Class 12 Physics Chapterwise PYQs

2026 – 2003 | All CBSE Board Papers

Chapter-wise previous year questions, sorted by marks and year

Chapter 2: Electrostatic Potential and Capacitance

Table of Contents

1-Mark Questions (100 questions · Section A · MCQ)

Q1. In a region, the electric potential varies as $V = 10 - 50x$, where V is in volts and x in meters. The electric field in the region is:

(A) 10 N/C along +x

(B) 10 N/C along -x

(C) 50 N/C along +x

(D) 50 N/C along -x

[2026 • Set 55-1-1]

Q2. A conducting wire connects two charged metallic spheres A and B of radii r_1 and r_2 respectively. The distance between the spheres is very large compared to their radii. The ratio of electric fields, (E_1/E_2) at the surfaces of spheres A and B will be:

(A) $\frac{r_1}{r_2}$

(B) $\frac{r_2}{r_1}$

(C) $\frac{r_2^2}{r_1^2}$

(D) $\frac{r_1^2}{r_2^2}$

[2026 • Set 55-1-1]

Q3. In a region electric field is given by $\vec{E} = 4x\,\hat{i}$ N/C. The potential difference between points A $(x = 1\text{ m})$ and B $(x = 3\text{ m})$, $(V_A - V_B)$ is:

(A) -16 V

(B) 16 V

(C) -8 V

(D) 8 V

[2026 • Set 55-1-2]

Q4. The electric potential for various points in x-y plane is given by $V = 1.0x^2 - 2.0y^2$, where V is in volts and x, y are in metres. The angle that the electric field at point $(2.0\text{ m}, 1.0\text{ m})$ makes with the positive x-axis is:

(A) $45°$

(B) $90°$

(C) $135°$

(D) $315°$

[2026 • Set 55-1-3]

Q5. Three point charges $2q$, $-2q$ and q are kept at the vertices of an equilateral triangle of side l. The potential energy of the system is:

(A) zero

(B) $\dfrac{-2q^2}{\pi\varepsilon_0 l}$

(C) $\dfrac{q^2}{2\pi\varepsilon_0 l}$

(D) $\dfrac{-q^2}{\pi\varepsilon_0 l}$

[2026 • Set 55-2-1]

Q6. Two metal spheres of radii r_1 and r_2 $(r_2 > r_1)$ having charges q_1 and q_2 respectively kept in air, are brought in contact. Which of the following statements is NOT correct?

(A) The total charge of the two spheres is conserved.

(B) Both spheres attain the same potential.

(C) The final potential of the system equals $\dfrac{1}{4\pi\varepsilon_0}\dfrac{(q_1 + q_2)}{(r_1 + r_2)}$.

(D) The final potential of the system equals $\dfrac{1}{4\pi\varepsilon_0}\dfrac{(q_1 + q_2)(r_1 + r_2)}{r_1 r_2}$.

[2026 • Set 55-2-1]

Q7. Three point charges $+q$, $-2q$ and $+q$ are placed along x-axis at points $x = -1$ m, $x = 0$ m and $x = 2$ m respectively. The potential energy of the system is:

(A) $\dfrac{q^2}{4\pi\varepsilon_0}$

(B) $\dfrac{-2q^2}{3\pi\varepsilon_0}$

(C) $\dfrac{q^2}{4\pi\varepsilon_0}$

(D) $\dfrac{-5q^2}{4\pi\varepsilon_0}$

[2026 • Set 55-2-2]

Q8. A point charge of $5\ \mu$C is located at $(1\text{ cm}, 1\text{ cm})$ in x-y plane. A second charge of $6\ \mu$C is brought from infinity to point $(-3\text{ cm}, 4\text{ cm})$. The work done in the process is:

(A) $0{\cdot}54$ J

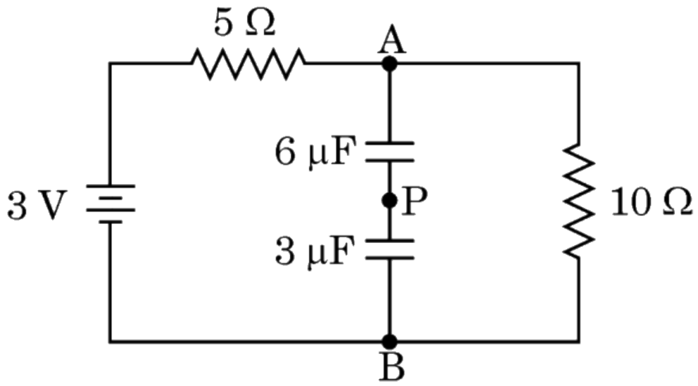
(B) $5{\cdot}4$ J

(C) $-0{\cdot}54$ J

(D) $10{\cdot}8$ J

[2026 • Set 55-2-3]

Q9. Case Study: Capacitors are manufactured with certain standard capacitances and working voltages. However, these standard values may not be the ones that are actually needed in a particular application. Two or more capacitors can be grouped in series or in parallel to achieve desired capacitance and voltage. When connected in series, the total capacitance decreases while the voltage rating increases, whereas in parallel connections, the total capacitance increases and maintains the same voltage rating. A capacitor stores energy in the electric field between its plates and stored energy is proportional to the square of the voltage and capacitance $U = \frac{1}{2}CV^2$, where symbols have their usual meanings.



Two capacitors, one of $3\ \mu$F and the other of $6\ \mu$F, are connected in series in the circuit as shown in the figure, for a long time. The total capacitance of the circuit is:

(A) $6\ \mu$F

(B) $3\ \mu$F

(C) $9\ \mu$F

(D) $2\ \mu$F

[2026 • Set 55-3-1]

Q10. The current in the $10\ \Omega$ resistor is:

(A) $0{\cdot}3$ A
(B) $0{\cdot}6$ A
(C) $0{\cdot}2$ A
(D) 0

[2026 • Set 55-3-1]

Q11. The potential difference between point A and B is:

(A) 2 V
(B) $0{\cdot}3$ V
(C) $0{\cdot}2$ V
(D) 3 V

[2026 • Set 55-3-1]

Q12. The value of charge on the plates of the $6\ \mu$F capacitor is:

(A) $6\ \mu$C
(B) $4\ \mu$C
(C) $12\ \mu$C
(D) $8\ \mu$C

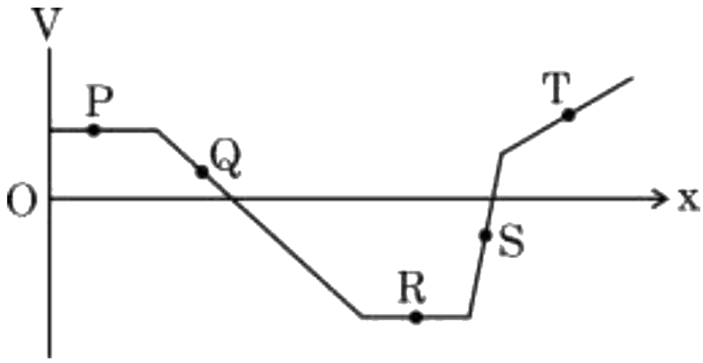
[2026 • Set 55-3-1]

Q13. The wire between two capacitors is cut at point P. The current in the circuit will:

(A) increase
(B) decrease
(C) remain the same
(D) first increase then become stable

[2026 • Set 55-3-1]

Q14. The figure represents the variation of the electric potential V at a point in a region of space as a function of its position along the x-axis. A charged particle will experience the maximum force at:



(A) P
(B) Q
(C) R
(D) S

[2026 • Set 55-5-1]

Q15. The electric field $\vec{E}$ in the region between the plates is:

(A) $\left(2 \times 10^2 \, \dfrac{\text{V}}{\text{m}}\right) \hat{k}$
(B) $-\left(2 \times 10^2 \, \dfrac{\text{V}}{\text{m}}\right) \hat{k}$
(C) $\left(2 \times 10^4 \, \dfrac{\text{V}}{\text{m}}\right) \hat{k}$
(D) $-\left(2 \times 10^4 \, \dfrac{\text{V}}{\text{m}}\right) \hat{k}$

[2026 • Set 55-5-1]

Q16. In the region between the plates, the electron moves with an acceleration $\vec{a}$ given by:

(A) $-(3.5 \times 10^{15} \, \text{ms}^{-2}) \, \hat{k}$
(B) $(3.5 \times 10^{15} \, \text{ms}^{-2}) \, \hat{k}$
(C) $(3.5 \times 10^{13} \, \text{ms}^{-2}) \, \hat{i}$
(D) $-(3.5 \times 10^{13} \, \text{ms}^{-2}) \, \hat{i}$

[2026 • Set 55-5-1]

Q17. (a) Time interval during which an electron moves through the region between the plates is:

(A) 9.0×10^{-9} s
(B) 1.67×10^{-8} s
(C) 1.67×10^{-9} s
(D) 2.17×10^{-9} s

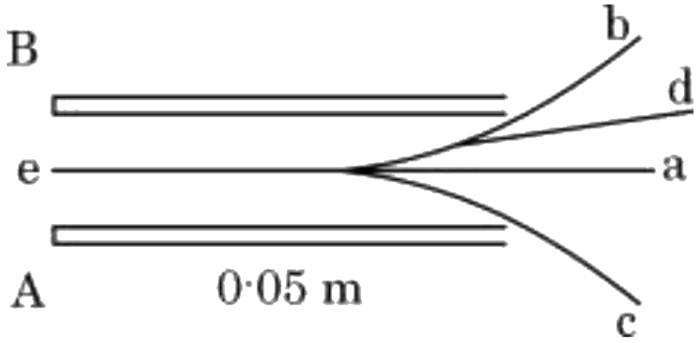
[2026 • Set 55-5-1]

Q18. (b) The vertical displacement of the electron which travels through the region between the plates is:

(A) $1.0\,\text{mm}$
(B) $4.9\,\text{mm}$
(C) $5.9\,\text{mm}$
(D) $3.0\,\text{mm}$

[2026 • Set 55-5-1]

Q19. Which one of the following is the path traced by the electron in between the two plates?



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

[2026 • Set 55-5-1]

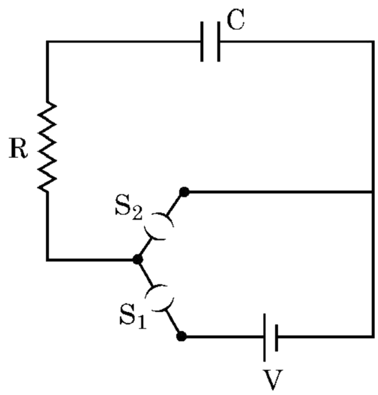
Q20. Two points R and S are equidistant from two charges $+Q$ and $-2Q$. The work done in moving a charge $-Q$ from point R to S is:

(A) Zero
(B) $\dfrac{Q}{4\pi\varepsilon_0\, d}$
(C) $\dfrac{2Q}{4\pi\varepsilon_0\, d}$
(D) $\dfrac{3Q}{4\pi\varepsilon_0\, d}$

[2026 • Set 55-5-3]

Q21. Case Study (Q29): A circuit consisting of a capacitor C, a resistor of resistance R and an ideal battery of emf V, as shown in figure, is known as an RC series circuit. As soon as the circuit is completed by closing key S_1 (keeping S_2 open), charges begin to flow between the capacitor plates and the battery terminals. The charge on the capacitor increases and consequently the potential difference $V_c\,(= q/C)$ across the capacitor also increases with time. When this potential difference equals the potential difference across the battery, the capacitor is fully charged ($Q = VC$). During this process of charging, the charge q on the capacitor changes with time t as $q = Q\left[1 - e^{-t/RC}\right]$. The charging current can be obtained by differentiating it and using $\dfrac{d}{dx}(e^{mx}) = m\,e^{mx}$. Consider the case when

$R = 20\,\text{k}\Omega$, $C = 500\,\mu\text{F}$ and $V = 10\,\text{V}$.



(i) The final charge on the capacitor, when key S_1 is closed and S_2 is open, is:

(A) $5\,\mu$C

(B) $5\,$mC

(C) $25\,$mC

(D) $0.1\,$C

[2025 • Set 55-1-1]

Q22. (ii) For sufficient time the key S_1 is closed and S_2 is open. Now S_2 is closed and S_1 is open. What is the final charge on the capacitor?

(A) Zero

(B) $5\,$mC

(C) $2.5\,$mC

(D) $5\,\mu$C

[2025 • Set 55-1-1]

Q23. (iii) The dimensional formula for RC is:

(A) $[ML^2T^{-3}A^{-2}]$

(B) $[M^0L^0T^{-1}A^0]$

(C) $[M^{-1}L^{-2}T^4A^2]$

(D) $[M^0L^0TA^0]$

[2025 • Set 55-1-1]

Q24. (iv) The key S_1 is closed and S_2 is open. The value of current in the resistor after 5 seconds is:

(A) $\frac{1}{2\sqrt{e}}$ mA

(B) $\sqrt{e}$ mA

(C) $\frac{1}{\sqrt{e}}$ mA

(D) $\frac{1}{2e}$ mA

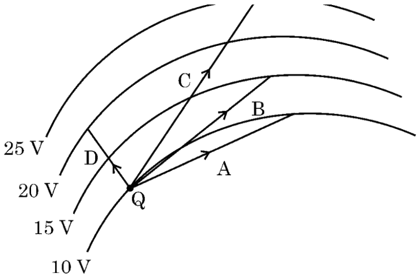
[2025 • Set 55-1-1]

Q25. (iv) OR: The key S_1 is closed and S_2 is open. The initial value of charging current in the resistor is:

(A) $5\,\text{mA}$
(B) $0.5\,\text{mA}$
(C) $2\,\text{mA}$
(D) $1\,\text{mA}$

[2025 • Set 55-1-1]

Q26. In the figure curved lines represent equipotential surfaces. A charge Q is moved along different paths A, B, C and D. The work done on the charge will be maximum along the path:



(A) A
(B) B
(C) C
(D) D

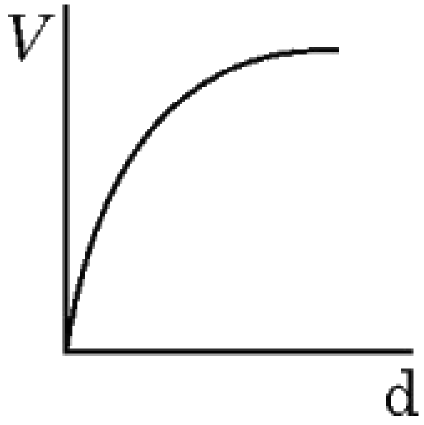
[2025 • Set 55-1-2]

Q27. Case study: A parallel plate capacitor has two parallel plates which are separated by an insulating medium like air, mica, etc. When the plates are connected to the terminals of a battery, they get equal and opposite charges and an electric field is set up in between them. This electric field between the two plates depends upon the potential difference applied, the separation of the plates and nature of the medium between the plates. The electric field between the plates of a parallel plate capacitor is E. Now the separation between the plates is doubled and simultaneously the applied potential difference between the plates is reduced to half of its initial value. The new value of the electric field between the plates will be:

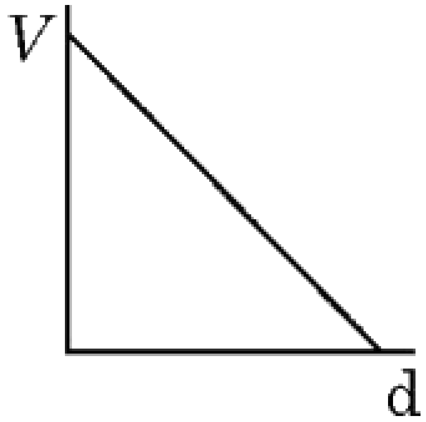
(A) E
(B) 2E
(C) $\frac{E}{4}$
(D) $\frac{E}{2}$

[2025 • Set 55-2-1]

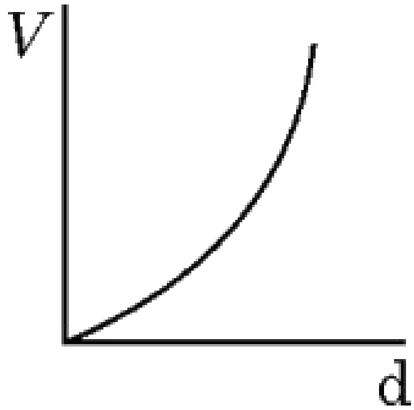
Q28. A constant electric field is to be maintained between the two plates of a capacitor whose separation d changes with time. Which of the graphs correctly depict the potential difference (V) to be applied between the plates as a function of separation between the plates (d) to maintain the constant electric field?



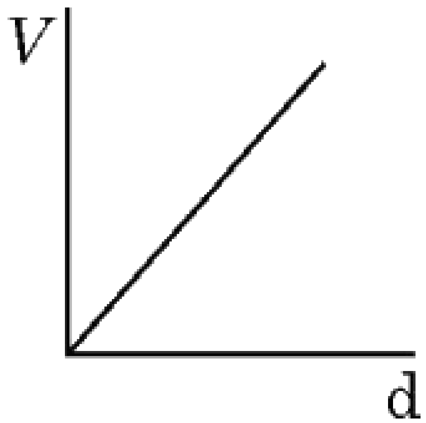
(A)



(B)



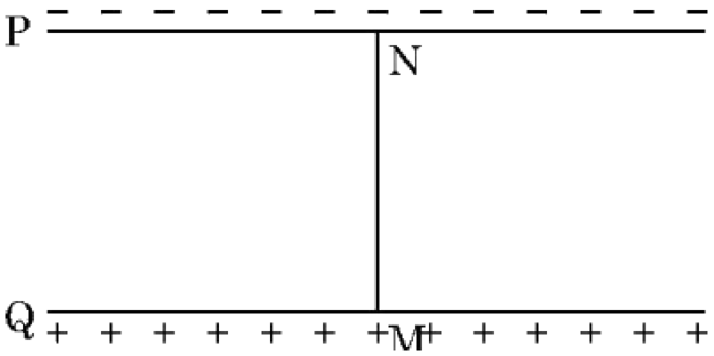
(C)

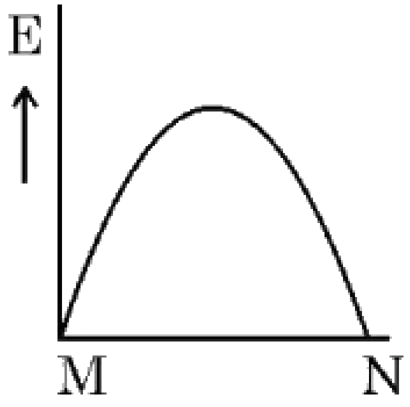


(D)

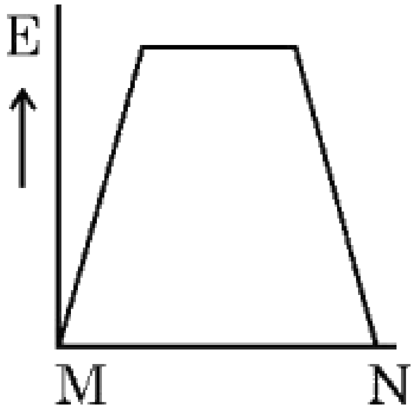
[2025 • Set 55-2-1]

Q29. In the above figure P, Q are the two parallel plates of a capacitor. Plate Q is at positive potential with respect to plate P. MN is an imaginary line drawn perpendicular to the plates. Which of the graphs shows correctly the variations of the magnitude of electric field strength E along the line MN?

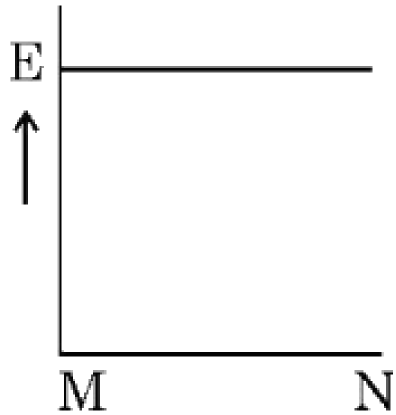




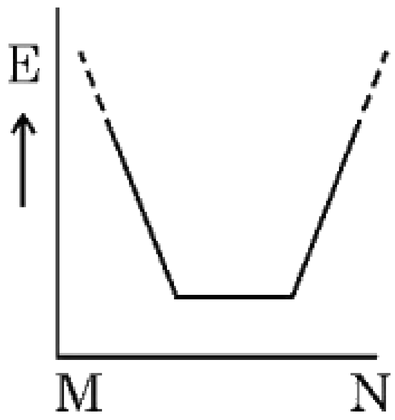
(A)



(B)



(C)

(D) 

[2025 • Set 55-2-1]

Q30. Three parallel plates are placed above each other with equal displacement d between neighbouring plates. The electric field between the first pair of the plates is $\vec{E}_1$ and the electric field between the second pair of the plates is $\vec{E}_2$. The potential difference between the third and the first plate is

(A) $(\vec{E}_1 + \vec{E}_2) \cdot \vec{d}$

(B) $(\vec{E}_1 - \vec{E}_2) \cdot \vec{d}$

(C) $(\vec{E}_2 - \vec{E}_1) \cdot \vec{d}$

(D) $\dfrac{\vec{d}(\vec{E}_1 + \vec{E}_2)}{2}$

[2025 • Set 55-2-1]

Q31. A material of dielectric constant K is filled in a parallel plate capacitor of capacitance C. The new value of its capacitance becomes

(A) C

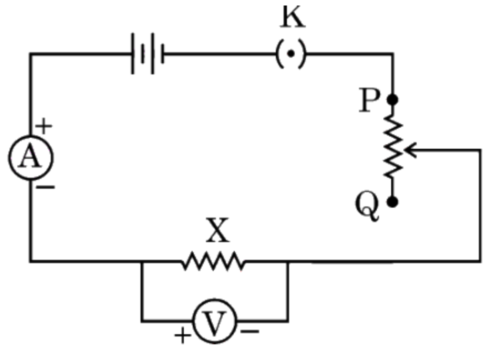
(B) $\dfrac{C}{K}$

(C) CK

(D) $C\left(1 + \dfrac{1}{K}\right)$

[2025 • Set 55-2-1]

Q32. Case Study (Q29): A parallel plate capacitor consists of two conducting plates kept generally parallel to each other at a distance. When the capacitor is charged, the charge resides on the inner surfaces of the plates and an electric field is set up between them. Thus, electrostatic energy is stored in the capacitor. The figure shows three large square metallic plates, each of side 'L' held parallel and equidistant from each other. The space between P_1 and P_2 and P_2 and P_3 is completely filled with mica sheets of dielectric constant 'K'. The plate P_2 is connected to point A and other plates P_1 and P_3 are connected to point B. Point A is maintained at a positive potential with respect to point B and the potential difference between A and B is V.



(i) The capacitance of the system between A and B will be :

(A) $\dfrac{\varepsilon_0 K L^2}{d}$

(B) $\dfrac{\varepsilon_0 K L^2}{2d}$

(C) $\dfrac{2\varepsilon_0 K L^2}{d}$

(D) $\dfrac{2\varepsilon_0 K d}{L^2}$

[2025 • Set 55-4-1]

Q33. (ii) The charge on plate P_2 is :

(A) $\dfrac{\varepsilon_0 V K L^2}{2d}$

(B) $\dfrac{\varepsilon_0 V K L^2}{d}$

(C) $\dfrac{2\varepsilon_0 V K L^2}{d}$

(D) $\dfrac{\varepsilon_0 V K L^2}{4d}$

[2025 • Set 55-4-1]

Q34. (iii) The electric field in the region between P_1 and P_2 is :

(A) $\dfrac{V}{d}$

(B) $\dfrac{2V}{d}$

(C) $\dfrac{V}{2d}$

(D) $\dfrac{d}{V}$

[2025 • Set 55-4-1]

Q35. (iv) The separation between the plates of same area (L^2) of a parallel plate air capacitor having capacitance equal to that of this system, will be :

(A) $\dfrac{d}{K}$

(B) $\dfrac{2d}{K}$

(C) $\dfrac{d}{2K}$

(D) $\dfrac{d}{4K}$

[2025 • Set 55-4-1]

Q36. (iv) OR: If the source of potential difference applied between A and B is removed, and then A and B are connected by a conducting wire, the net charge on the system will be :

(A) $\dfrac{\varepsilon_0 VKL^2}{4d}$

(B) $\dfrac{\varepsilon_0 VKL^2}{2d}$

(C) $\dfrac{\varepsilon_0 VKL^2}{d}$

(D) Zero

[2025 • Set 55-4-1]

Q37. A metal sheet is inserted between the plates of a parallel plate capacitor of capacitance C. If the sheet partly occupies the space between the plates, the capacitance:

(A) remains C

(B) becomes greater than C

(C) becomes less than C

(D) becomes zero

[2025 • Set 55-5-1]

Q38. The electric field at a point in a region is given by $\vec{E} = \dfrac{\alpha}{r^3}\vec{r}$, where α is a constant and r is the distance of the point from the origin. The magnitude of potential of the point is:

(A) $\dfrac{\alpha}{r}$

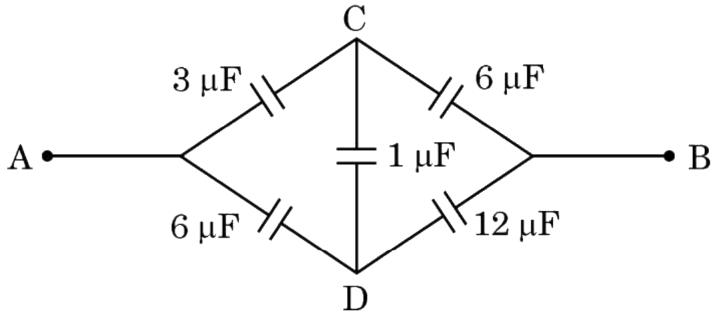
(B) $\dfrac{\alpha r^2}{2}$

(C) $\dfrac{\alpha}{2r}$

(D) $-\dfrac{\alpha}{r}$

[2025 • Set 55-5-1]

Q39. The effective capacitance of the network between points A and B shown in the figure is:



(A) $\dfrac{4}{3}\ \mu$F

(B) $2\ \mu$F
(C) $\frac{3}{4}\ \mu$F
(D) $6\ \mu$F

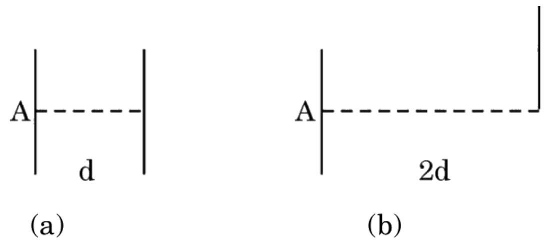
[2025 • Set 55-5-2]

Q40. Four point charges Q each, are held at the four corners of a square of side l. The amount of work done in bringing a charge Q from infinity to the centre of the square will be:

(A) $\frac{Q^2}{\pi\varepsilon_0 l}$
(B) $\frac{\sqrt{2}\,Q^2}{\pi\varepsilon_0 l}$
(C) $\frac{Q^2}{2\pi\varepsilon_0 l}$
(D) Zero

[2025 • Set 55-5-3]

Q41. Case Study (Capacitors): A capacitor is a system of two conductors separated by an insulator. In practice, the two conductors have charges Q and $-Q$ with potential difference $V = V_1 - V_2$ between them. The ratio $\frac{Q}{V}$ is a constant, denoted by C and is called the capacitance of the capacitor. It is independent of Q or V. It depends only on the geometrical configuration (shape, size, separation) of the two conductors and the medium separating the conductors. When a parallel plate capacitor is charged, the electric field E_0 is localised between the plates and is uniform throughout. When a slab of a dielectric is inserted between the charged plates (charge density σ), the dielectric is polarised by the field. Consequently opposite charges appear on the faces of the slab, near the plates, with surface charge density of magnitude σ_p. For a linear dielectric σ_p is proportional to $\vec{E}_0$. Introduction of a dielectric changes the electric field, and hence, the capacitance of a capacitor, and hence, the energy stored in the capacitor. Like resistors, capacitors can also be arranged in series or in parallel or in a combination of series and parallel. (i) Consider a capacitor of capacitance C, with plate area A and plate separation d, filled with air [Fig. (a)]. The distance between the plates is increased to $2d$ and one of the plates is shifted as shown in Fig. (b). The capacitance of the new system now is:



(A) $\frac{C}{4}$
(B) $\frac{C}{2}$
(C) $2C$
(D) $4C$

[2025 • Set 55-6-1]

Q42. (ii) A slab (area A and thickness d_1) of a linear dielectric of dielectric constant K is inserted between charged plates (charge density σ) of a parallel plate capacitor [plate area A and plate separation $d\,(> d_1)$] and opposite charges with charge density of magnitude σ_p appear on the faces of the slab. The dielectric constant K is given by:

(A) $\dfrac{\sigma - \sigma_p}{\sigma}$
(B) $\dfrac{\sigma}{\sigma - \sigma_p}$
(C) $\dfrac{\sigma + \sigma_p}{\sigma_p}$
(D) $\dfrac{\sigma}{\sigma_p}$

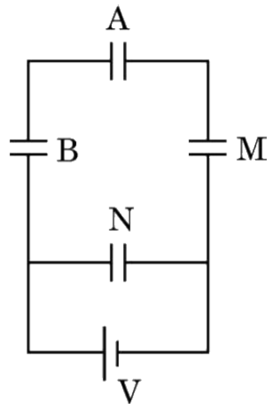
[2025 • Set 55-6-1]

Q43. (iii) An electric field E is established between the plates of an air filled parallel plate capacitor, with charges Q and $-Q$. V is the volume of the space enclosed between the plates. The energy stored in the capacitor is:

(A) $\frac{1}{2}\varepsilon_0 E^2$
(B) $\varepsilon_0 EQV$
(C) $\frac{1}{2}\varepsilon_0 E^2 V$
(D) $\varepsilon_0 EQV$

[2025 • Set 55-6-1]

Q44. (iv) (a) Three capacitors A, B and M, each of capacitance C are connected to a capacitor N of capacitance $2C$ and a battery as shown in the figure. If the charges on A and N are Q and Q' respectively, then $\dfrac{Q'}{Q}$ is:



OR (b) A slab (area A and thickness $\frac{d}{2}$) of dielectric constant K is inserted in a parallel plate capacitor of plate area A and plate separation d. If C and C_0 are the capacitances of the capacitors with and without the dielectric, then $\dfrac{C}{C_0}$ is:

(A) (a) $\frac{1}{6}$ | (b) $\dfrac{K+1}{2K}$

(B) (a) $\frac{1}{3}$ | (b) $\frac{2K}{K+1}$
(C) (a) 3 | (b) $\frac{K}{K-1}$
(D) (a) 6 | (b) $\frac{K-1}{K}$

[2025 • Set 55-6-1]

Q45. Two horizontal plates, separated by 1 cm, are arranged one above the other. A particle of mass 5 mg and charge 2 nC is released in air between the plates. The potential difference that should be applied to the plates so that the particle remains suspended between them, is:

(A) 250 V
(B) 200 V
(C) 100 V
(D) 50 V

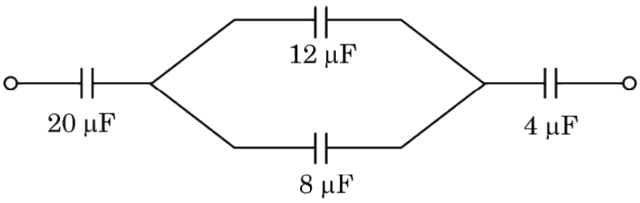
[2025 • Set 55-7-1]

Q46. The electric field (E) and electric potential (V) at a point inside a charged hollow metallic sphere are respectively:

(A) $E = 0$, $V = 0$
(B) $E = 0$, $V = V_0$ (a constant)
(C) $E \neq 0$, $V \neq 0$
(D) $E = E_0$ (a constant), $V = 0$

[2025 • Set 55-7-2]

Q47. In the circuit shown, the charge on the left plate of $20\ \mu$F capacitor is $-50\ \mu$C. The charge on the right plate of the $12\ \mu$F capacitor is:



(A) 20 μC (B) – 20 μC
(C) 30 μC (D) – 30 μC

(A) $20\ \mu$C
(B) $-20\ \mu$C
(C) $30\ \mu$C
(D) $-30\ \mu$C

[2025 • Set 55-7-3]

Q48. Ten capacitors, each of capacitance $1\ \mu$F, are connected in parallel to a source of 100 V.

The total energy stored in the system is equal to:

(A) 10^{-2} J

(B) 10^{-5} J

(C) 0.5×10^{-5} J

(D) 5.0×10^{-2} J

[2024 • Set 55-1-1]

Q49. The capacitance of a parallel plate capacitor having a medium of dielectric constant K = 4 in between the plates is C. If this medium is removed, then the capacitance of the capacitor becomes:

(A) $4C$

(B) C

(C) $\frac{C}{4}$

(D) $2C$

[2024 • Set 55-2-2]

Q50. Consider a group of charges $q_1, q_2, q_3, \ldots$ such that $\Sigma q \neq 0$. Then equipotentials at a large distance, due to this group are approximately:

(A) Plane

(B) Spherical surface

(C) Paraboloidal surface

(D) Ellipsoidal surface

[2024 • Set 55-3-1]

Q51. A proton is taken from point P_1 to point P_2, both located in an electric field. The potentials at points P_1 and P_2 are -5 V and $+5$ V respectively. Assuming that kinetic energies of the proton at points P_1 and P_2 are zero, the work done on the proton is:

(A) -1.6×10^{-18} J

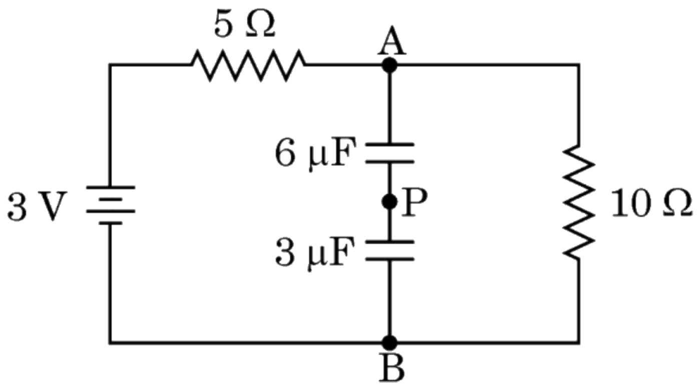
(B) 1.6×10^{-18} J

(C) Zero

(D) 0.8×10^{-18} J

[2024 • Set 55-3-1]

Q52. The figure shows four pairs of parallel identical conducting plates, separated by the same distance 2.0 cm and arranged perpendicular to x-axis. The electric potential of each plate is mentioned. The electric field between a pair of plates is uniform and normal to the plates.



For which pair of the plates is the electric field $\vec{E}$ along $\hat{i}$?

(A) I

(B) II

(C) III

(D) IV

[2024 • Set 55-3-1]

Q53. An electron is released midway between the plates of pair IV. It will:

(A) move along $\hat{i}$ at constant speed

(B) move along $-\hat{i}$ at constant speed

(C) accelerate along $\hat{i}$

(D) accelerate along $-\hat{i}$

[2024 • Set 55-3-1]

Q54. Let V_0 be the potential at the left plate of any set, taken to be at $x = 0$ m. Then potential V at any point ($0 < x < 2$ cm) between the plates of that set can be expressed as: (α is a constant, positive or negative.)

(A) $V = V_0 + \alpha x$

(B) $V = V_0 + \alpha x^2$

(C) $V = V_0 + \alpha x^{1/2}$

(D) $V = V_0 + \alpha x^{3/2}$

[2024 • Set 55-3-1]

Q55. Let E_1, E_2, E_3 and E_4 be the magnitudes of the electric field between the pairs of plates, I, II, III and IV respectively. Then:

(A) $E_1 > E_2 > E_3 > E_4$

(B) $E_2 > E_4 > E_1 > E_3$

(C) $E_4 > E_2 > E_3 > E_1$

(D) $E_4 > E_3 > E_2 > E_1$

[2024 • Set 55-3-1]

Q56. An electron is projected from the right plate of set I directly towards its left plate. It just comes to rest at the plate. The speed with which it was projected is about: (Take $e/m = 1.76 \times 10^{11}$ C/kg)

(A) 1.3×10^6 m/s

(B) 2.6×10^6 m/s

(C) 6.5×10^6 m/s

(D) 5.2×10^7 m/s

[2024 • Set 55-3-1]

Q57. The plates P_1 and P_2 of a $2\ \mu$F capacitor are at potentials 25 V and -25 V respectively. The charge on plate P_1 will be:

(A) 0.02 mC

(B) 0.1 mC

(C) $0.1\ \mu$C

(D) $1\ \mu$C

[2024 • Set 55-3-3]

Q58. Two charges $+q$ each are kept $2a$ distance apart. A third charge $-2q$ is placed midway between them. The potential energy of the system is

(A) $\dfrac{q^2}{8\pi\varepsilon_0 a}$

(B) $-\dfrac{6q^2}{8\pi\varepsilon_0 a}$

(C) $-\dfrac{7q^2}{8\pi\varepsilon_0 a}$

(D) $\dfrac{9q^2}{8\pi\varepsilon_0 a}$

[2024 • Set 55-4-1]

Q59. Three point charges, each of charge q are placed on vertices of a triangle ABC, with $AB = AC = 5L$, $BC = 6L$. The electrostatic potential at midpoint of side BC will be

(A) $\dfrac{11q}{48\pi\varepsilon_0 L}$

(B) $\dfrac{8q}{36\pi\varepsilon_0 L}$

(C) $\dfrac{5q}{24\pi\varepsilon_0 L}$

(D) $\dfrac{q}{16\pi\varepsilon_0 L}$

[2024 • Set 55-4-2]

Q60. Dielectrics play an important role in design of capacitors. The molecules of a dielectric may be polar or non-polar. When a dielectric slab is placed in an external electric field, opposite charges appear on the two surfaces of the slab perpendicular to electric field.

Due to this an electric field is established inside the dielectric. The capacitance of a capacitor is determined by the dielectric constant of the material that fills the space between the plates. Consequently, the energy storage capacity of a capacitor is also affected. Like resistors, capacitors can also be arranged in series and/or parallel. Which of the following is a polar molecule?

(A) O_2
(B) H_2
(C) N_2
(D) HCl

[2024 • Set 55-5-1]

Q61. Which of the following statements about dielectrics is correct?

(A) A polar dielectric has a net dipole moment in absence of an external electric field which gets modified due to the induced dipoles.
(B) The net dipole moments of induced dipoles is along the direction of the applied electric field.
(C) Dielectrics contain free charges.
(D) The electric field produced due to induced surface charges inside a dielectric is along the external electric field.

[2024 • Set 55-5-1]

Q62. When a dielectric slab is inserted between the plates of an isolated charged capacitor, the energy stored in it:

(A) increases and the electric field inside it also increases.
(B) decreases and the electric field also decreases.
(C) decreases and the electric field increases.
(D) increases and the electric field decreases.

[2024 • Set 55-5-1]

Q63. An air-filled capacitor with plate area A and plate separation d has capacitance C_0. A slab of dielectric constant K, area A and thickness $\left(\frac{d}{2}\right)$ is inserted between the plates. The capacitance of the capacitor will become:

(A) $\left[\frac{4K}{K+5}\right] C_0$
(B) $\left[\frac{K+5}{4K}\right] C_0$
(C) $\left[\frac{5K}{K+4}\right] C_0$
(D) $\left[\frac{K+4}{5K}\right] C_0$

[2024 • Set 55-5-1]

Q64. Two capacitors of capacitances $2\,C_0$ and $6\,C_0$ are first connected in series and then in parallel across the same battery. The ratio of energies stored in series combination to that in parallel is:

(A) $\frac{1}{4}$

(B) $\frac{1}{8}$

(C) $\frac{2}{15}$

(D) $\frac{3}{16}$

[2024 • Set 55-5-1]

Q65. Assertion (A): Work done in moving a charge around a closed path, in an electric field is always zero. Reason (R): Electrostatic force is a conservative force.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are true and Reason (R) is NOT the correct explanation of Assertion (A).

(C) Assertion (A) is true and Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

[2023 • Set 55-2-1]

Q66. A point P lies at a distance x from the mid point of an electric dipole on its axis. The electric potential at point P is proportional to

(A) $\frac{1}{x^2}$

(B) $\frac{1}{x^3}$

(C) $\frac{1}{x^{3/2}}$

(D) $\frac{1}{x^{5/2}}$

[2023 • Set 55-2-1]

Q67. A point charge q is moving along a circular path of radius a, with a point charge $-Q$ at the centre of the circle. The kinetic energy of q is

(A) $\frac{qQ}{4\pi\varepsilon_0 a}$

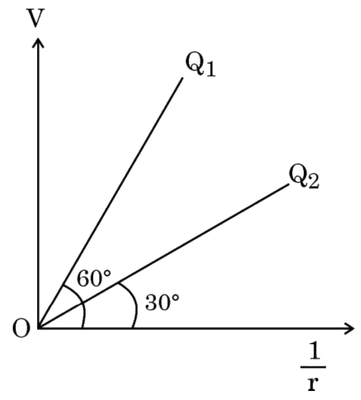
(B) $\frac{qQ}{8\pi\varepsilon_0 a}$

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

(D) $\frac{qQ}{8\pi\varepsilon_0 a^2}$

[2023 • Set 55-2-3]

Q68. (b) The figure shows the variation of potential V with $\frac{1}{r}$ for two point charges Q_1 and Q_2, where V is the potential at a distance r due to a point charge. Find $\frac{Q_2}{Q_1}$.



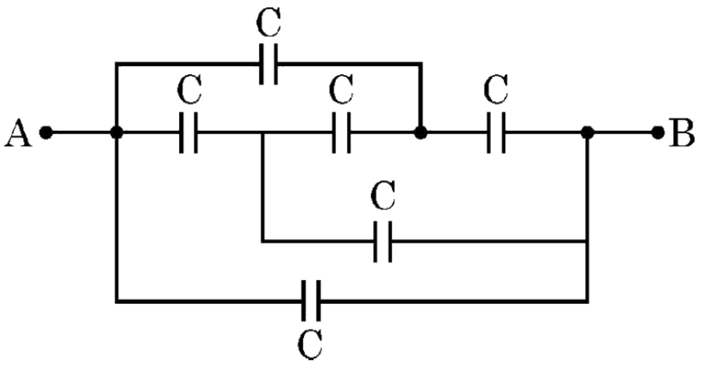
[2023 • Set 55-4-1]

Q69. The capacitors, each of $4\,\mu F$ are to be connected in such a way that the effective capacitance of the combination is $6\,\mu F$. This can be achieved by connecting

(A) All three in parallel
(B) All three in series
(C) Two of them connected in series and the combination in parallel to the third.
(D) Two of them connected in parallel and the combination in series to the third.

[2023 • Set 55-5-1]

Q70. Find the equivalent capacitance between points A and B in the given diagram.



[2023 • Set 55-5-1]

Q71. A dielectric slab is inserted between the plates of a parallel plate capacitor. The electric field between the plates decreases. Explain.

[2023 • Set 55-5-1]

Q72. An electric dipole consisting of charges $+q$ and $-q$ separated by a distance L is in stable equilibrium in a uniform electric field $\vec{E}$. The electrostatic potential energy of the dipole is

(A) qLE
(B) zero
(C) $-qLE$
(D) $-2qLE$

[2020 • Set 55-1-1]

Q73. The potential difference between two points in vacuum is V_0. If vacuum is replaced by a medium of dielectric constant K, the new value of potential difference will be ______.

[2020 • Set 55-2-3]

Q74. If a positive charge is displaced against the electric field in which it was situated, then
(A) work will be done by the electric field on the charge.
(B) the intensity of the electric field decreases.
(C) energy of the system will decrease.
(D) energy will be provided by external source displacing the charge.

[2020 • Set 55-3-1]

Q75. Two capacitors of capacitances C_1 and C_2 are connected in parallel. If a charge Q is given to the combination, the ratio of the charge on the capacitor C_1 to the charge on C_2 will be
(A) $\frac{C_1}{C_2}$
(B) $\frac{C_2}{C_1}$
(C) $\sqrt{\frac{C_1}{C_2}}$
(D) $\sqrt{\frac{C_2}{C_1}}$

[2020 • Set 55-3-1]

Q76. A charge Q is kept at the centre of a circle of radius r. A test charge q_0 is carried from a point X to the point Y on this circle such that arc XY subtends an angle of $60°$ at the centre of the circle. The amount of work done in this process will be
(A) $\frac{1}{4\pi\varepsilon_0}\frac{Qq_0}{2r}$
(B) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{3}\,Qq_0}{2r}$
(C) Zero
(D) $\frac{\sqrt{3}\,Qq_0}{4\pi\varepsilon_0\,r}$

[2020 • Set 55-3-2]

Q77. A parallel plate capacitor is charged to V volt by a battery. The battery is disconnected and the separation between the plates is halved. The new potential difference across the capacitor will be

(A) $\dfrac{V}{2}$

(B) V

(C) $2V$

(D) $\dfrac{V}{4}$

[2020 • Set 55-3-2]

Q78. A charge Q is uniformly distributed over the surface of a spherical shell of radius R. The work done in bringing a test charge Q_0 from its centre to its surface is

(A) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{QQ_0}{R}$

(B) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{QQ_0}{2R}$

(C) $\dfrac{QQ_0}{\varepsilon_0 R}$

(D) Zero

[2020 • Set 55-3-3]

Q79. A charged particle is placed between the two plates of a charged parallel plate capacitor. It experiences a force F. If one plate is removed, then the force on the particle will be

(A) $2F$

(B) F

(C) $\dfrac{F}{2}$

(D) Zero

[2020 • Set 55-3-3]

Q80. Fill in the blank with appropriate answer. A proton released from rest in an electric field, will start moving towards a region of ________ potential in the field.

[2020 • Set 55-4-1]

Q81. The work done in moving a charged particle between two points in a uniform electric field does not depend on the path followed by the particle. Why?

[2020 • Set 55-4-1]

Q82. A charged particle $(+q)$ moves in a uniform electric field $(\vec{E})$ in the direction opposite to $\vec{E}$. What will be the effect on its electrostatic potential energy during its motion?

[2020 • Set 55-4-3]

Q83. A point charge is placed at the centre of a hollow conducting sphere of internal radius r and outer radius $2r$. The ratio of the surface charge density of the inner surface to that of the outer surface will be __________ .

[2020 • Set 55-5-1]

Q84. Draw the equipotential surfaces due to an isolated point charge.

[2019 • Set 55-1-2]

Q85. Why is the electrostatic potential inside a charged conducting shell constant throughout the volume of the conductor?

[2019 • Set 55-5-1]

Q86. Does the charge given to a metallic sphere depend on whether it is hollow or solid? Give reason for your answer.

[2017]

Q87. A point charge Q is placed at point 'O' as shown in the figure. Is the potential at point A, i.e. V_A, greater, smaller or equal to potential, V_B, at point B, when Q is (i) positive, and (ii) negative charge?

O• A• B•

[2017]

Q88. What is the amount of work done in moving a point charge Q around a circular arc of radius r at the centre of which another point charge q is located?

[2016]

Q89. "For any charge configuration, equipotential surface through a point is normal to the electric field." Justify.

[2014]

Q90. What is the geometrical shape of equipotential surfaces due to a single isolated charge?

[2013]

Q91. Define the term 'dielectric constant' of a medium.

[2013]

Q92. Name the physical quantity whose S.I. unit is JC^{-1}. Is it a scalar or a vector quantity?

[2012]

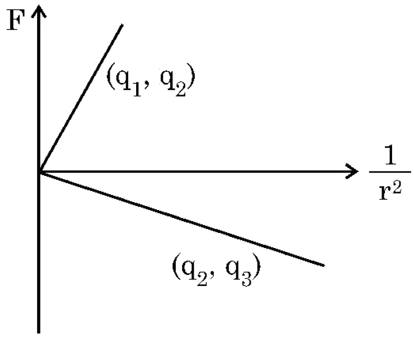
Q93. Why is the potential inside a hollow spherical charged conductor constant and has the same value as on its surface?

[2012]

Q94. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. What is the potential at the centre of the sphere?

[2011]

Q95. A point charge Q is placed at point O as shown in the figure. Is the potential difference $V_A - V_B$ positive, negative or zero, if Q is (i) positive (ii) negative?



[2011 • Set 55-1-1]

Q96. What is the electrostatic potential due to an electric dipole at an equatorial point?

[2009]

Q97. A $500\ \mu C$ charge is at the centre of a square of side $10\ cm$. Find the work done in moving a charge of $10\ \mu C$ between two diagonally opposite points on the square.

[2008]

Q98. Derive the expression for the electric potential at any point along the axial line of an electric dipole.

[2008]

Q99. Draw an equipotential surface for a system consisting of two charges Q, $-Q$ separated by a distance 'r' in air.

[2008]

Q100. Define the term 'dielectric constant' of a medium in terms of capacitance of a capacitor.

[2006]

2-Mark Questions (27 questions · Section B · VSA)

Q1. Two isolated metallic spheres S_1 and S_2 of radii 1 cm and 3 cm respectively are charged such that both have the same charge density $\left(\frac{2}{\pi} \times 10^{-9}\right)$ C/m^2. They are placed far away from each other and connected by a thin wire. Calculate the new charge on sphere S_2.

[2024 • Set 55-1-1]

Q2. (a) Obtain an expression for electrostatic potential energy of a system of three charges q, $2q$ and $-3q$ placed at the vertices of an equilateral triangle of side a.

OR

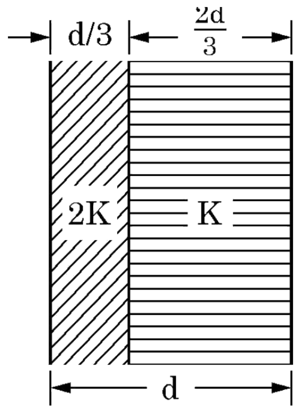
(b) Two small conducting balls A and B of radius r_1 and r_2 have charges q_1 and q_2 respectively. They are connected by a wire. Obtain the expression for charges on A and B, in equilibrium.

[2023 • Set 55-4-1]

Q3.(iii) A capacitor A of capacitance C, having charge Q is connected across another uncharged capacitor B of capacitance 2C. Find an expression for (a) the potential difference across the combination and (b) the charge lost by capacitor A.

OR

(iii) Two slabs of dielectric constants 2K and K fill the space between the plates of a parallel plate capacitor of plate area A and plate separation d as shown in figure. Find an expression for capacitance of the system.

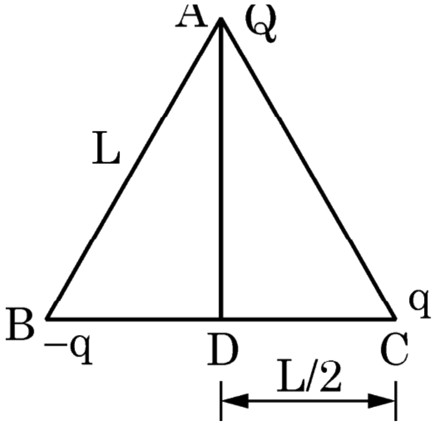


[2023 • Set 55-5-1]

Q4. Three point charges Q, q and $-q$ are kept at the vertices of an equilateral triangle of side L as shown in figure. What is

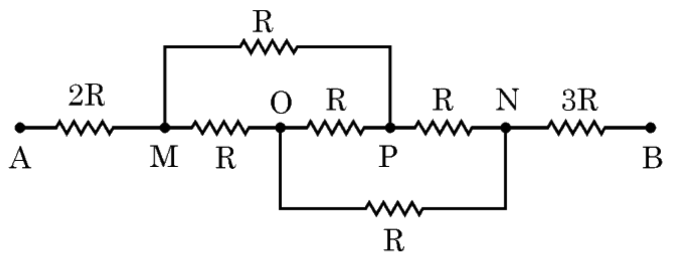
(i) the electrostatic potential energy of the arrangement? and

(ii) the potential at point D?



[2023 • Set 55-5-3]

Q5. The space between the plates of a parallel plate capacitor is completely filled in two ways. In the first case, it is filled with a slab of dielectric constant K. In the second case, it is filled with two slabs of equal thickness and dielectric constants K_1 and K_2 respectively as shown in the figure. The capacitance of the capacitor is same in the two cases. Obtain the relationship between K, K_1 and K_2.

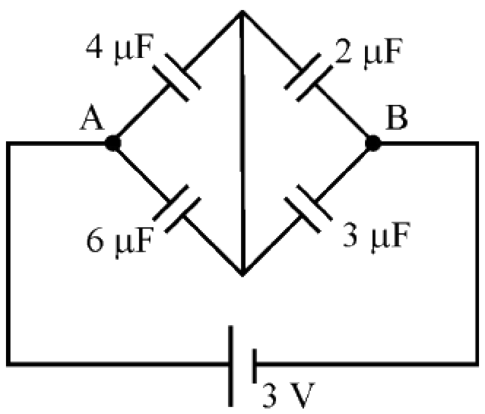


[2020 • Set 55-1-1]

Q6. N small conducting liquid droplets, each of radius r, are charged to a potential V each. These droplets coalesce to form a single large drop without any charge leakage. Find the potential of the large drop.

[2020 • Set 55-1-2]

Q7. Find the total charge stored in the network of capacitors connected between A and B as shown in figure:



[2020 • Set 55-4-1]

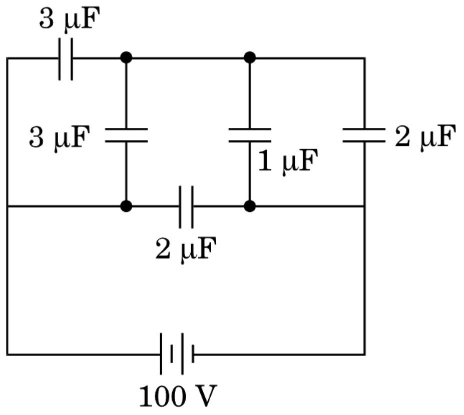
Q8. You are given three capacitors of $2\ \mu$F, $3\ \mu$F and $4\ \mu$F, respectively.

(a) Form a combination of all these capacitors of equivalent capacitance $\frac{13}{3}\ \mu$F.

(b) What is the maximum and minimum value of the equivalent capacitance that can be obtained by connecting these capacitors?

[2020 • Set 55-4-3]

Q9. The figure shows a network of five capacitors connected to a $100\,$V supply. Calculate the total energy stored in the network.



[2019 • Set 55-3-1]

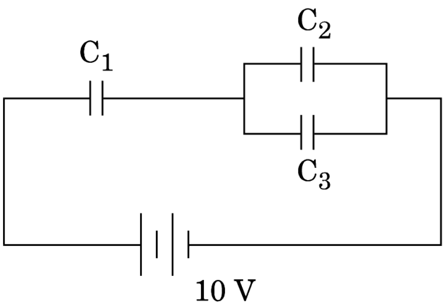
Q10. Two identical capacitors of 12 pF each are connected in series across a 50 V battery. Calculate the electrostatic energy stored in the combination. If these were connected in parallel across the same battery, find out the value of the energy stored in this combination.

[2019 • Set 55-5-1]

Q11. Two identical capacitors of 10 pF each are connected in turn (i) in series, and (ii) in parallel across a 20 V battery. Calculate the potential difference across each capacitor in the first case and charge acquired by each capacitor in the second case.

[2019 • Set 55-5-2]

Q12. The figure shows a network of three capacitors $C_1 = 2\,\mu F$; $C_2 = 6\,\mu F$ and $C_3 = 3\,\mu F$ connected across a battery of 10 V. If a charge of $6\,\mu C$ is acquired by the capacitor C_3, calculate the charge acquired by C_1.



[2019 • Set 55-5-3]

Q13. Why does current in a steady state not flow in a capacitor connected across a battery? However momentary current does flow during charging or discharging of the capacitor. Explain.

[2017]

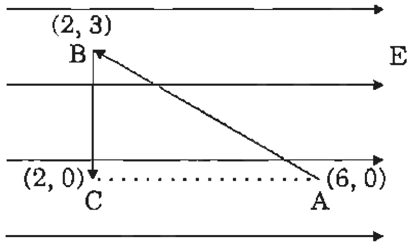
Q14. What is electrostatic shielding? How is this property used in actual practice? Is the potential in the cavity of a charged conductor zero?

[2016]

Q15. A parallel plate capacitor of capacitance C is charged to a potential V. It is then connected to another uncharged capacitor having the same capacitance. Find out the ratio of the energy stored in the combined system to that stored initially in the single capacitor.

[2014]

Q16. A test charge 'q' is moved without acceleration from A to C along the path from A to B and then from B to C in electric field $\vec{E}$ as shown in the figure. (i) Calculate the potential difference between A and C. (ii) At which point (of the two) is the electric potential more and why?



[2012]

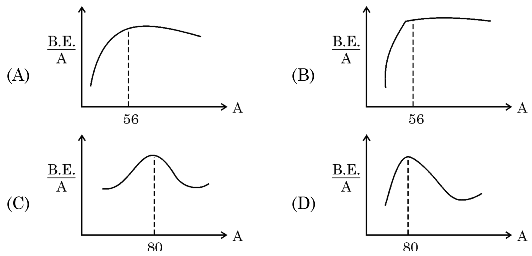
Q17. Draw a plot showing the variation of (i) electric field (E) and (ii) electric potential (V) with distance r due to a point charge Q.

[2012]

Q18. Net capacitance of three identical capacitors in series is $1\ \mu$F. What will be their net capacitance if connected in parallel? Find the ratio of energy stored in the two configurations if they are both connected to the same source.

[2011]

Q19. Figure shows two identical capacitors, C_1 and C_2, each of $1\ \mu$F capacitance connected to a battery of 6 V. Initially switch S is closed. After sometime S is left open and dielectric slabs of dielectric constant $K = 3$ are inserted to fill completely the space between the plates of the two capacitors. How will the (i) charge and (ii) potential difference between the plates of the capacitors be affected after the slabs are inserted?

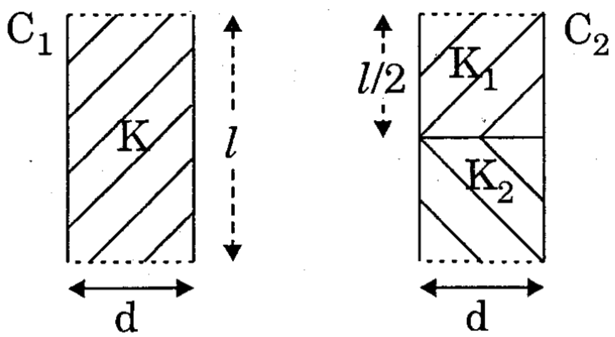


[2011 • Set 55-1-1]

Q20. Two uniformly large parallel thin plates having charge densities $+\sigma$ and $-\sigma$ are kept in the X-Z plane at a distance d apart. Sketch an equipotential surface due to electric field between the plates. If a particle of mass m and charge $-q$ remains stationary between the plates, what is the magnitude and direction of this field?

[2011 • Set 55-1-1]

Q21. Two identical parallel plate (air) capacitors C_1 and C_2 have capacitances C each. The space between their plates is now filled with dielectrics as shown. If the two capacitors still have equal capacitance, obtain the relation between dielectric constants K, K_1 and K_2.



[2011 • Set 55-2-1]

Q22. **(i)** Can two equi-potential surfaces intersect each other? Give reasons.

(ii) Two charges $-q$ and $+q$ are located at points $A(0, 0, -a)$ and $B(0, 0, +a)$ respectively. How much work is done in moving a test charge from point $P(7, 0, 0)$ to $Q(-3, 0, 0)$?

[2009]

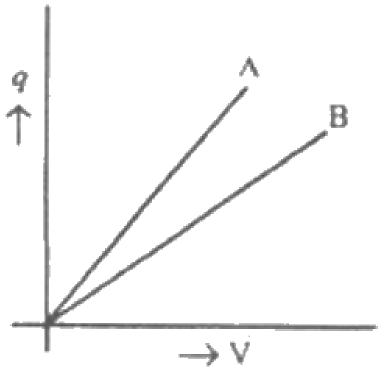
Q23. Draw 3 equipotential surfaces corresponding to a field that uniformly increases in magnitude but remains constant along Z-direction. How are these surfaces different from that of a constant electric field along Z-direction?

[2009]

Q24. Two point charges $4\,\mu$C and $-2\,\mu$C are separated by a distance of 1 m in air. Calculate at what point on the line joining the two charges is the electric potential zero.

[2007]

Q25. The given graph shows the variation of charge q versus potential difference V for two capacitors C_1 and C_2. The two capacitors C_1 and C_2 have same plate separation but the plate area of C_2 is double than that of C_1. Which of the lines in the graph correspond to C_1 and C_2 and why?



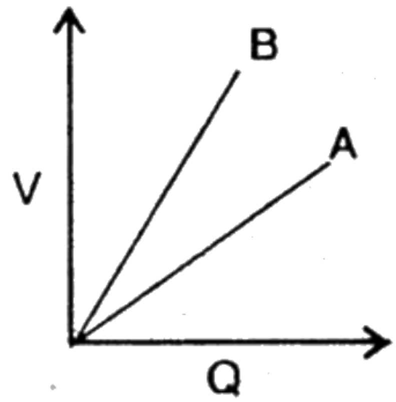
[2006]

Q26. (a) Why does the electric field inside a dielectric decrease when it is placed in an external electric field?

(b) A parallel plate capacitor with air between the plates has a capacitance of 8 pF. What will be the capacitance if the distance between the plates be reduced by half and the space between them is filled with a substance of dielectric constant $K = 6$?

[2005]

Q27. The graph shows the variation of voltage, 'V' across the plates of two capacitors A and B versus increase of charge, 'Q' stored on them. Which of the two capacitors has higher capacitance? Give reason for your answer.



[2004]

3-Mark Questions (62 questions · Section C · SA)

Q1. A parallel plate capacitor of capacitance C has a dielectric slab between its plates. It is charged to a potential difference V by connecting it across a battery. The battery is then disconnected. If the dielectric slab is now withdrawn from the capacitor, how will the following be affected?

(a) Capacitance of the capacitor,

(b) Energy stored in the capacitor, and

(c) The potential difference between the plates of the capacitor. Justify your answer in each case.

[2026 • Set 55-1-1]

Q2. A 12.0 μF capacitor is charged to a potential difference of 150 V. The terminals of the charged capacitor are then connected to those of an uncharged 6.0 μF capacitor. Calculate final potential difference across and charge on, each capacitor.

[2026 • Set 55-1-2]

Q3. A parallel plate capacitor of capacitance C is charged to V volt by a battery. After sometime the battery is disconnected and the distance between the plates is doubled. A slab of dielectric constant $k = 1.8$ is then introduced to completely fill the space between the plates. How will the following be affected?

(a) The capacitance of the capacitor.

(b) The electric field between the plates of the capacitor.

(c) The energy stored in the capacitor. Justify your answer in each case.

[2026 • Set 55-1-3]

Q4. (a) An electric field $\vec{E} = E_0\hat{i}$ exists in a region of space. Draw three equipotential surfaces in the region.

(b) Two point charges $-q$ and $+q$ are located at points $(-a, 0, 0)$ and $(a, 0, 0)$ respectively. Find the electrostatic potential at point $(x, 0, 0)$ where $x \gg a$.

[2026 • Set 55-2-1]

Q5. (i) Draw electric field lines and equipotential surfaces for a system of two equal and opposite point charges separated by some distance.

(ii) Why electric field $\vec{E}$ at a point on an equipotential surface must be perpendicular to the surface at that point?

[2026 • Set 55-2-2]

Q6. (a) Draw electric field lines and equipotential surfaces for a system of two equal positive charges separated by some distance.

(b) Using the drawing in (a) above, explain that electric field need not be a constant over each point of an equipotential surface.

[2026 • Set 55-2-3]

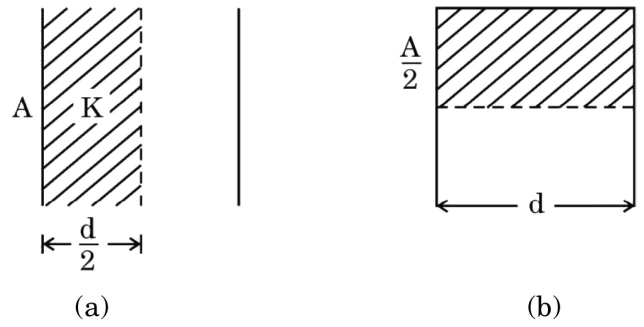
Q7. Two parallel plate capacitors X and Y are connected in series to a $6\,$V battery. They have the same plate area and same plate separation but capacitor X has air between its plates, whereas capacitor Y contains a material of dielectric constant 4.

(a) Calculate the capacitances of X and Y, if the equivalent capacitance of the combination of X and Y is $4\,\mu$F.

(b) Calculate the potential difference across the plates of X and Y.

[2026 • Set 55-5-1]

Q8. A parallel plate capacitor has plate area A and plate separation d. Half of the space between the plates is filled with a material of dielectric constant K in two ways as shown in the figure.



Find the values of the capacitance of the capacitors in the two cases.

[2025 • Set 55-5-1]

Q9. A capacitor of plate area A and plate separation d is charged by a battery to voltage V. The battery is disconnected and plates are slowly pulled apart till the separation becomes $2d$. Find the value of:

(a) potential difference between the plates,

(b) electric field between the plates,

(c) work done in pulling the plates apart.

[2025 • Set 55-5-2]

Q10. (a) "There is a limit to the amount of charge that can be stored on a given capacitor." Explain.

(b) A capacitor is charged by a battery to a potential difference V. It is disconnected from the battery and connected across another identical uncharged capacitor. Calculate the ratio of total energy stored in the combination to the initial energy stored in the capacitor.

[2025 • Set 55-5-3]

Q11. Two point charges of $-5\ \mu$C and $2\ \mu$C are located in free space at $(-4\text{ cm}, 0)$ and $(6\text{ cm}, 0)$ respectively.

(a) Calculate the amount of work done to separate the two charges at infinite distance.

(b) If this system of charges was initially kept in an electric field $\vec{E} = \frac{A}{r^2}\hat{r}$, where $A = 8 \times 10^4\ \text{N C}^{-1}\ \text{m}^2$, calculate the electrostatic potential energy of the system.

[2025 • Set 55-7-2]

Q12. An electric dipole (dipole moment $\vec{p} = p\hat{i}$), consisting of charges $-q$ and q, separated by distance $2a$, is placed along the x-axis, with its centre at the origin. Show that the potential V, due to this dipole, at a point x, $(x \gg a)$ is equal to $\frac{1}{4\pi\varepsilon_0} \cdot \frac{\vec{p} \cdot \hat{i}}{x^2}$.

[2024 • Set 55-1-1]

Q13. Three point charges Q_1, Q_2 and Q_3 are located in $x - y$ plane at points $(-d, 0)$, $(0, 0)$ and $(d, 0)$ respectively. Q_1 and Q_3 are identical and Q_3 is positive. What will be the nature and value of Q_2 so that the potential energy of the system is zero?

[2024 • Set 55-1-2]

Q14. An air-filled parallel plate capacitor with plate separation $1\,\text{mm}$ has a capacitance of $20\,\text{pF}$. It is charged to $4.0\,\mu\text{C}$. Calculate the amount of work done to pull its plates to a separation of $5\,\text{mm}$. Assume the charge on the plates remains the same.

[2024 • Set 55-1-3]

Q15. The electric field in a region is given by $\vec{E} = (10x + 4)\hat{i}$, where x is in m and E is in N/C. Calculate the amount of work done in taking a unit charge from

(i) $(5\,\text{m}, 0)$ to $(10\,\text{m}, 0)$

(ii) $(5\,\text{m}, 0)$ to $(5\,\text{m}, 10\,\text{m})$

[2024 • Set 55-4-1]

Q16. A thin spherical conducting shell of radius R has a charge q. A point charge Q is placed at the centre of the shell. Find

(i) The charge density on the outer surface of the shell, and

(ii) the potential at a distance of $(R/2)$ from the centre of the shell.

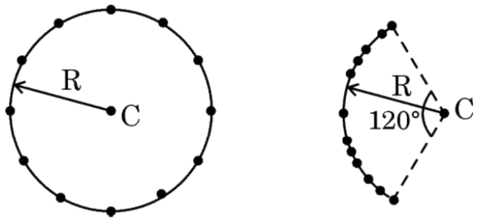
[2024 • Set 55-4-2]

Q17. Two conducting spherical shells A and B of radii R and $2R$ are kept far apart and charged to the same charge density σ. They are connected by a wire. Obtain an expression for final potential of shell A.

[2024 • Set 55-4-3]

Q18. (a) Twelve negative charges of same magnitude are equally spaced and fixed on the circumference of a circle of radius R as shown in Fig. (i). Relative to potential being zero at infinity, find the electric potential and electric field at the centre C of the circle.

(b) If the charges are unequally spaced and fixed on an arc of 120° of radius R as shown in Fig. (ii), find electric potential at the centre C.



(i) (ii)

[2023 • Set 55-1-1]

Q19. A $100\,\mu$F capacitor is charged by a 12 V battery.

(a) How much electrostatic energy is stored by the capacitor?

(b) The capacitor is disconnected from the battery and connected in parallel to another uncharged $100\,\mu$F capacitor. What is the electrostatic energy stored by the system?

[2023 • Set 55-1-2]

Q20. Three point charges Q_1 $(-15\,\mu$C), Q_2 $(10\,\mu$C) and Q_3 $(16\,\mu$C) are located at $(0$ cm, 0 cm), $(0$ cm, 3 cm) and $(4$ cm, 3 cm) respectively. Calculate the electrostatic potential energy of this system of charges.

[2023 • Set 55-1-3]

Q21. Two charged conducting spheres of radii a and b are connected to each other by a wire. Find the ratio of the electric fields at their surfaces.

[2023 • Set 55-2-1]

Q22. A parallel plate capacitor (A) of capacitance C is charged by a battery to voltage V. The battery is disconnected and an uncharged capacitor (B) of capacitance $2C$ is connected across A. Find the ratio of

(i) final charges on A and B.

(ii) total electrostatic energy stored in A and B finally and that stored in A initially.

[2023 • Set 55-2-1]

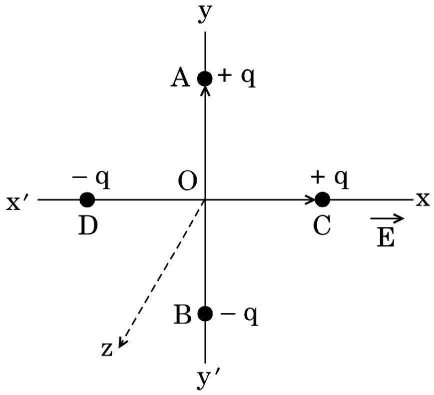
Q23. A capacitor of $4\ \mu$F is charged by a battery of 12 V. The battery is disconnected and a dielectric slab of dielectric constant 8 is inserted in between the plates of the capacitor to fill the space completely. Find the change in the (a) charge stored in the capacitor, (b) potential difference between the plates of the capacitor, and (c) energy stored in the capacitor.

OR

Two small identical electric dipoles AB and CD, each of dipole moment $\vec{p}$ are kept at an angle of $90°$ to each other in an external electric field $\vec{E}$ pointing along the x-axis as shown in the figure. Find the

(a) dipole moment of the arrangement, and

(b) magnitude and direction of the net torque acting on it.



[2020 • Set 55-2-3]

Q24. (a) Two point charges q_1 and q_2 are kept at a distance of r_{12} in air. Deduce the expression for the electrostatic potential energy of this system.

(b) If an external electric field ($\vec{E}$) is applied on the system, write the expression for the total energy of this system.

[2020 • Set 55-5-1]

Q25. (a) Two point charges $+Q_1$ and $-Q_2$ are placed r distance apart. Obtain the expression for the amount of work done to place a third charge Q_3 at the midpoint of the line joining the two charges.

(b) At what distance from charge $+Q_1$ on the line joining the two charges (in terms of Q_1, Q_2 and r) will this work done be zero.

[2020 • Set 55-5-3]

Q26. Draw the equipotential surfaces corresponding to a uniform electric field in the z-direction.

[2019 • Set 55-1-1]

Q27. Draw equipotential surfaces corresponding to the electric field that uniformly increases in magnitude along with the z-direction.

[2019 • Set 55-1-2]

Q28. Two charges $-q$ and $+q$ are located at points $(0, 0, -a)$ and $(0, 0, a)$. What is the electrostatic potential at the points $(0, 0, +z)$ and $(x, y, 0)$?

[2019 • Set 55-1-2]

Q29. Draw the equipotential surfaces due to an electric dipole.

[2019 • Set 55-1-3]

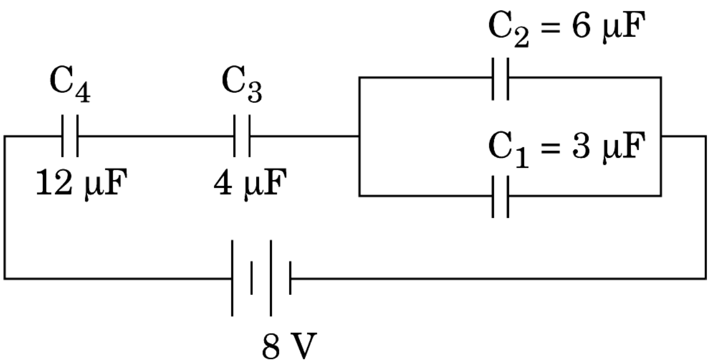
Q30. A $200\,\mu$F parallel plate capacitor having plate separation of 5 mm is charged by a 100 V dc source. It remains connected to the source. Using an insulated handle, the distance between the plates is doubled and a dielectric slab of thickness 5 mm and dielectric constant 10 is introduced between the plates. Explain with reason, how the (i) capacitance, (ii) electric field between the plates, (iii) energy density of the capacitor will change?

[2019 • Set 55-2-1]

Q31. A $100\,\mu$F parallel plate capacitor having plate separation of 4 mm is charged by 200 V dc. The source is now disconnected. When the distance between the plates is doubled and a dielectric slab of thickness 4 mm and dielectric constant 5 is introduced between the plates, how will (i) its capacitance, (ii) the electric field between the plates, and (iii) energy density of the capacitor get affected? Justify your answer in each case.

[2019 • Set 55-2-2]

Q32. In a network, four capacitors C_1, C_2, C_3 and C_4 are connected as shown in the figure.



(a) Calculate the net capacitance in the circuit.

(b) If the charge on the capacitor C_2 is $6\,\mu$C, (i) calculate the charge on the capacitors C_3 and C_4, and (ii) net energy stored in the capacitors C_3 and C_4 connected in series.

[2019 • Set 55-2-3]

Q33. (a) Explain briefly, using a proper diagram, the difference in behaviour of a conductor and a dielectric in the presence of external electric field.

(b) Define the term polarization of a dielectric and write the expression for a linear isotropic dielectric in terms of electric field.

[2019 • Set 55-3-1]

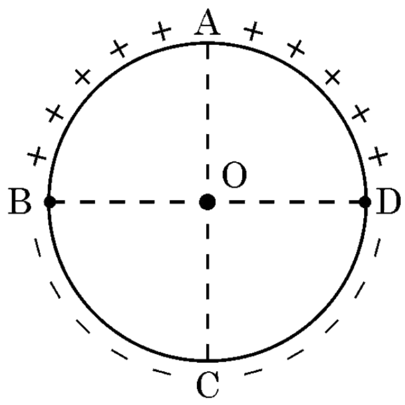
Q34. A charge Q is distributed over the surfaces of two concentric hollow spheres of radii r and R $(R >> r)$, such that their surface charge densities are equal. Derive the expression for the potential at the common centre.

OR

Three concentric metallic shells A, B and C of radii a, b and c $(a < b < c)$ have surface charge densities $+\sigma$, $-\sigma$ and $+\sigma$ respectively as shown.

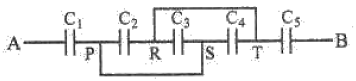
(a) Obtain the expressions for the potential of three shells A, B and C.

(b) If shells A and C are at the same potential, obtain the relation between a, b and c.



[2019 • Set 55-5-1]

Q35. (i) Find equivalent capacitance between A and B in the combination given below. Each capacitor is of $2\ \mu$F capacitance.



(ii) If a dc source of 7 V is connected across AB, how much charge is drawn from the source and what is the energy stored in the network?

[2017]

Q36. A 12 pF capacitor is connected to a 50 V battery. How much electrostatic energy is stored in the capacitor? If another capacitor of 6 pF is connected in series with it with the same battery connected across the combination, find the charge stored and potential difference across each capacitor.

[2017]

Q37. (i) Derive the expression for the electric potential due to an electric dipole at a point on its axial line.

(ii) Depict the equipotential surfaces due to an electric dipole.

[2017]

Q38. Two identical capacitors of 12 pF each are connected in series across a battery of 50 V. How much electrostatic energy is stored in the combination? If these were connected in parallel across the same battery, how much energy will be stored in the combination now? Also find the charge drawn from the battery in each case.

[2017]

Q39. A charge Q is distributed uniformly over a metallic sphere of radius R. Obtain the expressions for the electric field (E) and electric potential (V) at a point $0 < x < R$. Show on a plot the variation of E and V with x for $0 < x < 2R$.

[2017]

Q40. Two identical parallel plate capacitors A and B are connected to a battery of V volts with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant K. Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric.

[2017]

Q41. Define an equipotential surface. Draw equipotential surfaces:

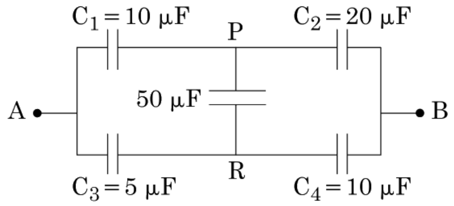
(i) in the case of a single point charge and

(ii) in a constant electric field in Z-direction. Why the equipotential surfaces about a single charge are not equidistant?

(iii) Can electric field exist tangential to an equipotential surface? Give reason.

[2016]

Q42. Calculate the equivalent capacitance between points A and B in the circuit below. If a battery of 10 V is connected across A and B, calculate the charge drawn from the battery by the circuit.



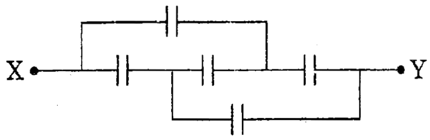
[2016]

Q43. (a) A parallel plate capacitor (C_1) having charge Q is connected, to an identical uncharged capacitor C_2 in series. What would be the charge accummulated on the capacitor C_2?

(b) Three identical capacitors each of capacitance $3\ \mu$F are connected, in turn, in series and in parallel combination to the common source of V volt. Find out the ratio of the energies stored in two configurations.

[2016]

Q44. Find the equivalent capacitance of the network shown in the figure, when each capacitor is of $1\,\mu$F. When the ends X and Y are connected to a 6 V battery, find out (i) the charge and (ii) the energy stored in the network.



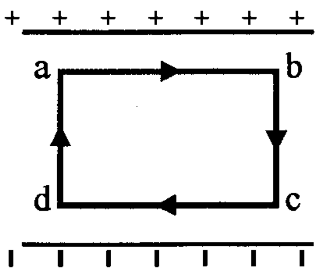
[2015]

Q45. Two capacitors of unknown capacitances C_1 and C_2 are connected first in series and then in parallel across a battery of 100 V. If the energy stored in the two combinations is 0.045 J and 0.25 J respectively, determine the value of C_1 and C_2. Also calculate the charge on each capacitor in parallel combination.

[2015]

Q46. (a) Obtain the expression for the energy stored per unit volume in a charged parallel plate capacitor.

(b) The electric field inside a parallel plate capacitor is E. Find the amount of work done in moving a charge q over a closed rectangular loop $abcda$.



OR

(a) Derive the expression for the capacitance of a parallel plate capacitor having plate area A and plate separation d.

(b) Two charged spherical conductors of radii R_1 and R_2 when connected by a conducting wire acquire charges q_1 and q_2 respectively. Find the ratio of their surface charge densities in terms of their radii.

[2014]

Q47. A capacitor of unknown capacitance is connected across a battery of V volts. The charge stored in it is $360\,\mu$C. When potential across the capacitor is reduced by 120 V, the charge stored in it becomes $120\,\mu$C. Calculate:

(i) The potential V and the unknown capacitance C.

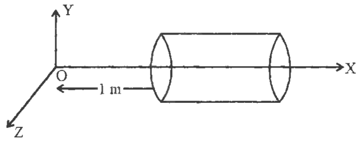
(ii) What will be the charge stored in the capacitor, if the voltage applied had increased by 120 V?

OR

A hollow cylindrical box of length 1 m and area of cross-section 25 cm^2 is placed in a three dimensional coordinate system as shown in the figure. The electric field in the region is given by $\vec{E} = 50\,x\,\hat{i}$, where E is in N C^{-1} and x is in metres. Find

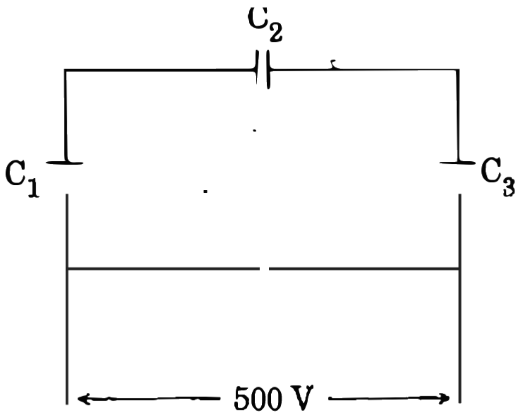
(i) Net flux through the cylinder.

(ii) Charge enclosed by the cylinder.



[2013]

Q48. A network of four capacitors each of $12\,\mu$F capacitance is connected to a 500 V supply as shown in the figure. Determine (a) equivalent capacitance of the network and (b) charge on each capacitor.



[2012]

Q49. Deduce the expression for the electrostatic energy stored in a capacitor of capacitance 'C' and having charge 'Q'. How will the (i) energy stored and (ii) the electric field inside the capacitor be affected when it is completely filled with a dielectric material of dielectric constant 'K'?

[2012]

Q50. A capacitor of 200 pF is charged by a 300 V battery. The battery is then disconnected and the charged capacitor is connected to another uncharged capacitor of 100 pF. Calculate the difference between the final energy stored in the combined system and the initial energy stored in the single capacitor.

[2012]

Q51. State the principle of the device that can build up high voltages of the order of a few million volts. Draw its labelled diagram. A stage reaches in this device when the potential at the outer sphere cannot be increased further by piling up more charge on it. Explain why.

[2011 • Set 55-2-1]

Q52. A parallel plate capacitor is charged by a battery. After sometime the battery is disconnected and a dielectric slab with its thickness equal to the plate separation is inserted between the plates. How will (i) the capacitance of the capacitor, (ii) potential difference between the plates and (iii) the energy stored in the capacitor be affected? Justify your answer in each case.

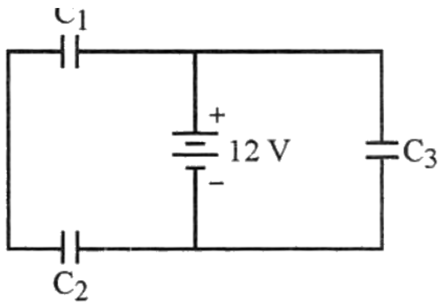
[2010]

Q53. (a) Depict the equipotential surfaces for a system of two identical positive point charges placed a distance 'd' apart.

(b) Deduce the expression for the potential energy of a system of two point charges q_1 and q_2 brought from infinity to the points $\vec{r}_1$ and $\vec{r}_2$ respectively in the presence of external electric field $\vec{E}$.

[2010]

Q54. Three identical capacitors C_1, C_2 and C_3 of capacitance $6\ \mu F$ each are connected to a $12\ V$ battery as shown.



Find

(i) charge on each capacitor

(ii) equivalent capacitance of the network

(iii) energy stored in the network of capacitors

[2009]

Q55. A positive point charge $(+q)$ is kept in the vicinity of an uncharged conducting plate.

Sketch electric field lines originating from the point on to the surface of the plate. Derive the expression for the electric field at the surface of a charged conductor.

[2009]

Q56. A parallel plate capacitor is charged by a battery. After some time the battery is disconnected and a dielectric slab of dielectric constant K is inserted between the plates. How would (i) the capacitance, (ii) the electric field between the plates and (iii) the energy stored in the capacitor, be affected? Justify your answer.

[2009]

Q57. Deduce an expression for the electric potential due to an electric dipole at any point on its axis. Mention one contrasting feature of electric potential of a dipole at a point as compared to that due to a single charge.

[2007]

Q58. A parallel plate capacitor, each with plate area A and separation d, is charged to a potential difference V. The battery used to charge it is then disconnected. A dielectric slab of thickness d and dielectric constant K is now placed between the plates. What change, if any, will take place in

(i) charge on the plates,

(ii) electric field intensity between the plates,

(iii) capacitance of the capacitor. Justify your answer in each case.

[2007]

Q59. Explain the underlying principle of working of a parallel plate capacitor. If two similar plates, each of area A having surface charge densities $+\sigma$ and $-\sigma$ are separated by a distance d in air, write expressions for

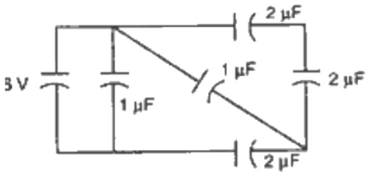
(i) the electric field at points between the two plates.

(ii) the potential difference between the plates.

(iii) the capacitance of the capacitor so formed.

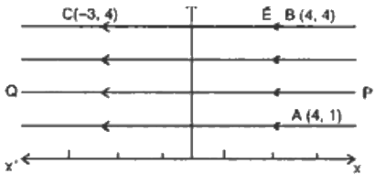
[2007]

Q60. Find the total energy stored in the capacitors in the given network.



[2004]

Q61. What is an equipotential surface? A uniform electric field of $E = 300\,\text{NC}^{-1}$ is directed along PQ. A, B and C are three points in the field having x and y coordinates (in metres) as shown in the figure. Calculate potential difference between the points (i) A and B and (ii) B and C.



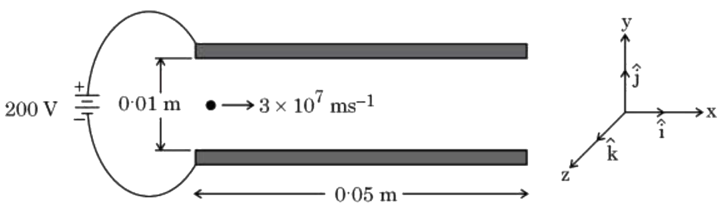
[2003]

Q62. Draw a labelled diagram of Van de Graaff generator. State its principle of working.

[2003]

4-Mark Questions (3 questions · Section D · Case Study)

Q1. The electric potential V and electric field E are closely related concepts in electrostatics. The electric field is a vector quantity that represents the force per unit charge at a given point in space, whereas electric potential is a scalar quantity that represents the potential energy per unit charge at a given point in space. Electric field and electric potential are related by the equations $E_r = -\dfrac{dV}{dr}$ and $\vec{E} = -\vec{\nabla}V$, i.e., electric field is the negative gradient of the electric potential. This means that electric field points in the direction of decreasing potential and its magnitude is the rate of change of potential with distance. The electric field is the force that drives a unit charge to move from higher potential region to lower potential region and electric potential difference between the two points determines the work done in moving a unit charge from one point to the other point. A pair of square conducting plates having sides of length $0.05\,\text{m}$ are arranged parallel to each other in x-y plane. They are $0.01\,\text{m}$ apart along z-axis and are connected to a $200\,\text{V}$ power supply as shown in the figure. An electron enters with a speed of $3 \times 10^7\,\text{ms}^{-1}$ horizontally and symmetrically in the space between the two plates. Neglect the effect of gravity on the electron.



[2026 • Set 55-5-1]

Q2. A capacitor is a system of two conductors separated by an insulator. The two conductors have equal and opposite charges with a potential difference between them. The capacitance of a capacitor depends on the geometrical configuration (shape, size and separation) of the system and also on the nature of the insulator separating the two conductors. They are used to store charges. Like resistors, capacitors can be arranged in series or parallel or a combination of both to obtain desired value of capacitance.

[2023 • Set 55-5-1]

Q3. While travelling back to his residence in the car, Dr. Pathak was caught up in a thunderstorm. It became very dark. He stopped driving the car and waited for thunderstorm to stop. Suddenly he noticed a child walking alone on the road. He asked the boy to come inside the car till the thunderstorm stopped. Dr. Pathak dropped the boy at his residence. The boy insisted that Dr. Pathak should meet his parents. The parents expressed their gratitude to Dr. Pathak for his concern for safety of the child. Answer the following questions based on the above information:

(a) Why is it safer to sit inside a car during a thunderstorm?

(b) Which two values are displayed by Dr. Pathak in his actions?

(c) Which values are reflected in parents' response to Dr. Pathak?

(d) Give an example of a similar action on your part in the past from everyday life.

[2013]

5-Mark Questions (28 questions · Section E · Long Answer)

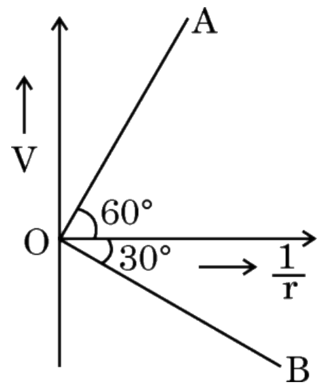
Q1. (a) Derive an expression for the capacitance of a parallel plate capacitor of plate area A and plate separation d with air present between the plates.

[2026 • Set 55-2-1]

Q2. (b) Two air-filled capacitors of capacitances C_1 and C_2 are connected in parallel with a dc battery. After the capacitors are fully charged, a slab of dielectric constant K is inserted between the plates of each capacitor. How will the (i) charge on each capacitor and (ii) energy stored in the capacitor be affected after the slab is introduced?

[2026 • Set 55-2-1]

Q3. (i) In the figure, OA and OB show the variation of electric potential V at a point due to two point charges Q_1 and Q_2 with $\frac{1}{r}$ respectively. Here r represents the distance of the point from the two point charges.



(I) Identify the nature of the two charges Q_1 and Q_2. (II) What is the value of $\left(\frac{Q_1}{Q_2}\right)$? Justify your answer.

[2026 • Set 55-3-1]

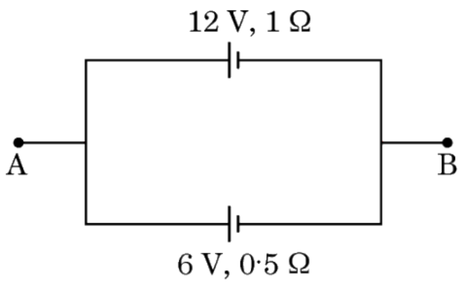
Q4. (ii) Two point charges $-2\ \mu$C and $5\ \mu$C are placed at $(-30\text{ cm}, 0)$ and $(30\text{ cm}, 0)$ respectively in an external electric field $\vec{E} = \frac{A}{x}\hat{i}$, where $A = 9 \times 10^5$ N m^2 C^{-1}. Find the electrostatic potential energy of this configuration.

[2026 • Set 55-3-1]

Q5. (a) (i) Explain the following statements giving reason: (I) An equipotential surface through a point is normal to the electric field at that point. (II) When a dielectric is placed in an external electric field, the electric field inside the dielectric is less than that outside it. (III) The potential difference between the plates of a charged parallel plate capacitor decreases when its plates are brought closer. (ii) Obtain an expression for the work done to dissociate the system of three charges q, $-4q$ and $2q$ placed at the vertices A, B and C respectively of an equilateral triangle of side 'a'.

OR

(b) (i) Answer the following giving reason: (I) The electron drift speed is estimated to be only a few mm/s for currents in the range of a few amperes. How, then, is the current established almost the instant a circuit is closed? (II) A low voltage supply from which one needs high currents must have very low internal resistance. Why? (III) The assertion that V = IR is a statement of Ohm's law is not true. Why? (ii) Two cells of emfs 12 V and 6 V are connected in parallel as shown in the figure. Their internal resistances are 1 Ω and 0·5 Ω respectively. Calculate the emf and internal resistance of the equivalent cell between points A and B.

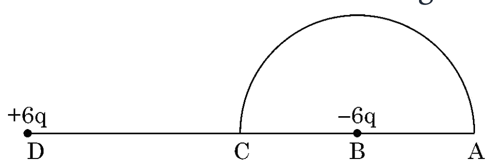


[2026 • Set 55-4-1]

Q6. (a) (i) Two point charges $5\,\mu$C and $-1\,\mu$C are placed at points $(-3\,\text{cm}, 0, 0)$ and $(3\,\text{cm}, 0, 0)$ respectively. An external electric field $\vec{E} = \dfrac{A}{r^2}\,\hat{r}$, where $A = 3\times10^5$ V m, is switched on in the region. Calculate the change in electrostatic energy of the system due to the electric field. (ii) A system of two conductors is placed in air and they have net charge of $+80\,\mu$C and $-80\,\mu$C which causes a potential difference of $16\,$V between them. (1) Find the capacitance of the system. (2) If the air between the capacitor is replaced by a dielectric medium of dielectric constant 3, what will be the potential difference between the two conductors? (3) If the charges on two conductors are changed to $+160\,\mu$C and $-160\,\mu$C, will the capacitance of the system change? Give reason for your answer.

OR

(b) (i) Consider three metal spherical shells A, B and C, each of radius R. Each shell is having a concentric metal ball of radius $R/10$. The spherical shells A, B and C are given charges $+6q$, $-4q$ and $14q$ respectively. Their inner metal balls are also given charges $-2q$, $+8q$ and $-10q$ respectively. Compare the magnitude of the electric fields due to shells A, B and C at a distance $3R$ from their centres. (ii) A charge $-6\,\mu$C is placed at the centre B of a semicircle of radius $5\,$cm, as shown in the figure. An equal and opposite charge is placed at point D at a distance of $10\,$cm from B. A charge $+5\,\mu$C is moved from point C to point A along the circumference. Calculate the work done on the charge.



[2025 • Set 55-1-1]

Q7. (i) A small conducting sphere A of radius r charged to a potential V_1 is enclosed by a spherical conducting shell B of radius R. If A and B are connected by a thin wire, calculate the final potential on sphere A and shell B.

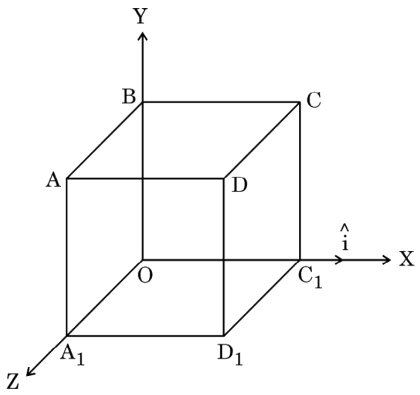
(ii) Write two characteristics of equipotential surfaces. A uniform electric field of 50 NC^{-1} is set up in a region along +x axis. If the potential at the origin (0, 0) is 220 V, find the potential at a point (4 m, 3 m).

[2025 • Set 55-2-1]

Q8. (a) (i) The electric field in a region is given by $\vec{E} = 40x\,\hat{i}$ N/C. Find the amount of work done in taking a unit positive charge from a point $(0, 3\,\text{m})$ to the point $(5\,\text{m}, 0)$. (ii) A charge Q is distributed over two concentric hollow spheres of radii r and $R\,(> r)$ such that their surface charge densities are equal. Find: (I) the electric field, and (II) the potential at their common centre.

OR

(b) (i) Obtain an expression for the electric field $\vec{E}$ due to a dipole of dipole moment $\vec{p}$ at a point on its equatorial plane and specify its direction. Hence, find the value of electric field: (I) at the centre of the dipole $(r = 0)$, and (II) at a point $r \gg a$, where $2a$ is the length of the dipole. (ii) An electric field $\vec{E} = (10x + 5)\,\hat{i}$ N/C exists in a region in which a cube of side L is kept as shown in the figure. Here x and L are in metres. Calculate the net flux through the cube.



[2025 • Set 55-6-1]

Q9. (a) (i) A parallel plate capacitor with plate area A and plate separation d has a capacitance C_0. A slab of dielectric constant K having area A and thickness $\left(\frac{d}{2}\right)$ is inserted in the capacitor, parallel to the plates. Find the new value of its capacitance. (ii) You are provided with a large number of $1\ \mu$F identical capacitors and a power supply of 1200 V. The dielectric medium used in each capacitor can withstand up to 200 V only. Find the minimum number of capacitors and their arrangement, required to build a capacitor system of equivalent capacitance of $2\ \mu$F for use with this supply.

OR

(b) (i) An electric dipole of dipole moment $\vec{p}$ consists of point charges q and $-q$, separated by $2a$. Derive an expression for electric potential in terms of its dipole moment at a point at a distance $x\ (\gg a)$ from its centre and lying (I) along its axis, and (II) along its bisector line. (ii) An electric dipole of dipole moment $\vec{p} = (0.8\hat{i} + 0.6\hat{j}) \times 10^{-29}$ C m is placed in an electric field $\vec{E} = 1.0 \times 10^7\,\hat{k}$ V/m. Calculate the magnitude of the torque acting on it and the angle it makes with the x-axis, at this instant.

[2025 • Set 55-7-1]

Q10. (i) Obtain the expression for the capacitance of a parallel plate capacitor with a dielectric medium between its plates.

(ii) A charge of $6\ \mu$C is given to a hollow metallic sphere of radius 0.2 m. Find the potential at (i) the surface and (ii) the centre of the sphere.

[2024 • Set 55-3-1]

Q11. (i) A dielectric slab of dielectric constant K and thickness t is inserted between plates of a parallel plate capacitor of plate separation d and plate area A. Obtain an expression for its capacitance.

(ii) Two capacitors of different capacitances are connected first (1) in series and then (2) in parallel across a dc source of 100 V. If the total energy stored in the combination in the two cases are 40 mJ and 250 mJ respectively, find the capacitance of the capacitors.

[2024 • Set 55-4-1]

Q12. (i) Draw equipotential surfaces for an electric dipole.

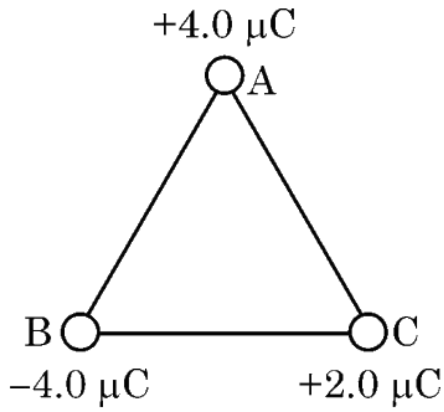
(ii) Two point charges q_1 and q_2 are located at $\vec{r}_1$ and $\vec{r}_2$ respectively in an external electric field $\vec{E}$. Obtain an expression for the potential energy of the system.

(iii) The dipole moment of a molecule is 10^{-30} Cm. It is placed in an electric field $\vec{E}$ of 10^5 V/m such that its axis is along the electric field. The direction of $\vec{E}$ is suddenly changed by 60° at an instant. Find the change in the potential energy of the dipole, at that instant.

[2024 • Set 55-5-1]

Q13. (i) Consider two identical point charges located at points $(0, 0)$ and $(a, 0)$. (1) Is there a point on the line joining them at which the electric field is zero? (2) Is there a point on the line joining them at which the electric potential is zero? Justify your answers for each case.

(ii) State the significance of negative value of electrostatic potential energy of a system of charges. Three charges are placed at the corners of an equilateral triangle ABC of side 2.0 m as shown in figure. Calculate the electric potential energy of the system of three charges.



[2023 • Set 55-2-1]

Q14. (i) (A) Why does the electric field inside a dielectric slab decrease when kept in an external electric field? (B) Derive an expression for the capacitance of a parallel plate capacitor filled with a medium of dielectric constant K.

(ii) A charge $q = 2\,\mu$C is placed at the centre of a sphere of radius $20\,$cm. What is the amount of work done in moving $4\,\mu$C from one point to another point on its surface?

(iii) Write a relation for polarisation $\vec{P}$ of a dielectric material in the presence of an external electric field.

[2021]

Q15. (i) Obtain an expression for the potential energy of an electric dipole placed in a uniform electric field.

(ii) Three capacitors of capacitance C_1, C_2 and C_3 are connected in series to a source of V volt. Show that the total energy stored in the combination of capacitors is equal to sum of the energy stored in individual capacitors.

(iii) A capacitor of capacitance C is connected across a battery. After charging, the battery is disconnected and the separation between the plates is doubled. How will (i) the capacitance of the capacitor, and (ii) the electric field between the plates be affected? Justify your answer.

[2021]

Q16. Find the expression for the potential energy of a system of two point charges q_1 and q_2 located at $\vec{r}_1$ and $\vec{r}_2$ respectively in an external electric field $\vec{E}$.

[2020 • Set 55-1-1]

Q17. Draw equipotential surfaces due to an isolated point charge $(-q)$ and depict the electric field lines.

[2020 • Set 55-1-1]

Q18. Three point charges $+1\,\mu$C, $-1\,\mu$C and $+2\,\mu$C are initially infinite distance apart. Calculate the work done in assembling these charges at the vertices of an equilateral triangle of side $10\,\text{cm}$.

[2020 • Set 55-1-1]

Q19. Describe briefly the process of transferring the charge between the two plates of a parallel plate capacitor when connected to a battery. Derive an expression for the energy stored in a capacitor.

[2019 • Set 55-1-1]

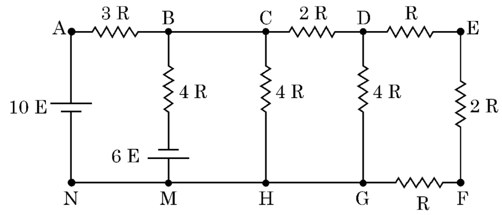
Q20. A parallel plate capacitor is charged by a battery to a potential difference V. It is disconnected from battery and then connected to another uncharged capacitor of the same capacitance. Calculate the ratio of the energy stored in the combination to the initial energy on the single capacitor.

[2019 • Set 55-1-1]

Q21. (a) When a parallel plate capacitor is connected across a dc battery, explain briefly how the capacitor gets charged.

(b) A parallel plate capacitor of capacitance 'C' is charged to 'V' volt by a battery. After some time the battery is disconnected and the distance between the plates is doubled. Now a slab of dielectric constant $1 < k < 2$ is introduced to fill the space between the plates. How will the following be affected? (i) The electric field between the plates of the capacitor. (ii) The energy stored in the capacitor. Justify your answer in each case.

(c) The electric potential as a function of distance 'x' is shown in the figure. Draw a graph of the electric field E as a function of x.



OR

(a) Derive an expression for the potential energy of an electric dipole in a uniform electric field. Explain conditions for stable and unstable equilibrium.

(b) Is the electrostatic potential necessarily zero at a point where the electric field is zero? Give an example to support your answer.

[2019 • Set 55-4-1]

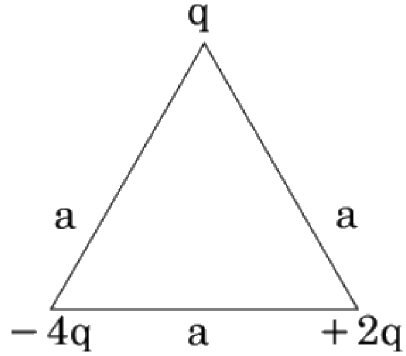
Q22. (a) Distinguish, with the help of a suitable diagram, the difference in the behaviour of a conductor and a dielectric placed in an external electric field. How does polarised dielectric modify the original external field?

(b) A capacitor of capacitance C is charged fully by connecting it to a battery of emf E. It is then disconnected from the battery. If the separation between the plates of the capacitor is now doubled, how will the following change? (i) charge stored by the capacitor. (ii) field strength between the plates. (iii) energy stored by the capacitor. Justify your answer in each case.

[2016]

Q23. (a) Explain why, for any charge configuration, the equipotential surface through a point is normal to the electric field at that point. Draw a sketch of equipotential surfaces due to a single charge $(-q)$, depicting the electric field lines due to the charge.

(b) Obtain an expression for the work done to dissociate the system of three charges placed at the vertices of an equilateral triangle of side a as shown below.



[2016]

Q24. (a) Explain, using suitable diagrams, the difference in the behaviour of a (i) conductor and (ii) dielectric in the presence of external electric field. Define the terms polarization of a dielectric and write its relation with susceptibility.

(b) A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge $\frac{Q}{2}$ is placed at its centre C and an other charge $+2Q$ is placed outside the shell at a distance x from the centre as shown in the figure. Find (i) the force on the charge at the centre of shell and at the point A, (ii) the electric flux through the shell.

[2015]

Q25. Define the term 'capacitance' of a capacitor. Derive an expression for the total capacitance of 'n' capacitors arranged in series.

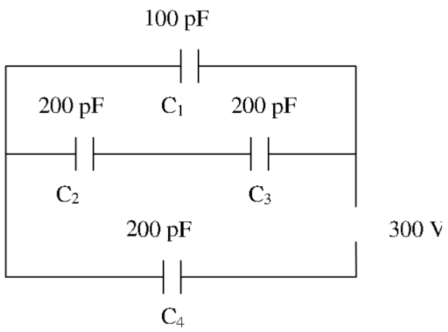
[2010]

Q26. Define electric potential at a point due to a point charge. Write its SI unit. Derive an expression for the electric potential at a point outside a charged sphere.

[2010]

Q27. (a) Derive an expression for the energy stored in a parallel plate capacitor C, charged to a potential difference V.

(b) Obtain the equivalent capacitance of the network given below. For a supply of $300\ V$, determine the charge and voltage across C_4.



[2008]

Q28. Explain the principle on which Van de Graaff generator operates. Draw a labeled schematic sketch and write briefly its working. A Van de Graaff type generator is capable of building up potential difference of $15 \times 10^6\ V$. The dielectric strength of the gas surrounding the electrode is $5 \times 10^7\ V\ m^{-1}$. What is the minimum radius of the spherical shell required?

[2008]