Q1.

Three identical conducting spheres (A, B, and C) are well separated from each other. Initial charges on them are $Q_A = Q$, $Q_B = -10e$, and $Q_C = 0$. Sphere A is touched by Sphere C and separated. Then Sphere B is touched by Sphere C and separated. If the final charge on sphere C is +10e, find Q.

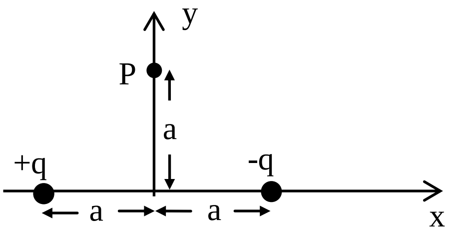
A) +60e
B) –60e
C) 0
D) +10e
E) –10e

Ans:

Q2. A conducting sphere of radius 10 cm carries a charge q, and produces an electric field E at a point 20 cm away from its center. The electric field at a point 30 cm radially away from its surface is:

A) E/4
B) E
C) 2E
D) E/2
E) 4E

Q3. What is the electric field at point P in **Figure 1**?



A) $\frac{1}{4\pi\varepsilon_0}\frac{q}{\sqrt{2}\,a^2}\hat{i}$

B) $\frac{1}{4\pi\varepsilon_0}\frac{q}{\sqrt{2}\,a^2}\hat{j}$

C) $\frac{1}{4\pi\varepsilon_0}\frac{q}{a^2}\hat{i}$

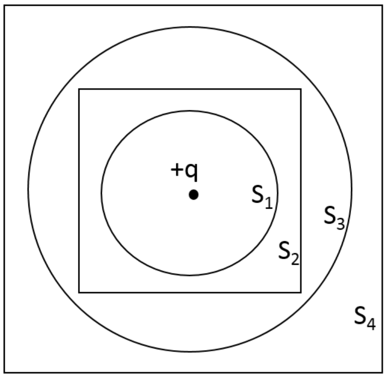
D) $\frac{-1}{4\pi\varepsilon_0}\frac{q}{\sqrt{2}\,a^2}\hat{i}$

E) Zero

Q4. An electric dipole having dipole moment of 2.0×10^{-9} C.m is present in a uniform external electric field of 300 N/C. The dipole moment is initially perpendicular to the field and the dipole rotates so that its dipole moment becomes parallel to the field. The work done by the field to rotate the dipole is:

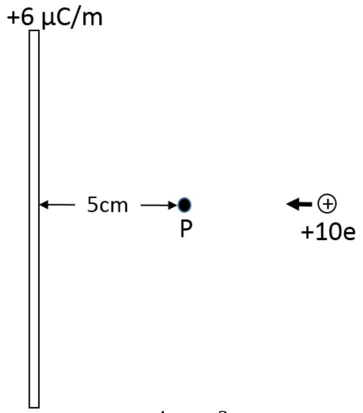
A) $+ 6.0 \times 10^{-7}$ J
B) -12×10^{-7} J
C) $- 6.0 \times 10^{-7}$ J
D) $+12 \times 10^{-7}$ J
E) Zero

Q5. **Figure 2** shows the cross section of two conducting spherical shells and two conducting hollow cubes that are centered on a particle of charge +q. If a charge –q is uniformly distributed on sphere S_3, rank the magnitude of net flux through the four surfaces S_1, S_2, S_3, and S_4, greatest first.



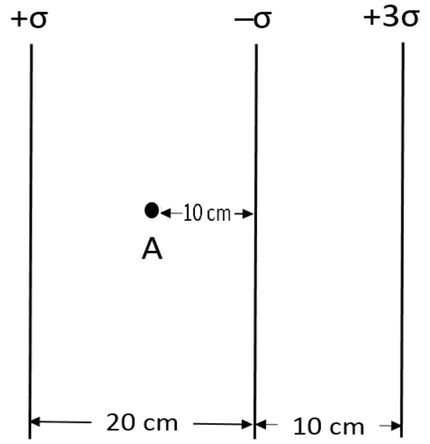
A) S_1 and S_2 tie, then S_3 and S_4 tie
B) S_1, S_2, S_3, S_4
C) S_1, S_2, then S_3 and S_4 tie
D) S_4 and S_2 tie, then S_1 and S_3 tie
E) S_3, S_1, S_2, S_4

Q6. A particle of charge +10e and mass 6.0×10^{-6} g is fired directly toward a very long straight conducting wire of linear charge density +6.0 μC/m as shown in **Figure 3**. Find the magnitude and direction of acceleration of the charged particle when it reaches point P, 5.0 cm from the wire. Ignore the effect of gravity.



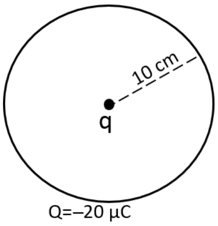
A) 5.8×10^{-4} m/s^2 to the right
B) 5.8×10^{-4} m/s^2 to the left
C) 2.6×10^{-6} m/s^2 to the left
D) 2.6×10^{-6} m/s^2 to the right
E) Zero

Q7. **Figure 4** shows a cross section of three large insulating sheets with their surface charge densities (σ = 8.85 pC/m^2). The magnitude of the electric field at point A is:



A) 5.00×10^{-1} N/C
B) 3.00×10^{-1} N/C
C) 1.50×10^{-1} N/C
D) 1.00×10^{-1} N/C
E) 1.30×10^{-1} N/C

Q8. An unknown charge q sits at the center of a thin conducting spherical shell of radius 10 cm which carries a charge of Q = −20 μC (see **Figure 5**). If the electric field at a point 15 cm from the center of the sphere is 1.2×10^{6} N/C radially outward, find the value of q.



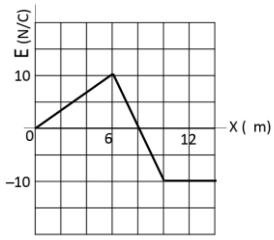
A) +23 μC
B) +30 μC
C) −23 μC
D) −30 μC
E) +50 μC

Q9. Two equal and opposite charges are placed at a certain separation. At the mid-point P between the charges, magnitude of electric field and electric potential are E and V, respectively. Assume potential at infinity is zero. Which of the following is true at P?

A) E is not zero but V is zero
B) Both E and V are not zero
C) Both E and V are zero
D) E is zero but V is not zero
E) None of the other

Q10. A graph of the x-component of electric field as a function of distance x in a region of space is shown in **Figure 6**. The y and z components of the electric field are zero in the region. If the electric potential at x = 12 m is 4.0 V, what is the electric potential at x=0?

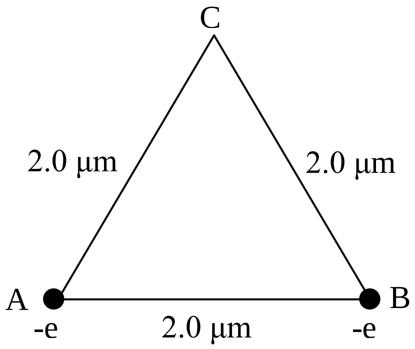
A) 14 V
B) 22 V
C) 38 V
D) 62 V
E) 40 V



Q11. A conducting sphere of radius R_1 = 20 cm carries a charge 30 μC and the electric potential at its surface is V_1. Another conducting sphere of radius R_2 = 50 cm also carries a charge 30 μC and the electric potential at its surface is V_2. What is the ratio V_2/V_1?

A) 0.40
B) 1.6
C) 1.0
D) 0.63
E) 2.0

Q12. As shown in **Figure 7**, two electrons are fixed at the corners A and B of an equilateral triangle of side length 2.0 μm. How much work must one do to bring a third electron to the corner C?

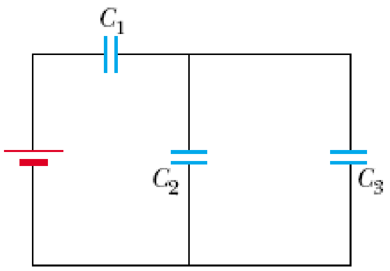


A) 2.3×10^{-22} J
B) 1.4×10^{-22} J
C) 2.3×10^{-13} J
D) 2.3×10^{-28} J
E) 1.4×10^{-13} J

Q13. The capacitance of a spherical drop of a conducting liquid is 2.0 pF. If an additional identical drop is merged with the first one, what is the capacitance of the new bigger drop?

A) 2.5 pF
B) 2.0 pF
C) 4.0 pF
D) 1.0 pF
E) 7.6 pF

Q14. Three capacitors are connected to a battery as shown in **Figure 8**. Their capacitances are C_1 = 3 μF, C_2 = 2 μF, and C_3 = 6 μF. Rank the capacitors according to the potential differences across them, greatest first.



A) C_1, then C_2 and C_3 tie
B) C_2 and C_3 tie, then C_1
C) C_1 and C_2 tie, then C_3
D) C_2, C_1, C_3
E) C_3, C_1, C_2

Q15. A parallel-plate capacitor is filled with a material of dielectric constant κ = 5.0. The area of each plate is 0.024 m^2 and the plates are separated by 4.0 mm. If the electric field between the plates is 100 kN/C, what is the total energy stored in the capacitor?

A) 2.1×10^{-5} J
B) 2.2×10^{-2} J
C) 8.8×10^{-12} J
D) 5.0×10^{-7} J
E) 1.3×10^{-5} J

Q16. Two parallel plates, each of area 50 cm^2, are separated by 0.20 mm. They are given charges of equal magnitudes 4.5×10^{-7} C but opposite signs. The electric potential difference between the plates is 560 V. The dielectric constant of the material is

A) 3.6
B) 7.3
C) 1.0
D) 0.56
E) 0.18

Q17. A Platinum resistance thermometer has a resistance of 50.0 Ω at 20.0 ^{0}C. When dipped in melting indium, its resistance increases to 76.8 Ω. Ignoring the change in dimensions of platinum, determine the melting point of indium. Temperature coefficient of resistivity of platinum is $3.92 \times 10^{-3}\ {}^0C^{-1}$.

A) 157 ^{0}C
B) 137 ^{0}C
C) 127 ^{0}C
D) 147 ^{0}C
E) 167 ^{0}C

Q18. Three wires (A, B, and C) of the same cross-sectional area are connected in parallel to a constant potential difference. The length and resistivity of the wires are given in the table.

Wire	Length	Resistivity
A	L	ρ
B	0.5L	1.5ρ
C	1.5L	1.2ρ

Rank the wires according to the rate at which electric energy is transferred to thermal energy, greatest first.

A) B, A, C
B) A, B, C
C) C, A, B
D) B, C, A
E) A, C, B

Q19. A copper wire with cross-sectional area of 1.5×10^{-5} m^2 and length 0.45 m carries a current of 300 A. What is the drift speed of the electrons in the wire if the number of conduction electrons per unit volume in copper is 8.5×10^{28} m^{-3}?

A) 1.5×10^{-3} m/s
B) 3.2×10^{-3} m/s
C) 8.5×10^{-3} m/s
D) 2.8×10^{-3} m/s
E) 4.5×10^{-3} m/s

Q20. An accelerator used for research on the treatment of tumors eject protons at a rate of 2.0×10^{13} protons/s. What is the current carried by this beam of protons?

A) 3.2×10^{-6} A
B) $2.0 \times 10^{+13}$ A
C) 1.6×10^{-19} A
D) 1.2×10^{-6} A
E) $4.0 \times 10^{+13}$ A

$F = k\frac{q_1 q_2}{r^2}$ $U = -\vec{p}\cdot\vec{E}$ $\vec{\tau} = \vec{p}\times\vec{E}$ $\Phi = \int_{Surface} \vec{E}.d\vec{A}$ $\Phi_c = \oint \vec{E}.d\vec{A} = \frac{q_{in}}{\varepsilon_0}$ $E = \frac{\sigma}{2\varepsilon_o}$ $E = \frac{\lambda}{2\pi\varepsilon_o r}$ $E = \frac{\sigma}{\varepsilon_o}$ $E = k\frac{q}{r^2}$ $E = k\frac{q}{R^3}r$ $E = \frac{2k\lambda}{r}$ $\Delta V = V_B - V_A = -\int_A^B \vec{E}.d\vec{S} = \frac{\Delta U}{q_0}$ $V = k\frac{q}{r}$ $E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}, \quad E_z = -\frac{\partial V}{\partial z}$ $U = k\frac{q_1 q_2}{r_{12}}$ $\Delta U = -W$ $C = \frac{q}{V}$ $C = 4\pi\varepsilon_o R$ $C = \kappa C_{air}$	$C = \frac{\varepsilon_o A}{d}$ (*for parallel plate capacitor*) $C = 2\pi\varepsilon_o \frac{L}{\ln\left(\frac{b}{a}\right)}$ (*for cylindrical capacitor*) $C = 4\pi\varepsilon_o\left(\frac{ab}{b-a}\right)$ (*for spherical capacitor*) $U = \frac{1}{2}CV^2$ $u = \frac{1}{2}\varepsilon_o E^2$ $I = \frac{dQ}{dt}$ $I = JA$ $R = \frac{V}{I} = \rho\frac{L}{A}$ $J = nev_d$ $J = \sigma E$ $\rho = \rho_0\,[1 + \alpha(T - T_0)]$ $P = IV$ -- $v = v_o + at$ $x - x_o = v_o t + \frac{1}{2}a t^2$ $v^2 = v_o^2 + 2a(x - x_o)$ **Constants:** k = 9.00 × 10^9 $N.m^2/C^2$ ε_0 = 8.85 × 10^{-12} $C^2/N.m^2$ e = 1.60 × 10^{-19} C m_e = 9.11 × 10^{-31} kg m_p = 1.67 × 10^{-27} kg g = 9.8 m/s^2 -- μ = micro = 10^{-6} n = nano = 10^{-9} p = pico = 10^{-12}