       b)  $4 \mu\text{F}$       c)  $6 \mu\text{F}$       d)  $8 \mu\text{F}$

228. A sphere of radius  $1 \text{ m}$  encloses a charge of  $5 \mu\text{C}$ . Another charge of  $-5 \mu\text{C}$  is placed inside the sphere. The net electric flux would be

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

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



- a) The charge on the  $12 \mu\text{F}$  capacitor is zero      b) The charge on the  $12 \mu\text{F}$  capacitor is  $30 \mu\text{C}$   
 c) The charge on the  $4 \mu\text{F}$  capacitor is  $30 \mu\text{C}$       d) None of these

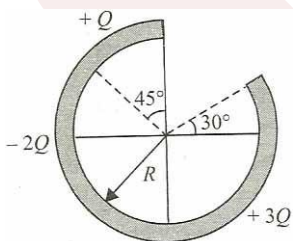
230. 27 identical drops of mercury are charged simultaneously to the same potential of  $10 \text{ V}$  each. Assuming drops to be spherical, if all the charged drops are made to combine to form one large drop, then the potential of larger drop would be

- a)  $45 \text{ V}$       b)  $135$       c)  $270 \text{ V}$       d)  $90 \text{ V}$

231. A ball of mass  $1$  carrying a charge  $10^{-8} \text{ C}$  moves from a point  $A$  at potential  $600 \text{ V}$  to a point  $B$  at zero potential. The change in its KE is

- a)  $-6 \times 10^{-6} \text{ erg}$       b)  $-6 \times 10^{-6} \text{ J}$       c)  $6 \times 10^{-6} \text{ J}$       d)  $6 \times 10^{-6} \text{ erg}$

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



- a)  $\frac{Q}{2\pi\epsilon_0 R}$       b)  $\frac{Q}{4\pi\epsilon_0 R}$       c)  $\frac{2Q}{\pi\epsilon_0 R}$       d)  $\frac{Q}{\pi\epsilon_0 R}$

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

- a)  $80 \text{ V}$       b)  $8 \times 10^6 \text{ V}$       c)  $9 \text{ V}$       d)  $9 \times 10^5 \text{ V}$



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

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

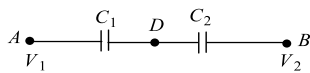
235. The electric potential at any point  $x, y, z$  in meters is given by  $V = 3x^2$ . The electric field at a point  $(2,0,1)$  is

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

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

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

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



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

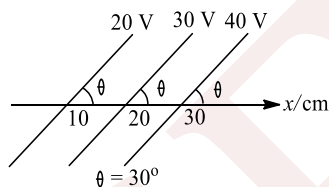
238. In a parallel plate capacitor, the capacity increases if

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

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

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

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



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

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

- a)  $\frac{2Q}{4\pi\epsilon_0 R}$                               b)  $\frac{2Q}{4\pi\epsilon_0 R} - \frac{2q}{4\pi\epsilon_0 R}$                               c)  $\frac{2Q}{4\pi\epsilon_0 R} + \frac{q}{4\pi\epsilon_0 R}$                               d)  $\frac{(q + Q)}{4\pi\epsilon_0 R}$

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

(Take  $\epsilon_0 = 8.8 \times 10^{-12} \text{ Fm}^{-1}$ )

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

243. Two insulated charged conducting spheres of radii  $20 \text{ cm}$  and  $15 \text{ cm}$  respectively and having an equal charge of  $10 \mu\text{C}$  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  $20 \text{ cm}$  sphere will be greater than that on the  $15 \text{ cm}$  sphere



- c) Surface charge density on the 15 cm sphere will be greater than that on the 20 cm sphere  
 d) Surface charge density on the two sphere will be equal

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

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

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

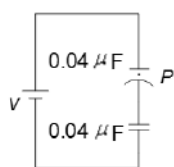
245. A capacitor of capacitance  $C$  is charged to a potential  $V$ . The flux of the electric field through a closed surface enclosing the capacitor is.

- a)  $\frac{CV}{\epsilon_0}$                                       b)  $\frac{2CV}{\epsilon_0}$                                       c)  $\frac{CV}{2\epsilon_0}$                                       d) Zero

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

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

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



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

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

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

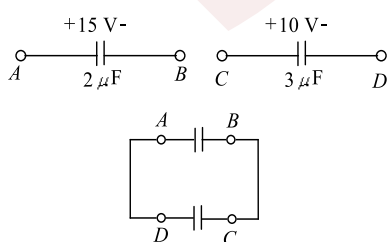
249. Two concentric spheres of radii  $R$  and  $r$  have similar charges with equal surface densities ( $\sigma$ ). What is the electric potential at their common centre?

- a)  $\frac{\sigma}{\epsilon_0}$                                       b)  $\frac{\sigma}{\epsilon_0}(R - r)$                                       c)  $\frac{\sigma}{\epsilon_0}(R + r)$                                       d) None of these

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

- a) Quantity of charge on the plates will be the same, but nature of charge will differ  
 b) Quantity of charge as well as nature of charge on the plates will be different  
 c) Quantity of charge on the plates will be different. But nature of charge will be the same  
 d) Quantity of charge as well as nature of charge will be the same

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



- a) Final charge on each capacitor will be zero  
 b) Final total electrical energy of the capacitance will be zero



- c) Total charge flown from  $A$  to  $D$  is  $30 \mu\text{C}$   
 d) Total charge flown from  $A$  to  $D$  is  $-30 \mu\text{C}$

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



- a)  $q/\epsilon_0$                       b)  $q/2\epsilon_0$                       c)  $q/4\epsilon_0$                       d) Zero

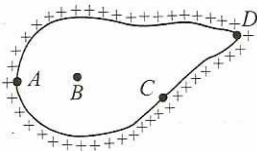
253. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at the centre of the sphere is

- a) 0V                                      b) 10V  
 c) Same as at point 5 cm away from the surface                      d) Same as at a point 20 cm away from the surface

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

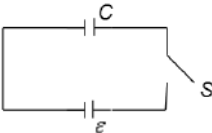
- a)  $64q, C$                       b)  $16q, 4C$                       c)  $64q, 4C$                       d)  $16q, 64C$

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



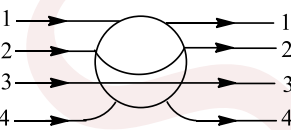
- a)  $V_A = V_B > V_C > V_D$                       b)  $V_D > V_C > V_B = V_A$                       c)  $V_D > V_C > V_B > V_A$                       d)  $V_D = V_C = V_B = V_A$

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



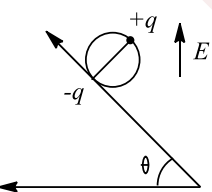
- a)  $\frac{Q}{2} + C\epsilon$                       b)  $\frac{Q}{2} - C\epsilon$                       c)  $-\frac{Q}{2}$                       d) None of these

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



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

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



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

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

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



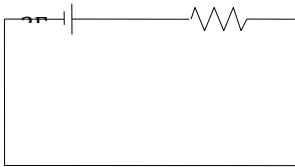
260. When a metal plate is introduced between the two plates of a charged capacitor and insulated from them, then
- The metal plate divides the capacitor into two capacitors connected in parallel to each other
  - The metal plate divides the capacitor into two capacitors connected in series with each other
  - The metal plate is equivalent to a dielectric of zero dielectric constant
  - Capacitance of the capacitor decreases

261. The potential function of an electrostatic field is given by  $V = 2x^2$ . Determine the electric field strength at the point  $(2m, 0, 3m)$
- $\vec{E} = 4\hat{i}(\text{NC}^{-1})$
  - $\vec{E} = -4\hat{i}(\text{NC}^{-1})$
  - $\vec{E} = 8\hat{i}(\text{NC}^{-1})$
  - $\vec{E} = -8\hat{i}(\text{NC}^{-1})$

262. Mark the correct statement:

- An electron and a proton when released from rest in a uniform electric field experience the same force and the same acceleration
- Two equipotential surfaces may intersect
- A solid conducting sphere holds more charge than a hollow conducting sphere of the same radius
- No work is done in taking a positive charge from one point to another inside a negatively charged metallic sphere

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

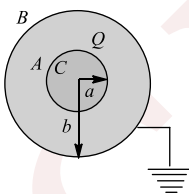


- $\frac{10}{e} \text{C}$
- $\frac{e}{10} \text{C}$
- $\frac{10}{e^2} \text{C}$
- $\frac{e^2}{10} \text{C}$

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

- $E \neq 0$  and  $V \neq 0$
- $E = 0$  and  $V = 0$
- $E \neq 0$  and  $V = 0$
- $E = 0$  and  $V \neq 0$

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



i. The potential at a distance  $r$  from  $C$ , where  $a \leq r \leq b$ , is  $\frac{1}{4\pi\epsilon_0} \left( \frac{Q}{r} \right)$

ii. The potential difference between  $A$  and  $B$  is

$$\frac{1}{4\pi\epsilon_0} Q \left( \frac{1}{a} - \frac{1}{b} \right)$$

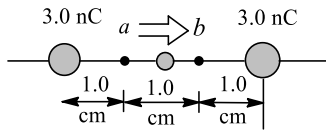
iii. The potential at a distance  $r$  from  $C$ , where  $a \leq r \leq b$ , is  $\frac{1}{4\pi\epsilon_0} Q \left( \frac{1}{r} - \frac{1}{b} \right)$

Which of the following statements are correct?

- Only (i) and (ii)
- Only (ii) and (iii)
- Only (i) and (iii)
- All

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





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

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

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

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

- a)  $36 \text{ J}$                                       b)  $3.6 \times 10^{-3} \text{ J}$                       c)  $3.6 \text{ J}$                                       d)  $3.6 \times 10^{-2} \text{ J}$

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

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

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



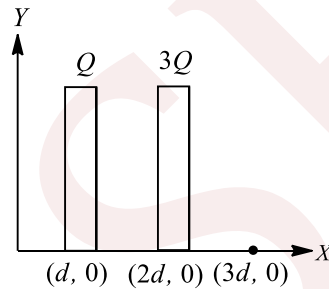
271. Large number of capacitors of rating  $10 \mu\text{F}/200 \text{ V}$  are available. The minimum number of capacitors required to design a  $10 \mu\text{F}/700 \text{ V}$  capacitor is

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

272. Two infinitely long parallel wires having linear charge densities  $\lambda_1$  and  $\lambda_2$ , respectively, are placed at a distance  $R$ . The force per length on either wire will be

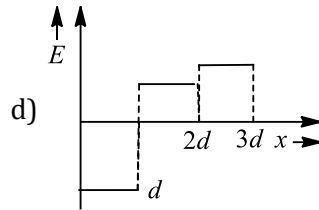
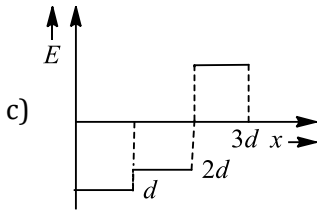
- a)  $k \frac{2\lambda_1\lambda_2}{R^2}$                                       b)  $k \frac{2\lambda_1\lambda_2}{R}$                                       c)  $k \frac{\lambda_1\lambda_2}{R^2}$                                       d)  $k \frac{\lambda_1\lambda_2}{R}$

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

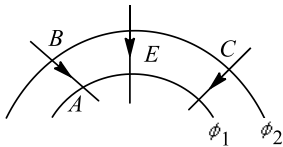


The variation of electric field as a function of  $x$  (for  $x = 0$  to  $x = 3d$ ) will be best represented by

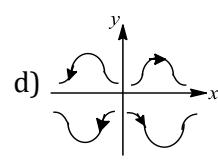
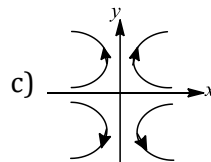
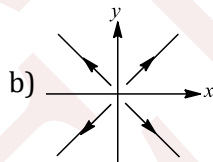
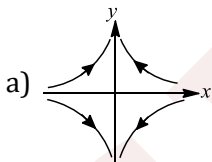




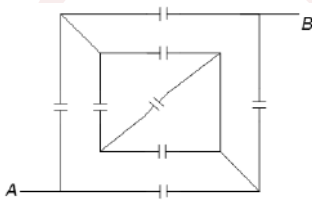
274. On moving a charge of 20 C by 2cm, 2J of work is done, then the potential difference between the points is  
 a) 0.1V                      b) 8V                      c) 2V                      d) 0.5V
275. In the above question, if plates  $P_1$  and  $P_2$  are connected by a thin conducting wire, then the amount of heat produced will be  
 a)  $\frac{Q^2}{A\epsilon_0} d$                       b)  $\frac{5Q^2}{A\epsilon_0} d$                       c)  $\frac{2Q^2}{A\epsilon_0} d$                       d) None of these
276. In moving from  $A$  to  $B$  along an electric field line, the work done by the electric field on an electron is  $6.4 \times 10^{-19}$  J. If  $\phi_1$  and  $\phi_2$  are equipotential surfaces, then the potential difference  $V_C - V_A$  is



- a) -4 V                      b) 4 V                      c) Zero                      d) 6.4 V
277. Two free protons are separated by a distance of 1Å. If they are released, the kinetic energy of each proton when at infinite separation is  
 a)  $11.5 \times 10^{-19}$  J                      b)  $23 \times 10^{-19}$  J                      c)  $46 \times 10^{-19}$  J                      d)  $5.6 \times 10^{-12}$  J
278. Two conducting spheres  $A$  and  $B$  of radius  $a$  and  $b$  respectively are at the same potential. The ratio of the surface charge densities of  $A$  and  $B$  is  
 a)  $\frac{b}{a}$                       b)  $\frac{a}{b}$                       c)  $\frac{a^2}{b^2}$                       d)  $\frac{b^2}{a^2}$
279. The potential field depends on the  $x$ - and  $y$ -coordinates as  $V = x^2 - y^2$ . The corresponding electric field lines in  $x - y$  plane are as



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



- a)  $C$                       b)  $C/2$                       c)  $36C/17$                       d)  $42C/17$
281. A charge  $(-q)$  and another charge  $(+Q)$  are kept at two points  $A$  and  $B$  respectively. Keeping the charge  $(+Q)$  fixed at  $B$ , the charge  $(-q)$  at  $A$  is moved to another point  $C$  such that  $ABC$  forms an equilateral triangle of side  $l$ . The net work done in moving the charge  $(-q)$  is  
 a)  $\frac{1}{4\pi\epsilon_0} \frac{Qq}{l}$                       b)  $\frac{1}{4\pi\epsilon_0} \frac{Qq}{l^2}$                       c)  $\frac{1}{4\pi\epsilon_0} Qql$                       d) Zero
282. The electric field in a region is given by

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



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

- a)  $1.1 \times 10^{-12} \text{ C}$       b)  $2.2 \times 10^{-12} \text{ C}$       c)  $4.4 \times 10^{-12} \text{ C}$       d)  $5.5 \times 10^{-12} \text{ C}$

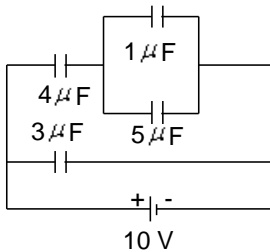
283. The plates of a parallel plate capacitor with air as medium are separated by a distance of 8 mm. A medium of dielectric constant 2 and thickness 4 mm having the same area is introduced between the plates. For the capacitance to remain the same, the distance between the plates is

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

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

- a)  $-\frac{2q^2}{4\pi\epsilon_0 a}$       b)  $\frac{2q^2 \log_e 2}{4\pi\epsilon_0 a}$       c)  $-\frac{2q^2 \log_e 2}{4\pi\epsilon_0 a}$       d) None of these

285. For the circuit shown in figure the charge on  $4 \mu\text{F}$  capacitor is



- a)  $40 \mu\text{C}$       b)  $30 \mu\text{C}$       c)  $24 \mu\text{C}$       d)  $54 \mu\text{C}$

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

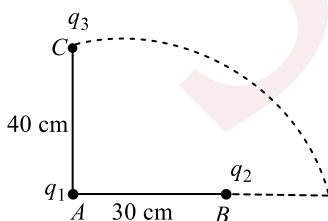
- a) The entire charge of inner sphere will be transferred to outer shell and then both will be at same potential  
 b) The entire charge of inner sphere will be transferred to outer shell and then both will be at different potential  
 c) The entire charge of outer shell will be transferred to inner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

287. Out of two copper spheres of the same size,  $x$  is hollow while  $y$  is solid. If they are charged at the same potential, what can be said about the charges on them?

- a) Charge on both the spheres is zero      b) Charge on both the spheres is equal  
 c) Sphere  $y$  will have more charge      d) Sphere  $x$  will have more charge

288. Two charges  $q_1$  and  $q_2$  are placed 30 cm apart, as shown in the figure. A third charge  $q_3$  is moved along the arc of a circle of radius 40 cm from  $C$  to  $D$ . The change in the potential energy of the system is  $\frac{q_3}{4\pi\epsilon_0} k$ ,

where  $k$  is



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

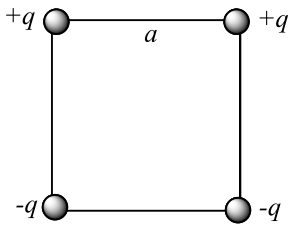
289.  $N$  identical drops of mercury are charged simultaneously to 10V. When combined to form one large drop, the potential is found to be 40V, the value of  $N$  is

- a) 4      b) 6      c) 8      d) 10

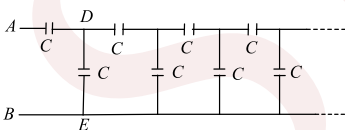
290. Four charges are placed at four corners of a square as shown (Figure). The side of the square is  $a$ . Two charges are positive and two are negative but their magnitudes are the same, Now, an external agent starts



decreasing all the sides of the square slowly and at the same rate. What happens to the electrical potential energy of the system and what will be the nature of work done by the agent?



- a) Increase, positive      b) Increase, positive      c) Decreases, negative      d) Increases, positive
291. A hollow metallic sphere of radius  $R$  is given a charge  $Q$ . Then, the potential at the centre is  
 a) Zero      b)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R}$       c)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{2Q}{R}$       d)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{2R}$
292. The electric potential  $V$  at any point  $(x, y, z)$  in space is given by  $V = 4x^2V$ . the electric field at  $(1,0,2)$  m in  $\text{Vm}^{-1}$  is  
 a) 8, along negative  $X$ -axis      b) 8, along positive  $X$ -axis  
 c) 16, along negative  $X$ -axis      d) 16, along positive  $X$ -axis
293. A dielectric of dielectric constant  $K$  is introduced such that half of its area of a capacitor of capacitance  $C$  is occupied by it. The new capacity is  
 a)  $2C$       b)  $\frac{C}{2}$       c)  $\frac{(1+K)C}{2}$       d)  $2C(1+K)$
294. If the plates of a parallel plate capacitor are not equal in area, then quantity of charge  
 a) On the plates will be same but nature of charge will differ  
 b) On the plates as well as nature of charge will be different  
 c) On the plates will be different but nature of charge will be same  
 d) As well as nature of charge will be same
295. A parallel plate capacitor is charged. If the plates are pulled apart  
 a) The capacitance increases      b) The potential difference increases  
 c) The total charge increases      d) The charge and potential difference remain the same
296. Three capacitors of capacitances 2, 3 and 4 pF are connected in parallel. What is the charge (in pC) on each capacitor if the combination is connected to a 100 V supply?  
 a) 200, 300, 400      b) 300, 200, 400      c) 400, 300, 200      d) 400, 200, 300
297. The capacitance of an infinite circuit formed by the repetition of the same link consisting of two identical capacitors, each with capacitance  $C$  (Fig), is



- a) Zero      b)  $\frac{\sqrt{5}-1}{2}C$       c)  $\frac{\sqrt{5}+1}{2}C$       d) Infinite
298. Two thin wire rings each having a radius  $R$  are placed at a distance  $d$  apart with their axes coinciding. The charges on the two rings are  $+q$  and  $-q$ . The potential difference between the centres of two rings is  
 a)  $\frac{qR}{4\pi\epsilon_0 d^2}$       b)  $\frac{q}{2\pi\epsilon_0} \left[ \frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}} \right]$   
 c) Zero      d)  $\frac{q}{4\pi\epsilon_0} \left[ \frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}} \right]$
299. An uncharged parallel-plate capacitor having a dielectric of dielectric constant  $K$  is connected to a similar air cored parallel-plate capacitor charged to a potential  $V_0$ . The two share the charge and the common potential becomes  $V$ . The dielectric constant  $K$  is



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

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

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

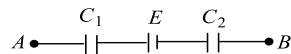
301. An automobile spring extends 0.2 m for 5000 N load. The ratio of potential energy stored in this spring when it has been compressed by 0.2 m to the potential energy stored in a  $10\mu\text{F}$  capacitor at a potential difference of 10000 V will be

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

302. A  $2\mu\text{F}$  capacitor is charged to 100 V and then its plates are connected by a conducting wire. The heat produced is

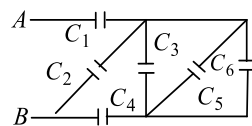
- a) 0.001 J      b) 0.01 J      c) 0.1 J      d) 1 J

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



- a)  $0\mu\text{C}$       b)  $20/3\mu\text{C}$       c)  $40/3\mu\text{C}$       d) None of these

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

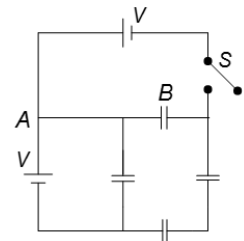


- a)  $1.22\mu\text{F}$       b)  $5.16\mu\text{F}$       c)  $2.25\mu\text{F}$       d)  $2.51\mu\text{F}$

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

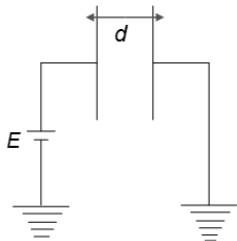
- a)  $2V$       b)  $V/2$       c)  $V/4$       d)  $V$

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



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

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

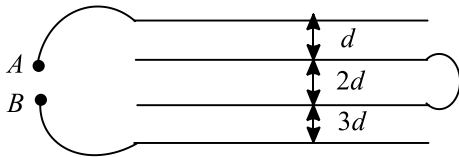


The charge drawn by plate is

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

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





- a)  $\frac{\epsilon_0 A}{6d}$       b)  $\frac{\epsilon_0 A}{4d}$       c)  $\frac{3\epsilon_0 A}{4d}$       d)  $\frac{\epsilon_0 A}{3d}$

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

- a)  $\frac{4\pi\epsilon_0 V^2}{r^2}$       b)  $\frac{\epsilon_0 V^2}{2r^2}$       c)  $\frac{2\epsilon_0 V^2}{r^2}$       d)  $\frac{\epsilon_0 V^2}{4r^2}$

310. In a capacitor of capacitance  $20\mu\text{F}$  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)  $22\mu\text{F}$       b)  $26.6\mu\text{F}$       c)  $52.2\mu\text{F}$       d)  $13\mu\text{F}$

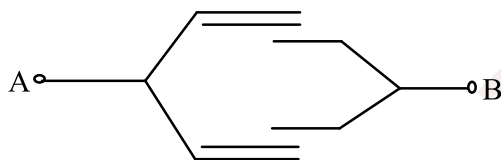
311. Two point charges  $4\mu\text{C}$  and  $-2\mu\text{C}$  are separated by a distance of 1m in air. At what point in between the charges and on the line joining the charges, is the electric potential zero?

- a) In the middle of the two charges      b)  $1/3$  m from  $4\mu\text{C}$   
 c)  $1/3$  m from  $-2\mu\text{C}$       d) Nowhere the potential is zero

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

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

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

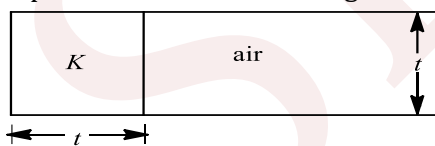


- a)  $\frac{2\epsilon_0 A}{d}$       b)  $\frac{3\epsilon_0 A}{d}$       c)  $\frac{3\epsilon_0 A}{2d}$       d)  $\frac{\epsilon_0 A}{d}$

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

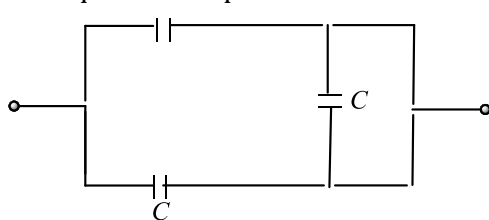
- a)  $\frac{Q_1 + Q_2}{2C}$       b)  $\frac{Q_1 + Q_2}{C}$       c)  $\frac{Q_1 - Q_2}{C}$       d)  $\frac{Q_1 - Q_2}{2C}$

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



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

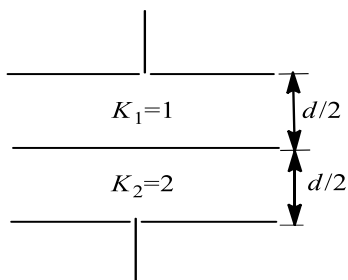
316. The equivalent capacitance of the combination shown in figure below is



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







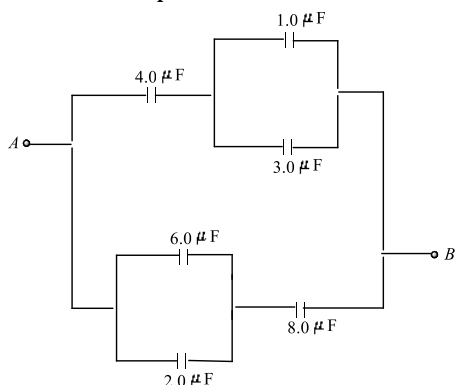
a)  $\frac{\epsilon_0 A}{2d}$

b)  $\frac{\epsilon_0 A}{d}$

c)  $\frac{3\epsilon_0 A}{d}$

d)  $\frac{4\epsilon_0 A}{3d}$

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



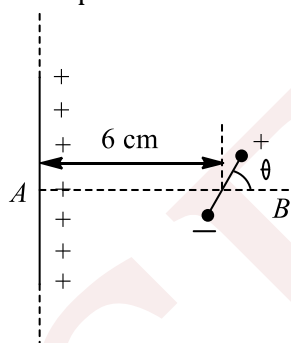
a)  $6.0 \mu\text{F}$

b)  $4.0 \mu\text{F}$

c)  $2.0 \mu\text{F}$

d)  $3.0 \mu\text{F}$

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



a)  $0.012 \text{ N}$

b)  $1.8 \text{ N}$

c)  $0.04 \text{ N}$

d) None of these

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

a) The potential at the origin is zero

b) The electric field at the origin is not zero

c) The potential at all points on the  $z$ -axis, other than the origin, is zero

d) The field at all points on the  $z$ -axis, other than the origin, acts along the  $z$ -axis

329. A simple pendulum has a length  $l$  and the mass of the bob is  $m$ . The bob is given a charge  $q$  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)  $2\pi \sqrt{\frac{l}{g + \frac{qE}{m}}}$

c)  $2\pi \sqrt{\frac{l}{g - \frac{qE}{m}}}$

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

330. A  $10\mu\text{F}$  capacitor and a  $20\mu\text{F}$  capacitor are connected in series across a 200 V supply line. The charged capacitors are then disconnected from the line and reconnected with their positive plates together and



negative plates together and no external voltage is applied. The potential difference across each capacitor is

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

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

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

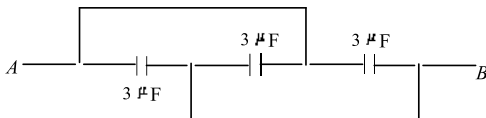
332. A parallel plate capacitor  $C$  is equally filled with parallel layers of materials of dielectric constant  $K_1$  and  $K_2$ . Then the ratio of new capacitance to the previous capacitor is

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

333. Seven capacitors, each of capacitance  $2 \mu\text{F}$ , are to be combined to obtain a capacitance of  $10/11 \mu\text{F}$ . Which of the following combination is possible?

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

334. The effective capacitance between points  $A$  and  $B$  is

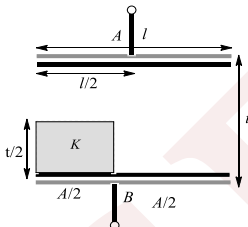


- a)  $9 \mu\text{F}$                       b)  $3 \mu\text{F}$                       c)  $6 \mu\text{F}$                       d)  $1 \mu\text{F}$

335. A variable condenser is permanently connected to a 100 V battery. If capacity is changed from  $2 \mu\text{F}$  and  $10 \mu\text{F}$ , then energy change is equal to

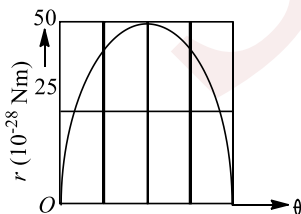
- a)  $2 \times 10^{-2}$  J                      b)  $2.5 \times 10^{-2}$  J                      c)  $6.5 \times 10^{-2}$  J                      d)  $4 \times 10^{-2}$  J

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



- a)  $\frac{\epsilon_0 A}{t} \left( \frac{3K + 1}{2(K + 1)} \right)$                       b)  $\frac{2\epsilon_0 A}{t} \left( \frac{K + 1}{K + 3} \right)$                       c)  $\frac{\epsilon_0 A}{t} \left( \frac{K + 1}{K + 3} \right)$                       d)  $\frac{\epsilon_0 A}{t} \left( \frac{2K + 1}{2K + 3} \right)$

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



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

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

- a)  $30 \mu\text{F}$                       b)  $120 \mu\text{F}$                       c)  $40 \mu\text{F}$                       d)  $160 \mu\text{F}$

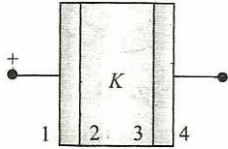


339. The electric field lines closer together near object  $A$  than they are near object  $B$ . We can conclude
- a) The potential near  $A$  is greater than the potential near  $B$       b) The potential near  $A$  is less than the potential near  $B$
- c) The potential near  $A$  is equal to the potential near  $B$       d) Nothing about the relative potentials near  $A$  and  $B$

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

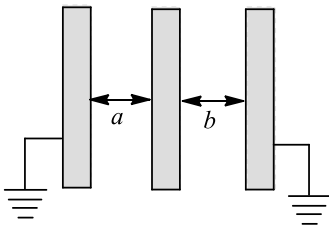
- a)  $R^{-1}$       b)  $R^2$       c)  $R^{-2}$       d)  $R$

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



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

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



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

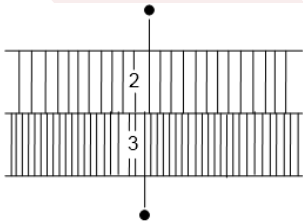
343. There is an electric field  $E$  in the  $x$ -direction. If the work done by electric field in moving a charge of  $0.2$  C through a distance of  $2$  m along a line making an angle  $60^\circ$  with the  $x$ -axis is  $4$  J, then what is the value of  $E$ ?

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

344. 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

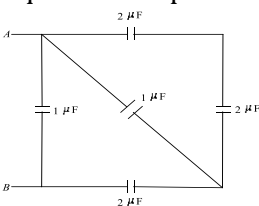
- a)  $Vn$       b)  $V/n$       c)  $Vn^{1/3}$       d)  $Vn^{2/3}$

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



- a)  $1.2 \mu\text{F}$       b)  $1.8 \mu\text{F}$       c)  $1.25 \mu\text{F}$       d) None of these

346. Equivalent capacitance between  $A$  and  $B$  is



- a)  $14 \mu\text{F}$                       b)  $4 \mu\text{F}$                       c)  $6 \mu\text{F}$                       d)  $2 \mu\text{F}$

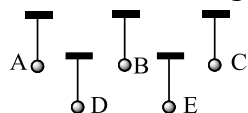
347. A parallel plate condenser with a dielectric of dielectric constant  $K$  between the plates has a capacity  $C$  and is charged to a potential  $V$  volt. The dielectric slab is slowly removed from between the plates and then reinserted. The net work done by the system in this process is

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

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

- (i) Ball  $A$  repels  $C$  and attracts  $B$   
(ii) Ball  $D$  attracts  $B$  and has no effect on  $E$   
(iii) a negatively charged rod attracts both  $A$  and  $E$

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



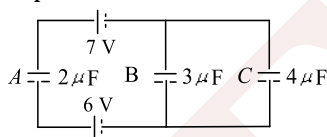
$A$      $B$      $C$      $D$      $E$

- a) +    -    +    0    +                      b) +    -    +    +    0  
c) -    +    -    0    0                      d) -    -    +    0    0

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

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

350. Three capacitors  $A$ ,  $B$  and  $C$  are connected in a circuit as shown in Fig. What is the charge in  $\mu\text{C}$  on the capacitor  $B$ ?



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

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

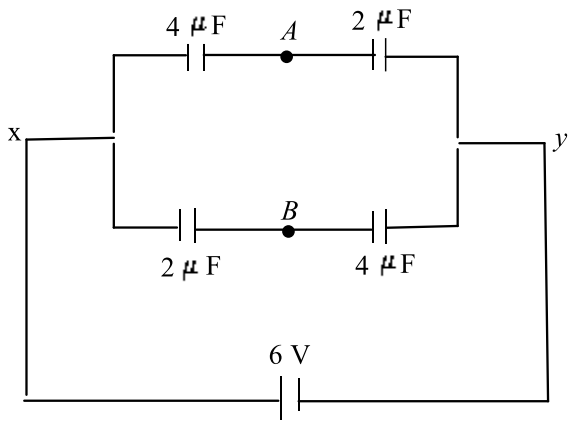
- a)  $16\text{V}$                       b)  $8\text{V}$                       c)  $4\text{V}$                       d)  $2\text{V}$

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

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

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





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

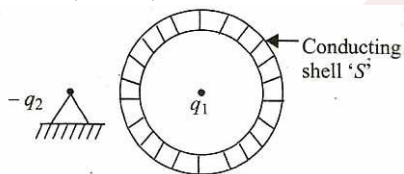
354. A spherical drop of mercury having a potential of 2.5V is obtained as a result of merging 125 droplets. The potential of a constituent droplets would be

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

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



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



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

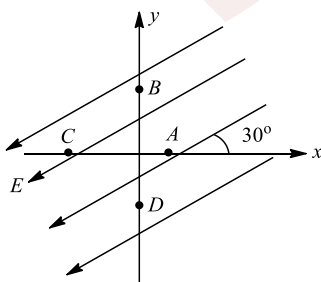
357. The flux entering and leaving a closed surface are  $5 \times 10^5$  and  $4 \times 10^5$  MKS units respectively, then the charge inside the surface will be

- a)  $-8.86 \times 10^{-7}C$                       b)  $8.85 \times 10^{-7}C$                       c)  $8.85 \times 10^7C$                       d)  $6.85 \times 10^{-7}C$

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

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

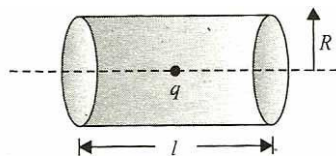
359. There exists a uniform electric field in the space as shown. Four points A, B, C and D are marked which are equidistant from the origin. If  $V_A, V_B, V_C$  and  $V_D$  are their potentials, respectively,



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







Find the flux crossing through the curved surface

a) Zero

b)  $\frac{q}{\epsilon_0} \left[ 1 - \frac{l}{\sqrt{R^2 + (l^2/4)}} \right]$

c)  $\frac{q}{2\epsilon_0} \left[ 1 - \frac{l}{2\sqrt{(l^2/4) + R^2}} \right]$

d)  $\frac{ql}{2\epsilon_0\sqrt{(l^2/4) + R^2}}$

368. A charge  $+q$  is placed at each of the points  $x = x_0, x = 3x_0, x = 5x_0$  at infinity on the  $x$ -axis and a charge  $-q$  is placed at each of the points  $x = 2x_0, x = 4x_0, x = 6x_0$  at infinity. Here,  $x_0$  is a positive constant. Take the electric potential at a point due to a charge  $Q$  at a distance  $r$  from it to be  $Q/4\pi\epsilon_0 r$ . Then the potential at the origin due to the above system of charges is

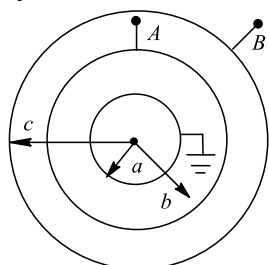
a) 0

b)  $\frac{q}{8\pi\epsilon_0 x_0 \log 2}$

c)  $\infty$

d)  $\frac{q \log 2}{4\pi\epsilon_0 x_0}$

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



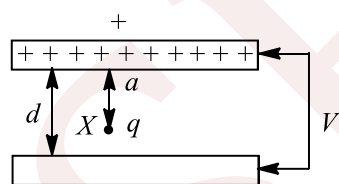
a)  $\frac{4\pi\epsilon_0 ac}{c - a}$

b)  $\frac{4\pi\epsilon_0 bc}{c - b} + \frac{4\pi\epsilon_0 ab}{b - a}$

c)  $\frac{4\pi\epsilon_0 bc}{c - b} + \frac{4\pi\epsilon_0 abc}{ab + c(b - a)}$

d)  $\frac{4\pi\epsilon_0 ac}{c - a} + 4\pi\epsilon_0 c$

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



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

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

c)  $\frac{Q}{4\pi\epsilon_0 a^2}$

d)  $\frac{qQ}{4\pi\epsilon_0 a^2}$

371. A hollow conducting sphere of 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)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{r}$

b)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{r^2}$

c)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R}$

d) Zero

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

a) It will remain in equilibrium

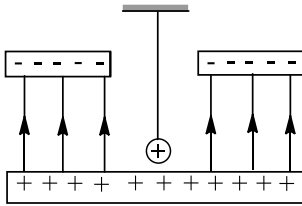
b) It can move inside  $S$ , but it cannot cross  $S$

c) It must cross  $S$  at some time

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



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



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

374. In question 32, if the conducting spherical shell is not earthed but is neutral, then the force on  $q_2$  is

- a) Zero  
 b)  $\frac{q_1 q_2}{4\pi\epsilon_0 r^2}$   
 c)  $\frac{q_1 q_2}{4\pi\epsilon_0 (r - R^2)}$   
 d) None of these

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

- a)  $40 \mu\text{C}$   
 b)  $50 \mu\text{C}$   
 c)  $60 \mu\text{C}$   
 d)  $110 \mu\text{C}$

376. Capacitance of a capacitor made by a thin metal foil is  $2 \mu\text{F}$ . If the foil is folded with paper of thickness  $0.15 \text{ mm}$ , dielectric constant of paper is  $2.5$  and width of paper is  $400 \text{ mm}$ , the length of foil will be

- a)  $0.34 \text{ m}$   
 b)  $1.33 \text{ m}$   
 c)  $13.4 \text{ m}$   
 d)  $33.9 \text{ m}$

377. How does the electric field strength vary when we enter a uniformly charged spherical cloud?

- a) Decreases inversely as the square of the distance from the surface  
 b) Decreases directly as the square of the distance from the surface  
 c) Decreases directly as the square of the distance from the centre  
 d) Decreases directly as the distance from the centre or  $E \propto r$

378. The electrostatic potential energy between proton and electron separated by a distance  $1 \text{ \AA}$  is

- a)  $13.6 \text{ eV}$   
 b)  $27.2 \text{ eV}$   
 c)  $14.4 \text{ eV}$   
 d)  $1.44 \text{ eV}$

379. The capacitance of a parallel plate capacitor with air as medium is  $3 \mu\text{F}$ . With the introduction of a dielectric medium between the plates, the capacitance becomes  $15 \mu\text{F}$ . The permittivity of the medium is

- a)  $5 \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$   
 b)  $15 \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$   
 c)  $0.44 \times 10^{-10} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$   
 d)  $8.854 \times 10^{-11} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$

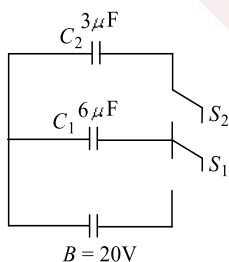
380. When the separation between two charges is increased, the electric potential energy of the charges

- a) Increase  
 b) Decrease  
 c) Remains the same  
 d) May increase or decrease

381. Ten capacitors are joined in parallel and charged with a battery up to a potential  $V$ . They are then disconnected from battery and joined in series. Then, the potential of this combination will be

- a)  $1 \text{ V}$   
 b)  $10 \text{ V}$   
 c)  $5 \text{ V}$   
 d)  $2 \text{ V}$

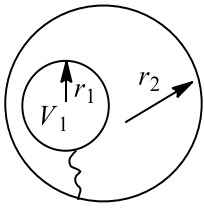
382. In the circuit shown in Fig  $C_1 = 6 \mu\text{F}$ ,  $C_2 = 3 \mu\text{F}$  and battery  $B = 20 \text{ V}$ . The switch  $S_1$  is first closed. It is then opened and afterwards  $S_2$  is closed. What is the final charge on  $C_2$ ?



- a)  $120 \mu\text{C}$   
 b)  $80 \mu\text{C}$   
 c)  $40 \mu\text{C}$   
 d)  $20 \mu\text{C}$

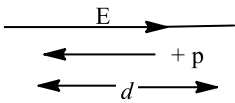


383. A metal sphere having a radius  $r_1$  charged to a potential  $V_1$  is enveloped by a thin-walled conducting spherical shell of radius  $r_2$ . Determine the potential  $V_1$  acquired by the sphere after it has been connected for a short time to the shell by a conductor

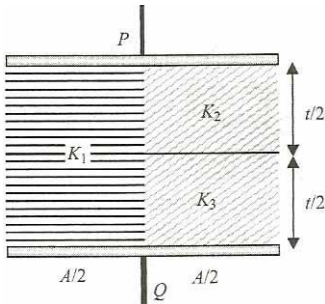


- a)  $\frac{V_1 r_2}{r_1}$       b)  $\frac{V_1 r_1}{r_2}$       c)  $V_1$       d)  $\frac{V_1(r_1 + r_2)}{r_2}$

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

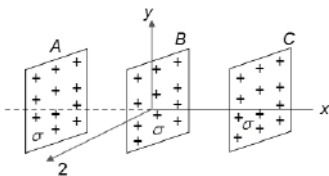


- a) Negative, increase      b) Positive, decrease      c) Negative, decrease      d) Positive, increase
385. A metal foil of negligible thickness is introduced between two plates of a capacitor at the centre. The capacitance of capacitor will be
- a) Same      b) Double      c) Half      d)  $K$  times
386. A parallel-plate capacitor is constructed using three different dielectric materials as shown in Fig. What is the capacitance across  $P$  and  $Q$ ?



- a)  $\left(\frac{K_1}{2} + \frac{K_2 K_3}{K_2 + K_3}\right) \frac{\epsilon_0 A}{t}$       b)  $\left(K_1 + \frac{K_2 K_3}{K_2 + K_3}\right) \frac{\epsilon_0 A}{t}$
- c)  $\left(K_1 + \frac{2K_2 K_3}{K_2 + K_3}\right) \frac{\epsilon_0 A}{t}$       d)  $\left(K_1 + \frac{K_2 K_3}{2(K_2 + K_3)}\right) \frac{\epsilon_0 A}{t}$

387. In bringing an electron towards another electron, the electrostatic potential energy of the system
- a) Decreases      b) Increases      c) Remains same      d) Becomes zero
388. Three infinite planes have a uniform surface charge distribution  $\sigma$  on its surface. All charges are fixed. On each of the three infinite planes, parallel to the  $y - z$  plane placed at  $x = -a, x = 0$  and  $x = a$ . There is a uniform surface charge of the same density,  $\sigma$

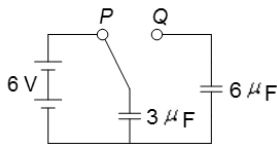


The potential difference between  $A$  and  $C$  is

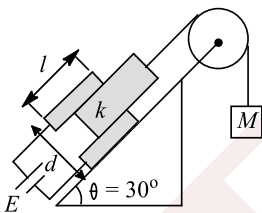
- a)  $\frac{\sigma}{2\epsilon_0} a$       b)  $\frac{\sigma}{\epsilon_0} a$       c)  $\frac{\sigma a}{2\epsilon_0}$       d) None of the above



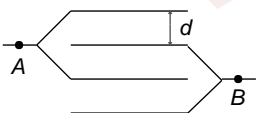
389. In the circuit shown, a capacitor of capacitance  $3 \mu\text{F}$  is charged from a battery of e. m. f.  $6 \text{ V}$  with switch connected to terminal  $P$ . The switch is now connected to  $Q$ . This charges the  $6 \mu\text{F}$  capacitor from the  $3 \mu\text{F}$  one. What is the new potential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



- a)  $1 \text{ V}$                       b)  $2 \text{ V}$                       c)  $4 \text{ V}$                       d)  $6 \text{ V}$
390. Two capacitor of capacity  $6 \mu\text{F}$  and  $12 \mu\text{F}$  in series are connected by potential of  $150 \text{ V}$ . the potential of capacitor of capacity  $12 \mu\text{F}$  will be
- a)  $25 \text{ V}$                       b)  $50 \text{ V}$                       c)  $100 \text{ V}$                       d)  $150 \text{ V}$
391. A parallel plate air capacitor has a capacitance  $18 \mu\text{F}$ . If the distance between the plates is trapped and a dielectric medium is introduced, the capacitance becomes  $72 \mu\text{F}$ . The dielectric constant of the medium is
- a)  $4$                               b)  $9$                               c)  $12$                               d)  $2$
392. A parallel plate capacitor with air between the plates has a capacitance of  $9 \text{ pF}$ . 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)  $1.8 \text{ pF}$                       b)  $45 \text{ pF}$                       c)  $40.5 \text{ pF}$                       d)  $20.25 \text{ pF}$
393. The capacitor plates are fixed on an inclined plane and connected to a battery of e. m. f.  $E$ . The capacitor plates have plate area  $a$ , length  $l$  and the distance between them is  $d$ . A dielectric slab of mass  $m$  and dielectric constant  $K$  is inserted into the capacitor and tied to mass  $M$  by a massless string as shown in the figure. Find the value of  $M$  for which the slab will stay in equilibrium. There is no friction between slab and plates.



- a)  $\frac{m}{2} + \frac{E^2 \epsilon_0 A (k - 1)}{2lgd}$                       b)  $\frac{m}{2} - \frac{E^2 \epsilon_0 A (k - 1)}{2lgd}$                       c)  $\frac{m}{2} + \frac{E^2 \epsilon_0 A (k - 1)}{lgd}$                       d)  $\frac{m}{2} - \frac{E^2 \epsilon_0 A (k - 1)}{lgd}$
394. A uniformly charged and infinitely long line having a linear charge density  $\lambda$  is placed at a normal distance  $y$  from a point  $O$ . Consider a sphere of radius  $R$  with  $O$  as centre and  $R > y$ . Electric flux through the surface of the sphere is
- a) Zero                              b)  $\frac{2\lambda R}{\epsilon_0}$                               c)  $\frac{2\lambda \sqrt{R^2 - y^2}}{\epsilon_0}$                               d)  $\frac{\lambda \sqrt{R^2 + y^2}}{\epsilon_0}$
395. The equivalent capacity between points  $A$  and  $B$  in figure will be, while capacitance of each capacitor is  $3 \mu\text{F}$ .



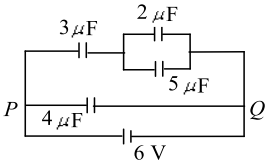
- a)  $2 \mu\text{F}$                       b)  $4 \mu\text{F}$                       c)  $7 \mu\text{F}$                       d)  $9 \mu\text{F}$
396. Two capacitors of capacitance  $C$  are connected in series. If one of them is filled with dielectric substance  $K$ , what is the effective capacitance?
- a)  $\frac{KC}{(1 + K)}$                       b)  $C(K + 1)$                       c)  $\frac{2KC}{(1 + K)}$                       d) None of these



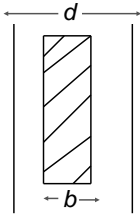
397. Two metallic charged spheres of radii  $R_1$  and  $R_2$  having charges  $Q_1$  and  $Q_2$ , respectively, are connected to each other. There is
- No change in the energy of the system
  - An increase in the energy of the system
  - Always a decrease in the energy of the system
  - A decrease in energy of the system unless  $Q_1 R_2 = Q_2 R_1$

398. Two charges  $-10\text{C}$  and  $+10\text{C}$  are placed  $10\text{cm}$  apart. Potential at the centre of the line joining the two charges is
- Zero
  - $2\text{V}$
  - $-2\text{V}$
  - None of these

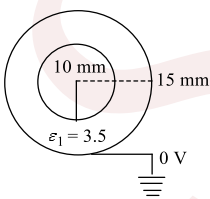
399. In the circuit of Fig, find the charge of the condenser having capacity  $5\ \mu\text{F}$



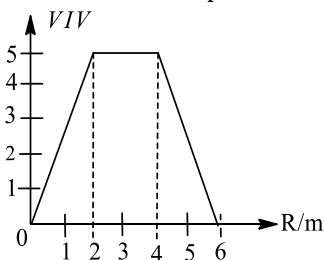
- $4.5\ \mu\text{C}$
  - $9\ \mu\text{C}$
  - $7\ \mu\text{C}$
  - $30\ \mu\text{C}$
400. A slab of copper of thickness  $b$  is inserted in between the plates of parallel plate capacitor as shown in figure. The separation between the plates is  $d$  if  $b = d/2$ , then the ratio of capacities of capacitors after and before inserting the slab will be



- $\sqrt{2} : 1$
  - $2 : 1$
  - $1 : 1$
  - $1 : \sqrt{2}$
401. A charged body has an electric flux  $\phi$  associated with it the body is now placed inside a metallic container. The electric flux  $\phi_1$  associated with the container will be
- $\phi_1 = 0$
  - $0 < \phi_1 < \phi$
  - $\phi_1 = \phi$
  - $\phi_1 > \phi$
402. Two positive point charges of  $12\ \mu\text{C}$  and  $5\ \mu\text{C}$  are placed  $10\text{cm}$  apart in air. The work needed to bring them  $4\text{cm}$  closer is
- $2.4\text{J}$
  - $3.6\text{J}$
  - $1.6\text{J}$
  - $6.0\text{J}$
403. The cross section of a cable is shown in Fig. The inner conductor has a radius of  $10\text{mm}$  and the dielectric has a thickness of  $5\text{mm}$ . the cable is  $8\text{km}$  long. Then, the capacitance of the cable is (given  $\log_e 1.5 = 0.4$ )



- $3.8\ \mu\text{F}$
  - $1.1\ \mu\text{F}$
  - $4.8 \times 10^{-10}\text{F}$
  - None of these
404. The variation of potential with distance  $R$  from fixed point is shown in Fig



The electric field at  $R = 5\text{m}$  is



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

405. 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)  $-3Q$

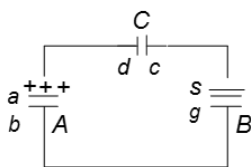
406. A fully charged capacitor has a capacitance  $C$ . It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity  $s$  and mass  $m$ . If the temperature of the block is raised by  $\Delta T$ , the potential difference  $V$  across the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

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

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

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

408. Two capacitors  $A$  and  $B$  with capacities  $C_1$  and  $C_2$  are charged to potential difference of  $V_1$  and  $V_2$ , respectively. The plates of the capacitors are connected as shown in the figure with one wire free from each capacitor. The upper plate of  $A$  is positive and that of  $B$  is negative. An uncharged capacitor of capacitance  $C_3$  and lead wires falls on the free ends to complete circuit, then



- a) The final charge on each capacitor are same to each other  
 b) The final sum of charge on plates  $a$  and  $d$  is  $C_1 V_1$   
 c) The final sum of charge on plates  $b$  and  $g$  is  $C_2 V_2 - C_1 V_1$   
 d) Both (b) and (c) are correct

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

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

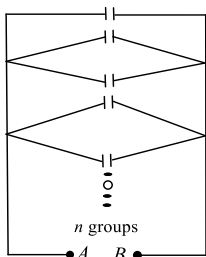
410. A photographic flash unit constant of a xenon-filled tube. It gives a flash of average power  $2000 \text{ W}$  for  $0.04 \text{ s}$ . The flash is due to discharge of a fully charged capacitor of  $40 \mu\text{F}$ . The voltage to which it is charged before a flash is given by the unit is

- a)  $1500 \text{ V}$                       b)  $2000 \text{ V}$                       c)  $2500 \text{ V}$                       d)  $3000 \text{ V}$

411. Inside a hollow charged spherical conductor, the potential

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

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



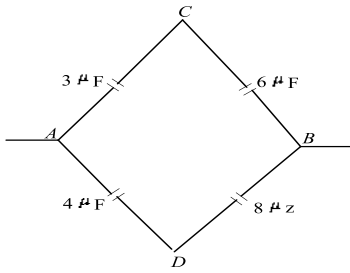
a)  $n^2 C$

b)  $(2n + 1)C$

c)  $\frac{(n - 1)n}{2} C$

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

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



a)  $\frac{3}{14} \mu F$

b)  $\frac{14}{3} \mu F$

c)  $21 \mu F$

d)  $23 \mu F$

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

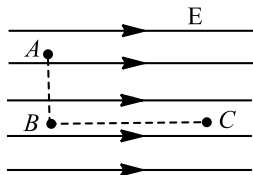
a)  $16\text{ kV}$

b)  $4\text{ kV}$

c)  $400\text{ V}$

d)  $160\text{ V}$

415. Figure shows three points  $A$ ,  $B$  and  $C$  in a region of uniform electric field  $\mathbf{E}$ . The line  $AB$  is perpendicular and  $BC$  is parallel to the field lines. Then which of the following holds good?



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

a)  $V_A = V_B = V_C$

b)  $V_A = V_B > V_C$

c)  $V_A = V_B < V_C$

d)  $V_A > V_B = V_C$

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

a) High  $K$  and high  $X$

b) High  $K$  and low  $X$

c) Low  $K$  and high  $X$

d) Low  $K$  and low  $X$

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

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

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

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

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

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

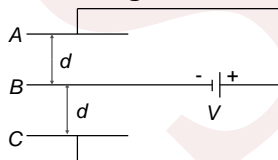
a)  $\frac{Q_1 Q_2}{4\pi\epsilon_0 R^2}$

b) Zero

c)  $\frac{Q_1 Q_2}{4\pi\epsilon_0 R}$

d) Infinite

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



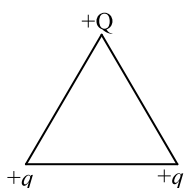
a)  $\frac{\epsilon_0 A V^2}{2d}$

b)  $\frac{\epsilon_0 A V^2}{d}$

c)  $\frac{2\epsilon_0 A V^2}{d}$

d)  $\frac{3\epsilon_0 A V^2}{2d}$

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



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

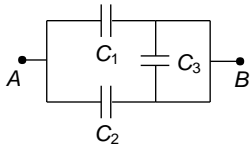
421. Charges  $2q$ ,  $-q$  and  $-q$  lie at the vertices of an equilateral triangle. The value of  $E$  and  $V$  at the centroid of the triangle will be

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

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

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

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

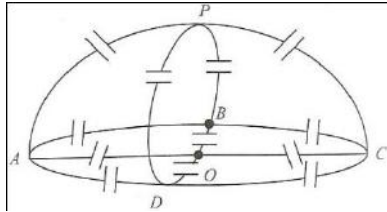


- a)  $\frac{C}{2}$                       b)  $\frac{3C}{2}$                       c)  $\frac{1}{3C}$                       d)  $2C$

424. Three capacitors  $2$ ,  $3$  and  $6 \mu\text{F}$  are joined with each other. What is the minimum effective capacitance?

- a)  $\frac{1}{2} \mu\text{F}$                       b)  $1 \mu\text{F}$                       c)  $2 \mu\text{F}$                       d)  $3 \mu\text{F}$

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

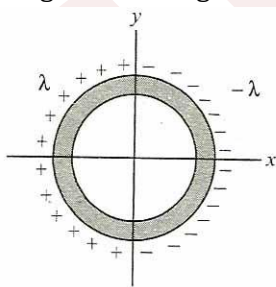


- a)  $2C$                       b)  $3C$                       c)  $8C$                       d)  $6C$

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

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

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



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

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

- a)  $5 \text{ s}$                       b)  $25 \text{ s}$                       c)  $20 \text{ s}$                       d)  $50 \text{ s}$

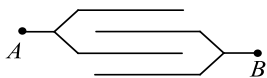
429. An air capacitor is charged with an amount of charge  $q$  and dipped into an oil tank. If the oil is pumped out, the electric field between the plates of capacitor will

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

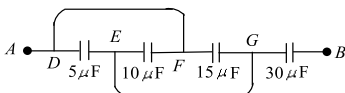
430. An electric dipole is placed at origin in the  $x - y$  plane with its orientation along the positive  $x$ -axis. The direction of electric field



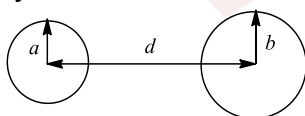
- a) At  $(-x_0, 0, 0)$  is along the positive  $x$ -axis  
 c) At  $(0, 0, z_0)$  is along the negative  $x$ -axis  
 431. An AC source is rated at 220 V, 50 Hz. The time taken for voltage to change from its peak value to zero is  
 a) 50 s                      b) 0.02 s                      c) 5 s                      d)  $5 \times 10^{-3}$  s  
 432. Two plates are 20 cm apart and the potential difference between them is 10 V. The electric field between the plates is  
 a)  $50 \text{ Vm}^{-1}$                       b)  $500 \text{ Vm}^{-1}$                       c)  $0.5 \text{ Vm}^{-1}$                       d)  $20 \text{ Vm}^{-1}$   
 433. Four metallic plates, each with a surface area of one side  $A$ , are placed at a distance  $d$  from each other. The alternate plates are connected to point  $A$  and  $B$  as shown in Fig. Then the capacitance of the system is



- a)  $\frac{\epsilon_0 A}{d}$                       b)  $\frac{2\epsilon_0 A}{d}$                       c)  $\frac{3\epsilon_0 A}{d}$                       d)  $\frac{4\epsilon_0 A}{d}$   
 434. The electric potential inside a conducting sphere  
 a) Increases from centre to surface                      b) Decreases from centre to surface  
 c) Remains constant from centre to surface                      d) Is zero at every point inside  
 435. A uniform electric field having a magnitude  $E_0$  and direction along the positive  $X$ -axis, exists. If the potential  $V$  is zero at  $x = 0$ , then its value at  $x = +x$  will be  
 a)  $V(x) = +x E_0$                       b)  $V(x) = -x E_0$                       c)  $V(x) = +x^2 E_0$                       d)  $V(x) = -x^2 E_0$   
 436. The resultant capacitance between the points  $A$  and  $B$  in Fig is



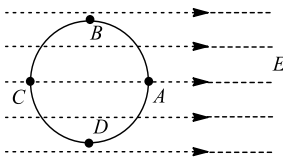
- a)  $15 \mu\text{F}$                       b)  $30 \mu\text{F}$                       c)  $60 \mu\text{F}$                       d)  $45 \mu\text{F}$   
 437. A capacitor of capacitance value  $1 \mu\text{F}$  is charged to 30 V and the battery is then disconnected. If the remaining circuit is connected across a  $2 \mu\text{F}$  capacitor, the remaining circuit is connected across a  $2 \mu\text{F}$  capacitor, the energy lost by the system is  
 a)  $300 \mu\text{J}$                       b)  $450 \mu\text{J}$                       c)  $225 \mu\text{J}$                       d)  $150 \mu\text{J}$   
 438. A parallel-plate capacitor has plates of area  $A$  and separation  $d$  and is charge to a potential difference  $V$ . The charging battery is then disconnected and the plates are pulled apart until their separation is  $2d$ . What is the work required to separate the plates?  
 a)  $2\epsilon_0 AV^2/d$                       b)  $\epsilon_0 AV^2/d$                       c)  $3\epsilon_0 AV^2/2d$                       d)  $\epsilon_0 AV^2/2d$   
 439. Two capacitors of capacitance  $2 \mu\text{F}$  and  $4 \mu\text{F}$  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)  $4 : 1$   
 440. Two free protons are separated by a distance of  $1 \text{ \AA}$ . If one proton is kept at least and the other is released, the kinetic energy of second proton when at infinite separation is  
 a)  $23.0 \times 10^{-19} \text{ J}$                       b)  $11.5 \times 10^{-19} \text{ J}$                       c)  $2.3 \times 10^{-19} \text{ J}$                       d) Zero  
 441. Two metallic spheres of radii  $A$  and  $B$  are separated by a distance  $d$  as shown in Fig. The capacity of the system is



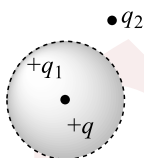
- a)  $\frac{4\pi\epsilon_0}{\frac{1}{a} + \frac{1}{b} - \frac{2}{d}}$                       b)  $\frac{4\pi\epsilon_0}{\frac{1}{a} + \frac{1}{b} + \frac{2}{d}}$                       c)  $\frac{4\pi\epsilon_0}{\frac{1}{a} - \frac{1}{b} + \frac{2}{d}}$                       d)  $\frac{4\pi\epsilon_0}{\frac{1}{a} - \frac{1}{b} - \frac{2}{d}}$   
 442. 27 small drops each having charge  $q$  and radius  $r$  coalesce to form big drop. How many times charge and capacitance will become?  
 a) 3, 27                      b) 27, 3                      c) 27, 27                      d) 3, 3



443. The electric field in a region surrounding the origin is uniform and along the  $x$ -axis. A small circle is drawn with the centre at the origin cutting the axes at point  $A, B, C$  and  $D$  having coordinates  $(a, 0), (0, a), (-a, 0)$  and  $(0, -a)$ , respectively, as shown in Fig. Then, the potential is minimum at



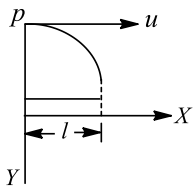
- a)  $A$                                       b)  $B$                                       c)  $C$                                       d)  $D$
444. Two identical rings  $P$  and  $Q$  of radius  $0.1$  m are mounted coaxially at a distance  $0.5$  m apart. The charges on the two rings are  $2$  and  $4 \mu\text{C}$ , respectively. The work done in transferring a charge of  $5 \mu\text{C}$  from the centre of  $P$  to that of  $Q$  is
- a)  $1.28$  J                                      b)  $0.72$  J                                      c)  $0.144$  J                                      d)  $2.24$  J
445. A point charge  $q$  is placed inside a conducting spherical shell of inner radius  $2R$  and outer radius  $3R$  at a distance of  $R$  from the centre of the shell. Find the electric potential at the centre of the shell
- a)  $\frac{1}{4\pi\epsilon_0} \frac{q}{2R}$                                       b)  $\frac{1}{4\pi\epsilon_0} \frac{4q}{3R}$                                       c)  $\frac{1}{4\pi\epsilon_0} \frac{5q}{6R}$                                       d)  $\frac{1}{4\pi\epsilon_0} \frac{2q}{3R}$
446. A point charge  $+Q$  is placed at the centroid of an equilateral triangle. When a second charge  $+Q$  is placed at a vertex of the triangle, the magnitude of the electrostatic force on the central charge is  $8$  N. The magnitude of the net force on the central charge when a third charge  $+Q$  is placed at another vertex of the triangle is
- a) Zero                                      b)  $4$  N                                      c)  $4\sqrt{2}$  N                                      d)  $8$  N
447. Variation in potential is maximum if one goes
- a) Along the line of force                                      b) Perpendicular to the line of force  
c) In any direction                                      d) None of these
448. For making a parallel-plate capacitor you have two plates of copper, a sheet of mica (thickness =  $0.10$  mm,  $K = 5.4$ ), a sheet of glass (thickness =  $0.20$  mm,  $K = 7$ ) and a slab of paraffin (thickness =  $1.0$  cm,  $K = 2$ ). To obtain the largest capacitance, which sheet should you place between the copper plates?
- a) Mica                                      b) Copper  
c) Glass                                      d) Information is insufficient
449. Consider the charge configuration and a spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface, the electric field will be due to



- a)  $q_2$                                       b) Only the positive charge  
c) All the charges                                      d)  $+q_1$  and  $-q_1$
450. A capacitor is charged to store an energy  $U$ . The charging battery is disconnected. An identical capacitor is now connected to the first capacitor in parallel. The energy in each of the capacitor is now
- a)  $3U/2$                                       b)  $U$                                       c)  $U/4$                                       d)  $U/2$
451. Electric potential at the centre of a charged hollow metal sphere is
- a) Zero                                      b) Twice as that on the surface  
c) Half of that on the surface                                      d) Same as that on the surface
452. A small conducting sphere of radius  $a$ , carrying a charge of  $+Q$ , is placed inside an equal and oppositely charged conducting shell of radius  $b$  such that their centres coincide. Determine the potential at a point which is at a distance of  $c$  from centre such that  $a < c < b$
- a)  $k(Q/c + Q/b)$                                       b)  $k(Q/a + Q/b)$                                       c)  $k(Q/a - Q/b)$                                       d)  $k(Q/c - Q/b)$

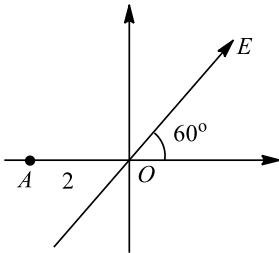


453. The electron is projected from a distance  $d$  and with initial velocity  $u$  parallel to a uniformly charged flat conducting plate as shown in figure. It strikes the plate after travelling a distance  $l$  along the direction. The surface charge density of conducting plate is equal to



- a)  $\frac{2d\epsilon_0mu^2}{el^2}$       b)  $\frac{2d\epsilon_0mu}{el}$       c)  $\frac{d\epsilon_0mu^2}{el}$       d)  $\frac{d\epsilon_0mu}{el}$

454. A uniform electric field of  $100 \text{ Vm}^{-1}$  is directed at  $60^\circ$  with the positive  $x$ -axis as shown in Figure. If  $OA = 2\text{m}$ , the potential difference  $V_O - V_A$  is



- a) 50 V      b) 50 V      c) 100 V      d) -100 V

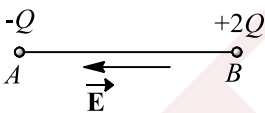
455. A parallel-plate capacitor is made by stacking  $n$  equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is  $C$ , then the resultant capacitance is

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

456. A parallel plate air capacitor has a capacitance  $C$ . When it is half filled with a dielectric constant 5, the percentage increase in the capacitance will be

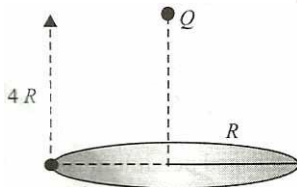
- a) 400 %      b) 66.6 %      c) 33.3 %      d) 200 %

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



- a) Somewhere between  $-Q$  and  $+2Q$       b) Somewhere on the left of  $-Q$   
 c) Somewhere on the right of  $+2Q$       d) Somewhere on the right bisector of line joining  $-Q$  and  $+2Q$ .

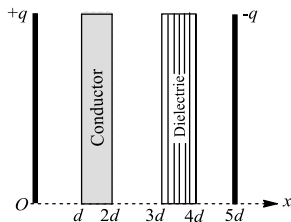
458. A charge  $Q$  is placed at a distance of  $4R$  above the centre of a disk of radius  $R$ . The magnitude of flux through the disk is  $\phi$ . Now, a hemispherical shell of radius  $R$  is placed over the disk such that it forms a closed surface. The flux through the curved surface, taking direction of area vector along outward normal as positive, is



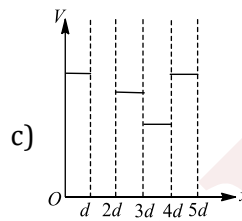
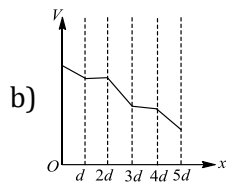
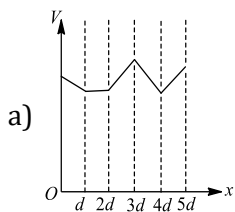
- a) Zero      b)  $\phi$       c)  $-\phi$       d)  $2\phi$

459. The distance between plates of a parallel-plates capacitor is  $5d$ . The positively charged plate is at  $x = 0$  and negatively charged plate is at  $x = 5d$



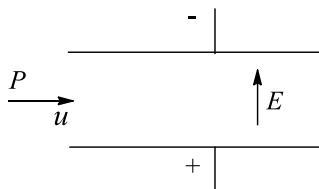


Two slabs, one of conductor and the other of a dielectric of same thickness  $d$ , are inserted between the plates as shown in Fig. Potential  $V$  versus distance  $x$  graph will be



d) None of these

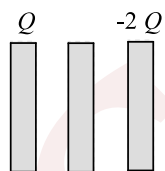
460. A positively charged particle  $P$  enters the region between two parallel plate with a velocity  $u$ , in a direction parallel to the plate. There is a uniform electric field in this region.  $P$  Emerges from this region with a velocity  $v$



Taking  $C$  as a constant,  $v$  will depend on  $u$  as

- a)  $v = Cu$       b)  $v = \sqrt{u^2 + Cu}$       c)  $v = \sqrt{u^2 + \frac{C}{u}}$       d)  $v = \sqrt{u^2 + \frac{C}{u^2}}$

461. Three identical metal plates with large surface areas are kept parallel to each other as shown in Figure. The leftmost plate is given a charge  $Q$ . The rightmost a charge  $-2Q$  and the middle one remains neutral. Find the charge appearing on the outer surface of the rightmost plate



- a)  $-Q/4$       b)  $-2Q$       c)  $-Q$       d)  $-Q/2$

462. Three identical capacitors, each of capacitance  $C$ , are connected in series with a battery of e.m.f  $V$  and get fully charged. Now, the battery is removed and the capacitors are connected in parallel with positive terminals at one point and negative terminals at other point. Then, the common potential will be

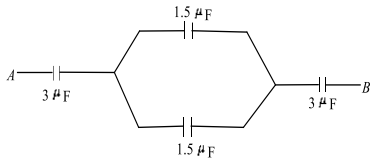
- a)  $V$       b)  $3V$       c)  $V/3$       d) Zero

463. A parallel-plate capacitor is connected to a battery. The plates are pulled apart with uniform speed. If  $x$  is the separation between the plates, then the rate of change of electrostatic energy of the capacitor is proportional to

- a)  $x^2$       b)  $x$       c)  $\frac{1}{x}$       d)  $\frac{1}{x^2}$

464. The equivalent capacitance between the points  $A$  and  $B$  in the following circuit is





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

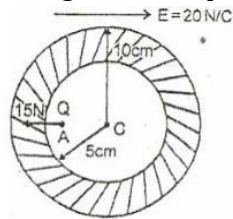
465. Two points  $P$  and  $Q$  are maintained at the potentials of  $10\text{V}$  and  $-4\text{V}$  respectively. The work done in moving  $100$  electrons from  $P$  to  $Q$  is

- a)  $-19 \times 10^{-17}\text{J}$               b)  $9.60 \times 10^{-17}\text{J}$               c)  $-2.24 \times 10^{-16}\text{J}$               d)  $2.24 \times 10^{-16}\text{J}$

466. 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

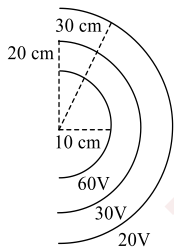
- a)  $800$  units                      b)  $300$  units                      c)  $400$  units                      d)  $1500$  units

467. In a conducting hollow sphere of inner and outer radii  $5\text{ cm}$  and  $10\text{ cm}$ , respectively, a point charge  $1\text{ C}$  is placed at point  $A$ , that is  $3\text{ cm}$  from the centre  $C$  of the hollow sphere. An external uniform electric field of magnitude  $20\text{ N/C}$  is also applied. Net electric force on this charge is  $15\text{ N}$ , away from the centre of the sphere as shown. Find the magnitude of net force exerted on the charge placed at point  $A$  by the induced charges on the sphere



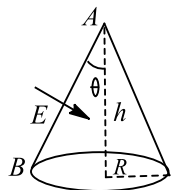
- a)  $15\text{ N}$                               b)  $20\text{ N}$                               c)  $5\text{ N}$                               d)  $35\text{ N}$

468. Figure shows equipotential surfaces concentric at  $O$ , the magnitude of electric field at a distance  $r$  measured from  $O$  is



- a)  $\frac{9}{r^2} (\text{Vm}^{-1})$                       b)  $\frac{6}{r^2} (\text{Vm}^{-1})$                       c)  $\frac{2}{r^2} (\text{Vm}^{-1})$                       d)  $\frac{16}{r^2} (\text{Vm}^{-1})$

469. A conic surface is placed in a uniform electric field  $E$  as shown such that field is perpendicular to the surface on the side  $AB$ . The base of the cone is of radius  $R$  and height of the cone is  $h$ . The angle of cone is  $\theta$  as shown. Find the magnitude of that flux which only enters the cone curved surface. Do not count the outgoing flux. Take  $\theta < 45^\circ$



- a)  $ER[h \cos \theta + \pi(R/2) \sin \theta]$                       b)  $ER[h \sin \theta + \pi R \cos \theta]$   
 c)  $ER[h \cos \theta + \pi R \sin \theta]$                       d) None of these

470. Six identical capacitors are joined in parallel, charged to a potential difference of  $10\text{ V}$ , separated and then connected in series, i.e., the positive plate of one is connected to negative plate of other. Then potential difference between free plates is



a) 10 V

b) 30 V

c) 60 V

d)  $\frac{10}{6}V$ 

471. A thin aluminium sheet is placed between the plates of a parallel-plate capacitor. Its capacitance will

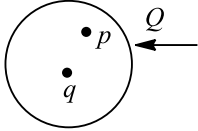
a) Increases

b) Decreases

c) Remain same

d) Become infinite

472. Inside a hollow conducting sphere, which is uncharged, a charge  $q$  is placed at its centre. Let electric field at a distance  $x$  From centre at point  $p$  be  $E$  and potential at this point be  $V$ . Now, some positive charge  $Q$  is given to this sphere, then

a)  $E$  will remain the sameb)  $E$  will increasec)  $V$  will decreased)  $V$  will the same

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

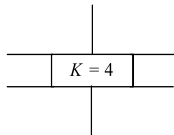
a) 4 : 1

b) 1 : 2

c) 2 : 1

d) 1 : 4

474. Consider a parallel-plate capacitor of capacity  $10 \mu\text{F}$  with air filled in the gap between the plates. Now, one half of the space between the plates is filled with a dielectric of dielectric constant 4 as shown in Fig. The capacity of the capacitor changes to

a)  $25 \mu\text{F}$ b)  $20 \mu\text{F}$ c)  $40 \mu\text{F}$ d)  $5 \mu\text{F}$ 

475. Electric charges  $q$ ,  $q$  and  $-2q$  are placed at the corners of an equilateral triangle  $ABC$  of side  $l$ . The magnitude of electric dipole moment of the system is

a)  $ql$ b)  $2ql$ c)  $\sqrt{3}ql$ d)  $ql$ 

476. Three charges  $1 \mu\text{C}$ ,  $2 \mu\text{C}$ ,  $3 \mu\text{C}$  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

477. The plates of a parallel capacitor are charged up to 100 V. Now, after removing the battery, a 2 mm thick plate is inserted between the plates. Then, to maintain the same potential difference, the distance between the capacitor plates is increased by 1.6 mm. Dielectric constant of the plate is

a) 5

b) 1.25

c) 4

d) 2.5

478. 4 point charges each  $+q$  is placed on the circumference of a circle of diameter  $2d$  in such a way that they form a square. The potential at the centre is

a) 0

b)  $\frac{4q}{d}$ c)  $\frac{4d}{q}$ d)  $\frac{q}{4d}$ 

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

a) Zero

b) 10 V

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

d) Same as at point 10cm away from the surface

480. The voltage of clouds is  $4 \times 10^6\text{V}$  with respect to ground. In a lightning strike lasting 100ms, a charge of 4C is delivered to the ground. The power of lightning strike is

a) 160 MW

b) 80 MW

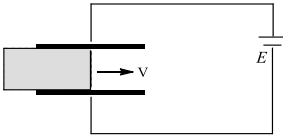
c) 20 MW

d) 500 kW

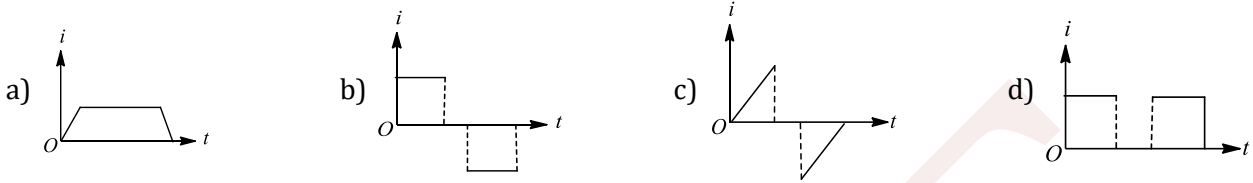
481. Two points are at distances  $a$  and  $b$  ( $a < b$ ) from a long string of charge per unit length  $\lambda$ . The potential difference between the points is proportional to

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

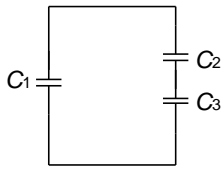
482. A dielectric slab of area  $A$  and thickness  $d$  is inserted between the plates of a capacitor of area  $2A$  with constant speed  $v$  as shown in Fig. Distance between the plates is  $d$



The capacitor is connected to a battery of e.m.f.  $E$ . The current in the circuit varies with time as



483. Capacitor  $C_1$  is connected to a battery and charged till the magnitude of the charge on each plate is  $q_0$  then, the battery is disconnected and  $C_1$  is connected to two other uncharged capacitor  $C_2$  and  $C_3$  as shown (figure) final charge on the capacitors ( $q_1, q_2$  and  $q_3$ ) are related by



- a)  $q_0 = q_1 + q_2 + q_3$       b)  $q_1 + q_2 + q_3 = 0$   
 c)  $q_0 = q_3 + q_2 + q_1 = 0$       d)  $q_0 = q_1 + q_2, q_2 = q_3$

484.  $n$  charged drops, each of radius  $r$  and charge  $q$ , coalesce to form a big drop of radius  $R$  and charge  $Q$ . If  $V$  is the electric potential and  $E$  is the electric field at the surface of a drop, then

- a)  $E_{\text{big}} = n^{2/3} E_{\text{small}}$       b)  $V_{\text{big}} = n^{1/3} V_{\text{small}}$       c)  $E_{\text{small}} = n^{2/3} E_{\text{big}}$       d)  $V_{\text{big}} = n^{2/3} V_{\text{small}}$

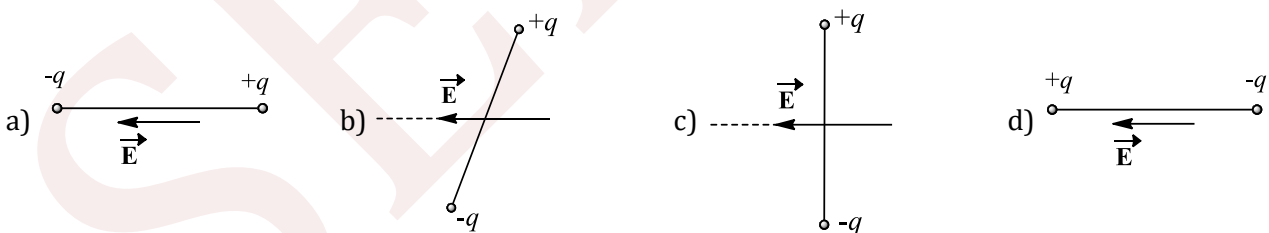
485. An electric field is given by  $\vec{E} = (y\hat{i} + x\hat{j}) \text{ m NC}^{-1}$ . The work done in moving a 1 C charge from  $\vec{r}_A = (2\hat{i} + 2\hat{j}) \text{ m}$  to  $\vec{r}_B = (4\hat{i} + 2\hat{j}) \text{ m}$  is

- a) +8 J      b) +4 J      c) Zero      d) -4 J

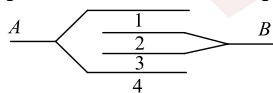
486. How many  $6 \mu\text{F}, 200 \text{ V}$  condensers are needed to make a condenser of  $18 \mu\text{F}, 600 \text{ V}$ ?

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

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

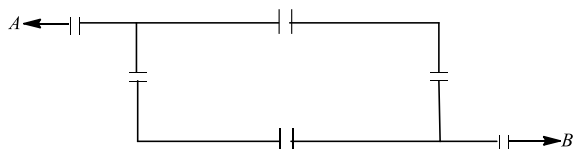


488. Four identical metal plates, each with a surface area  $A$  (on one side), are placed at a distance  $d$  from each other as shown in Fig. The two inner plates are connected to point  $B$  and the other two plates to another point  $A$ . Then, the capacitance of the system is



- a)  $\epsilon_0 A/d$       b)  $2\epsilon_0 A/d$       c)  $3\epsilon_0 A/d$       d)  $2\epsilon_0 A/3d$

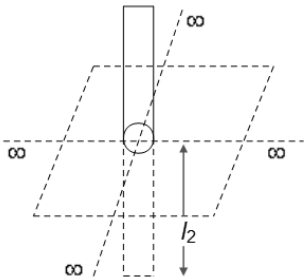
489. A network of six identical capacitors, each of value  $C$ , is made as shown in the figure.



The equivalent capacitance between the points  $A$  and  $B$  is

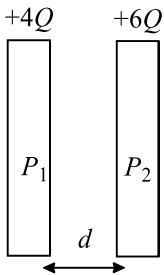
- a)  $\frac{4C}{11}$                       b)  $\frac{3C}{4}$                       c)  $\frac{3C}{2}$                       d)  $3C$

490. An infinite non-conducting sheet has surface charge density  $s$ . there is a small hole in the sheet as shown in the figure. A uniform rod of length  $\ell$  having linear charge density  $\lambda$  is hinged in the hole as shown. If the mass of the rod is  $m$ , then the time period of oscillations for small angular displacement is



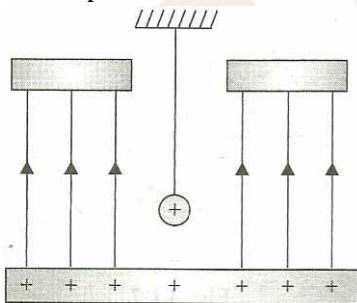
- a)  $\pi \sqrt{\frac{m\epsilon_0}{3\sigma\lambda}}$                       b)  $2\pi \sqrt{\frac{2m\epsilon_0}{3\sigma\lambda}}$                       c)  $\frac{\pi}{2} \sqrt{\frac{m\epsilon_0}{3\sigma\lambda}}$                       d)  $4\pi \sqrt{\frac{m\epsilon_0}{3\sigma\lambda}}$

491. Two identical conducting very large plates  $P_1$  and  $P_2$  having charges  $+4Q$  and  $+6Q$  are placed very closed to each other at separation  $d$ . The plate area of either face of the plate is  $A$ . The potential difference between plates  $P_1$  and  $P_2$  is



- a)  $V_{P_1} - V_{P_2} = \frac{Qd}{A\epsilon_0}$                       b)  $V_{P_1} - V_{P_2} = \frac{-Qd}{A\epsilon_0}$                       c)  $V_{P_1} - V_{P_2} = \frac{5Qd}{A\epsilon_0}$                       d)  $V_{P_1} - V_{P_2} = \frac{-5Qd}{A\epsilon_0}$

492. If a positively charged pendulum is oscillating in a uniform electric field as show in Figure. its time period as compared with that when it was uncharged



- a) Will increase                      b) Will decrease  
c) Will not change                      d) Will first increase and then decrease

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

- a)  $6.4 \times 10^6 F$                       b)  $700 F$                       c)  $711 \mu F$                       d)  $700 pF$

494. A positive charge is moved from a low potential point  $A$  to a high potential point  $B$ . Then, the electric potential energy of the system

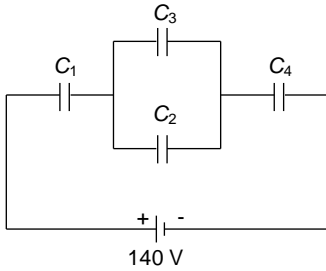
- a) Increase                      b) Decrease  
c) Will remain the same                      d) Nothing definite can be predicted

495. Find the potential at the centre of a square of side  $\sqrt{2}m$ . Which carries at its four corners charges  $q_1 = 3 \times 10^{-6}C, q_2 = -3 \times 10^{-6}C, q_3 = -4 \times 10^{-6}C, q_4 = 7 \times 10^{-6}C$



- a)  $2.7 \times 10^4 V$       b)  $1.5 \times 10^3 V$       c)  $3 \times 10^2 V$       d)  $5 \times 10^3 V$

496. In the circuit arrangement shown in figure, the value of  $C_1 = C_2 = C_3 = 30 \text{ pF}$  and  $C_4 = 120 \text{ pF}$ . If the combination of capacitors is charged with 140V DC supply, the potential differences across the four capacitors will be respectively

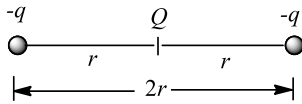


- a) 80, 40, 40 and 20 V      b) 20, 40, 40 and 80 V      c) 35, 35, 35 and 35 V      d) 80, 20, 20 and 20 V

497. Two conducting sphere of radii  $r_1$  and  $r_2$  are at the same potential. The ratio of their charges is

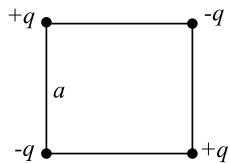
- a)  $r_1^2 / r_2^2$       b)  $r_2^2 / r_1^2$       c)  $r_1 / r_2$       d)  $r_2 / r_1$

498. Charges  $-q$ ,  $Q$  and  $-q$  are placed at an equal distance on a straight line. If the total potential energy of the system of three charges is zero, then find the ratio  $Q/q$



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

499. Four charges  $+q$ ,  $-q$ ,  $+q$  and  $-q$  are put together at four corners of a square as shown in Fig. The work done by external agent in assembling this configuration is

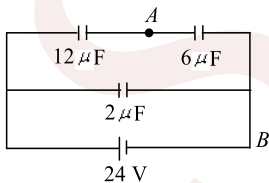


- a) Zero      b)  $-2.59 kq^2/a$       c)  $+2.59 kq^2/a$       d) None of these

500. A large insulated sphere of radius  $r$  charged with  $Q$  units of electricity is placed in contact with a small insulated uncharged sphere of radius  $r'$  and is then separated. The charge on the smaller sphere will now be

- a)  $\frac{Q(r' + r)}{r'}$       b)  $\frac{Q(r' + r)}{r}$       c)  $\frac{Qr}{r' + r}$       d)  $\frac{Qr'}{r' + r}$

501. In Fig, if the potential at point B is taken as zero, then the potential at point A will be



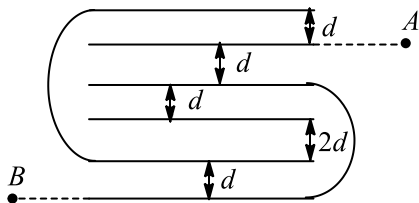
- a) 8 V      b) 16 V      c) 24 V      d) None of the above

502. Given a metallic uniformly charged sphere. The radius of the sphere is increased keeping its potential same. What is the effect on the value of electric field intensity at its surface?

- a) Increases      b) Decreases      c) remains constant      d) Cannot say

503. Find the equivalent capacitance between A and B. [Assume each conducting plate is having same dimensions and neglect the thickness of the plate,  $\epsilon_0 A/d = 7 \mu\text{F}$  [where  $A$  is area of plates,  $A \gg d$ ]]





- a)  $7 \mu\text{F}$                       b)  $11 \mu\text{F}$                       c)  $12 \mu\text{F}$                       d)  $15 \mu\text{F}$

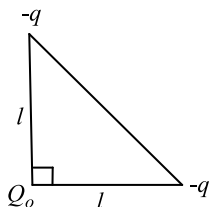
504. A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor

- a) Decreases                      b) Remain unchanged                      c) Becomes infinite                      d) Increases

505. Across each of two capacitors  $1 \mu\text{F}$  and  $4 \mu\text{F}$ , a potential difference of  $10 \text{ V}$  is applied. Then positive plate of one is connected to the negative plate of the other, and negative plate of one is connected to the positive plate of the other. After contact

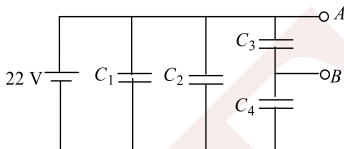
- a) Charge on each is zero                      b) Charge on each is same but non-zero  
c) Charge on each is different but non-zero                      d) None of the above

506. Three charges  $Q_0$ ,  $-q$  and  $-q$  are placed at the vertices of an isosceles right angle triangle as in the figure. The net electrostatic potential energy is zero if  $Q_0$  is equal to



- a)  $\frac{q}{4}$                       b)  $\frac{2q}{\sqrt{32}}$                       c)  $\sqrt{2}q$                       d)  $+q$

507. In Fig, given  $C_1 = 3 \mu\text{F}$ ,  $C_2 = 5 \mu\text{F}$ ,  $C_3 = 9 \mu\text{F}$  and  $C_4 = 13 \mu\text{F}$ . What is the potential difference between points A and B?



- a)  $13 \text{ V}$                       b)  $9 \text{ V}$                       c)  $0 \text{ V}$                       d)  $11 \text{ V}$

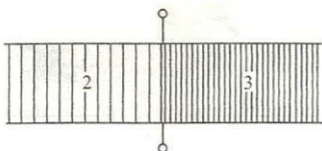
508. Two identical air core capacitors are connected in series to a voltage source of  $15 \text{ V}$ . If one of the capacitors is filled with a medium of dielectric constant 4, the new potential across this capacitor is

- a)  $5 \text{ V}$                       b)  $8 \text{ V}$                       c)  $10 \text{ V}$                       d)  $12 \text{ V}$

509. If the electric flux entering and leaving an enclosed surface respectively is  $\phi_1$  and  $\phi_2$ , then, charge enclosed in closed surface is

- a)  $\frac{\phi_2 - \phi_1}{\epsilon_0}$                       b)  $\frac{\phi_1 + \phi_2}{\epsilon_0}$                       c)  $\frac{\phi_1 - \phi_2}{\epsilon_0}$                       d)  $\epsilon_0(\phi_2 - \phi_1)$

510. Solve the above question if the dielectric materials were filled as shown in Fig



- a)  $1.2 \mu\text{F}$                       b)  $1.25 \mu\text{F}$                       c)  $1.80 \mu\text{F}$                       d) None of these

511. Along the  $x$ -axis, three charges  $\frac{q}{2}$ ,  $-q$  and  $\frac{q}{2}$  are placed at  $x = 0$ ,  $x = a$  and  $x = 2a$

respectively. The resultant electric potential at a point  $P$  located at a distance  $r$  from the charge  $-q$  ( $a \ll r$ ) is ( $\epsilon_0$  is the permittivity of free space)



a)  $\frac{qa}{4\pi\epsilon_0 r^2}$

b)  $\frac{qa^2}{4\pi\epsilon_0 r^3}$

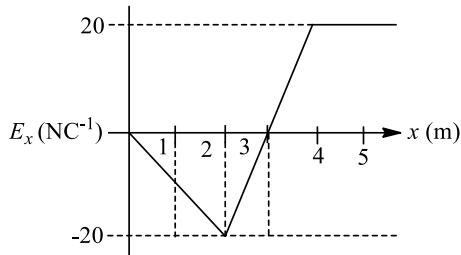
c)  $\frac{q\left(\frac{a^2}{4}\right)}{4\pi\epsilon_0 r^3}$

d)  $\frac{q}{4\pi\epsilon_0 r}$

512. We wish to obtain a capacitance of 5  $\mu\text{F}$ , by using some capacitors, each of 2  $\mu\text{F}$ . Then, the minimum number of capacitors required is

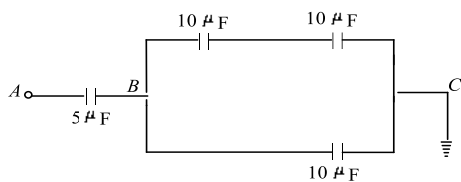
- a) 3                                      b) 4                                      c) 5                                      d) Not possible

513. A graph of the  $x$ -component of the electric field as a function of  $x$  in a region of space is shown in Figure. The  $y$ - and  $z$ -components of the electric field are zero in this region. If the electric potential is 10 V at the origin, then the potential at  $x = 2.0$  m is



- a) 10 V                                      b) 40 V                                      c) -10 V                                      d) 30 V

514. As shown in figure, if the point  $C$  is earthed and the point  $A$  is given a potential of 2000 V, then the potential at point  $B$  will be



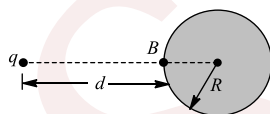
- a) 400 V                                      b) 500 V                                      c) 1000 V                                      d) 1300 V

### Multiple Correct Answers Type

515. A particle of mass 2 kg and charge 1 mC is projected vertically with a velocity  $10\text{ms}^{-1}$ . There is a uniform horizontal electric field of  $10^4\text{NC}^{-1}$ . Then,

- a) The horizontal range of the particle is 10 m                                      b) The time of flight of the particle is 2 s  
c) The maximum height reached is 5 m                                      d) The horizontal range of the particle is 0

516. For the situation shown in Fig, mark out the correct statement(s)



- a) Potential of the conductor is  $q/[4\pi\epsilon_0(d + R)]$   
b) Potential of the conductor is  $q/4\pi\epsilon_0 d$   
c) Potential of the conductor cannot be determined as nature of distribution of induced charges is not known  
d) Potential at point  $B$  due to induced charges is  $-qR[4\pi\epsilon_0(d + R)d]$

517. Mark out the incorrect statement(s)

- a) A proton tends to go from a region of low electric potential to a region of high electric potential  
b) The electric potential of a negatively charged conductor must be negative  
c) If  $\vec{E} = 0$  at a point  $P$ , then  $V$  must be zero at  $P$   
d) If  $V = 0$  at a point  $P$ , then  $\vec{E}$  must be zero at  $P$

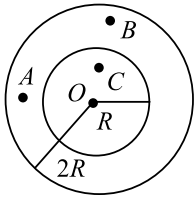
518. The electric potential at a point certain distance from a point charge is 600 V and the electric field is  $200\text{NC}^{-1}$ . Which of the following statements will be true?

- a) The magnitude of the charge is  $20 \times 10^{-3}\text{C}$



- b) The distance of the given point from the charge is 3 m
- c) The potential at a distance of 9 m will be 200 V
- d) The work done by an external agent in moving a point charge of 1 mC from the given point to a point to a point at a distance of 9 m will be  $4 \times 10^{-4}$  J

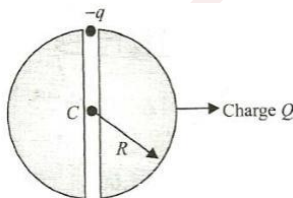
519. A hollow conducting sphere of inner radius  $r$  and outer radius  $2R$  is given charge  $Q$  as shown in the figure. Then the



- a) Potential at  $A$  and  $B$  is same
  - b) Potential at  $O$  and  $B$  is same
  - c) Potential at  $O$  and  $C$  is same
  - d) Potential at  $A, B, C$  and  $O$  is same
520. If a charged conductor is enclosed by a hollow charged conducting shell (assumed concentric and spherical in shape), and they are connected by a conducting wire, then which of the following statement(s) would be correct?
- a) Potential difference between two conductors becomes zero
  - b) If charge on inner conductor is  $q$  and on outer conductor it is  $2q$ , then finally charge on outer conductor will be  $3q$
  - c) The charge on the inner conductor is totally transferred to the outer conductor
  - d) If charge on the inner conductor is  $q$  and charge on the outer conductor is zero, then finally charge on each conductor will be  $q/2$
521. A spherical metal shell  $A$  of radius  $R_A$  and a solid metal sphere  $B$  of radius  $R_B$  ( $< R_A$ ) are kept far apart and each is given charge  $+Q$ . Now they are connected by a thin metal wire. Then

- a)  $E_A^{\text{inside}} = 0$
- b)  $Q_A > Q_B$
- c)  $\frac{\sigma_A}{\sigma_B} = \frac{R_B}{R_A}$
- d)  $E_A^{\text{on surface}} < E_B^{\text{on surface}}$

522. In a uniformly charged dielectric sphere, a very thin tunnel has been made along the diameter as shown in Figure below. A charge particle  $-q$  having mass  $m$  is released from rest at one end of the tunnel. For the situation described, mark out the correct statement(s) [neglect gravity]



- a) Charge particle will perform S.H.M. about centre of the sphere as mean position
  - b) Time period of the particle is  $2\pi \sqrt{\frac{2\pi\epsilon_0 m R^3}{qQ}}$
  - c) Particle will perform oscillation but not S.H.M.
  - d) Speed of the particle while crossing the mean position is  $\sqrt{\frac{qQ}{4\pi\epsilon_0 m R}}$
523. A parallel plate capacitor of plate area  $A$  and plate separation  $d$  is charged to potential difference  $V$  and then the battery is disconnected. A Slab of dielectric constant  $K$  is then inserted between the plates of the capacitor so as to fill the space between the plates. If  $Q, E$  and  $W$  denote respectively the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted) and work done on the system, in question, in the process of inserting the slab, then

- a)  $Q = \frac{\epsilon_0 AV}{d}$
- b)  $Q = \frac{\epsilon_0 K AV}{d}$
- c)  $E = \frac{V}{Kd}$
- d)  $W = \frac{\epsilon_0 AV^2}{2d} \left[ 1 - \frac{1}{K} \right]$



524. A parallel-plate air capacitor has initial capacitance  $C$ . If plate separation is slowly increased from  $d_1$  to  $d_2$ , then mark the correct statement(s). [Take potential of the capacitor to be constant, i.e., throughout the process it remains connected to battery.]

- a) Work done by electric force =  $-$ work done by external agent
- b) Work done by electric force =  $-\int \vec{F} \cdot d\vec{x}$ , where  $\vec{F}$  is the electric force of attraction between the plates of plate separation is  $x$
- c) Work done by electric force  $\neq$   $-$ ve of work done by external agent
- d) Work done by battery = 2 times the change in electric potential energy stored in capacitor

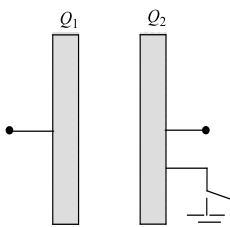
525. A particle with a specific charge  $s$  start from rest in a region where the electric field has a constant direction, but whose magnitude increases linearly with time. The particle acquires velocity  $v$  in time  $t$

- a)  $v \propto s$
- b)  $v \propto \sqrt{s}$
- c)  $v \propto t$
- d)  $v \propto t^2$

526. Two point charges of different magnitudes and of opposite signs are separated by some distance. There can be

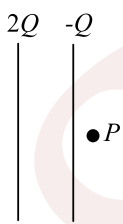
- a) Only one point in space where net electric field intensity is zero
- b) Only two points in space where net electric potential is zero
- c) Infinite number of points in space where net electric field intensity is 0
- d) Infinite number of points in space where net electric potential is zero

527. To two plates of a parallel-plate capacitors, charge  $Q_1$  and  $Q_2$  are given. The capacity of the capacitor is  $C$ . When the switch is closed, mark the correct statement(s). [Assume both  $Q_1, Q_2$  to be +ve]



- a) The charge flown through switch is zero
- b) The charge flown through switch is  $Q_1 + Q_2$
- c) Potential difference across the capacitor plate is  $Q_1/C$
- d) The charge of the capacitor is  $Q_1$

528. In figure the plates of a parallel plate capacitor have unequal charges. It capacitance is  $C$ .  $P$  is a point outside the capacitor and close to the plate of charge  $-Q$ . The distance between the plates is  $d$



Then,

- a) A point charge at point  $P$  will experience electric force due to the capacitor
- b) The potential difference between the plates will be  $3Q/2C$
- c) The energy stored in the electric field in the region between the plates is  $9Q^2/8C$
- d) The force on one plate due to the other plate is  $Q^2/2\pi\epsilon_0 d^2$

529. A positive charge  $Q$  is located at the centre of a thin metallic spherical shell. Select the correct statement(s) from the following.

- a) the electric field at any point outside the shell is zero
- b) The electrostatic potential at any point outside the shell is  $\frac{Q}{4\pi\epsilon_0 r}$ , where  $r$  is the distance of the points from centre.
- c) The outer surface of the spherical shell is an equipotential surface
- d) The electric field at any point inside the shell, other than centre point is, zero



530. The electric potential at a certain distance from a point charge is 600 V and the electric field is 200 NC<sup>-1</sup>. Which of the following statements will be true?

- a) The work done in moving a point charge of 1 μC from the given point to a point at a distance of 9 m will be  $4 \times 10^{-4}$  J
- b) The distance of the given point from the charge is 3 m
- c) The potential at a distance of 9 m will be 200 V
- d) The magnitude of charge is  $0.2 \times 10^{-3}$  C

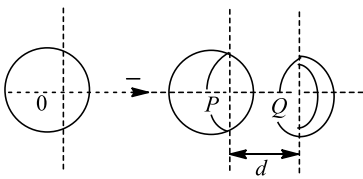
531. A point charge  $\mu$  is placed at origin let  $\vec{E}_A, \vec{E}_B$  and  $\vec{E}_C$  be the electric field at three points  $A(1,2,3), B(1,1,-1)$  and  $C(2,2,2)$  due to charge  $\mu$ . Then

- a)  $\vec{E}_A \perp \vec{E}_B$
- b)  $\vec{E}_A \parallel \vec{E}_B$
- c)  $|\vec{E}_B| = 4|\vec{E}_C|$
- d)  $\vec{E}_B = 16|\vec{E}_C|$

532. An insulating spherical shell of uniform surface charge density is cut into two parts and placed at a distance  $d$  apart as shown in Figure

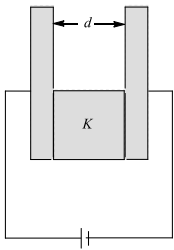
$\vec{E}_P$  and  $\vec{E}_Q$  denote the electric fields at  $P$  and  $Q$ , respectively

As  $d$  (i. e.  $PQ$ )  $\rightarrow \infty$



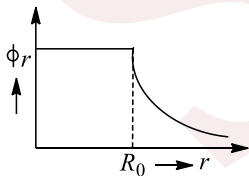
- a)  $|\vec{E}_P| > |\vec{E}_Q|$
- b)  $|\vec{E}_P| = |\vec{E}_Q|$
- c)  $|\vec{E}_P| < |\vec{E}_Q|$
- d)  $|\vec{E}_P| + |\vec{E}_Q| = 0$

533. A dielectric slab fills the lower half region of parallel-plate capacitor as shown in Fig. [Take plate area as  $A$ ]



- a) Equivalent capacity of the system is  $\frac{\epsilon_0 A}{2d} (1 + K)$
- b) The net charge of lower half of the left hand plate is  $1/K$  times the charge on upper half of the plate
- c) Net charges on lower and upper halves of left hand plate are different
- d) Net charge on lower half of left hand plate is  $\frac{K\epsilon_0 A}{2d} \times V$

534. The electrostatic potential ( $\phi_r$ ) of a spherical symmetric system, kept at origin, is shown in the adjacent figure and given as  $\phi_r = \frac{q}{4\pi\epsilon_0 r}$  ( $r \geq R_0$ ) and  $\phi_r = \frac{q}{4\pi\epsilon_0 r}$  ( $r \leq R_0$ ) which of the following option (s) is/are correct?



- a) For spherical region  $r \leq R_0$ , total electrostatic energy stored is zero.
- b) Within  $r = 2R_0$ , total charge is  $q$
- c) There will be no charge anywhere except at  $r = R_0$
- d) Electric field is discontinuous at  $r = R_0$

535. Four identical particles, each having mass  $m$  and charge  $q$ , are placed at the vertices of a square of side  $l$ . All the particles are free to move without any friction and released simultaneously from rest. Then,

- a) At all instants, the particles remain at vertices of square whose edge length is changing
- b) The configuration is changing (not remaining square) as the time passes



The speed of the particles when one of the particles gets

c) displaced by  $\frac{1}{\sqrt{2}}$  is  $\sqrt{\frac{q^2}{8\pi\epsilon_0 ml} \left(2 + \frac{1}{\sqrt{2}}\right)}$

d) The speed of the particles cannot be found

536. An ellipsoidal cavity is curved within a perfect conductor. A positive charge  $q$  is placed at the centre of the cavity. The points  $A$  and  $B$  are on the cavity surface as shown in the figure. Then

a) Electric field near  $A$  in the cavity = electric field near  $B$  in the cavity

b) Charge density at  $A$  = charge density at  $B$

c) Potential at  $A$  = potential at  $B$

d) Total electric field flux through the surface of the cavity is  $\frac{q}{\epsilon_0}$

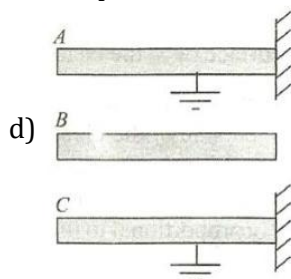
537.  $A, B$  and  $C$  are three large, parallel conducting plates, placed horizontally.  $A$  and  $C$  are rightly fixed and earthed (figure).  $B$  is given some charge. Under electrostatic and gravitation forces,  $B$  may be

a) In equilibrium if it is closer to  $A$  than to  $C$

b) In equilibrium midway between  $A$  and  $C$

c)  $B$  can never be in stable equilibrium

In equilibrium if it is closer to  $C$  than to  $A$



538. When a positively charged sphere is brought near a metallic sphere, it is observed that a force of attraction exists between the two. It means

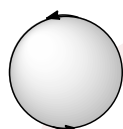
a) The metallic sphere may be electrically neutral

b) The metallic sphere is necessarily negatively charged

c) Nothing can be said about the charge of the metallic sphere

d) The metallic sphere may be negatively charged

539. In the diagram a line of force of a particular field, shown out of the following options, can never represent



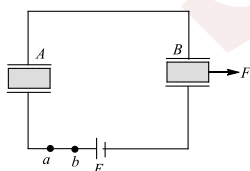
a) Induced electric field

b) Magnetostatic field

c) Gravitational field of a mass at rest

d) Electrostatic field

540. Two identical capacitors with identical dielectric slabs in between them are connected in series as shown in Fig. Now, the slab of one capacitor is pulled out slowly with the help of an external force  $F$  at steady state as shown. Mark out the correct statement(s)



a) During the process, charge (positive) flows from  $b$  to  $a$

b) During the process, charge of capacitor  $B$  is equal to charge in  $A$  at all instants

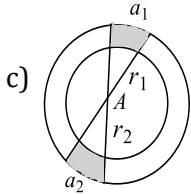
c) Work done by  $F$  is positive

d) During the process, the battery has been charged



541. A wire having a uniform linear charge density  $\lambda$ , is bent in the form of a ring of radius  $R$ . Point  $A$  as shown in Fig, is in the plane of the ring but not at the centre. Two elements of the ring of lengths  $a_1$  and  $a_2$  subtend very small same angle at the point  $A$ . They are at distances  $r_1$  and  $r_2$  from the point  $A$ , respectively. ( $r_2 > r_1$ )

- a) The ratio of charges of element  $a_1$  to that of element  $a_2$  is  $r_1/r_2$   
 b) The element  $a_1$  produced greater magnitude of electric field at  $A$  than element  $a_2$   
 The elements  $a_1$  and  $a_2$  produce same potential at  $A$



- d) The direction of net electric field produced by elements only at  $A$  is towards element  $a_2$

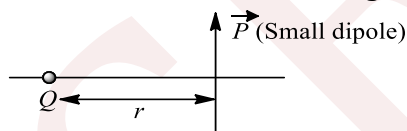
542. Two infinite, parallel, non-conducting sheets carry equal positive charge density  $\sigma$ . One is placed in the  $y - z$  plane and the other at distance  $x = a$ . Take potential  $V = 0$  at  $x = 0$ . Then

- a) For  $0 \leq x \leq a$ , potential  $V = 0$   
 b) For  $x \geq a$ , potential  $V = \frac{\sigma}{\epsilon_0}(x - a)$   
 c) For  $x \leq 0$  potential  $V = -\frac{\sigma}{\epsilon_0}(x - a)$   
 d) For  $x \leq 0$ , potential  $V = \frac{\sigma}{\epsilon_0}x$

543. A small conducting sphere of radius  $a$  mounted on an insulated handle and a positive charge  $q$  is inserted through a hole in the wall of a hollow conducting sphere of inner radius  $b$  and outer radius  $c$ . The hollow sphere is supported on an insulating stand and is initially uncharged. The small sphere is placed at the centre of the hollow sphere. Neglect any effect of the hole. Which of the following statements will be true for this system?

- a) No work will be done in carrying a small charge from the inner conductor to the outer conductor  
 b) The electric field at a point in the region between the spheres at a distance  $r$  from the centre is equal to  $q/4\pi\epsilon_0r^2$   
 c) The electric field at a point outside the hollow sphere at a distance  $r$  from the centre is  $q/4\pi\epsilon_0r^2$   
 d) The potential of the inner sphere with respect to the outer sphere is given by  $V_{ab} = \frac{q}{4\pi\epsilon_0} \left( \frac{1}{a} - \frac{1}{b} \right)$

544. For the situation shown in Figure. (assume  $r \gg$  length of dipole) mark out the correct statement(s).



- a) Force acting on the dipole is zero  
 b) Force acting on the dipole is approximately  $\frac{pQ}{4\pi\epsilon_0r^3}$  and is acting upward  
 c) Torque acting on the dipole is  $\frac{pQ}{4\pi\epsilon_0r^2}$  in clock-wise direction  
 d) Torque acting on the dipole is  $\frac{pQ}{4\pi\epsilon_0r^3}$  in anti-clockwise direction

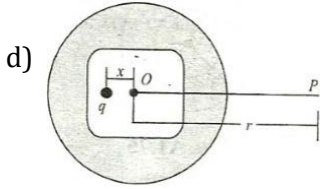
545. An electric charge  $2 \times 10^{-8} C$  is placed at the point  $(1, 2, 4)$ . At the point  $(3, 2, 1)$ , the electric

- a) Field will increase by a factor  $K$  if the space between the points is filled with a dielectric of dielectric constant  $K$   
 b) Field will be along the  $y$ -axis  
 c) Potential will be  $49.9 V$   
 d) Field will have no  $y$ -component

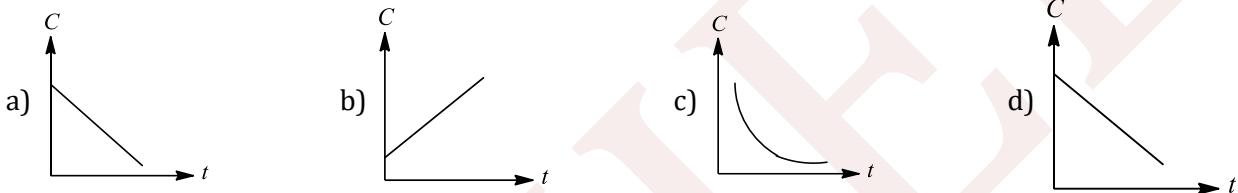
546. A point charge  $q$  is placed within the cavity of an electrically neutral conducting shell whose outer surface has spherical shape. Then,



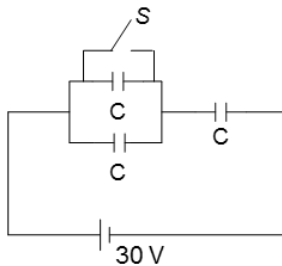
- a) The potential  $V$  at point  $P$  lying outside the shell at a distance  $r$  from the centre  $O$  of the outer surface depends upon the value of  $x$
- b) Potential at  $P$  does not depend upon the value of  $x$
- c) A total charge  $q$  will be induced on the outer surface of the shell which will be distributed uniformly on the outer surface  
A total charge  $-q$  will be induced on the inner surface of the shell which will be distributed non-uniformly on the inner surface



547. A parallel-plate capacitor has a dielectric slab in it. The slab just fills the space inside the capacitor. The capacitor is charged by a battery and then battery is disconnected. Now the slab is started to pull out slowly at  $t = 0$ . If at difference between the plates capacitors is  $V$ , then which of the following graphs is/are correct



548. Three capacitors, each having capacitance  $C = 2\mu\text{F}$ , are connected with a battery of e.m.f. 30 V as shown in the figure

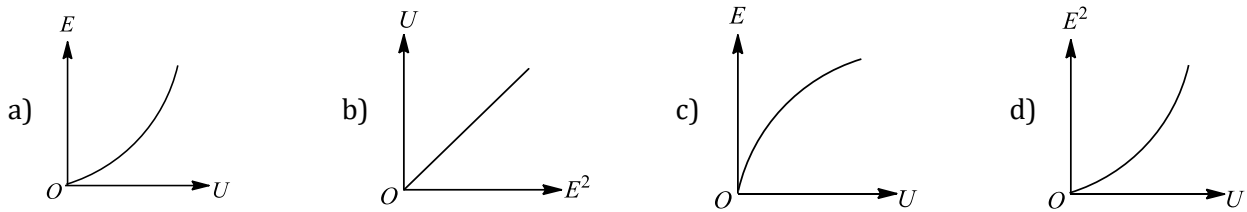


When the switch  $S$  is closed

- a) The amount of charge flow through the battery is  $20\mu\text{C}$
  - b) The heat generated in the circuit is 0.6 mJ
  - c) The energy supplied by the battery is 0.6 mJ
  - d) The amount of charge flow through the switch  $S$  is  $\mu\text{C}$
549. A small sphere is charged uniformly and placed at some point  $A(x_0, y_0)$  so that at point  $B(9\text{m}, 4\text{m})$  electric field strength is  $\vec{E} = (54\hat{i} + 72\hat{j})\text{NC}^{-1}$  and potential is 1800 V. Then
- a) The magnitude of charge on the sphere is  $4\mu\text{C}$
  - b) The magnitude of charge on the sphere is  $2\mu\text{C}$
  - c) Coordinates of  $A$  are  $x_0 = -3\text{m}, y_0 = -12\text{m}$
  - d) Coordinates of  $A$  are  $x_0 = 4\text{m}, y_0 = -1\text{m}$
550. A parallel-plate capacitor is charged from a cell and then isolated from it. The separation between the plates is now increased
- a) The force of attraction between the plates will decrease
  - b) The field in the region between the plates will not change
  - c) The energy stored in the capacitor will increase
  - d) The potential difference between the plates will decrease



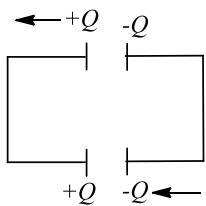
551. If at distance  $r$  from a positively charged particle, electric field strength and energy density are  $E$  and  $U$ , respectively, which of the following graphs is/are correct?



552. Mark out the correct statements.

- a) A given conducting sphere cannot be charged to a potential greater than a certain value
- b) A given conducting sphere can be charged to a potential less than a certain minimum value
- c) A given conducting sphere can be charged to any extent
- d) None of the above

553. A charge  $Q$  is imparted to two identical capacitors in parallel. Separation of the plates in each capacitor is  $d_0$ . Suddenly, the first plate of the first capacitor and the second plate of the second capacitor start moving to the left with speed  $v$ , then



Charges on the two capacitors as a function of time are

a)  $\frac{Q(d_0 - vt)}{2d_0}, \frac{Q(d_0 + vt)}{2d_0}$

Charges on the two capacitors as a function of time are

b)  $\frac{Qd_0}{2(d_0 - vt)}, \frac{Qd_0}{2(d_0 + vt)}$

- c) Current in the circuit will increase as time passes on
- d) Current in the circuit will be constant

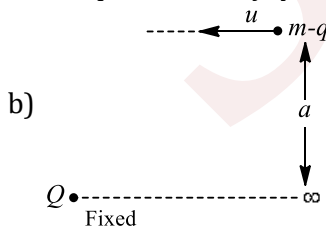
554. A non-conducting solid sphere of radius  $R$  is uniformly charged. The magnitude of the electric field due to the sphere at a distance  $r$  from its centre

- a) Increases as  $r$  increases for  $r < R$
- b) decreases as  $r$  increases for  $0 < r < \infty$
- c) decreases as  $r$  increases for  $R < r < \infty$
- d) Is discontinuous at  $r = R$

555. A charge particle  $q$  is projected in an electric field produced by a fixed point charge  $Q$  as shown in Figure

Mark out the correct statements

- a) The path taken by  $q$  is a straight line
- The path taken by  $q$  is not a straight line



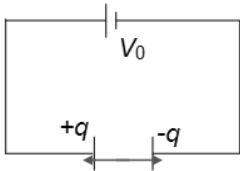
- c) The minimum distance between the two particles is  $\frac{\frac{qQ}{2\pi\epsilon_0} + \sqrt{\left(\frac{qQ}{2\pi\epsilon_0}\right)^2 + 4m^2u^2a^2}}{2mu^2}$
- d) Velocity of the particle  $q$  is changing in both magnitude and direction



556. Two identical parallel-plate capacitors are connected in one case in parallel and in the other in series. In each case the plates of one capacitor are brought closer by a distance  $a$  and the plates of the other are moved apart by the same distance  $a$ . then

- a) Total capacitance of first system increases      b) Total capacitance of first system decreases  
 c) Total capacitance of second system decreases      d) Total capacitance of second system remain constant

557. Two plates of a parallel-plate capacitors carry charge  $q$  and  $-q$  and are separated by a distance  $a$  from each other. The capacitor is connected to a constant voltage source  $V_0$ . The distance between the plates is changed to  $x + dx$



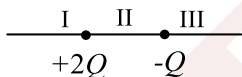
Then in steady state

- a) Change in electrostatic energy stored in the capacitor is  $-Udx/x$   
 b) Charge in electrostatic energy in the capacitor is  $-Udx/dx$   
 c) Attraction force between the plates is  $1/2qE$   
 d) Attraction force between the plates is  $qE$  (where  $E$  is electric field between the plates)

558. A thin-walled spherical conducting shell  $S$  of radius  $R$  is given charge  $Q$ . The same amount of charge is also placed at its centre  $C$ . Which of the following statements are correct?

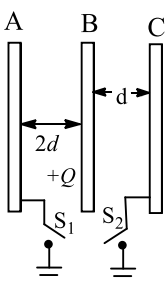
- a) On the outer surface of  $S$ , the charge density is  $\frac{1}{2} \frac{Q}{\pi R^2}$   
 b) The electric field is zero at all point inside  $S$   
 c) At a point just outside  $S$ , the electric field is double the field at a point just inside  $S$  in the cavity  
 d) At any point inside  $S$  (i.e. within its cavity), the electric field is inversely proportional to the square of its distance from  $C$

559. The figure shows two point charges  $2Q (> 0)$  and  $-Q$ . The charges divide the line joining them in three parts I, II and III



- a) Region III has a local maxima of electric field  
 b) Region I has a local minima of electric field  
 c) Equilibrium position for a test charge lies in region II  
 d) The equilibrium (if there is any) is stable for a negative test charge

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

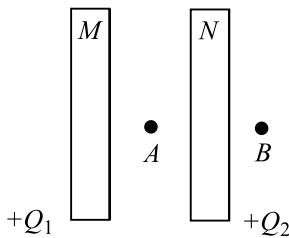


- a) If  $S_1$  is closed, with  $S_2$  open, a charge of amount  $Q$  will pass through  $S_1$   
 b) If instead  $S_2$  were closed with  $S_1$  open, a charge of amount  $Q$  will pass through  $S_2$   
 c) If  $S_1$  and  $S_2$  are closed together, a charge of amount  $Q/3$  will pass through  $S_1$ , and a charge of amount  $2Q/3$  will pas through  $S_2$



- d) If  $S_1$  and  $S_2$  are closed together, a charge of amount  $2Q/3$  will pass through  $S_1$ , and a charge of amount  $Q/3$  will pass through  $S_2$

561. Two conducting plates  $M$  and  $N$ , each having large surface area  $A$  (on the side), are placed parallel to each other (figure) the plate  $M$  is given charge  $Q_1$  and  $N$ , charge  $Q_2 (< Q_1)$ . Then,



- a) Electric field at point  $A$  is  $\frac{Q_1 - Q_2}{2A\epsilon_0}$  towards right      b) Electric field at point  $B$  is  $\frac{Q_1 + Q_2}{2A\epsilon_0}$  towards right  
 c) Electric potential of  $N$  is greater than  $M$       d) All of the above
562. A conducting sphere of radius  $R$  has a charge. then,  
 a) The charge is uniformly distributed over its surface, if there is no external electric field  
 b) The distribution of charge over its surface will be non-uniform if an external electric field exists in the space  
 c) The potential at every point of the sphere must be the same  
 d) The electric field strength inside the sphere will be equal to zero only when no external electric field exists
563. A capacitor of  $5 \mu\text{F}$  is charged to a potential of  $100 \text{ V}$ . Now, this charged capacitor is connected to a battery of  $100 \text{ V}$  with positive terminal of battery connected to negative plate for the capacitor. For the given situation, mark the correct statement(s)

- a) The charge flown through  $100 \text{ V}$  battery is  $500 \mu\text{C}$       b) The charge flown through  $100 \text{ V}$  battery is  $1000 \mu\text{C}$   
 c) Heat dissipated in the circuit is  $0.1 \text{ J}$       d) Work done on the battery is  $0.1 \text{ J}$

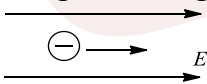
564. A dipole is placed in  $x - y$  plane parallel to the line  $y = 2x$ . There exists a uniform electric field along  $z$ -axis. Net force acting on the dipole will be zero. But it experiences some torque. We can show that the direction of this torque will be parallel to the line

- a)  $y = 2x + 1$       b)  $y = -2x$       c)  $y = \frac{1}{2}x$       d)  $y = -\frac{1}{2}x + 2$

565. A parallel plate capacitor is charged to a definite potential and the charging battery is disconnected. Now, if the plates of the capacitor are moved apart, then

- a) The stored energy of the capacitor increases      b) Charge on the capacitor increases  
 c) Voltage of the capacitor increases      d) The capacitance increases

566. A negative charge is moved by an external agent in the direction of electric field



Then

- a) Potential energy of the charge increase      b) Potential energy of the charge decrease  
 c) Positive work is done by the electric field      d) Negative work is done by the electric field

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

- a) Periodic, for all values of  $z_0$  satisfying  $0 < z_0 < \infty$       b) Simple harmonic, for all values of  $z_0$  satisfying  $0 \leq z_0 \leq R$   
 c) Approximately simple harmonic, provided  $z_0 \ll R$       d) Such that  $P$  crosses  $O$  and continues to move along the negative  $z$ -axis towards  $z_0 = -\infty$

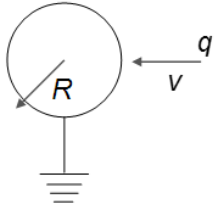


568. The electric potential in a region along the  $x$ -axis varies with  $x$  according to the relation  $V(x) = 4 + 5 \times x$ .

Then,

- a) Potential difference between the points  $x = 1$  and  $x = -2$  is 15 V
- b) The force experienced by the above will be towards the  $+x$ -axis
- c) A uniform electric field exists in this region along the  $+x$ -axis
- d) Force experienced by a 1 C charge at  $x = -1$  m will be 10 N

569. A charged particle having a positive charge  $q$  approaches a grounded metallic sphere of radius  $R$  with a constant small speed  $v$  as shown in Figure



In this situation,

- a) As the charge draws nearer to the surface of the sphere, a current flows into the ground
- b) As the charge draws nearer to the surface of the sphere, a current flows out of the ground into the sphere
- c) As the charged particle draws nearer, the magnitude of the current flowing in the connector joining the shell to the ground increases
- d) As the charged particle draws nearer, the magnitude of the current flowing in the connector joining the sphere to the ground decreases

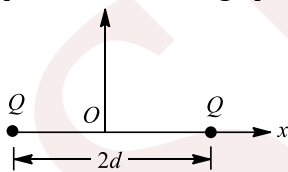
570. A circular ring of radius  $R$  with uniformly distributed charge  $q$  is placed in their  $y$ - $z$  plane with its centre at the origin. Select the correct statement(s) out of the following.

- a) The electric intensity is maximum at  $x = \pm\sqrt{2}R$
- b) The electric intensity is maximum at  $x = \pm\frac{\sqrt{2}}{2}R$
- c) The maximum intensity has a magnitude  $\frac{q}{6\sqrt{3}\pi\epsilon_0 R^2}$
- d) The maximum intensity is  $\frac{q}{6\sqrt{6}\pi\epsilon_0 R^2}$

571. About an electric field, which of the following statements are false?

- a) If  $E = 0, V$  must be zero
- b) If  $V = 0, E$  must be zero
- c) If  $E \neq 0, V$  cannot be zero
- d) If  $V \neq 0, E$  cannot be zero

572. Consider two identical charges placed distance  $2d$  apart, along the  $x$ -axis (figure). The equilibrium of a positive test charge placed at point  $O$  midway between them is



- a) Stable for displacements along the  $x$ -axis
- b) Neutral
- c) Unstable for displacement along the  $y$ -axis
- d) Stable for displacements along the  $y$ -axis



## 2. ELECTROSTATIC POTENTIAL AND CAPACITANCE

### : ANSWER KEY :

1)	a	2)	a	3)	d	4)	b	161)	b	162)	b	163)	c	164)	d
5)	c	6)	a	7)	b	8)	a	165)	c	166)	b	167)	d	168)	a
9)	d	10)	b	11)	c	12)	c	169)	b	170)	d	171)	a	172)	a
13)	d	14)	b	15)	b	16)	b	173)	a	174)	a	175)	c	176)	a
17)	b	18)	c	19)	c	20)	b	177)	d	178)	d	179)	a	180)	d
21)	d	22)	b	23)	d	24)	d	181)	a	182)	a	183)	b	184)	a
25)	c	26)	d	27)	c	28)	a	185)	a	186)	a	187)	b	188)	b
29)	a	30)	c	31)	c	32)	a	189)	a	190)	c	191)	c	192)	c
33)	a	34)	b	35)	a	36)	b	193)	a	194)	a	195)	d	196)	a
37)	b	38)	a	39)	a	40)	c	197)	b	198)	a	199)	b	200)	b
41)	a	42)	c	43)	b	44)	a	201)	d	202)	b	203)	d	204)	b
45)	d	46)	c	47)	b	48)	d	205)	c	206)	a	207)	c	208)	d
49)	d	50)	c	51)	d	52)	c	209)	a	210)	b	211)	a	212)	d
53)	c	54)	a	55)	c	56)	c	213)	b	214)	b	215)	c	216)	a
57)	d	58)	a	59)	a	60)	b	217)	a	218)	d	219)	d	220)	c
61)	b	62)	b	63)	a	64)	b	221)	c	222)	a	223)	d	224)	d
65)	a	66)	b	67)	c	68)	b	225)	c	226)	a	227)	a	228)	c
69)	a	70)	a	71)	b	72)	a	229)	a	230)	d	231)	c	232)	a
73)	c	74)	c	75)	b	76)	b	233)	b	234)	c	235)	d	236)	d
77)	c	78)	d	79)	a	80)	a	237)	c	238)	c	239)	c	240)	c
81)	b	82)	c	83)	b	84)	a	241)	c	242)	b	243)	c	244)	a
85)	b	86)	b	87)	a	88)	a	245)	d	246)	d	247)	a	248)	c
89)	d	90)	c	91)	a	92)	b	249)	c	250)	a	251)	d	252)	c
93)	b	94)	b	95)	b	96)	a	253)	b	254)	c	255)	d	256)	b
97)	d	98)	d	99)	a	100)	c	257)	d	258)	b	259)	b	260)	b
101)	c	102)	d	103)	a	104)	d	261)	d	262)	d	263)	a	264)	c
105)	d	106)	c	107)	d	108)	a	265)	b	266)	c	267)	c	268)	d
109)	b	110)	c	111)	b	112)	c	269)	d	270)	c	271)	a	272)	b
113)	d	114)	a	115)	c	116)	a	273)	c	274)	a	275)	d	276)	b
117)	c	118)	c	119)	b	120)	a	277)	a	278)	a	279)	a	280)	a
121)	b	122)	d	123)	a	124)	c	281)	d	282)	b	283)	c	284)	c
125)	c	126)	b	127)	b	128)	b	285)	c	286)	a	287)	b	288)	a
129)	a	130)	b	131)	c	132)	d	289)	c	290)	c	291)	b	292)	a
133)	b	134)	b	135)	d	136)	a	293)	c	294)	a	295)	b	296)	a
137)	b	138)	c	139)	a	140)	c	297)	b	298)	b	299)	a	300)	b
141)	c	142)	c	143)	c	144)	a	301)	b	302)	b	303)	c	304)	d
145)	b	146)	d	147)	c	148)	c	305)	a	306)	d	307)	b	308)	b
149)	b	150)	c	151)	a	152)	c	309)	b	310)	b	311)	c	312)	a
153)	b	154)	a	155)	a	156)	a	313)	a	314)	d	315)	a	316)	d
157)	a	158)	b	159)	c	160)	b	317)	b	318)	c	319)	d	320)	b



321) a	322) d	323) d	324) d	477) a	478) b	479) b	480) a
325) d	326) a	327) c	328) d	481) d	482) b	483) d	484) d
329) d	330) a	331) b	332) a	485) c	486) d	487) a	488) b
333) d	334) a	335) d	336) a	489) a	490) b	491) b	492) a
337) c	338) a	339) d	340) d	493) c	494) a	495) a	496) a
341) b	342) d	343) d	344) d	497) c	498) b	499) b	500) d
345) a	346) d	347) d	348) d	501) b	502) b	503) b	504) b
349) b	350) b	351) b	352) a	505) c	506) b	507) a	508) c
353) a	354) d	355) c	356) c	509) d	510) b	511) b	512) b
357) a	358) b	359) b	360) c	513) d	514) b	1) a,b,c	2)
361) a	362) c	363) c	364) b	a,d	3) a,b,c,d	4) b,c	
365) c	366) d	367) c	368) d	5) a,b,c,d	6) a,b,c	7) a,b,c,d	8)
369) c	370) a	371) c	372) c	a,b,d			
373) a	374) b	375) c	376) d	9) a,c,d	10) a,b,d	11) a,d	12)
377) d	378) c	379) c	380) d	a,d			
381) b	382) c	383) b	384) d	13) b,c,d	14) a,b,c	15) b,c	16)
385) a	386) a	387) b	388) d	a,b,c			
389) b	390) b	391) c	392) c	17) a,c	18) b,d	19) a,c,d	20)
393) a	394) c	395) d	396) a	a,b,c,d			
397) d	398) a	399) b	400) b	21) a,c	22) c,d	23) a,c	24)
401) c	402) b	403) a	404) a	a,d			
405) a	406) d	407) a	408) d	25) c,d	26) b,c,d	27) a,b,c,d	28)
409) b	410) b	411) a	412) d	a,c,d			
413) b	414) b	415) b	416) a	29) b,c,d	30) b,c	31) c,d	32)
417) c	418) b	419) b	420) d	b,c,d			
421) c	422) a	423) d	424) b	33) a,c	34) a,c,d	35) a,c	36)
425) a	426) b	427) b	428) d	b,c			
429) a	430) d	431) d	432) a	37) b,c	38) a,b	39) a,d	40)
433) c	434) c	435) b	436) a	a,c			
437) a	438) d	439) b	440) b	41) b,c,d	42) a,d	43) a,c	44)
441) a	442) b	443) a	444) b	a,c,d			
445) c	446) d	447) a	448) a	45) a,d	46) a,b,c	47) a,b	48)
449) c	450) c	451) d	452) d	a,b,c			
453) a	454) d	455) d	456) b	49) b,c	50) c,d	51) a,c	52)
457) b	458) c	459) b	460) d	a,d			
461) d	462) c	463) d	464) a	53) a,c	54) a,c,d	55) a,c	56)
465) d	466) b	467) d	468) b	b,c			
469) a	470) c	471) c	472) a	57) a,b,c,d	58) a,c		
473) c	474) a	475) c	476) c				

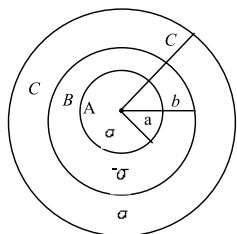


## 2. ELECTROSTATIC POTENTIAL AND CAPACITANCE

### : HINTS AND SOLUTIONS :

1 (a)  
 $\frac{q_1}{1} = \frac{q_2}{2} = \frac{q_3}{3} = K$   
 $q_1 + q_2 + q_3 = 6$   
 Solving, we get  
 $K = 1$   
 $\Rightarrow q_3 = 3\mu\text{C}$

2 (a)  
 The electric potential on the surface of shell A



$$V_A = V_a + V_b + V_c$$

$$V_A = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_a}{a} + \frac{1}{4\pi\epsilon_0} \cdot \frac{q_b}{b} + \frac{1}{4\pi\epsilon_0} \cdot \frac{q_c}{c}$$

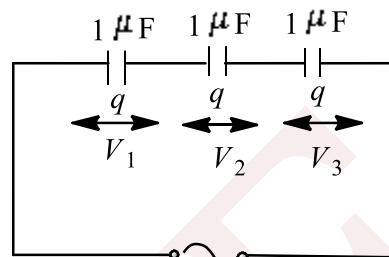
Or

$$V_A = \frac{1}{4\pi\epsilon_0} \cdot \frac{4\pi a^2 \sigma}{a} + \frac{1}{4\pi\epsilon_0} \cdot \frac{4\pi b^2 (-\sigma)}{b} + \frac{1}{4\pi\epsilon_0} \cdot \frac{4\pi c^2 \sigma}{c}$$

$$(\because q = 4\pi r^2 \sigma)$$

$$\text{or } V_A = \frac{\sigma}{\epsilon_0} (a - b + c)$$

3 (d)  
 Let potential difference between the plates of the capacitors  $C_1, C_2$  and  $C_3$  be  $V_1, V_2$  and  $V_3$  and  $q$  be the charge.



$$V = 11 \text{ volt}$$

$$\text{Then, } V = \frac{q}{C_1}, V_2 = \frac{q}{C_2}, V_3 = \frac{q}{C_3}$$

The total potential difference  $V = 11$  volt

$$\therefore V = V_1 + V_2 + V_3$$

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

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

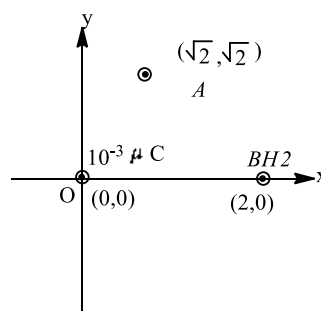
$$\therefore 11 = q \left( \frac{1}{1} + \frac{1}{2} + \frac{1}{3} \right)$$

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

$$\Rightarrow q = 6\mu\text{C}$$

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

4 (b)  
 Potential at A due to charge at O



$$V_A = \frac{1}{4\pi\epsilon_0} \frac{(10^{-3})}{OA}$$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{(10^{-3})}{\sqrt{(\sqrt{2})^2 + (\sqrt{2})^2}}$$

Potential at B due to charge at O



$$V_B = \frac{1}{4\pi\epsilon_0} \cdot \frac{(10^{-3})}{OB}$$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{(10^{-3})}{2}$$

So,

$$V_A - V_B = 0$$

- 6 (a) Since,  $C_1$  and  $C_2$  are parallel to their equivalent capacitance will be  $(C_1 + C_2)$ . Now,  $(C_1 + C_2)$  and  $C_3$  are in series, so the net equivalent capacitances of circuit.

$$\frac{1}{C} = \frac{1}{C_1 + C_2} + \frac{1}{C_3}$$

$$= \frac{C_1 + C_2 + C_3}{(C_1 + C_2)C_3}$$

$$C = \frac{(C_1 + C_2)C_3}{C_1 + C_2 + C_3}$$

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

$$C' = C_1 + C_2$$

$$\therefore \text{New charge stored}$$

$$q' = C'V$$

$$q' = (C_1 + C_2)V$$

Change in total charge

$$\Delta q = q' - q \quad (\because q' > q)$$

$$= (C_1 + C_2)V - \frac{(C_1 + C_2)C_3V}{C_1 + C_2 + C_3}$$

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

$$\Delta q = (C_1 + C_2)V \left[ 1 - \frac{C_3}{C_1 + C_2 + C_3} \right]$$

- 7 (b) At equatorial point

$$E_e = \frac{1}{4\pi\epsilon_0} \frac{p}{r^3}$$

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

- 8 (a)
- $$V_B - V_A = - \left[ \int_1^2 2dx + \int_2^1 3dy \right]$$

$$= -[2(2 - 1) + 3(1 - 2)]$$

$$= -[2 - 3] = 1 \text{ V}$$

Hence,  $V_A - V_B = -1 \text{ V}$

- 9 (d) At each point on the surface of a conducting sphere the potential is equal.

$$\text{So, } V_A = V_B = V_C$$

- 10 (b)  $W_{eq} = q(V_A - V_B)$   
 $50 \times 10^{-6} = 2 \times 10^{-6}(V_A - V_B)$   
 $V_A - V_B = 25 \text{ V}$

- 11 (c) In series combination,
- $$\frac{1}{C_1} = \frac{1}{1} + \frac{1}{2} + \frac{1}{4} = \frac{4 + 2 + 1}{4} = \frac{7}{4}$$
- $$\Rightarrow C_1 = \frac{4}{7} \mu\text{F}$$

In parallel combination,

$$C_2 = 1 + 2 + 4 = 7 \mu\text{F}$$

$$\therefore \frac{C_1}{C_2} = \frac{4/7}{7} = \frac{4}{49}$$

- 12 (c) When a capacitor is charged, work is done by the charging battery. As the capacitor charges, the potential difference across its plates rises. The total amount of work in charging the capacitor is stored up in the capacitor, in the form of electric potential energy between the plates.

- 13 (d)  $W = q(V_f - V_i) = 0$ , since  $V_f = V_i$

- 14 (b) Capacitance of two capacitors each of area  $\frac{A}{2}$ , plate separation  $d$  but dielectric constants  $K_1$  and  $K_2$  respectively joined in parallel

$$C_1 = \frac{K_1\epsilon_0 \left(\frac{A}{2}\right)}{d/2} + \frac{K_2\epsilon_0 \left(\frac{A}{2}\right)}{d/2} = \frac{(K_1 + K_2)\epsilon_0 A}{d}$$

It is in series with a capacitor of plate area  $A$ , plate separation  $d/2$  and dielectric constant  $K_3$  i.e.,  $C_2 = \frac{K_3\epsilon_0 A}{d/2}$ .

If resultant capacitance be taken as  $C = \frac{K\epsilon_0 A}{d}$ ,

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

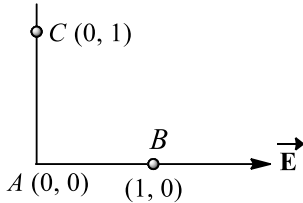
$$\therefore \frac{d}{K\epsilon_0 A} = \frac{d}{(K_1 + K_2)\epsilon_0 A} + \frac{d/2}{K_3\epsilon_0 A}$$



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

15 (b)

As electric field is along positive  $x$ -axis and  $E = -\frac{dV}{dx}$ , hence potential at  $A$  must be greater than that at  $B$  i.e.,  $V_A > V_B$



16 (b)

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

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

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

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

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

$$U = 0.32 \text{ J}$$

17 (b)

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

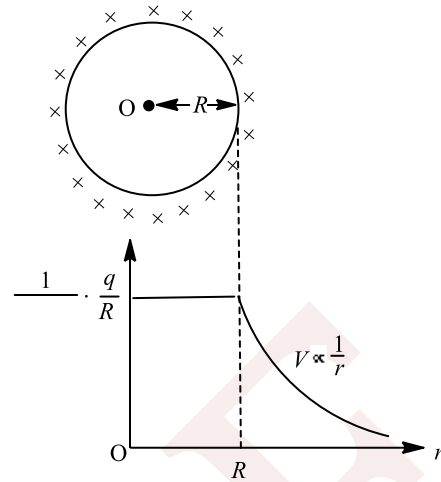
$$C_s = \frac{2}{3} \text{ F}$$

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

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

18 (c)

If we take a charge from one point to another inside a charged spherical shell, then no work will be done. This means that inside a spherical charge the potential at all points is the same and its value is equal to that on the surface, that is



$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{R} \text{ volt}$$

Also outside the metallic sphere

$$V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r}$$

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

19 (c)

$p$  and  $q$  are in parallel and then  $r$  in series

20 (b)

Given, the capacity of capacitor,  $C = 10 \times 10^{-6}\mu\text{F}$

Potential  $V = 400\text{volt}$

Stored energy = Heat generated

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

0.8 J

21 (d)

$$q_i = C_i V = 2V = q$$

(say)

This charge will remain constant after switch is shifted from position 1 to position 2.

$$U_i = \frac{1}{2} \frac{q^2}{C_i} = \frac{q^2}{2 \times 2} = \frac{q^2}{4}$$

$$U_f = \frac{1}{2} \frac{q^2}{C_f} = \frac{q^2}{2 \times 10} = \frac{q^2}{20}$$

$\therefore$  Energy dissipated ( $\frac{q^2}{5}$ ) is 80% of the initial

stored energy ( $= \frac{q^2}{4}$ ).

22 (b)

The two charges form an electric dipole and for this dipole any point on  $y$ -axis is at the equatorial



line. Hence,  $\vec{E}$  at all point on y-axis will be in a direction opposite to  $\vec{p}$  and  $\vec{p}$  is along negative x-axis. So  $\vec{E}$  is along positive x-axis, i.e., along  $\hat{i}$ .

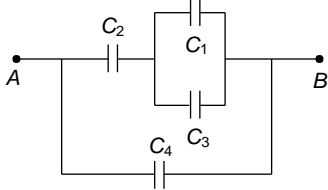
23 (d)

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

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

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

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



24 (d)

The arrangement of  $n$  metal plates separated by dielectric acts as parallel combination of  $(n - 1)$  capacitors.

$$\text{Therefore, } C = \frac{(n-1)K\epsilon_0 A}{d}$$

$$\text{Here, } C = 100 \text{ pF} \\ = 100 \times 10^{-12} \text{ F}$$

$$K = 4, \epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \\ A = \pi r^2 = 3.14 \times (1 \times 10^{-2})^2 \\ d = 1 \text{ mm} = 1 \times 10^{-3}$$

$$\therefore 100 \times 10^{-12} = \frac{(n-1) \times 4 \times (8.85 \times 10^{-12}) \times 3.14 \times (1 \times 10^{-2})^2}{1 \times 10^{-3}}$$

$$\text{or } n = \frac{1111.156}{111.156} = 9.99 \approx 10$$

25 (c)

$$\frac{kQ}{x} = \frac{1}{2} \left( \frac{3kQ}{R} \right) \Rightarrow x = 4R/3$$

Distance from surface :  $x - R = R/3$

26 (d)

When two conductors of capacities  $C_1$  and  $C_2$  and potentials  $V_1$  and  $V_2$  are connected by a conducting wire, charge redistributes in these conductors till potential of both the conductors become equal, known as common potential.

$$\text{Common potential} = \frac{\text{net charge}}{\text{total capacity}}$$

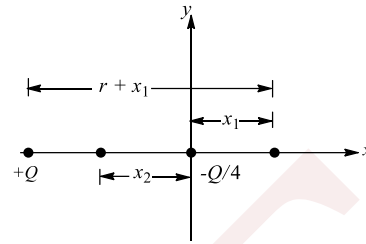
$$\text{i.e. } V = \frac{q_1 + q_2}{C_1 + C_2}$$

$$\text{or } V = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$$

27 (c)

$$\frac{kQ}{4x_1} = \frac{kQ}{r + x_1} \Rightarrow r + x_1 = 4x_1 \Rightarrow x_1 = r/3$$

$$\frac{kQ}{4x_2} = \frac{kQ}{r - x_2} \Rightarrow x_2 = \frac{r}{5}$$



28 (a)

Potential energy of the system

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

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

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

29 (a)

Required work done,

$$W = QV$$

$$= (2e) \times 25$$

$$= 50e = 50 \times 1.6 \times 10^{-19}$$

$$= 8 \times 10^{-18} \text{ J}$$

30 (c)

$$\frac{\epsilon_0 A}{d} = \frac{\epsilon_0 A}{d' - t + \frac{t}{K}}$$

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

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

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

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

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

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

$$\therefore K = 5$$

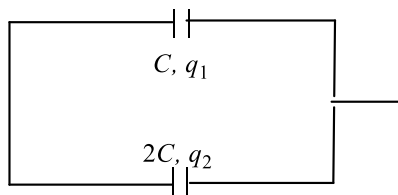
31 (c)

The charge  $q_1 = CV_0$

or



$$V_0 = \frac{q_1}{C} \quad \dots(i)$$



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

$$\therefore \text{For second capacitor } V_0 = \frac{q_2}{2C} \quad \dots(ii)$$

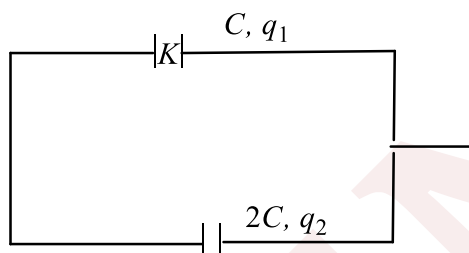
From Eqs. (i) and (ii),

$$q_2 = 2q_1 \quad \dots(iii)$$

After disconnecting the battery, the region between the plates of the capacitor  $C$  is completely filled with a material of dielectric constant ( $K = 2$ ).

$$\text{Then, } V_1 = \frac{q_1}{CK} = \frac{q_1}{2C}$$

$$\text{and } V_1 = \frac{q_2}{2C} = \frac{2q_1}{2C} = \frac{q_1}{C} \quad [\text{from Eq. (iii)}]$$



Charge will flow from 2 to 1 till

$$\frac{q'_2}{2C} = \frac{q'_1}{KC}$$

$$\frac{q'_2}{2C} = \frac{q'_1}{2C}$$

$$\text{ie, } q'_1 = q'_2$$

$$\text{Earlier potential } V_0 = \frac{q_1}{C}$$

$$\text{Now it is } V_0 = \frac{q'_1}{2C}$$

$$\text{Now, } q_1 + q_2 = 3q_1 \quad [\text{from Eq.(iii)}]$$

$$\text{and } q'_1 + q'_2 = 3q_1$$

$$\text{or } 2q'_1 = 3q_1 \text{ or } q'_1 = \frac{3q_1}{2}$$

$$\therefore \text{Now potential } \frac{q'_1}{2C} = \frac{3q_1}{4C}$$

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

$$[\because q_1 = V_0 C]$$

32 (a)

The potential  $V_1$  of smaller sphere is given by

$$V_1 = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r} + \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R} \quad \dots \dots (i)$$

The potential  $V_2$  of bigger sphere is given by

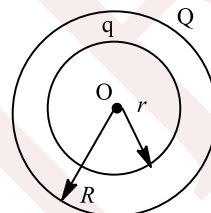
$$V_2 = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R} + \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{R}$$

So, the potential difference between the plates

$$V = V_1 - V_2$$

Or

$$\begin{aligned} V &= \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r} + \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R} - \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R} - \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{R} \\ &= \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r} - \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{R} = \frac{1}{4\pi\epsilon_0} \left( \frac{q}{r} - \frac{q}{R} \right) \end{aligned}$$



33 (a)

The energy which is stored in the condenser is given by

$$E = \frac{1}{2} \cdot \frac{q^2}{C} \quad \dots(i)$$

where  $q$  is charge and  $C$  the capacitance.

$$\text{Also, } C = \frac{\epsilon_0 A}{d} \quad \dots(ii)$$

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

$$E = \frac{1}{2} \cdot \frac{q^2 d}{\epsilon_0 A} \Rightarrow E \propto d$$

When plate separation ( $d$ ) is increased energy increases.

34 (b)

$$V = 10r = 10\sqrt{x^2 + y^2 + z^2}$$

$$\begin{aligned} E_x &= -\frac{dv}{dx} = -\frac{10(2x)}{2\sqrt{x^2 + y^2 + z^2}} \\ &= \frac{-10}{\sqrt{x^2 + y^2 + z^2}} = \frac{-10 \times 3}{\sqrt{x^2 + 4^2 + 5^2}} = -3\sqrt{2} \end{aligned}$$

$$\text{Similarly, } E_y = -4\sqrt{2}$$

$$E_z = 5\sqrt{2}; \vec{E} = E_x \hat{i} + E_y \hat{j} + E_z \hat{k}$$

35 (a)



Let  $R$  and  $r$  be the radii of bigger and each smaller drop respectively

$$\therefore \frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$$

$$\Rightarrow R = 2r \quad \dots(i)$$

The capacitance of a smaller spherical drop is

$$C = 4\pi\epsilon_0 r \quad \dots(ii)$$

The capacitance of bigger drop is

$$C' = 4\pi\epsilon_0 R$$

$$= 2 \times 4\pi\epsilon_0 r \quad (\because R = 2r)$$

$$= 2C \quad [\text{From Eq. (ii)}]$$

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

$$= \frac{1}{2}\mu\text{F} \quad (\because C' = 1\mu\text{F})$$

36 (b)

$E$  is a vector quantity,  $V$  is a scalar quantity

37 (b)

$$W_{BA} = q(V_A - V_B) = q \left[ \frac{Q}{4\pi\epsilon_0 a} - \frac{Q}{4\pi\epsilon_0 b} \right]$$

$$= \frac{qQ}{4\pi\epsilon_0} \left[ \frac{1}{a} - \frac{1}{b} \right]$$

38 (a)

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

$$\therefore V \propto d$$

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

39 (a)

By using  $W = Q(\mathbf{E} \cdot \Delta\mathbf{r})$

$$\Rightarrow W = Q[e_1\hat{i} + e_2\hat{j} + e_3\hat{k}] \cdot (a\hat{i} + b\hat{j})$$

$$= Q(e_1a + e_2b)$$

40 (c)

At junction  $A$ ,  $Q_1$  will divide into  $Q_2$  and  $Q_3$ . Hence,  $Q_1 = Q_2 + Q_3$

$C_2$  and  $C_3$  are in parallel, so potential on them will be the same, i.e.,  $V_2 = V_3$

$V$  will divide into  $V_1$  and  $V_2$  (or  $V_3$ )

Hence,  $V = V_1 + V_2$  or  $V = V_1 + V_3$

41 (a)

As we add  $-3Q$  charge on the surface, the potential on the surface changes by the same amount as that inside. Therefore, the potential difference remains the same

42 (c)

Net dipole moment =  $\sqrt{3}qa$

$$\tau = -\sqrt{3}qa \frac{|\sigma_1 - \sigma_2|\theta}{2\epsilon_0} = l\alpha$$

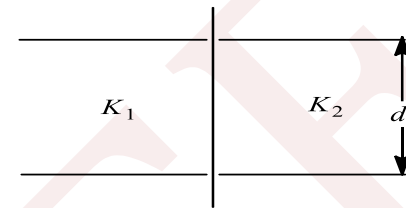
$$\frac{\sqrt{3}qa|\sigma_1 - \sigma_2|}{2\epsilon_0} = l \left( \frac{2\pi}{T} \right)^2$$

$$T = 2\pi \sqrt{\frac{2\epsilon_0 l}{\sqrt{3}qa|\sigma_1 - \sigma_2|}}$$

43

(b)

Initially, the capacitance of capacitor



$$C = \frac{\epsilon_0 A}{d}$$

$$\therefore \frac{\epsilon_0 A}{d} = 1\mu\text{F}$$

...(i)

When it is filled with dielectric of dielectric constant  $K_1$  and  $K_2$  as shown, then there are two capacitors connected in parallel. So,

$$C' = \frac{K_1 \epsilon_0 \left(\frac{A}{2}\right)}{d} + \frac{K_2 \epsilon_0 \left(\frac{A}{2}\right)}{d}$$

(as area

becomes half)

$$C' = \frac{4\epsilon_0 A}{2d} + \frac{6\epsilon_0 A}{2d} = \frac{2\epsilon_0 A}{d} + \frac{3\epsilon_0 A}{d}$$

Using Eq. (i), we obtain

$$C' = 2 \times 1 + 3 \times 1 = 5 \mu\text{F}$$

44

(a)

$$\text{Here, } U_1 = \frac{Q(-q)}{4\pi\epsilon_0 r}; U_2 = \frac{Q(-q)}{4\pi\epsilon_0 (r/2)}$$

$$U_1 - U_2 = \frac{Q(-q)}{4\pi\epsilon_0} \left[ \frac{1}{r} - \frac{2}{r} \right]$$

$$= \frac{Qq}{4\pi\epsilon_0} = 9 \quad \dots(i)$$

When negative charge travels first half of distance, i.e.,  $r/4$ , potential energy of the system

$$U_3 = \frac{Q(-q)}{4\pi\epsilon_0 (3r/4)} = -\frac{Qr}{4\pi\epsilon_0 r} \times \frac{4}{3}$$

$$\therefore \text{work done} = U_1 - U_3$$

$$= \frac{Q(-q)}{4\pi\epsilon_0 r} + \frac{Qr}{4\pi\epsilon_0 r} \times \frac{4}{3}$$

$$= \frac{Qq}{4\pi\epsilon_0 r} \times \frac{1}{3} = \frac{9}{3} = 3\text{J}$$

45

(d)



Potential due to charge  $-q$  at A

$$V_A = \frac{1}{4\pi\epsilon_0 k} \frac{-q}{(r^2)^{1/2}}$$

Potential due to charge  $-q$  at B

$$V_B = \frac{1}{4\pi\epsilon_0 k} \frac{-q}{(r^2)^{1/2}}$$

Potential due to charge  $-q$  at C

$$V_C = \frac{1}{4\pi\epsilon_0 k} \frac{-q}{(r^2)^{1/2}}$$

Total potential at centre.

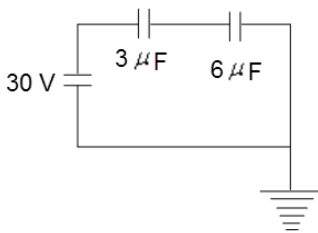
$$V = V_A + V_B + V_C$$

$$V = 0$$

From charge configuration at the centre electric field in non zero.

46 (c)

Circuit is redrawn as shown in Figure



Equivalent capacity of combination

$$C_{eq} = \frac{3 \times 6}{9} = 2 \mu\text{F}$$

Hence, charge  $q = C_{eq}V$

$$q = 2 \mu\text{F} \times 30 \text{ V} = 60 \mu\text{C}$$

47 (b)

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

$$C_s = 2 \mu\text{F}$$

$$C_p = 4 + 6 + 12 = 22 \mu\text{F}$$

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

48 (d)

$$C_{eq} = \frac{\epsilon_0}{\frac{d}{K_1} + \frac{d}{K_2} + \frac{d}{K_3}}$$

Here,  $K_1 = K_3 = 1, K_2 = \epsilon/\epsilon_0$

49 (d)

With  $S_1$  and  $S_3$  closed, the capacitors  $C_1$  and  $C_2$  are in series arrangement. In series arrangement potential difference developed across capacitors are in the inverse ratio of their capacities. Hence,

$$\frac{V'_1}{V'_2} = \frac{C_2}{C_1} = \frac{3pF}{3pF} = \frac{3}{2} \text{ and}$$

$$V'_1 + V'_2 = V_1 + V_2 = 30 + 20 = 50V$$

On simplification, we get  $V'_1 = V_1 = 30V$  and  $V'_2 = V_2 = 20V$

50 (c)

$Q = CV$ . As  $V$  is constant, therefore,  $Q \propto C$

Hence,  $C$  becomes  $\frac{100}{40} = 2.5$  times

$\therefore K = 2.5$

51 (d)

The electric field of a hollow spherical capacitor is localised in between inner and outer surface of the spherical conductor.

Therefore, at point  $r_1 < r < r_2$ , the electric field will not be zero.

52 (c)

The charge on capacitor before dielectric is

$$q_1 = CV = 50 \times 10^{-6} \text{ C}$$

Final charge on capacitor after dielectric is

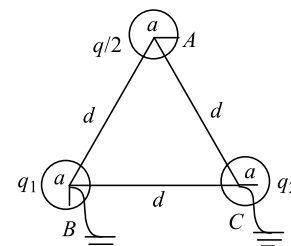
$$q_2 = (KC)V = 5 \times 50 \times 10^{-9} \\ = 250 \times 10^{-9} \text{ C}$$

Charge flow from battery,  $\Delta q = q_2 - q_1 = 200 \text{ nC}$

53 (c)

$$\frac{kq_1}{a} + \frac{kq}{2d} = 0 \Rightarrow q_1 = \frac{-qa}{2d}$$

$$\frac{kq_2}{a} + \frac{kq}{2d} + \frac{kq_1}{d} = 0 \Rightarrow q_2 = \frac{-qa}{2d} \left( \frac{d-a}{d} \right)$$



55 (c)

In steady state no current flows through the capacitor segment. The steady current in remaining loop  $I = \frac{2V-V}{2R+R} = \frac{V}{3R}$  (anti-clockwise).

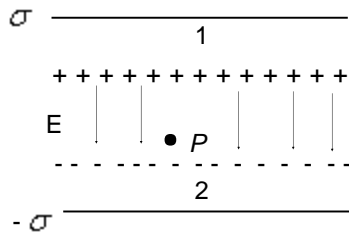
Now applying Kirchoff's second law to loop containing  $2V, 2R, C$  and  $V$ , we have  $V_c = 2V -$

$$1.2V - \frac{V}{3R} \cdot 2R - V = \frac{V}{3}$$

56 (c)



The situation is shown in the figure. Plate 1 has surface charge density  $\sigma$  and plate 2 has surface charge density  $-\sigma$ . The electric fields



at point  $P$  due to two charged plates add up, giving

$$E = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon_0}$$

Given,  $\sigma = 26.4 \times 10^{-12} \text{Cm}^{-2}$   
 $\epsilon_0 = 8.85 \times 10^{-12} \text{C}^2\text{N}^{-1}\text{m}^{-2}$

Hence,  $E = \frac{26.4 \times 10^{-12}}{8.85 \times 10^{-12}} \approx 3 \text{NC}^{-1}$

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

57 (d)

$V$  is a scalar quantity,  $E$  is a vector quantity

58 (a)

The points  $S$  and  $R$  are inside the uniform electric field, so these will be at equal potential.

59 (a)

$$\vec{E} = E_1\hat{i} + E_2\hat{j}$$

As  $W = \vec{F} \cdot \vec{r} = Q\vec{E} \cdot \vec{r}$

$$= Q(E_1\hat{i} + E_2\hat{j}) \cdot (a\hat{i} + b\hat{j})$$

$$= QE_1a + QE_2b = Q(E_1a + E_2b)$$

60 (b)

Electric field will remain the same, because electric field due to surface charge distributed uniformly will be zero at any point inside the sphere

61 (b)

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

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

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

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

$$\Rightarrow V_{\text{out}} = \frac{2}{3}V$$

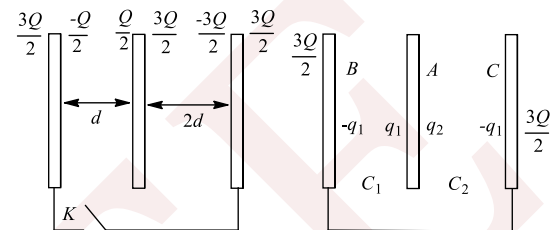
62 (b)

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

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

$$= -qEa$$

63 (a)



$$q_1 + q_2 = 2Q$$

$$V_{AB} = V_{AC} \Rightarrow \frac{q_1}{C_1} = \frac{q_2}{C_2}$$

$$\frac{q_1}{q_2} = \frac{C_1}{-C_2} = 2 \Rightarrow q_1 = 2q_2$$

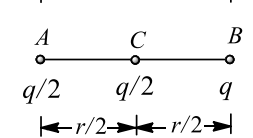
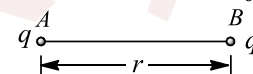
Solving, we get  $q_1 = \frac{4Q}{3}, q_2 = \frac{2Q}{3}$

Charge flown through  $K$ :

$$= -\frac{Q}{2} - (-q_1) = -\frac{Q}{2} + \frac{4Q}{3} = 5Q/6$$

64 (b)

Initially,  $F_{AB} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q \cdot q}{r^2} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{r^2}$



Finally, force on

$$F_C = F_{AB} - F_{CA} = \frac{1}{4\pi\epsilon_0} \cdot \frac{\left(\frac{q}{2}\right)(q)}{\left(\frac{r}{2}\right)^2} - \frac{1}{4\pi\epsilon_0} \cdot \frac{\left(\frac{q}{2}\right)\left(\frac{q}{2}\right)}{\left(\frac{r}{2}\right)^2}$$

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

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

65 (a)

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

66 (b)

In parallel, potential is same, say  $V$



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

67 (c)

Here,

$$\begin{aligned} \vec{E} &= \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = \\ &= \left(+\frac{\sigma}{2\epsilon_0}\right)(-\hat{k}) + \left(\frac{2\sigma}{2\epsilon_0}\right)(-\hat{k}) + \left(\frac{\sigma}{2\epsilon_0}\right)(-\hat{k}) \\ &= -\left(\frac{2\sigma}{\epsilon_0}\right) \cdot \hat{k} \end{aligned}$$

68 (b)

Potential decreases in the direction of electric field. Hence, electric field should be along PA

$$E = \frac{\Delta V}{\Delta r} = \frac{5 - 2}{0.1 \times \sqrt{2}} = 15\sqrt{2} \text{ V/m}$$

69 (a)

Inside the hollow sphere,  $V = \text{constant} = \text{potential on the surface of the sphere}$ . Outside the sphere,  $V \propto \frac{1}{r}$ . Hence figure (a) represents the correct graph.

70 (a)

$$u = \frac{q^2}{2C} = \frac{(8 \times 10^{-18})^2}{2 \times 100 \times 10^{-6}} = \frac{64 \times 10^{-36}}{2 \times 10^{-4}} = 32 \times 10^{-32} \text{ J}$$

71 (b)

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

$\therefore$  Distance of point from origin,

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

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

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

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

$\therefore E \propto r$

72 (a)

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

$$\text{From } C = \frac{4\pi\epsilon_0 r_a r_b}{r_b - r_a}$$

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

$$r_b^2 = 9, r_b = 3\text{m}$$

73 (c)

Charge resides only on the outer surfaces

74 (c)

$$\int \vec{E} \cdot d\vec{l} \rightarrow \text{NC}^{-1}\text{m} = \text{JC}^{-1}$$

75 (b)

Potential energy of an electron at any point is  $U = -eV$ , where  $V$  is the potential at that point.  $V$  is negative maximum at point B, hence  $U$  is maximum for this point

76 (b)

In capacitor, energy is stored in electric field between the plates.

Increase in energy

$$\begin{aligned} \Delta U &= U_f - U_i \\ &= \frac{1}{2}CV_f^2 - \frac{1}{2}CV_i^2 = \frac{1}{2}C(V_f^2 - V_i^2) \end{aligned}$$

Given,  $C = 6\mu\text{F} = 6 \times 10^{-6}$ ,  $V_i = 10$  volt,  $V_f = 20$  volt

$$\begin{aligned} \therefore \Delta U &= \frac{1}{2} \times 6 \times 10^{-6} [(20)^2 - (10)^2] \\ &= 3 \times 10^{-6} \times 300 = 9 \times 10^{-4} \text{ J} \end{aligned}$$

77 (c)

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

$$\begin{aligned} &= \frac{1}{2} \times 5 \times 10^{-6} \times (800)^2 \\ &= 1.6 \text{ J} \end{aligned}$$

78 (d)

For equilibrium net electric force on any charge (say charge  $-Q$  at A) should be zero. Hence,

$$\vec{F}_A = \vec{F}_{AB} + \vec{F}_{AD} + \vec{F}_{AC} + \vec{F}_{AO} = \vec{0}, \vec{F}_{AB} = \frac{1}{4\pi\epsilon_0} \frac{Q^2}{a^2}$$

along

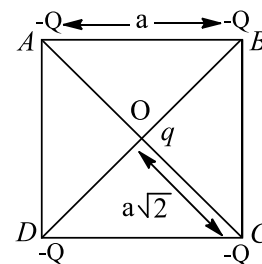
$$BA, \vec{F}_{AD} = \frac{1}{4\pi\epsilon_0} \frac{Q^2}{a^2} \text{ along } DA, \vec{F}_{AC} = \frac{1}{4\pi\epsilon_0} \frac{Q^2}{a^2} \text{ along}$$

$$CA, \text{ and } \vec{F}_{OA} = -\frac{1}{4\pi\epsilon_0} \frac{2Qq}{a^2} \text{ along } AO$$

$$\text{Resultant of } \vec{F}_{AB} \text{ and } \vec{F}_{AD} = \frac{1}{4\pi\epsilon_0} \frac{Q^2}{a^2} \sqrt{2} \text{ along } COA,$$

$$\therefore \vec{F}_A = \frac{1}{4\pi\epsilon_0} \frac{Q^2}{a^2} \sqrt{2} + \frac{1}{4\pi\epsilon_0} \frac{Q^2}{2a^2} - \frac{1}{4\pi\epsilon_0} \frac{2Qq}{a^2} = \vec{0}$$

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



79 (a)

Given plates can be rearranged as shown:

$$C_1 = \frac{\epsilon_0 A}{d}; C_2 = \frac{\epsilon_0 A}{2d}$$



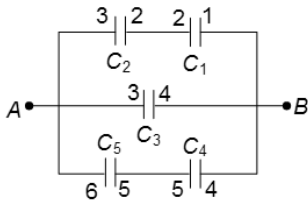
$$C_3 = \frac{\epsilon_0 A}{3d}; C_4 = \frac{\epsilon_0 A}{2d}; C_5 = \frac{\epsilon_0 A}{d}$$

$C_1$  and  $C_2$  are in series and its effective capacity is

$$\frac{\frac{\epsilon_0 A}{d} \times \frac{\epsilon_0 A}{2d}}{\frac{\epsilon_0 A}{d} + \frac{\epsilon_0 A}{2d}} = \frac{\epsilon_0 A}{3d}$$

Effective capacitance of  $C_4$  and  $C_5 = \frac{\epsilon_0 A}{3d}$

$$\therefore C_{AB} = \frac{\epsilon_0 A}{3d} + \frac{\epsilon_0 A}{3d} + \frac{\epsilon_0 A}{3d} = \frac{\epsilon_0 A}{d}$$



80 (a)

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

81 (b)

Common potential of system

$$V = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$$

$$40 = \frac{10 \times 100 + C_2 \times 0}{10 + C_2}$$

$$\text{or } 40(10 + C_2) = 1000$$

$$\Rightarrow C_2 = 15 \mu\text{F}$$

82 (c)

A positively charged particle free to move in electric field will move in the direction of electric field whereas a negatively charged particle will move in opposite direction of the field

83 (b)

$$C_1 = \frac{K_1 \epsilon_0 A}{d/2} = \frac{2K_1 \epsilon_0 A}{d}$$

$$C_2 = \frac{2K_2 \epsilon_0 A}{d}$$

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{d}{2K_1 \epsilon_0 A} + \frac{d}{2K_2 \epsilon_0 A}$$

$$= \frac{d}{2\epsilon_0 A} \left( \frac{K_1 + K_2}{K_1 K_2} \right)$$

$$C_s = \frac{2\epsilon_0 A}{d} \left( \frac{K_1 K_2}{K_1 + K_2} \right)$$

84 (a)

$$\left( 0 - \frac{1}{2} m v^2 \right) = q(V_P - V_Q) \quad \dots(i)$$

$$\left( \frac{1}{2} m v_1^2 - \frac{1}{2} m v^2 \right) = -q(V_P - V_Q) \dots(ii)$$

From Eqs. (i) and (ii),  $v_1 = \sqrt{2}v$

85

(b)

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

The capacity of each capacitor,

$$C = \frac{\epsilon_0 A}{d}$$

$$= \frac{8.854 \times 10^{-12} \times 5 \times 10^{-4}}{0.885 \times 10^{-2}} = 0.5 \text{ pF}$$

Hence, the capacity of 8 capacitors

$$= 8C = 8 \times 0.5 = 4 \text{ pF}$$

86

(b)

Charge on each plate of each capacitor

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

$$= \pm 5 \times 10^{-3} \text{ C}$$

87

(a)

Effective capacitance of  $C_2$  and  $C_3$

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

$$\therefore C = 1 \mu\text{F}$$

Now,  $C_1$  and  $C$  are in parallel, therefore effective capacitance  $C'$

$$C' = 1 + 1 = 2 \mu\text{F}$$

Now,  $C'$  and  $C_4$  are in series, therefore, effective capacitance between points A and B

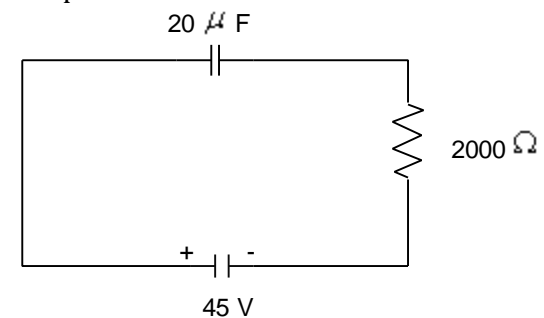
$$\frac{1}{C''} = \frac{1}{2} + \frac{1}{4} = \frac{3}{4}$$

$$\Rightarrow C'' = \frac{4}{3} \mu\text{F}$$

88

(a)

We know that in steady state the capacitor behaves like as an open circuit *ie*, capacitor will not pass the current.



So, the potential difference across the capacitor = 45 V

Hence, the final charge on the capacitor is



$$q = CV$$

Here,  $C = 20\mu\text{F}$ ,  $V = 45\text{ V}$

$$\therefore q = 20 \times 10^{-6} \times 45$$

$$\text{or } q = 900 \times 10^{-6}$$

$$\text{or } q = 9 \times 10^{-4}\text{ C}$$

89 (d)

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

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

Capacitance between A and B

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

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

90 (c)

Potential at a point in a field is defined as the amount of work done in bringing a unit positive test charge, from infinity to that point along any arbitrary path, *i. e.*,

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

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

91 (a)

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

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

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

$$C_2 = 25 - C_1 = 25 - 10 = 15 \mu\text{F}$$

92 (b)

From Gauss's law,  $\phi = \frac{q}{\epsilon_0}$

$$\text{So, } \frac{\phi_{\max}}{\phi_{\min}} = \frac{Q_{\max}}{Q_{\min}} = \frac{\lambda(l^2 + b^2 + h^2)^{1/2}}{\lambda h}$$

$$= \frac{\sqrt{l^2 + b^2 + h^2}}{h}$$

93 (b)

$$\vec{E}_1 = \frac{1}{4\pi\epsilon_0} \cdot \frac{2\vec{P}}{r^3} \text{ and}$$

$$\vec{E}_2 = -\frac{1}{4\pi\epsilon_0} \cdot \frac{\vec{P}}{(2r^3)} = -\frac{1}{4\pi\epsilon_0} \cdot \frac{\vec{P}}{8r^3}$$

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

(Here negative sign means direction)

94 (b)

Equal and opposite charges get induced on the inner surface of conductor, so the net charge enclosed by the surface is zero and hence flux crossing through the surface is zero

95 (b)

$$C_p = 3 + 3 = 6 \mu\text{F}$$

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

$$C_s = 2\mu\text{F}$$

96 (a)

Due to additional charge of  $-3Q$  given to external spherical shell, the potential difference between conducting sphere and the outer shell will not change because by presence of charge on outer shell, potential everywhere inside and on the surface of the shell will change by same amount. Therefore, the potential difference between sphere and shell remain unchanged.

97 (d)

Heat produced = energy stored in capacitor

$$\frac{1}{2} CV^2 = \frac{1}{2} (10 \times 10^{-6})(500)^2$$

$$= 1.25 \text{ J}$$

98 (d)

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

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

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

99 (a)

By definition  $\int_{l=\infty}^{l=0} -E \cdot dl = V$ , the potential at the

$$\text{centre of ring and } V = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R} = \frac{9 \times 10^9 \times 1.11 \times 10^{-10}}{0.5} =$$

$$2V$$

Hence value of given line integral is  $2V$ .

100 (c)

$$0 - \frac{Q}{C} + 10 - \frac{Q}{2C} = 0$$

$$Q = \frac{20C}{3} = \frac{20 \times 6}{3} = 40 \mu\text{C}$$

101 (c)

$$\phi = E(ds) \cos \theta = E(2\pi r^2) \cos 0^\circ = 2\pi r^2 E$$

102 (d)

$E = \sigma/\epsilon_0$ . The value of  $E$  does not depend upon radius of the sphere.

103 (a)

$$V_1 = \frac{C \times 100}{3C + C} = 25 \text{ V}, V_2 = 100 - 25 = 75 \text{ V}$$



104 (d)

Capacitance with air

$$C = \frac{A\epsilon_0}{d}$$

When interspace between the plates is filled with wax, then

$$C' = \frac{KA\epsilon_0}{2d}$$

or  $C' = \left(\frac{A\epsilon_0}{d}\right) \frac{K}{2}$

or  $C' = C \frac{K}{2}$

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

105 (d)

$$V_C = \frac{Q_1 + Q_2}{C_1 + C_2} = \frac{CV + 2CV}{KC + 2C} = \frac{3V}{K + 2}$$

106 (c)

Here, magnetic force = electrostatic force

$$qvB = qE$$

$$v = \frac{E}{B} = \frac{\sigma}{\epsilon_0 B}$$

The time taken by electron to travel a distance  $l$  in that space

$$t = \frac{1}{v} = \frac{l}{\frac{\sigma}{\epsilon_0 B}} = \frac{\epsilon_0 l B}{\sigma}$$

108 (a)

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

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

$\therefore$  charge on each capacitor

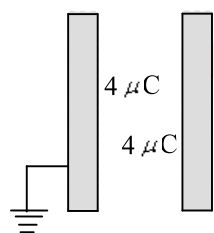
$$= C_s V = \frac{20}{3} \times 200 = \frac{4000}{3} \mu\text{C}$$

Common potential =  $\frac{\text{total charge}}{\text{total capacity}}$

$$= \frac{2 \times 4000/3}{10 + 20} = \frac{800}{9} \text{V}$$

109 (b)

Final charges will be as shown in Figure.



So, charge flowing from earth to plate = final charge - initial charge =  $-4 - 10 = -14 \mu\text{C}$

110 (c)

The arrangement shows a Wheatstone bridge.

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

$$\frac{1}{C_{s1}} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2}, C_{s1} = 2\mu\text{F}$$

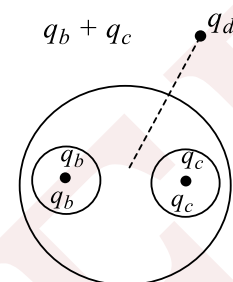
Similarly,  $C_{s2} = 2\mu\text{F}$

$\therefore$  effective capacitance

$$= C_p = C_{s1} + C_{s2} = 2 + 2 = 4\mu\text{F}$$

111 (b)

$$F_3 = \frac{k(a_b + q_d)}{r^2}$$



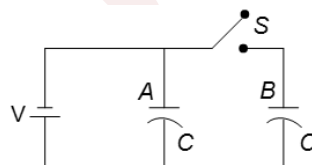
$$F_1 = F_2 = \text{zero}$$

112 (c)

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

113 (d)

$$\text{Initial total energy} = \frac{1}{2} CV^2 + \frac{1}{2} CV^2 = CV^2$$



When the switch is open, dielectric is introduced

Then capacitance  $C = KC = 3C$

$$\text{Energy stored in } C = \frac{1}{2} 3CV^2 = \frac{3}{2} CV^2$$

Since the switch is open, charge will be the same in B so

$$\text{Energy } B = \frac{1}{2} \frac{C}{3} V^2$$

$$\text{So, total final energy} = \frac{3}{2} CV^2 + \frac{1}{6} CV^2$$

$$= \frac{9CV^2 + 1CV^2}{6} = \frac{10}{6} CV^2$$

$$\text{So, required ratio} = \frac{CV^2}{\frac{10}{6} CV^2} = \frac{3}{5} = 3:5$$

114 (a)

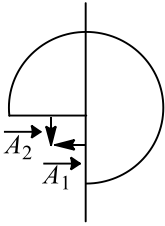
Electric field due to large metal plate =  $\sigma/\epsilon_0$

Since the electron has energy of 100 eV, so it can cross a potential difference of 100 V only. So

$$100 = \frac{\sigma}{\epsilon_0} d, \text{ solve to get } d$$



115 (c)



From Fig. we have

$$\vec{A}_1 = \frac{\pi R^2}{2} \hat{i}$$

$$\vec{A}_2 = \frac{\pi R^2}{2} \hat{j}$$

$$\vec{E} = E \cos 45^\circ \hat{i} + E \sin 45^\circ \hat{j} = \frac{E}{\sqrt{2}} \hat{i} + \frac{E}{\sqrt{2}} \hat{j}$$

$$\phi = \vec{E} \cdot (\vec{A}_1 + \vec{A}_2) = \frac{-E \pi R^2}{\sqrt{2}} \frac{1}{2} - \frac{E \pi R^2}{\sqrt{2}} \frac{1}{2}$$

$$\frac{\pi R^2 E}{\sqrt{2}}$$

This is the flux entering, so flux leaving =  $\frac{\pi R^2 E}{\sqrt{2}}$

116 (a)

Let radius of big drop be  $R$  and of smaller be  $r$ .  
Then,

Volume of bigger drop = 8 × volume of single drop

Also, since shape of drop is assumed spherical,  
volume of a sphere of radius  $a$  is  $\frac{4}{3} \pi a^3$

$$\therefore \frac{4}{3} \pi R^3 = 8 \times \frac{4}{3} \pi r^3$$

$$\Rightarrow = 2r$$

Capacitance of sphere of radius  $a$  is

$$C = 4\pi\epsilon_0 a$$

$\therefore$  Capacitance of big drop

$$C = 4\pi\epsilon_0 R$$

Capacitance of small drop

$$C' = 4\pi\epsilon_0 (2r)$$

$$\therefore \frac{C'}{C} = \frac{4\pi\epsilon_0 (2r)}{4\pi\epsilon_0 R} = \frac{2}{1}$$

117 (c)

This work done by us is stored in the capacitor in the volume  $A(d_2 - d_1)$  where new electric field is created. If you calculate the work done by using the expression

$$W_{ext} - W_{el} = dU = \frac{\epsilon_0 A V^2}{2} \left[ \frac{1}{d_2} - \frac{1}{d_1} \right] < 0, \text{ You may}$$

get confused. Here, battery is also doing work, do from energy conservation principle, we get

$$W_{est} + W_{el} + W_{battery} = 0$$

118 (c)

As potential at  $A$  and  $B$  is the same,  $V_A = V_B = kQ/d$ . So, work done in both the cases will be the same

119 (b)

Extra charge will flow through battery, so work is done by battery. External agent will do negative work

120 (a)

According to Gauss's law, electric field at any point on Gaussian surface is due to all the charges present inside or outside

121 (b)

Here,  $r_1 = 10$  cm,  $r_2 = 15$  cm,

$V_1 = 150$  V,  $V_2 = 100$  V

Common potential

$$V = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2} = \frac{4\pi\epsilon_0 (r_1 V_1 + r_2 V_2)}{4\pi\epsilon_0 (r_1 + r_2)}$$

$$= 120 \text{ V}$$

$$q_1 = C_1 V = 4\pi\epsilon_0 r_1 V = \frac{10^{-1}}{9 \times 10^9} \times 120C$$

$$= \frac{12}{9 \times 10^9} \times 3 \times 10^9 \text{ esu} = 4 \text{ esu}$$

122 (d)

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

$\therefore$  charge on smaller sphere after contact

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

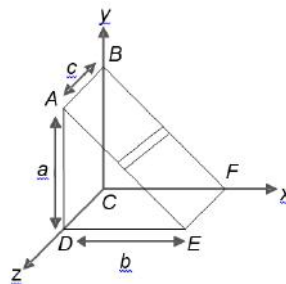
$$= \frac{4\pi\epsilon_0 r_1 (10^{-2} + 5 \times 10^{-2})}{4\pi\epsilon_0 (r_1 + r_2)}$$

$$= \frac{10^{-2} \times 6 \times 10^{-2}}{3 \times 10^{-2}} = 2 \times 10^{-2} C$$

123 (a)

$$\phi_{ABCD} = -acd \text{ unit}$$

$$\phi_{CDEF} = -bcE_0 \text{ unit}$$



$$\phi_{ABEF} = bcE_0 + c \int_0^a (d+x) dy$$



$$= +bcE_0 + acd + c \int_0^a xdy$$

$$= +bcE_0 + acd + \frac{ca}{b} \int_0^a xdx$$

[since  $\frac{x}{b} + \frac{y}{a} = 1 \Rightarrow \frac{dx}{b} = \frac{-dy}{a}$ ]

$$= \left[ +bcE_0 + acd + \frac{acd}{2} \right] \text{unit}$$

Using Gauss's law, we get

$$\phi_{net} = \frac{q_{in}}{\epsilon_0} \Rightarrow q_{in} = \frac{abc\epsilon_0}{2}$$

124 (c)

$$W = \frac{1}{2}C[(2V)^2 - V^2] = \frac{3}{2}CV^2$$

$$W' = \frac{1}{2}[(2V)^2 - (2V)^2] = 6CV^2$$

$$= \frac{6 \times 2W}{3} = 4W$$

125 (c)

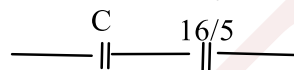
There are two capacitors in parallel

$$U = \frac{1}{2}CV^2, C = \frac{2\epsilon_0 A}{d}$$

126 (b)

$$3 = \frac{\frac{16}{5}C}{\frac{16}{5} + C}$$

or  $C = 48\mu\text{F}$



127 (b)

Initially, when the switch is closed on position 1, the capacitor  $C$  is connected in series with batteries  $E_1$  and  $E_2$ . From KVL, we have

$$\frac{Q_i}{C} = E_2 + E_1 = 0$$

Or  $Q_i = (E_2 - E_1)C$  (i)

Depending upon the sign of  $(E_2 - E_1)$ , charge  $Q_i$ , on the left plate may be positive

(if  $E_2 > E_1$ ), or negative (if  $E_2 < E_1$ ); charge on right plate would be equal and opposite

When the switch is moved to position 2, the left plate (earlier having charge  $+Q_i$ ) will now have charge

$$Q_f = -E_1C \quad \text{(ii)}$$

The net charge flow through the circuit is

$$\Delta Q = Q_f - Q_i = [-E_1 - (E_2 - E_1)]C = -E_2C$$

We can say that a net possible charge equal to  $E_2C$  is pulled by the battery of e.m.f.  $E_1$  from the left plate of the capacitor, which flows through battery  $E_1$  and is transferred to the right plate of the capacitor. Work done by battery  $E_1$  in the process of charge transfer is

$$\Delta W = E_1E_2C \quad \text{(iii)}$$

A part of this work changes the energy of the capacitor:

$$\Delta W_c = \frac{Q_f^2}{2C} - \frac{Q_i^2}{2C} = \frac{1}{2}E_1^2C - \frac{1}{2}(E_2 - E_1)^2C$$

$$= \frac{1}{2}(2E_1E_2 - E_2^2)C$$

And the remaining part is lost as joule heating:

$$H = \Delta W - \Delta W_c = \frac{1}{2}E_2^2C$$

128 (b)

Here,  $\text{KE} = 100 \text{ eV} = 100 \times 1.6 \times 10^{-19} \text{ J}$

This is lost when electron moves through a distance ( $d$ ) towards the negative plate.

$$\text{KE} = \text{work done} = F \times s \Rightarrow qE \times s = e \left( \frac{\sigma}{\epsilon_0} \right) d =$$

$$\left( \frac{(\text{KE})\epsilon_0}{e\sigma} \right)$$

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

$$= 4.43 \times 10^{-4} \text{ m}$$

$$= 0.443 \text{ mm}$$

129 (a)

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

130 (b)

Electric field will do the negative work, because the force of electric field is opposite to the displacement. So external agent has to do positive work. So its energy will be used

131 (c)

$$E_1 = E_2 \Rightarrow \frac{kQ_1}{r_1^2} = \frac{kQ_2}{r_2^2}$$

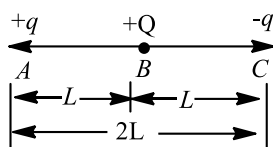
$$\frac{Q_1}{Q_2} = \left( \frac{r_1}{r_2} \right)^2$$

$$\frac{V_1}{V_2} = \frac{Q_1}{r_1} \times \frac{r_2}{Q_2} = \left( \frac{r_1}{r_2} \right)^2 \frac{r_2}{r_1} = \frac{r_1}{r_2}$$



132 (d)

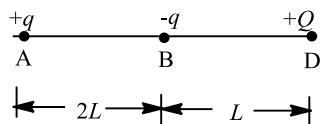
In 1st case, when charge  $+Q$  is situated at C.



Electric potential energy of system

$$U_1 = \frac{1}{4\pi\epsilon_0} \frac{(q)(-q)}{2L} + \frac{1}{4\pi\epsilon_0} \frac{(-q)Q}{L} + \frac{1}{4\pi\epsilon_0} \frac{qQ}{L}$$

In 2nd case, when charge  $+Q$  is moved from C to D.



Electric potential energy of system in that case

$$U_2 = \frac{1}{4\pi\epsilon_0} \frac{(q)(-q)}{2L} + \frac{1}{4\pi\epsilon_0} \frac{qQ}{3L} + \frac{1}{4\pi\epsilon_0} \frac{(-q)(Q)}{L}$$

$$\therefore \text{Work done} = \Delta U = U_2 - U_1$$

$$= \left( \frac{1}{4\pi\epsilon_0} \frac{q^2}{2L} + \frac{1}{4\pi\epsilon_0} \frac{qQ}{3L} - \frac{1}{4\pi\epsilon_0} \frac{qQ}{L} \right)$$

$$- \left( \frac{1}{4\pi\epsilon_0} \frac{q^2}{2L} + \frac{1}{4\pi\epsilon_0} \frac{qQ}{L} + \frac{1}{4\pi\epsilon_0} \frac{qQ}{L} \right)$$

$$= \frac{qQ}{4\pi\epsilon_0} \left[ \frac{1}{3L} - \frac{1}{L} \right]$$

$$= \frac{qQ}{4\pi\epsilon_0} \frac{(1-3)}{3L}$$

$$= \frac{-2qQ}{12\pi\epsilon_0 L} = -\frac{qQ}{6\pi\epsilon_0 L}$$

133 (b)

When a conductor of capacitance  $C$  is given a charge  $q$ , it acquires a potential given by

$$V = \frac{q}{C}$$

The work done in charging the conductor is stored as potential energy in the electric field in the vicinity of the conductor.

134 (b)

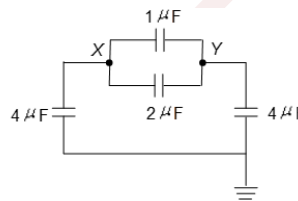
Work done = potential energy of configuration of charges

$$\frac{1}{4\pi\epsilon_0 a} [q(-q) + (9-q)q + q(-q) + (-q)(q)] + \frac{(-q)(-q) + q^2}{4\pi\epsilon_0 a\sqrt{2}}$$

$$= \frac{1}{4\pi\epsilon_0} \left[ -\frac{4q^2}{a} + \frac{2q^2}{a\sqrt{2}} \right] = -\frac{2.6 q^2}{4\pi\epsilon_0 a}$$

135 (d)

Circuit is redrawn as shown in Figure.



In the circuit, capacitors  $4\mu\text{F}$  capacitors and  $4\mu\text{F}$  are connected in series. Combination of this is in parallel with  $1\mu\text{F}$  and  $2\mu\text{F}$  capacitors

136 (a)

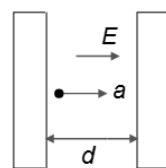
Negative charge itself goes from low to high potential

137 (b)

$$E = \frac{Q}{2A\epsilon_0}$$

$$a = \frac{qE}{m} = \frac{qQ}{2A\epsilon_0 m}$$

$$d = \frac{1}{2} at^2; t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2d2A\epsilon_0}{qQ}}$$



138 (c)

$+q$  will not provide restoring torque

139 (a)

Total charge enclosed in surface A is

$$Q = (q_1 + q_2 + q_3) = (-14 + 78.85 - 56)\text{nC}$$

$$\phi = \frac{Q}{\epsilon_0} = \frac{8.85 \times 10^{-9}}{8.85 \times 10^{-12}} = 10^3 \text{ Nm}^3 \text{ C}^{-1}$$

140 (c)

For a ring  $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{qx}{(x^2+R^2)}$  and  $E$  is maximum

when

$$x = \frac{R}{\sqrt{2}}$$



$$\Rightarrow E_{\max} = \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{3\sqrt{3} \cdot R^2}$$

141 (c)

6  $\mu\text{F}$  and 3  $\mu\text{F}$  capacitors are in series

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

$$C_1 = 2$$

$C_1$  is parallel to 2  $\mu\text{F}$  capacitor

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

$$\begin{aligned} \text{Total energy, } U &= \frac{1}{2} CV^2 \\ &= \frac{1}{2} \times 4 \times (2)^2 = 8\mu\text{J} \end{aligned}$$

142 (c)

Potential energy

$$U = \frac{q_1 q_2}{4\pi\epsilon_0 r}$$

$$\text{Or } U \propto \frac{1}{r}$$

When  $r$  decreases  $U$  increases and *vice – versa*.

Moreover, potential energy as well as force is positive, if there is repulsion between the particles and negative if there is attraction.

143 (c)

Potential difference between two equipotential surfaces  $A$  and  $B$ .

$$V_A - V_B = kq \left( \frac{1}{r_A} - \frac{1}{r_B} \right)$$

$$= kq \left( \frac{r_B - r_A}{r_A r_B} \right)$$

$$= \frac{kqt_1}{r_A r_B}$$

Or

$$t_1 = \frac{(V_A - V_B)r_A r_B}{kq}$$

$$\text{Or } t_1 \propto r_A r_B$$

$$\text{Similarly, } t_2 \propto r_B r_C$$

Since,

$$r_A < r_B < r_C, \text{ therefore } r_A r_B < r_B r_C$$

$$\therefore t_1 < t_2$$

144 (a)

Though effective value of  $g$  will change, as the time period of spring block system does not depend on  $g$ , so time period will remain the same, i. e.  $T$

145 (b)

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

$$\text{And } C_p = C_1 + C_2 = 16\mu\text{F}$$

$$\text{Solve to get, } C_1 = 4\mu\text{F and } C_2 = 12\mu\text{F}$$

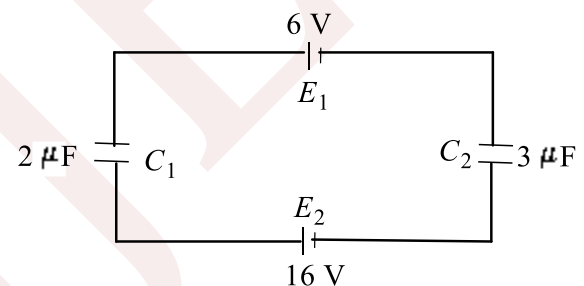
146 (d)

$$PE = \frac{q_1 q_2}{4\pi\epsilon_0 r} = \frac{9 \times 10^9 (2 \times 10^{-6})^2}{1} = 0.036 \text{ J}$$

147 (c)

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

148 (c)



Net emf in the circuit here

$$E = E_2 - E_1 = 16 - 6 = 10 \text{ volt}$$

While the equivalent capacity

$$C = \frac{C_1 C_2}{C_1 + C_2} = \frac{2 \times 3}{2 + 3} = \frac{6}{5} \mu\text{F}$$

Charge on each capacitor

$$q = CV = \frac{6}{5} \times 10 = 12\mu\text{C}$$

$\therefore$  Potential difference across 2 $\mu\text{F}$  capacitor

$$V_1 = \frac{q}{C_1} = \frac{12}{2} = 6 \text{ volt}$$

149 (b)

Dielectric strength, it is the maximum electric field which a material can bear

150 (c)

From eq. (i)  $A$  and  $C$  both are charged, either positively or negatively. From eq. (ii),  $B$  is charged and  $D$  and  $E$  have no charge. From eq. (iii),  $A$  is positively charged.

Therefore, from eq. (i),  $B$  is negatively charged

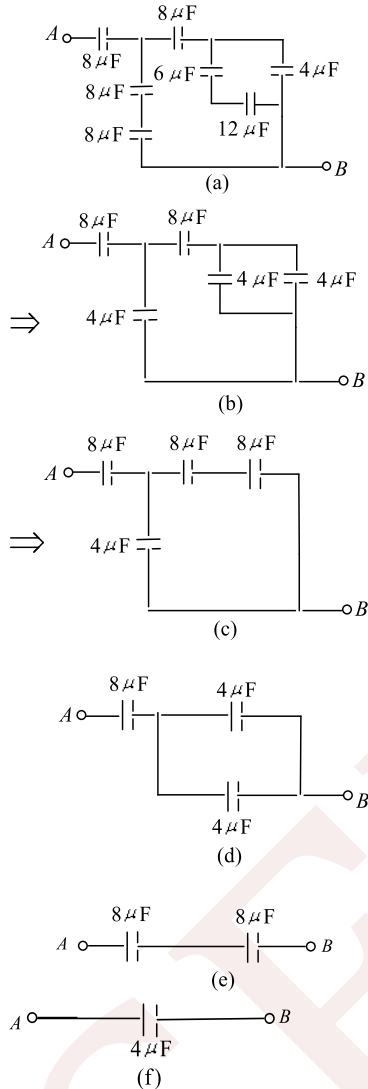
151 (a)



All the statements are general properties of electric lines of force

152 (c)

Using the method of successive reduction (see Fig)



153 (b)

Common potential,

$$V = \frac{\text{total charge}}{\text{total capacity}} = \frac{Q + 0}{4\pi\epsilon_0(r + r')}$$

$\therefore$  charge on smaller sphere

$$= 4\pi\epsilon_0 r' \times V = \frac{Qr'}{r + r'}$$

154 (a)

Here,  $t = 2 \text{ mm}$ ,  $x = 1.6 \text{ mm}$ ,  $K = ?$

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

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

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

155 (a)

$$\begin{aligned} \text{Change in energy } \Delta U &= \frac{1}{2} \left[ \frac{q_1^2 - q_2^2}{C} \right] \\ &= \frac{1}{2} \left[ \frac{(0.5)^2 - (0.1)^2}{48 \times 10^{-6}} \right] \\ &= \frac{1}{2} \left[ \frac{0.25 - 0.01}{48 \times 10^{-6}} \right] \\ &= \frac{1}{2} \left[ \frac{0.24}{48 \times 10^{-6}} \right] = \frac{1}{2} \left[ \frac{10^4}{2} \right] \\ &= 2500 \text{ J} \end{aligned}$$

156 (a)

Their potential will be same i.e.,  $V_1 = V_2$

$$\frac{kq_1}{R_1} = \frac{kq_2}{R_2} \Rightarrow \frac{q_1}{R_1} = \frac{q_2}{R_2}$$

$$\frac{E_1}{E_2} = \frac{kq_1/R_1^2}{kq_2/R_2^2} = \frac{q_1}{q_2} \left(\frac{R_2}{R_1}\right)^2$$

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

157 (a)

Since the two spheres are joined by a wire, their potential are equal i.e.,

$$\frac{q_1}{4\pi\epsilon_0 R_1} = \frac{q_2}{4\pi\epsilon_0 R_2} \Rightarrow \frac{q_1}{q_2} = \frac{R_1}{R_2}$$

$$\text{Now, } \sigma_1 = \frac{q_1}{4\pi\epsilon_0 R_1^2}$$

$$\text{And } \sigma_2 = \frac{q_2}{4\pi\epsilon_0 R_2^2},$$

$$\text{Hence } \frac{\sigma_2}{\sigma_1} = \frac{q_2}{q_1} \times \frac{R_1^2}{R_2^2} = \left(\frac{R_2}{R_1}\right) \left(\frac{R_1}{R_2}\right)^2$$

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

158 (b)

Find potential at A and C due to charge at B, then the required work done is  $W = q(V_A - V_C)$

159 (c)

Refer concepts and formulate isolated sphere and non-isolated sphere

160 (b)

Potential  $V_1$  due to a ring is given by:

$$V_1 = \frac{1}{4\pi\epsilon_0} \times \frac{q}{\sqrt{R^2 + r^2}}$$

$$= \frac{1}{4\pi\epsilon_0} \times \frac{q}{\sqrt{R^2 + 3R^2}} = \frac{1}{4\pi\epsilon_0} \frac{q}{2R}$$

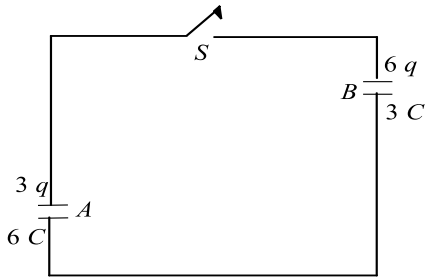
$$\text{At the centre, } V_2 = \frac{1}{4\pi\epsilon_0} \frac{q}{R}$$

$$\text{K.E.} = q_0(V_2 - V_1) = \frac{1}{4\pi\epsilon_0} \left(\frac{qq_0}{2R}\right)$$



161 (b)

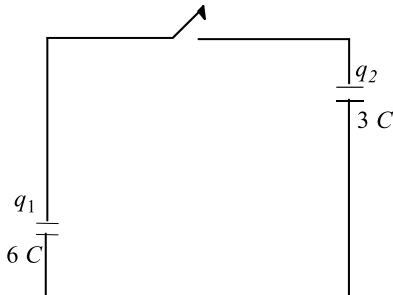
The circuit is given as



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

Then,

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



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

$$\Rightarrow q_1 = 2q_2 \quad \dots(i)$$

But we know that, charge is conserved

$$q_1 + q_2 = 3q + 6q$$

$$\text{or } q_1 + q_2 = 9q \quad \dots(ii)$$

On putting the value of  $q_1$  Eq. (ii)

$$2q_2 + q_2 = 9q$$

$$\Rightarrow 3q_2 = 9q$$

$$q_2 = 3q$$

Now, from Eq. (i)

$$q_1 = 2 \times 3q$$

$$\Rightarrow q_1 = 6q$$

$$\text{Hence, } q_1 = 6q, q_2 = 3q$$

162 (b)

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

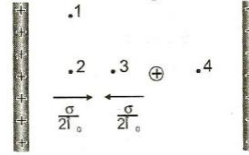
$$\text{Linear momentum of photon, } p_p = \sqrt{2m_p eV}$$

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

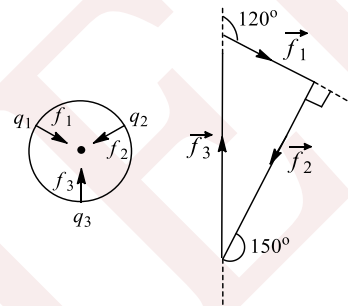
$$\frac{p_e}{p_p} = \sqrt{\frac{m_e}{m_p}}$$

163 (c)

Electric field due to both the plates will be cancelled out for all the points. So the net electric field at the points will be governed only by the sphere. The farther the point from the sphere, the lesser the magnitude of the electric field



Since the charges exert force on one another that are in action-reaction pair, sum of force  $\vec{f}_1$ ,  $\vec{f}_2$  and  $\vec{f}_3$  is zero. So force vectors form a triangle, as shown in the figure



Applying sine rule, we have

$$\frac{f_1}{\sin 30} = \frac{f_2}{\sin 60} = \frac{f_3}{\sin 90}$$

$$\text{Or } 2f_1 = \frac{2f_2}{\sqrt{3}} = f_3 = K \text{ (suppose)}$$

$$f_1 = \frac{k}{2}, f_2 = \frac{\sqrt{3}}{2}K, f_3 = K$$

$$\text{So } f_1 : f_2 : f_3 = \frac{1}{2} : \frac{\sqrt{3}}{2} : 1 = 1 : \sqrt{3} : 2$$

164 (d)

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

$$\therefore \text{Total capacitance} = (n-1)x$$

165 (c)

$$E_x = \frac{dV}{dx} = \frac{120 - 80}{2} = 20 \text{ Vcm}^{-1}$$

There may be the  $y$ - and  $z$ - components of field also

166 (b)

On connecting, the entire amount of charge will shift to the outer sphere

Heat generated

$$U_i - U_f = \frac{q^2}{8\pi\epsilon_0 R_1} - \frac{q^2}{8\pi\epsilon_0 R_2}$$



$$= \frac{(20 \times 10^{-6}) \times 9 \times 10^9}{2} \left[ \frac{1}{0.10} - \frac{1}{0.20} \right] = 9 \text{ J}$$

167 (d)

$$\begin{aligned} \text{Work done} &= U_2 - U_1 = \frac{q_1 q_2}{4\pi\epsilon_0} \left[ \frac{1}{r_2} - \frac{1}{r_1} \right] \\ &= 12 \times 10^{-6} \times 8 \times 10^{-6} \times 9 \times 10^9 \left[ \frac{10^2}{6} - \frac{10^2}{10} \right] \\ W &= 96 \times 9 \times 10^{-3} \times 10^2 \times \frac{4}{60} = 5.8 \text{ J} \end{aligned}$$

168 (a)

Each plate is taking part in the formation of two capacitors except the plates at the ends. These capacitors are in parallel and  $n$  plates form  $(n - 1)$  capacitors. Thus, equivalent capacitance between points  $A$  and  $B = (n - 1)C$

169 (b)

$$C' = \frac{\epsilon_0 A}{d - t} = \frac{\epsilon_0 A}{d - d/2} = \frac{2\epsilon_0 A}{d}$$

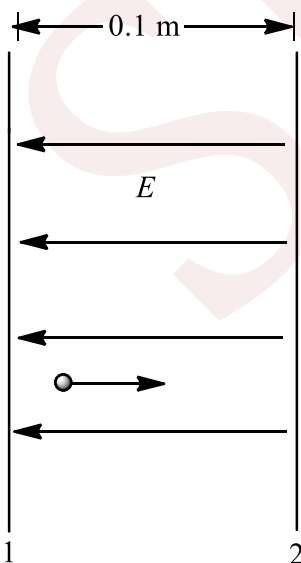
Hence, capacitance is doubled

170 (d)

The net field at  $O$ .  
 $E = 2\vec{E}_R$ , when  $\vec{E}_p + \vec{E}_s = \vec{0}$ ,  $\vec{E}_Q + \vec{E}_T = \vec{0}$  and  $\vec{E}_R = \vec{E}_U$  along  $ROU$  direction. It is possible in arrangement of (d) as shown in a joining figure.

171 (a)

Since  $V_2 > V_1$ , so electric field will point from plate 2 to plate 1. The electron will experience an electric force, opposite to the direction of electric field, and hence move towards the plate 2.



Use work-energy theorem to find speed of electron when it strikes the plate 2.

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

Where  $v$  is the required speed.

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

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

172 (a)

$$\therefore V = 4x^2$$

$$\text{Hence, } \vec{E} = -\frac{dV}{dr} = -8x\hat{i}$$

Hence, value of  $\vec{E}$  at  $(1\text{m}, 0, 2\text{m})$  will be  $\vec{E} = -8 \times 1\hat{i} = -8\hat{i} \text{ Vm}^{-1}$

173 (a)

In series combination, charge is constant.

$$\therefore V \propto \frac{1}{C}$$

$$\text{Now, } \frac{V_2}{V_1} = \frac{KC}{C} = \frac{K}{1}$$

$$\text{But } V_1 + V_2 = V$$

$$\text{or } \frac{V_2}{K} + V_2 = V \text{ or } V_2 = \frac{K}{K+1} V$$

174 (a)

When a positive charge is moved from one point to another in an electric or magnetic field, then under the influence of the field force acts on the particle and an external agent will have to do work against this force. But in the given case the charge moves under influence of no field, hence it does not experience any force therefore, no work is done.

$$W_A = W_B = W_C = 0$$

175 (c)

$$\begin{aligned} F_e &= mg \tan \theta \\ &= (1.20 \times 10^{-3} \text{ kg})(10 \text{ ms}^{-2}) \tan(37^\circ) \\ &= 0.0090 \text{ N} \end{aligned}$$

$$F_e = Eq = \frac{Vq}{d}$$

$$\therefore V = \frac{F_e d}{q} = \frac{(0.009 \text{ N})(0.0500 \text{ m})}{9.0 \times 10^{-6} \text{ C}} = 50.0 \text{ V}$$

176 (a)

$$a_x = \frac{qE}{m} = \frac{10^{-6} \times 2 \times 10^7}{2} = 10 \text{ ms}^{-2}$$



$$\text{Time of flight } T = \frac{2u \sin \theta}{g} = \frac{2 \times 10 \times \frac{1}{\sqrt{2}}}{10}$$

$$T = \sqrt{2} \text{ sec}$$

$$\text{Hence, range } R = u_s T + \frac{1}{2} a_x T^2$$

$$R = 10 \cos 45^\circ \times T + \frac{1}{2} a_x T^2$$

$$= \frac{10}{\sqrt{2}} \times \sqrt{2} + \frac{1}{2} \times 10 \times 2$$

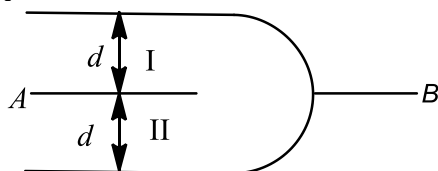
$$\Rightarrow R = 20 \text{ m}$$

177 (d)

In series, charge is the same on each capacitor

178 (d)

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



$$\text{So, } C = C_1 + C_2 = \frac{\epsilon_0 A}{d} + \frac{\epsilon_0 A}{d} = \frac{2\epsilon_0 A}{d}$$

179 (a)

The potential due to charge  $q$  at distance  $r$  is given by

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

If  $W$  be the work done in moving the charge from  $A$  to  $B$  then the potential difference ( $V$ ) is given by

$$V_A - V_B = \frac{W}{q}$$

Both work ( $W$ ) and charge ( $q$ ) are scalar quantities hence potential difference ( $V_A - V_B$ ) will also be a scalar quantity.

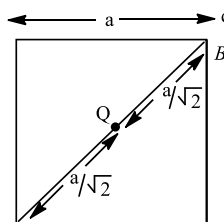
Here,

$$V_A = V_B = \frac{1}{4\pi\epsilon_0} \frac{Q}{a/\sqrt{2}}$$

Since,  $Q$  is same for both,

$$V_A - V_B = 0$$

$$W = 0$$



180 (d)

The two capacitor the circuit are in parallel order, hence

$$C' = C + \frac{C}{2} = \frac{3C}{2}$$

The work done in charging the equivalent capacitor is stored in the form of potential energy.

$$\text{Hence, } W = U = \frac{1}{2} C' V^2$$

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

$$= \frac{3}{4} C V^2$$

181 (a)

Potential due to charge ( $q$ ) at point ( $r$ ) is given by

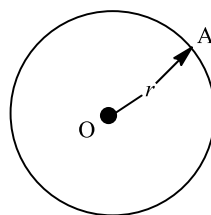
$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

Since, charge  $Q$  is rotated in a circle of radius  $r$ , hence its potential remains same at all points on the path, hence  $\Delta V = 0$ .

$$\text{Also, work done} = q\Delta V$$

Where  $q$  is charge and  $\Delta V = 0$ .

$$\therefore \text{Work done} = 0.$$



182 (a)

$$V_C = V_1 = V_2$$

$$\frac{kq_1}{r_1} = \frac{kq_2}{r_2}$$

$$\frac{q_1}{r_1} = \frac{q_2}{r_2} \quad \dots(i)$$

$$\frac{q_1}{r_1} = \frac{q_2}{r_2} \quad \dots(ii)$$

$$q_1 + q_2 = Q \quad \dots(ii)$$

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



$$q_1 = \frac{Qr_1}{r_1 + r_2}$$

Putting  $V_1$ , we get  $V_C = \frac{kQ}{r_1 + r_2}$

183 (b)

$$\vec{E} = a(y\hat{i} + x\hat{j})$$

$$V_2 - V_1 = - \int (ay dx + ax dy)$$

Take  $V_1 = C$  and  $V_2 = V$

$$V = -a \int (y dx + x dy) + C$$

$$= -a \int d(yx) + C = -axy + C$$

184 (a)

$$F = Kx$$

$$\frac{Q^2}{2A\epsilon_0} = K(0.2d)$$

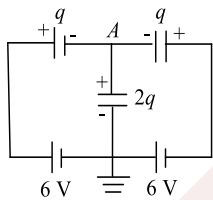
$$\frac{(\frac{\epsilon_0 A}{0.8d} E)^2}{2A\epsilon_0} = 0.2 Kd$$

$$K = 3.9 \epsilon_0 A E^2 / d^3$$

$$K = 4\epsilon_0 A E^2 / d^3$$

185 (a)

$$6 = \frac{q}{2} + \frac{2q}{4} \Rightarrow q = 6 \mu\text{C}$$



186 (a)

Let  $q$  be charge on each small drop of radius  $r$ . If  $R$  is radius of big drop, then

$$\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^3$$

$$\therefore R = 10r$$

$$C' = 10C$$

$$\text{Initial energy } E_1 = 1000 \times \frac{q^2}{2C'}$$

$$\text{Final energy } E_2 = \frac{(1000q)^2}{C'}$$

$$\frac{E_2}{E_1} = \frac{1000 \times C}{C'}$$

$$= 1000 \times \frac{1}{10} = 100$$

187 (b)

$$W_{AB} = W_{AC} + W_{CB}$$

$W_{CB}$  should be zero, because in moving from  $C$  to  $B$ , we always move perpendicular to field. Hence,

force applied by field and displacement will be at  $90^\circ$

$$W_{AC} = -e(V_C - V_A)$$

$$V_C - V_A = -E \times AC$$

$$= -10 \times 4 = -40$$

$$W_{AC} = -e \times (-40) = 40e$$

$$\text{So } W_{AB} = 40e \text{ J} = 40 \text{ eV}$$

188 (b)

$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

$$\lambda = 2\pi\epsilon_0 r E$$

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

$$= 10^{-7} \text{ Cm}^{-1}$$

189 (a)

$$W = \vec{F} \cdot \vec{r} = q\vec{E} \cdot \vec{r}$$

190 (c)

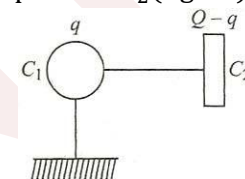
$$\text{K.E.}_i + \text{P.E.}_i = \text{K.E.}_f + \text{P.E.}_f$$

$$0 + q \times 600 = \text{K.E.}_f + q \times 0$$

$$\text{K.E.}_f = 600 \times 10^{-8} = 6 \times 10^{-6} \text{ J}$$

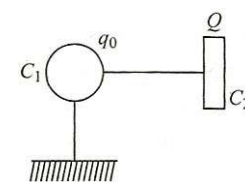
191 (c)

Let capacitance of the conductor be  $C_1$  and that of plate be  $C_2$  (figure). After first operation, we get



$$\frac{q}{C_1} = \frac{Q-q}{C_2} \quad \text{(i)}$$

Let  $q_0$  be the maximum charge that can be transferred to the conductor (figure) then,



$$\frac{q_0}{C_1} = \frac{Q}{C_2} \quad \text{(ii)}$$

$$\text{From Eqs. (i) and (ii), } q_0 = \frac{Qq}{Q-q}$$

192 (c)

Energy given by the cell

$$E = CV^2$$

Here,  $C$  = capacitance of capacitor =  $\frac{A\epsilon_0}{d}$

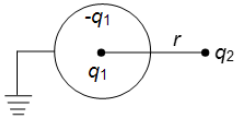
$V$  = potential difference across the plates =  $Ed$

$$\text{Therefore, } E = \left(\frac{A\epsilon_0}{d}\right) (Ed)^2 = A\epsilon_0 E^2 d$$



193 (a)

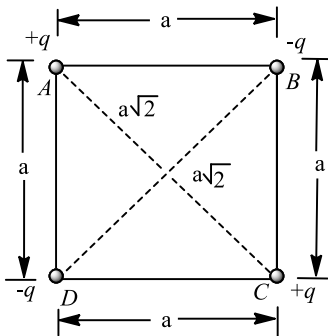
There is no charge on the outer surface. Hence, no force on  $q_2$  (figure)



194 (a)

Work is required to set up the four charge configuration

$$q_1 = +q, q_2 = -q, q_3 = +q \text{ and } q_4 = -q$$



$$W = \frac{1}{4\pi\epsilon_0} \left[ \frac{(+q)(-q)}{AB} + \frac{(-q)(+q)}{BC} + \frac{(+q)(-q)}{CD} + \frac{(-q)(+q)}{DA} + \frac{(+q)(+q)}{AC} + \frac{(-q)(-q)}{BD} \right]$$

$$W = \frac{1}{4\pi\epsilon_0} \left[ -\frac{q^2}{a} - \frac{q^2}{a} - \frac{q^2}{a} - \frac{q^2}{a} + \frac{q^2}{a\sqrt{2}} + \frac{q^2}{a\sqrt{2}} \right]$$

$$W = \frac{1}{4\pi\epsilon_0} \frac{q^2}{a} [-4 + \sqrt{2}] = \frac{1}{4\pi\epsilon_0} \frac{q^2}{a} [-4 + 1.414]$$

$$W = -0.21 \times \frac{q^2}{\epsilon_0 a} \quad (\text{approx.})$$

195 (d)

Ratio of energy stored in the capacitor and the work done by the battery

$$= \frac{\frac{1}{2}qV}{qV} = \frac{1}{2}$$

196 (a)

When  $S$  is open, spheres  $A$  and  $B$  have same, positive potential. When  $S$  is closed, potential of  $B$  will become zero. So, the potential of  $B$  will decrease. This decrease of potential takes place

due to flow of electrons from earth to inner sphere  $B$ . But magnitude of charge acquired by inner sphere will be less than  $Q$

197 (b)

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

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

198 (a)

$$E = \frac{v}{d}, F = eE = eV/d$$

$$a = \frac{F}{m} = \frac{eV}{md}$$

$$d = \frac{1}{2}at^2 \Rightarrow t = \sqrt{\frac{2d}{a}}$$

$$t = \sqrt{\frac{2d \cdot md}{eV}} = \sqrt{\frac{2md^2}{eV}}$$

199 (b)

Energy of a charged capacitor,

$$E = \frac{1}{2} \frac{Q^2}{C}$$

$$C = \frac{2\pi\epsilon_0 L}{\log_e \left( \frac{b}{a} \right)}$$

$$E' = \frac{1}{2} \frac{Q^2}{2\pi\epsilon_0 L} \log_e \left( \frac{b}{a} \right)$$

...(i)

For a cylindrical capacitor.

where  $L$  = length of the cylinders

$a$  and  $b$  = radii of two concentric cylinders

$$C' = \frac{2\pi\epsilon_0(2L)}{\log_e \left( \frac{b}{a} \right)}$$

$$E' = \frac{1}{2} \frac{(2Q)^2}{C'}$$

$$= \frac{1}{2} \frac{(2Q)^2}{2\pi\epsilon_0(2L)} \log_e \left( \frac{b}{a} \right)$$

...(ii)

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



$$E' = 2E$$

200 (b)

The effective capacitance of three capacitor connected in parallel =  $3C$

When  $3C$  is connected in series to  $C$

$$C_{\text{resul}} = \frac{3C \times C}{3C + C} = 3.75$$

$$\Rightarrow C = 5\mu\text{F}$$

201 (d)

$$W = \frac{1}{2} \frac{q^2}{C}$$

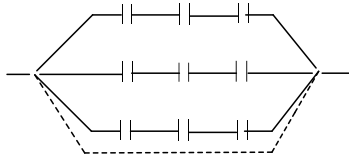
$$= \frac{1}{2} \times \frac{(8 \times 10^{-18})^2}{100 \times 10^{-6}} = \frac{1}{2} \times \frac{64 \times 10^{-36}}{100 \times 10^{-6}}$$

$$= 32 \times 10^{-32} \text{ J}$$

202 (b)

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

$$N = m \times n$$



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

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

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

$$\therefore C'' = 16 = 2 \times m$$

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

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

203 (d)

For charge  $Q_1$ , electronic field is

$$E_1 = \frac{Q_1}{2\epsilon_0 A}$$

where  $A$  is area.

For charge  $Q_2$  electronic field is

$$E_2 = \frac{Q_2}{2\epsilon_0 A}$$

Resultant electronic field

$$E = E_1 - E_2 = \frac{(Q_1 - Q_2)}{2\epsilon_0 A}$$

Potential difference between plates when they are brought close together to form a parallel plate capacitor is

$$V = Ed = \frac{(Q_1 - Q_2)}{2\epsilon_0 A} d$$

Since,  $C = \frac{\epsilon_0 A}{d}$  for parallel plate capacitor.

$$\therefore V = \frac{(Q_1 - Q_2)}{2C}$$

204 (b)

$$V - 0 = \frac{Q}{C} = \frac{Q(b-a)}{K4\pi\epsilon_0 ab}$$

$$V = \frac{9 \times 10^9 \times 2.5 \times 10^{-6} (0.13 - 0.12)}{32 \times 0.13 \times 0.12}$$

$$= 450 \text{ V}$$

205 (c)

Wheatstone bridge will be formed

207 (c)

When battery remains connected

$$C' = kC$$

$$Q' = kQ$$

$$V' = V$$

$$E' = E$$

$$U' = kU$$

$U$  and  $Q$  Both increases.

208 (d)

$$C_p = 1 + 1 + 1 = 3\mu\text{F}$$

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

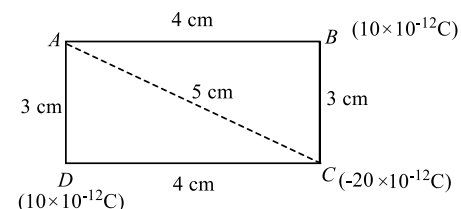
$$\therefore C_s = \frac{3}{4} \mu\text{F}$$

209 (a)

The situation is summarised in figure.

$$BC = AD = 3\text{ cm}, \quad AB = DC = 4\text{ cm},$$

$$\text{So, } AC = 5\text{ cm.}$$



Now, potential at  $A$

$$V_A = \frac{1}{4\pi\epsilon_0} \frac{q_B}{AB} + \frac{1}{4\pi\epsilon_0} \frac{q_C}{AC} + \frac{1}{4\pi\epsilon_0} \frac{q_D}{AD}$$



$$= \frac{1}{4\pi\epsilon_0} \left[ \frac{10 \times 10^{-12}}{4 \times 10^{-2}} - \frac{20 \times 10^{-12}}{5 \times 10^{-2}} + \frac{10 \times 10^{-12}}{3 \times 10^{-2}} \right]$$

$$= 9 \times 10^9 \times 10^{-10} \left[ \frac{10}{4} - \frac{20}{5} + \frac{10}{3} \right]$$

$$= \frac{9 \times 10^{-1} \times 11}{6}$$

$$= 16.5 \times 10^{-1} = 1.65V$$

210 (b)

$$\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$$

$$= (-6x + 4)\hat{i}$$

So, the equipotential surfaces would be planes parallel to YZ plane, as  $\vec{E}$  is perpendicular to the equivalent surface

211 (a)

Electricity neutral means net charge zero. Potential of a neutral conductor may or may not be zero. It depends upon the other charges present in the surrounding

212 (d)

$$\frac{\lambda q}{2\pi\epsilon_0 r} = \frac{mv^2}{r} \text{ or } v = \sqrt{\frac{\lambda}{2\pi\epsilon_0 m q}} \text{ independent of } r$$

213 (b)

Presence of point charge (+q) induces negative charge on inner surface of hollow conducting sphere and positive charge on outer of sphere. Hence, field lines will be directed radially outward from surface of sphere as shown in(b)

215 (c)

$$\text{Capacitance } C = \frac{Q}{V}$$

$$\text{For a dielectric media } C = \frac{\epsilon A}{d}$$

$\therefore$  Capacitance  $C$  of a capacitor is independent of the geometrical configuration of the capacitor.

216 (a)

The energy stored is given by

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

When capacitors are connected in parallel, resultant capacitance is

$$C' = C_1 + C_2$$

$$= 2\mu F + 2\mu F = 4\mu F$$

$$V = 100 \text{ volt}$$

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

$$E = 0.02J$$

217 (a)

$$V_A - 0 = \frac{2q}{4} = 3V$$

218 (d)

Here, battery is disconnected, so charge remains the same

219 (d)

As the capacitor is isolated, so charge will remain the same. Now, as the separation between the plates is increased, capacitance ( $\epsilon_0 A/d$ ) will decrease

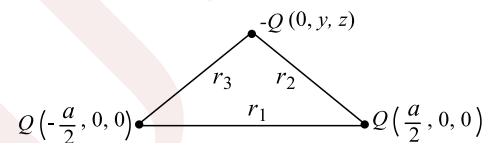
$$V = \frac{Q}{C}, \text{ if } C \text{ decreases, } V \text{ increases}$$

220 (c)

For charge  $q$  placed at the centre of circle, the circular path is an equipotential surface and hence works done along all paths  $AB$  or  $AC$  or  $AD$  or  $AE$  is zero.

221 (c)

As in none of the options, the  $x$ -coordinate appears, so we have to find the locus in the  $y-z$  plane



$$U = \frac{kQ^2}{r_1} - \frac{kQ^2}{r_2} - \frac{kQ^2}{r_3} = 0$$

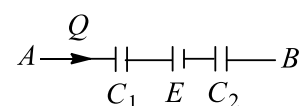
$$kQ^2 \left[ \frac{1}{a} - \frac{1}{\sqrt{(a/2)^2 + y^2 + z^2}} \right]$$

$$- \frac{1}{\sqrt{(a/2)^2 + y^2 + z^2}} \Big] = 0$$

$$\frac{1}{a} = \frac{2}{\sqrt{a^2/4 + y^2 + z^2}} \Rightarrow y^2 + z^2 = 15a^2/4$$

222 (a)

Let the charge following through section  $AB$  be  $Q$ (figure)



Applying kirchhoff's law, we get

$$V_A - \frac{Q}{C_1} + E - \frac{Q}{C_2} = V_B$$

$$V_A - V_B + E = Q \left( \frac{1}{C_1} + \frac{1}{C_2} \right)$$



$$5 + 10 = Q \left( \frac{C_1 + C_2}{C_1 C_2} \right) = Q \left( \frac{1 + 2}{2} \right)$$

$$Q = \frac{15 \times 2}{3} = 10 \mu\text{C}$$

So, potential difference across  $2 \mu\text{F}$  capacitor

$$V = \frac{Q}{C_2} = \frac{10 \mu\text{C}}{2 \mu\text{F}} = 5\text{V}$$

223 (d)

$E = \frac{\sigma}{\epsilon_0}$  does not depend upon radius if  $\sigma$  is constant

224 (d)

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

$$\begin{aligned} &= \frac{15 \times 10^{-6} \times 5 \times 10^{-6} (2000 - 1000)^2}{2 (5 + 5) \times 10^{-6}} \\ &= \frac{5 \times 5}{2 \times 10} = 1.25\text{J} \end{aligned}$$

225 (c)

Apply conservation of mechanical energy,

$$\frac{-9 \times 10^9 \times 10^{-12}}{2}$$

$$= \frac{-9 \times 10^9 \times 10^{-12}}{1} + \frac{1}{2} (2m)v^2$$

$$\Rightarrow v = 3/10 \text{ m/s}$$

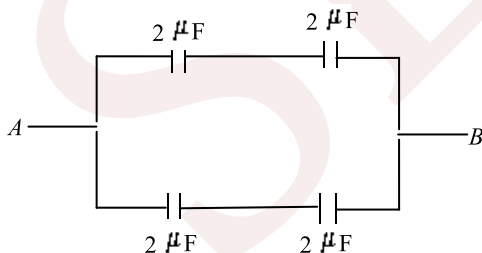
226 (a)

$$\text{Potential of outer sphere } V = \frac{kq_1}{3r} + \frac{kq_2}{3r} + \frac{kq_3}{3r} = 0$$

$$\Rightarrow q_1 + q_3 = -q_2$$

227 (a)

The figure is a balanced Wheatstone bridge, so diagonal capacitor will be ineffective. So, the equivalent circuit will be as shown in the figure.



Equivalent capacitance of upper arms in series

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

Similarly, for lower arm

$$C_2 = 1 \mu\text{F}$$

$$\begin{aligned} \therefore C_{AB} &= C_1 + C_2 \\ &= 1 + 1 = 2 \mu\text{F} \end{aligned}$$

228 (c)

$$\phi_E = \frac{\sum q}{\epsilon_0} = \frac{(+5-5) \times 10^{-6}}{\epsilon_0} = \text{zero}$$

229 (a)

The potential of point B is +10 V, therefore no potential difference exists across  $12 \mu\text{F}$  capacitor, hence  $q_{12} = 0$ . Charge on the  $4 \mu\text{F}$  capacitor is  $q_4 = (4)(10) = 40 \mu\text{C}$

230 (d)

Radius of big drop,  $R = 3r$

$$\left[ \because \frac{4}{3} \pi R^3 = 27 \times \frac{4}{3} \pi r^3 \right]$$

$$V = \frac{27q}{4\pi\epsilon_0 R} = \frac{27q}{4\pi\epsilon_0 (3r)}$$

$$= 9 \left( \frac{q}{4\pi\epsilon_0 r} \right) = 9 \times 10 = 90 \text{ V}$$

231 (c)

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

$$\text{KE} = W = E = q(V_A - V_B)$$

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

232 (a)

$$V = V_1 + V_2 + V_3$$

$$= \frac{1}{4\pi\epsilon_0} \frac{Q}{R} + \frac{1}{4\pi\epsilon_0} \left( \frac{-2Q}{R} \right) + \frac{1}{4\pi\epsilon_0} \left( \frac{3Q}{R} \right)$$

$$= \frac{1}{4\pi\epsilon_0} \left( \frac{2Q}{R} \right) = \frac{Q}{2\pi\epsilon_0 R}$$

233 (b)

$$\text{Apply } V = \frac{kQ}{R}, \text{ where } Q = Ze$$

234 (c)

The capacitance of air capacitor

$$C = \frac{\epsilon_0 A}{d}$$

When a dielectric slab of thickness  $t = \frac{d}{2}$  is

inserted between plates, the capacity becomes

$$C' = \frac{A\epsilon_0}{d - \frac{d}{2} \left( 1 - \frac{1}{K} \right)}$$

$$\frac{4}{3} \frac{A\epsilon_0}{d} = \frac{\epsilon_0 A}{d - \frac{d}{2} \left( 1 - \frac{1}{K} \right)}$$

$$3d = 4d \left( 1 - \frac{1}{2} + \frac{1}{2K} \right)$$

$$3 = 4 \left( \frac{1}{2} + \frac{1}{2K} \right)$$

$$\text{or } \frac{4}{2K} = 3 - 2$$

$$\text{or } K = 2$$

235 (d)

Here, electric potential



$$V = 3x^2$$

Electric field,

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

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

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

236 (d)

$V + Ed$ . As  $d$  increases,  $V$  also increases. Note that  $E$  remains the same

237 (c)

$V_1 - V_2$  will be divided between  $C_1$  and  $C_2$  in series. Potential difference across  $C_1$ :

$$V_1 - V_D = \frac{C_2(V_1 - V_2)}{C_1 + C_2}$$

$$V_D = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

238 (c)

In a parallel plate capacitor, the capacity of capacitor,

$$C = \frac{k\epsilon_0 A}{d}$$

$$\therefore C \propto A$$

So, the capacity of capacitor increases if area of the plate is increased.

239 (c)

Inside a charged sphere, electric field intensity at all points is zero and electric potential is same at all the points.

Electrical potential,

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{R}$$

Therefore, potential at the centre is equal to the potential at the surface.

240 (c)

Perpendicular distance between equipotential surfaces:

$$d = 10 \sin 30^\circ = 5 \text{ cm}$$

$$E = \frac{\Delta V}{d} = \frac{30 - 20}{5/100} = 200 \text{ Vm}^{-1}$$

Direction of electric field will be in the direction of decreasing potential

241 (c)

At  $P$  due to shell, potential

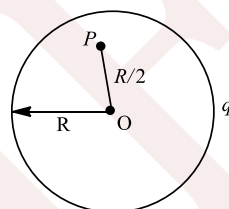
$$V_1 = \frac{q}{4\pi\epsilon_0 R}$$

at  $P$  due to  $Q$ , potential

$$V_2 = \frac{Q}{4\pi\epsilon_0 \frac{R}{2}} = \frac{2Q}{4\pi\epsilon_0 R}$$

$\therefore$  Net potential at  $P$

$$V = V_1 + V_2 = \frac{q}{4\pi\epsilon_0 R} + \frac{2Q}{4\pi\epsilon_0 R}$$



242 (b)

$A = 90 \text{ cm}^2$ ,  $d = 2 \text{ mm}$

$$E = \frac{V}{d}, V = 400 \text{ V}$$

$$u = \frac{1}{2} \epsilon_0 E^2 = \frac{1}{2} \epsilon_0 \left(\frac{V}{d}\right)^2$$

$$= \frac{1}{2} (8.85 \times 10^{-12}) \left(\frac{400}{2 \times 10^{-3}}\right)^2 = 0.177 \text{ Jm}^{-3}$$

243 (c)

On connecting, potential becomes equal  $q \propto C \propto$

$$r \text{ and } \sigma = \frac{q}{A} \propto \frac{r}{r^2} \rightarrow \frac{1}{r}$$

$\therefore$  Surface charge density on 15 cm sphere will be greater than that on 20 cm sphere.

244 (a)

Capacitance of parallel plate capacitor

$$C_0 = \frac{\epsilon_0 A}{d}$$

Where  $A$  = area of the plates,

$d$  = separation between the plates,

Charge stored in the capacitor

$$Q = C_0 V_0$$

When battery is disconnected, then charge remains same.

$$\text{So, energy } E_1 = \frac{1}{2} \frac{Q^2}{C}$$



$C$  = capacitance when plate separation is doubled.

$$\text{So, } C_1 = \frac{C_0}{2}$$

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

When battery is connected, then

$$\text{Energy } E_2 = \frac{1}{2} C V_0^2$$

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

$$\therefore \frac{E_1}{E_2} = \frac{C_0 V_0^2}{\frac{1}{4} C_0 V_0^2} = 4$$

$$E_1 : E_2 = 4 : 1$$

246 (d)

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

$$\text{New potential } V' = \frac{nq}{4\pi\epsilon_0 r} = n^{2/3} V$$

247 (a)

Electrical force is balanced by the weight of the mass

$$mg = qE, \text{ where } E = \text{electric field}$$

$$\text{Or } mg = q \frac{V}{d} \text{ (where } d = \text{separation at the plates)}$$

$$= q \cdot \frac{V}{2} \left( \because \frac{\epsilon_0 A}{d} = C \frac{1}{d} = \frac{C}{\epsilon_0 A} \right)$$

$$\text{Or } V = \frac{2mg\epsilon_0 A}{qC}$$

$$= \frac{10^{-6} \times 10 \times 2.2 \times 10^{-12} \times 10^{-2}}{10^{-5} \times 4 \times 10^{-8}}$$

$$= \frac{10^{-6} \times 9.8 \times 8.88 \times 10^{-12} \times 100 \times 10^{-4}}{10^{-8} \times 0.04 \times 10^{-6}}$$

$$= 43 \text{ mV}$$

248 (c)

$$\text{Here } V = \frac{q}{4\pi\epsilon_0 r} - \frac{q}{4\pi\epsilon_0 (3r)} = \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{3r} \text{ and}$$

$$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{(3r)^2} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{9r^2}$$

$$\text{On simplification, we get } \frac{E}{V} = \frac{1}{6r} \text{ or } E = \frac{V}{6r}$$

249 (c)

Let  $Q$  and  $q$  be the charges on the spheres. The potential at the common centre will be

$$V = \frac{1}{4\pi\epsilon_0} \left( \frac{Q}{R} \right) + \frac{1}{4\pi\epsilon_0} \left( \frac{q}{r} \right)$$

$$= \frac{1}{\epsilon_0} \left[ \frac{Q}{4\pi R^2} \times R + \frac{q}{4\pi r^2} \times r \right]$$

But

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

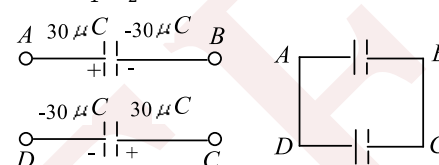
$$\therefore V = \frac{1}{\epsilon_0} [\sigma R + \sigma r] = \frac{\sigma}{\epsilon_0} (R + r)$$

250 (a)

The total charge on each plate will have to be same. They should also carry opposite charges

251 (d)

$$V = \frac{Q_1 + Q_2}{C_1 + C_2} = 0, \text{ where } Q_1 = 30 \mu\text{C}, Q_2 = -30 \mu\text{C}$$



Final potential difference = zero

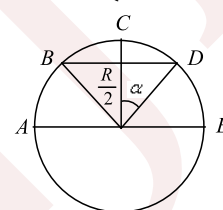
Finally energy = zero

Charge flow  $30 \mu\text{C}$  from  $A$  to  $d$

252 (c)

$\alpha = 60^\circ$ , solid angle subtended by  $BCD$ :

$$\omega = 2\pi(1 - \cos \alpha) = \pi$$



Solid angle subtended by  $ABDE$  is

$$\omega_{(ABDE)} - \omega_{(BCD)} = 2\pi - \pi = \pi$$

$$\text{Hence, flux through } ABDE: \phi = \frac{q}{\epsilon_0} \frac{\pi}{4\pi} = \frac{q}{4\epsilon_0}$$

253 (b)

The potential at the surface of a hollow or conducting sphere is same as the potential at the centre of the sphere and any point inside the sphere

254 (c)

64 drops have formed a signal drop of radius  $R$ .

Volume of big drop = Volume of small' drops

$$\therefore \frac{4}{3} \pi R^3 = 64 \times \frac{4}{3} \pi r^3$$

$$\Rightarrow R = 4r$$

So, the total current is

$$Q_{\text{total}} = 64q$$

$$\text{As, } C' = \frac{Q}{V} \text{ and } V = \frac{1}{4\pi\epsilon_0} \frac{Q}{R}; C' = 4\pi\epsilon_0 R$$

$$C' = (4\pi\epsilon_0) 4r$$

$$\Rightarrow C' = 4C$$



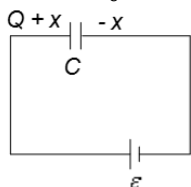
255 (d)

A conductor is an equipotential body. Potential on it or within it is the same everywhere

256 (b)

Electric field between the capacitor plates:

$$E = \frac{Q+x}{2A\epsilon_0} + \frac{x}{2A\epsilon_0} = \frac{1}{2A\epsilon_0} [Q+2x]$$



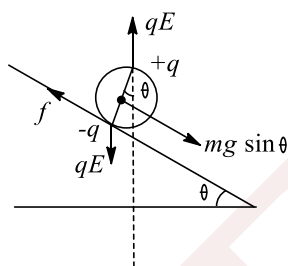
$$\text{Potential difference} = Ed = \frac{d}{2A\epsilon_0} [Q+2x] = \epsilon$$

$$\epsilon = \frac{Q+2x}{2C} - x = \frac{Q}{2} - C\epsilon$$

257 (d)

In a uniform electric field, field line should be straight but line of force cannot pass through the body of metal sphere and must end/start from the sphere normally. All these conditions are fulfilled only in plot (d).

258 (b)



Balancing torque about  $-q$  is

$$qE \cdot 2R \sin \theta = mg \sin \theta \cdot R \Rightarrow E = \frac{mg}{2q}$$

259 (b)

$$q_1 = CV_1 = 16 \times 5 = 80 \mu\text{C}, q_f = CV_f = 16 \times 10 = 160 \mu\text{C}$$

$$\text{Given } \frac{dq}{dt} = 40t \Rightarrow \int_{q_i}^{q_f} dq = \int_0^t 40t dt$$

$$\Rightarrow q_f - q_i = \frac{40t^2}{2}$$

$$\Rightarrow 160 - 80 = 20t^2 \Rightarrow T = 2\text{ s}$$

260 (b)

Knowledge based

261 (d)

$$E_x = -\frac{dV}{dx} = -4x = -4 \times 2 = -8,$$

$$E_y = 0, E_z = 0$$

$$\text{Hence, } \vec{E} = -8\hat{i}\text{NC}^{-1}$$

262 (d)

Option (a) is wrong, because force will be the same, but acceleration will be different because masses of electrons and protons are different

Option (b) is wrong, because at a point there can be only one potential

Option (c) is wrong, because charge always lies on the outer surface of a conductor

Option (d) is correct, because the whole conductor will be an equipotential body

263 (a)

Final charge on capacitor is

$$q = q_0 e^{-t/RC}$$

where  $q_0$  = charge on capacitor at  $t = 0$ ,  
 $RC$  = time constant of the circuit.

Putting  $q_0 = CV_0$

$$\therefore q = CV_0^{-1/RC}$$

Given,  $C = 2\text{F}, V_0 = 5\text{ volt}, R = 6\ \Omega, t = 12\text{ s}$

Hence,  $q = (2 \times 5) e^{-(12/6 \times 2)}$

$$= 10e^{-1} = \frac{10}{e}\text{ C}$$

264 (c)

The potential due to charge  $q$  at a distance  $r$  is given by

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

Since, potential is a scalar quantity, it can be added to find the sum due to individual charges.

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

$$V_A = \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{x}$$

$$V_B = -\frac{1}{4\pi\epsilon_0} \cdot \frac{q}{x}$$

$$V_C = -\frac{1}{4\pi\epsilon_0} \cdot \frac{q}{x}$$

$$\therefore V = \frac{1}{4\pi\epsilon_0} \left( \frac{2q}{x} - \frac{q}{x} - \frac{q}{x} \right) = 0$$

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



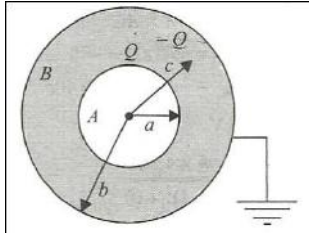
$$E = \frac{1}{4\pi\epsilon_0} \left( \frac{2q}{x^2} + \frac{2q}{x^2} \cos\theta \right) \neq 0$$

265 (b)

Charge +Q will flow into earth

$$V_C = \frac{kQ}{r} - \frac{kQ}{b}$$

$$V_A = \frac{kQ}{a} - \frac{kQ}{b}$$



Potential at B is zero

266 (c)

Apply conservation of mechanical energy between point a and b :

$$(K.E. + P.E.)_a = (K.E. + P.E.)_b$$

$$\Rightarrow 0 + \frac{k(3 \times 10^{-9})q_0}{0.01} - \frac{k(3 \times 10^{-9})q_0}{0.02} = \frac{1}{2}mv^2 + \frac{k(3 \times 10^{-9})q_0}{0.02} - \frac{k(3 \times 10^{-9})q_0}{0.01}$$

$$\text{Put the values and get: } v = 12\sqrt{15} = 46 \text{ ms}^{-1}$$

267 (c)

$$\text{In equilibrium, } F = qE = (ne) \frac{v}{d} = mg$$

$$n = \frac{mgd}{eV} = \frac{1.96 \times 10^{-15} \times 9.8 \times 0.02}{1.6 \times 10^{-19} \times 800} = 3$$

Therefore,  $q = 3e$

269 (d)

The capacitance of parallel plate air capacitor

$$C = \frac{\epsilon_0 A}{d} \quad \dots(i)$$

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

$$C' = \frac{K\epsilon_0 A'}{d'}$$

$$\text{Given, } A' = A, d' = 2d, C' = 2C$$

$$\therefore 2C = \frac{K\epsilon_0 A}{2d} \quad \dots(ii)$$

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

$$K = 4$$

270 (c)

$$V = \frac{kQ}{r} \Rightarrow u = \frac{1}{2} \epsilon_0 E^2 = \frac{1}{2} \frac{\epsilon_0 k^2 Q^2}{r^4}$$

$$V^4 \propto u$$

271 (a)

Number of capacitors to be connected in series

$$V = \frac{\text{voltage rating required}}{\text{voltage rating of given capacitor}} = \frac{700}{200}$$

$$= 3.5 \Rightarrow 4$$

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

Number of rows required

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

$$\therefore \text{total number of capacitors required} = 4 \times 4 = 16$$

272 (b)

$$\text{Electric field due to one wire} = \frac{1}{4\pi\epsilon_0} \frac{2\lambda_1}{R}$$

$$\text{Charge per unit length on other wire: } q_2 = \lambda_2 l$$

$$\Rightarrow q_2 = \lambda_2 \times 1 = \lambda_2$$

Force per metre length on other wire

$$F = q_2 E = \lambda_2 E = \frac{1}{4\pi\epsilon_0} \frac{2\lambda_1 \lambda_2}{R} = K \times \frac{2\lambda_1 \lambda_2}{R}$$

273 (c)

Using the formula for electric field produced by large

Sheet,  $E = Q/2A\epsilon_0$  and we get

$$E_A = \frac{4Q}{2A\epsilon_0} (-\hat{i}); E_B = \frac{2Q}{2A\epsilon_0} (-\hat{i})$$

$$E_C = \frac{4Q}{2A\epsilon_0} (+\hat{i})$$

274 (a)

Potential difference between two points in a electric fields is,

$$V_A - V_B = \frac{W}{q_0}$$

Where W is work done by moving charge  $q_0$  from point A to B.

So,

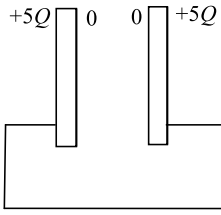
$$V_A - V_B = \frac{2}{20}$$

$$(\text{Here } W = 2, q_0 = 20C) = 0.1V$$

275 (d)

Final charges are as shown. Energy stored in the capacitor will be zero finally





$$\text{Heat produced} = \Delta H \Rightarrow U_1 - U_f = \frac{1}{2} \frac{Q^2}{A/d} - 0$$

276 (b)

$$\begin{aligned} W_{\text{el.}} &= q(V_i - V_f) \\ \Rightarrow 6.4 \times 10^{-19} &= -1.6 \times 10^{-19}(V_A - V_B) \\ \Rightarrow V_A - V_B &= -4 \text{ V} \\ \Rightarrow V_A - V_C &= -4 \text{ V} (\because V_B = V_C) \\ \Rightarrow V_C - V_A &= 4 \text{ V} \end{aligned}$$

277 (a)

$$\begin{aligned} \text{KE} &= \text{PE of two protons} \\ &= \frac{e^2}{4\pi\epsilon_0 r} = \frac{9 \times 10^9 \times (1.6 \times 10^{-19})^2}{10^{-10}} \\ &= 23 \times 10^{-19} \text{ J} \\ \therefore \text{KE of each proton} &= \frac{23}{2} \times 10^{-19} \text{ J} \\ &= 11.5 \times 10^{-19} \text{ J} \end{aligned}$$

278 (a)

Given electric potential of spheres are same i.e.,

$$V_A = V_B$$

$$\frac{1}{4\pi\epsilon_0} \frac{\theta_1}{a} = \frac{1}{4\pi\epsilon_0} \frac{\theta_2}{b}$$

$$\frac{\theta_1}{\theta_2} = \frac{a}{b} \dots \dots \dots (i)$$

A surface charge density

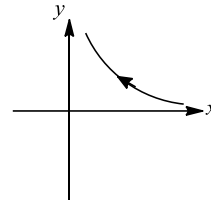
$$\sigma = \frac{a}{4\pi r^2}$$

$$\Rightarrow \frac{\sigma_1}{\sigma_2} = \frac{\theta_1}{\theta_2} \times \frac{b^2}{a^2}$$

$$= \frac{a}{b} \times \frac{b^2}{a^2} = \frac{b}{a}$$

279 (a)

$$V = x^2 - y^2$$



$$E_x = -\frac{dV}{dx} = -2x$$

$$E_y = 2y$$

280 (a)

This is the case of a balanced wheatstone bridge. The middle five capacitors will have no charge and will be useless

281 (d)

Net work done = final PE - initial PE

$$= \frac{Qq}{4\pi\epsilon_0 l} - \frac{Qq}{4\pi\epsilon_0 l} = \text{Zero.}$$

282 (b)

Given:

$$E = \frac{E_0}{l} \vec{l}, l = 2 \text{ cm}, a = 1 \text{ cm}, E_0 = 5 \times 10^3 \text{ N/C}$$

We see that flux passes mainly through surface area ABCD and EFGH. as the AEFB and CHGD are parallel to the flux again in ABCD = 0. Hence, the flux only passes through the surface area EFGHE = 0

$$\text{Flux,} = E_0 \frac{a}{l} \times \text{area} = 5 \times 10^3 \times \frac{a}{l} \times a^2$$

$$= 5 \times 10^3 \times \frac{a^3}{l}$$

$$= 5 \times 10^3 \times \frac{(0.01)^3}{2 \times 10^{-2}} = 2.5 \times 10^{-1}$$

So,  $q = \epsilon_0 \text{ flux}$

$$= 8.85 \times 10^{-12} \times 2.5 \times 10^{-1}$$

$$= 22.125 \times 10^{-13} = 2.2125 \times 10^{-12} \text{ C}$$

283 (c)

Original capacity, with air

$$C = \frac{\epsilon_0 A}{d}$$

When dielectric plate (medium) of thickness  $t$  is introduced between the plates, then capacity becomes

$$C' = \frac{\epsilon_0 A}{d' - t(1 - \frac{1}{K})}$$

but as given,  $C' = C$

$$\therefore \frac{\epsilon_0 A}{d} = \frac{\epsilon_0 A}{d' - t(1 - \frac{1}{K})}$$

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

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



or  $8 = d' - 2$   
or  $d' = 10 \text{ mm}$

284 (c)

$$U = 2kq^2 \left[ -\frac{1}{a} + \frac{1}{2a} - \frac{1}{3a} + \frac{1}{4a} + \dots \right]$$

$$= -\frac{2q^2}{4\pi\epsilon_0 a} \left[ 1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \dots \right] = -\frac{2q^2 \log_e 2}{4\pi\epsilon_0 a}$$

285 (c)

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

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

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

Charge in the arm containing  $4\mu\text{F}$  capacitor is

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

286 (a)

We know that any extra charge resides on the outer surface. Finally, both will be at the same potential. It is because both are connected

287 (b)

For a charged sphere or shell of charge potential

$$V_s = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r}$$

Hence, charge on both the spheres will be equal.

288 (a)

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

$$U_C = \frac{1}{4\pi\epsilon_0} \left( \frac{q_1 q_3}{0.4} + \frac{q_2 q_3}{0.5} \right)$$

Where charge  $q_3$  is at  $D$ , then

$$U_D = \frac{1}{4\pi\epsilon_0} \left( \frac{q_1 q_3}{0.4} + \frac{q_2 q_3}{0.1} \right)$$

Hence, change in potential energy

$$\Delta U = U_D - U_C$$

$$= \frac{1}{4\pi\epsilon_0} \left( \frac{q_2 q_3}{0.1} - \frac{q_2 q_3}{0.5} \right)$$

$$\text{but } \Delta U = \frac{q_3}{4\pi\epsilon_0} k$$

$$\therefore \frac{q_3}{4\pi\epsilon_0} k = \frac{1}{4\pi\epsilon_0} \left( \frac{q_2 q_3}{0.1} - \frac{q_2 q_3}{0.5} \right)$$

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

289 (c)

After combining, the volume remains same *i. e.*,

Volume of bigger drop =  $N \times$  volume of smaller drop

Or

$$\frac{4}{3}\pi R^3 = N \times \frac{4}{3}\pi r^3$$

Or

$$N = \left( \frac{R}{r} \right)^3 \dots \dots \dots (i)$$

As charge is conserved, hence

$$Q = Nq \dots \dots \dots (ii)$$

Capacity of bigger drop =  $4\pi\epsilon_0 R$

Capacity of smaller drop =  $4\pi\epsilon_0 r$

From Eq. (ii), we have

$$(4\pi\epsilon_0 R)V_{big} = N(4\pi\epsilon_0 r)V_{small}$$

$$\text{or } (4\pi\epsilon_0 R) \times 40 = N(4\pi\epsilon_0 r) \times 10$$

$$\text{or } 4R = Nr$$

$$\text{or } \frac{R}{r} = \frac{N}{4} \dots \dots \dots (iii)$$

From Eqs. (i) and (iii), we have

$$N = \left( \frac{N}{4} \right)^3$$

or

$$N = \frac{N^3}{64}$$

or

$$N^2 = 64$$



OR  $N=8$

290 (c)

Electrical potential energy of system

$$U = -2 \left[ \frac{kq^2}{\sqrt{2}a} \right] = \frac{-\sqrt{2}kq^2}{a} \text{ (four pairs will cancel each other)}$$

If  $a$  decreases,  $U$  also decreases and if  $U$  decreases, the agent will do negative work

291 (b)

Potential at the centre of hollow metallic sphere

$$V = \frac{1}{4\pi\epsilon_0} \frac{Q}{R}$$

292 (a)

$$E = -\frac{dV}{dr} = -\frac{d}{dx}(4x^2) = -8x$$

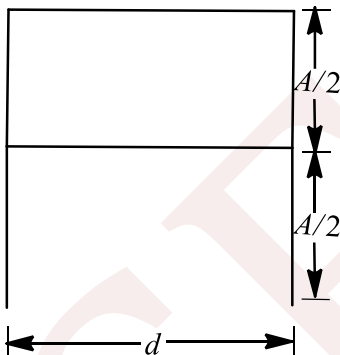
$$= -8(1) = -8 \text{ V m}^{-1}$$

Negative sign indicates  $\vec{E}$  is along negative direction of  $X$ -axis.

293 (c)

The dielectric is introduced such that, half of its area is occupied by

It.



In the given case the two capacitors are in parallel.

$$\therefore C' = C_1 + C_2$$

$$C_1 = \frac{A\epsilon_0}{2d}$$

And

$$C_2 = \frac{KA\epsilon_0}{2d}$$

Thus,

$$C' = \frac{A\epsilon_0}{2d} + \frac{KA\epsilon_0}{2d}$$

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

294 (a)

If the plates of a parallel plate capacitor are not equal in area, then quantity of charge on the

plates will be same but nature of charge will differ.

295 (b)

The electric field between the plates is

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

or

$$V = Ed \text{ or } V \propto d$$

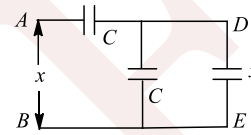
Hence, if the plates are pulled apart the potential difference increases.

296 (a)

In parallel, potential is same on each capacitor

297 (b)

Let capacitance between  $A$  and  $B$  be  $x$ . If we remove the first two capacitors, then capacitance across  $D$  and  $E$  will also be  $x$ . So the circuit can be redrawn as follows



$$x = \frac{C(C+x)}{C+(C+x)}, \text{ Solve to get } x = \frac{\sqrt{5}-1}{2}C$$

299 (a)

$$C_1 = C, V_1 = V_0, C_2 = KC, V_2 = 0 \text{ and } V_{\text{common}} = V$$

$$\text{We know that } V_{\text{common}} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

$$V = \frac{CV_0 + KC \times 0}{C + KC}$$

$$K = \frac{V_0}{V} - 1$$

300 (b)

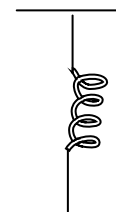
$$V_x - V_\infty = -\int_\infty^x E_x dx \Rightarrow V_x - 0 = -\int_\infty^x \frac{A}{x^3} dx$$

$$\Rightarrow V_x = \frac{A}{2x^2}$$

301 (b)

When a force of  $F$  Newton is applied the potential energy is given by

$$U = \frac{1}{2}Fx$$



Load  
(5000N)

Energy stored by capacitor is  $\frac{1}{2}CV^2$



$$\therefore \text{Ratio is } \frac{\frac{1}{2}Fx}{\frac{1}{2}CV^2} = \frac{5000 \times 0.2}{10 \times 10^{-6} \times (10^4)^2} = 1$$

302 (b)

The whole amount of energy stored in capacitor will convert into heat

$$\text{Heat} = \frac{1}{2}CV^2 = \frac{1}{2} \times 2 \times 10^{-6} \times (100)^2 = 0.01 \text{ J}$$

303 (c)

$$V_A - \frac{q}{C_1} - E - \frac{q}{C_2} = V_B \Rightarrow V_A - V_B - E = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)q$$

$$\Rightarrow q = -\frac{40}{3} \mu\text{C}$$

304 (d)

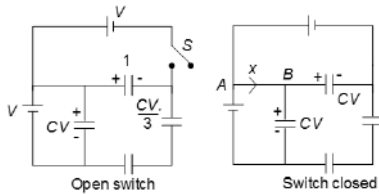
$C_3, C_5$  and  $C_6$  are in parallel and  $C_4$  is in series with it. Then  $C_2$  is in parallel and  $C_1$  is in series

305 (a)

$V = ER$ ; If  $R$  is doubled,  $V$  also gets doubled

306 (d)

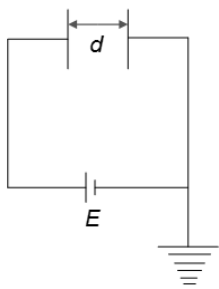
Charge flown from  $A$  to  $B$ :



$$x = \text{change in charge on capacitor '1'} \\ = CV - \frac{CV}{3} = \frac{2CV}{3}$$

307 (b)

The circuit can be redrawn as shown in Figure.



Charge on capacitor is

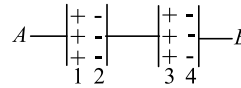
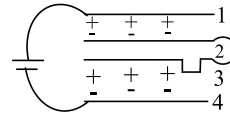
$$Q = CE = \frac{\epsilon_0 AE}{d}$$

Option (a), (c) and (d) are incorrect

308 (b)

Plates can be rearranged as shown in Figure  
Plates 1 and 2 and plates 3 and 4 from two capacitors which are in series between  $A$  and  $B$ .

Plates 2 and 3 do not form any capacitor as they are at same potential



$$\text{So, } C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{\left(\frac{\epsilon_0 A}{d}\right) \times \left(\frac{\epsilon_0 A}{3d}\right)}{\frac{\epsilon_0 A}{d} + \frac{\epsilon_0 A}{3d}} \\ = \frac{\epsilon_0 A}{4d}$$

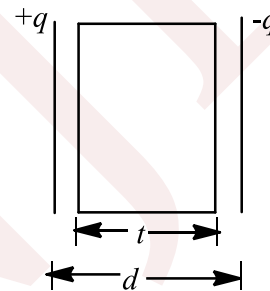
309 (b)

Electrical pressure (force/area)

$$\Rightarrow p = \frac{1}{2} \epsilon_0 E^2 \text{ and } E = \frac{V}{r} \therefore p = \frac{1}{2} \epsilon_0 \frac{V^2}{r^2}$$

310 (b)

The capacitance  $C$  of a capacitor of area  $A$  and distance between plates is  $d$ , then



$$C = \frac{\epsilon_0 A}{d}$$

When a dielectric slab of thickness  $t$  is placed between the plates, we have

$$C' = \frac{\epsilon_0 A}{d - t + \frac{t}{K}}$$

Given,  $C = 20 \mu\text{F} = 20 \times 10^{-6} \text{ F}$ ,

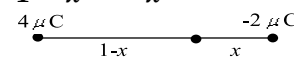
$$d = 2 \text{ mm} = 2 \times 10^{-3} \text{ m}, t = 1 \text{ mm} \\ = 1 \times 10^{-3} \text{ m}, K = 2$$

$$\therefore \frac{C'}{C} = \frac{d}{d - t \left(1 - \frac{1}{K}\right)} \\ = \frac{2 \times 10^{-3}}{2 \times 10^{-3} - 1 \times 10^{-3} \left(1 - \frac{1}{2}\right)} = 1.33$$

$$\Rightarrow C' = 1.33 \times 20 \times 10^{-6} = 26.6 \mu\text{F}$$

311 (c)

$$\frac{k \times 4}{1 - x} = \frac{k \times 2}{x} \Rightarrow x = \frac{1}{3} \text{ m}$$



312 (a)

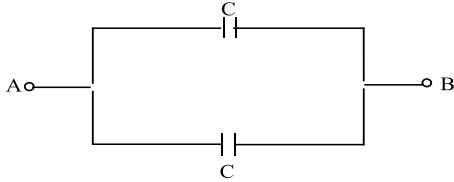


$$\int \vec{E} \cdot d\vec{s} = NC^{-1}(M^2)$$

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

313 (a)

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

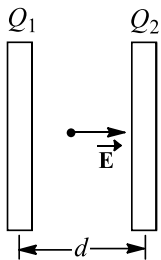


Hence, equivalent capacitance between points A and B is

$$C = \frac{\epsilon_0 A}{d} + \frac{\epsilon_0 A}{d} = \frac{2\epsilon_0 A}{d}$$

314 (d)

On bringing the charged metal plates closer, electric field  $\vec{E}$  in the intervening space is



$$E = \frac{\sigma_1}{2\epsilon_0} - \frac{\sigma_2}{2\epsilon_0} = \frac{\sigma_1}{2A\epsilon_0} - \frac{\sigma_2}{2A\epsilon_0}$$

$$\text{Or } E = \frac{Q_1 - Q_2}{2A\epsilon_0} = \frac{V}{d} \text{ or } V = \frac{(Q_1 - Q_2)d}{2A\epsilon_0}$$

$$\Rightarrow V = \frac{Q_1 - Q_2}{2C} \quad (\because C = \frac{\epsilon_0 A}{d})$$

315 (a)

The capacitor with air as the dielectric has capacitance

$$C_1 = \frac{\epsilon_0}{d} \left( \frac{3A}{4} \right) = \frac{3\epsilon_0 A}{4d}$$

Similarly, the capacitor with K as the dielectric constant has capacitance  $C_2 =$

$$\frac{\epsilon_0 K}{d} \left( \frac{A}{4} \right) = \frac{\epsilon_0 AK}{4d}$$

Since,  $C_1$  and  $C_2$  are in parallel

$$C_{\text{net}} = C_1 + C_2$$

$$= \frac{3\epsilon_0 A}{4d} + \frac{\epsilon_0 AK}{4d}$$

$$= \frac{\epsilon_0 A}{d} \left[ \frac{3}{4} + \frac{K}{4} \right]$$

$$= \frac{C}{4} (K + 3)$$

316 (d)

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

317 (b)

Electric intensity inside is zero, whereas outside it is not zero

319 (d)

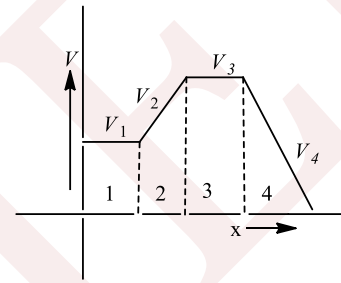
Equipotential surfaces are perpendicular to the electric lines of forces

320 (b)

Electric field

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

For I region,  $V_1 = \text{constant}$



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

$$\therefore E_1 = 0$$

For II region,

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

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

For III region,

$$V_3 = \text{constant}$$

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

$$\therefore E_3 = 0$$

For IV region,  $V_4 = -f(x)$

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

From these values, we have



$$E_2 > E_4 > E_1 = E_3$$

321 (a)

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

$$C' = 10\mu\text{F} + 6\mu\text{F} = 16\mu\text{F}$$

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

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

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

322 (d)

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

$$C = \frac{K\epsilon_0 A}{d} \quad \dots(i)$$

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

$$C = \frac{\epsilon_0 A}{d} \quad \dots(ii)$$

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

$$C = KC_0$$

$$\Rightarrow C_0 = \frac{C}{K} = \frac{C}{2} \quad (\because K = 2)$$

323 (d)

Start with  $C_3$  and  $C_4$  in parallel, then  $C_2$  in series, then  $C_5$  in parallel, then  $C_1$  in series and finally  $C_6$  in parallel

324 (d)

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

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

$$Q' = QU' = U/K$$

$$V' = V/K$$

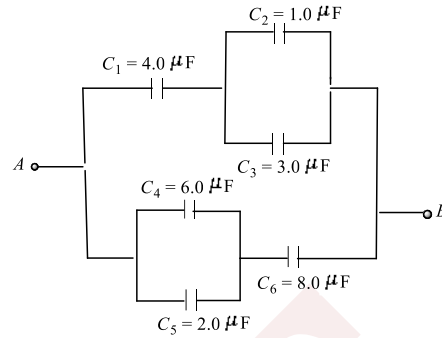
325 (d)

$$C = \frac{\epsilon_0 A}{\frac{d_1}{K_1} + \frac{d_2}{K_2}}$$

$$= \frac{\epsilon_0 A}{\frac{d}{2} \left( \frac{1}{1} + \frac{1}{2} \right)} = \frac{4\epsilon_0 A}{3d}$$

326 (a)

In given figure  $C_2$  and  $C_3$  are in parallel,



$$\therefore C' = C_2 + C_3 = 4\mu\text{F}$$

As  $C'$  and  $C_1$  are in series,

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

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

Similarly,  $C_4$  and  $C_5$  are in parallel

$$C''' = 6 + 2 = 8\mu\text{F}$$

$C'''$  and  $C_6$  are in series

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

$$\Rightarrow C'''' = 4\mu\text{F}$$

Now,  $C''''$  and  $C''$  are in parallel.

$$\therefore C = 4\mu\text{F} + 2\mu\text{F} = 6\mu\text{F}$$

327 (c)

$$P = 2 \times 10^{-8} \times 2 \times 10^{-3} = 4 \times 10^{-11} \text{ Cm}$$

$$E = \frac{\lambda}{2\pi\epsilon_0 x}, F = p \cos\theta \frac{dE}{dx}$$

$$F = -\frac{p \cos\theta \lambda}{2\pi\epsilon_0 x^2} = \frac{-4 \times 10^{-11} \times \cos 60^\circ \times 4 \times 10^{-4}}{\frac{1}{2 \times 9 \times 10^9} \times \left( \frac{6}{100} \right)^2}$$

$$= 0.04 \text{ N}$$

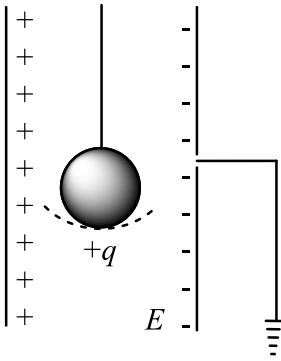
328 (d)

All the charges are placed in the  $x$ - $y$  plane such that they form a square with origin as its centre. So, electric field at the origin will be zero but at other points on  $z$ -axis, field will be along  $z$ -axis

329 (d)

Time period of simple pendulum in air





when it is suspended between vertical plates of a charged parallel plate capacitor, then acceleration due to electric field,

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

This acceleration is acting horizontally and acceleration due to gravity is acting vertically. So, effective acceleration

$$g' = \sqrt{g^2 + a^2} = \sqrt{g^2 + \left(\frac{qE}{m}\right)^2}$$

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

330 (a)

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

$$Q = C_s V$$

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

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

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

331 (b)

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

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

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

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

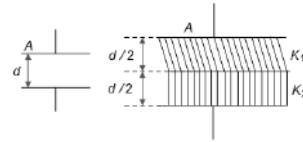
$$\Rightarrow \frac{U_{\text{before}}}{U_{\text{after}}} = \frac{C_1 + C_2}{C_1}$$

Here,  $C_1 = C_2 = C$

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

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

332 (a)



$$C_0 = \frac{\epsilon_0 A}{d}$$

$$C_1 = \frac{k_1 \epsilon_0 A}{d/2} \Rightarrow C_2 = \frac{k_2 \epsilon_0 A}{d/2}$$

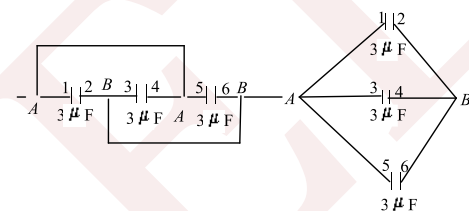
$C_1$  and  $C_2$  are in series

Equivalent dielectric constant  $K = \frac{2k_1 k_2}{k_1 + k_2}$  which is the ratio of capacitor

333 (d)

Check each option separately

334 (a)



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

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

335 (d)

$$E_1 = \frac{1}{2} C_1 V^2$$

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

$$E_1 = \frac{1}{2} C_2 V^2$$

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

Energy change =  $E_2 - E_1$

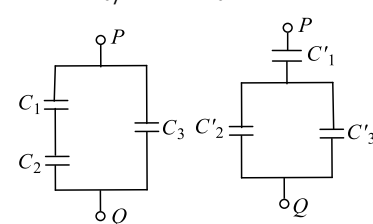
$$= 0.05 - 0.01 = 0.04\text{J} = 4 \times 10^{-2}\text{J}$$

336 (a)

We can make equivalent circuit of given system in two ways as in Fig (a) and (b). But (b) is wrong and (a) is correct

Hence  $C_1 = \frac{\epsilon_0 A/2}{t/2} = \frac{\epsilon_0 A}{t}$

$$C_2 = \frac{K \epsilon_0 A/2}{t/2} = \frac{K \epsilon_0 A}{t} \text{ and } C_3 = \frac{\epsilon_0 A/2}{t} = \frac{\epsilon_0 A}{2t}$$



(a) (Right)

(b) (Wrong)



$$\text{Now, } C_{\text{eq}} = \frac{C_1 C_2}{C_1 + C_2} + C_3$$

$$= \frac{\epsilon_0 A}{t} \left[ \frac{3K + 1}{2(K + 1)} \right]$$

337 (c)

$$\vec{\tau} = \vec{p} \times \vec{E}$$

$$\tau_{\text{max}} = pE$$

$$50 \times 10^{-28} = p40 \Rightarrow p = 1.25 \times 10^{-28} \text{ column}$$

338 (a)

$$C_1 = 40 \mu\text{F}, C_2 = K \times 40 = 3 \times 40 = 120 \mu\text{F}$$

$$C_{\text{eq}} = \frac{C_1 C_2}{C_1 + C_2} = \frac{40 \times 120}{40 + 120} = 30 \mu\text{F}$$

339 (d)

Potential decreases in the direction of electric field. So it depends whether the lines of forces are from A to B or from B to A

340 (d)

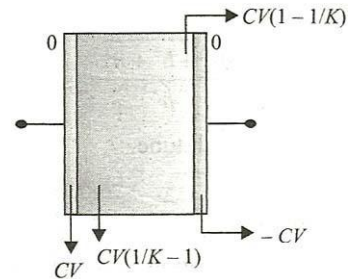
The capacity of an isolated spherical conductor of radius R is  $4\pi\epsilon_0 R$

$$\therefore C \propto R$$

341 (b)

Due to polarization, charge on dielectric slab would be

$$CV \left( 1 - \frac{1}{K} \right)$$



So, charge on 1=0

$$\text{Charge on 2} = CV - CV \left( 1 - \frac{1}{K} \right) = \frac{CV}{K}$$

$$\text{Charge on 3} = CV \left( 1 - \frac{1}{K} \right) - CV = -\frac{CV}{K}$$

Charge on 3 = 0

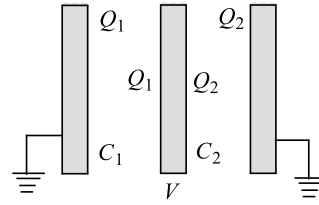
342 (d)

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

$$Q_1 + Q_2 = Q$$

$$\text{Where } C_1 = \epsilon_0 A/a \text{ and } C_2 = \epsilon_0 A/b$$

$$\text{Solve to find } Q_2 = \frac{Qa}{a+b}$$



343 (d)

$$F = qE, W = qE \times 2 \cos 60^\circ$$

$$\Rightarrow 4 = 0.2 E \times 2 \times \frac{1}{2} \Rightarrow E = 20 \text{ NC}^{-1}$$

344 (d)

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

$$V' = \frac{1}{4\pi\epsilon_0} \frac{q'}{r'} = \frac{1}{4\pi\epsilon_0} \frac{nq}{n^3 r}$$

$$(\because q' = nq, r' = n^3 r)$$

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

345 (a)

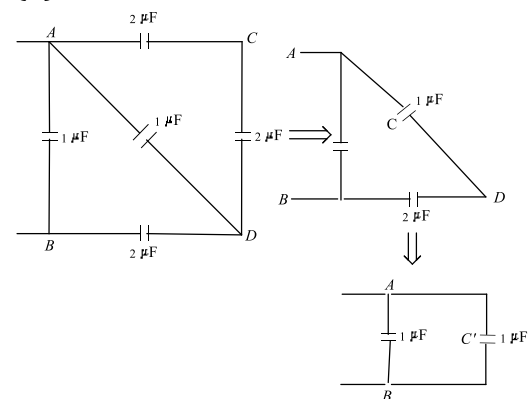
$$C = \frac{\epsilon_0 A}{d} = 0.5$$

New capacitance

$$C' = \frac{\epsilon_0 A}{\frac{d/2}{2} + \frac{d/2}{3}} = \frac{\epsilon_0 A}{d} \left[ \frac{1}{\frac{1}{4} + \frac{1}{6}} \right]$$

$$= C \times 2.4 = 1.2 \mu\text{F}$$

346 (d)



The capacitors  $2 \mu\text{F}$  and  $2 \mu\text{F}$  of arm ACD are in series. So, their equivalent capacitance is  $1 \mu\text{F}$  which is in parallel with capacitor of  $1 \mu\text{F}$  of arm AD.

So, equivalent capacitance now is  $2 \mu\text{F}$ .

This capacitance is now in series with  $2 \mu\text{F}$  capacitance of arm BD which equivalent to  $1 \mu\text{F}$  is in parallel with  $1 \mu\text{F}$  capacitance of arm AB.



So, final effective capacitance = 2  $\mu$ F.

347 (d)

On introduction and removal and again on introduction, the capacity and potential remain same. So, net work done by the system in this process

$$W = U_f - U_i \\ = \frac{1}{2} CV^2 - \frac{1}{2} CV^2 = 0$$

348 (d)

Ball D has no effect on E, it means both D and E should be neutral

Repulsion



Attraction Attraction No effect

A Repels C, so both should have similar type of charge. Negatively charged rod attracts A, so A should have positive charge. So C should also have positive charge.

A attracts B, so B is either negatively charged or has no charge. But B attracts D which is uncharged, so B should have negative charge

349 (b)

$\frac{1}{2} CV^2 = \text{mass} \times \text{specific heat} \times \text{change in temperature}$

$$V^2 = \frac{2 \times m \times s \times T}{C}; V = \sqrt{\frac{2msT}{C}}$$

350 (b)

Capacitors B and C are in parallel, then A is in series

$$C_{eq} = \frac{2 \times (3 + 4)}{2 + (3 + 4)} = \frac{14}{9} \mu\text{F}$$

$$Q = C_{eq}V = \frac{14}{9} (7 - 6) = \frac{14}{9} \mu\text{C}$$

Q will be divided between B and C. So charge on B is

$$q = \frac{3 \times (14/9)}{3 + 4} = \frac{2}{3} \mu\text{C}$$

351 (b)

Potential on bubble,

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

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

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

352 (a)

$$V_C = \frac{C_1 V_1}{C_1 + C_2} = 100 \text{ V}$$

Energy lost =  $U_i - U_f$

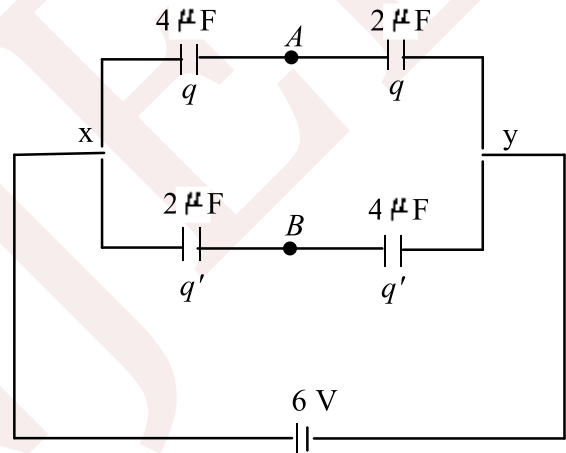
$$= \frac{1}{2} C_1 V_1^2 - \frac{1}{2} (C_1 + C_2) V_C^2$$

$$= 6 \times 10^{-6} \text{ J}$$

353 (a)

Consider the charge distribution as shown.

Considering the branch on upper side, we have



$$\frac{q}{V_x - V_A} = 4 \times 10^{-6}$$

$$\frac{q}{V_A - V_y} = 2 \times 10^{-6}$$

Here,  $V_x = 6 \text{ volt}, V_y = 0$

$$\therefore \frac{q}{6 - V_A} = 4 \times 10^{-6}$$

...(i)

$$\frac{q}{V_A - 0} = 2 \times 10^{-6}$$

...(ii)

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

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

$$\therefore V_A = 4 \text{ volt}$$

Similarly for the lower side branch

$$\frac{q'}{6 - V_B} = 2 \times 10^{-6}$$

...(iii)

$$\frac{q'}{V_B - 0} = 4 \times 10^{-6}$$

...(iv)

From Eqs. (iii) and (iv)



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

$$\therefore V_B = 2 \text{ volt}$$

$$\therefore V_A - V_B = 4 - 2 = 2 \text{ volt}$$

354 (d)

Potential of big drop  $V = n^{2/3}V'$

$V'$  = potential of small drop

$n$  = no. of drops = 125

$$V = 2.5$$

$$\therefore 2.5 = (125)^{2/3} V'$$

$$2.5 = 25V'$$

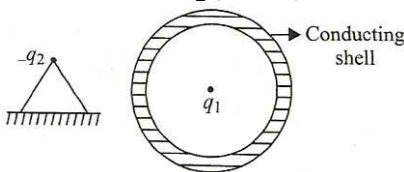
$$V' = 0.1 \text{ volt}$$

355 (c)

Trajectory will be tangent to the electric field

356 (c)

Net force on  $q_1$  is zero, while that on the conducting sphere is towards the left due to attraction of  $-q_2$  (figure)



357 (a)

Net flux leaving the surface

$$\phi = 4 \times 10^5 - 5 \times 10^5 = -10^5 \text{ MKS units}$$

$\therefore$  charges must be negative

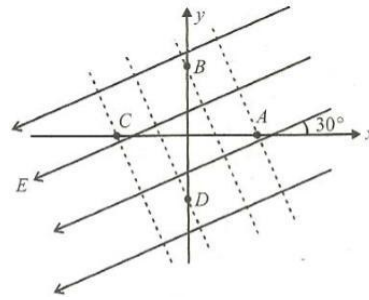
$$q = \phi \epsilon_0 = -10^5 \times 8.86 \times 10^{-12} \\ = -8.86 \times 10^{-7} \text{ C}$$

358 (b)

$$\text{Power} = \frac{\text{Energy}}{\text{Time}} = \frac{(12)CV^2}{\text{Time}} \\ = \frac{40 \times 10^{-6} \times (3000)^2}{2 \times 2 \times 10^{-3}} = \frac{40 \times 10^{-6} \times 9 \times 10^6}{4 \times 10^{-3}} \\ = 9 \times 10 = 90 \text{ kW}$$

359 (b)

Four lines perpendicular to lines of electric field and passing through  $A, B, C$  and  $D$  are drawn. These are equipotential lines. As potential decreases in the direction of electric field,  $V_A > V_B > V_D > V_C$



360 (c)

Since magnitude of forces is proportional to  $m$  as  $f = mv^2/r, m_1:m_2:m_3 = 1:\sqrt{3}:2$

361 (a)

If a dielectric slab is inserted between the plates of a charged capacitor, the intensity of electric field potential difference of capacitor and the energy stored all reduce to  $\frac{1}{K}$  times and capacity of the capacitor increases  $K$  times. But the charge on the capacitor remains unchanged.

Here,  $K$  is the dielectric constant of dielectric.

362 (c)

$$E = -\frac{dV}{dr} = -\frac{(1-3)}{0.3-0.1} Vm^{-1} = 10 V m^{-1}$$

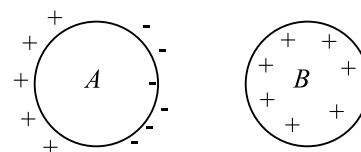
363 (c)

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

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

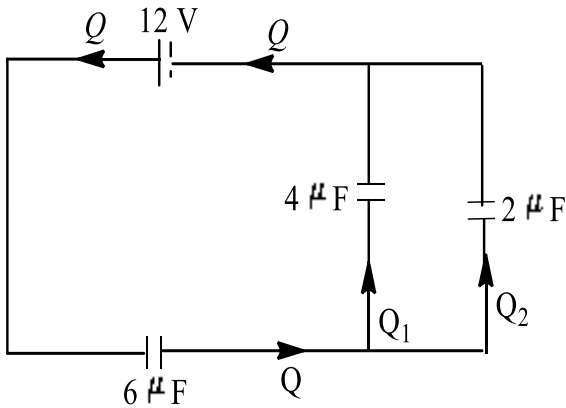
364 (b)

Charge on  $B$  will remain the same as it is not touched with any other body. Charge induced on  $A$  will decrease the potential of  $B$  (figure)



365 (c)



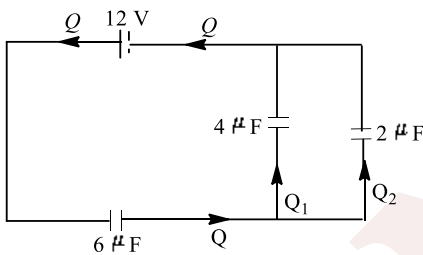


As the capacitors  $4 \mu\text{F}$  and  $2 \mu\text{F}$  are connected in parallel and are in series with  $6 \mu\text{F}$  capacitor, their equivalent capacitance is

$$\frac{(2+4) \times 6}{2+4+6} = 3 \mu\text{F}$$

Charge in the circuit

$$Q = 3 \mu\text{F} \times 12\text{V} = 36 \mu\text{C}$$



Since, the capacitors  $4 \mu\text{F}$  and  $2 \mu\text{F}$  are connected in parallel, therefore potential difference across them is same.

$$\Rightarrow \frac{Q_1}{Q_2} = \frac{C_1}{C_2} = \frac{4}{2} \text{ or } Q_1 = 2Q_2$$

$$\text{Also } Q = Q_1 + Q_2$$

$$\therefore 36 \mu\text{C} = 2Q_2 + Q_2 \text{ or } Q_2 = \frac{36 \mu\text{C}}{3} = 12 \mu\text{C}$$

$$Q_1 = Q - Q_2 = 36 \mu\text{C} - 12 \mu\text{C} = 24 \mu\text{C} = 24 \times 10^{-6} \text{C}$$

366 (d)

(i)  $Q/2, Q/2, 0$

(ii)  $Q/2, Q/4, Q/4$

(iii)  $3Q/8, Q/4, 3Q/8$

(iv)  $5Q/16, 5Q/16, 3Q/8$

(v)  $5Q/16, 11Q/32, 11Q/32$

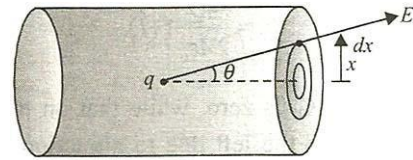
367 (c)

$$\phi = \phi_{ps_1} + \phi_{cs} + \phi_{ps_2}$$

$$= 2\phi_{ps} + \phi_{cs} \quad [\because \phi_{ps_1} = \phi_{ps_2}]$$

$$\phi_{cs} = \phi - 2\phi_{ps} = \frac{q}{\epsilon_0} - 2\phi_{ps}$$

To find  $\phi_{ps}$ , use integration technique.



$$\vec{E} = \frac{q}{4\pi\epsilon_0} \times \frac{1}{(x^2 + l^2/4)}$$

$$d\phi_{ps} = \vec{E} \cdot \vec{ds} = E \times 2\pi x dx \times \cos\theta$$

$$= \frac{q}{2\epsilon_0} \times \frac{x dx}{(x^2 + l^2/4)} \times \frac{l}{\sqrt{x^2 + l^2/4}}$$

$$= \frac{ql}{4\epsilon_0} \times \frac{x dx}{(x^2 + l^2/4)^{3/2}}$$

$$\phi_{ps} = \frac{ql}{4\epsilon_0} \int_0^R \frac{x dx}{(x^2 + l^2/4)^{3/2}}$$

$$= \frac{q}{2\epsilon_0} - \frac{ql}{4\epsilon_0 \sqrt{R^2 + l^2/4}}$$

368 (d)

$$V = K \left[ \frac{q}{x_0} - \frac{q}{2x_0} + \frac{q}{3x_0} - \frac{q}{4x_0} + \dots \right]$$

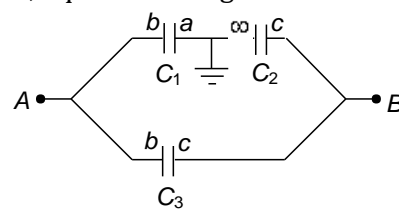
$$= \left( \frac{q}{x_0} \right) K \left[ 1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \dots \right]$$

$$= \frac{1}{4\pi\epsilon_0} \frac{q}{x_0} \log 2$$

369 (c)

The innermost conductor is at zero potential (the same potential as we assumed for infinity) The conductors with radius  $a$  and  $b$  make one capacitor, between  $b$  and  $c$ ; other conductor and  $c$  make a capacitor with its other plate at infinity.

So, equivalent diagram can be drawn as



$$\text{Here, } C_1 = \frac{4\pi\epsilon_0 ab}{b-a}$$

$$C_2 = 4\pi\epsilon_0 c$$

$$C_3 = \frac{4\pi\epsilon_0 bc}{c-b}$$

$$\therefore C_{eq} = C_3 + \frac{C_1 C_2}{C_1 + C_2}$$

$$= 4\pi\epsilon_0 \left[ \frac{bc}{c-b} + \frac{abc}{ab + c(b-a)} \right]$$

370 (a)



The electric field strength in a parallel-plate capacitor with applied voltage of  $V$  and separation  $d$  is given by  $E = V/d$

371 (c)

Electric potential inside the hollow conducting sphere is constant and equal to potential at the surface of the sphere  $= \frac{Q}{4\pi\epsilon_0 R}$ .

372 (c)

A positive charge, which is free to move, will always move from higher to lower potential

373 (a)

Bob will experience an additional force  $F = qE$  in vertically upward direction and hence effective acceleration due to gravity is reduced from  $g$  to

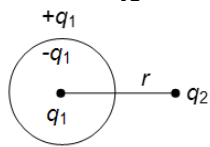
$$(g-a) = \left(g - \frac{qE}{m}\right).$$

Consequently, time period of oscillation will

become  $T = 2\pi \sqrt{\frac{l}{(g-a)}}$  ie, time period will increase.

374 (b)

The charge on outer surface of shell will supply a force on  $q_1$



$$F = \frac{kq_1q_2}{r^2}$$

375 (c)

Initial charge on  $C_1$ :  $Q_1 = C_1V = 110 \mu\text{C}$

Let  $x$  charge flow through wires  $\frac{Q_1-x}{C_1} = \frac{x}{C_{eq}}$

Where  $C_{eq} = \frac{C_2 \times C_3}{C_2 + C_3}$ . Solve to get  $x = 60 \mu\text{C}$

376 (d)

If length of the foil is them

$$C = \frac{K\epsilon_0(l \times b)}{d}$$

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

$$\Rightarrow l = 33.9 \text{ m.}$$

377 (d)

$$E = \frac{1}{4\pi\epsilon_0} \left( \frac{\frac{4}{3}\pi r^3 \rho}{r^2} \right) = \frac{1}{4\pi\epsilon_0} \left( \frac{4}{3}\pi r \rho \right) \text{ or } E \propto r$$

378 (c)

$$U = \frac{1}{4\pi\epsilon_0} \frac{q_1q_2}{r}$$

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

$$= -9 \times 10^9 \times 1.6 \times 10^{-19} \times 10^{10} \text{ eV}$$

$$= -14.4 \text{ eV}$$

379 (c)

The capacitance of air capacitor

$$C_0 = \frac{A\epsilon_0}{d} = 3 \mu\text{F} \quad \dots(i)$$

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

$$C = \frac{KA\epsilon_0}{d} = 15 \mu\text{F} \quad \dots(ii)$$

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

$$\frac{C}{C_0} = \frac{\frac{KA\epsilon_0}{d}}{\frac{A\epsilon_0}{d}} = \frac{15}{3}$$

$$\therefore K = 5$$

Permittivity of the medium

$$\begin{aligned} \epsilon_r &= \epsilon_0 K \\ &= 8.854 \times 10^{-12} \times 5 \\ &= 44.27 \times 10^{-12} \\ &= 0.44 \times 10^{-10} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \end{aligned}$$

380 (d)

It depends whether both charges are of the same or opposite sign

381 (b)

In series, all the potentials will be added

382 (c)

After closing  $S_1$ , charge on  $C_1$ ;  $q = 6 \times 20 = 120 \mu\text{C}$ . Now,  $S_1$  is opened. On closing  $S_2$ , charge  $q$  will be distributed between  $C_1$  and  $C_2$  according to their capacitances.

$$\text{So, charge on } C_2: q_2 = \frac{C_2 q}{C_1 + C_2} = \frac{3 \times 120}{3 + 6} = 40 \mu\text{C}$$

383 (b)

$$\text{Charge on the metal sphere: } V_1 = \frac{kq}{r_1} \Rightarrow q = \frac{V_1 r_1}{k}$$

On connecting the sphere with shell, entire charge will be transferred to the shell. So, potential of sphere now is

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

384 (d)



Since, the proton is moving against the direction of electric field so, work is done by the proton against electric field. It implies that electric field does negative work on the proton.

Again, proton is moving in electric field from low potential region to high potential region hence, its potential energy increases.

385 (a)

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

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

$\therefore$  capacity remains the same

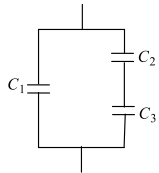
386 (a)

$$C_1 = \frac{K_1 \epsilon_0 A / 2}{t}$$

$$C_2 = \frac{K_2 \epsilon_0 A / 2}{t/2}$$

$$C_3 = \frac{K_3 \epsilon_0 A / 2}{t/2}$$

$$\text{Now, } C_{\text{eq}} = C_1 + \frac{C_2 C_3}{C_2 + C_3}$$



387 (b)

Electrostatic potential energy of system of two electrons

$$U = \frac{1}{4\pi\epsilon_0} \frac{(-e)(-e)}{r} = \frac{1}{4\pi\epsilon_0} \frac{e^2}{r}$$

Thus, as  $r$  decreases, potential energy  $U$  increases.

388 (d)

$$\Delta V = - \int_A^B \vec{E} \cdot d\vec{l} = \text{zero}$$

389 (b)

Initially at switch position  $Q$ , by conservation of charge, the voltage  $V$  across the two capacitors is thus given by

$$q = q_1 + q_2 = C_1 V + C_2 V = (C_1 + C_2) V$$

$$\Rightarrow 18 = (3 + 6)V$$

$$\Rightarrow V = (18/9) = 2 \text{ V}$$

390 (b)

Given,  $C_1 = 6\mu\text{F}$ ,  $C_2 = 12\mu\text{F}$ ,  $V = 150\text{volt}$ .

$$\begin{aligned} \text{Total capacity, } \frac{1}{C} &= \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{6} + \frac{1}{12} \\ &= \frac{2 + 1}{12} = \frac{3}{12} \\ &= \frac{1}{4} \Rightarrow C = 4\mu\text{F} \end{aligned}$$

Potential of  $12\mu\text{F}$  capacitor

$$V = \frac{q}{C}$$

$$V = \frac{4 \times 150}{12}$$

$$V = 50 \text{ volt}$$

391 (c)

$$C_0 = \frac{\epsilon_0 A}{d} = 18$$

$$C_0 = \frac{K\epsilon_0 A}{3d} = 72$$

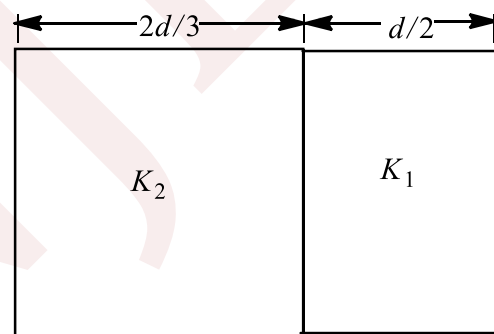
Dividing Eq. (ii) by Eq. (i)

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

$$K = 12$$

392 (c)

$$C = \frac{C_1 C_2}{C_1 + C_2} \quad \dots(i)$$



$$\text{where } C_1 = \frac{K_1 \epsilon_0 A}{d/3} \quad \dots(ii)$$

$$\text{And } C_2 = \frac{K_2 \epsilon_0 A}{2d/3} \quad \dots(iii)$$

It is given that  $\frac{\epsilon_0 A}{d} = 9\text{pF}$

On substituting Eqs. (ii) and (iii) in Eq. (i), we get the result

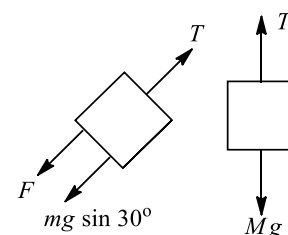
$$C_{\text{eq}} = 40.5\mu\text{F}$$

393 (a)

For equilibrium, we have

$$T = Mg$$

$$\text{And } T = F + \sin 30^\circ$$

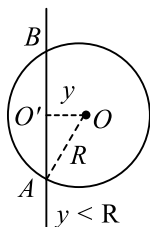


$$\Rightarrow Mg = F + \frac{mg}{2}$$

$$\Rightarrow m = \frac{m}{2} + \frac{F}{g} = \frac{m}{2} + \frac{E^2 \epsilon_0 A (k-1)}{2lgd}$$

394 (c)

$$\text{Electric flux } \oint_S \vec{E} \cdot \vec{ds} = \frac{q_{in}}{\epsilon_0}$$



$q_{in}$  is the charge enclosed by the Gaussian surface which, in the present case, is the surface of given sphere. As shown, length  $AB$  of the line lies inside the sphere.

$$\text{In } \triangle OO'A, R^2 = y^2 + (O'A)^2$$

$$O'A = \sqrt{R^2 - y^2} \text{ and } AB = 2\sqrt{R^2 - y^2}$$

$$\text{Charge on length } AB = 2\sqrt{R^2 - y^2} \times \lambda$$

$$\text{Therefore, electric flux } \oint_S \vec{E} \cdot \vec{ds} = \frac{2\lambda\sqrt{R^2 - y^2}}{\epsilon_0}$$

395 (d)

Positive plate of all the three condensers is connected to one point ( $A$ ) and negative plate of all the three condensers is connected to point ( $B$ ) ie, they are joined in parallel.

$$C_p = 3 + 3 + 3 = 9\mu\text{F}$$

396 (a)

When plates of capacitor are separated by a dielectric medium of dielectric constant  $K$ , its capacity

$$C_m = \frac{K\epsilon_0 A}{d} = KC_0$$

$$\text{ie, } C_m = KC_0$$

$$\text{Here, } C_0 = C$$

$$\therefore C_m = KC$$

Now, two capacitors of capacities  $KC$  and  $C$  are in series, their effective capacitance

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

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

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

397 (d)

Let their potentials is be the same

$$V_1 = V_2 \Rightarrow \frac{kQ_1}{R_1} = \frac{kQ_2}{R_2} \Rightarrow Q_1 R_2 = Q_2 R_1$$

If potential are the same, then no flow of charge will occur, otherwise charge will flow and there will be loss of energy

398 (a)

$$V = \frac{\sum q}{4\pi\epsilon_0 r} = \frac{-10 + 10}{4\pi\epsilon_0 r} = 0$$

399 (b)

Potential on  $5\mu\text{F}$  capacitor is

$$\frac{3 \times 6}{3 + (2 + 5)} = 1.8\text{V}$$

$$\text{So, charge on this capacitor} = CV = 5 \times 1.8 = 9\mu\text{C}$$

400 (b)

$$C = \frac{A\epsilon_0}{d}$$

After inserting the slab

$$C' = \frac{A\epsilon_0}{(d-b)} = \frac{A\epsilon_0}{d - \frac{d}{2}}$$

$$C' = \frac{2A\epsilon_0}{d} \therefore \frac{C'}{C} = \frac{2}{1}$$

401 (c)

Total electric flux,  $\phi_1 = \phi = \frac{1}{\epsilon_0}$  (charge enclosed) and ie, charge of given body is body is constant.

402 (b)

Potential energy of charges  $q_1$  and  $q_2$ ,  $r$  distance apart

$$U = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r}$$

For  $r = 0.1\text{m}$ ,

$$U_1 = \frac{1}{4\pi\epsilon_0} \frac{12 \times 10^{-6} \times 5 \times 10^{-6}}{0.1} = \frac{9 \times 10^9 \times 60 \times 10^{-12}}{0.1} = 5.4\text{J}$$

For  $r = 0.06\text{m}$ ,

$$U_2 = \frac{9 \times 10^9 \times 60 \times 10^{-12}}{0.06} = 9\text{J}$$

$$\therefore \text{Work done} = (9 - 5.4)\text{J} = 3.6\text{J}$$

403 (a)

$$C = \frac{K\epsilon_0 2\pi l}{\ln(b/a)} = \frac{3.5 \times 2\pi \times 8.85 \times 10^{-12} \times 8 \times 10^3}{\ln(15/10)}$$

$$= 3.84 \times 10^{-6}\text{F}$$

404 (a)



$$E = -\frac{dV}{dr} = \text{negative of the slope of } V - r \text{ graph}$$

406 (d)

$$E = \left(\frac{1}{2}\right) CV^2 \quad \dots(i)$$

The energy stored in capacitor is lost in form of heat energy

$$H = ms \Delta T \dots(ii)$$

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

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

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

407 (a)

Charge on nucleus

$$Q = Ze = 47 \times 1.6 \times 10^{-19}$$

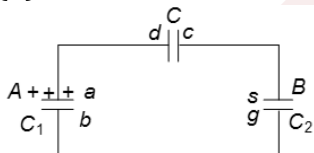
$$= 7.52 \times 10^{-18} \text{C}$$

Potential on the surface of nucleus is

$$V = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$$

$$= \frac{9 \times 10^9 \times 7.52 \times 10^{-18}}{3.4 \times 10^{-14}} = 1.99 \times 10^6 \text{V}$$

408 (d)



Charge on positive plate of A =  $C_1 V_1$

Charge on negative plate of B =  $-C_2 V_2$

When  $d$  plate of capacitor  $C$  is connected with the plate of A, then the total charge of  $(d, a)$  plate system will be  $C_1 V_1$  (conservation of charge)

Similarly on  $(C, S)$  plates, total charge will be  $-C_2 V_2$

The total charge on  $(b, g)$  plate system will be  $+C_2 V_2 - C_1 V_1$

409 (b)

Potential of larger capacitor after the first charging

$$V_1 = \frac{C_0 V_0}{(C + C_0)}$$

After the second charging

$$V_2 = \frac{C_0 V_1}{(C + C_0)} \Rightarrow V_2 = \left(\frac{C_0}{C + C_0}\right)^2 V_0$$

After the  $n^{\text{th}}$  charging,

$$V_n = \left(\frac{C_0}{C + C_0}\right)^n V_0, \text{ but } V_n = V$$

$$\Rightarrow C = C_0 \left[ \left(\frac{V_0}{V}\right)^{1/n} - 1 \right]$$

410 (b)

$$2000 \times 0.04 = \frac{1}{2} \times 40 \times 10^{-6} V^2$$

$$V^2 = 4 \times 10^6 \Rightarrow V = 2000 \text{V}$$

411 (a)

Because electric field intensity is zero inside a spherical conductor

412 (d)

$$C_{\text{eq}} = C + 2C + 3C + \dots + nC$$

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

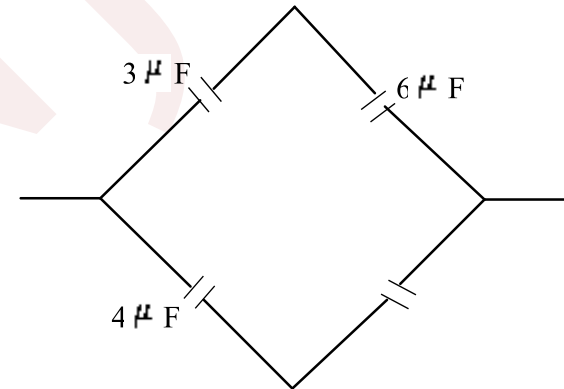
413 (b)

The points C and D will be at same potentials

$$\text{since, } \frac{3}{6} = \frac{4}{8}$$

Therefore, capacitance of  $2\mu\text{F}$  will be unaffected.

So, the equivalent circuit can be shown as.



The effective capacitance in upper arm in series, is given by

$$C_1 = \frac{3 \times 6}{3 + 6} = \frac{18}{9} = 2 \mu\text{F}$$

The effective capacitance in lower arm in series is given by

$$C_2 = \frac{4 \times 8}{4 + 8} = \frac{32}{12} = \frac{8}{3} \mu\text{F}$$

Hence, the resultant capacitance in parallel is given by

$$C = C_1 + C_2 = 2 + \frac{8}{3} = \frac{14}{3} \mu\text{F}$$

414 (b)



$$V = \frac{1}{4\pi\epsilon_0} \left( \frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3} \right)$$

$$= \frac{1}{4\pi\epsilon_0} \left( \frac{33 \times 10^{-9}}{93 \times 10^{-3}} - \frac{51 \times 10^{-9}}{\sqrt{2} \times 93 \times 10^{-3}} + \frac{47 \times 10^{-9}}{93 \times 10^{-3}} \right)$$

$$= \frac{1}{4\pi\epsilon_0} \times \frac{10^{-9}}{93 \times 10^{-3}} \left( 33 - \frac{51}{\sqrt{2}} + 47 \right)$$

$$\approx 4 \times 1000 \text{ V} = 4 \text{ kV}$$

415 (b)

The electric field intensity of a point in an electric field in a given direction is equal to the negative potential gradient in that direction, *ie*,

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

The negative sign signifies that the potential decreases in the direction of electric field, *ie*, electric lines of force flow from higher potential region to lower potential region.

Since, *AB* is perpendicular to field lines, so *A* and *B* are at same potential.

Hence,  $V_A = V_B > V_C$

416 (a)

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

417 (c)

On sharing of charges loss in electrical energy,

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

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

418 (b)

Since electrical potential at any point of circle of radius *R* due to charge  $Q_2$  at its centre is same

$$V = \frac{Q_2}{4\pi\epsilon_0 R}, \text{ hence work done in carrying a charge } Q_1 \text{ round the circle is zero.}$$

419 (b)

The arrangement behaves as a combination of 2 capacitors each of capacitance  $C = \frac{\epsilon_0 A}{d}$ .

Thus, equivalent capacity =  $2C$

$$\therefore \text{ total energy stored } U = \frac{1}{2} \times (2C)V^2 = CV^2 =$$

$$\frac{\epsilon_0 A}{d} V^2$$

420 (d)

Electrostatic potential energy of the system of charges is

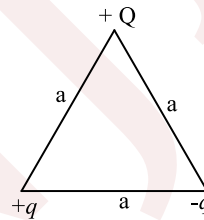
$$U = \frac{1}{4\pi\epsilon_0} \left[ \frac{Qq}{a} + \frac{Qq}{a} + \frac{q^2}{a} \right]$$

$$U = \frac{1}{4\pi\epsilon_0 a} [2Qq + q^2]$$

Given,  $U = 0$

$$\Rightarrow 2Qq + q^2 = 0$$

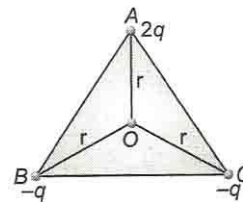
$$\Rightarrow Q = -\frac{q}{2}$$



421 (c)

In an equilateral triangle distance of centroid from all the vertices is same (say *r*).

$$\therefore V = V_1 + V_2 + V_3 = \frac{1}{4\pi\epsilon_0} \left[ \frac{2q}{r} - \frac{q}{r} - \frac{q}{r} \right] = 0$$



$$\text{But } \vec{E}_A = \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{r^2} \text{ along } AO, \vec{E}_B = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2} \text{ along } OB$$

and

$$\vec{E}_C = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2} \text{ along } OC. \text{ obviously } \vec{E}_B + \vec{E}_C \text{ will}$$

also be in the direction of *AO* extended and hence  $\vec{E}_A$  and  $(\vec{E}_B + \vec{E}_C)$  being in same direction will not give zero resultant.

422 (a)



$$\phi_E = \frac{q}{K\epsilon_0} = \frac{0.5}{10 \times 8.85 \times 10^{12}} = 5.65 \times 10^9$$

423 (d)

In the arrangement shown both plates of capacitors  $C_3$  are joined to point B. Hence, it does not act as a capacitor and is superfluous. Now  $C_1$  and  $C_2$  are in parallel, hence  $C_{AB} = C_1 + C_2 = C + C = 2C$

424 (b)

Minimum effective capacitance

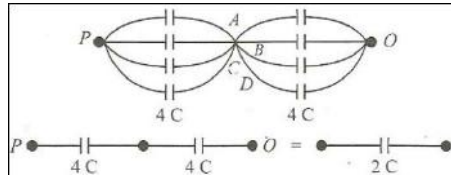
$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$= \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{3+2+1}{6} = 1$$

$$C = 1\mu\text{F}$$

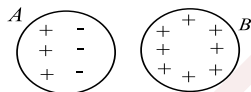
425 (a)

A, B, C and D are equipotential points (see Fig)



426 (b)

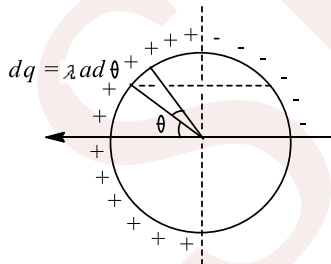
Charge will induce on A but total charge on A will remain zero. Negative charge of A will be more closer to B than positive charge on A. So potential of B will decrease



427 (b)

From figure, we get

$$dp = (\lambda ad\theta)2a\cos\theta$$



$$p = \int dp = 2\lambda a^2 \int_{-\pi/2}^{\pi/2} \cos\theta d\theta$$

$$= 2\lambda a^2 [\sin\theta]_{-\pi/2}^{\pi/2}$$

$$|p| = 4\lambda a^2$$

428 (d)

Given that,

$$C = 500\mu\text{F}$$

$$\frac{dq}{dt} = 100 \mu\text{Cs}^{-1}$$

$$V = 10 \text{ volt}$$

Then the total charge on the capacitor

$$q = CV$$

$$= 500 \times 10^{-6} \times 10$$

$$= 5 \times 10^{-3} \text{ C}$$

Hence, time =  $\frac{\text{total charge}}{\text{charge rate}}$

$$E = \frac{5 \times 10^{-3} \text{ C}}{100 \times 10^{-6} \text{ C}^{-1} \text{ s}^{-1}}$$

$$= 50 \text{ s}$$

429 (a)

In free space, the electric field between plates of capacitor.

$$E_0 = \frac{q}{A\epsilon_0}$$

...(i)

When plates of capacitor dipped in oil tank then, the electric field between the plates is

$$E = \frac{q}{A\epsilon}$$

...(ii)

(when  $\epsilon$  is the permittivity of medium)

or  $E = \frac{E_0}{AK\epsilon_0}$  [ $\because \epsilon = K\epsilon_0$ ]

From Eqs. (i) and (ii),

$$E = \frac{E_0}{K}$$

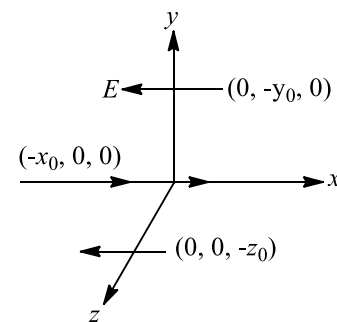
(where  $K$  is the dielectric

constant)

Hence, the electric field between the plates is increase.

430 (d)

Field on the axis of the dipole lies in the direction of dipole



Field on the bisector of the dipole lies opposite to the direction of dipole

431 (d)



Frequency  $n = 50\text{Hz}$

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

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

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

432 (a)

Potential gradient relates with electric field

according to the relation,  $E = -\frac{dV}{dr}$

$$= -\frac{10}{20 \times 10^{-2}} = 50 \text{ Vm}^{-1}$$

433 (c)

The four plates are alternately connected. They form three capacitors in parallel. Capacity of each capacitor is  $\epsilon_0 A/d$ . So, the net capacity is  $3\epsilon_0 A/d$

434 (c)

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

435 (b)

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

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

$$\text{or } V_x = -E_0 x$$

436 (a)

$5 \mu\text{F}$ ,  $10 \mu\text{F}$ ,  $15 \mu\text{F}$  will be in parallel, then  $30 \mu\text{F}$  will be in series

437 (a)

$$\begin{aligned} \text{Energy } E_1 &= \frac{1}{2} C_1 V_1^2 \\ &= \frac{1}{2} \times 1 \times 10^{-6} \times (30)^2 = 450 \times 10^{-6} \text{ J} \end{aligned}$$

Common potential

$$\begin{aligned} V &= \frac{q_1 + q_2}{C_1 + C_2} \\ &= \frac{1 \times 30 + 0}{1 + 2} = 10 \text{ volt} \end{aligned}$$

$$\begin{aligned} E_2 &= \frac{1}{2} (C_1 + C_2) V^2 \\ &= \frac{1}{2} (1 + 2) \times 10^{-6} \times (10)^2 \\ &= 1.5 \times 100 \times 10^{-6} = 150 \times 10^{-6} \text{ J} \end{aligned}$$

Loss of energy  $= E_2 - E_1 = 300 \mu\text{J}$

438 (d)

$$W = U_2 - U_1 = \frac{q^2}{2} \left[ \frac{1}{C_2} - \frac{1}{C_1} \right]$$

$$C_1 = \frac{\epsilon_0 A}{d}, C_2 = \frac{C_1}{2} = \frac{\epsilon_0 A}{2d}$$

$$q = C_1 V = \frac{\epsilon_0 A V}{d}$$

$$\text{Solve to get, } W = \frac{1}{2} \frac{\epsilon_0 A V^2}{d}$$

$$\text{Alternatively: } W = Fd = \frac{Q^2}{2A\epsilon_0} d = \frac{C_1^2 V^2}{2\epsilon_0 A} d = \frac{1}{2} \frac{\epsilon_0 A V^2}{d}$$

439 (b)

Given,  $C = 2 \mu\text{F}$ ,  $C_2 = 4 \mu\text{F}$ , and  $V = 10\text{volt}$

Capacitors are connected in series

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

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

The charge of combination

$$q = CV = \frac{4}{3} \times 10 = \frac{40}{3}$$

The energy of  $2 \mu\text{F}$  capacitor

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

The energy of  $4 \mu\text{F}$  capacitor

$$E_2 = \frac{1}{2} \times \frac{q^2}{C_2} = \frac{1}{2} \times \frac{1600}{9 \times 4} = \frac{200}{9}$$

The ratio of energies is

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

440 (b)

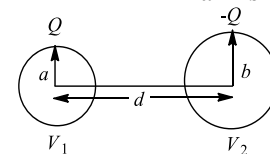
Energy of second proton = PE of the system

$$\begin{aligned} &= \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r} \\ &= 9 \times 10^9 \times \frac{1.6 \times 10^{-19} \times 1.6 \times 10^{-19}}{1 \times 10^{-10}} \\ &= 23.0 \times 10^{-19} \text{ J} \end{aligned}$$

441 (a)

$$V_1 = \frac{kQ}{a} - \frac{kQ}{d}, V_2 = \frac{-kQ}{b} + \frac{kQ}{d}$$

$$C = \frac{Q}{V_1 - V_2} = \frac{4\pi\epsilon_0}{\frac{1}{a} + \frac{1}{b} - \frac{2}{d}}$$



442 (b)

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

Hence, charge on bigger drop

$= 27 \times$  charge on smaller drop

ie,  $q' = 27q$



Now, before and after coalescing, 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

$$C' = 4\pi\epsilon_0 R = 4\pi\epsilon_0(3r) \\ = 3(4\pi\epsilon_0 r) = 3C$$

443 (a)

Potential decreases in the direction of electric field

444 (b)

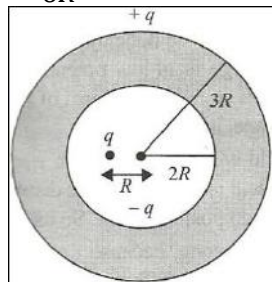
$$V_1 = \frac{k \times 2 \times 10^{-6}}{0.1} + \frac{k \times 4 \times 10^{-6}}{\sqrt{(0.1)^2 + (0.5)^2}}$$

$$V_2 = \frac{k \times 4 \times 10^{-6}}{0.1} + \frac{k \times 2 \times 10^{-6}}{\sqrt{(0.1)^2 + (0.5)^2}}$$

$$\text{Work done} = q(V_2 - V_1) = 0.72 \text{ J}$$

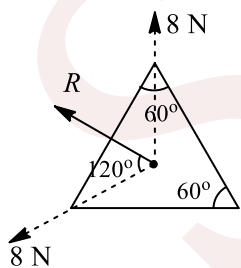
445 (c)

$$V = k \frac{q}{R} - \frac{kq}{2R} + \frac{kq}{3R} = \frac{kq}{R} \left[ 1 - \frac{1}{2} + \frac{1}{3} \right] \\ = \frac{k5q}{6R}$$



446 (d)

$$R = \sqrt{8^2 + 8^2 + 2 \times 8 \times 8 \cos 120^\circ} = 8\text{N}$$



447 (a)

$$dV = -E dr \cos \theta$$

Along the line of force,  $\theta$  is  $0^\circ$ , hence  $dV$  is maximum. So, the variation of potential is maximum along the line of force

448 (a)

$C = \frac{K\epsilon_0 A}{d}$ , find  $K/d$  for each sheet. Capacitance will be largest for which  $K/d$  is largest

449 (c)

Electric flux may be due to the charges present inside the Gaussian surface, but for the purpose of calculation of electric field  $E$  at any point we shall have to consider contribution of all the charges.

450 (c)

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

Potential of each capacitor now =  $V/2$

$$U' = \frac{1}{2} C \left(\frac{V}{2}\right)^2 = \frac{U}{4}$$

451 (d)

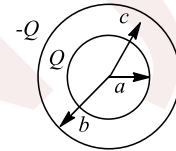
Electric potential of charged spherical shell

$$V = \frac{q}{4\pi\epsilon_0 R} \quad (0 \leq r \leq R)$$

$\therefore$  Electric potential at centre = Electric potential on the surface.

452 (d)

$$V = \frac{kQ}{c} - \frac{kQ}{b}$$



453 (a)

Here,  $E = \frac{\sigma}{\epsilon_0}$  and  $t = \frac{1}{u}$

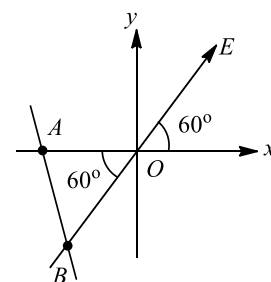
Along  $Y$ -axis,  $u = 0$ ,  $a = \frac{f}{m} = \frac{eE}{m}$

$$s = d = \frac{1}{2} at^2 = \frac{1}{2} \frac{eE}{m} t^2 = \frac{1}{2} \frac{e\sigma}{m\epsilon_0} \frac{l^2}{u^2}$$

$$\sigma = \frac{2d\epsilon_0 m u^2}{el^2}$$

454 (d)

$$OB = OA \cos 60^\circ = 2 \times \frac{1}{2} = 1 \text{ m}$$



$$V_B - V_O = E(OB) = 100 \times 1 = 100V$$

$$V_A - V_O = 100V [\because V_B = V_A]$$

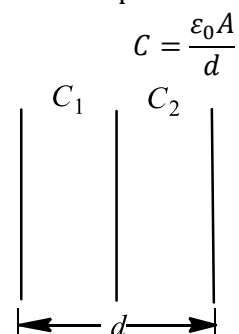
$$V_O - V_A = -100V$$

455 (d)

There will be  $n - 1$  capacitors, all connected in parallel

456 (b)

Initial capacitance



When it is half filled by a dielectric of dielectric constant  $K$ , then

$$C_1 = \frac{K\epsilon_0 A}{d/2} = 2K \frac{\epsilon_0 A}{d}$$

and

$$C_2 = \frac{\epsilon_0 A}{d/2} = \frac{2\epsilon_0 A}{d}$$

$\therefore$

$$\begin{aligned} \frac{1}{C'} &= \frac{1}{C_1} + \frac{1}{C_2} \\ &= \frac{d}{2\epsilon_0 A} \left( \frac{1}{K} + 1 \right) = \frac{d}{2\epsilon_0 A} \left( \frac{1}{5} + 1 \right) \\ &= \frac{6}{10} \frac{d}{\epsilon_0 A} \end{aligned}$$

$\therefore$

$$C' = \frac{5\epsilon_0 A}{3d}$$

Hence, increase in capacitance

$$\begin{aligned} &= \frac{\frac{5\epsilon_0 A}{3d} - \frac{\epsilon_0 A}{d}}{\frac{\epsilon_0 A}{d}} = \frac{5}{3} - 1 = \frac{2}{3} \\ &= 66.6\% \end{aligned}$$

457 (b)

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

458 (c)

After covering with a hemispherical shell;

$$\phi_{\text{shell}} + \phi_{\text{disc}} = 0 \text{ (from gauss's law)}$$

$$\phi_{\text{shell}} = -\phi_{\text{disc}} = -\phi$$

459 (b)

Electric field is the  $-ve$  of slope of  $V - x$  graph.

Inside the conductor, electric field is zero, so slope of  $V - x$  graph is zero. Inside dielectric, field decreases, so slope also decreases

460 (d)

$l$  = length of the each tube

$u_x = u = \text{constant}$

Time of travel between the plates  $t = l/u$

Let  $a$  = constant acceleration in  $y$ -direction

So,  $v_y = at$  when the particle emerges from the plates

$$\text{So, } v^2 = u_x^2 + v_y^2 = u^2 + a^2 t^2$$

$$= u^2 + a^2 \frac{l^2}{u^2} = u^2 + \frac{C}{u^2} \text{ (where } a^2 l^2 = C)$$

$$\text{So, } v = \sqrt{u^2 + \frac{C}{u^2}}$$

461 (d)

Consider the Gaussian surface where the induced charge is as shown in the figure

The net field at  $P$  due to all the charges is zero, i.e.,

$$\begin{aligned} -2Q + \frac{q}{2A\epsilon_0} \text{ (left)} + \frac{q}{2A\epsilon_0} \text{ (right)} + q \\ - \frac{q}{2A\epsilon_0} \text{ (right)} = 0 \end{aligned}$$

$$\Rightarrow -2q + q - Q + q = 0$$

$$\Rightarrow q = \frac{3}{2} Q$$

Charge on the right side of the rightmost plate is

$$-2Q + Q = -2Q + \frac{3}{2} Q = -\frac{Q}{2}$$

462 (c)

In series, potential is divided

463 (d)

The capacitance of capacitor  $C = \frac{\epsilon_0 A}{x}$

Charge on capacitor

$$q = CV = \frac{\epsilon_0 AV}{x}; U = \frac{1}{2} qV = \frac{1}{2} \frac{\epsilon_0 AV^2}{x}$$

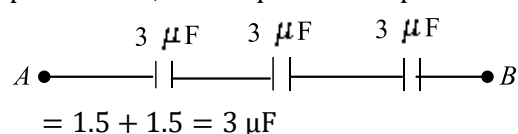
$$\text{So, } \frac{dU}{dt} = \frac{1}{2} \epsilon_0 AV^2 \left( -\frac{1}{x^2} \right) \frac{dx}{dt}$$

$$= \frac{1}{2} \epsilon_0 AV^2 v \left( -\frac{1}{x^2} \right)$$

From the earlier expression,  $\frac{dU}{dt} \propto \frac{1}{x^2}$

464 (a)

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



Now, three capacitors each of value  $3\mu\text{F}$  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

$$C = 1\mu\text{F}$$

465 (d)

$$W = Q dV = Q(V_q - V_p)$$

$$= -100 \times (1.6 \times 10^{-19}) \times (-4 - 10)$$

$$= +100 \times 1.6 \times 10^{-19} \times 14$$

$$= +2.24 \times 10^{-16} \text{ J}$$

466 (b)

$$\text{Here, } \vec{E} = 8\hat{i} + 4\hat{j} + 3\hat{k}$$

$$\vec{S} = 100\hat{k}$$

(direction of area is perpendicular to x-y plane)

$$\phi = \vec{E} \cdot \vec{S} = (8\hat{i} + 4\hat{j} + 3\hat{k}) \cdot 100\hat{k}$$

$$= 300 \text{ unit}$$

467 (d)

External applied field's effect is neutralized by charge induced on outer surface, i.e. their combined effect is zero. Hence, force applied by induced charges on outer surface should be equal and opposite to that applied by electric field. This is equal to  $qE = 1 \times 20 = 20\text{N}$  towards left. 15 N force is only due to induced charge on the inside surface of the hollow sphere. Hence, net force by induced charges is  $15 + 20 = 35\text{ N}$

468 (b)

Equipotential lines are concentric circles, These pattern of equipotential lines should be due to point charge at the centre of circles

Let us consider few equipotential lines,

$$20 = \frac{1}{4\pi\epsilon_0} \frac{q}{30 \times 10^{-2}} \Rightarrow \frac{q}{4\pi\epsilon_0} = 6$$

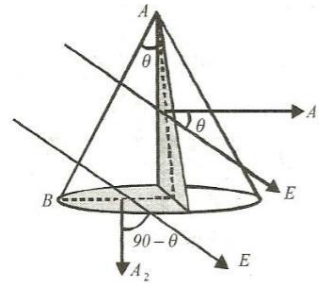
$$60 = \frac{1}{4\pi\epsilon_0} \frac{q}{10 \times 10^{-2}} \Rightarrow \frac{q}{4\pi\epsilon_0} = 6$$

For point charge, electric field should be in radial direction

$$\text{The value is } E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} = \frac{6}{r^2} (\text{Vm}^{-1})$$

469 (a)

Flux entering the cone from side AB will ultimately also pass through area  $A_1$  and  $A_2$ .



$$\text{Hence, } \phi = EA_1 \cos \theta + EA_2 \cos(90 - \theta)$$

$$= E \left( \frac{1}{2} 2Rh \cos \theta + \frac{\pi}{2} R^2 \sin \theta \right)$$

$$= ER(h \cos \theta + \pi(R/2) \sin \theta)$$

470 (c)

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

$$(\because V = 10\text{V})$$

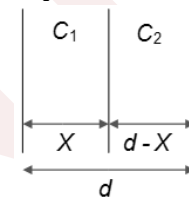
When connected in series, potential difference

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

$$= \frac{10\text{ C}}{C/6} = 60\text{ V}$$

471 (c)

On placing this aluminium sheet, it will form two capacitors in series, say initial separation is  $d$



$$C_1 = \frac{\epsilon_0 A}{x}, C_2 = \frac{\epsilon_0 A}{d-x}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{\frac{\epsilon_0 A}{x} \cdot \frac{\epsilon_0 A}{d-x}}{\frac{\epsilon_0 A}{x} + \frac{\epsilon_0 A}{d-x}}$$

$$= \frac{\epsilon_0 A}{x(d-x) \left[ \frac{1}{x} + \frac{1}{d-x} \right]} = \frac{\epsilon_0 A}{x + d - x}$$

$$= \frac{\epsilon_0 A}{d}$$

Hence, capacitance remains unchanged

472 (a)

Electric field produced due to charge  $Q$  will be zero at  $P$ , but potential produced by  $Q$  at  $P$  will not be zero

473 (c)

Here  $\frac{r_1}{r_2} = \frac{1\text{mm}}{2\text{mm}} = \frac{1}{2}$ , when the spheres are connected by a conducting wire  $V_1 = V_2$

$$\text{Or } \frac{q_1}{4\pi\epsilon_0 r_1} = \frac{q_2}{4\pi\epsilon_0 r_2} \Rightarrow \frac{q_1}{q_2} = \frac{r_1}{r_2} = \frac{1}{2}$$



Now,  $\frac{E_1}{E_2} = \frac{q_1}{q_2} \cdot \left(\frac{r_2}{r_1}\right)^2 = \frac{1}{2} \times \left(\frac{2}{1}\right)^2 = 2 : 1$

474 (a)

Given  $\frac{\epsilon_0 A}{d} = 10$

$$C' = \frac{\epsilon_0 A/2}{d} + \frac{4\epsilon_0(A/2)}{d} = 10 \left[ \frac{1}{2} + 2 \right] = 25 \mu\text{F}$$

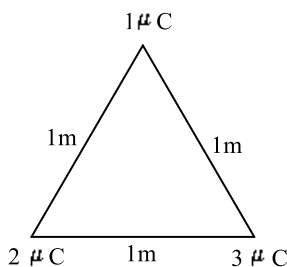
475 (c)

There will be two dipoles inclined to each other at an angle of  $60^\circ$ . The dipole moment of each dipole will be  $q\lambda$ . The resultant dipole moment is

$$\sqrt{(q\lambda)^2 + (q\lambda)^2 + 2(q\lambda)(q\lambda) \cos 60^\circ} = \sqrt{3}q\lambda$$

476 (c)

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

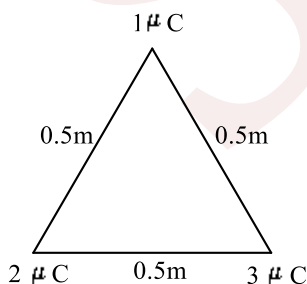


$$U_1 = \frac{1}{4\pi\epsilon_0} \cdot \frac{1 \times 2 \times 10^{-12}}{(1)} + \frac{1}{4\pi\epsilon_0} \cdot \frac{2 \times 3 \times 10^{-12}}{(1)}$$

$$+ \frac{1}{4\pi\epsilon_0} \cdot \frac{3 \times 1 \times 10^{-12}}{(1)}$$

$$= 11 \times \frac{1}{4\pi\epsilon_0} \times 10^{-12} \text{J}$$

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



$$U_1 = \frac{1}{4\pi\epsilon_0} \cdot \frac{1 \times 2 \times 10^{-12}}{(0.5)} + \frac{1}{4\pi\epsilon_0} \cdot \frac{2 \times 3 \times 10^{-12}}{(0.5)}$$

$$+ \frac{1}{4\pi\epsilon_0} \cdot \frac{3 \times 1 \times 10^{-12}}{(0.5)}$$

$$= 22 \times \frac{1}{4\pi\epsilon_0} \times 10^{-12} \text{J}$$

$$\therefore \text{Work done} = \Delta U = U_2 - U_1$$

$$= 22 \times \frac{1}{4\pi\epsilon_0} \times 10^{-12} - 11 \times \frac{1}{4\pi\epsilon_0} \times 10^{-12}$$

$$= 11 \times \frac{1}{4\pi\epsilon_0} \times 10^{-12}$$

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

$$= 0.099 \text{J} \approx 0.01 \text{J}$$

477 (a)

As battery is disconnected, so charge will remain the same. It is given that final potential is the same. So, final capacitance should be equal to initial capacitance

$$\frac{\epsilon_0 A}{d} = \frac{\epsilon_0 A}{(1.6 + d) - t(1 - 1/k)}$$

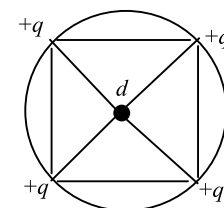
$$\Rightarrow K = 5$$

478 (b)

Potential at centre due to all charges are

$$= \frac{1}{4\pi\epsilon_0} \left[ \frac{q}{d} + \frac{q}{d} + \frac{q}{d} + \frac{q}{d} \right]$$

$$= \frac{1}{4\pi\epsilon_0} \frac{4q}{d} \text{ in SI units}$$



$$= \frac{4q}{d} \text{ in CGS units}$$

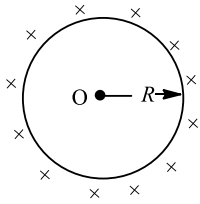
479 (b)

Electric field inside a spherical charge is everywhere zero, hence, inside a spherical charge the potential at all points is the same and its value is equal



to that on the surface.

∴ Potential at surface = 10V.



480 (a)

Work done in delivering  $q$  coulomb of charge from clouds to ground.

$$W = Vq$$

$$= 4 \times 10^6 \times 4 = 16 \times 10^6 \text{ J}$$

The power of lightning strike is

$$P = \frac{W}{t}$$

$$= \frac{16 \times 10^6}{0.1} = 160 \times 10^6 \text{ W}$$

$$= 160 \text{ MW}$$

481 (d)

$$E = \frac{\lambda}{2\pi\epsilon_0 r} = -\frac{\partial V}{\partial r} \quad \text{or} \quad \int_{V_a}^{V_b} dV = -\int_a^b \frac{\lambda}{2\pi\epsilon_0 r} dr$$

$$V_a - V_b = \frac{\lambda}{2\pi\epsilon_0} \log\left(\frac{b}{a}\right)$$

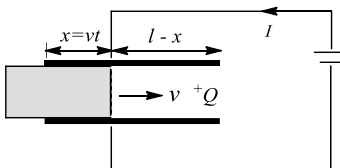
$$\text{Hence, } V_a - V_b \propto \log\frac{b}{a}$$

482 (b)

$$C = \frac{K\epsilon_0 vtb}{d} + \frac{\epsilon_0(l-vt)b}{d}; q = CV$$

$$I = \frac{dq}{dt} = V \frac{dC}{dt} = V \left[ \frac{K\epsilon_0 bv}{d} - \frac{\epsilon_0 bv}{d} \right] = \text{constant}$$

So, till the dielectric is fully inserted, a constant current will flow. When the dielectric is fully inside,  $C$  will be constant, so  $I = 0$ . And when dielectric starts coming out, again a constant current will flow but in opposite direction

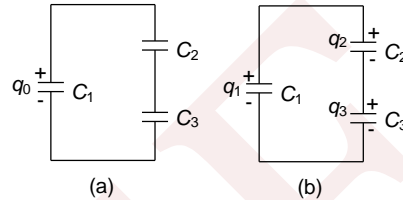


483 (d)

Initial situation after the reconnection is shown in Figure and the final situation in figure

The charge transferred by  $C_1$  is  $q_0 - q_1$  and the capacitors  $C_2$  and  $C_3$  are in series, so  $q_2 = q_3$

Other way to solve the questions is to equalize the potentials across  $C_1$  and series combination of  $C_2$  and  $C_3$



484 (d)

$$Q = nq, R = n^{1/3}r$$

$$E_{\text{small}} = \frac{kq}{r^2}, E_{\text{big}} = \frac{kQ}{R^2}$$

$$E_{\text{big}} = \frac{k n q}{n^{2/3} r^2} = (n^{1/3}) \frac{kq}{r^2} = n^{1/3} E_{\text{small}}$$

$$V_{\text{small}} = \frac{kq}{r}, V_{\text{big}} = \frac{kQ}{R}$$

$$V_{\text{big}} = \frac{k n q}{n^{1/3} r} = n^{2/3} \frac{kq}{r} = n^{2/3} V_{\text{small}}$$

485 (c)

$$\text{Work done} = Fs \cos \theta = F(2\pi r) \cos 90^\circ = 0.$$

486 (d)

In series arrangement potential difference is the sum of the individual potential difference of each capacitor.

$$\text{ie, } V = V_1 + V_2 + V_3 + \dots$$

$$\therefore 600 = x \times 200$$

$$x = 3$$

So, there should be 3 capacitors in series to obtain the required potential difference.

The equivalent capacitance of the 3 capacitors in series is

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

$$C_{\text{eq}} = 2$$

Now, we require 18  $\mu\text{F}$  capacitance, for this we need 9 such combinations in parallel.

$$\text{Hence, } 9 \times 3 = 27$$

487 (a)

Potential energy of electric dipole,  $U = -\vec{p} \cdot \vec{E}$

$$\vec{E} = -pE \cos \theta.$$

In Fig. (a),  $\theta = \pi$  rad hence  $U = -pE \cos \pi = +pE = \text{maximum}.$

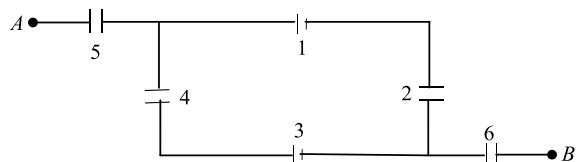


488 (b)

Plate 2 and 3 will be at the same potential. So, there will be two capacitors in parallel

489 (a)

In the given circuit capacitor's (1) (2) and (3) are connected in series, hence equivalent capacitance is



$$\frac{1}{C'} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C}$$

$$\Rightarrow C' = \frac{C}{3}$$

This is connected in parallel with (4).

$$\therefore C'' = C' + C = \frac{C}{3} + C = \frac{4C}{3}$$

The three capacitor's (5),  $\frac{4C}{3}$ , (6) are now connected in series.

$\therefore$  Equivalent capacitance is

$$\frac{1}{C'''} = \frac{1}{C} + \frac{3}{4C} + \frac{1}{C}$$

$$\frac{1}{C'''} = \frac{11}{4C}$$

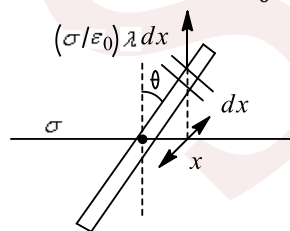
$$\Rightarrow C''' = \frac{4C}{11}$$

490 (b)

$$\tau = 2 \left( \frac{\sigma}{2\epsilon_0} \lambda dx \right) x \sin \theta$$

$$= \frac{\sigma}{\epsilon_0} \lambda \int_0^{l/2} x \cdot dx \sin \theta$$

$$= \frac{\sigma}{2\epsilon_0} \lambda \frac{l^2}{4} \sin \theta$$



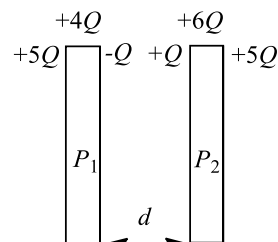
$$\tau = -I\alpha \Rightarrow \alpha = -\tau I = \frac{\sigma}{2\epsilon_0} \lambda \frac{l^2}{4} \frac{12}{ml^2} \sin \theta$$

$$\alpha = -\left( \frac{3\sigma\lambda}{2m\epsilon_0} \theta \right) \text{ (for small angle)}$$

$$T = \frac{2\pi}{\omega} = 2\pi \sqrt{\frac{2m\epsilon_0}{3\sigma\lambda}}$$

491 (b)

Potential difference between the plates



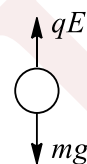
492 (a)

$$T = 2\pi \sqrt{\frac{l}{g_{\text{eff}}}}$$

$$\text{Here, } g_{\text{eff}} = g - \frac{qE}{m}$$

$\Rightarrow g_{\text{eff}}$  will decrease

Hence,  $T$  will increase



493 (c)

$$C = 4\epsilon_0 R, \text{ where } R = 6.4 \times 10^6 \text{ m}$$

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

494 (a)

Because work is to be done by an external agent in moving a positive charge from low potential to high potential and this work gets stored in the form of potential energy of the system. Hence, it increases

495 (a)

The potential

$$V = \frac{1}{4\pi\epsilon_0 r} (q_1 + q_2 + q_3 + q_4)$$

$$V = (9 \times 10^9) \left( \frac{1}{1\text{m}} \right) \{ (3 - 3 - 4 + 7) \times 10^{-6} \text{C} \}$$

$$= 2.7 \times 10^4 \frac{\text{N} \cdot \text{m}}{\text{C}}$$

$$= 2.7 \times 10^4 \text{J} \cdot \text{C}^{-1}$$

$$= 2.7 \times 10^4 \text{V}$$

496 (a)

Here,  $C_{13} = 30 + 30 = 60 \text{ pF}$ . total equivalent capacitance is given by



$$\frac{C}{1} = \frac{1}{C_1} + \frac{1}{C_{23}} + \frac{1}{C_4} = \frac{1}{30} + \frac{1}{60} + \frac{1}{120} = \frac{1}{170} \Rightarrow C = \frac{170}{7} \text{ pF}$$

$$\therefore \text{Total charge } Q = CV = \frac{170}{7} \times 140 \text{ pC} = 2400 \text{ pC}$$

$$\therefore V_1 = \frac{Q}{C_1} = \frac{2400 \text{ pC}}{30 \text{ pF}} = 80 \text{ V}$$

$$V_2 = V_3 = V_{23} = \frac{Q}{C_{23}} = \frac{2400 \text{ pC}}{60 \text{ pF}} = 40 \text{ V and}$$

$$V_4 = \frac{Q}{C_4} = \frac{2400 \text{ pC}}{120 \text{ pF}} = 20 \text{ V}$$

497 (c)

$$\text{As } V_1 = V_2$$

$$\frac{q_1}{4\pi\epsilon_0 r_1} = \frac{q_2}{4\pi\epsilon_0 r_2}$$

$$\therefore \frac{q_1}{q_2} = \frac{r_1}{r_2}$$

498 (b)

$$U = -\frac{kqQ}{r} - \frac{kqQ}{r} + \frac{kq^2}{2r} = 0 \Rightarrow Q/q = 1/4$$

499 (b)

$U = \sum \frac{kq_1 q_2}{r}$ . There will be six pairs, four on a side of square and two as diagonal

500 (d)

Let the charge on the smaller sphere be  $q$ . As the potential of both will be the same finally, i.e.,

$$\frac{q}{r'} = \frac{Q - q}{r} \Rightarrow q = \frac{Qr'}{r + r'}$$

501 (b)

Potential across  $6 \mu\text{F}$  capacitor:

$$V_A - V_B = \frac{12 \times 24}{12 + 6} = 16$$

$$\Rightarrow V_A - 0 = 16$$

$$\Rightarrow V_A = 16 \text{ V}$$

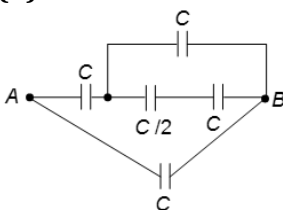
502 (b)

$$V = \frac{kQ}{R}, E = \frac{kQ}{R^2}$$

$$\frac{V}{E} = R \Rightarrow E = \frac{V}{R}$$

If  $R$  increases,  $E$  decreases

503 (b)



$$C_{\text{eq}} = \frac{\frac{4C}{3} \times C}{\frac{7C}{3}} + C = \frac{11C}{7}$$

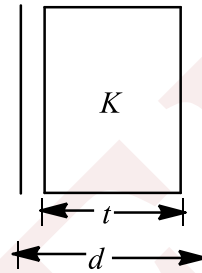
504 (b)

From the formula ,

$$C = \frac{\epsilon_0 A}{d - t + \frac{t}{K}}$$

$\Rightarrow$  Here,  $K = \infty$  and  $t \rightarrow 0$

$$\text{So, } C = \frac{\epsilon_0 A}{d+0} = \frac{\epsilon_0 A}{d} = C_0$$



505 (c)

Stored charge on capacitor becomes zero only when it is discharged through resistance or when two capacitors of equal capacitances are charged and then connected to opposite terminals. Here the capacitances are different.

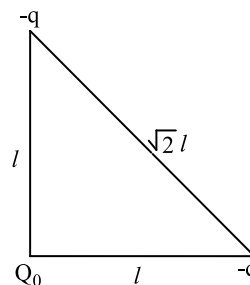
506 (b)

Here total electrostatic potential energy is zero

$$\text{ie, } \frac{-Q_0 q}{l} - \frac{q Q_0}{l} + \frac{q^2}{\sqrt{2}l} = 0$$

On solving,

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



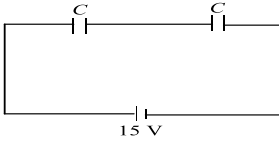
507 (a)

22 V get will divide into series combination of  $C_3$  and  $C_4$

508 (c)

Let capacitance of each capacitor is  $C$ .





Then equivalent capacitance in series is

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

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

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

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

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

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

$$\frac{C}{2} \times 15 = \frac{4C}{5} \times V'$$

$$\Rightarrow V' = \frac{15 \times 5}{4 \times 2} = 9.4V$$

$$\approx 10V$$

509 (d)

Net electric flux of surface

$$(\phi_2 - \phi_1) = \frac{1}{\epsilon_0}(q) \Rightarrow q = \epsilon_0(\phi_2 - \phi_1)$$

510 (b)

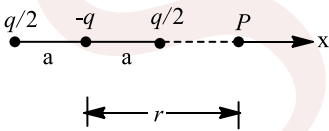
$$C' = \frac{2\epsilon_0 A/2}{d} + \frac{3\epsilon_0 A/2}{d}$$

$$C \left[1 + \frac{3}{2}\right] = \frac{5}{2} \times 0.5 = 1.25 \mu F$$

511 (b)

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

So, potential at point p



$$V = \frac{1}{4\pi\epsilon_0} \left[ \frac{\frac{q}{2}}{r+a} - \frac{q}{r} + \frac{\frac{q}{2}}{r-a} \right]$$

$$= \frac{1}{4\pi\epsilon_0} \frac{q}{2} \left[ \frac{1}{r+a} - \frac{2}{r} + \frac{1}{r-a} \right]$$

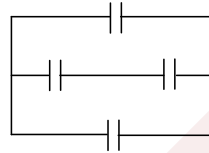
$$= \frac{q}{8\pi\epsilon_0} \left[ \frac{r(r-a) - 2(r^2 - a^2) + r(r+a)}{r(r^2 - a^2)} \right]$$

$$= \frac{q}{8\pi\epsilon_0} \cdot \frac{2a^2}{r(r^2 - a^2)}$$

$$= \frac{qa^2}{4\pi\epsilon_0 r^3} \quad (\text{as } r \gg a)$$

512 (b)

Minimum number of capacitors is 4



513 (d)

$$V_B - V_A = -\int E_x dx = -[\text{Area under } E_x - x \text{ curve}]$$

$$V_B - 10 = -\frac{1}{2} \times 2 \times (-20) = 20$$

$$V_B = 30V$$

514 (b)

Equivalent capacitance between points B and C is

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

Now equivalent capacitance between points A and 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,  $V_A = 2000 \text{ volt}$

Hence,  $V_B = 2000 - 1500 = 500 \text{ volt}$ .

515 (a,b,c)

$$\text{Time of flight } (t) = \frac{2u}{g} = \frac{2 \times 10}{10} = 2 \text{ sec}$$

$$H = \frac{u^2}{2g} = \frac{10^2}{2 \times 10} = 5 \text{ m}$$

$$R = 0 + \frac{1}{2} \left( \frac{qE}{m} \right) t^2 = \frac{1}{2} \times \frac{10^{-3} \times 10^4 \times 2 \times 2}{2}$$

$$= 10 \text{ m}$$

516 (a,d)

As no charge is present inside the conductor, potential at any point inside the conductor is same as that of the potential of conductor



So, potential of the conductor = Potential at the centre

$$= V_q + V_{\text{induced charges}}$$

$$\text{i.e., } V_{\text{conductor}} = \frac{q}{4\pi\epsilon_0(d+R)} + 0$$

As the total induced charge at conductor's surface is equal to zero, hence the potential at centre due to the induced charges is zero

For point B

$$V_{\text{conductor}} = V_{\text{at point B}} = V_q + V_{\text{induced charges}}$$

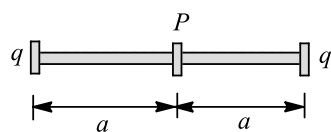
$$V_{\text{induced charges}} = \frac{q}{4\pi\epsilon_0(d+R)} - \frac{q}{4\pi\epsilon_0 d}$$

$$= \frac{-qR}{4\pi\epsilon_0 d(d+R)}$$

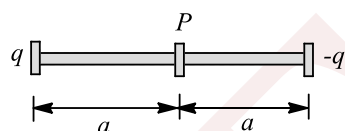
517 (a,b,c,d)

Positive charge moves from a region of high electric potential to a region of low electric potential, while for negative charge it reverses. If some charge is present near the conductor, then its potential gets affected

For figure,  $\vec{E} = 0$  at point P but V is not



For figure V = 0 at point P but E is not



518 (b,c)

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{x} = 600 \quad (\text{i})$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{x^2} = 200 \quad (\text{ii})$$

From Eq. (i) and Eq. (ii),  $x = 3$  m

$$\text{From Eq. (i), } q = \frac{600 \times 3}{9 \times 10^9} = 2 \times 10^{-7} \text{ C}$$

$$V' = \frac{1}{4\pi\epsilon_0} \frac{q}{x'} = 9 \times 10^9 \times \frac{2 \times 10^{-7}}{9} = 200 \text{ V}$$

$$W = q(V' - V) = 10^{-6}(200 - 600) = -4 \times 10^{-4} \text{ J}$$

519 (a,b,c,d)

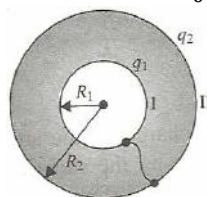
Points A and B lie within the same metal hence  $V_A = V_B$ . The potential inside a hollow sphere is same as potential at the surface,

$$\text{hence } V_A = V_B = V_C = V_0$$

520 (a,b,c)

This question is based on the working principle of a generator

$$V_I - V_{II} = \left( \frac{q_1}{4\pi\epsilon_0 R_1} + \frac{q_2}{4\pi\epsilon_0 R_2} \right) - \left( \frac{q_1 + q_2}{4\pi\epsilon_0 R_2} \right)$$



As two conductors are connected, transfer of charge takes place from one conductor to other till both acquire same potential, i.e., here  $V_I - V_{II} = 0$

Potential difference depends only on  $q_1$  (charge of inner conductor), so  $V_I - V_{II} = 0$ , where  $q_1 = 0$ , i.e., total charge is transferred to the outer conductor

521 (a,b,c,d)

Inside a conducting shell electric field is always zero. Therefore, option (a) is correct. When the two are connected, their potentials become the same

$$\therefore V_A = V_B$$

Or

$$\frac{Q_A}{R_A} = \frac{Q_B}{R_B} \quad \left( V = \frac{1}{4\pi\epsilon_0} \frac{Q}{R} \right)$$

Since,  $R_A > R_B$

$$\therefore Q_A > Q_B$$

Potential is also equal to,

$$V = \frac{\sigma R}{\epsilon_0}$$

$$V_A = V_B$$

$$\therefore \sigma_A R_A = \sigma_B R_B$$

$$\text{or } \frac{\sigma_A}{\sigma_B} = \frac{R_B}{R_A}$$

$$\text{or } \sigma_A < \sigma_B$$

Electric field on surface,



$$E = \frac{\sigma}{\epsilon_0}$$

Or  $E \propto \sigma$

Since,

$$\sigma_A < \sigma_B$$

$$\therefore E_A < E_B$$

$\therefore$  Correct options are (a), (b), (c) and (d).

522 (a,b,d)

At a centre, the force experienced by the charge particle is zero, so it is a position of equilibrium. As we displace the charge from the equilibrium position. Electric force starts acting on it towards equilibrium position and hence equilibrium is a stable one

At a distance  $x$  from the centre of sphere (equilibrium position), force experienced by the charge particle is

$$F = \frac{qQx}{4\pi\epsilon_0 R^2} \text{ [for } x < R \text{]}$$

As  $F \propto x$ , it performs S.H.M. about the centre  
Time period can be calculated by using  $F = m\omega^2 x$

523 (a,c,d)

On inserting the dielectric slab electric charge on plates remains unchanged at  $Q = \frac{\epsilon_0 AV}{d}$  in accordance with conservation of charge principle. But new electric field is  $\frac{1}{K}$  times of original value.

Hence,  $E = \frac{V}{Kd}$ . As now potential different  $V' = \frac{V}{K}$ ,

$$\text{hence work done } W = \frac{1}{2} QV - \frac{1}{2} QV' = \frac{QV}{2} \left[ 1 - \frac{1}{K} \right] \text{ or } W = \frac{\epsilon_0 AV}{d} \cdot \frac{V}{2} \left[ 1 - \frac{1}{K} \right] = \frac{\epsilon_0 AV^2}{2d} \left[ 1 - \frac{1}{K} \right]$$

524 (a,b,d)

$$C = \frac{\epsilon_0 A}{d_1}, C' = \frac{\epsilon_0 A}{d_2}$$

$$\text{Extra charge flown} = Q' - Q = (C' - C)V$$

$$= \epsilon_0 AV \left[ \frac{1}{d_2} - \frac{1}{d_1} \right]$$

Work done by battery:

$$W_b = V \times \text{charge flown} = \epsilon_0 AV^2 \left[ \frac{1}{d_2} - \frac{1}{d_1} \right]$$

$$\text{Charge in P.E. of capacitor} = \Delta U = \frac{1}{2} (C' - C)V^2$$

$$= \frac{1}{2} \epsilon_0 AV^2 \left[ \frac{1}{d_2} - \frac{1}{d_1} \right]$$

525 (a,d)

$$E = at (a = \text{constant}) F = QE$$

$$a = F/m = QE/m = Es = ast$$

$$= \frac{dv}{dt} = ast$$

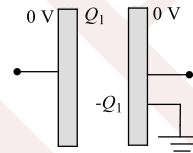
$$\text{Or } v = \frac{1}{2} ast^2 \Rightarrow v \propto s \text{ and } t^2$$

526 (a,d)

$E$  is a vector quantity;  $V$  is a scalar quantity

527 (b,c,d)

As the switch is closed, the charge on the outer surface of the second plate becomes zero. From the concept in electrostatics that electric field inside the bulk of the material of conductor is zero, we can find the charges on various faces. So, it is clear that  $Q_1 + Q_2$  charge goes from the second plate to the earth. Charge on capacitor is  $Q_1$  and hence its potential is  $Q_1/C$



528 (a,b,c)

$$\text{i. } E = \frac{2Q}{2A\epsilon_0} + \frac{Q}{2A\epsilon_0} \Rightarrow E = \frac{3Q}{2A\epsilon_0}$$

$$E = \frac{3Q}{2Cd} \Rightarrow Ed = \frac{3Q}{2C} = V$$

$$\text{ii. } F = E(-Q); F = \left( \frac{2Q}{2A\epsilon_0} \right) \times \frac{(-Q)}{1} = \frac{Q^2}{A\epsilon_0}$$

$$\Rightarrow F = \frac{Q^2}{A\epsilon_0}$$

$$\text{iii. Energy} = \frac{1}{2} \epsilon_0 E^2 Ad = \frac{1}{2} \epsilon_0 \left( \frac{3Q}{2Cd} \right)^2 Ad = \frac{9Q^2}{8C}$$

529 (b,c)

At any point outside the shell  $V = \frac{Q}{4\pi\epsilon_0 r}$ , where  $r$  is the radius of spherical shell.

The outer surface of the spherical shell is an equipotential surface.

530 (a,b,c)

$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{r} = 600V$$

$$\text{And } E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} = 200 \text{ NC}^{-1}$$

$$\text{Hence, } \frac{V}{E} = r = \frac{600}{200} = 3\text{m}$$



Now,  $\frac{q}{4\pi\epsilon_0 r} = 600; \frac{q}{4\pi\epsilon_0 r'} = V'$

$\therefore \frac{V'}{600} = \frac{r}{r'} = \frac{3}{9}$

Or  $V' = 200V$

$W = q(V - V') = 10^{-6}(600 - 200)$   
 $= 4 \times 10^{-4} \text{ J}$

531 (a,c)

$\vec{E}_A$  is along  $\vec{OA}$  and  $\vec{OA} = \hat{i} + 2\hat{j} + 3\hat{k}$

$\vec{E}_B$  is along  $\vec{OB} = \hat{i} + \hat{j} - \hat{k}$

Since  $\vec{OA} \cdot \vec{OB} = (\hat{i} + 2\hat{j} + 3\hat{k}) \cdot (\hat{i} + \hat{j} - \hat{k}) = 0$

So  $\vec{OA} \perp \vec{OB} \Rightarrow \vec{E}_A \perp \vec{E}_B$

So, option (a) is correct.

Since  $\vec{E}_B = \frac{kq}{|OC|^2} = \frac{kq}{3}$

$\vec{E}_C = \frac{kq}{|OC|^2} = \frac{kq}{12}$

So  $\frac{E_B}{E_C} = 4$  or  $|\vec{E}_B| = 4|\vec{E}_C|$

So option (c) is correct

Option (b) and (d) are wrong from the explanation

532 (b,d)

The electric field inside any point of the sphere is zero

533 (a,c,d)

This system can be considered as two capacitor in parallel, with  $C_1 = \frac{\epsilon_0 A}{2d}$  and  $C_2 = \frac{K\epsilon_0 A}{2d}$

$C_1$  is due to upper half of two plates while  $C_2$  is due to lower half

As potential difference across two capacitors is the same, charge would be difference as capacitors are different

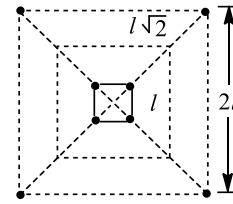
534 (a,b,c,d)

As for  $r \leq R_0$ , electric potential is constant, hence  $E$  inside the sphere is zero and consequently electrostatic energy is not stored at all inside the sphere. This indicates that the sphere is a thin spherical shell and charge lies only on its surface  $ie$ , at  $r = R_0$ . No charge is outside. moreover, as for  $r < R_0$ ,  $E = 0$  and at  $r = R_0$  electric field suddenly appears, it shows that  $E$  is discontinuous at  $r = R_0$ .

535 (a,c)

Since the situation is having symmetry, the particles move symmetrically along the diagonal as shown in figure

The energy conservation law is to be used



$U_i = \frac{1}{4\pi\epsilon_0} \left[ \frac{4q^2}{l} + \frac{2q^2}{\sqrt{2}l} \right]$

$U_f = \frac{1}{4\pi\epsilon_0} \left[ \frac{4q^2}{2l} + \frac{2q^2}{\sqrt{2} \times \sqrt{2}l} \right]$

$U_i = U_f + \frac{4mv^2}{2}$

$2mv^2 = \frac{1}{4\pi\epsilon_0} \left[ \frac{2q^2}{l} + \frac{q^2}{l\sqrt{2}} \right]$

$v = \left[ \frac{q^2}{8\pi\epsilon_0 ml} \left( 2 + \frac{1}{\sqrt{2}} \right) \right]^{1/2}$

536 (c,d)

As points  $A$  and  $B$  are at different distances from charge  $q$ , hence electric field at  $A$  and  $B$  is different. Induced charge is present on the inner surface of cavity but surface density of charge at  $A$  and  $B$  are different due to different curvatures at these points.

Potentials at  $A$  and  $B$  are equal because  $A$  and  $B$  lie on a metallic conductor and a metallic surface is an equipotential surface.

As per gauss theorem total flux  $\phi_E = \frac{q}{\epsilon_0}$ .

537 (a,c)

As  $A$  and  $C$  are earthed, they are connected to each other. Hence, ' $A + B$ ' and ' $B + C$ ' are two capacitors with the same potential difference. If  $B$  is closer to  $A$  than to  $C$ ; then the capacitance  $C_{AB} > C_{BC}$ . The upper surface of  $B$  will have greater charge than the lower surface. As the force of attraction between the plates of a capacitor is proportional to  $Q^2$ , there will be a net upward force on  $B$ . This can balance its weight.

538 (a,d)

Suppose a positively charged sphere is brought near an uncharged metallic sphere, Then on nearer surface of the uncharged sphere, negative charge is induced and on farther surface, positive charge is induced. Hence, a force of attraction will be observed between these two spheres.

Therefore, if a force of attraction is observed



between a positively charged sphere and a metallic sphere, it cannot be concluded that the metallic sphere is necessarily negatively charged. Therefore, option (b) is wrong and options (a) and (d) are correct

539 (c,d)

A close loop shaped line of force can never represent an electrostatic field as well as gravitational field of a mass at rest. However, magnetostatic field line is always a closed loop and field line due to induced electric field (being non-conservative) may also on a closed loop.

540 (b,c,d)

As the dielectric slab is pulled out, the equivalent capacity of the system decreases and hence charge supplied by the battery decrease as potential of the system remains constant. It means charging of battery takes place and a positive charge flows  $a$  to  $b$ . As the two capacitors are connected in series, so charge on both capacitors remains the same at all instants

From energy conservation law,

$$U_i + W_{\text{ext}} = U_f + \text{work done on battery} + \Delta H$$

As dielectric slab is attracted by the plates of capacitors, to pull it out  $F$  has to perform some work, i.e.,  $W_{\text{ext}}(F) > 0$

541 (a,b,c,d)

Charge on  $a_1 = (r_1\theta)\lambda$

Charge on  $a_2 = (r_2\theta)\lambda$

Ration of the charges =  $\frac{r_1}{r_2}$

$$E_1 (\text{Field produced by } a_1) = \frac{K[(r_1\theta)\lambda]}{r_1^2} = \frac{K\theta\lambda}{r_1}$$

$$E_2 (\text{Field produced by } a_2) = \frac{K\theta\lambda}{r_2}$$

As  $r_2 > r_1$ , therefore  $E_1 > E_2$

i.e., Net field at  $A$  is towards  $a_2$

$$V_1 = \frac{K(r_1\theta)}{r_1} = K\theta\lambda$$

$$V_2 = \frac{K(r_2\theta)}{r_2} = K\theta\lambda$$

$$V_1 = V_2$$

542 (a,c,d)

$$0 \leq x \leq a; V_x = \left[ - \int_0^x E_x dx \right] + V_{(0)} = 0$$

(as  $E_x = 0$ )

$$x \geq a; V = - \int_a^x E_x dx + V_{(a)}$$

$$V = \left[ - \int_a^x \frac{\sigma}{\epsilon_0} dx \right] + V_{(a)} = - \frac{\sigma}{\epsilon_0} (x - a) = \frac{-\sigma}{\epsilon_0} (x - a)$$

$$x \leq 0; V = - \int_a^x E_x dx + V_{(0)} \left[ \because E_x = \frac{-\sigma}{\epsilon_0} \right] = - \left( - \frac{\sigma}{\epsilon_0} x \right) + V_{(0)} = \frac{\sigma}{\epsilon_0} x$$

543 (b,c,d)

Charge on inner sphere can be supposed to be concentrated as a point charge at the centre, hence electric field at a point in the region between the spheres at a distance  $r$  from the centre =  $(q/4\pi\epsilon_0 r^2)$ . Due to induction, equal and opposite charges will appear on the inner and outer surfaces of the outer sphere. Hence, net charge which can be supposed to be placed at the centre =  $q$  and electric field due to it at a point outside the hollow sphere at a distance  $r$  from centre =  $(\frac{q}{4\pi} \epsilon_0 r^2)$

$$\text{Potential of inner sphere} = \frac{q}{4\pi\epsilon_0} \left( \frac{1}{a} + \frac{1}{b} + \frac{1}{c} \right)$$

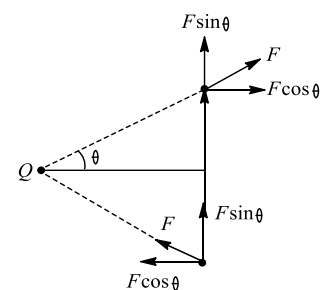
$$\text{And potential of outer sphere} = \frac{q}{4\pi\epsilon_0 c}$$

Potential of inner sphere with respect to the outer sphere

$$\frac{q}{4\pi\epsilon_0} \left( \frac{1}{a} - \frac{1}{b} \right)$$

544 (b,c)

The situation is shown in Figure



$$\vec{F}_{\text{net}} = 2F\sin\theta \uparrow = \frac{PQ}{4\pi\epsilon_0 r^3}$$

$$\vec{\tau} = F \cos\theta \times 2a \text{ in clockwise direction}$$

$$= \frac{PQ}{4\pi\epsilon_0 r^2}$$

545 (c,d)

$$\vec{r}_p = \hat{i} + 2\hat{j} + 4\hat{k}; \vec{r}_q = 3\hat{i} + 2\hat{j} + \hat{k}$$

$$|\vec{r}_q - \vec{r}_p| = \sqrt{[(2)^2 + (-3)^2]} = \sqrt{13}$$

As  $q = 2 \times 10^{-8} \text{C}$ , hence



$$V = \frac{1}{4\pi\epsilon_0} \frac{q}{|\vec{r}_q - \vec{r}_p|}$$

$$= \frac{9 \times 10^9 \times 2 \times 10^{-8}}{\sqrt{13}} = 49.9 \text{ V}$$

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{|\vec{r}_q - \vec{r}_p|^2} \frac{(\vec{r}_q - \vec{r}_p)}{|\vec{r}_q - \vec{r}_p|}$$

$$= \frac{1}{4\pi\epsilon_0} \frac{q}{|\vec{r}_q - \vec{r}_p|^3} (2\hat{i} - 3\hat{k})$$

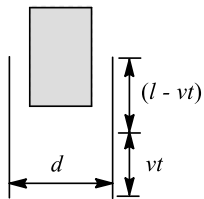
(By filling a dielectric of dielectric constant  $K$ , electric field gets decreased as  $E = E_0/K$  and  $K > 1$ )

546 (b,c,d)

$$V_P = \frac{kq}{r} (\text{independent of } x)$$

547 (a,c)

Let the length, width and thickness of slab be  $l$ ,  $b$  and  $d$  respectively.  $K$  be the dielectric constant of dielectric



At time  $t$  length  $vt$  of the slab has been pulled out, so at this instant the capacitor may be considered as a parallel combination of two capacitors as shown. The capacitance of combination is

$$C = \frac{\epsilon_0 vt b}{d} + \frac{\epsilon_0 K b (l - vt)}{d};$$

$$C = \frac{\epsilon_0 b}{d} [vt + K(l - vt)]$$

$$\Rightarrow C = \frac{\epsilon_0 b}{d} [Kl - (K - 1)vt]$$

This equation is of straight line, having positive intercept and negative slope. Hence, option (a) is correct and option (b) is incorrect

Since battery is disconnected, so charge on capacitor remains constant

$$V = \frac{q}{C} \text{ or } V \propto \frac{1}{C}$$

Hence, current between  $V$  and  $C$  will be rectangular hyperbola

So, option (c) is correct and option (d) is incorrect

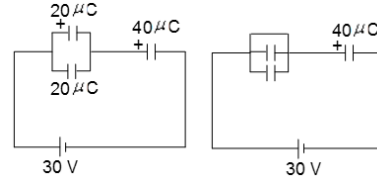
548 (a,c,d)

The amount of charge flown through the battery is  $q = 20\mu\text{C}$ . Because charge on the right capacitor changes by  $20\mu\text{C}$ . Charge flown through the

switch is  $60\text{mC}$ . It is because the sum of charge of both the left capacitors and the charge which flows through the battery will pass through the switch

Therefore, energy supplied by the battery is

$$U = qV = (20 \times 10^{-6})(30) = 0.6 \text{ mJ}$$



Energy stored in all the capacitors before closing the switch  $S$  is

$$U_i = \frac{1}{2} C_{\text{net}} V^2 = \frac{1}{2} \left( \frac{4}{3} \times 10^{-6} \right) (30)^2 = 0.6 \text{ mJ}$$

And after closing the switch

$$U_f = \frac{1}{2} C_{\text{net}} V^2 = \frac{1}{2} (2 \times 10^{-6}) (30)^2 = 0.3 \text{ mJ}$$

Therefore, heat generated  $H = U(U_f - U_i) = 0.3 \text{ mJ}$

549 (a,c)

$$\vec{E} = 54\hat{i} + 74\hat{j}, E = 90\text{NC}^{-1}$$

$$90 = \frac{9 \times 10^9 Q}{r^2} \quad (\text{i})$$

$$V = 1800 = \frac{9 \times 10^9 Q}{r} \quad (\text{ii})$$

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

$$r = 20\text{M}, q = 4\mu\text{C}$$

$$\text{Now, } \frac{(9-x_0)\hat{i} + (4-y_0)\hat{j}}{20} = \frac{54\hat{i} + 72\hat{j}}{90}$$

$$\Rightarrow x_0 = -3, y_0 = -12$$

550 (b,c)

$$C = \frac{Q}{V} \text{ also, } C = \frac{\epsilon_0 A}{d}$$

As  $d$  increases,  $C$  will decrease

Therefore,  $V$  should increase, as  $Q$  remains the

$$\text{same } E = \frac{V}{d} = \frac{Q}{A\epsilon_0} \text{ will be constant}$$

Energy,  $U = \frac{Q^2}{2C}$ . As  $C$  decreases,  $U$  will increase

551 (b,c)

$$\text{Energy density, } u = \frac{1}{2} \epsilon_0 E^2$$

552 (a,b)

If the charge is given to a conducting sphere, then an electric field is established in the surrounding space. Magnitude of electric field is maximum just outside the sphere. This maximum electric field may be increased to the dielectric strength of the surrounding medium. Therefore, there is a



limiting value of maximum charge which can be given to the conducting sphere. Hence, option (c) is wrong. Obviously, the conducting sphere cannot be charged to a potential greater than a certain value. Hence, option (a) is correct. It can be easily said that option (b) is also correct

553 (a,d)

Let  $q_1$  and  $q_2$  be the instantaneous charges on capacitors. Since they are in parallel, then

$$\frac{q_1}{C_1} = \frac{q_2}{C_2} \text{ and } q_1 + q_2 = Q$$

$$C_1 = \frac{\epsilon_0 A}{d_0 + vt}, C_2 = \frac{\epsilon_0 A}{d_0 - vt}$$

$$\text{So } \frac{q_1}{q_2} = \frac{C_1}{C_2} = \frac{d_0 - vt}{d_0 + vt} \Rightarrow q_2 \left( \frac{d_0 - vt}{d_0 + vt} \right) + q_2 = 0$$

$$\text{So } q_2 = \frac{Q(d_0 + vt)}{2d_0} \text{ and } q_1 = \frac{Q(d_0 - vt)}{2d_0}$$

Hence, option (a) is correct and option (b) is incorrect

$$i = \frac{-dq_1}{dt} \text{ or } \frac{dq_2}{dt} \text{ or } i = \frac{Qv}{2d_0}$$

Which does not depend on time. So option (d) is correct and option (c) is incorrect

554 (a,c)

For a non-conducting solid charged sphere

(i) For  $0 < r < R$ , magnitude of electric field  $E \propto r$  and hence increases with increase in  $r$ .

(ii) For  $R < r < \infty$ , magnitude of electric field  $E \propto \frac{1}{r^2}$  and hence decreases with increases in  $r$ .

555 (b,c,d)

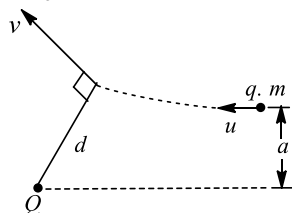
The path traced by  $q$  is shown in Figure, the path is curvilinear and acceleration is due to the force exerted by  $Q$  on  $q$

The separation between them is minimum if relative velocity of the particle along the line joining them is zero. Let  $d$  be the minimum separation between them. As torque about  $Q$  is zero, angular momentum remains conserved

$$mu a = mvd \Rightarrow v = \frac{ua}{d}$$

From energy conservation law,  $\frac{mu^2}{2} = \frac{mv^2}{2} +$

$$\frac{1}{4\pi\epsilon_0} \frac{qQ}{d}$$



556 (a,d)

When capacitors are connected in parallel, initial capacitance is  $C = 2\epsilon_0 A/d$ . After the distance between the plates is changed, the capacitance becomes

$$C = \frac{\epsilon_0 A}{d+a} + \frac{\epsilon_0 A}{d-a} \text{ or}$$

$$C = \frac{2\epsilon_0 A}{d - (a^2/d)}$$

Which is greater than initial one. Hence, option (a) is correct and option (b) is incorrect

When capacitors are connected in series, then

$$\frac{1}{C} = \frac{2d}{\epsilon_0 A}$$

After the distance between the plates is changed,

$$\frac{1}{C} = \frac{d+a}{\epsilon_0 A} + \frac{d-a}{\epsilon_0 A} = \frac{2d}{\epsilon_0 A}$$

That is, the capacitance remains unchanged.

Hence, option (d) is correct and option (c) is incorrect

557 (a,c)

$$\text{Initial stored energy } U_i = \frac{1}{2} \frac{\epsilon_0 AV_1^2}{x}$$

$$\text{Final stored energy } U_f = \frac{1}{2} \frac{\epsilon_0 AV_0^2}{2(x+dx)}$$

$$\text{So } \Delta U = U_f - U_i = \frac{1}{2} \epsilon_0 AV_0^2 \left[ \frac{1}{x+dx} - \frac{1}{x} \right]$$

$$= \frac{1}{2} \epsilon_0 AV_0^2 \left[ \frac{x - x - dx}{x(x+dx)} \right]$$

$$= \frac{1}{2} \frac{\epsilon_0 AV_0^2}{x^2} dx = -\frac{1}{2} \frac{\epsilon_0 AV_0^2}{x} \cdot \frac{dx}{x} = \frac{U dx}{x}$$

So, option (a) is correct and option (b) is incorrect

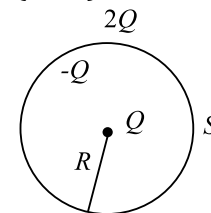
$$F = -\frac{dU}{dx} = -\frac{U}{x}$$

$$= -\frac{1}{2} \frac{\epsilon_0 A}{x} \cdot \frac{V_0^2}{x} = -\frac{1}{2} \left( \frac{\epsilon_0 A}{x} V_0 \right) \frac{V_0}{x} = -\frac{1}{2} qE$$

So magnitude of attractive force is  $\frac{1}{2} qE$

So option (c) is correct and option (d) is incorrect

558 (a,c,d)



Charge density at the outer surface (figure) is

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

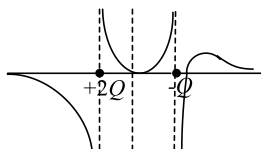


$$E_{\text{inside}} = \frac{2Q}{4\pi\epsilon_0 R^2}, E_{\text{outside}} = \frac{2Q}{4\pi\epsilon_0 R^2}$$

$$\therefore E_{\text{outside}} = 2E_{\text{inside}}$$

559 (a,d)

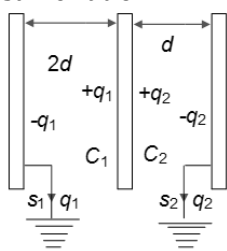
Electric field is zero only at a point in region III. Equilibrium at this point will be stable for a negative charge



560 (a,b,c)

When either A or C is earthed (but not both together), a parallel-plate capacitor is formed with B, with  $\pm Q$  charges on the inner surfaces. (The other plate, which is not earthed, plays no role.) Hence, charge of amount  $+Q$  flows to the earth.

When both area earthed together, A and C effectively become connected. The plates now form two capacitors in parallel, with capacitances in the ratio 1:2, and hence share charge  $Q$  in the same ratio



Now we can write  $\frac{q_1}{q_2} = \frac{C_1}{C_2} = \frac{1}{2}$ , because potential difference of both the capacitors is same. And

$q_1 + q_2 = Q$ . solving these, we get

$$q_1 = \frac{Q}{3}, q_2 = \frac{2Q}{3}$$

561 (a,b)

Electric field lines will be from M to N, so potential of N will be less than that of M

562 (a,b,c)

If there is no external electric field, then the charge given to a conducting sphere gets uniformly distributed over its surface. Therefore, option (a) is correct. If an external electric field exists, then the charge gets distributed over the surface of the sphere in such a way that the electric field inside the sphere can become equal

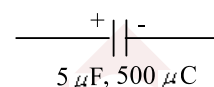
to zero. Hence, distribution of the charge on the surface of sphere will be non-uniform.

Therefore, option (b) is correct. Obviously, option (d) is wrong.

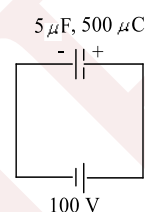
Since electric field inside the conducting sphere is equal to zero, therefore, potential difference between two points in the sphere is equal to zero. It means, the potential is same at every point of the sphere. Therefore, option (c) is correct

563 (b,c)

Initial condition just after the connection of battery



Condition after a long time:



It means battery supplies  $1000 \mu\text{C}$  charge from its positive terminal and an equal and opposite charge enters from its negative terminal, i.e., charge flow through battery is  $1000 \mu\text{C}$

Work done by the battery,  $W_{\text{battery}} = 100 \text{ V} \times 10^3 \mu\text{C} = 0.1 \text{ J}$

From energy conservation law,  $U_i + W_{\text{battery}} = U_f + \Delta H$

$U_i = U_f$  so  $\Delta H = 0.1 \text{ J}$

564 (c,d)

Torque will be perpendicular to the line  $y = 2x$  and it should be in  $x - y$  plane, because electric field is in  $z$ -direction. The lines in options (c) and (d) are perpendicular to  $y = 2x$

565 (a,c)

After disconnecting battery if plates of a parallel plate capacitor are moved apart then capacity  $C$  decreases,  $V$  and  $E$  increase,  $Q$  remains unchanged and electrical energy  $U$  increases.

566 (a,d)

When a negative charge moves from high potential to low potential, its potential energy increases

$$W_{\text{el}} = q(V_1 - V_2)$$

As  $V_1 > V_2$  and  $q$  is negative, hence



$W_{el}$  = negative

567 (a,c)

Force on a negative charge  $\vec{F} = -q_0\vec{E}$  is always directed towards the centre of ring and is variable as  $E = \frac{1}{4\pi\epsilon_0} \frac{dx}{(x^2+R^2)^{3/2}}$ . consequently, motion of charged particle will definitely be periodic.

Moreover, if  $x \ll R$ , then  $E = \frac{1}{4\pi\epsilon_0 R^2} \cdot x$  and  $F = -\frac{qq_0}{4\pi\epsilon_0 R^2} \cdot x$  i.e.,  $F \propto -x$ . It shows that motion will be simple harmonic.

568 (a,c,d)

$$V(x) = 4 + 5x^2$$

$$V(x = 1) = 9V$$

$$\text{And } V(x = -2) = 24V$$

$$\text{Hence, } \Delta V = 15V$$

$$E = -(\Delta V/\Delta x) = -10x$$

$$\therefore E(\text{at } x = -1\text{m}) = 10 \text{ NC}^{-1}$$

$$\text{So, } F = qE = +10 \text{ N (along +ve } x\text{-axis)}$$

569 (a,c)

$$\frac{1}{4\pi\epsilon_0} \frac{Q}{R} + \frac{1}{4\pi\epsilon_0} \frac{q}{(R_0 - vt)} = 0$$

Where  $R_0$  is the initial distance of the charged particle

$$Q = \frac{Rq}{R_0 - vt} \Rightarrow \frac{dQ}{dt} = i = \frac{Rqv}{(R_0 - vt)^2}$$

570 (b,c)

For a uniformly charged circular ring the electric field intensity is maximum at its axial line at a distance  $x = \pm \frac{R}{\sqrt{2}}$  from the centre of ring and

$$|E_{\max}| = \frac{1}{4\pi\epsilon_0} \cdot \frac{2q}{3\sqrt{3}R^2} = \frac{q}{6\sqrt{3}\pi\epsilon_0 R^2}$$

571 (a,b,c,d)

Here all the four statements are false. If  $E = 0$ ,  $V$  may or may not be zero. Similarly, if  $V = 0$  the  $E$  may not be zero. Again  $E \neq 0$  does not necessarily mean that  $V \neq 0$  and *vice-versa*.

572 (a,c)

If positive test charge is displaced along  $x$ -axis, then net force will always act in a direction opposite to that of displacement and the test charge will always come back to its original position. But if test charge is displaced along  $y$ -axis, it will never come back to its original position and will fly away along  $y$ -axis.

