Q1. A hot object and a cold object are placed in thermal contact and the combination is isolated. They transfer energy until they reach a final equilibrium temperature. The change in the entropy of the hot object (ΔS_h), the change in the entropy of the cold object (ΔS_c), and the change in the entropy of the combination (ΔS_{total}) are:

A) $\Delta S_h < 0$, $\Delta S_c > 0$, $\Delta S_{\text{total}} > 0$
B) $\Delta S_h > 0$, $\Delta S_c > 0$, $\Delta S_{\text{total}} > 0$
C) $\Delta S_h < 0$, $\Delta S_c > 0$, $\Delta S_{\text{total}} = 0$
D) $\Delta S_h > 0$, $\Delta S_c < 0$, $\Delta S_{\text{total}} > 0$
E) $\Delta S_h > 0$, $\Delta S_c < 0$, $\Delta S_{\text{total}} < 0$

Q2. A Carnot heat engine operates between 300 K and 500 K. To double the efficiency, the temperature of the hot reservoir is fixed, and the temperature of the cold reservoir is changed to:

A) 100 K
B) 150 K
C) 200 K
D) 250 K
E) 350 K

Q3. Five moles of an ideal monatomic gas are cooled from 25.0 ^{o}C to – 18.0 ^{o}C. What is the change in the entropy of the gas if the cooling is done at a constant pressure of 1.00 atm?

A) – 16.2 J/K
B) + 16.2 J/K
C) – 34.1 J/K
D) + 34.1 J/K
E) – 9.71 J/K

Q4. Two fixed particles of charges $q_1 = + 3.0 \times 10^{-6}$ C and $q_2 = -27 \times 10^{-6}$ C, are 10 cm apart. How far from q_1 should a third charge be located so that the net force on it is zero?

A) 5.0 cm
B) 15 cm
C) 20 cm
D) 10 cm
E) 35 cm

Q5. Two neutral metal spheres are separated by 300 m. How many electrons must be transferred from one sphere to the other so that their force of attraction has a magnitude of 10^6 N?

A) 2×10^{19}
B) 1×10^{19}
C) 3×10^{19}
D) 0.5×10^{19}
E) 4×10^{19}

Q6. Figure 1 shows a particle with positive charge Q and a particle with negative charge $-Q$, both fixed in place. What is the electric field at point P? [Take Q = 1.00 μC]

Fig#

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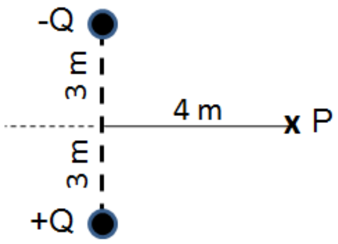

A) $+ 432\ \hat{\mathbf{j}}$ (N/C)
B) $- 432\ \hat{\mathbf{j}}$ (N/C)
C) $+ 576\ \hat{\mathbf{j}}$ (N/C)
D) $- 576\ \hat{\mathbf{j}}$ (N/C)
E) $- 540\ \hat{\mathbf{i}}$ (N/C)

Q7. An electric dipole consists of a particle with a charge of $+6.0 \times 10^{-6}$ C at the origin and a particle with a charge of -6.0×10^{-6} C on the x axis at $x = 3.0 \times 10^{-3}$ m. Its dipole moment is:

A) 1.8×10^{-8} C.m, in the negative x direction
B) 1.8×10^{-8} C.m, in the positive x direction
C) 0 because the net charge is 0
D) 1.8×10^{-8} C.m, in the positive y direction
E) 1.8×10^{-8} C.m, in the negative y direction

Q8. A proton with a speed of 4.0×10^{6} m/s moves in uniform electric field of 3.8×10^{3} N/C. The field is acting to decelerate the proton. How far does the proton travel before it is brought momentarily to rest?

A) 22 m
B) 5.6 μm
C) 55 μm
D) 44 m
E) 11 m

Q9. A non-uniform electric field given by $\vec{E} = 3.0\, x\,\hat{\mathbf{i}} + 4.0\,\hat{\mathbf{j}}$ pierces the Gaussian surface that is in the form of a cylinder of radius 1.0 m (see Figure 2). What is the net charge inside the cylinder?

Fig#

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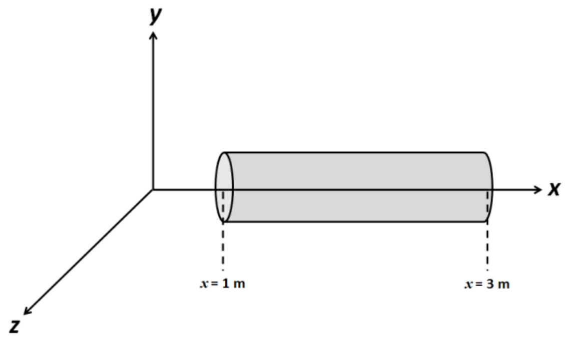

A) $6\pi\varepsilon_o$
B) $12\ \pi\varepsilon_o$
C) $-12\ \pi\varepsilon_o$
D) $-\ 6\ \pi\varepsilon_o$
E) zero

Q10. Three parallel positively-charged non-conducting sheets are separated by a distance *d* between adjacent sheets. The surface charge density on each of the sheets is σ. The electric field in the regions between adjacent sheets has magnitude:

A) $\sigma/2\varepsilon_o$
B) σ/ε_o
C) $3\sigma/2\varepsilon_o$
D) $2\sigma/3\varepsilon_o$
E) zero

Q11. Figure 3 shows a cross section of a neutral spherical metal shell of inner radius *R*. A point charge $q = 5.0\ \mu C$ is located at a distance *4R/5* from the center of the shell. Points 1, 2, 3, and 4 are all the same distance from the center of the spherical shell. At which point is the magnitude of the electric field the largest?

Fig#

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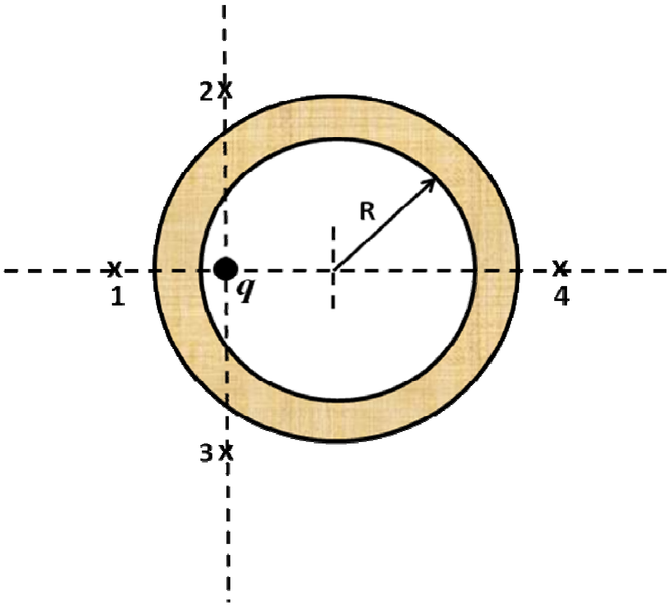

A) The electric field is the same at points 1, 2, 3 and 4
B) The electric field is zero outside a conductor
C) Point 1
D) Points 2 and 3
E) Point 4

Q12. A very long non -conducting cylinder of radius 4.0 cm has a uniform volume charge density of 25 μC/m^3. What is the magnitude of the electric field at r = 2.0 cm, where r is the distance from the axis of the cylinder?

A) 2.8×10^4 N/C
B) 5.6×10^4 N/C
C) 1.8×10^4 N/C
D) 4.7×10^3 N/C
E) zero

Q13. A charge of +28 nC is placed at the origin in a uniform electric field that is directed along the positive y-axis and has a magnitude of 4.0×10^4 V/m. The work done by the electric field when the charge moves to the point (3.0 m, 4.0 m) is:

A) +4.5 mJ
B) +6.0 mJ
C) +3.4 mJ
D) –4.5 mJ
E) –6.0 mJ

Q14. An electron is placed in an *xy* plane where the electric potential depends on *x* and *y* as shown in Figure 4 (the potential does not depend on *z*). What is the electric field (in units of kV/m)?

Fig#

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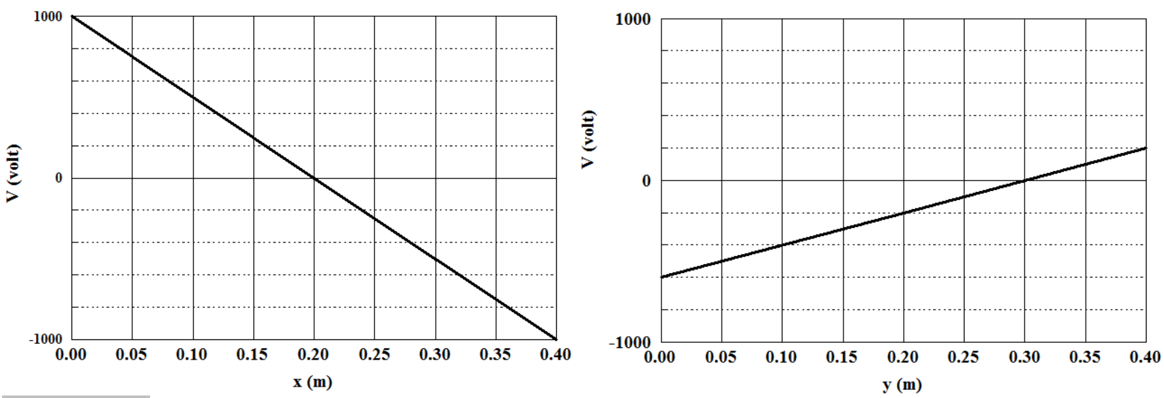

A) $5\,\hat{\mathbf{i}} - 2\,\hat{\mathbf{j}}$
B) $5\,\hat{\mathbf{i}} + 2\,\hat{\mathbf{j}}$
C) $-5\,\hat{\mathbf{i}} + 2\,\hat{\mathbf{j}}$
D) $5\,\hat{\mathbf{i}} + \hat{\mathbf{j}}$
E) $10\,\hat{\mathbf{i}} - \hat{\mathbf{j}}$

Q15. An isolated conducting sphere has radius $R = 0.20$ m and a charge of +20 μC. Point A is at a distance of $3R$ from the center of the sphere. If V_C is the electric potential at the center of the sphere, what is the electric potential difference $V_C - V_A$?

A) $+6.0 \times 10^5$ V
B) -6.0×10^5 V
C) $+1.2 \times 10^7$ V
D) -3.0×10^5 V
E) $+3.0 \times 10^5$ V

Q16. An electron is projected with an initial kinetic energy of 3.6×10^{-24} J toward a fixed proton. If the electron is initially infinitely far from the proton, at what distance from the proton is its speed equal to twice its initial speed?

A) 21 μm
B) 16 μm
C) 83 μm
D) 2.9 μm
E) 3.8 μm

Q17. Three electrons are initially infinitely far from each other. How much work (by an external agent) is required to place them on the corners of an equilateral triangle of side length 1.00 nm?

A) $+ 6.91 \times 10^{-19}$ J
B) -6.91×10^{-19} J
C) $+4.61 \times 10^{-19}$ J
D) -4.61×10^{-19} J
E) $+89.9 \times 10^{-19}$ J

Q18. Three capacitors are arranged as shown in Figure 5. C_1 has a capacitance of 5.00 pF, C_2 has a capacitance of 10.0 pF, and C_3 has a capacitance of 15.0 pF. Find the charge stored in capacitor C_1 if the voltage drop across C_2 is 311 V.

Fig#

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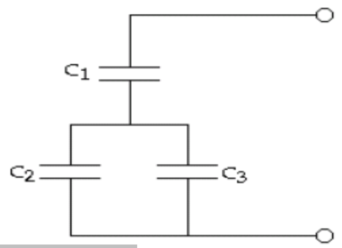

A) 7.78 nC
B) 1.56 nC
C) 5.20 nC
D) 15.6 nC
E) 3.89 nC

Q19. Each of the three 25-μF capacitors shown in Figure 6 is initially uncharged. How much charge is stored in the combination after the switch S is closed?

Fig#

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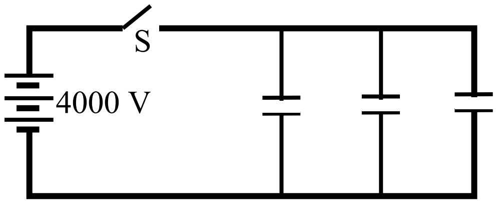

A) 0.30 C
B) 0.10 C
C) 0.20 C
D) 0.050 C
E) 5.0 C

Q20. In Figure 7, two capacitors, C_1= 2.00 μF and C_2 = 5.00 μF, are separately charged by a 100-volt battery and then connected, with opposite polarity, by closing switches S_1 and S_2. What will be the potential difference across C_1 after the switches are closed?

Fig#

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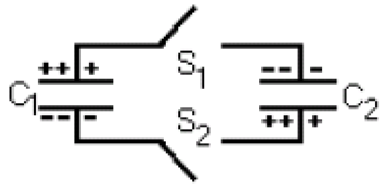

A) 42.9 V
B) 95.2 V
C) 100 V
D) 71.4 V
E) 84.5 V

$\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors along the positive directions of x-axis, y-axis and z-axis respectively.

$T_c = T - 273$

$Q = n\,C_V\,\Delta T$

$Q = n\,C_P\,\Delta T$

$W = Q_H - Q_L$

$$\varepsilon = \frac{W}{Q_H} = 1 - \frac{Q_L}{Q_H}$$

$$K = \frac{Q_L}{W}$$

$$\Delta S = \int \frac{dQ}{T}$$

$$F = \frac{kq_1q_2}{r^2}\ , \quad F = q_0 E$$

$$\Phi = \int_{\text{Surface}} \vec{E} \cdot d\vec{A}\ , \quad E = \frac{kq}{r^2}$$

$$E = \frac{kQ}{R^3} r\ , \quad E = \frac{2k\lambda}{r}$$

$$\varphi_c = \oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\varepsilon_o}$$

$$E = \frac{\sigma}{2\varepsilon_o}; \quad E = \frac{\sigma}{\varepsilon_o}$$

$$V = \frac{kQ}{r}\ , \quad W = \pm\,\Delta U$$

$$\Delta V = V_B - V_A = -\int_A^B \vec{E} . d\vec{s} = \frac{\Delta U}{q_0}$$

$$E_x = -\frac{\partial V}{\partial x},\ E_y = -\frac{\partial V}{\partial y},\ E_z = -\frac{\partial V}{\partial z}$$

$$U = \frac{kq_1q_2}{r_{12}}$$

$$C = \frac{Q}{V}\ , \quad C_o = \frac{\varepsilon_0 A}{d}\ , \quad C = 4\pi\varepsilon_o \frac{ab}{b-a},$$

$$v = v_o + at$$

$$x - x_o = v_o t + \frac{1}{2} a t^2$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

$R = 8.31$ J/mol K

$\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N.m^2$

$k = 9.0 \times 10^9$ $N.m^2/C^2$

$e = -1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

$m_p = 1.67 \times 10^{-27}$ kg

$g = 9.8$ m/s^2

micro (μ) = 10^{-6}

nano (n) = 10^{-9}

pico (p) = 10^{-12}