ELECTROSTATIC POTENTIAL AND CAPACITANCE

FACT/DEFINITION TYPE QUESTIONS

1. In a region of constant potential
   (a) the electric field is uniform
   (b) the electric field is zero
   (c) the electric field shall necessarily change if a charge is placed outside the region
   (d) None of these
2. 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
3. It becomes possible to define potential at a point in an electric field because electric field
   (a) is a conservative field
   (b) is a non-conservative field
   (c) is a vector field
   (d) obeys principle of superposition
4. Which of the following about potential at a point due to a given point charge is true ?
   The potential at a point P due to a given point charge
   (a) is a function of distance from the point charge.
   (b) varies inversely as the square of distance from the point charge.
   (c) is a vector quantity
   (d) is directly proportional to the square of distance from the point charge.
5. Which of the following quantities do not depend on the choice of zero potential or zero potential energy?
   (a) Potential at a point
   (b) Potential difference between two points
   (c) Potential energy of a two-charge system
   (d) None of these
6. A cube of a metal is given a positive charge Q. For this system, which of the following statements is true?
   (a) Electric potential at the surface of the cube is zero
   (b) Electric potential within the cube is zero
   (c) Electric field is normal to the surface of the cube
   (d) Electric field varies within the cube
7. A unit charge moves on an equipotential surface from a point A to point B, then
   (a) $V_A - V_B = +ve$ (b) $V_A - V_B = 0$
   (c) $V_A - V_B = -ve$ (d) it is stationary
8. An equipotential surface is that surface
   (a) on which each and every point has the same potential
   (b) which has negative potential
   (c) which has positive potential
   (d) which has zero potential
9. To obtain 3 μF capacity from three capacitors of 2 μF each, they will be arranged.
   (a) all the three in series
   (b) all the three in parallel
   (c) two capacitors in series and the third in parallel with the combinatioin of first two
   (d) two capacitors in parallel and the third in series with the combinatioin of first two
10. There are two metallic spheres of same radii but one is solid and the other is hollow, then
    (a) solid sphere can be given more charge
    (b) hollow sphere can be given more charge
    (c) they can be charged equally (maximum)
    (d) None of the above
11. If a unit positive charge is taken from one point to another over an equipotential surface, then
    (a) work is done on the charge
    (b) work is done by the charge
    (c) work done is constant
    (d) no work is done
12. On moving a charge of Q coulomb by X cm, W J of work is done, then the potential difference between the points is
    (a) $\frac{W}{Q}$ V (b) QWV (c) $\frac{Q}{W}$ V (d) $\frac{Q^2}{W}$ V
13. The positive terminal of 12 V battery is connected to the ground. Then the negative terminal will be at
    (a) –6 V (b) +12 V (c) zero (d) –12 V
14. The maximum electric field that a dielectric medium can withstand without break-down is called its
    (a) permittivity (b) dielectric constant
    (c) electric susceptibility (d) dielectric strength

15. The potential energy of a system of two charges is negative when
(a) both the charges are positive
(b) both the charges are negative
(c) one charge is positive and other is negative
(d) both the charges are separated by infinite distance

16. The electric potential at a point on the equatorial line of an electric dipole is
(a) directly proportional to distance
(b) inversely proportional to distance
(c) inversely proportional to square of the distance
(d) None of these

17. An electric dipole is kept in non-uniform elecric field. it experiences
(a) a force and a torque
(b) a force but not a torque
(c) a torque but not a force
(d) Neither a force nor a torque

18. The value of electric potential at any point due to any electric dipole is
(a) $k.\frac{\vec{p}\times\vec{r}}{r^2}$ (b) $k.\frac{\vec{p}\times\vec{r}}{r^3}$
(c) $k.\frac{\vec{p}.\vec{r}}{r^2}$ (d) $k.\frac{\vec{p}.\vec{r}}{r^3}$

19. An electric dipole of moment $\vec{p}$ is placed normal to the lines of force of electric intensity $\vec{E}$, then the work done in deflecting it through an angle of 180° is
(a) pE (b) $+2pE$
(c) $-2pE$ (d) zero

20. The energy required to charge a parallel plate condenser of plate separation d and plate area of cross-section A such that the uniform electric field between the plates is E, is
(a) $\epsilon_0 E^2$Ad (b) $\frac{1}{2}\epsilon_0 E^2$Ad
(c) $\frac{1}{2}\epsilon_0 E^2$/Ad (d) $\epsilon_0 E^2$/Ad

21. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at a distance of 2 cm from the centre of the sphere is
(a) zero (b) 10 V (c) 4 V (d) 10/3 V

22. A charge is brought from a point on the equatorial plane of a dipole to its mid-point. Which of the following quantities remains constant ?
(a) Electric field
(b) Force on the charge brought.
(c) Torque exerted by the charge on dipole.
(d) Electric potential

23. On decreasing the distance between the plates of a parallel plate capacitor, its capacitance
(a) remains unaffected
(b) decreases
(c) first increases then decreases.
(d) increases

24. Energy is stored in a capacitor in the form of
(a) electrostatic energy (b) magnetic energy
(c) light energy (d) heat energy

25. If in a parallel plate capacitor, which is connected to a battery, we fill dielectrics in whole space of its plates, then which of the following increases?
(a) Q and V (b) V and E
(c) E and C (d) Q and C

26. A capacitor works in
(a) A. C. circuits (b) D. C. circuits
(c) both (a) and (b) (d) neither (a) nor (b)

27. In a charged capacitor, the energy is stored in
(a) the negative charges
(b) the positive charges
(c) the field between the plates
(d) both (a) and (b)

28. A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor
(a) decreases (b) remains unchanged
(c) becomes infinite (d) increases

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

30. When air in a capacitor is replaced by a medium of dielectric constant K, the capacity
(a) decreases K times (b) increases K times
(c) increases K^2 times (d) remains constant

31. A parallel plate condenser is immersed in an oil of dielectric constant 2. The field between the plates is
(a) increased, proportional to 2
(b) decreased, proportional to $\frac{1}{2}$
(c) increased, proportional to – 2
(d) decreased, proportional to $-\frac{1}{2}$

32. A conductor carries a certain charge. When it is connected to another uncharged conductor of finite capacity, then the energy of the combined system is
(a) more than that of the first conductor
(b) less than that of the first conductor
(c) equal to that of the first conductor
(d) uncertain

33. The energy stored in a condenser of capacity C which has been raised to a potential V is given by
(a) $u = \frac{1}{2}CV$ (b) $u = \frac{1}{2}CV^2$
(c) $u = CV$ (d) $u = \frac{1}{2VC}$

34. Capacitiors are used in electrical circuits where applicances need more
(a) voltage (b) current
(c) resistance (d) power

35. The work done in placing a charge of 8×10^{-18} coulomb on a condenser of capacity 100 micro-farad is
(a) 3.1×10^{-26} joule (b) 4×10^{-10} joule
(c) 32×10^{-32} joule (d) 16×10^{-232} joule

36. An arrangement which consists of two conductors separated by a dielectric medium is called
(a) resistor (b) inductor
(c) rectifier (d) capacitor

37. Capacity of a parallel plate condenser can be increased by
(a) increasing the distance between the plates
(b) increasing the thickness of the plates
(c) decreasing the thickness of the plates
(d) decreasing the distance between the plates

38. In a charged capacitor, the energy resides
(a) in the positive charges.
(b) in both the positive and negative charges.
(c) in the field between the plates.
(d) around the edges of the capacitor plates.

39. The resultant capacitance of n condenser of capacitances $C_1, C_2 .... C_n$ connected in series is given by
(a) $C_s = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$
(b) $\frac{1}{C_s} = \frac{1}{C_1} + ... + \frac{1}{C_n}$
(c) $C_s = C_1 + C_2 + ... + C_n$
(d) $C_s = C_1 - C_2 + ... - C_n$

40. The resultant capacity of n condensers of capacitances C_1, $C_2 .... C_n$ connected in parallel is
(a) $C_p = C_1 + C_2 + ... + C_n$
(b) $C_p = C_1 - C_2 - C_3 .... - C_n$
(c) $\frac{1}{C_p} = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$
(d) $C_p = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$

41. ...*X*... is a machine that can build up high voltages of the order of a few million volts. Here, A refers to
(a) Dynamo (b) Van De Graaff generator
(c) DC generator (d) AC generator

42. In case of a Van de Graaff generator, the breakdown field of air is
(a) $2 \times 10^8\ V\ m^{-1}$ (b) $3 \times 10^6\ V\ m^{-1}$
(c) $2 \times 10^8\ V\ m^{-1}$ (d) $3 \times 10^4\ V\ m^{-1}$

43. Van de Graaff generator is used to
(a) store electrical energy
(b) build up high voltage of few million volts
(c) decelerate charged particle like electrons
(d) both (a) and (b)

44. Which of the following is / are true about the principle of Van de Graaff generator?
(a) The action of sharp points.
(b) The charge given to a hollow conductor is tranferred to outer surface and is distributed uniformly over it.
(c) It is used for accelerating uncharged particle.
(d) Both (a) and (b)

STATEMENT TYPE QUESTIONS

45. Which of the following about potential difference between any two points is true?
I. It depends only on the initial and final position.
II. It is the work done per unit positive charge in moving from one point to other.
III. It is more for a positive charge of two units as compared to a positive charge of one unit.
(a) I only (b) II only
(c) I and II (d) I, II and III

46. An electric dipole of moment $\vec{P}$ is placed in a uniform electric field $\vec{E}$. Then which of the following is/are correct?
I. The torque on the dipole is $\vec{p} \times \vec{E}$.
II. The potential energy of the system is $\vec{p}.\vec{E}$.
III. The resultant force on the dipole is zero.
(a) I, II and II (b) I and III
(c) II and III (d) I, II and III

47. Consider the following statements and select the correct option
I. In an external electric field, the positive and negative charges of a non–polar molecule are displaced in opposite directions.
II. In non –polar molecules displacement stops when the external force on the constituent charges of the molecule is balanced by the restoring force.
III. The non–polar molecule develops an induced dipole moment.
(a) I and II (b) II and III
(c) I and III (d) I, II and III

48. Consider the following statements and select the correct statement(s).
I. Electric field lines are always perpendicular to equipotential surface.
II. No two equipotential surfaces can intersect each other.
III. Electric field lines are in the direction of tangent to an equipotential surface.
(a) I only (b) II only
(c) I and II (d) I, II and III

49. The energy stored in a parallel plate capacitor is given by $V_E = \frac{Q^2}{2C}$. Now which of the following statements is not true ?

I. The work done in charging a capacitor is stored in the form of electrostatic potential energy given by expression $V_E = \frac{Q^2}{2C}$

II. The net charge on the capacitor is Q.

III. The magnitude of the net charge on one plate of a capacitor is Q.

(a) I only (b) II only
(c) I and II (d) I, II and III

50. Which of the following statements is/are correct for equipotential surface ?

I. The potential at all the points on an equipotential surface is same.

II. Equipotential surfaces never intersect each other.

III. Work done in moving a charge from one point to other on an equipotential surface is zero.

(a) I only (b) II only
(c) I and II (d) I, II and III

51. When a metal plate is introduced between the two plates of a charged capacitor and insulated from them, then which of following statement(s) is/are correct ?

I. The metal plate divides the capacitor into two capacitors connected in parallel to each other

II. The metal plate divides the capacitors into two capacitors connected in series with each other

III. The metal plate is equivalent to a dielectric of zero dielectric constant

(a) I only (b) II only
(c) I and II (d) I, II and III

52. Consider the followoing statements regarding series grouping of capacitors and select the correct statements.

I. Charge on each capacitor remains same and equals to the main charge supplied by the battery.

II. Potential difference and energy distributes in the reverse ratio of capacitance.

III. Effective capacitance is even les than the least of teh individual capacitances.

(a) I and II (b) I and III
(c) II and III (d) I, II and III

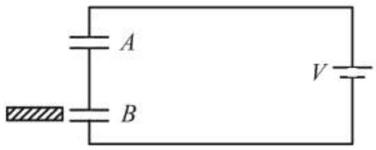
MATCHING TYPE QUESTIONS

53. Match the Column I and Column II.

	Column-I		Column-II
(A)	Electric potential near an isolated positive charge	(1)	Negative
(B)	Electric potential near an isolated negative charge	(2)	Positive
(C)	Electric potential due to a charge at its own location is not defined	(3)	Varies inversly of radius
(D)	Electric potential due to uniformly charged solid non-conducting sphere	(4)	Infinite

(a) (A)→(2); (B)→(1); (C)→(4); (D)→(3)
(b) (A)→(1); (B)→(3); (C)→(4); (D)→(2)
(c) (A)→(4); (B)→(1); (C)→(3); (D)→(4)
(d) (A)→(3); (B)→(2); (C)→(1); (D)→(4)

54. When a dielectric slab is inserted between the plates of one of the two identical capacitors shown in the figure then match the following:



	Column-I		Column-II
(A)	Charge on A	(1)	Increases
(B)	Potential difference across A	(2)	Decreases
(C)	Potential difference across B	(3)	Remains constant
(D)	Charge on B	(4)	Cannot say

(a) (A)→(1); (B)→(2); (C)→(2); (D)→(1)
(b) (A)→(1); (B)→(1); (C)→(2); (D)→(2)
(c) (A)→(2); (B)→(2); (C)→(2); (D)→(4)
(d) (A)→(1); (B)→(2); (C)→(2); (D)→(3)

55. Match the entries of Column I and Column II

	Column I		Column II
(A)	Inside a conductor placed in an external electric field.	(1)	Potential energy = 0
(B)	At the centre of a dipole	(2)	Electric field = 0
(C)	Dipole in stable equilibrium	(3)	Electric potential = 0
(D)	Electric dipole perpendicular to uniform electric field.	(4)	Torque = 0

(a) (A)→(2); (B)→(4); (C)→(3); (D)→(1)
(b) (A)→(2); (B)→(3); (C)→(4); (D)→(1)
(c) (A)→(2); (B)→(3); (C)→(1); (D)→(4)
(d) (A)→(1); (B)→(3); (C)→(4); (D)→(2)

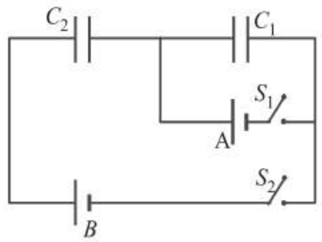
56. Match the types of capacitors in Column I and expressions of capacitances in Column II.

	Column I		Column II
(A)	Spherical capacitor	(1)	$\frac{\varepsilon_0 KA}{d}$
(B)	Cylindrical capacitor	(2)	$\frac{\varepsilon_0 A}{d}$

(C)	Parallel plate capacitor air filled	(3)	$\dfrac{2\pi\varepsilon_0 \ell}{\ln\left(\dfrac{r_2}{r_1}\right)}$
(D)	Parallel plate capacitor with dielectric slab between the plates.	(4)	$\dfrac{4\pi\varepsilon_0 r_1 r_2}{r_1 - r_2}$

(a) (A) $\rightarrow$ (4); (B) $\rightarrow$ (2); (C) $\rightarrow$ (3); (D) $\rightarrow$ (1)
(b) (A) $\rightarrow$ (4); (B) $\rightarrow$ (3); (C) $\rightarrow$ (1); (D) $\rightarrow$ (2)
(c) (A) $\rightarrow$ (3); (B) $\rightarrow$ (4); (C) $\rightarrow$ (2); (D) $\rightarrow$ (1)
(d) (A) $\rightarrow$ (4); (B) $\rightarrow$ (3); (C) $\rightarrow$ (2); (D) $\rightarrow$ (1)

57. In the given circuit diagram, both capacitors are initially uncharged. The capacitance C_1 = 2F and C_2 = 4F emf of battery A and B are 2V and 4V respectively.

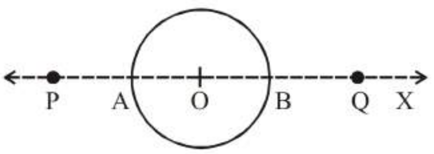


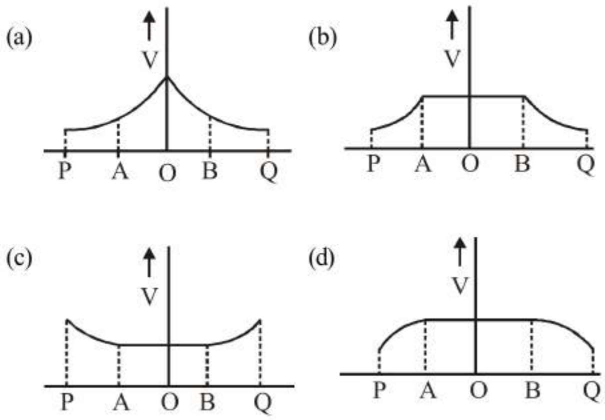
	Column - I		Column - II (Magnitude only)
(A)	On closing switch S_1 with S_2 open work done by battery A is	(1)	$\dfrac{64}{3}$
(B)	Switch S_1 is open and S_2 is closed, work done by battery B is	(2)	4
(C)	Charge on capacitor C_2 is (after S_1 open and S_2 closed)	(3)	8
(D)	Charge on C_1 when both are closed	(4)	$\dfrac{16}{3}$
		(5)	zero

(a) (A) $\rightarrow$ (1); (B) $\rightarrow$ (2); (C) $\rightarrow$ (2); (D) $\rightarrow$ (4)
(b) (A) $\rightarrow$ (4); (B) $\rightarrow$ (3); (C) $\rightarrow$ (3); (D) $\rightarrow$ (1)
(c) (A) $\rightarrow$ (2); (B) $\rightarrow$ (3); (C) $\rightarrow$ (2); (D) $\rightarrow$ (1)
(d) (A) $\rightarrow$ (3); (B) $\rightarrow$ (1); (C) $\rightarrow$ (4); (D) $\rightarrow$ (2)

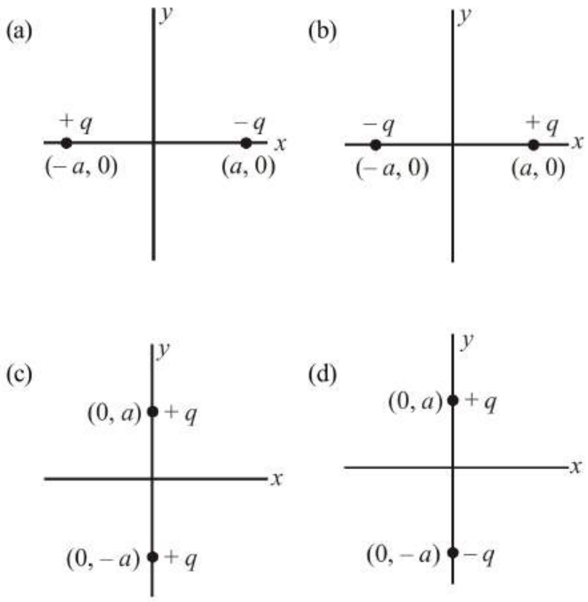
DIAGRAM TYPE QUESTIONS

58. Which of the following graphs correctly shows the variation of electric potential due to uniformly charged thin spherical shell with its centre at origin, as we move from point P to Q along x-axis?

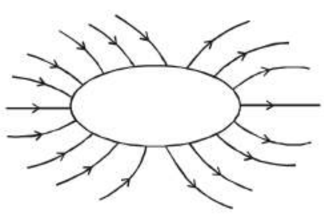




59. In which of the following cases is the electric field zero but potential is not zero at a point on x-axis ?

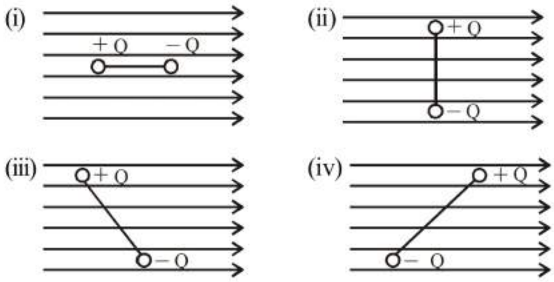


60. Figure below shows a hollow conducting body placed in an electric field. Which of the quantities are zero inside the body?



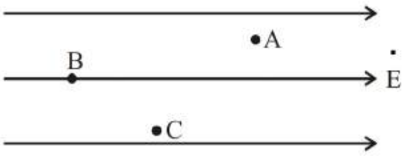
(a) Electric field and potential
(b) Electric field and charge density
(c) Electric potential and charge density.
(d) Electric field, potential and charge density.

61. The following figures show an electric dipole in four orientations in uniform electric field. Arrange them in increasing order of potential energy.



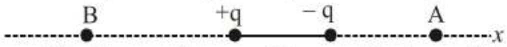
(a) (i), (ii), (iii), (iv) (b) (iv), (iii), (ii), (i)
(c) (iv), (ii), (i), (iii) (d) (iv), (ii), (iii), (i)

62. A, B and C are three points in a uniform electric field. The electric potential is



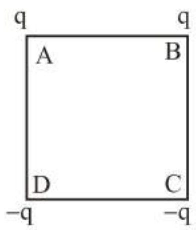
(a) maximum at B
(b) maximum at C
(c) same at all the three points A, B and C
(d) maximum at A

63. The figure shows the electric dipole placed along x-axis. As we move from point A to point B potential changes from



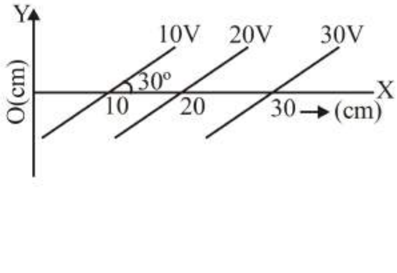
(a) positive to negative (b) negative to positive
(c) positive to zero (d) does not change

64. Charges are placed on the vertices of a square as shown. Let $\vec{E}$ be the electric field and V the potential at the centre. If the charges on A and B are interchanged with those on D and C respectively, then



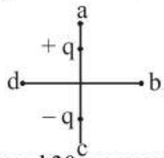
(a) $\vec{E}$ changes, V remains unchanged
(b) $\vec{E}$ remains unchanged, V changes
(c) both $\vec{E}$ and V change
(d) $\vec{E}$ and V remain unchanged

65. Equipotential surfaces are shown in figure. Then the electric field strength will be



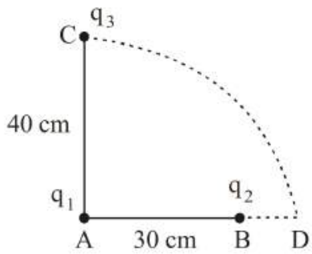
(a) 100 Vm^{-1} along X-axis
(b) 100 Vm^{-1} along Y-axis
(c) 200 Vm^{-1} at an angle 120° with X-axis
(d) 50 Vm^{-1} at an angle 120° with X-axis

66. Four points a, b, c and d are set at equal distance from the centre of a dipole as shown in figure. The electrostatic potential V_a, V_b, V_c, and V_d would satisfy the following relation:



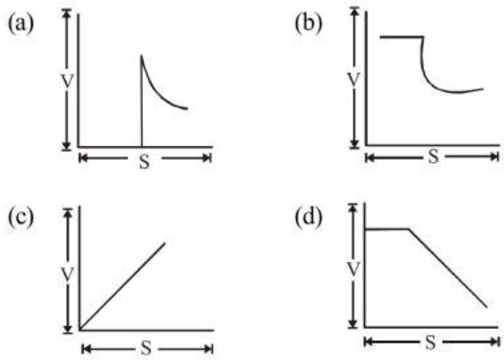
(a) $V_a > V_b > V_c > V_d$
(b) $V_a > V_b = V_d > V_c$
(c) $V_a > V_c = V_b = V_d$
(d) $V_b = V_d > V_a > V_c$

67. 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

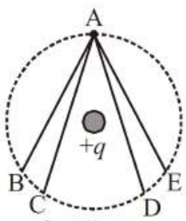


(a) $8q_1$ (b) $6q_1$ (c) $8q_2$ (d) $6q_2$

68. In a hollow spherical shell, potential (V) changes with respect to distance (s) from centre as

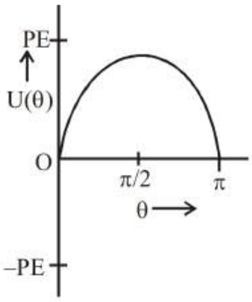


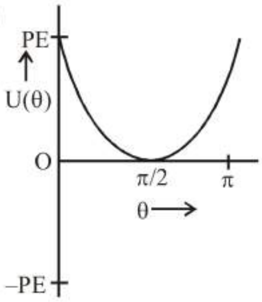
69. In the electric field of a point charge *q*, a certain charge is carried from point *A* to *B, C, D* and *E*. Then the work done is

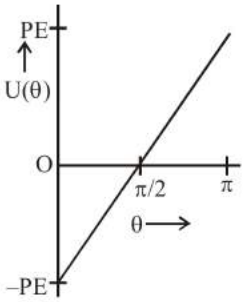


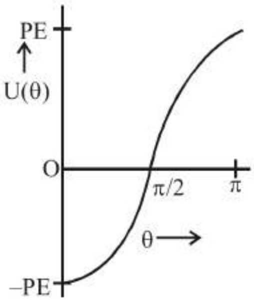
(a) least along the path *AB*
(b) least along the path *AD*
(c) zero along all the paths *AB*, *AC*, *AD* and *AE*
(d) least along *AE*

70. Which of the following graphs show the correct variation of magnitude of potential energy of a dipole when rotated from stable equillibrium to unstable equillibrium?

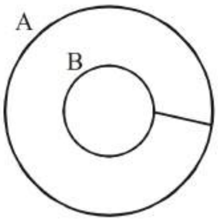
(a)


(b)


(c)


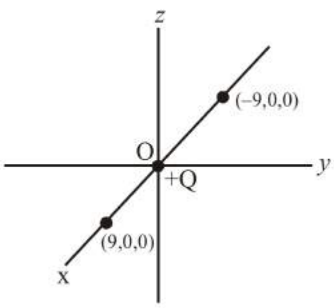
(d)


71. Figure shows two hollow charged conductors A and B having same positive surface charge densities. B is placed inside A and does not touches it. On connecting them with a conductor



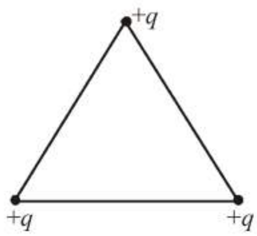
(a) charge will flow from A to B
(b) charge will flow from B to A
(c) charge oscillates between A and B
(d) No charge will flow.

72. Figure shows a charge + Q placed at origin. Another charge + q is brought from infinity to (9, 0, 0) from positive direction of x-axis in case I and from infinity to (–9, 0, 0) from negative direction of x-axis in case II. Which one of the following is true?



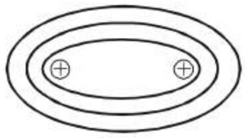
(a) The potential energy is positive in case I and negative in case II.
(b) The potential energy is negative in case I and positive in case II.
(c) The potential energy is same in both the cases and is negative.
(d) The potential energy is same in both the cases and is positive.

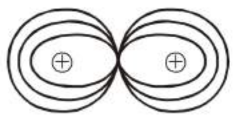
73. Figure shows a system of three positive charges placed at the vertices of an equilateral triangle. To decrease the potential energy of the system,

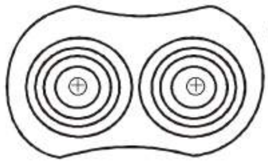


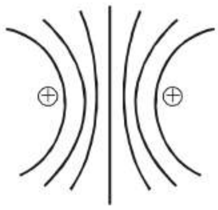
(a) a positive charge should be placed at centroid
(b) a negative charge should be placed at centroid.
(c) distance between the charges should be decreased.
(d) it should be rotated by an angle of $\frac{\pi}{2}$ radian.

74. Which of the following figure shows the correct equipotential surfaces of a system of two positive charges?

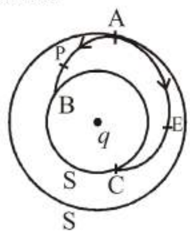
(a)


(b)


(c)


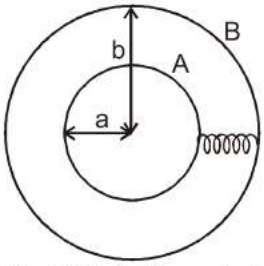
(d)


75. Two equipotential surfaces S_1 and S_2 are around a charge q. A test charge is moved from S_1 to S_2 along the paths APB and AEC as shown in figure. The work done is



(a) more in case of APB
(b) more in case of AEC
(c) same in both the cases
(d) cannot say

76. Two spherical conductors A and B of radii a and b (b>a) are placed concentrically in air. The two are connected by a copper wire as shown in figure. Then the equivalent capacitance of the system is



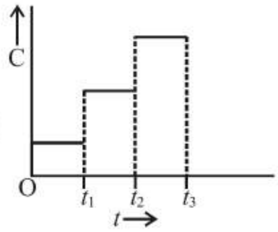
(a) $4\pi\varepsilon_0 \dfrac{ab}{b-a}$

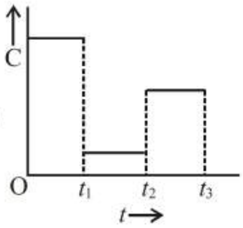
(b) $4\pi\varepsilon_0(a+b)$

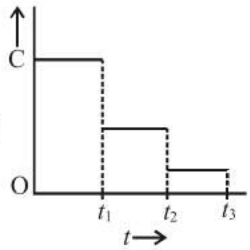
(c) $4\pi\varepsilon_0 b$

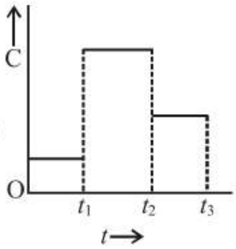
(d) $4\pi\varepsilon_0 a$

77. A parallel plate capacitor is charged in air (dielectric constant = 1.0006). For time 0 to t_1 only air is in between the plates of capacitor. For time t_1 to t_2 only water (dielectric constant = 81) and for time t_2 to t_3 only glycerine (dielectric constant = 56) is there in between the plates of capacitor. Which of the following graphs shows the correct variation of capacitance C with time t qualitatively?

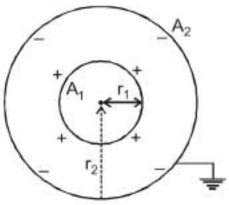
(a)


(b)


(c)


(d)


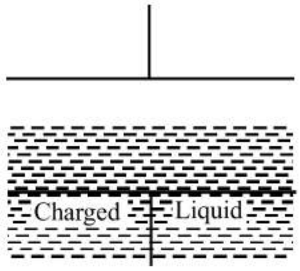
78. Two spherical conductors A_1 and A_2 of radii r_1 and r_2 $(r_2 > r_1)$ are placed concentrically in air. A_1 is given a charge +Q while A_2 is earthed. Then the equivalent capacitance of the system is



(a) $\dfrac{4\pi\epsilon_0 r_1 r_2}{r_2 - r_1}$ (b) $4\pi\epsilon_0 (r_1 + r_2)$

(c) $4\pi\epsilon_0 r_2$ (d) $4\pi\epsilon_0 r_1$

79. A parallel plate capacitor is located horizontally such that one of the plates is submerged in a liquid while the other is above the liquid surface. When plates are charged the level of liquid



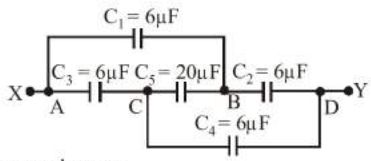
(a) rises

(b) falls

(c) remains unchanged

(d) may rise or fall depending on the of charge amount

80. What is the effective capacitance between points X and Y?



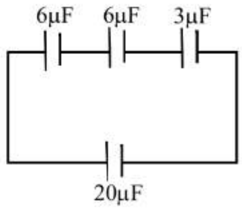
(a) 24 μF

(b) 18 μF

(c) 12 μF

(d) 6 μF

81. The capacitor, whose capacitance is 6, 6 and 3μF respectively are connected in series with 20 volt line. Find the charge on 3μF.



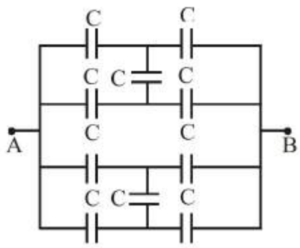
(a) 30 μc

(b) 60 μF

(c) 15 μF

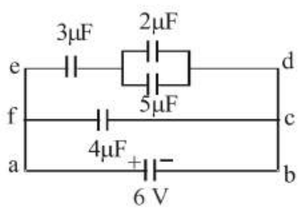
(d) 90 μF

82. The effective capacitance of combination of equal capacitors between points A and B shown in figure is



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

83. In the circuit given below, the charge in μC, on the capacitor having capacitance 5 μF is



(a) 4.5 (b) 9 (c) 7 (d) 15

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

84. **Assertion:** The potential difference between any two points in an electric field depends only on initial and final position.
Reason: Electric field is a conservative field so the work done per unit positive charge does not depend on path followed.

85. **Assertion :** Electric field inside a conductor is zero.
Reason: The potential at all the points inside a conductor is same.

86. **Assertion :** Electric field is discontinuous across the surface of a spherical charged shell.
Reason : Electric potential is continuous across the surface of a spherical charged shell.

87. **Assertion :** Work done in moving a charge between any two points in an electric field is independent of the path followed by the charge, between these points.
Reason: Electrostatic force is a non conservative force.

88. **Assertion :** Two adjacent conductors of unequal dimensions, carrying the same positive charge have a potential difference between them.
Reason : The potential of a conductor depends upon the charge given to it.

89. **Assertion :** Electric potential and electric potential energy are different quantities.
Reason : For a system of positive test charge and point charge electric potential energy = electric potential.

90. **Assertion :** For a non-uniformly charged thin circular ring with net charge is zero, the electric field at any point on axis of the ring is zero.
Reason : For a non-uniformly charged thin circular ring with net charge zero, the electric potential at each point on axis of the ring is zero.

91. **Assertion :** For a charged particle moving from point P to point Q, the net work done by an electrostatic field on the particle is independent of the path connecting point P to point Q.
Reason : The net work done by a conservative force on an object moving along a closed loop is zero.

92. **Assertion :** Polar molecules have permanent dipole moment.
Reason : In polar molecules, the centres of positive and negative charges coincide even when there is no external field.

93. **Assertion :** Dielectric polarisation means formation of positive and negative charges inside the dielectric.
Reason: Free electrons are formed in this process.

94. **Assertion :** In the absence of an external electric field, the dipole moment per unit volume of a polar dielectric is zero.
Reason : The dipoles of a polar dielectric are randomly oriented.

95. **Assertion :** For a point charge, concentric spheres centered at a location of the charge are equipotential surfaces.
Reason : An equipotential surface is a surface over which potential has zero value.

96. **Assertion :** Electric energy resides out of the spherical isolated conductor.
Reason : The electric field at any point inside the conductor is zero.

97. **Assertion :** Two equipotential surfaces cannot cut each other.
Reason : Two equipotential surfaces are parallel to each other.

98. **Assertion.** Two equipotential surfaces can be orthogonal.
Reason: Electric field lines are normal to the equipotential surface.

99. **Assertion.** The equatorial plane of a dipole is an equipotential surface.
Reason: The electric potential at any point on equatorial plane is zero.

100. **Assertion:** The electric potential at any point on the equatorial plane of a dipole is zero.
Reason: The work done in bringing a unit positive charge from infinity to a point in equatorial plane is equal for the two charges of the dipole.

101. **Assertion :** A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant k is introduced between the plates. The energy stored becomes k times.
Reason : The surface density of charge on the plate remains constant.

102. **Assertion :** Two metal plates having charges Q, $-Q$ face each other at some separation and are dipped into an oil tank. If the oil is pumped out, the electric field between the plates increases.
Reason : Electric field between the plates, $E_{med} = \frac{E_{air}}{\kappa}$.

103. **Assertion :** When a dielectric slab is gradually inserted between the plates of an isolated parallel-plate capacitor, the energy of the system decreases.
Reason : The force between the plates decreases.

104. **Assertion :** A dielectric is inserted between the plates of a battery connected capacitor. The energy of the capacitor increases.
Reason : Energy of the capacitor, $U = \frac{1}{2}CV^2$.

CRITICAL THINKING TYPE QUESTIONS

105. A long, hollow conducting cylinder is kept coaxially inside another long, hollow conducting cylinder of larger radius. Both the cylinders are initially electrically neutral. Then

(a) a potential difference appears between the two cylinders when a charge density is given to the inner cylinder.
(b) a potential difference appears between the two cylinders when a charge density is given to the outer cylinder.
(c) no potential difference appears between the two cylinders when a uniform line charge is kept along the axis of the cylinders
(d) no potential difference appears between the two cylinders when same charge density is given to both the cylinders.

106. Two equally charged spheres of radii a and b are connected together. What will be the ratio of electric field intensity on their surfaces?

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

107. A given charge is situated at a certain distance from an electric dipole in the end-on position experiences a force *F*. If the distance of the charge is doubled, the force acting on the change will be

(a) $2F$ (b) $F/2$
(c) $F/4$ (d) $F/8$

108. An electric charge 10^{-3} ≠C is placed at the origin (0, 0) of X – Y co-ordinate 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) 4.5 volt (b) 9 volt
(c) zero (d) 2 volt

109. The potential at a point x (measured in μ m) due to some charges situated on the x-axis is given by $V(x) = 20/(x^2 - 4)$ volt
The electric field E at x = 4 μ m is given by

(a) (10/9) volt/ μ m and in the +ve x direction
(b) (5/3) volt/ μ m and in the –ve x direction
(c) (5/3) volt/ μ m and in the +ve x direction
(d) (10/9) volt/ μ m and in the –ve x direction

110. The expression $E = -\frac{dv}{dr}$ implies, that electric field is in that direction in which

(a) increase in potential is steepest.
(b) decrease in potential is steepest.
(c) change in potential is minimum.
(d) None of these

111. Two parallel metal plates having charges + Q and – Q face each other ata certain distance between them. If the plates are now dipped in kerosene oil tank, the electric field between the plates will

(a) remain same (b) become zero
(c) increases (d) decrease

112. Four point charges $-Q$, $-q$, $2q$ and $2Q$ are placed, one at each corner of the square. The relation between Q and q for which the potential at the centre of the square is zero is

(a) $Q = -q$ (b) $Q = -\frac{1}{q}$
(c) $Q = q$ (d) $Q = \frac{1}{q}$

113. A conducting sphere of radius R is given a charge Q. The electric potential and the electric field at the centre of the sphere respectively are:

(a) Zero and $\frac{Q}{4\pi\varepsilon_0 R^2}$
(b) $\frac{Q}{4\pi\varepsilon_0 R}$ and Zero
(c) $\frac{Q}{4\pi\varepsilon_0 R}$ and $\frac{Q}{4\pi\varepsilon_0 R^2}$
(d) Both are zero

114. In a region, the potential is represented by $V(x, y, z) = 6x - 8xy - 8y + 6yz$, where V is in volts and x, y, z are in metres. The electric force experienced by a charge of 2 coulomb situated at point (1, 1, 1) is

(a) $6\sqrt{5}$ N (b) 30 N
(c) 24 N (d) $4\sqrt{35}$ N

115. Two conducting spheres of radii R_1 and R_2 having charges Q_1 and Q_2 respectively are connected to each other. There is

(a) no change in the energy of the system
(b) an increase in the energy of the system
(c) always a decrease in the energy of the system
(d) a decrease in the energy of the system unless $Q_1R_2 = Q_2R_1$

116. A parallel plate capacitor is charged by connecting it to a battery. Now the distance between the plates of the capacitor is increased. Which of the following remains constant ?

(a) Capacitance
(b) Charge on each plate of the capacitor.
(c) Potential difference between the plates of capacitor
(d) Energy stored in the capacitor.

117. Two vertical metallic plates carrying equal and opposite charges are kept parallel to each other like a parallel plate capacitor. A small spherical metallic ball is suspended by a long insulated thread such that it hangs freely in the centre of the two metallic plates. The ball, which is uncharged, is taken slowly towards the positively charged plate and is made to touch that plate. Then the ball will

(a) stick to the positively charged plate
(b) come back to its original position and will remain there
(c) oscillate between the two plates touching each plate in turn
(d) oscillate between the two plates without touch them

118. When air is replaced by a dielectric medium of force constant K, the maximum force of attraction between two charges, separated by a distance

(a) decreases K-times (b) increases K-times

(c) remains unchanged (d) becomes $\frac{1}{K^2}$ times

119. A parallel plate capacitor is charged and then isolated. What is the effect of increasing the plate separation on charge, potential, capacitance, respectively?

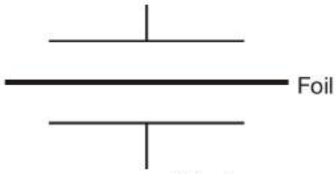
(a) Constant, decreases, decreases

(b) Increases, decreases, decreases

(c) Constant, decreases, increases

(d) Constant, increases, decreases

120. A foil of aluminium of negligible thickness is inserted in between the space of a parallel plate condenser. If the foil is electrically insulated, the capacity of the condenser will



(a) increase (b) decrease

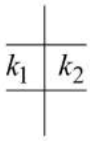
(c) remain unchanged (d) become zero

121. Eight drops of mercury of equal radii possessing equal charges combine to form a big drop. Then the capacitance of bigger drop compared to each individual small drop is

(a) 8 times (b) 4 times

(c) 2 times (d) 32 times

122. A parallel plate condenser is filled with two dielectrics as shown. Area of each plate is A m^2 and the separation is t m. The dielectric constants are k_1 and k_2 respectively. Its capacitance in farad will be



(a) $\frac{\varepsilon_0 A}{t}(k_1 + k_2)$ (b) $\frac{\varepsilon_0 A}{t}.\frac{k_1 + k_2}{2}$

(c) $\frac{2\varepsilon_0 A}{t}(k_1 + k_2)$ (d) $\frac{\varepsilon_0 A}{t}.\frac{k_1 - k_2}{2}$

123. A capacitor of capacity C_1 is charged upto V volt and then connected to an uncharged capacitor of capacity C_2. Then final potential difference across each will be

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

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

124. A parallel plate capacitor with air between the plates is charged to a potential difference of 500V and then insulated. A plastic plate is inserted between the plates filling the whole gap. The potential difference between the plates now becomes 75V. The dielectric constant of plastic is

(a) 10/3 (b) 5 (c) 20/3 (d) 10

125. From a supply of identical capacitors rated 8 mF, 250V, the minimum number of capacitors required to form a composite 16 mF, 1000V is

(a) 2 (b) 4 (c) 16 (d) 32

126. A parallel plate air capacitor of capacitance C is connected to a cell of emf V and then disconnected from it. A dielectric slab of dielectric constant K, which can just fill the air gap of the capacitor, is now inserted in it. Which of the following is incorrect ?

(a) The energy stored in the capacitor decreases K times.

(b) The chance in energy stored is $\frac{1}{2}CV^2\left(\frac{1}{K} - 1\right)$

(c) The charge on the capacitor is not conserved.

(d) The potential difference between the plates decreases K times.

127. In a Van de Graaff generator, a spherical metal shell is to be 15×10^6 V electrode. The dielectric strength of the gas surrounding the electrode is $5 \times 10^7 V\ m^{-1}$. The minimum radius of the spherical shell required is

(a) 1 m (b) 2 m

(c) 1.5 m (d) 3 m

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. (b)
2. (c) Electric potential inside a conductor is constant and it is equal to that on the surface of the conductor.
3. (a) Potential energy is defined only in case of conservative forces like electrostatic force (and due to which electrostatic field is a conservative field). It is not defined for non-conservative forces like friction.
4. (a) Since $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$, for a given point charge, q is constant, therefore V depends only on r. Hence V is a function of distance.
5. (b)
6. (d) Surface of metallic cube is an equipotential surface. Therefore, electric field is normal to the surface of the cube.
7. (b) 8. (a)
9. (c) $C = \frac{2\times 2}{2+2} + 2 = 3\,\mu F$
10. (c) Because in case of metallic spheres either solid or hollow, the charge will reside on the surface of the sphere. Since both spheres have same surface area, so they can hold equal maximum charge.
11. (d) On the equipotential surface, electric field is normal to the charged surface (where potential exists) so that no work will be done.
12. (a) Potential difference between two points in a electric field is,

$$V_A - V_B = \frac{W}{q_0}$$

13. (d) When negative terminal is grounded, positive terminal of battery is at +12 V. When positive terminal is grounded, the negative terminal will be at –12 V.
14. (d)
15. (c) The potential energy is negative whenever there is attraction. Since a positive and negative charge attract each other therefore their energy is negative. When both the charges are separated by infinite distance, they do not attract each other and their energy is zero.
16. (d)
17. (a) As the dipole will feel two forces, which are although opposite but not equal.
$\therefore$ A net force will be there and as these forces act at different points of a body, a torque is also present.
18. (d) $V = k\frac{\vec{p}.\vec{r}}{r^3} = \frac{k\,pr\cos\theta}{r^3}$

$= k\frac{p\cos\theta}{r^2}$.
19. (d) $W = PE(\cos 90° - \cos 270°) = 0$.
20. (a) Energy required to charge the capacitor is $W = U = QV$

$$\Rightarrow U = CV^2 = \frac{\varepsilon_0 A}{d}.V^2 = \frac{\varepsilon_0 Ad}{d^2}.V^2 = \varepsilon_0 E^2 Ad$$

$\left[\because E = \frac{V}{d}\right]$.
21. (b) Potential at any point inside the sphere = potential at the surface of the sphere = 10V.
22. (d) The equatorial plane of a dipole is an equipotential surface, therefore potential remains constant.
23. (d) Since capacitance $C = \frac{\varepsilon_0 A}{d}$, as d decreases capacitance increases.
24. (a) 25. (d) 26. (a) 27. (c) 28. (b) 29. (b)
30. (b) $C_{medium} = K \times C_{air}$
31. (b) In oil, C becomes twice, V becomes half. Therefore, E = V/d becomes half.
32. (b) Energy will be lost during transfer of charge (heating effect).
33. (b) $U = \int_0^V CV\,dV = \frac{1}{2}CV^2$
34. (b)
35. (c) Work done $= \frac{1}{2}\frac{q^2}{C} = \frac{(8\times 10^{-18})^2}{2\times 100\times 10^{-6}} = 32\times 10^{-32}$ J
36. (d) 37. (d) 38. (c) 39. (b) 40. (a)
41. (b) Van De graff generator is a machine that can built up high voltages of the order of a few million volts. The resulting large electric fields are used to accelerate charged particles (electrons, protons, ions) to high energies needed for experiments to probe the small scale structure of matter.
42. (b) 43. (b) 44. (d)

STATEMENT TYPE QUESTIONS

45. (c) Since $V = \frac{W}{Q}$, more work will be done for a positive charge of two units as compared to positive charge of one unit, but the ratio $\frac{W}{Q}$ is same. Therefore potential difference is same.

46. (b) In a uniform electric field $\vec{E}$, dipole experiences a torque $\vec{\tau}$ given by $\vec{\tau} = \vec{p}\times\vec{E}$ but experiences no force. The potential energy of the dipole in a uniform electric field $\vec{E}$ is $U = -\vec{p}.\vec{E}$

47. (d) In an external electric field, the positive and negative charges of a non-polar molecule are displaced in opposite directions. The displacement stops when the external force on the constituent charges of the molecule is balanced by the restoring force (due to internal fields in the molecule). The non-polar molecule thus develops an induced dipole moment. The dielectric is said to be polarised by the external field.

48. (c) Electric field lines are always perpendicular to equipotential surface so, they cannot be in a direction of tangent to an equipotential surface.

49. (b) There is equal and opposite charge on the plates of a parallel plate capacitor. Therefore there is no net charge on capacitor.

50. (d) Since potential at every point on an equipotential surface is same therefore, for any two points on equipotential surface the potential difference is zero.

51. (b) 52. (d)

MATCHING TYPE QUESTIONS

53 (a) A - 2; B - 1; C - 4; D - 3

54. (b) If V is the potential applied across the capacitor then p.d. across each capacitor will be $\frac{V}{2}$. When

A- 1 : dielectric is inserted in capacitor B, then

B- 1 : $V_1 + V_2 = V$

C- 2 : and $CV_1 = kCV_2$

D-2 : On solving above equations, we get

$$V_1 = \left(\frac{kV}{k+1}\right) \text{ and } V_2 = \left(\frac{V}{k+1}\right).$$

Clearly potential of A increases and that of B decreases. Initial charges on the capacitors are :

$$q_1 = \frac{CV}{2}, \quad q_2 = \frac{CV}{2}$$

charges :

$$q_1' = CV_1 = \frac{kCV}{k+1} \quad \text{and} \quad q_2' = \frac{CV}{k+1}.$$

Charge on capacitor A will increase, and on B will decrease.

55. (b) A → (2); B → (3); C → (4); D → (1)

56. (d) A → (4); B → (3); C → (2); D → (1)

57. (d) A → (3); B → (1); C → (4); D → (2)

W.d. by battery A, $= 2\left(\frac{1}{2}C_1V_1^2\right) = 2\times 2^2 = 8J$

W.d. by battery B, $= 2\left[\frac{1}{2}CV_2^2\right]$

$$= 2\left[\frac{1}{2}\times\frac{4\times 2}{4+2}\times 4^2\right] = \frac{64}{3}J$$

$$q_2 = CV = \left(\frac{4\times 2}{4+2}\right)\times 4 = \frac{16}{3}$$

$$q_1 = C_1V_1 = 2\times 2 = 4$$

DIAGRAM TYPE QUESTIONS

58. (b) For regions outside the spherical shell potential is given by $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$, i.e. $V \propto \frac{1}{r}$ and it increases as we come closer to the spherical shell. Therefore potential increases as we move from P to A according to $V \propto \frac{1}{r}$.

For the regions inside the shell potential has a constant value at that on the surface, hence it remains constant for A to B. After B as we move away from the spherical shell it decreases as $V \propto \frac{1}{r}$.

59. (c) In this case electric fields due to the two charges at origin are just equal and opposite and thus cancel each other whereas potential due to the two charges add up and is not zero.

60. (b) Electric field is always zero inside a conductor. If there is any excess of charge on a hollow conductor it always resides on the outer surface of conductor. Therefore inside a hollow conductor there is no charge and hence charge density is zero.

61. (d) The potential energy of a dipole in uniform electric field is given by

$U = -\vec{p}\cdot\vec{E} = -pE\cos\theta$.

(i) For $\theta = 180°$,

$U = -pE\cos 180° = pE$. This is maximum value.

(ii) For $\theta = 90°$, $U = -pE\cos 90° = 0$

(iii) For $90° < \theta < 180°$,

∴ $\cos\theta$ is negative and hence U is positive.

(iv) For $0° < \theta < 90°$,

∴ $\cos\theta$ is positive and hence U is negative.

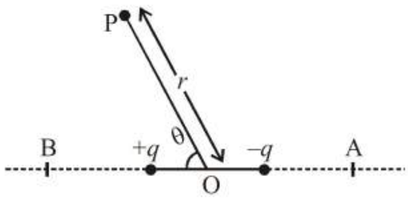
Therefore the correct increasing order is (iv), (ii), (iii), (i)

62. (a) Potential at B, V_B is maximum

$$V_B > V_C > V_A$$

As in the direction of electric field potential decreases.

63. (b) The potential due to dipole at any arbitrary point P is given by



$$V = \frac{1}{4\pi\varepsilon_0}\frac{P\cos\theta}{r^2}$$

For A, $\theta = 180°$

$\therefore \quad V_A = \frac{1}{4\pi\varepsilon_0}\frac{P\cos 180°}{r^2} = -\frac{1}{4\pi\varepsilon_0}\frac{P}{r^2} =$ a negative quantity.

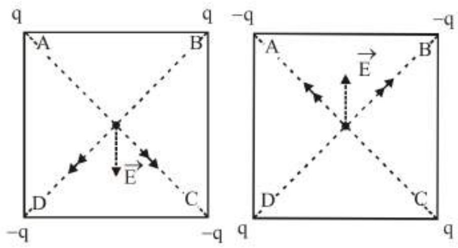
For B, $\theta = 0°$.

$\therefore \quad V_B = \frac{1}{4\pi\varepsilon_0}\frac{P\cos 0°}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{P}{r^2} =$ a positive quantity.

Therefore as we move from A to B potential change from negative to positive.

64. (a) As shown in the figure, the resultant electric fields before and after interchanging the charges will have the same magnitude, but opposite directions.

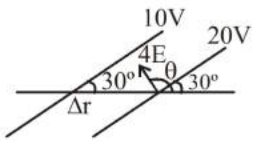
Also, the potential will be same in both cases as it is a scalar quantity.



65. (c) Using $dV = -\vec{E}.d\vec{r}$

$\Rightarrow \quad \Delta V = -E\,\Delta r\cos\theta$

$\Rightarrow \quad E = \frac{-\Delta V}{\Delta r\cos\theta}$



$\Rightarrow \quad E = \frac{-(20-10)}{10\times10^{-2}\cos 120°}$

$= \frac{-10}{10\times10^{-2}(-\sin 30°)}$

$= \frac{-10^2}{-1/2} = 200\ V/m$

Direction of E be perpendicular to the equipotential surface *i.e.* at 120° with X-axis.

66. (b)

67. (c) We know that potential energy of discrete system of charges is given by

$$U = \frac{1}{4\pi\epsilon_0}\left(\frac{q_1q_2}{r_{12}} + \frac{q_2q_3}{r_{23}} + \frac{q_3q_1}{r_{31}}\right)$$

According to question,

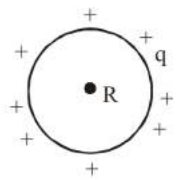
$$U_{initial} = \frac{1}{4\pi\epsilon_0}\left(\frac{q_1q_2}{0.3} + \frac{q_2q_3}{0.5} + \frac{q_3q_1}{0.4}\right)$$

$$U_{final} = \frac{1}{4\pi\epsilon_0}\left(\frac{q_1q_2}{0.3} + \frac{q_2q_3}{0.1} + \frac{q_3q_1}{0.4}\right)$$

$$U_{final} - U_{initial} = \frac{1}{4\pi\epsilon_0}\left(\frac{q_2q_3}{0.1} - \frac{q_2q_3}{0.5}\right)$$

$$= \frac{1}{4\pi\epsilon_0}\left[10q_2q_3 - 2q_2q_3\right] = \frac{q_3}{4\pi\epsilon_0}(8q_2)$$

68. (b) In shell, q charge is uniformly distributed over its surface, it behaves as a conductor.



V= potential at surface $= \frac{q}{4\pi\varepsilon_0 R}$ and inside

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

Because of this it behaves as an equipotential surface.

69. (c) ABCDE is an equipotential surface, on equipotential surface no work is done in shifting a charge from one place to another.

70. (d) The potential energy of a dipole placed in uniform electric field is given by

$$U(\theta) = -\vec{p}\cdot\vec{E} = -pE\cos\theta$$

$$= pE(-\cos\theta).$$

For stable equillibrium $\theta = 0°$ and for unstable equillibrium $\theta = 180°$. Therefore the correct variation is shown by graph of $-\cos\theta$ from 0 to π with maximum and minimum values pE and – pE respectively.

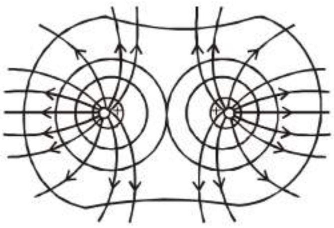
71. (b) Irrespective of the charges on the inner and outer conductors, the inner conductor is always at a higher potential as long as the charge on inner conductor is not zero. Therefore charge flows from B to A. When the whole charge of B flows to A and charge on B becomes zero then A and B are at same potential.

72. (d) The potential energy of a system of two charges q_1 and q_2 is given by

$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$ where r_{12} is the distance between the charges. Here $q_1 = +Q$ and $q_2 = +q$. Distance between both the charges is same in both the cases which is $|a| = |-a| = a$. Therefore potential energy is same in both the cases and is positive.

73. (c) Potential energy decreases whenever there is attraction. A negative charge placed at centroid causes attraction.

74. (c) Equipotential surfaces are normal to the electric field lines. The following figure shows the equipotential surfaces along with electric field lines for a system of two positive charges.



75. (c) B and C are at the same potential, therefore potential difference between A and B and that between A and C is same in both the cases. Hence work done is same in both the cases.

76. (c) All the charge given to inner sphere will pass on to the outer one. So capacitance that of outer one is $4\pi \in_0 b$.

77. (d) The capacitance of a parallel plate capacitor is given by

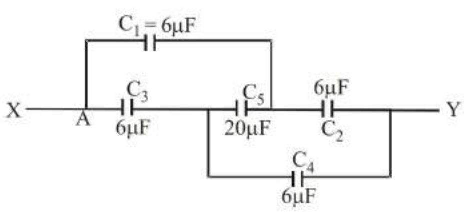
$C = \frac{\varepsilon_0 K A}{d}$ where K is dielectric constant of the dielectric.

Therefore more the dielectric constant, more will be the capacitance.

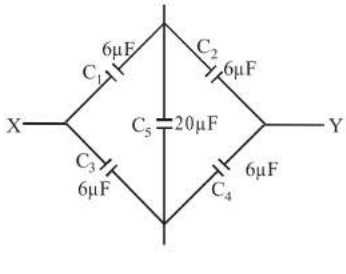
78. (a)

79. (a) The molecules of liquid will convert into induced dipole, get oriented along the electric field produced between the plates and rise due to force of attraction.

80. (d)

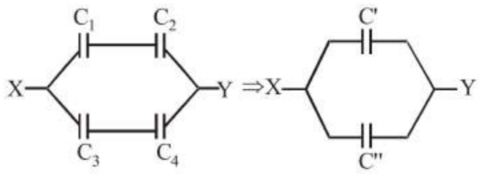


Equivalent circuit



As $\frac{C_1}{C_3} = \frac{C_2}{C_4}$

Hence no charge will flow through $20\mu F$



C_1 and C_2 are in series, also C_3 and C_4 are in series.

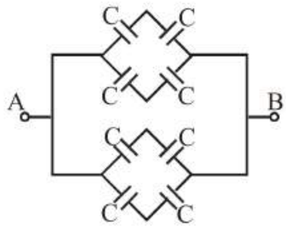
Hence $C' = 3\ \mu F$, $C'' = 3\ \mu F$

C' and C'' are in parallel hence net capacitance

$= C' + C'' = 3 + 3 = 6\ \mu F$

81. (a) In series $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ and charge on each capacitor is same.

82. (b)



The figure shows two independent balanced wheatstone Brides connected in parallel each having a capacitance C. So,

$$C_{net} = C_{AB} = 2C$$

83. (b) Potential difference across the branch de is 6 V. Net capacitance of de branch is 2.1 μF

So, $q = CV$

$\Rightarrow q = 2.1 \times 6\ \mu C$

$\Rightarrow q = 12.6\ \mu C$

Potential across 3 μF capacitance is

$V = \frac{12.6}{3} = 4.2$ volt

Potential across 2 and 5 combination in parallel is $6 - 4.2 = 1.8$ V

So, $q' = (1.8)(5) = 9\ \mu C$

ASSERTION- REASON TYPE QUESTIONS

84. (a) **85.** (b) **86.** (b) **87.** (c) **88.** (b)

89. (c) Potential and potential energy are different quantities and cannot be equated.

90. (d) For a non-uniformly charged thin circular ring with net zero charge, electric potential at each point on its axis is zero. Hence electric field at each point on its axis must be perpendicular to the axis. Therefore Assertion is false and Reason is true.

91. (a) **92.** (c) **93.** (c) **94.** (a) **95.** (c)

96. (a) As these is no electric field inside the conductor, and so no energy inside it.

97. (c) Reason is false because the work done in bringing a unit positive charge from infinity to a point in equatorial plane is equal and opposite for the two charges of the dipole.

98. (d) Two equipotential surfaces never intersect each other so they cannot be orthogonal.

99. (b)

100. (d) Two equipotential surfaces are not necessarily parallel to each other.

101. (c) $C' = kC$, and so, $U' = \frac{1}{2}(kC)V^2 = kU$. Also $q' = C'V$ $= kCV = kq$, and so charge density increases.

102. (c) Reason is the correct explanation of statement-1.

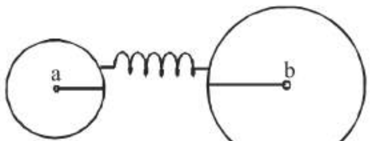
103. (c) $C' = kC$, and $U' = \frac{q^2}{2C'} = \frac{q^2}{2kC}$. With the introduction of dielectric, energy of the system decreases. As charge on the capacitor remains same, and so force between them remains same.

104. (a) $U = \frac{1}{2}CV^2$. In the battery connected capacitor V remains constant while C increases with the introduction of dielectric and so U will increase.

CRITICALTHINKING TYPE QUESTIONS

105. (a) When a charge density is given to the inner cylinder, the potential developed at its surface is different from that on the outer cylinder. This is because the potential decreases with distance for a charged conducting cylinder when the point of consideration is outside the cylinder. But when a charge density is given to the outer cylinder, it will charge its potential by the same amount as that of the inner cylinder. Therefore no potential difference will be produced between the cylinders in this case.

106. (c)



Let charge on each sphere $= q$
when they are connected together their potential will be equal .

Now let charge on $a = q_1$ and on $b = 2q - q_1$

$$\Rightarrow V_a = V_b \text{ or } \frac{1}{4\pi\varepsilon_o}\frac{q_1}{a} = \frac{1}{4\pi\varepsilon_o}\frac{2q - q_1}{b}$$

$$\Rightarrow \frac{q_1}{2q - q_1} = \frac{a}{b}$$

$$\frac{E_a}{E_b} = \frac{\frac{1}{4\pi\varepsilon_o}\frac{q_1}{a^2}}{\frac{1}{4\pi\varepsilon_o}\frac{q_2}{b^2}} = \left(\frac{q_1}{2q - q_1}\right)\frac{b^2}{a^2} = \frac{a}{b}.\frac{b^2}{a^2} = \frac{b}{a}$$

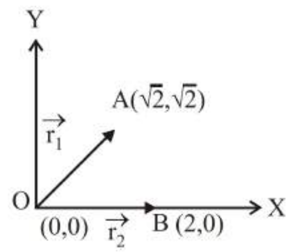
$$= b : a$$

107. (d) Force on charge $F = q\,(E_a) = q \times \frac{k.2p}{r^3}$

$$\Rightarrow F \propto \frac{1}{r^3}$$

When $r \to$ doubled; $F \to \frac{1}{8}$ times

108. (c)



The distance of point $A\left(\sqrt{2}, \sqrt{2}\right)$ from the origin,

$$OA = |\vec{r_1}| = \sqrt{(\sqrt{2})^2 + (\sqrt{2})^2}$$

$= \sqrt{4} = 2$ units.

The distance of point B(2, 0) from the origin,

$$OB = |\vec{r_2}| = \sqrt{(2)^2 + (0)^2} = 2 \text{ units.}$$

Now, potential at A, $V_A = \frac{1}{4\pi \epsilon_0}.\frac{Q}{(OA)}$

Potential at B, $V_B = \frac{1}{4\pi \epsilon_0}.\frac{Q}{(OB)}$

$\therefore$ Potential difference between the points A and B is given by

$$V_A - V_B = \frac{1}{4\pi \epsilon_0}.\frac{Q}{OA} - \frac{1}{4\pi \epsilon_0}.\frac{Q}{OB}$$

$$= \frac{Q}{4\pi \epsilon_0}\left(\frac{1}{OA} - \frac{1}{OB}\right) = \frac{Q}{4\pi \epsilon_0}\left(\frac{1}{2} - \frac{1}{2}\right)$$

$$= \frac{10^{-3} \times 10^{-6}}{4\pi \epsilon_0} \times 0 = 0.$$

109. (a) Here, $V(x) = \frac{20}{x^2 - 4}$ volt

We know that $E = -\frac{dV}{dx} = -\frac{d}{dx}\left(\frac{20}{x^2-4}\right)$

or, $E = +\frac{40x}{(x^2-4)^2}$

At $x = 4\,\mu m$,

$E = +\frac{40 \times 4}{(4^2-4)^2} = +\frac{160}{144} = +\frac{10}{9}$ volt / μm.

Positive sign indicates that $\vec{E}$ is in +ve x-direction.

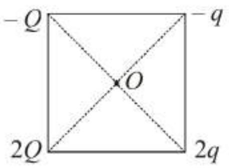
110. (b) As we move towards a positive charge distribution V increases i.e., $\frac{dV}{dr}$ is positive. The increase in potential is steepest when we move exactly towards charge distribution. But E is in a direction exactly away from charge distribution, therefore E is in exactly opposite direction in which increase in potential is steepest. Hence $E = -\frac{dV}{dr}$.

111. (d) Electric field $E = \frac{\sigma}{\varepsilon} = \frac{Q}{A\varepsilon}$

ε of kerosine oil is more than that of air.

As ε increases, E decreases.

112. (a) Let the side length of square be 'a' then potential at centre O is



$V = \frac{k(-Q)}{\left(\frac{a}{\sqrt{2}}\right)} + \frac{k(-q)}{\frac{a}{\sqrt{2}}} + \frac{k(2q)}{\frac{a}{\sqrt{2}}} + \frac{k(2Q)}{\frac{a}{\sqrt{2}}} = 0$ (Given)

$= -Q - q + 2q + 2Q = 0 = Q + q = 0$

$= Q = -q$

113. (b) Due to conducting sphere

At centre, electric field E = 0

And electric potential $V = \frac{Q}{4\pi \epsilon_0 R}$

114. (d) $\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$

$= -[(6-8y)\hat{i} + (-8x - 8 + 6z)\hat{j} + (6y)\hat{k}]$

At (1, 1, 1), $\vec{E} = 2\hat{i} + 10\hat{j} - 6\hat{k}$

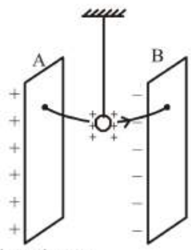
$\Rightarrow (\vec{E}) = \sqrt{2^2 + 10^2 + 6^2} = \sqrt{140} = 2\sqrt{35}$

$\therefore F = q\vec{E} = 2 \times 2\sqrt{35} = 4\sqrt{35}$

115. (d) When $\frac{Q_1}{R_1} - \frac{Q_2}{R_2}$; current will flow in connecting wire so that energy decreases in the form of heat through the connecting wire.

116. (c) As the capacitor remains connected to the battery, the potential difference provided by the battery remains constant.

117. (c) The ball on touching plate A will get positively charged. It will be repelled by A and get attracted towards B. After touching B it will get negatively charged. It will now be repelled by B and get attracted towards A. Thus it will remain oscillating and at the extreme position touch the plates.



118. (a) In air $F_{air} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$

In medium $F_m = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{Kr^2}$

$\therefore \frac{F_m}{F_{air}} = \frac{1}{K} \Rightarrow F_m = \frac{F_{air}}{K}$ (decreases K-times)

119. (d)

120. (c)

121. (c) Volume of 8 small drops = Volume of big drop

$8 \times \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R^3 \Rightarrow R = 2r$

As capacity is proportional to r, hence capacity becomes 2 times.

122. (b) The two capacitors are in parallel so

$C = \frac{\varepsilon_0 A}{t \times 2}(k_1 + k_2)$

123. (c) Common potential $V' = \frac{C_1 V + C_2 \times 0}{C_1 + C_2} = \frac{C_1}{C_1 + C_2} . V$

124. (c) $V_0 = \frac{q}{C_0}$

$V = \frac{q}{C} \Rightarrow \frac{V}{V_0} = \frac{C_0}{C}$

$\Rightarrow \frac{C_0}{C} = \frac{500}{75} = \frac{20}{3}$

By definition, $C = kC_0 \Rightarrow k = \frac{20}{3}$

125. (d) Let 'n' such capacitors are in series and such 'm' such branch are in parallel.

$\therefore 250 \times n = 1000 \quad \therefore \quad n = 4 \qquad \ldots(i)$

Also $\dfrac{8}{n} \times m = 16$

$$m = \frac{16 \times n}{8} = 8 \qquad \ldots(ii)$$

$\therefore$ No. of capacitor $= 8 \times 4 = 32$

126. (c) Capacitance of the capacitor, $C = \dfrac{Q}{V}$

After inserting the dielectric, new capacitance
$C^{I} = K.C$
New potential difference

$$V^{1} = \frac{V}{K}$$

$$u_i = \frac{1}{2}cv^2 = \frac{Q^2}{2C} \qquad (\because Q = cv)$$

$$u_f = \frac{Q^2}{2f} = \frac{Q^2}{2kc} = \frac{C^2V^2}{2KC} = \left(\frac{u_i}{k}\right)$$

$$\Delta u = u_f - u_i = \frac{1}{2}cv^2\left\{\frac{1}{k} - 1\right\}$$

As the capacitor is isolated, so change will remain conserved p.d. between two plates of the capacitor

$$L = \frac{Q}{KC} = \frac{V}{K}$$

127. (d) : Here, $V = 15 \times 10^6\ V$ dielectric strength $= 5 \times 10^7\ V\ m^{-1}$

Maximum electric field, E = 10% of dielectirc stength

$$\therefore \quad E = \frac{10}{100} \times 5 \times 10^7 = 5 \times 10^6\ V\ m^{-1}$$

As $E = \dfrac{V}{r}$

$$\therefore \quad r = \frac{V}{E} = \frac{15 \times 10^6}{5 \times 10^6} = 3\ m$$