UNIT-1 ELECTROSTATICS

VERY SHORT ANSWER QUESTIONS (1 Mark)

1. Draw schematically an equipotential surface of a uniform electrostatic field along x-axis.
2. Sketch field lines due to (i) two equal positive charges near each other (ii) a dipole.
3. Name the physical quantity whose SI unit is volt/meter. Is it a scalar or a vector quantity?
4. Two point charges repel each other with a force F when placed in water of dielectric constant 81. What will the force between them when placed the same distance apart in air? **Ans. :** (81F)
5. Electric dipole moment of $CuSO_4$ molecule is 3.2×10^{-32} Cm. Find the separation between copper and sulphate ions. **Ans. :** (10^{-3}m)
6. Net capacitance of three identical capacitors connected in parallel is 12 microfarad. What will be the net capacitance when two of them are connected in (i) parallel (ii) series? **Ans. :** $C_p = 8\mu f$ $Cs = 2\mu f$
7. A charge q is placed at the centre of an imaginary spherical surface. What will be the electric flux due to this charge through any half of the sphere. **Ans :** $q/2\epsilon_0$
8. Draw the electric field vs distance (from the centre) graph for (i) a long charged rod having linear charge density $\lambda < 0$ (ii) spherical shell of radius R and charge $Q > 0$.
9. Diagrammatically represent the position of a dipole in (i) stable (ii) unstable equilibrium when placed in a uniform electric field.
10. A charge Q is distributed over a metal sphere of radius R. What is the electric field and electric potential at the centre? **Ans. :** $E = 0$, $V = kQ/R$
11. If a body contains n_1 electrons and n_2 protons then what is the total charge on the body? **Ans. :** $(n_2 - n_1)e$
12. What is the total positive or negative charge present in 1 molecule of water. **Ans. :** 10e.
13. How does the energy of dipole change when it in rotated from unstable equilibrium to stable equilibrium in a uniform electric field.

Ans. : decreases

14. Write the ratio of electric field intensity due to a dipole at apoint on the equatorial line to the field at a point at a point on the axial line, when the points are at the same distance from the centre of dipole.

15. Draw equipotential surface for a dipole.

16. An uncharged conductor A placed on an insulating stand is brought near a charged insulated conductor B. What happens to the charge and potential of B? **Ans :** charge same, p.d. decrease

17. A point charge Q is placed at point O shown in Fig. Is the potential difference $V_A - V_B$ positive, negative or zero, if Q is (i) positive (ii) negative charge. **Ans :** When Q is + ive. $V_A - V_B > 0$

When Q is – ive, $V_A - V_B < 0$

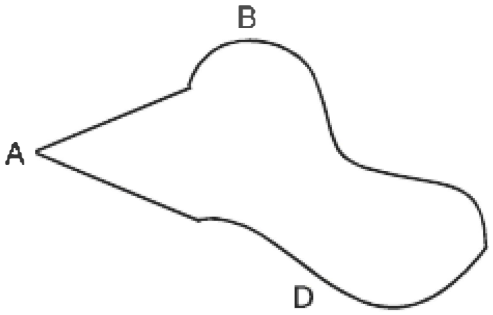
18. An electron and proton are released from rest in a uniform electrostatic field. Which of them will have larger acceleration? **Ans :** $a_e > a_p$

19. In an uniform electric field of strength E, a charged particle Q moves point A to point B in the direction of the field and back from B to A. Calculate the ratio of the work done by the electric field in taking the charge particle from A to B and from B to A. **Ans : 1 : 1**

20. If a dipole of charge 2μC is placed inside a sphere of radius 2m, what is the net flux linked with the sphere. **Ans :** Zero

21. Four charges + q, –q, +q, –q are placed as shown in the figure. What is the work done in bringing a test charge from ∞ to point 0.

23. If the metallic conductor shown in the figure is continuously charged from which of the points A,B,C or D does the charge leak first. Justify.



Ans : 'A'

24. What is dielectric strength? Write the value of dielectric strength of air.
Ans : 3×10^6 Vm^{-1}

25. Two charge –q and +q are located at points A (0, 0, –a) and B(0, 0, +a). How much work is done in moving a test charge from point (b, 0, 0) to Q (–b 0, 0)? **Ans :** Zero

26. If an electron is accelerated by a Potential difference of 1 Volt, Calculate the gain in energy in Joul and electron volt. **Ans.** 1.6×10^{-19} J, 1eV

27. Draw schematically the equipotential surface corresponding to a field that uniformly increases in magnitude but remains in a constant (say z) direction.

28. What is the work done in rotating a dipole from its unstable equilibrium to stable equilibrium? Does the energy of the dipole increase or decrease?

SHORT ANSWER QUESTIONS (2 Marks)

1. An oil drop of mass m carrying charge –Q is to be held stationary in the gravitational field of the earth. What is the magnitude and direction of the electrostatic field required for this purpose? **Ans :** E = mg/Q, downward
2. Find the number of field lines originating from a point charge of q = 8.854 μC.
Ans : $\phi = 10^{2}$ NC^{-1} m^2
3. If q is the positive charge on each molecule of water, what is the total positive charge in (360g) a Mug of water.
Ans : $q\left(\frac{360}{18} \times 6.02 \times 10^{23}\right)C$

4. Derive an expression for the work done in rotating an electric dipole from its equilibrium position to an angle θ with the uniform electrostatic field.

5. Show that there is always a loss of energy when two capacitors charged to different potentials share charge (connected with each other).

6. A thin long conductor has linear charge density of 20 μC/m. Calculate the electric field intensity at a point 5 cm from it. Draw a graph to show variation of electric field intensity with distance from the conductor.
Ans. : 72×10^5 N/C

7. What is the ratio of electric field intensity at a point on the equatorial line to the field at a point on axial line when the points are at the same distance from the centre of the dipole? **Ans :** 1:2

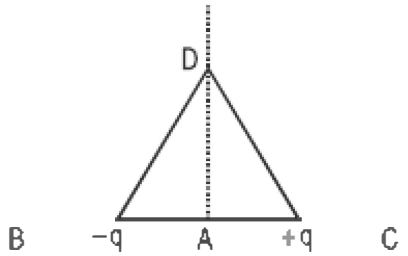
8. Show that the electric field intensity at a point can be given as negative of potential gradient.

9. A charged metallic sphere A having charge q_A is brought in contact with an uncharged metallic sphere of same radius and then separated by a distance d. What is the electrostatic force between them.

Ans : $\frac{1}{16\pi \epsilon_0} \frac{q_A^2}{d^2}$

10. An electron and a proton fall through a distance in an uniform electric field E. Compare the time of fall.

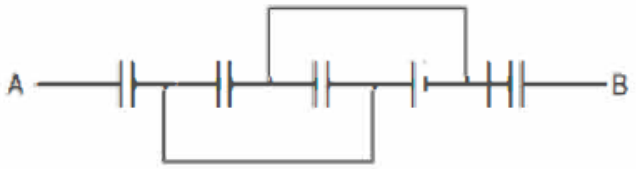
11. Two point charges –q and +q are placed 2l metre apart, as shown in fig. Give the direction of electric field at points A,B,C and D.



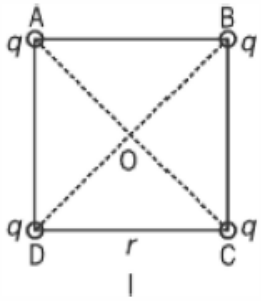
12. The electric potential V at any point in space is given $V = 20x^3$ volt, where x is in meter. Calculate the electric intensity at point P (1, 0, 2).
Ans : $60 NC^{-1}$

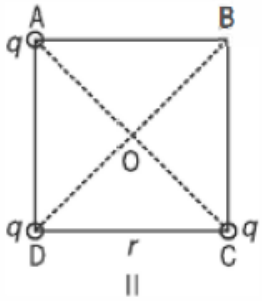
13. Justify why two equipotential surfaces cannot intersect.

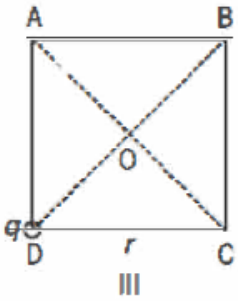
14. Find equivalent capacitance between A and B in the combination given below : each capacitor is of 2 μF. **Ans. :** 6/7 μF



15. What is the electric field at O in Figures (i), (ii) and (iii). ABCD is a square of side *r*.







Ans : (I) Zero, (II) $\frac{q}{4\pi\epsilon_0}\frac{1}{r^2}$ **(III)** $\frac{2q}{4\pi\epsilon_0}$

16. What should be the charge on a sphere of radius 4 cm, so that when it is brought in contact with another sphere of radius 2cm carrying charge of 10 μC, there is no transfer of charge from one sphere to other?

Ans : Va = Vb, Q = 20μC

17. For an isolated parallel plate capacitor of capacitance C and potential difference V, what will happen to (i) charge on the plates (ii) potential difference across the plates (iii) field between the plates (iv) energy stored in the capacitor, when the distance between the plates is increased?

Ans : (i) No change (ii) increases (iii) No change (iv) increases.

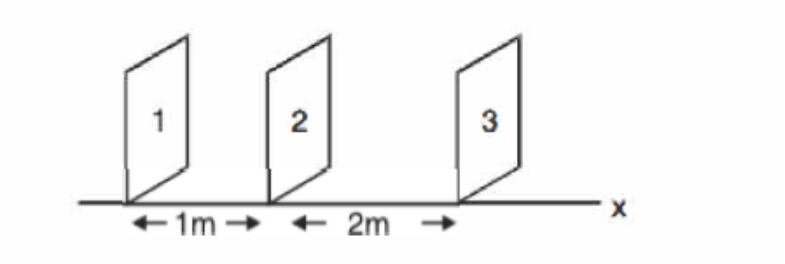
18 Does the maximum charge given to a metallic sphere of radius R depend on whether it is hollow or solid? Give reason for your answer. **Ans :** No charge resides on the surface of conductor.

19. Two charges Q_1 and Q_2 are separated by distance r. Under what conditions will the electric field be zero on the line joining them (i) between the charges (ii) outside the charge?

Ans : (i) Charge are alike (ii) Unlike charges of unequal magnitude.

20 Obtain an expression for the field due to electric dipole at any point on the equatorial line.

21. The electric field component in the figure are $\vec{E}_x = 2x\hat{i}$, $\vec{E}_y = E_z = 0$, . Calculate the flux through, (1,2,3) the square surfaces of side 5m.



22. Calculate the work required to separate two charges 4μc and –2μc placed at (–3cm, 0, 0) and (+3cm, 0, 0) infinitely away from each other.

23. What is electric field between the plates with the separation of 2cm and (i) with air (ii) dielectric medium of dielectric constant K. Electric potential of each plate is marked in Fig.

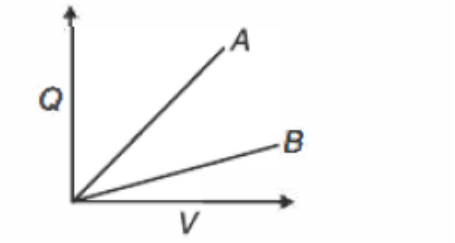
150 V

(i) –50 V

Ans. : $E_0 = 10^4 NC^{-1}$, $E = \frac{10^4}{k} NC^{-1}$

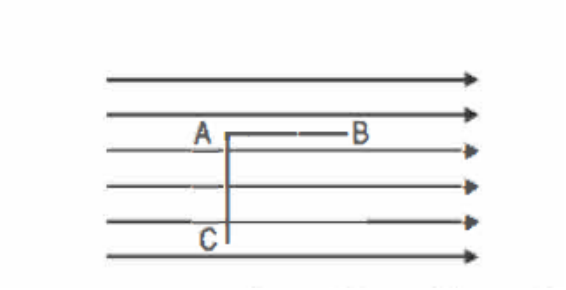
24. A storage capacitor on a RAM (Random Access Memory) chip has a capacity of 55pF. If the capacitor is charged to 5.3V, how may excess electrons are on its negative plate? **Ans. :** 1.8×10^9

25. The figure shows the Q (charge) versus V (potential) graph for a combination of two capacitors. Identify the graph representing the parallel combination.



Ans : A represents parallel combination

26. Calculate the work done in taking a charge of 1 μC in a uniform electric field of 10 N/C from B to C given AB = 5 cm along the field and AC = 10 cm perpendicular to electric field.



Ans : $W_{AB} = W_{BC} = 50 \times 10^{-8}$ J, $W_{AC} = 0$J

27. Can two equi potential surfaces intersect each other? Give reasons. 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)? (zero)

28. The potential at a point A is –500V and that at another point B is +500V. What is the work done by external agent to take 2 units (S.I.) of negative charge from B to A.

29. How does the Potential energy of (i) mutual interaction (ii) net electrostatic P.E. of two charges change when they are placed in an external electric field.

30. With the help of an example, show that Farad is a very large unit of capacitance.

31. What is meant by dielectric polarisation? Why does the electric field inside a dielectric decrease when it in placed in an external field?

SHORT ANSWER QUESTIONS (3 Marks)

1. Define electrostatic potential and its unit. Obtain expression for electrostatic potential at a point P in the field due to a point charge.

2. Calculate the electrostatic potential energy for a system of three point charges placed at the corners of an equilateral triangle of side 'a'.

3. What is polarization of charge? With the help of a diagram show why the electric field between the plates of capacitor reduces on introducing a dielectric slab. Define dielectric constant on the basis of these fields.

4. Using Gauss's theorem in electrostatics, deduce an expression for electric field intensity due to a charged spherical shell at a point (i) inside (ii) on its surface (iii) outside it. Graphically show the variation of electric field intensity with distance from the centre of shell.

5. Three capacitors are connected first in series and then in parallel. Find the equivalent capacitance for each type of combination.

6. A charge Q is distributed over two concentric hollow sphere of radii r and R (R>r), such that their surface density of charges are equal. Find Potential at the common centre.

7. Derive an expression for the energy density of a parallel plate capacitor.

8. You are given an air filled parallel plate capacitor. Two slabs of dielectric constants K_1 and K_2 having been filled in between the two plates of the capacitor as shown in Fig. What will be the capacitance of the capacitor of initial area was A distance between plates d?

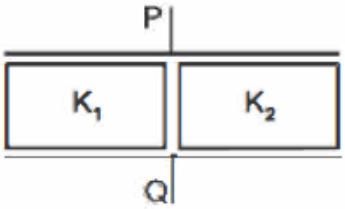


Fig. 1

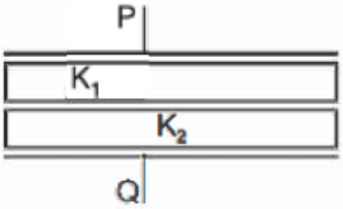
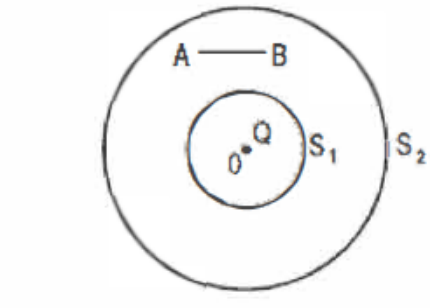


Fig. 2

$$C_1 = (K_1 + K_2)C_0$$

$$C_2 = \frac{K_1 K_2 C_0}{(K_1 - K_2)}$$

9 In the figure shown, calculate the total flux of the electrostatic field through the sphere S_1 and S_2. The wire AB shown of length l has a liner charge density λ given $\lambda = kx$ where x is the distance measured along the wire from end A.



Ans. Total charge on wire AB = $Q = \int_0^l \lambda\, dx = \int_0^l k\, x\, dx = \frac{1}{2}Kl^2$

By Gauss's theorem.

Total flux through $S_1 = \frac{Q}{\epsilon_0}$

Total flun through $S_2 = \frac{Q+\frac{1}{2}kl^2}{\epsilon_0}$

0. Explain why charge given to a hollow conductor is transferred immediately to outer surface of the conductor.

. Derive an expression for total work done in rotating an electr ic dipole through an angle θ in an uniform electric field Hence calculate the potential energy of the dipole.

2. Define electric flux. Write its SI unit. An electric flux of ϕ units passes normally through a spherical Gaussian surface of radius r, due to point charge placed at the centre.

   (1) What is the charge enclosed by Gaussian surface?

   (2) If radius of Gaussian surface is doubled, how much flux will pass through it?

13. A conducting slab of thickness 't' is introduced between the plates of a parallel plate capacitor, separated by a distance d (t<d). Derive an expression for the capacitance of the capacitor. What will be its capacitance when t = d?

14. If a dielectric slab is introduced between the plates of a parallel plate capacitor after the battery is disconnected, then how do the following quantities change.

   (i) Charge

   (ii) Potential

   (iii) Capacitance

   (iv) Energy.

15. What is an equipotential surface? Writc ils three properties Sketch equipotential surfaces of

   (i) Isolated point charge

(ii) Uniform electric field

(iii) Dipole

LONG ANSWER QUESTIONS (5 MARKS)

1. State the principle of Van de Graaff generator. Explain its working with the help of a neat labelled diagram.

2. Derive an expression for the strength of electric field intensity at a point on the axis of a uniformly charged circular coil of radius R carrying charge Q.

3. Derive an expression for potential at any point distant *r* from the centre O of dipole making an angle θ with the dipole.

4. Suppose that three points are set at equal distance r = 90 cm from the centre of a dipole, point A and B are on either side of the dipole on the axis (A closer to +ve charge and B closer to B) point C which is on the perpendicular bisector through the line joining the charges. What would be the electric potential due to the dipole of dipole moment 3.6×10^{-19} Cm at points A, B and C?

5. Derive an expression for capacitance of parallel plate capacitor with dielectric slab of thickness t(t<d) between the plates separated by distance d. How would the following (i) energy (ii) charge, (iii) potential be affected if dielectric slab is introduced with battery disconnected, (b) dielectric slab is introduced after the battery is connected.

6. Derive an expression for torque experienced by dipole placed in uniform electric field. Hence define electric dipole moment.

7. State Gauss's theorem. Derive an expression for the electric field due to a charged plane sheet. Find the potential difference between the plates of a parallel plate capacitor having surface density of charge 5×10^{-8} Cm^{-2} with the separation between plates being 4 mm.

8. Derive an expression for capacitance of parallel plate capacitor with dielectric slab of thickness t (t<d) between the plates separated by distance d. If the dielectric slab is introduced with the battery connected, then how do the following quantities change (i) charge (ii) potential (iii) capacitance (iv) energy.

9. Using Gauss's theorem obtain an expression for electric field intensity due to a plane sheet of charge. Hence obtain expression for electric field intensity in a parallel plate capac'tor.

10. Write five to six important results regarding eloectro statics of conductors.