Electrostatic potential and capacitors

Multiple choice –

1.n small drops of the same size are charged to V volt each. If they coalesce to from a single large drop, then its potential will be:

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

2.Two conduction spheres of radii r_1 and r_2 are at the same potential. The ratio of their charges is:

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

3.Two conduction spheres of radii r_1 and r_2 are equally charged. The ratio of their potential is:

(a) (r_1^2/r_2^2) (b) (r_2^2/r_1^2) (c) (r_1/r_2) (d) (r_2/r_1)

4. Two concentric thin metallic sphere of radii R_1 and R_2 ($R_1 > R_2$) bear charge Q_1 and Q_2 respectively. Then the potential at radius r between R_1 and R_2 will be $1/(4\pi\varepsilon_0)$ times:

(a) $Q_1 + Q_2/r$ (b) $Q_1R_1 + Q_2/r$ (c) $Q_1/R_1 + Q_2/R_2$ (d) $Q_1/R_2 + Q_2/R_1$

5. An electron of mass m and charge e is accelerated from rest through a potential difference V in vacuum. Its final speed will be:

(a) √2eV/m (b) √eV/m (c) √eV/2m (d) eV/m

6. The kinetic energy of an electron, which is accelerated in the potential difference of 100 V, is:

(a) 1.6×10^{-17} J (b) 1.6×10^{-14} J (c) 1.6×10^{-10} J (d) 1.6×10^{-8} J

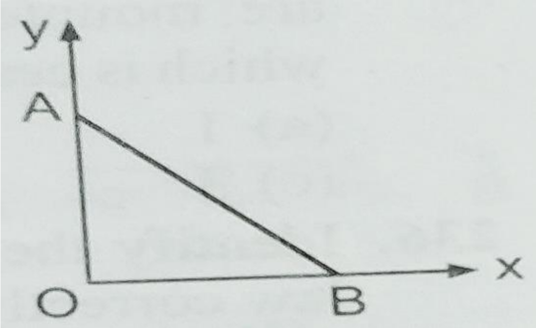
7. The radii of two sphere are a and b respectively. They are at equal electric potential. The ratio of their surface density of charge is:

(a) a^2/b^2 (b) b/a (c) a/b (d) b^2/a^2

8. Potential at a point x-distance from the centre inside the conduction sphere of radius R and charged with charge Q is:

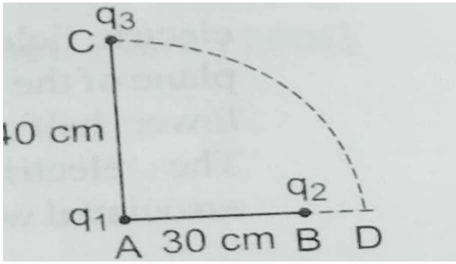
(a) Q/x^2 (b) Q/x (c) Q/R (d) xQ

9. As per diagram, a point charge +q is placed at the origin O. Work done in taking another charge -Q from the point A [co-ordinate (0, a)] to another point B [co-ordinate (a, 0)] along the straight path AB is:



(a) $(Qq/4\pi\varepsilon_0 a^2)\ \sqrt{2}a$
(b) zero
(c) $(-Qq/4\pi\varepsilon_0 a^2)\ \sqrt{2}a$
(d) $(Qq/4\pi\varepsilon_0 a^2)\ a/\sqrt{2}$

10. Two charge q_1 and q_2 are placed 30 cm apart, as shown in the figure. A third charge q_3 is moved along the are of a circle of radius 40 cm from C to D. The change in the potential energy of the system is $q_3/4\pi\varepsilon_0\, k$, where k is:



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

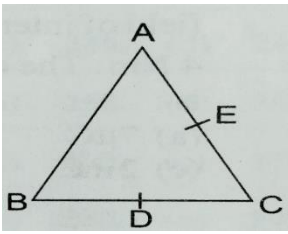
11. The potential of a large liquid drop when eight liquid drop are combined is 20 V. Then, the potential of each single drop was:

(a) 10 V (b) 7.5 V (c) 5 V (d) 2.5 V

12. Two point charge +5μC and -2μC are kept at a distance of 1m in free space. The distance between the two zero potential points on the line joining the charges is:

(a) 2/7m (b) 2/3m (c) 22/21m (d) 20/21m (e) 8/21m

13. Three charges, each + q , are placed at the corners of an isosceles triangle ABC of sides BC and AC, 2a. D and E are the mid-points of BC and CA. The work done in taking a charge Q from D to E, is: fig



(a) $3qQ/4\pi\varepsilon_0 a$ (b) $3qQ/8\pi\varepsilon_0 a$ (c) $qQ/4\pi\varepsilon_0 a$ (d) zero

Fill in the blanks-

1. Electric field E at a point is perpendicular to the ___________________________ surface through the point.

Ans. Equipotential

2. The potential energy of a charge q is placed in potential $V(r)$ is ___________________________.

Ans. $\{qV(r)\}$

3. It is safer to be inside the car rather than standing outside under a trace during lightening is based on concept.

Ans. Electrostatic shielding

4. A capacitor plates are charged by a battery. After charging battery is disconnected and a dielectric slab is inserted between the plates, the charge on the plates of capacitor __________________.

Ans. Remain same

5. The amount of work done is bringing a charge q from infinity to a point un-accelerated and is equal to acquired by the charge.

Ans. Electrostatic potential energy

6. The value of potential energy of an electric dipole in uniform electric field along the dissection of field is_______________________________________.

Ans. $U = -\vec{p}.\vec{E}$

7. Electric field is always ……………… to the equipotential surface.

Ans. (perpendicular)

8. Work done to bring a unit positive charge un-accelerated from infinity to a point in electric field is called ……….

Ans. (electric potential)

9. Unit of capacitance is………………..

Ans. (Farad)

10. Unit of electric potential is ……………

Ans. (Volt)

11. A capacitor is charged and is not connected to a battery; Potential between plates of the capacitor ……………. when it is filled with dielectric.

Ans. (Decrease)

12. Equipotential surface due to a point charge will be ………. in shape.

Ans. (Spherical)

13. Equipotential surfaces due to long linear charge distribution will be ………. in shape.

Ans. (Cylindrical)

14. Two capacitors each of capacitance 2μF are connected in series . Equivalent capacitance will be ……..

Ans. (1μF)

Very short answer type questions (1 marks)-

1. Draw an equipotential surface for a uniform electric field .

2. Define electrostatic potential ,write its unit , is it a scaler or vector ?

3. Deduce dimensionl formula of potential difference.

4. Why electrostatic potential surface is constant throughout the volume of the cnductor and has the same value as on the surface?

5. Can two equipotential surface intersect each other? Justify your anwer.

6. What is the electric potential due to an electric dipole at an equitorial line?

7. Draw the equipotential surface due to a single point charge.

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

9. Why there is no work done in moving a charge fro one point to other on an equipotential surface?

Short answer type questions (2 marks)-

1. Establish relation between electric field and potential gradient.

2. Derive the expression for the electric potential V with distance r due to a point charge Q.

3.Find out the expression for the potential energy of a system of three charges q_1,q_2 and q_3 iocated at r_1 ,r_2 and r_3 with respect to the common origin O .

4. Draw three equipotential surfaces corresponding to a field that uniformally increases in magnitude but remain constant along Z direction . How are these surfaces different from that of a constant electric field along Z direction.

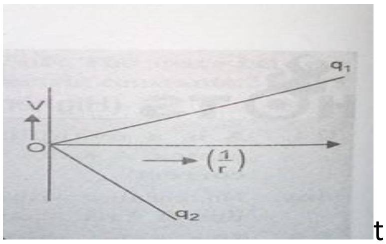
5. Write two charecteristics of equipotential surfaces . Draw the equipotential surfaces due to an electric dipole.

6. Derive the expression for the electric potential at any point on the axial line of an electric dipole .

7. Derive the expression for the electric potential at a point due to an electric dipole . Mention the constrasting features of electric potential of a dipole at a point as compared to that due to a single charge

8. The two graph drawn below show that the variation of electrostatic potential (V) with 1/r for two point charges q1 and q2 (r is the distance between the charges) , what are the sign of two

charges, and which of



the two charges has largest magnitude and why?

Long answer type questions (3 and 5 marks)-

1. Two uniformly large parallel thin plates having charge densities +σ and - σ 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' remain stationary between the plates, what is the magnitude and direction of this field?

2. Draw schematically equipotential surface corresponding to(a) A constant electric field in Z- direction.(b) A filed that uniformly increases in magnitude but remains in a constant (say Z) direction.(c) A single positive charge at the origin.(d) A uniform grid consisting of along equally spaced parallel charged wires in a plane.

3. 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 exists tangential to an equipotential surface? Give reason.

4. Deduce an expression for the potential energy of the system of two point charges q_1 and q_2 brought from infinity to the points $r1$ and r_2 respectively in the presence of external electric field E.

5. A small sphere of radius r_1 and charge q_1 is enclosed by a spherical shell of radius r_2 and charge q_2. Show that if q_1 is positive, charge will necessarily flow from the sphere to the shell (when the two are connected by a wire), no matter, what the charge q_2 on the shell is.

6. A cube of side b has a charge q at each of its vertices. Determine the potential and electric field due to this charge-array at the centre of the cube.

7. 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 dialectic slab of thickness d and dielectric constant K is now placed between the plates. What changes 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.

8. A parallel plate is charged by a battery. When the battery remains connected, a dielectric slab is inserted in the space between the plates. Explain what changes if any, occur in the values of (i) potential difference between the plates (ii) electric field strength between the plates (iii) Capacitance (iv) charge on the plates (v) energy stored in the capacitor?

Numericals-

1. An electric dipole of length 10 cm having charges 6×10^{-3} C, placed at 30° with respect to uniform electric field, experience a torque of magnitude $6\sqrt{3}$ Nm. Calculate (i) magnitude of electric field and (ii) potential energy of electric dipole.

2. 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.

3. A capacitor of unknown capacitance is connected across the battery of V votes. The charge stored in it is 360 μC. When potential across the capacitor is reduced by 120 V, the charge stored in it becomes 120 μC. 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?

4. A 600 pF capacitor is charged by a 200 V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. How much electrostatic energy is lost in the process?

5. Three capacitors of capacitances 2 pF, 3 pF and 4 pF are connected in parallel (a) What is the total capacitance of the combination?(b) Determine the charge on the each capacitor if the combination is connected to 100 V supply.

6. (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 accumulated on the capacitor C_2? (b) Three identical capacitors each of capacitance 3 μF are connected, in tern, in series and in parallel combination to the common source of the V volt. Find out the ratio of the energies stored in two configurations.

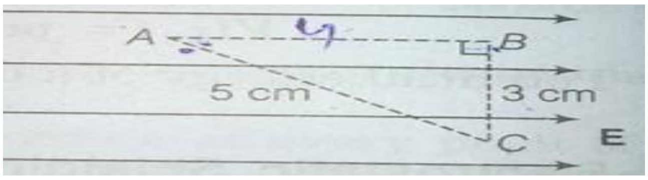
7. A network of four capacitors each of 15 μF capacitance is connected to a 500 V supply as shown in the figure. Determine (a) equivalent capacitance of the network and (b) charge on each capacitor.

8. A 4 μF capacitor is charged by a 200 V supply. It is then disconnected from the supply and is connected to another unchanged 2 μF capacitor. How much electrostatic energy of the first capacitor is lost in the form of heat and electromagnetic radiation?

9. In the following arrangement of capacitors, the energy stored in the 6 μF capacitor is E. Find the value of the following:(i) Energy stored in 12 μF capacitor. (ii) Energy stored in 3 μF capacitor.(iii) Total energy drawn from the battery.

10.Two point charges $q_1=10\times10^{-8}$C and $q_2=-2\times10^{-8}$C are separated by a distance of 60 cm in air. (1)what a distance from the first charge q_1 would the electric potential be zero? (2)Also calculate the electrostatic potential energy of the system.

11. A test chargeq is moved withought acceleration from A to B and then from B to C along the path from A to B and then from B to C in electri field E as shown in fig. (i) calculate the potential difference between A and C . (ii) at which point is the electric potential more and why?



12. Two parallel plate capacitors X and Y have the same area of plates and same separation between them. X has air between the plates and Y contains a dielectric medium _____ (Page , Q44)

(i) Calculate the capacitance of each capacitor if equivalent capacitance of the combination is 4 μF.

(ii) Calculate the potential difference between the plates of X and Y.

(iii) Estimate the ratio of electrostatic energy stored in X and Y.

Hots –

Q1. Find the potential difference of V_{AB} between A (2, 1, 0) and B (0, 2, 4) in the electric filed

$\vec{E} = x\vec{i} - 2x\vec{j} + z\vec{k}$.

Q2.Two point charges q_1 and q_2 are placed a distance r apart . represent graphically the variation of force F on q_2 with (i) magnitude of q_2 (ii) the distance r from q_2 . (iii) $1/r^2$.

Q3. Equipotential surfaces with potential 2V, 4V, 6V, 8V parallel to Y axis are as shown.

Calculate the electric field intensity in the region.

Q4. Two charges of magnitude q each are placed 4 m apart. Represent variation of electrostatic potential at P as x increases from 0 cm to 4 cm. At what position will the potential become minimum?

Q5. In the adjoining figure; two large flat parallel sheets have uniform surface charge density + σ and - σ respectively.

Represent the variation of electric field as we move from O to A.

$$V_{AB} = -\int_B^A \vec{E}\,\vec{dr} = -\int_B^A (E_x dx + E_y dy + E_z dz)$$

Q6. Two uniformally charged parallel large thin plane sheet having charge densities +σ and -σ are kept in the X-Z plane at a distance d apart . sketch an equipotential surface due the electric field between the plates . If a particle of mass m and charge -q remain stationary between the plates what is the magnitude and direction of this field ?

Q7. Calculate the equivalent capacitance of the combination shown between A and B.

Q8. Given two characteristic fundamental properties of electric charge . A uniform electric field ‘E’ of NC^{-1} is directed along PQ. A, B and C are three points in the filed having x and y coordinates (in meters) as shown in the figure. Calculate potential difference between the points. (a) A and B and (b) B and C.

Q9. A proton is to be accelerated to a speed equal to 10% that of light. To what potential difference is the proton to be subjected?

Q10. Two charges Q_1 and Q_2 and the electric filed lines around them are a shown.

(a) What is the nature of the charges Q_1 and Q_2?

(b) What is the sign of potential difference

(i) V_P-V_Q (ii) V_B-V_A?

(c) What is the sign of potential energy difference of a small negative charge between points (i) Q and P (ii) A and B?

(d) Give the sign of work done by the electric field in moving a small positive charge from Q to P.

(e) A small negative charge move from B to A. Will its kinetic energy increase or decrease?

Q11. A dielectric slab is introduced in the space between the plates of a parallel plate capacitor so that it just fills the space. The capacitor is charged and then disconnected from the source. Plot the variation of

(i) Charge (ii) capacitance

(iii) potential difference across the plates and the length of the dielectric slab pulled out. Justify your answer.

Q12. Consider parallel plate capacitor with a dielectric in between the plates as shown

Given $\sigma_1 = 8.85\ \mu\ C/m^2$

$\sigma_2 = -\ 8.85\ \mu\ C/m^2$

Dielectric constant = 2.

Represent graphically the variation of electric field intensity as we move from plate (1) to plate (2).

Q13. n identical capacitors when joined in series give an effective capacitance of C units. What will be the capacitance if the capacitors are now placed in parallel combination.

Q14. Eight capacitors of capacitance 'C' each connected in parallel to a source store a total energy of 64 units. How much energy will be stored if the capacitors are now joined in series to the same source.