PHYSICS

BOOKS - CHHAYA PHYSICS (BENGALI ENGLISH)

ELECTRIC POTENTIAL

Numerical Examples

1. A region is specified by the potential function $V = 2x^2 + 3y^3 - 5z^2$. Calculate the electric field intensity at a point (2,4,5) in this region.

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2. Two point A and B are situated at distance 1 m and 2m form the source of an electrostatic field. The field at a distance x from the source is $E = \frac{5}{x^2}$. What is the potential difference between A and B?

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3. In an electric field, the potential V(x), depending only on the x-coordinate, is given by $V(x) = ax - bx^3$, where a and b are constants,

find out the points on the x -axis where the electric field intensity would vanish.

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4. Two point charges of +49 esu and +81 esu are placed at a separation of 100 cm in air. Determine the position of the neutral point in the electric fields of the two charges. What is the electric potential at the natural point?

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5. An electron is subjected to a potential difference of 180 V. Mass and charge of an electron are $9 \times 10^{-31} kg$ and $1.6 \times 10^{-19} C$, respectively. Find the velocity acquired by the electron.

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6. At each of the four vertices of a square of side 10 cm, four positive charges each of 20 esu are placed. Find the potential at the point of intersection of the two diagonals.

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7. The distance between two points A and B in vacuum is 2d. At each of these two points a + Q charge is placed. P is the midpoint of AB. Find the intensity and potential at P due to the electric field. How will the values of these quantities change if the charge at B is replaced by a charge -Q ?

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8. Four point charges of +100 esu,-50 esu +20 esu and +30 esu are placed respectively at the four vertices A,B,C,D of a square of side 10 cm. Find the

electric intensity and potential at the point of intersection of the diagonals.

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9. Electrons starting from rest and passing through a potential difference of 60 kV are found to acquire a velocity of $1.46 \times 10^{10} cm \cdot s^{-1}$. Calculate the ratio of charge to the mass of an electron.

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10. A particle charged with $1.6 \times 10^{-19} C$ is in motion. It enters the space between two parallel metal plates, parallely along the midway between them. The plates are 10 cm long and the separation between them is 2 cm. A potential difference of 300V exists between the plates. Find out the maximum velocity of the charged particle at the point of entry, for which it would be unable to emerge from the space between the plates. Given, mass of the particle = $12 \times 10^{-24} kg$.

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11. An infinite number of charges, each of value q, are placed on the x-axis at the points x = 1 , x = 2, x = 4 , x = 8, ... Find the potential and intensity due to these charges at x = 0. If the charges are alternately positive and negative what will be the potential and intensity at the same point?

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12. Two equally charged soap bubbles of equal volume are joined together to form a larger bubble . If each bubble had a potential V, find the potential of the resultant bubble.

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13. An electric dipole of moment $5 \times 10^{-8} C \cdot m$ is placed in an electric field of magnitude $4 \times 10^{5} N \cdot C^{-1}$. What amount of work is to be done to deflect it through an angle 60° ?

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14. Find out the maximum charge on an unearthed hollow metal sphere of radius 3.0m for which it would not discharge into air. What would be the potential of the sphere in that condition? Assume

that, electric discharge into air initiates at a field intensity of $3 \times 10^6 V \cdot m^{-1}$.

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15. Find the potential at the centre of a square of side $\sqrt{2}m$ which carries at its four corners charges $+2 \times 10^{-9} C$, $+1 \times 10^{-9} C$, $-2 \times 10^{-9} C$ and $+3 \times 10^{-9} C$.

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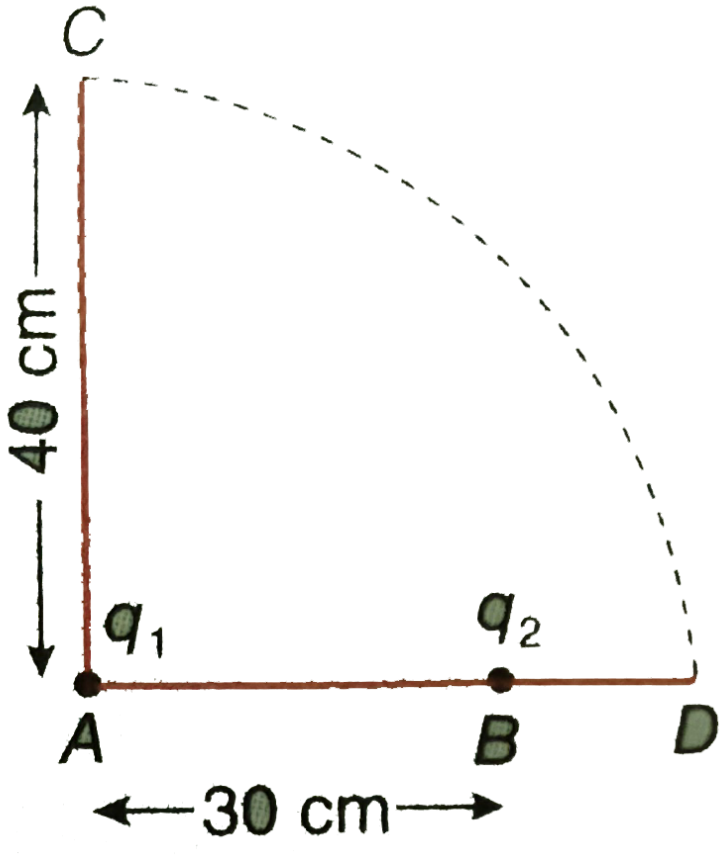
16. Two charge q_1 and q_2 are placed 30 cm apart as shown in fig. A third charge q_3 is moving along the arc of a circle of radius 40 cm from C to D. The change in the potential energy of the system is

$\frac{q^3}{4\pi\varepsilon_0}k$. What is the value of k?



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17. Two charges, each of $+10^3$ esu, are placed at two points A and B separated by a distance of 200 cm. From the middle point of AB, along its perpendicular bisector, a particle having -10^3 esu of charge is thrown upwards with energy 10^4 erg. Determine the maximum height attained by the particle. The effect of gravitation can be neglected.

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18. Two point charges of values -20 esu and +20 esu are placed on the x-axis at $x = -10cm$ and $x = +10cm$ respectively.

Calculate

The potentials at the middle of them

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19. Two point charges of values -20 esu and +20 esu are placed on the x-axis at $x = -10cm$ and $x = +10cm$ respectively. Calculate

(ii) The electric fields at the points $P(1, 10)$ and $Q(20, 0)$.

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20. Two point charges of values -20 esu and +20 esu are placed on the x-axis at $x = -10cm$ and $x = +10cm$ respectively. Calculate

(iii) Find the work done in carrying a positive charge of value +6 esu from P to Q along a straight the joining them.

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21. Two point charges of values -20 esu and +20 esu are placed on the x-axis at $x = -10cm$ and $x = +10cm$ respectively.

Calculate

(iv) Is there any path along which the work done is less than the above value ? Why?

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22. Two circular loops of radii 0.05 m and 0.09m are placed such that their axes coincide and their centres are 0.12m apart. Charge of $10^{-6}C$ is spread uniformly on each loop. Find the potential difference between the centres of loops.

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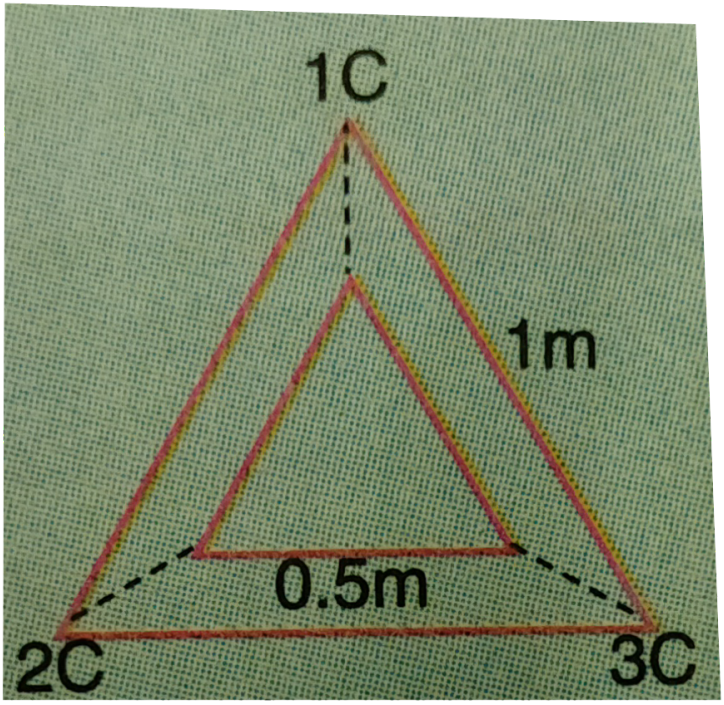
23. Three point charges 1C, 2C and 3C are placed at the corners of an equilateral triangle of side 1m. Calculate the work required to move these charges to the corners of a smaller equilateral triangle of side 0.5 m as shown.



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24. A non-conducting disc of radius a with uniform positive surface charge density σ is placed on the ground with its axis vertical. A particle of mass m and positive charge q is dropped along the axis of the disc from a height H with zero initial velocity. Charge per unit mass of the particle is $\frac{q}{m} = \frac{4\varepsilon_0 g}{\sigma}$.

(i) Find the value of H if the particle just reaches the disc.

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25. A non-conducting disc of radius a with uniform positive surface charge density σ is placed on the

ground with its axis vertical. A particle of mass m and positive charge q is dropped along the axis of the disc from a height H with zero initial velocity. Charge per unit mass of the particle is $\frac{q}{m} = \frac{4\varepsilon_0 g}{\sigma}$.

(ii) Find the height for its equilibrium position.

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26. Positive charges of magnitude 6nC, 12 nC, and 24 nC are placed at the vertices, A, B and C of a square ABCD of side 20 cm. What is the amount of work done to place a charge of 1C at vertex D?

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27. A proton is fired with a velocity $7.45 \times 10^5 m/s$ towards another free proton at rest. Calculate the minimum distance of approach between the protons. The mass of a proton = $1.66 \times 10^{-22} kg$.

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28. Charge Q is distributed between two concentric hollow sphere placed in vacuum in such a way that their surface densities of charges are equal. If the radii of the two spheres be r and R (R gt r), calculate the potential at their centre.

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29. Charges $+2 \times 10^{-7} C, -4 \times 10^{-7} C$ and $+8 \times 10^{-7} C$ are placed at the vertices of an equilateral triangle of side 10 cm in air. Determine the electrical potential energy of this system of charges.

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30. In vacuum, three small spheres are placed on the circumference of a circle of radius r in such a way that an equilateral triangle is formed. If q be

the charge on each sphere, determine the intensity of electric field and potential at the centre of the circle.

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31. A charged particle q is thrown with a velocity v towards another charged particle Q at rest. It approaches Q up to a closest distance r and then returns. If q is thrown with a velocity 2v, what should be the closest distance of approach?

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32. In vacuum, four charges each equal to q are placed at each of the four vertices of a square. Find the intensity and potential of the electric field at the point of intersection of two diagonals.

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33. Three point charges q , 2q and 8q are to be placed on a 0.09m long straight line. Find the positions of the charges so that the potential energy of this system becomes minimum. In this situation, find the intensity at the position of the charge q due to the other two charges?

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Section Related Questions

1. What do you mean by potential of a charged body?

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2. Define potential at a point in an electric field.

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3. What do mean by the potential difference between two points in an electric field?

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4. What do you mean by a potential difference of 1 volt?

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5. What is the SI unit of electric potential?

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6. What is the relation between the CGS and SI unit of potential?

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7. What is the relation between statvolt and volt?

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8. Define 1 esu of potential.

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9. The potential of the earth is zero. Explain the statement.

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10. The potential difference between two points in an electric field does not depend on the path connecting them. Explain.

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11. Determine the potential at a distance r from a point charge +q. How can the potential at a point

be determined due to a number of point charges?

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12. Define electric potential. Determine the electric potential at a distance r from a point charge q placed in vacuum. What would be the change in the potential if the charge is placed in a medium of dielectric constant k?

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13. For a small dipole,

(i) find out an expression for the electric potential at an axial point.

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14. For a small dipole,

(ii) Show that the electric potential vanishes at all points on the perpendicular bisector of the dipole.

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15. For a small dipole,

(iii) Find out an expression for the electric potential at a distance r from the centre of an electric dipole and inclined at an angle θ with the axis.

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16. Deduce the relation between electric field intensity and potential at a point in an electric field.

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17. What do you mean by potential gradient?

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18. What are the values of electric potential and intensity at (i) an external point.

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19. What are the values of electric potential and intensity at

(i) an external point.

(ii) an internal point, due to a uniformly charged sphere?

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20. What do you mean by the electrical potential energy of a system of charges?

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21. Define electron volt. Express it in joule.

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22. How will you determine the electrical potential energy of a system of charges?

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23. How does a charged body obtain kinetic energy under the influence of an electric field? Find out an expression for the kinetic energy.

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24. Distinguish between electric potential and electric potential energy.

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25. What do you mean by the potential energy of an electric dipole?

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Higher Order Thinking Skill Hots Questions

1. If the intensity at a point in an electric field is zero, will the electric potential be also zero at that point? If the electric potential be zero at a point, will the intensity be also zero at the point?

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2. Two hollow conductors are charged positively. The potential of the smaller conductor is 50V and that of the larger conductor is 100V. How are these two conductors to be placed so that when connected by a wire, charges will flow from the smaller conductor to the larger one?

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3. Explain the variations of potential and field intensity with distance due to a hollow charged spherical conductor (radius a and charge q), both inside and outside the sphere, with a graph.

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4. Potential difference between two conductors is very large. What will happen under the following three conditions?

(i) The conductors are connected by a metallic wire.

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5. Potential difference between two conductors is very large. What will happen under the following three conditions?

(ii) Both positive and negative ions are present in the air medium in between the conductors.

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6. Potential difference between two conductors is very large. What will happen under the following

three conditions?

(iii) The conductors are placed in vacuum.

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7. Give an example of a line in the electric field of an electric dipole along which a positive charge may be moved without any work being done.

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8. Can two different equipotential surfaces intersect each other?

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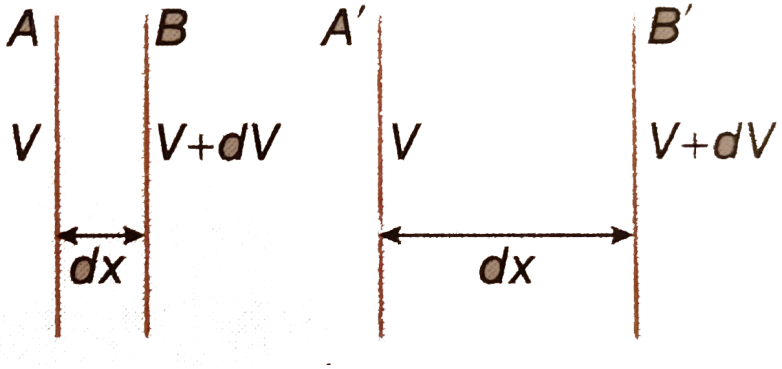
9. In fig., two pairs of planes A,B and A', B' are kept in two uniform electric fields. Potential difference between the planes in the two cases are equal. Which pair of planes is situated in a stronger electric field?



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10. A positively charged and a negatively charged body are connected to the earth separately. What will be their potentials before and after connection ?

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11. When a body is connected with earth, electrons are found to move from the earth to the body. What is your idea about the nature of charge of the body?

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12. In vacuum, equal charges of the same nature are placed at the vertices of an equilateral triangle. What will be the electric field intensity and potential at the centroid of the triangle?

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

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14. A unit positive charge is moving along PQR in an electric field of intensity E (fig). What is the potential difference between the points P and R?

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15. Fig. shows the variation of electric potential V with $\frac{1}{r}$ for two charge Q_1 and Q_2 (where r is the distance from a point charge).

(i) What are the natures of the charges Q_1 and Q_2 ?

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16. Fig. shows the variation of electric potential V with $\frac{1}{r}$ for two charge Q_1 and Q_2 (where r is the distance from a point charge).

(ii) Which of the two charges is greater in magnitude ? Justify.

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17. Two electric charges q and -2q are placed 6m apart on a horizontal plane. Find the locus of any point on this plane where the potential has a value zero.

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18. A charge Q is uniformly distributed over a long rod AB of length L as shown in the figure. Determine the electric potential at the point O lying at a distance L from the end A.

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19. A conducting bubble of radius a, thickness t (lt lt a) has a potential V. Now the bubble transforms into a droplet. Find the potential on the surface of the droplet.

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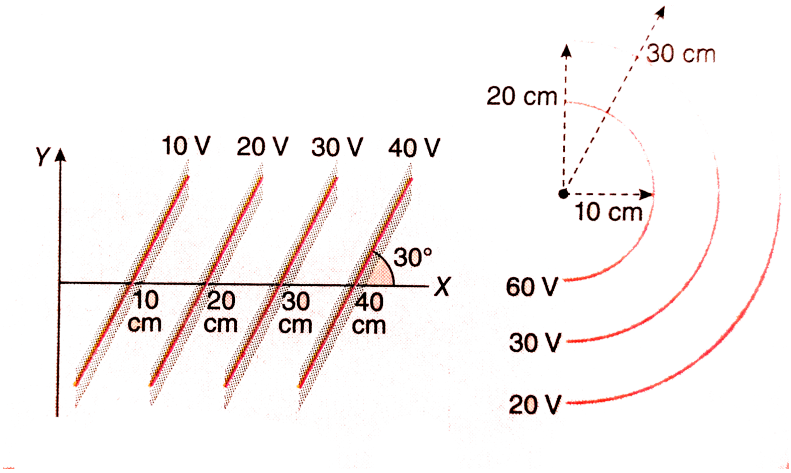
20. Some equipotential surfaces are shown in fig. What can you say about the magnitude and the

direction of the electric field intensity?



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21. The radii of two concentric metal spheres are a and b (b gt a). The outer sphere is charged with a charge q. If the inner sphere is connected to the earth, what will be its charge?

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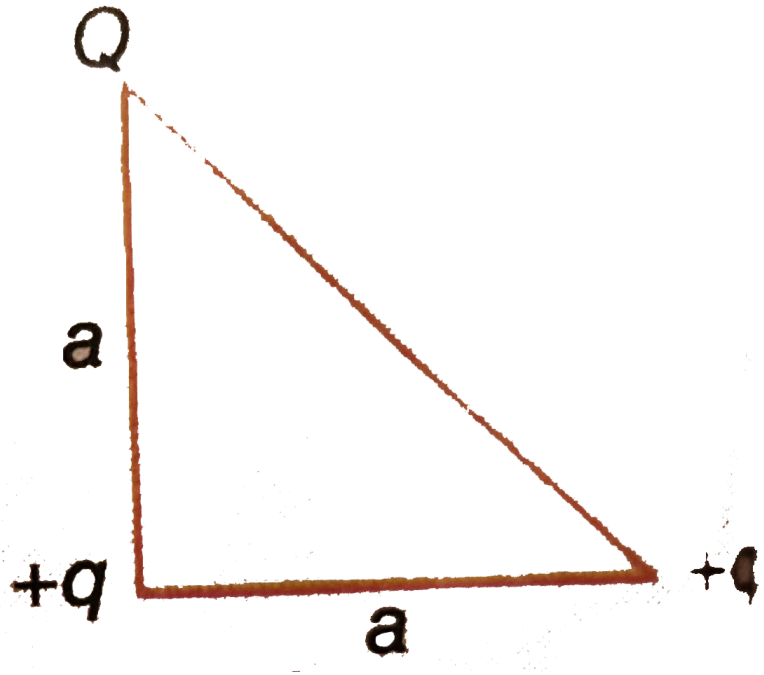
22. In fig., +Q, +q, +q charges are placed on the vertices of an isosceles right-angled triangled. If the electric potential energy of the system of charges is zero, what will be the value of Q?



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23. Discuss the variation of electric potential due to positive and negative point charges with distance from a charge.

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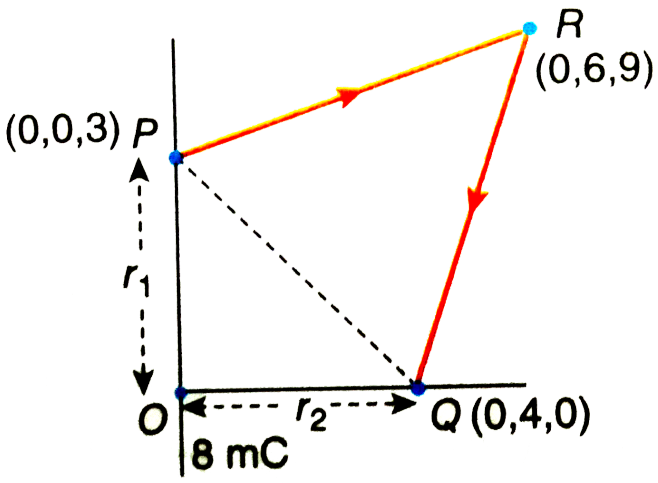
Ncert Textbook Questions With Answer Hint

1. A charge of 8 mC is located at origin. Calculate the work done in taking a small charge of $-2 \times 10^{-9} C$ from a point P(0,0,3cm) to a point Q

(0,4cm,0), via a point R (0,6cm, 9cm).



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2. In a hydrogen atom, the electron and proton are bound at a distance of about 0.53 Å.

(a) Estimate the potential energy of the system in eV, taking the zero of the potential energy at infinite separation of the electron from proton.

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3. In a hydrogen atom, the electron and proton are bound at a distance of about 0.53 Å.

(a) Estimate the potential energy of the system in eV, taking the zero of the potential energy at infinite separation of the electron from proton.

(b) What is the minimum work to free the electron, given that its kinetic energy in the orbit is half the magnitude of potential energy obtained in (a)?

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4. In a hydrogen atom, the electron and proton are bound at a distance of about 0.53 Å.

(a) Estimate the potential energy of the system in eV, taking the zero of the potential energy at infinite separation of the electron from proton.

(b) What is the minimum work to free the electron, given that its kinetic energy in the orbit is half the magnitude of potential energy obtained in (a)?

(c) What are the answer to (a) and (b) above if the zero of the potential energy is taken at 1.06 Å separation?


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5. Two charges -q and +q are located at points (0,0,-a) and (0,0,a) respectively.

(a) What is the electrostatic potential at the points (0,0,z) and (x,y,0) ?

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6. Two charges -q and +q are located at points (0,0,-a) and (0,0,a) respectively.

(b) Obtain the dependence of potential on the distance r of a point from the origin when $r > > a$.

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7. Two charges -q and +q are located at points (0,0,-a) and (0,0,a) respectively.

(c) How much work is done in moving a small test charge from the point (5, 0, 0) to (-7, 0, 0) along the x-axis?

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8. Fig shows a charge array known as electric quadrupole. For a point on the axis of the quadrupole, obtain the dependence of potential on

r for $\frac{r}{a} > > 1$, and contrast your results with that due to an electric dipole and an electric monopole (i.e., single charge).

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9. If Coulomb's law involved $\frac{1}{r^3}$ dependence (instead of $\frac{1}{r^2}$), would Gauss'law be still true?

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10. Describe schematically the equipotential surfaces corresponding to

(a) a constant electric field in the z-direction.

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11. Describe schematically the equipotential surfaces corresponding to

(b) A field that uniformly increases in magnitude but remains in a constant (say, z) direction.

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12. Describe schematically the equipotential surfaces corresponding to

(c) A single positive charge at the origin.

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13. Describe schematically the equipotential surfaces corresponding to

(d) A uniform grid consisting of long equally spaced parallel charged wires in a plane.

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14. The top of the atmosphere is at about 440 kV with respect to the surface of the earth, corresponding to an electric field that decreases with altitude. Near the surface of the earth the field is about $100V \cdot m^{-1}$. Why then we do not get an electric shock as we step out of our house into the open? (Assume the house to be a still cage so there is no field inside.)

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Ncert Examplar Questions With Answer Hint Mcq 1 Single Option Correct

1. A positively charged particle is released from rest in a uniform electric field. The electric potential energy of the charge

A. remains constant because the electric field is uniform

B. increases because the charge moves along the electric field

C. decreases because the charge moves along the electric field

D. decreases because the charge moves opposite to the electric field

Answer: C

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2. The electrostatic potential on the surface of a charged conducting sphere is 100 V. Two statement are made in this regard -

S_1 : At any point inside the sphere, electric intensity is zero.

S_2: At any point inside the sphere, the electrostatic potential is 100V.

Which of the following is a correct statement?

A. S_1 is true but S_2 is false

B. both S_1 and S_2 are false

C. S_1 is true, S_2 is also true and S_1 is the cause of S_2

D. S_1 is true, S_2 is also true but the statement are independent.

Answer: C

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3. Equipotentials at a great distance from a collection of charges whose total sum is not zero are approximately

A. spheres

B. planes

C. paraboloids

D. ellipsoids

Answer: A

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Ncert Examplar Questions With Answer Hint Mcq 2 Multiple Options Correct

1. Equipotential surfaces

A. are closer in regions of large electric fields compared to regions of lower electric fields

B. will be more crowded near sharp edges of a conductor

C. will be more crowded near regions of large charge densities

D. will always be equally spaced

Answer: A::B::C

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2. The work done to move a charge along an equipotential from A to B

A. cannot be defined as $-\int_A^B \vec{E} \cdot d\vec{l}$

B. must be defined as $-\int_A^B \vec{E} \cdot d\vec{l}$

C. is zero

D. can have a non - zero value

Answer: B::C

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3. In a region of constant potential

A. the electric field is uniform

B. the electric field field is zero

C. there can be no charge inside the region

D. the electric field shall necessarily change if a charge is placed outside the region

Answer: B::C

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Exercise Multiple Choice Questions Mark 1

1. Number of statvolt corresponding to 1 volt is

A. $\frac{1}{100}$

B. 10^9

C. $\frac{1}{300}$

D. 300

Answer: C

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2. $1V \cdot m^{-1} = ?$

A. $1N \cdot C^{-1}$

B. $3 \times 10^{10} N \cdot C^{-1}$

C. $10^{7} N \cdot C^{-1}$

D. $10^{10} N \cdot C^{-1}$

Answer: A

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3. When a body is connected to the earth, electrons flow from the earth to the body. The body is

A. negatively charged

B. insulator

C. uncharged

D. positively charged

Answer: D

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4. Four point changes each +q is placed on the circumference of a circle of diameter 2d in such a way that they form a square. The potential at the centre of the circle (in CGS) is

A. 0

B. $\frac{4q}{d}$

C. $\frac{4q}{q}$

D. $\frac{q}{4q}$

Answer: B

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5. The radius of a soap bubble whose potential is 16V is doubled. The new potential of the bubble is

A. 2V

B. 4V

C. 8V

D. 16V

Answer: C

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6. Work done to carry a charge q once along the circular path of radius r with charge q' at its centre, will be

A. zero

B. $\frac{qq'}{4\pi\varepsilon_0}\left(\frac{1}{\pi r}\right)$

C. $\frac{qq'}{4\pi\varepsilon_0}\left(\frac{1}{2\pi r}\right)$

D. $\frac{qq'}{4\pi\varepsilon_0 r}$

Answer: A

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7. If a charge is displaced against the Coulomb force in an electric field,

A. work is done by the electric force

B. work is done by an external agency

C. the energy of the electric field decrease

D. the energy of the system decreases

Answer: B

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8. Three point charges each equal to q are placed on the vertices of an equilateral triangle of side l. The potential energy of the system is

A. $\frac{1}{4\pi\varepsilon_0}\frac{q^2}{l}$

B. $\frac{1}{4\pi\varepsilon_0}\frac{2q^2}{l}$

C. $\frac{1}{4\pi\varepsilon_0}\frac{3q^2}{l}$

D. $\frac{1}{4\pi\varepsilon_0}\frac{4q^2}{l}$

Answer: C

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9. There is a charge of $10\mu C$ at the centre of a circle of radius 10m. The work done is moving a unit positive charge once around the circle is

A. 0

B. 100 J

C. 10 J

D. 150 J

Answer: A

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10. 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. $\sqrt{\frac{2eV}{m}}$

B. $\sqrt{\frac{2V}{m}}$

C. $\frac{eV}{m}$

D. $\frac{eV}{2m}$

Answer: A

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11. The radius of a charged hollow metal sphere is 5 cm and its surface potential is 10V. Potential at its centre is

A. zero

B. 10 V

C. equal to the potential at a distance 5 cm away from its surface

D. equal to the potential at a distance 25 cm away from its surface

Answer: B

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12. If the equation of an electric field is $\vec{E} = \left(y\hat{i} + x\hat{j}\right)$, then the equation of electric potential is represented by

A. $V = -(x + y) + \text{constant}$

B. $C = \text{constant}$

C. $V = -\left(x^2 + y^2\right) + \text{constant}$

D. $V = -xy + \text{constant}$

Answer: D

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13. A charge of 3C experiences a force of 3000 N in a uniform electric field. The potential difference between two points situated 1 cm apart along the electric lines of force will be

A. 300 V

B. 100 V

C. 30 V

D. 10 V

Answer: D

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14. The electric potential V at any point (x, y, z) all in meters in space is given by $V = 4x^2V$. The electric field at the point (1,0,2) in $V \cdot m^{-1}$ is

A. 8 along negative X-axis

B. 8 along positive X-axis

C. 16 along negative X-axis

D. 16 along positive X-axis

Answer: A

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Exercise Very Short Answer Type Questions Mark 1

1. What is the relation between statvolt and volt?

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2. A free electron moves from a higher to a lower potential. Is the statement correct?

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3. Write down the name of the physical quantity whose unit is $J \cdot C^{-1}$.

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4. 1 esu of potential = _____ V. [fill in the blank]

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5. What is the electric field intensity inside a charged conductor?

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6. What are the shapes of the equipotential surfaces in the field of a point charge?

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7. The electric field lines pass through an equipotential surface _____. [Fill in the blank]

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8. The surface of a charged conductor is a/an _____surface. [fill in the blank]

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9. What will be the shape of the equipotential surface situated at infinity due to a point charge?

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10. Which physical quantity has the unit eV?

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11. Is electric field conservative or non-conservative?

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12. If a charge q moves through a potential difference V, what will be the kinetic energy of the charge?

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13. The electric potential energy of a unit charge placed at a point in an electrical field is the _____at that point. [Fill in the blank]

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14. In an electric field, if a charged body loses its potential energy, it gains an equal amount of _____.[Fill in the blank]

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15. A positive charge +Q is placed at a point. A circle of radius r is drawn with the point as the centre. Another charge q is carried once in that circular path. What will be the work done?

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16. To transfer a charge of 20 C through a distance of 2 cm, 2J work is performed. What the potential difference between the end-point of that distance?

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17. If the potential is constant around a point, what will be the electric field intensity at that point?

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Exercise Short Answer Type Questions I Mark 2

1. A positively charged body and a negatively charged body are separated connected to the earth. What will be their potential before and after the earth-connection?

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2. Two point charges +q and -q are placed d distance apart. What is the zero potential plane for them?

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3. Two insulated conductors A and B are connected by a metallic wire. A positively charged rod is kept near A (on the other side of B). What will be the potential difference between A and B?

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4. Explain with a graph, the variation of potential and field intensity of a hollow charged spherical conductor, both inside and outside the sphere, with distance.

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5. The potential difference of two conductors is very high. What will happen under the following conditions-

(i) The two conductors are connected by a metallic wire.

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6. The potential difference of two conductors is very high. What will happen under the following conditions-

(ii) Both types of ions, positive and negative, are present in air between the two conductors.

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7. The potential difference of two conductors is very high. What will happen under the following conditions-

(iii) The space between the two conductors is vacuum.

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Exercise Short Answer Type Questions Ii Mark 3 Or 4

1. "Electric field lines always meet the surface of a conductor normally" - justify the statement.

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2. "In the region where an electrical potential exists an electric charge always experience a force". Is the statement true? If not, write its correct form. Give an example in favour of your corrected statement.

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3. How can you show from physical argument that for an electrical conductor in equilibrium, its surface must be an equipotential surface?

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Exercise Problem Set I Marks 2

1. A charge of 100 esu is placed at a point. What will be the amount of work done

(i) to bring a unit positive charge from infinity to a point 20 cm away from the charge.

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2. A charge of 100 esu is placed at a point. What will be the amount of work done

(ii) To carry a unit positive charge once, along a

circle of radius 10 cm around the given charge? Answer with reasons.

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3. A conducting sphere of radius 5 cm has a charge of 20 esu. What is the electric potential at a distance of 10 cm away from its centre?

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4. A hollow conducting sphere of radius 10 cm has a charge of +10 esu. What is the potential at an

internal point of the sphere?

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5. What will be the amount of work done to rotate an electric dipole of moment $2.0 \times 10^{-20} C \cdot m$ through an angle of 180° in an electric field of intensity $1.2 \times 10^{4} V \cdot m^{-1}$?

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6. The potentials at two points in an electric field are 400 V and 1000 V. What will be the work done

to carry a positive charge $3 \times 10^{-8} C$ from one point to the other?

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7. The electric field intensity between two parallel conducting plates separated by a distance 2 cm is $1.5 statV \cdot cm^{-1}$. Determine the potential difference between the plates in volt.

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8. One of two parallel conducting plates separated by a distance 2 cm is charged to a potential 1800V, and the outer plate is connected to the earth. What is the magnitude of the electric field intensity in the space between the two plates?

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Exercise Problem Set Ii Marks 3 Or 4

1. A negative charge of 30 esu is at a distance of 30 cm from a positive charge of 20 esu. What is the potential at a point 10 cm from the first charge on

the line joining the two charges? Where will the potential be zero?

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2. Find the electric field and potential at the centre of curvature of a uniformly charged semicircular rod of radius R with a total charge Q in SI. λ is the linear charge density.

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3. At the three vertices of an equilateral triangle of side 10 cm, $+1.0 \times 10^{-7}C$, $+2.0 \times 10^{-7}C$ and $-4.0 \times 10^{-7}C$ charges are placed. Calculated the potential energy of the system of these charges.

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4. An electron of mass $8.9 \times 10^{-28}g$ and charge 4.8×10^{-10} esu starts from rest and acquires a velocity of $10^{9}cm \cdot s^{-1}$ at another point. What is the potential difference in volt between the two points?

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5. Two identical thin rings, each of the radius R are coaxially placed at a distance R from each other. If Q_1 and Q_2 are the charges uniformly distributed on the rings, then calculate the work done in moving a charge q from the centre of one ring to the centre of the other.

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6. Determine the electrostatic potential energy of a system consisting of two charges,

$7\mu C$ and $-2\mu C$ (and with no external field) placed at (-9,0,0) cm and (9,0,0) cm respectively.

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7. How much work has to be done to isolate the two charges and take them infinitely away from each other?

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8. In a certain place, the electric potential changes according to the relation $V = 3x + 2y^2, V$ is

measured in volt and x,y in metre. What is the electric field intensity at the point (3,1)?

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9. The electric potential V(x) in an electric field depends only on x and $V(x) = ax - bx^3$ where a and b are constants. Where on the x-axis will electric field intensity be zero?

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10. Two point charges of magnitude +q and -q are placed at $\left(-\frac{d}{2}, 0, 0\right)$ and $\left(\frac{d}{2}, 0, 0\right)$ respectively. Find the equation of the equipotential surface where the potential is zero.

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11. What is the magnitude of the electric field at the point $\left(3\hat{i} - 2\hat{j} + 4\hat{j}\right)m$ if the electric potential is given by $V = 2xyz^2$, where V is in volt and x, y, z are in meters?

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Exercise Hots Numerical Problems Marks 3 4 5

1. Three charges of magnitude q, 2q and 8q are to be placed on a line of length 9 cm in such a way that the potential energy of the system of charges is minimum. Determine the positions of the charges.

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2. A small pith ball of mass 0.3 g is suspended by a weightless thread between two vertical parallel plates, separated by a distance of 5 cm. The ball

carries a charge of 49 esu. What potential difference should be applied between the plates so that the thread is deflected by 45° from the vertical?

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3. Two spherical conductors A and B, having equal radii and carrying equal charges on them, repel each other with a force F when kept apart at some distance. A third spherical uncharged conductor C having the same radius is brought in contact with A. It is then detached from A and brought in contact with B and finally removed away form both.

What is the new force of repulsion between A and B?

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4. There are charges +q at each of the points $x = x_0, x = 3x_0, x = 3x_0$.....up to infinity on the x-axis and charges -q at each of the points $x = 2x_0, x = 4x_0, x = 6x_0$, ...up to infinity. Here x_0 is a positive constant. What is the potential at the orgin due to the above system of charges?

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5. Electric potential is given by , $V = 6x - 8xy^2 - 8y + 6yz - 4z^2$. What is the electric force acting on 2C point charge placed at the origin?

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6. A path ball of mass 1g carrying an electric charge of 980 esu is dropped on a charged sphere of radius 10 cm from a height of 1m above the centre of the latter. It is found that the pith ball momentarily comes to rest on the charged sphere

before being repelled away again. Calculate the charge on the sphere.

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7. The electric potential V(x) in a region along the x-axis varies with the distance x (in metre) according to $V(x) = 4x^2$. Calculate the force experienced by a $1\mu C$ charge placed at x = 1m.

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8. ABC is a small, isosceles right angled triangle of hypotenuse 1cm. A charge of $+40pC$ (picocoulomb) is placed at the right angled corner A and -20 pC and -20 pC at B and C respectively. Show that this system of charges may be treated as a dipole for all external points at large distances. Calculate the potential due to this system of charges at a point on the extended side AC at a distance 40 cm from A.

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Entrance Corner Assertion Reason Type

1. Statement I : For practical purpose, the potential of the earth is used as a reference, and is assumed to be the zero of potential in electrical circuits.

Statement II : The electrical potential ofa sphere of radius R, with charge Q uniformly distributed on its surface is given by $\frac{Q}{4\pi\varepsilon_0 R}$.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for

statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true

Answer: A

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2. Statement I : A non-zero electric potential may exist at a point where electric field strength is zero.

Statement II : Both electric potential and electric field strength depends on the source charge and not on the test charge.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true

Answer: B

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3. Statement I : If two source charges produce potentials V_1 and V_2 at a point, then the total potential at that point is $V_1 + V_2$

Statement II : Electric potential is a scalar quantity.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true

Answer: A

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4. Statement I : A and B are two conducting spheres of the same radius, A being solid and B hollow. Both are charged to the same potential. Then, charge on A = charge on B.

Statement II : Potentials on both are the same.

A. Statement I is true, statement II is true, statement II is a correct explanation for

statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true

Answer: A

5. Statement I : For a charged particle moving form point P to point Q, the net work done by an electrostatic field on the particle is independent of the path connecting points P and Q.

Statement II : The net work done by a conservative force on an object moving along a closed loop is zero.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true

Answer: A

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6. Statement I : Due to an infinitely long linear charge distribution, potential at any point at a

distance r from the line is proportional to log r.

Statement II : $E \propto \frac{1}{r}$ and $E = -\frac{dV}{dr}$.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true

Answer: A

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7. Statement I : Though electric potential is scalar, electric potential gradient is a vector quantity.

Statement II : Potential gradient is the rate of change of potential with distance.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for

statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true

Answer: B

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8. Statement I : A system of three positive charges, each having a charge q and placed at equal distance from each other along a straight line cannot be in equilibrium.

Statement II : The charge in the middle experiences

zero net force, but the force acting on the charges at the extreme ends is not zero.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I.

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I.

C. Statement I is true, statement II is false

D. Statement I is false, statement II is true

Answer: A

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Entrance Corner Multiple Correct Answers Type

1. Which of the following quantities do not depend on zero potential energy?

A. potential at a point

B. potential difference between two points

C. potential energy of a two-charge system

D. change in potential energy of a two-charge system

Answer: B::D

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2. P is a point on an equipotential surface S. The field at P is E.

A. E is perpendicular to S in all cases.

B. E is perpendicular to S only if S is a plane surface

C. E cannot have a component along a tangent to S

D. E may have a non-zero component along a tangent to S if S is a curved surface.

Answer: B::C

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3. When a proton is accelerated from rest through a potential difference of 1000 V, its kinetic energy becomes

A. $1.6 \times 10^{-16} J$

B. $1.6 \times 10^{-16} eV$

C. $1000J$

D. $1000eV$

Answer: A::B::C::D

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4. In a uniform electric field, equipotential surfaces must

A. be plane surfaces

B. be normal to the direction of the field

C. be spaced such that the surfaces having equal differences in potential are separated by equal distance.

D. have decreasing potentials in the direction of the field

Answer: A::C

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5. Four charges, all of the same magnitude, are placed at the four corners of a square. At the centre

of the square, the potential is V and the field is E.

Which of the following are possible?

A. $V = 0, E = 0$

B. $V = 0, E \neq 0$

C. $V \neq 0, E = 0$

D. $V \neq 0, E \neq 0$

Answer: A::B::C

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6. Which of the following statement(s) is/are correct?

A. if the electric field due to a point charge varies as $r^{-2.5}$ instead of r^{-2}, then Gauss' law will still be valid

B. The Gauss'law can be used to calculate the field distribution around an electric dipole

C. If the electric field at some point between two point charges in zero, then the sign of two charges is the same

D. The work done by the external force in moving a unit positive charge from point A at potential V_A to point B at potential V_B is $(V_B - V_A)$

Answer: A::B::C::D

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Entrance Corner Comprehension Type

1. Two point A and B are 2 cm apart and a uniform electric field $\vec{E}$ acts along the straight line AB

directed from A to B with $E = 200N \cdot C^{-1}$. A particle of charge $+10^{-6}C$ is taken from A to B along AB.

(i) The force on the charge is

A. $2 \times 10^{-4}N$

B. $3N$

C. $2N$

D. $2 \times 10^{-2}N$

Answer: A

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2. Two point A and B are 2 cm apart and a uniform electric field $\overrightarrow{E}$ acts along the straight line AB directed from A to B with $E = 200N \cdot C^{-1}$. A particle of charge $+10^{-6}C$ is taken from A to B along AB.

(ii) The potential difference between A and B is

A. $4 \times 10^{-6}V$

B. $1V$

C. $4V$

D. $2V$

Answer: C

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3. Two point A and B are 2 cm apart and a uniform electric field $\vec{E}$ acts along the straight line AB directed from A to B with $E = 200N \cdot C^{-1}$. A particle of charge $+10^{-6}C$ is taken from A to B along AB.

(iii) The work done on the charge by $\vec{E}$ is

A. $4J$

B. $1 \times 10^{-6}J$

C. $2 \times 10^{-6}J$

D. $4 \times 10^{-6}J$

Answer: D

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4. Two point charge $q_1 = 10 \times 10^{-8} C$ and $q_2 = -2 \times 10^{-8} C$ are separated by a distance of 6 cm in air.

(i) The distance from q_1 of the point of zero electric potential is

A. 5 cm

B. 2.5 cm

C. 8 cm

D. 10 cm

Answer: A

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5. Two point charge $q_1 = 10 \times 10^{-8} C$ and $q_2 = -2 \times 10^{-8} C$ are separated by a distance of 6 cm in air.

(ii) The electrostatic potential energy of the system is

A. $15 \times 10^{-3} J$

B. $24 \times 10^{-4} J$

C. $18 \times 10^{-3} J$

D. $-18 \times 10^{-4} J$

Answer: B

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6. A positively charged oil drop is in equilibrium in the electric field existing in the space between two horizontal plates separated by a distance of 1cm. The charge of the oil drop is $3.2 \times 10^{-19} C$ and its mass is $10^{-17} g$.

(i) The potential difference between the plates is

A. 1020 V

B. 1531 V

C. 3062 V

D. 2454 V

Answer: C

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7. A positively charged oil drop is in equilibrium in the electric field existing in the space between two horizontal plates separated by a distance of 1cm. The charge of the oil drop is $3.2 \times 10^{-19} C$ and its

mass is $10^{-17}g$.

(ii) The instantaneous acceleration of the oil drop, when the polarity of the two plates is reversed, is

A. $24.25m \cdot s^{-2}$

B. $19.60m \cdot s^{-2}$

C. $29.70m \cdot s^{-2}$

D. $34.52m \cdot s^{-2}$

Answer: b

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8. Each of two concentric spheres of radii 5 cm and 10 cm are given a charge of $10\mu C$.

(i) The electric potential at a point situated at a distance of 2.5 cm from the centre is

A. $27 \times 10^5 V$

B. $0V$

C. $16.5 \times 10^5 V$

D. $24.2 \times 10^4 V$

Answer: D

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9. Each of two concentric spheres of radii 5 cm and 10 cm are given a charge of $10\mu C$.

(ii) The electric potential at a point situated at a distance of 8 cm from the centre is

A. $10.52 \times 10^4 V$

B. $20.25 \times 10^5 V$

C. $32.24 \times 10^5 V$

D. $42.28 \times 10^5 V$

Answer: C

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10. Each of two concentric spheres of radii 5 cm and 10 cm are given a charge of $10\mu C$.

(iii) The electric potential at a point situated at a distance of 20 cm form the centre is

A. $4 \times 10^5 V$

B. $32 \times 10^4 V$

C. $9 \times 10^5 V$

D. $16 \times 10^5 V$

Answer: D

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Entrance Corner Integer Answer Type

1. Three charges -q, Q and -q are placed at equal distances on a straight line. If the total potential energy of the system is zero, then what is the ratio $\frac{q}{Q}$?

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2. A small sphere, having a charge of $10^{-6}C$ and a mass of 2g, moved from a point A to a point B. Potential at A is 36000 V and that at B is zero. If the

velocity of the sphere at B be $10 m / s$, what was its velocity at A (in $m \cdot s^{-1}$) ?

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3. An electric field is expressed as $\overrightarrow{E} = \hat{i}x + \hat{k}z$. What is the potential difference (in volt) between A(0,0,0) and B(2,2,0)?

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1. Write down the name of the physical quantity whose unit is joule/coulomb.

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2. Determine how much work is to be done to move a 10 C positive charge 1 m along the y-axis in a uniform electric field $\overrightarrow{E} - 5\left(\hat{i} + \hat{j}\right)V \cdot m^{-1}$.

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3. Show that the direction of electric field is normal to the equipotential surface.

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4. The electric field strength at a point in an electric field is zero. Is the electric potential also zero at that point? Answer with reason.

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5. 64 tiny drops of water having same radius and same charge are combined to form one large drop. The ratio of potential of the large drop to the small drop is

A. $4:1$

B. $1:4$

C. $16:1$

D. $1:16$

Answer: C

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6. The statvolt corresponding to one volt is

A. $\frac{1}{100}$

B. 10^9

C. $\frac{1}{300}$

D. 300

Answer: C

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7. What is an equipotential surface? Show that the electric field is always normal to an equipotential

surface.

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8. The electric potential at a point (x, y, z) is given by $V = -x^2y - xz^3 + 4$. Find the intensity of electric field $\vec{E}$ at that point.

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Examination Archive With Solutions Wbjee

1. An infinite sheet carrying a uniform surface charge density σ lies on the xy-plane. The work done to carry a charge q from point $\overrightarrow{A} = a\left(\hat{i} + 2\hat{j} + 3\hat{k}\right)$ to the point $\overrightarrow{B} = a\left(\hat{i} - 2\hat{j} + 6\hat{k}\right)$ (where a is a constant with the dimension of length and ε_0 is the permittivity of free space) is

A. $\frac{3\sigma aq}{2\varepsilon_0}$

B. $\frac{2\sigma aq}{\varepsilon_0}$

C. $\frac{5\sigma aq}{2\varepsilon_0}$

D. $\frac{3\sigma aq}{\varepsilon_0}$

Answer: A

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2. A hollow metal sphere of radius R is charged with a charge Q. The electric potential and intensity inside the sphere are respectively

A. $\frac{Q}{4\pi\varepsilon_0 R^2}$ and $\frac{Q}{4\pi\varepsilon_0 R}$

B. $\frac{Q}{4\pi\varepsilon_0 R}$ and zero

C. zero and zero

D. $\frac{4\pi\varepsilon_0 Q}{R}$ and $\frac{Q}{4\pi\varepsilon_0 R^2}$

Answer: B

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3. Angle between an equipotential surface and electric lines of force is

A. 0°

B. 90°

C. 180°

D. 270°

Answer: B

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4. A point charge -q is carried from a point A to anther point B on the axis of a charged ring of radius r carrying a charge +q. If the point A is at a distance $\frac{4}{3}r$ from the centre of the ring and the point B is $\frac{3}{4}r$ from the centre but on the opposite side, what is the net work that need to be done for this

A. $-\frac{7}{5}\frac{q^2}{4\pi\varepsilon_0 r}$

B. $-\frac{1}{5}\frac{q^2}{4\pi\varepsilon_0 r}$

C. $\frac{7}{5}\frac{q^2}{4\pi\varepsilon_0 r}$

D. $\frac{1}{5}\frac{q^2}{4\pi\varepsilon_0 r}$

Answer: B

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5. Two positive charges Q and 4Q are placed at points A and B respectively, where B is at a distance d units to the right of A. The total electric potential due to these charges is minimum at P on the through A and B. What is (are) the distance(s) of P from A?

A. $\frac{d}{3}$ units to the right of A

B. $\frac{d}{3}$ units to the left of A

C. $\frac{d}{5}$ units to the right of A

D. d units to the left of A

Answer: A

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Examination Archive With Solutions Jee Main

1. Assume than an electric field $\overrightarrow{E} = 30x^2\hat{i}$ exists in space. Then the potential difference $V_A - V_O$,

where V_O is the potential at the origin and V_A the potential at x = 2 m is

A. 80 J

B. 120 J

C. $-120J$

D. $-80J$

Answer: D

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2. A uniformly charged solid sphere of radius R has potential V_0 (measured with respect to ∞) on its surface. For this sphere the equipotential surfaces with potentials $\frac{3V_0}{2}, \frac{5V_0}{4}, \frac{3V_0}{4}$ and $\frac{V_0}{4}$ have radius R_1, R_2, R_3 and R_4 respectively. Then

A. $R_1 = 0$ and $R_2 > (R_4 - R_3)$

B. $R_1 \neq 0$ and $(R_2 - R_1) > (R_4 - R_3)$

C. $R_1 = 0$ and $R_2 < (R_4 - R_3)$

D. $2R < R_4$

Answer: C

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3. Three concentric metal shells A, B, and C of respective radii a,b and c (a lt b lt c) have surface charge densities $+\sigma, -\sigma$ and $+\sigma$ respectively. The potential of shell B is

A. $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2-c^2}{b}+a\right]$

B. $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2-c^2}{c}+a\right]$

C. $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2-b^2}{a}+c\right]$

D. $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2-b^2}{b}+c\right]$

Answer: D

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Examination Archive With Solutions Aipmt

1. 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

Answer: B

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2. 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. $30N$

C. $24N$

D. $4\sqrt{35}N$

Answer: D

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Examination Archive With Solutions Neet

1. A molecule of a substance has permanent dipole moment p. A mole of this substance is polarised by applying a strong electrostatic field E. The direction of the field is suddenly changed by an angle of 60°. If N is the Avogadro's number the amount of work done by the field is

A. $2NpE$

B. $\frac{1}{2}NpE$

C. NpE

D. $\frac{3}{2}NpE$

Answer: B

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Cbse Scanner

1. A test charge q is moved without acceleration along the path from A to B from B to C in electric

field E as shown in fig.

(i) Calculate the potential difference between A and C.

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2. A test charge q is moved without acceleration along the path from A to B from B to C in electric field E as shown in fig.

(ii) At which point (or the two) is the electric potential more and why?

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3. Draw the equipotential surfaces due to an electric dipole. Locate the points where the potential due to the dipole is zero.

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4. Derive the expression for the potential energy of an electric dipole of dipole moment $\vec{p}$ placed in a uniform electric field $\vec{E}$.

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5. Explain why, for any charge configuration the equipotential surface through a point is normal to the electric field at that point.

Draw a sketch of equipotential surfaces due to a single charge (-q), depicting the electric field lines due to the charge.

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6. Obtain an expression for the work done to dissociate the system of three placed at the vertices of an equilateral of side a as shown below.

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7. Derive the expression for the electric potential due to an electric dipole at a point on its axial line.

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8. Depict the equipotential surfaces due to an electric dipoel.

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9. An infinitely large thin plane sheet has a uniform surface charge density $+\sigma$. Obtain the expression for the amount of work done in bringing a point charge q from infinity to a point, distant r, in front of the charged plane sheet.

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10. Four point charges Q , q, Q and q are placed at the corners of a square of side a as shown in the figure.

Find the

(i) resultant electric force on a charge Q.

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11. Four point charges Q , q, Q and q are placed at the corners of a square of side a as shown in the figure.

Find the

(ii) Potential energy of this system.

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12. Three point charges q, -4q and 2q are placed at the vertices of an equilateral triangle ABC of side l as shown in the figure. Obtain the expression for the magnitude of the resultant electric force acting on the charge q.

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13. Find out the amount of the work done to separated the charges at infinite distance.

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