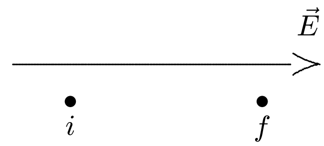
Chapter 24: ELECTRIC POTENTIAL

1. An electron moves from point i to point f, in the direction of a uniform electric field. During this displacement:



A. the work done by the field is positive and the potential energy of the electron-field system increases
B. the work done by the field is negative and the potential energy of the electron-field system increases
C. the work done by the field is positive and the potential energy of the electron-field system decreases
D. the work done by the field is negative and the potential energy of the electron-field system decreases
E. the work done by the field is positive and the potential energy of the electron-field system does not change

ans: B

2. A particle with a charge of $5.5 \times 10^{-8\,\mathrm{C}}$ is 3.5 cm from a particle with a charge of -2.3×10^{-8} C. The potential energy of this two-particle system, relative to the potential energy at infinite separation, is:

A. 3.2×10^{-4} J
B. -3.2×10^{-4} J
C. 9.3×10^{-3} J
D. -9.3×10^{-3} J
E. zero

ans: B

3. A particle with a charge of 5.5×10^{-8} C is fixed at the origin. A particle with a charge of -2.3×10^{-8} C is moved from $x = 3.5$ cm on the x axis to $y = 4.3$ cm on the y axis. The change in potential energy of the two-particle system is:

A. 3.1×10^{-3} J
B. -3.1×10^{-3} J
C. 6.0×10^{-5} J
D. -6.0×10^{-5} J
E. 0

ans: C

4. A particle with a charge of 5.5×10^{-8} C charge is fixed at the origin. A particle with a charge of -2.3×10^{-8} C charge is moved from $x = 3.5$ cm on the x axis to $y = 3.5$ cm on the y axis. The change in the potential energy of the two-particle system is:

A. 3.2×10^{-4} J
B. -3.2×10^{-4} J
C. 9.3×10^{-3} J
D. -9.3×10^{-3} J
E. 0

ans: E

5. Three particles lie on the x axis: particle 1, with a charge of 1×10^{-8} C is at $x = 1$ cm, particle 2, with a charge of 2×10^{-8} C, is at $x = 2$ cm, and particle 3, with a charge of -3×10^{-8} C, is at $x = 3$ cm. The potential energy of this arrangement, relative to the potential energy for infinite separation, is:

A. $+4.9 \times 10^{-4}$ J
B. -4.9×10^{-4} J
C. $+8.5 \times 10^{-4}$ J
D. -8.5×10^{-4} J
E. zero

ans: B

6. Two identical particles, each with charge q, are placed on the x axis, one at the origin and the other at $x = 5$ cm. A third particle, with charge $-q$, is placed on the x axis so the potential energy of the three-particle system is the same as the potential energy at infinite separation. Its x coordinate is:

A. 13 cm
B. 2.5 cm
C. 7.5 cm
D. 10 cm
E. -5 cm

ans: A

7. Choose the correct statement:

A. A proton tends to go from a region of low potential to a region of high potential
B. The potential of a negatively charged conductor must be negative
C. If $\vec{E} = 0$ at a point P then V must be zero at P
D. If $V = 0$ at a point P then $\vec{E}$ must be zero at P
E. None of the above are correct

ans: E

8. If 500 J of work are required to carry a charged particle between two points with a potential difference of 20 V, the magnitude of the charge on the particle is:

A. 0.040 C
B. 12.5 C
C. 20 C
D. cannot be computed unless the path is given
E. none of these

ans: B

9. The potential difference between two points is 100 V. If a particle with a charge of 2 C is transported from one of these points to the other, the magnitude of the work done is:

A. 200 J
B. 100 J
C. 50 J
D. 100 J
E. 2 J

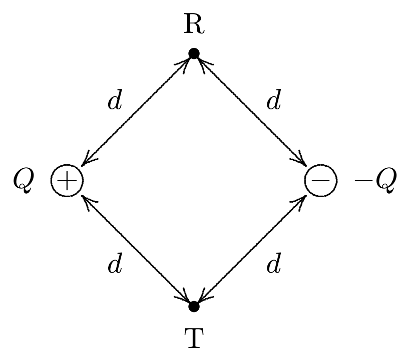
ans: A

10. During a lightning discharge, 30 C of charge move through a potential difference of 1.0×10^8 V in 2.0×10^{-2} s. The energy released by this lightning bolt is:

A. 1.5×10^{11} J
B. 3.0×10^9 J
C. 6.0×10^7 J
D. 3.3×10^6 J
E. 1500 J

ans: B

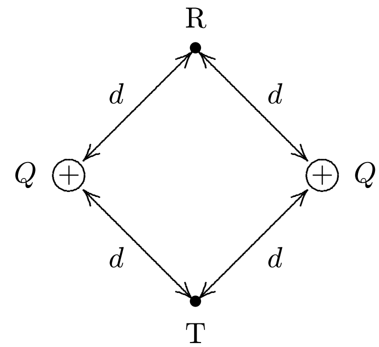
11. Points R and T are each a distance d from each of two particles with charges of equal magnitudes and opposite signs as shown. If $k = 1/4\pi\epsilon_0$, the work required to move a particle with a negative charge q from R to T is:



A. 0
B. kqQ/d^2
C. kqQ/d
D. $kqQ/(\sqrt{2}d)$
E. $kQq/(2d)$

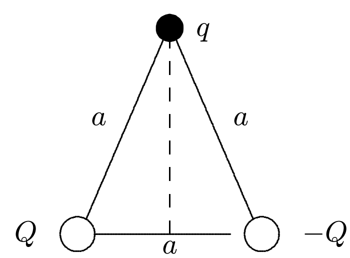
ans: A

12. Points R and T are each a distance d from each of two particles with equal positive charges as shown. If $k = 1/4\pi\epsilon_0$, the work required to move a particle with charge q from R to T is:



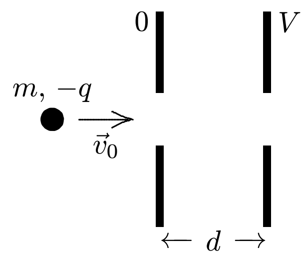
A. 0
B. kQq/d^2
C. kQq/d
D. $kQq/(\sqrt{2}d)$
E. $kQq/(2d)$
ans: A

13. Two particle with charges Q and $-Q$ are fixed at the vertices of an equilateral triangle with sides of length a. If $k = 1/4\pi\epsilon_0$, the work required to move a particle with charge q from the other vertex to the center of the line joining the fixed particles is:



A. 0
B. kQq/a
C. kQq/a^2
D. $2kQq/a$
E. $\sqrt{2}kQq/a$
ans: A

14. A particle with mass m and charge $-q$ is projected with speed v_0 into the region between two parallel plates as shown. The potential difference between the two plates is V and their separation is d. The change in kinetic energy of the particle as it traverses this region is:



A. $-qV/d$
B. $2qV/mv_0^2$
C. qV
D. $mv_0^2/2$
E. none of these

ans: C

15. An electron is accelerated from rest through a potential difference V. Its final speed is proportional to:

A. V
B. V^2
C. $\sqrt{V}$
D. $1/V$
E. $1/\sqrt{V}$

ans: C

16. In separate experiments, four different particles each start from far away with the same speed and impinge directly on a gold nucleus. The masses and charges of the particles are

particle 1: mass m_0, charge q_0
particle 2: mass $2m_0$, charge $2q_0$
particle 3: mass $2m_0$, charge $q_0/2$
particle 4: mass $m_0/2$, charge $2q_0$

Rank the particles according to the distance of closest approach to the gold nucleus, from smallest to largest.

A. 1, 2, 3, 4
B. 4, 3, 2, 1
C. 3, 1 and 2 tie, then 4
D. 4, 1 and 2 tie, then 1
E. 1 and 2 tie, then 3, 4

ans: C

17. Two large parallel conducting plates are separated by a distance d, placed in a vacuum, and connected to a source of potential difference V. An oxygen ion, with charge $2e$, starts from rest on the surface of one plate and accelerates to the other. If e denotes the magnitude of the electron charge, the final kinetic energy of this ion is:

A. $eV/2$
B. eV/d
C. eVd
D. Vd/e
E. $2eV$

ans: E

18. An electron volt is :

A. the force acting on an electron in a field of 1 N/C
B. the force required to move an electron 1 meter
C. the energy gained by an electron in moving through a potential difference of 1 volt
D. the energy needed to move an electron through 1 meter in any electric field
E. the work done when 1 coulomb of charge is moved through a potential difference of 1 volt.

ans: C

19. An electron has charge $-e$ and mass m_e. A proton has charge e and mass $1840m_e$. A "proton volt" is equal to:

A. 1 eV
B. 1840 eV
C. (1/1840) eV
D. $\sqrt{1840}$ eV
E. $(1/\sqrt{1840})$ eV

ans: A

20. Two conducting spheres, one having twice the diameter of the other, are separated by a distance large compared to their diameters. The smaller sphere (1) has charge q and the larger sphere (2) is uncharged. If the spheres are then connected by a long thin wire:

A. 1 and 2 have the same potential
B. 2 has twice the potential of 1
C. 2 has half the potential of 1
D. 1 and 2 have the same charge
E. all of the charge is dissipated

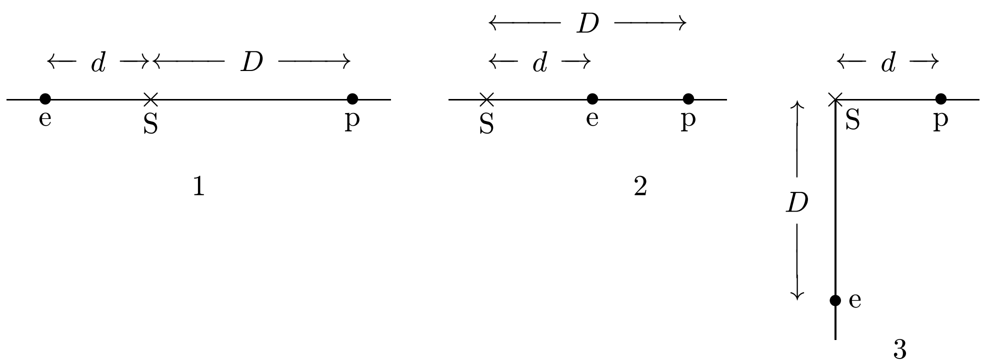
ans: A

21. Two conducting spheres are far apart. The smaller sphere carries a total charge Q. The larger sphere has a radius that is twice that of the smaller and is neutral. After the two spheres are connected by a conducting wire, the charges on the smaller and larger spheres, respectively, are:

A. $Q/2$ and $Q/2$
B. $Q/3$ and $2Q/3$
C. $2Q/3$ and $Q/3$
D. zero and Q
E. $2Q$ and $-Q$

ans: B

22. Three possible configurations for an electron e and a proton p are shown below. Take the zero of potential to be at infinity and rank the three configurations according to the potential at S, from most negative to most positive.



A. 1, 2, 3
B. 3, 2, 1
C. 2, 3, 1
D. 1 and 2 tie, then 3
E. 1 and 3 tie, then 2

ans: D

23. A conducting sphere with radius R is charged until the magnitude of the electric field just outside its surface is E. The electric potential of the sphere, relative to the potential far away, is:

A. zero
B. E/R
C. E/R^2
D. ER
E. ER^2

ans: D

24. A 5-cm radius conducting sphere has a surface charge density of $2 \times 10^{-6}\,\mathrm{C/m^2}$ on its surface. Its electric potential, relative to the potential far away, is:

A. 1.1×10^4 V
B. 2.2×10^4 V
C. 2.3×10^5 V
D. 3.6×10^5 V
E. 7.2×10^6 V

ans: A

25. A hollow metal sphere is charged to a potential V. The potential at its center is:

A. V
B. 0
C. $-V$
D. $2V$
E. πV

ans: A

26. Positive charge is distributed uniformly throughout a non-conducting sphere. The highest electric potential occurs:

A. at the center
B. at the surface
C. halfway between the center and surface
D. just outside the surface
E. far from the sphere

ans: A

27. A total charge of 7×10^{-8} C is uniformly distributed throughout a non-conducting sphere with a radius of 5 cm. The electric potential at the surface, relative to the potential far away, is about:

A. -1.3×10^4 V
B. 1.3×10^4 V
C. 7.0×10^5 V
D. -6.3×10^4 V
E. 0

ans: B

28. Eight identical spherical raindrops are each at a potential V, relative to the potential far away. They coalesce to make one spherical raindrop whose potential is:

A. $V/8$
B. $V/2$
C. $2V$
D. $4V$
E. $8V$

ans: D

29. A metal sphere carries a charge of 5×10^{-9} C and is at a potential of 400 V, relative to the potential far away. The potential at the center of the sphere is:

A. 400 V
B. -400 V
C. 2×10^{-6} V
D. 0
E. none of these

ans: A

30. A 5-cm radius isolated conducting sphere is charged so its potential is +100 V, relative to the potential far away. The charge density on its surface is:

A. $+2.2 \times 10^{-7}\,\mathrm{C/m^2}$
B. $-2.2 \times 10^{-7}\,\mathrm{C/m^2}$
C. $+3.5 \times 10^{-7}\,\mathrm{C/m^2}$
D. $-3.5 \times 10^{-7}\,\mathrm{C/m^2}$
E. $+1.8 \times 10^{-8}\,\mathrm{C/m^2}$

ans: E

31. A conducting sphere has charge Q and its electric potential is V, relative to the potential far away. If the charge is doubled to $2Q$, the potential is:

A. V
B. $2V$
C. $4V$
D. $V/2$
E. $V/4$

ans: B

32. The potential difference between the ends of a 2-meter stick that is parallel to a uniform electric field is 400 V. The magnitude of the electric field is:

A. zero
B. 100 V/m
C. 200 V/m
D. 400 V/m
E. 800 V/m

ans: E

33. In a certain region of space the electric potential increases uniformly from east to west and does not vary in any other direction. The electric field:

A. points east and varies with position
B. points east and does not vary with position
C. points west and varies with position
D. points west and does not vary with position
E. points north and does not vary with position

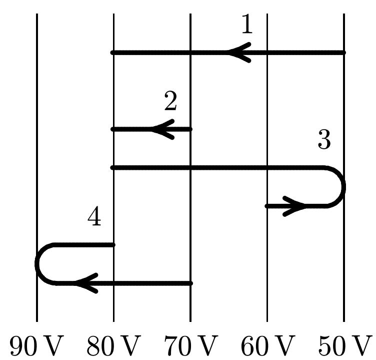
ans: B

34. If the electric field is in the positive x direction and has a magnitude given by $E = Cx^2$, where C is a constant, then the electric potential is given by $V =$:

A. $2Cx$
B. $-2Cx$
C. $Cx^3/3$
D. $-Cx^3/3$
E. $-3Cx^3$

ans: D

35. An electron goes from one equipotential surface to another along one of the four paths shown below. Rank the paths according to the work done by the electric field, from least to greatest.



A. 1, 2, 3, 4
B. 4, 3, 2, 1
C. 1, 3, 4 and 2 tie
D. 4 and 2 tie, then 3, then 1
E. 4, 3, 1, 2

ans: D

36. The work required to carry a particle with a charge of 6.0 C from a 5.0-V equipotential surface to a 6.0-V equipotential surface and back again to the 5.0-V surface is:

A. 0
B. 1.2×10^{-5} J
C. 3.0×10^{-5} J
D. 6.0×10^{-5} J
E. 6.0×10^{-6} J

ans: A

37. The equipotential surfaces associated with a charged point particles are:

A. radially outward from the particle
B. vertical planes
C. horizontal planes
D. concentric spheres centered at the particle
E. concentric cylinders with the particle on the axis.

ans: D

38. The electric field in a region around the origin is given by $\vec{E} = C(x\,\hat{\imath} + y\,\hat{\jmath})$, where C is a constant. The equipotential surfaces in that region are:

A. concentric cylinders with axes along the z axis
B. concentric cylinders with axes along the x axis
C. concentric spheres centered at the origin
D. planes parallel to the xy plane
E. planes parallel to the yz plane

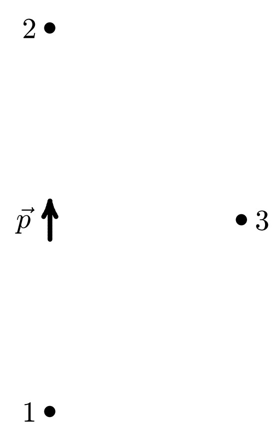
ans: A

39. The electric potential in a certain region of space is given by $V = -7.5x^2 + 3x$, where V is in volts and x is in meters. In this region the equipotential surfaces are:

A. planes parallel to the x axis
B. planes parallel to the yz plane
C. concentric spheres centered at the origin
D. concentric cylinders with the x axis as the cylinder axis
E. unknown unless the charge is given

ans: B

40. In the diagram, the points 1, 2, and 3 are all the same very large distance from a dipole. Rank the points according to the values of the electric potential at them, from the most negative to the most positive.



A. 1, 2, 3
B. 3, 2, 1
C. 2, 3, 1
D. 1, 3, 2
E. 1 and 2 tie, then 3

ans: D

41. A particle with charge q is to be brought from far away to a point near an electric dipole. No work is done if the final position of the particle is on:

A. the line through the charges of the dipole
B. a line that is perpendicular to the dipole moment
C. a line that makes an angle of 45° with the dipole moment
D. a line that makes an angle of 30° with the dipole moment
E. none of the above

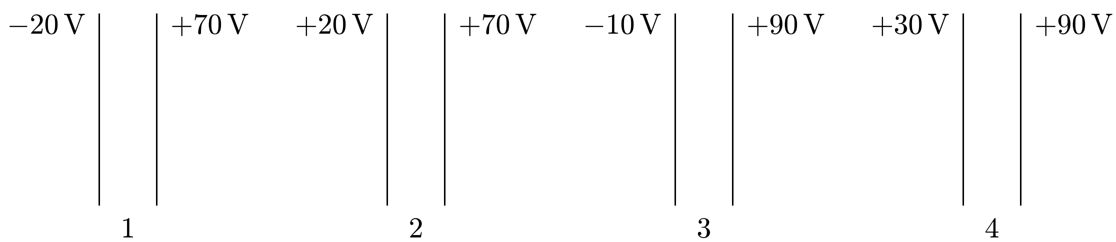
ans: B

42. Equipotential surfaces associated with an electric dipole are:

A. spheres centered on the dipole
B. cylinders with axes along the dipole moment
C. planes perpendicular to the dipole moment
D. planes parallel to the dipole moment
E. none of the above

ans: E

43. The diagram shows four pairs of large parallel conducting plates. The value of the electric potential is given for each plate. Rank the pairs according to the magnitude of the electric field between the plates, least to greatest.



A. 1, 2, 3, 4
B. 4, 3, 2, 1
C. 2, 3, 1, 4
D. 2, 4, 1, 3
E. 3, 2, 4, 1

ans: D