CPP-02
SS JEE(M) &
ADVANCED

Physics

Chapterwise Practise Problems (CPP) for JEE (Main & Advanced)

Chapter - Electrostatic Potential and Capacitance

Level-1

SECTION - A

Straight Objective Type

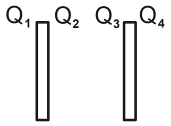
This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. There exists a uniform electric field in space. Electric field is parallel to xy plane. The potential of points A(2,2), B(–2,2) and C(2, 4) are 4V, 16V, 12V respectively. The electric field is (co-ordinates given are in m)

(A) $\left(4\hat{i}+5\hat{j}\right)$ V/m (B) $\left(3\hat{i}+4\hat{j}\right)$ V/m

(C) $-\left(3\hat{i}+4\hat{j}\right)$ V/m (D) $\left(3\hat{i}-4\hat{j}\right)$ V/m

2. In an isolated charged capacitor of capacitance 'C', the four surfaces have charges Q_1, Q_2, Q_3 and Q_4 as shown. Magnitude of potential difference between the plates of the capacitor is



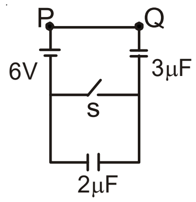
(A) $\dfrac{Q_1+Q_2+Q_3+Q_4}{C}$

(B) $\dfrac{Q_2+Q_3}{C}$

(C) $\dfrac{|Q_2-Q_3|}{2C}$

(D) $\dfrac{|Q_1-Q_4|}{2C}$

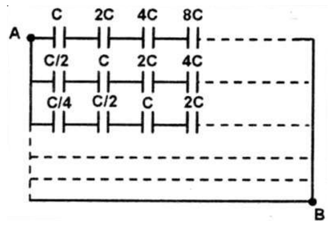
3. The charge flown from P to Q when the switch S is closed is



(A) $3\mu C$ (B) $6\mu C$

(C) $\dfrac{54}{5}\mu C$ (D) $15\mu C$

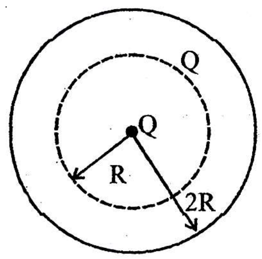
4. Consider an infinite matrix of capacitor as shown in the figure. The effective capacitance between point A and B will be



(A) C (B) 2C

(C) $\dfrac{3C}{2}$ (D) $\dfrac{C}{2}$

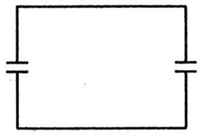
5. A spherical shell is uniformly charged by a charge Q. A point charge Q is at its centre. The work of electric forces upon the expansion of shell from radius R to 2R is



(A) $\dfrac{Q^2}{8\pi \epsilon_0 R}$ (B) $\dfrac{3Q^2}{8\pi \epsilon_0 R}$

(C) $\dfrac{3Q^2}{16\pi \epsilon_0 R}$ (D) $\dfrac{3Q^2}{2Q\pi \epsilon_0 R}$

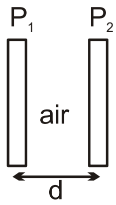
6. A charge capacitor of capacitance C and having charge Q is to be connected with another uncharged capacitor of capacitance C′ as shown. For which value of C′ from the ones below, the heat liberated through the wires will be maximum?



(A) Zero (B) C

(C) C/2 (D) 2C

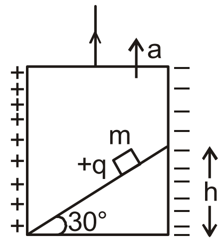
7. Two conducting large plates P_1 and P_2 are placed parallel to each other at very small separation 'd'. The plate area of either face of plate is A. A charge +2Q is given to plate P_1 and –Q to the plate P_2 (neglect ends effects). If plate P_1 and P_2 are now connected by conducting wire, then total amount of heat produced is



(A) $\frac{4Q^2d}{3\epsilon_0 A}$ (B) $\frac{9Q^2d}{8\epsilon_0 A}$

(C) $\frac{3Q^2d}{4\epsilon_0 A}$ (D) None of these

8. A small block of mass 'm' is kept on a smooth inclined plane of angle 30° placed in an elevator going upward with acceleration 'a'. Electric field E exists between the vertical sides of the wall of the elevator. The charge on the block is +q. The time taken by the block to come to the lowest point of the inclined plane is (Take the surface to be smooth)



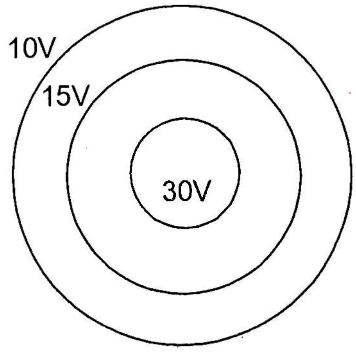
(A) $\sqrt{\frac{2h}{g}}$

(B) $\sqrt{\frac{2h}{(g-a)+\frac{qE}{m}}}$

(C) $2\sqrt{\frac{2h}{(g+a)-\frac{qE}{m}\sqrt{3}}}$

(D) $\sqrt{\frac{2h}{(g+a)^2-\left(\frac{qE}{m}\right)h^2}}$

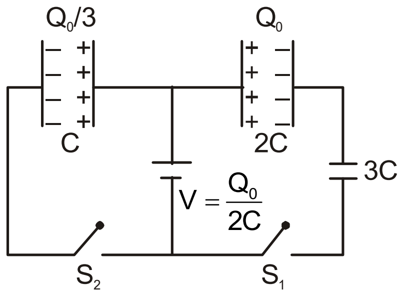
9. The diagram shows three concentric conducting spherical shells having radii R, 2R and 3R. The initial potential of each shell is shown in the figure. If the inner most shell is earthed then the charge present on the outer surface of the innermost shell would be equal to



(A) Zero (B) $40\pi\varepsilon_0 R$

(C) $4\pi\varepsilon_0 R$ (D) $-\pi\varepsilon_0 R$

10. In the given circuit, the initial charges on the capacitors are shown in the figure. The charge flown through the switches S_1 and S_2 respectively after closing the switches are



(A) Zero, $\frac{Q_0}{6}$ (B) $\frac{Q_0}{5}, \frac{Q_0}{2}$

(C) Zero, $\frac{Q_0}{2}$ (D) $\frac{3}{5}Q_0, \frac{Q_0}{6}$

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

11. Three concentric spherical metallic shells A, B and C of radii a, b and c (a < b < c) have charge densities of σ, $-\sigma$ and σ respectively. Choose correct alternatives

(A) The potential at A is $\frac{\sigma}{\varepsilon_0}(a-b+c)$

(B) The potential at B is $\frac{\sigma}{2\varepsilon_0}\left(\frac{a^2}{c}-\frac{b^2}{c}+c\right)$

(C) The potential at C is $\frac{\sigma}{\varepsilon_0}\left(\frac{a^2}{c}-\frac{b^2}{c}+c\right)$

(D) The electric field at surface of A is $\frac{\sigma}{2\varepsilon_0}$

12. An ellipsoidal cavity is carved within a perfect conductor. A positive charge q is placed at the centre of the cavity. The points A and B are any two points on the cavity surface. Then

(A) Electric field near A in the cavity must be equal to the electric field near B in the cavity

(B) Surface charge density at A must be equal to the surface charge density at B

(C) Potential at A must be equal to the potential at B

(D) Total electric field flux through the surface of the cavity is $\frac{2q}{\varepsilon_0}$

13. A capacitor of capacity C_0 is connected to a battery of emf V_0. When steady state is attained a dielectric slab of dielectric constant K is slowly introduced in the capacitor to fill the capacitor completely. Mark the correct statement (s), in final steady state

(A) Magnitude of induced charge on the each surface of slab is $[C_0V_0(K-1)]$

(B) Electric force due to induced charges on any plate is zero

(C) Force of attraction between plates of capacitor is $\frac{K(C_0V_0)^2}{2\in_0 A}$

(D) Field due to induced charges in dielectric slab is $\frac{(K-1)C_0V_0}{\in_0 A}$

14. Two concentric metallic shell's of radius R and 2R, out of which the inner shell is having charge Q and outer shell is uncharged. If they are connected with a conducting wire. Then,

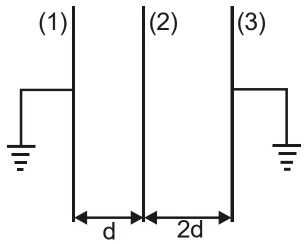
(A) Q amount of charge will flow from inner to outer shell

(B) Q/e number of electrons will flow from inner to outer shell, where e is charge of electron

(C) $\frac{KQ^2}{8R}$ amount of heat is produced in the wire

(D) $\frac{KQ^2}{4R}$ amount of heat is produced in the wire

15. Three identical large metallic plates of area A are arranged as shown. A charge + Q is given to plate-2. Then select correct alternative/s



(A) charge – Q/3 appears on inner surface of plate-3

(B) charge on right surface of plate 2 is Q/3

(C) charge +2Q/3 appears on left surface of plate-2

(D) charge –2Q/3 appears on inner surface of plate-1

SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/are correct.

Paragraph for Question Nos. 16 to 18

A capacitor of capacitance C is connected through a battery of emf E. When charging is completed capacitor is disconnected from the battery and then plate of capacitor is cut such that each plate is divided into two parts without changing plate separation and the areas of plates become A/3 and 2A/3 and then both capacitors are connected with each other such that +ve terminal of one plate is connected with –ve terminal of other plate and vice versa. Then answer the following questions.

16. Find final potential difference across the capacitor having plate area A/3.

(A) E (B) E/3
(C) 2E/3 (D) E/2

17. Find the heat rejected by the system

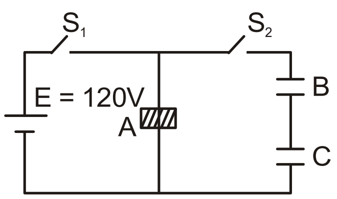
(A) $\frac{1}{2}CE^2$ (B) CE^2
(C) $\frac{1}{4}CE^2$ (D) $\frac{4}{9}CE^2$

18. Find the final charge on the capacitor having plate area 2A/3.

(A) EC (B) EC/3
(C) 2EC/9 (D) EC/2

Paragraph for Question Nos. 19 to 21

When the capacitor A is filled with a dielectric (K = 2) it has capacitance C_1 = 2 μF as per the circuit shown. Capacitors B and C are air capacitors and have capacitances C_2 = 2μF and C_3 = 4 μF respectively



19. Find charge on capacitor A when only S_1 is closed and S_2 is open

(A) 240 μC (B) 360 μC
(C) 180 μC (D) 420 μC

20. If both switches S_1 and S_2 are closed the charge on capacitor C_2 will be

(A) 144 μC (B) 360 μC
(C) 160 μC (D) 240 μC

21. If keeping S_1 and S_2 closed the dielectric slab of A is removed then charge that flows, through the battery will be

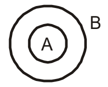
(A) 144 μC (B) 120 μC
(C) 180 μC (D) 240 μC

SECTION-D

Matrix-Match Type

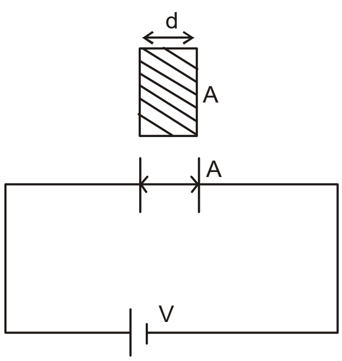
This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

22. Two concentric metal shells of radii r_A = 1 and r_B = 2 cm are given charges and action performed as shown.



Column I	Column II
(A) q_A = 2 μC, q_B = 4μC, A grounded	(p) Final $\left\|\frac{q_A}{q_B}\right\|$ = 1
(B) q_A = 4 μC, q_B = –4 μC, B grounded	(q) Final $\left\|\frac{q_A}{q_B}\right\|$ = 0
(C) q_A = –2 μC, q_B = 4 μC, A and B connected	(r) Final $\left\|\frac{q_A}{q_B}\right\|$ < 1, non zero
(D) q_A = –1 μC, q_B = 2 μC, A grounded	(s) q_A and q_B do not change during the process
	(t) Electric field between A and B is zero

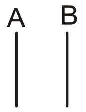
23. Some events related to a capacitor are listed in column-I. Match these events with their effect(s) in column-II



	Column I		**Column II**
	(Events)		(Effects)
(A)	Insertion of dielectric while battery remain attached	(p)	Electric field between plates changes
(B)	Removal of dielectric while battery is not present	(q)	Charge present on plates changes
(C)	Slow decrease in separation between plates while battery is attached	(r)	Energy stored in capacitor increases
(D)	Slow increase of separation between plates while battery is not present	(s)	Work done by external agent is positive

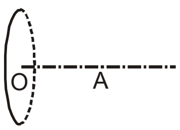
24. Consider an arrangement shown in Column-I, a value related to arrangement is asked. Choose the proper value from Column - II and Column - I

Column I **Column II**

(A) 

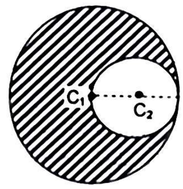
(P) 1

A and B are two large metallic plates having charges zero and '3Q' respectively. Now plate A is grounded by a wire. Then if Q_1 is charge flown through wire and Q_2 is charge on right surface of A then $\left|\frac{Q_2}{Q_1}\right|$ is

(B) 

(Q) 2

A is a point on axis of conducting ring having charge 'Q'. Now another point charge of $\frac{128}{125}Q$ is placed at centre of ring. If E_1 and E_2 are Electric fields at A before and after placing point charge then $\frac{E_2}{E_1}$ is (radius of ring is 3R and OA = 4R)

(C) 

(R) 3

Spherical cavity of radius $\frac{R}{2}$ is made inside a uniform non-conducting sphere of radius R as shown in figure. If maximum difference of electrostatic potential between any two points inside cavity is $\frac{4\pi\rho R^2 K}{k}$ then $\frac{k}{2}$ is : (ρ is volume charge density of material of sphere, $K = \frac{1}{4\pi\varepsilon_0}$)

SECTION-E

Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

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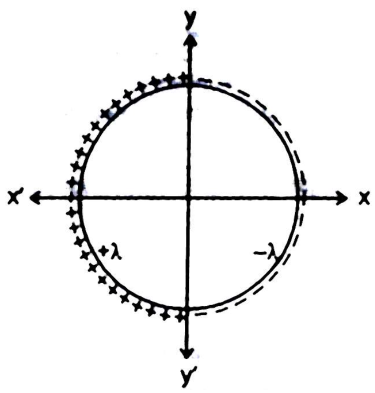
25. A thin ring of radius R is placed in x-y plane such that its centre lies at origin. The half ring in region x < 0 carries uniform linear charge density $+\lambda$ and the remaining half ring in region x > 0 carries uniform linear charge density $-\lambda$. Then the electric potential (in volts) at point P whose coordinates are $\left(0, \frac{R}{2}\right)$



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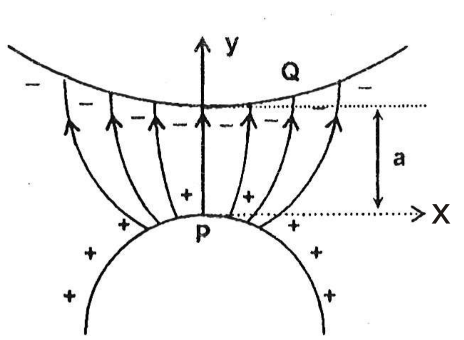
SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

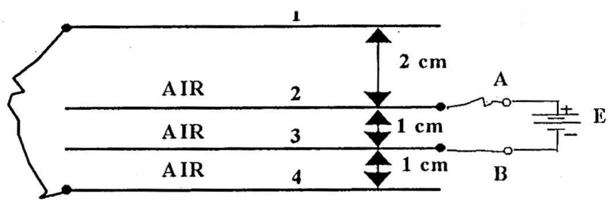
1. P and Q are two conductors carrying equal and opposite charge. The electric field created by two conductor is shown in the figure which is non uniform. the magnitude of electric field along y-axis is given by $E = E_0(1 - ky^3)$, where k is a constant. The electric potential of conductor 'P' is $2E_0\left(a - \frac{ka^4}{4}\right)$. Then the potential of conductor Q is



(A) $2E_0\left(a - \frac{ka^4}{4}\right)$ (B) $E_0\left(a - \frac{ka^4}{4}\right)$

(C) $\frac{E_0}{2}\left(a - \frac{ka^4}{4}\right)$ (D) $3E_0\left(a - \frac{ka^4}{4}\right)$

2. The arrangement of parallel conducting plates shown in the figure are of same surface area $A = 10 cm^2$. A battery of e.m.f. E = 10V is connected across the ends A and B. The plate 2 is slowly moved upwards by some external force.

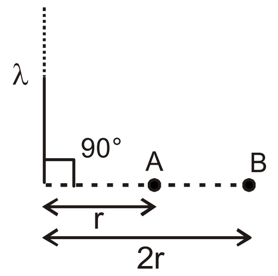


Find the distance between plate 2 and plate 3 at which energy stored in the system is minimum.

(A) 2 (B) 1

(C) 3 (D) 4

3. In the figure shown points A and B are at distance r and 2r respectively from one end of uniformly charged infinitely long wire having linear charge density λ. Find potential difference $V_A - V_B$



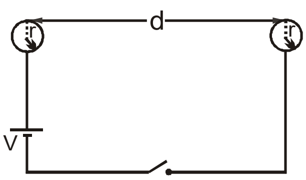
(A) $\frac{\lambda}{4\pi\varepsilon_o}\ell n2$

(B) $\frac{\lambda}{2\pi\varepsilon_0}\ell n2$

(C) $\frac{\lambda}{\pi\varepsilon_0}\ell n2$

(D) $\frac{\lambda}{8\pi\varepsilon_0}\ell n2$

4. There are two identical uncharged small metallic spheres of radius r at a distance of d >>r, as shown. What is the force exerted between the two spheres if switch is closed. Given emf of battery is V.



(A) $\frac{4\pi\varepsilon_0 V^2 r^2}{d^2}$

(B) $\frac{\varepsilon_0 V^2 d^2}{r^2}$

(C) $\pi\varepsilon_0 \frac{V^2 r^2}{d^2}$

(D) $\pi\varepsilon_0 V^2$

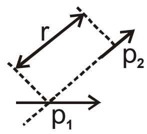
5. There are two electric dipoles kept as shown in figure. Locus of all points having zero potential is

(A) Straight line

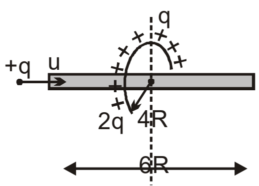
(B) Plane

(C) Circle

(D) Sphere



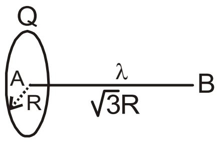
6. On a fixed semicircular ring of radius = 4R, charge + 3q is distributed in such a way that on one quarter + q is uniformly distributed and on another quarter + 2q is uniformly distributed. Along its axis a smooth nonconducting and uncharged pipe of length 6R is fixed axially as shown. A small ball of mass m and charge +q is thrown from one end of pipe with speed u. The speed 'u' so that ball will come out from the other end of pipe is



(A) $u > \sqrt{\dfrac{3q^2}{40\pi \in_0 Rm}}$ (B) $u > \sqrt{\dfrac{7q^2}{40\pi \in_0 Rm}}$

(C) $u \geq \sqrt{\dfrac{8q^2}{40\pi \in_0 Rm}}$ (D) $u \geq \sqrt{\dfrac{9q^2}{40\pi \in_0 Rm}}$

7. A non conducting rod AB of length $\sqrt{3}R$, uniformly distributed charge of linear charge density λ and a non conducting ring of uniformly distributed charge Q, are placed as shown in the figure. Point A is the centre of ring and line AB is the axis of the ring, perpendicular to plane of ring. The electrostatic interaction energy between ring and rod is



(A) $\dfrac{Q\lambda}{4\pi\varepsilon_0}\ell n\left(2+\sqrt{3}\right)$ (B) $\dfrac{Q\lambda}{2\pi\varepsilon_0}\ell n\left(2+\sqrt{3}\right)$

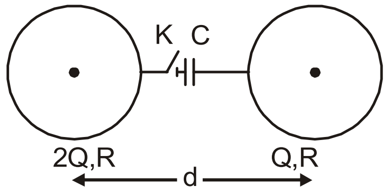
(C) $\dfrac{Q\lambda}{4\pi\varepsilon_0}\ell n\left(2-\sqrt{3}\right)$ (D) $\dfrac{Q\lambda}{2\pi\varepsilon_0}\ell n\left(2-\sqrt{3}\right)$

8. Two concentric spherical conductors have radii 1cm and 4cm. A potential difference of 3000 V exists between the two spheres, the smaller sphere being at higher potential. The velocity of an electron starting from a point (at r = 3cm), from rest to a point (at r = 2cm) along a radius measured from the common centre is

(A) 0.37×10^7 m/s (B) 0.57×10^7 m/s

(C) 0.77×10^7 m/s (D) 1.54×10^7 m/s

9. Two metallic spheres each of radius R having charges 2Q and Q are joined through a capacitor of capacitance C as shown in the figure. Assuming R << d the charge on the capacitor long time after the key "K" is closed is



(A) $\dfrac{Q}{1+\dfrac{4\pi\varepsilon_0 R}{C}}$ (B) $\dfrac{Q}{2+\dfrac{4\pi\varepsilon_0 R}{C}}$

(C) $\dfrac{Q}{3+\dfrac{4\pi\varepsilon_0 R}{C}}$ (D) $\dfrac{Q}{4+\dfrac{4\pi\varepsilon_0 R}{C}}$

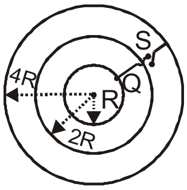
10. In the following diagram the conducting shells are concentric. The amount of charge that flows through the switch(s) after closing it is.

(A) Q

(B) $\dfrac{Q}{2}$

(C) $\dfrac{Q}{3}$

(D) $\dfrac{Q}{4}$



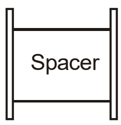
11. A capacitor is to be designed to operate, with constant capacitance, in an environment of fluctuating temperature. As shown in the figure, the capacitor Is a parallel plate capacitor with 'spacer* to change the distance for compensation of temperature effect. If α_1 be the coefficient of linear expansion of plates and α_2 that of spacer, the condition for no change in capacitance with small change of temperature is (The capaci-tance of the capacitor is equal to C and spacer have insulated ends. Assume K of spacer to be = 1).

(A) $\alpha_1 = \alpha_2$

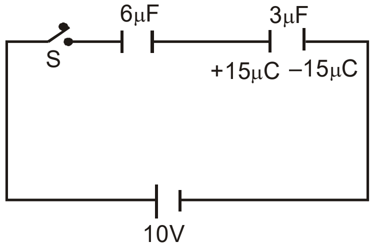
(B) $\alpha_1 = 2\alpha_2$

(C) $2\alpha_1 = \alpha_2$

(D) $2\alpha_1 = 3\alpha_2$

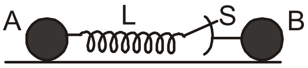


12. The $3\mu F$ capacitor is charged till $15\mu C$ charge is acquired by it whereas $6\mu F$ is uncharged on closing switch S, the heat loss will be



(A) 20 μJ (B) 25 μJ
(C) 30 μJ (D) 35 μJ

13. Two fixed identical metallic spheres A and B of radius R = 50 cm each are placed on a non-conducting plane at a very large distance from each other and they are connected by a coil of inductance L = 9 mH as shown in figure. One of the spheres (say A) is imparted an initial charge and the other is kept uncharged. The switch S is closed at t = 0. After what minimum time t does the charge of the first sphere decrease to half of its initial value?



(A) $\pi \times 10^{-5}$ sec (B) $\frac{\pi}{4}\times10^{-6}$ sec

(C) $\frac{\pi}{2}\times10^{-6}$ sec (D) $2\pi\times10^{-6}$ sec

14. Two small identical blocks are kept on a frictionless horizontal table and connected by a spring of stifness 'k' and of original length l_0. A total charge Q is distributed on the blocks such that maximum elongation takes place in the spring. if extension at equilibrium, is equal to x. Then value of Q is

(A) $2l_0\sqrt{4\pi\varepsilon_0 k(l_0+x)}$ (B) $2x\sqrt{4\pi\varepsilon_0 k(l_0+x)}$

(C) $(l_0+x)\sqrt{4\pi\varepsilon_0 kx}$ (D) $2(l_0+x)\sqrt{4\pi\varepsilon_0 kx}$

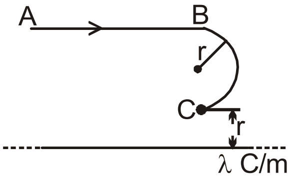
15. The figure shows an infinite line charge of density λ C/m. The work done by the electrostatic force on a unit positive charge, when it is moved along the path ABC, is (plane of the curve ABC contains the line charge)

(A) zero

(B) $(-\lambda/2\pi\varepsilon_0)\ln 2$

(C) $(\lambda/2\pi\varepsilon_0)\ln 3$

(D) $(-\lambda/2\pi\varepsilon_0)\ln 3$



16. The capacitance of an isolated spherical conductor increases to n times if enclosed by an earthed concentric conducting spherical shell, then the ratio of the radii of shell and sphere is :

(A) $\frac{n^2}{n^2-1}$ (B) $\frac{n^2}{n^2+1}$

(C) $\frac{n}{n-1}$ (D) $\frac{n}{n+1}$

17. In arrangement shown in figure-1, force on point charge at origin due to short dipole is $F\hat{i}$. If the dipole is now roated anticlockwise by 90° (as shown in figure 2), force acting on point charge will be

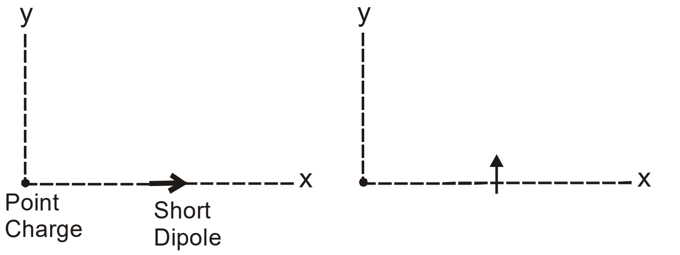


Figure-1 Figure-2

(A) $2F\ \hat{j}$ (B) $-2F\ \hat{j}$

(C) $\frac{F}{2}\hat{j}$ (D) $-\frac{F}{2}\hat{j}$

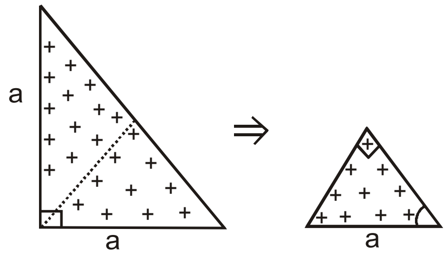
18. Figure shows an isosceles right triangular sheet of uniform surface charge density σ. The self energy of the sheet is U_0. What will be self energy of the sheet if it is folded along the dotted line.

(A) $\sqrt{2}U_0$

(B) $\frac{1}{\sqrt{2}}U_0$

(C) $2U_0$

(D) $2\sqrt{2}U_0$



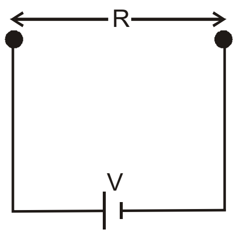
19. Two uncharged (tiny) metallic spherical balls with radii r_1 and r_2 separated by a distance R, R >> r_1,r_2, are connected by a battery of e.m.f V as shown in the figure. The interaction force between the balls is (Neglect any other interaction apart from electrostatic)

(A) $4\pi\varepsilon_0 V^2\frac{r_1^2 r_2^2}{(r_1+r_2)^2}\frac{1}{R^2}$

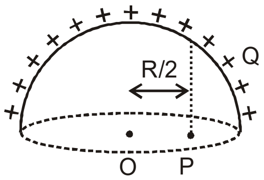
(B) $4\pi\varepsilon_0\frac{V^2 r_1 r_2^2}{(r_1+r_2)^2}\frac{1}{R}$

(C) $4\pi\varepsilon_0 V^2\left(\frac{r_1 r_2}{r_1+r_2}\right)\frac{1}{R}$

(D) $4\pi\varepsilon_0 V^2\frac{r_1 r_2}{(r_1+r_2)^3}R$



20. Charge Q is uniformly distributed over surface of a thin hemispherical shell (radius R). Find electric potential at P, at a distance R/2 from centre as shown.



(A) $\frac{2KQ}{R}$

(B) $\frac{KQ}{R}$

(C) $\frac{3KQ}{2R}$

(D) $\frac{\sqrt{2}KQ}{R}$

21. A point charge of magnitude +1μC is fixed at (0,0,0). An isolated uncharged solid spherical conductor of radius 2 m, is fixed with its centre at (4m,0,0). The potential and electric field due to induced charge at the centre of the sphere is (Assume electric field to be positive along x–axis)

(A) 0 V and 0 V/m

(B) 0 V and -5.625×10^2V/m

(C) 2.25×10^5 V and 0 V/m

(D) 2.25×10^5 V and 5.625×10^2 V/m

22. On an imaginary planet the acceleration due to gravity is same as that on Earth but there is also a downward electric field that is uniform close to the planet's surface. A ball of mass m carrying a charge q is thrown upward at a speed v and hits the ground after an interval t. What is the magnitude of electrical potential difference between starting point and the top point of the trajectory?

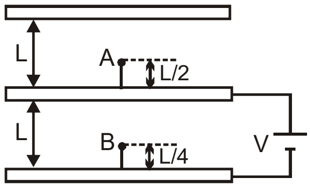
(A) $\frac{mv}{2q}\left(v-\frac{gt}{2}\right)$

(B) $\frac{mv}{q}\left(v-\frac{gt}{2}\right)$

(C) $\frac{mv}{2q}(v-gt)$

(D) $\frac{2mv}{q}(v-gt)$

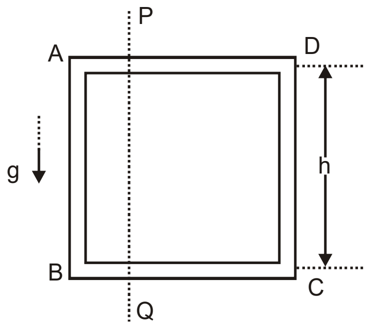
23. In a gravity free space, three identical metal plates have been placed parallel to each other as shown. In the initial state shown in the diagram, the potential difference between the points A and B is V_1. Now, the middle plate is shifted down a distance L/2, keeping the battery connected. The other plates are kept fixed. The potential difference between the points A and B now becomes V_2. The value V_1/V_2 is equal to



(A) 1 (B) 5/6

(C) 5/4 (D) 3/2

24. ABCD is a square frame of conductor of electrical resistivity ρ. The frame lies in a vertical plane, PQ is an imaginary boundary separating space into two parts. Left of PQ, a uniform gravitational field $\vec{g}$ exists (figure) whereas no gravitational field is present right of PQ. The electrical potential difference between A and B will be (m , e are mass and charge of an electron)



(A) $\frac{mgh}{e}$ (B) $\frac{mgh}{2e}$

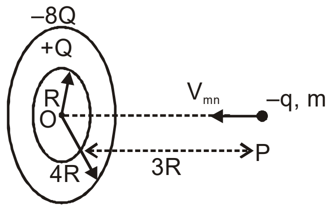
(C) $\frac{3}{4}\frac{mgh}{e}$ (D) $\frac{mgh}{4e}$

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

25. As shown in figure there are two fixed uniformly charged concentric coplanar conducting rings having radius ‘R’ and ‘4R’ and charges ‘+Q’ and ‘–8Q’ respectively. A charge particle of mass ‘m’ and charge ‘–q’ is projected along the axis of rings from point ‘P’ so that particle can just reach the centre of rings (point ‘O’). (Assume Qq > 0)



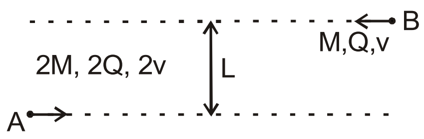
(A) Required minimum velocity is zero

(B) Speed of particle at the position ‘O’ will be non zero

(C) Particle perform oscillatory motion about ‘O’

(D) Speed of the particle will be minimum at a distance of 2R from ‘O’

26. Two particles A and B approach each other from very large distance as shown in the figure. Their masses, charges and speeds are mentioned in the figure. (Neglect gravitational force)



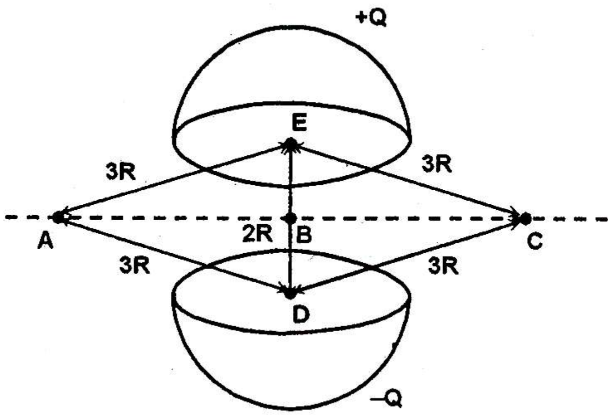
(A) If the least separation between the particles is b, the speed of M in center of mass frame when particles are closest is 2Lv/b

(B) If the least separation between the particles is b, the speed of M in center of mass frame when particles are closest is Lv/b

(C) If the least separation between the particles is b, the speed of 2M in center of mass frame when particles are closest is 2Lv/b

(D) If the least separation between the particles is b, the speed of 2M in center of mass frame when particles are closest is Lv/b

27. Charge Q and –Q is distributed uniformly on two hemispheres of radii R as shown in the figure then



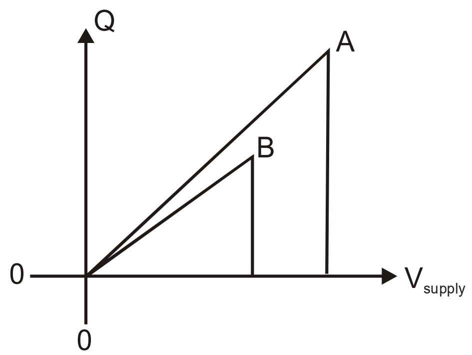
(A) Potential at points each A and C is same

(B) Potential at points A, B and C is same

(C) Potential at points E and D is same

(D) None of these

28. Two parallel plate capacitor of equal size are charged by a power supply of voltage V_{supply}. What is true of these capacitor when their stored charge is plotted as a function of supply voltage?



(A) Capacitor B has a higher dielectric constant between the plates; capacitor A has a higher breakdown voltage

(B) Capacitor A has a higher dielectric constant between the plates;capacitor A has a higher breakdown voltage

(C) Capacitor B has a higher dielectric constant between the plates; capacitor A has a lower breakdown voltage

(D) Capacitor A has a higher dielectric constant between the plates; capacitor B has a lower breakdown voltage

29. The radii of a spherical capacitor are equal to a and b (b > a). The space between them is filled with a dielectric of dielectric constant K and resistivity ρ. At t = 0 the inner electrode is given a charge q_0. Choose the correct options

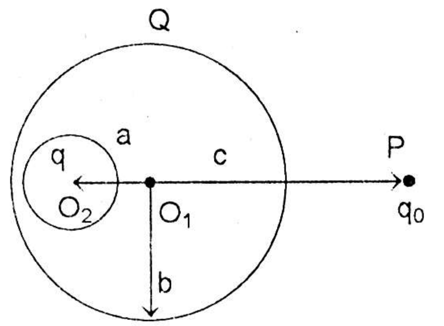
(A) Charge q on the inner electrode as a function of time is given by $q = q_0\, e^{-\frac{t}{\rho K \varepsilon_0}}$

(B) In a short time, the charge on the inner electrode will become zero

(C) After a long time, the charge on the outer sphere will become q_0

(D) The total amount of heat generated during the spreading of charge will be given by $H = \left(\frac{1}{a} - \frac{1}{b}\right)\frac{q_0^2}{8\pi\varepsilon_0 K}$

30. A conducting sphere of radius b has a spherical cavity with its centre displaced by a from centre of sphere. A point charge q is placed at the centre of cavity, Q charge is given to conducting sphere and charge q_0 is placed at a distance c from centre (O_1) of sphere such that O_1, O_2 and P are collinear



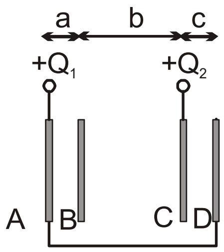
(A) Charge distribution on inner surface of cavity is uniform

(B) Potential of conductor is $\left(\frac{q_0}{4\pi\epsilon_0 c} + \frac{Q+q}{4\pi\epsilon_0 b}\right)$

(C) Charge distribution of outer surface of conducting sphere is non uniform

(D) None of these

31. Figure shows an arrangement of four identical rectangular plates A, B, C and D each of area S. Find the charges appearing on each face (from left to right) of the plates. Separations between the plates is negligible in comparison to the plate dimensions



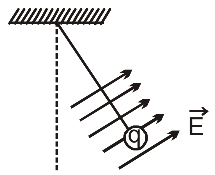
(A) Potential difference between plates A and B is independent of Q_1

(B) Potential difference between plates C and D is independent of Q_1

(C) Potential difference between plates A and B is independent of Q_2

(D) Potential difference between plates C and D is independent of Q_2

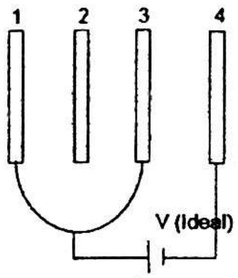
32. A charged cork ball having mass of 1 gram and charge q is suspended on a light string in a uniform electric field as shown in the figure. The ball is in equilibrium at $\theta = 37°$, when value of electric field is $\vec{E} = \left(3\hat{i} + 5\hat{j}\right) \times 10^5$ N/C. Assume T as tension in the string. Which of the following options are correct? (Given : sin37° = 0.60 and g = 10 m/s^2)



(A) $q = 11\times10^{-9}$ C (B) $T = 5.55\times10^{-3}$ N

(C) $q = 12\times10^{-9}$ C (D) $T = 4.55\times10^{-3}$ N

33. Four identical plates (equally spaced) and a battery are connected as shown. If the capacitance between two consecutive plates is C then choose the correct statement(s)



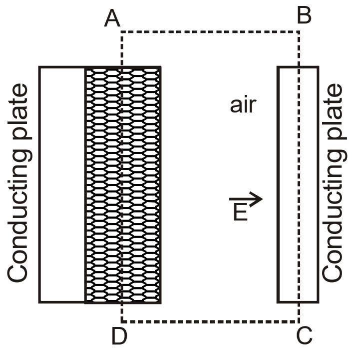
(A) Energy supplied by the battery is CV^2

(B) Energy linked in the space between plates 1 and 2 is $\frac{1}{6}$ CV^2

(C) Potential difference between plates 2 and 4 is V

(D) The surface charge density on plate 3 on its right side is equal to than that of on left side

34. The figure shows two thin large identical parallel conducting plates in air (dielectric constant = 1) with a slab of dielectric constant k placed between them. The width of the small gap between the conducting plates is d while the thickness of the dielectric slab is t. The conducting plates are given equal and opposite charges due to which the strength of the electric field in air region is E as shown. The area of plates perpendicular to the plane of figure is A and consider it to be large. Neglect the edge effects (The portion ABCD has the same dimensions perpendicular to the plane of the figure as that of plate or dielectric medium) Mark the correct options



(A) The net charge in the portion ABCD (volume) is zero

(B) The net charge in the portion ABCD (volume) is $-\dfrac{\varepsilon_0 EA}{k}$

(C) The electrostatic energy stored in the dielectric medium is $\dfrac{\varepsilon_0 E^2 At}{2k}$

(D) The electrostatic energy stored in the dielectric medium is $\dfrac{\varepsilon_0 E^2 At}{2k^2}$

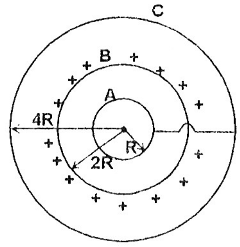
SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/ are correct.

Paragraph for Question Nos. 35 to 37

Three concentric spherical conductors A, B and C have radii R, 2R and 4R respectively. A and C are shorted and are initially neutral and B is uniformly charged (charge +Q)



35. Charge on conductor A is

(A) Q/3 (B) –Q/3

(C) 2Q/3 (D) –Q/2

36. Potential at A is

(A) $\dfrac{Q}{4\pi\varepsilon_0 R}$ (B) $\dfrac{Q}{16\pi\varepsilon_0 R}$

(C) $\dfrac{Q}{20\pi\varepsilon_0 R}$ (D) $\dfrac{Q}{32\pi\varepsilon_0 R}$

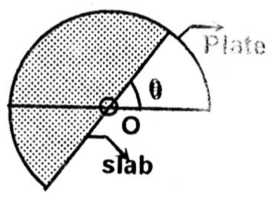
37. Potential at B is

(A) $\dfrac{Q}{4\pi\varepsilon_0 R}$ (B) $\dfrac{Q}{16\pi\varepsilon_0 R}$

(C) $\dfrac{5Q}{48\pi\varepsilon_0 R}$ (D) $\dfrac{5Q}{36\pi\varepsilon_0 R}$

Paragraph for Question Nos. 38 to 40

A capacitor consists of two fixed semicircular plates of radius R and separation d. A movable semicircular slab of thickness d and mass m made of dielectric with the dielectric constant K placed between them. The slab can freely rotate about the axis O as shown in the figure. A constant voltage V is maintained between the plates. Then answer the following question.



38. The equivalent capacitance of the given system as shown in the figure.

(A) $\dfrac{\varepsilon_0 R^2\theta}{2d}+\dfrac{\varepsilon_0 K(\pi-\theta)R^2}{2d}$

(B) $\dfrac{\varepsilon_0 R^2\theta}{2d}+\dfrac{\varepsilon_0 K(\pi+\theta)R^2}{2d}$

(C) $\dfrac{\varepsilon_0 R^2\theta}{2d}+\dfrac{\varepsilon_0 K(\pi-\theta)R^2}{4d}$

(D) $\dfrac{\varepsilon_0 R^2\theta}{2d}-\dfrac{\varepsilon_0 K(\pi+\theta)R^2}{2d}$

39. Find the magnitude of torque of electrostatic forces acting on the slab about point O, in the given configuration

(A) $\dfrac{\varepsilon_0 R^2V^2(K-1)}{2d}$

(B) $\dfrac{\varepsilon_0 R^2V^2(K-1)}{4d}$

(C) $\dfrac{\varepsilon_0 R^2V^2(K+1)}{2d}$

(D) $\dfrac{\varepsilon_0 R^2V^2(K+1)}{4d}$

40. Find the magnitude of the angular acceleration of the movable slab if the mass of the slab is m.

(A) $\dfrac{\varepsilon_0 V^2(K-1)}{2md}$

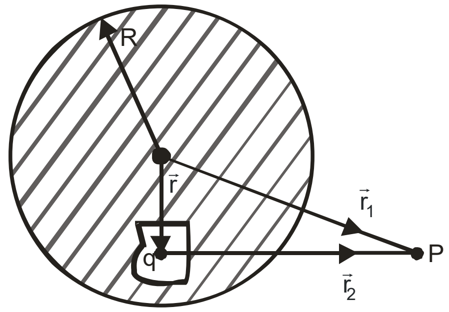
(B) $\dfrac{\varepsilon_0 V^2(K-1)}{4dm}$

(C) $\dfrac{\varepsilon_0 R^2V^2(K+1)}{2md}$

(D) $\dfrac{\varepsilon_0 V^2(K+1)}{4dm}$

Paragraph for Question Nos. 41 and 42

An uncharged spherical conductor of radius R centered at the origin has a cavity of some arbitrary shape carved out of it as shown in figure. Somewhere within the cavity lies a charge 'q' as shown in figure



41. The field at P outside the sphere due to induced charge on the sphere is

(A) $\dfrac{Kq\vec{r}_1}{r_1^3}$ (B) $\dfrac{Kq\vec{r}_2}{r_2^3}$

(C) $Kq\left(\dfrac{\vec{r}_1}{r_1^3}+\dfrac{\vec{r}_2}{r_2^3}\right)$ (D) $Kq\left(\dfrac{\vec{r}_1}{r_1^3}-\dfrac{\vec{r}_2}{r_2^3}\right)$

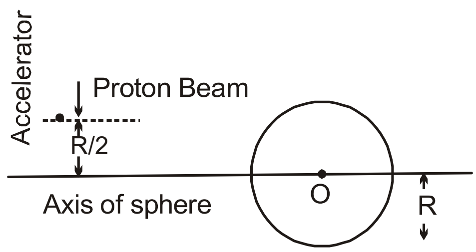
42. The potential at P due to induced charge is

(A) $Kq\left(\dfrac{1}{r_1}-\dfrac{1}{r_2}\right)$ (B) $Kq\left(\dfrac{1}{r_1}+\dfrac{1}{r_2}\right)$

(C) $Kq\left(-\dfrac{1}{r_1}+\dfrac{1}{r_2}\right)$ (D) $\dfrac{Kq}{r_1}$

Paragraph for Question Nos. 43 to 45

An accelerator produces a narrow beam of protons, each having an initial speed of v_0. The beam is directed towards an initially uncharged distant metal sphere of radius R and centred at fixed point O. The initial path of the beam is parallel to the axis of the sphere at a distance of (R/2) from the axis, as indicated in the diagram.



The protons in the beam that collide with the sphere will cause it to become charged. The subsequent potential field at the accelerator due to the sphere can be neglected. The angular momentum of a particle is defined in a similar way to the moment of a force. It is defined as the moment of its linear momentum; linear momentum replacing the force. We may assume the angular momentum of a proton about point O to be conserved. Assume the mass of the proton as m_p and the charge on it as e. Given that the potential of the sphere increases with time and eventually reaches a constant value.

Now, answer the following questions based on above passage.

43. The total mechanical energy (E) of a proton in the beam, travelling with speed v at a distance of r($r \geq R$) from point O, assuming that the sphere has acquired an electrostatic charge Q, is

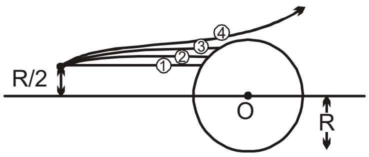
(A) $\frac{eQ}{4\pi\varepsilon_0 r}$

(B) less than $\frac{eQ}{4\pi\varepsilon_0 r}$

(C) greater than $\frac{eQ}{4\pi\varepsilon_0 r}$

(D) zero

44. After a long time, when the potential of the sphere reaches a constant value, the trajectory of proton is correctly sketched as



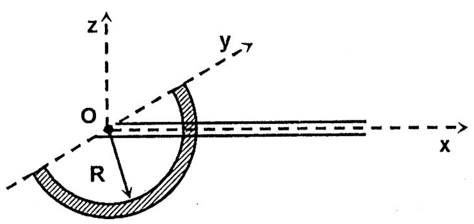
(A) 1 (B) 2
(C) 3 (D) 4

45. Once the potential of the sphere has reached its final, constant value, the minimum speed v of a proton along its trajectory path is given by

(A) v_0 (B) $v_0/2$
(C) $2v_0$ (D) None of these

Paragraph for Question Nos. 46 to 48

There is a fixed semicircular ring of radius R, lying in y-z plane, with centre of arc at origin and it is uniformly charged with charge Q. There is a long hollow pipe of very small radius, inner surface of pipe is smooth and it is made of insulated material. Pipe is fixed along x axis from origin. A small ball with charge q and mass m is projected in pipe in with negligible velocity, ball can smoothly move in pipe. Whole arrangement lies in gravity free space.



46. The maximum acceleration of ball in pipe is

(A) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{mR^2}$ (B) $\frac{1}{12\sqrt{3}\pi\varepsilon_0}\frac{Qq}{mR^2}$

(C) $\frac{1}{6\sqrt{3}\pi\varepsilon_0}\frac{Qq}{mR^2}$ (D) $\frac{1}{8\pi\varepsilon_0}\frac{Qq}{mR^2}$

47. The kinetic energy of particle when its acceleration is maximum is

(A) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{R}\left(1-\sqrt{\frac{2}{3}}\right)$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{R}\left(\frac{1}{2}\right)$

(C) $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{R}\left(\frac{1}{\sqrt{2}}\right)$ (D) $\frac{Qq}{4\pi\varepsilon_0 R}\left(1+\sqrt{\frac{2}{3}}\right)$

48. Normal reaction exerted by pipe on ball when ball is moving in pipe is along

(A) z axis always

(B) –z axis always

(C) initially along y-axis and then along z-axis

(D) y axis always

Paragraph for Question Nos. 49 to 51

An uncharged soap bubble of radius 'a' is electrified to a potential V. Due to the charge given to the bubble, the bubble expands and its radius becomes 'b'. P_0 is the pressure of atmosphere surrounding the soap bubble and T is the surface tension of the soap solution. Assume that the charge on the bubble is uniformly distributed

49. After the soap bubble has attained a radius 'b', the pressure inside the soap bubble is

(A) $P_0 - \frac{4T}{b} + \frac{V^2\varepsilon_0}{2b^2}$ (B) $P_0 + \frac{4T}{b} + \frac{V^2\varepsilon_0}{2b^2}$

(C) $P_0 + \frac{4T}{b} - \frac{V^2\varepsilon_0}{2b^2}$ (D) $P_0 - \frac{4T}{b} - \frac{V^2\varepsilon_0}{2b^2}$

50. If after electrification of the soap bubble, the pressure inside the soap bubble is equal to P_0 then

(A) $V = \sqrt{\frac{8Ta}{\varepsilon_0}}$ (B) $V = \sqrt{\frac{8Tb}{\varepsilon_0}}$

(C) $V = \sqrt{\frac{8Tb}{\varepsilon_0(a-b)}}$ (D) $V = \sqrt{\frac{8Tb}{\varepsilon_0(a+b)}}$

51. After the sphere has been electrified and has attained a radius b and potential V, the force of interaction between 2 halves (hemisphere) of the spherical bubble due to electrostatic repulsion will be

(A) $\frac{\pi V^2 \varepsilon_0}{2}$ (B) $\pi \varepsilon V^2$

(C) $\frac{2\pi V^2 \varepsilon_0}{3}$ (D) $\frac{\pi V^2 \varepsilon_0}{3}$

SECTION-D

Matrix-Match Type

This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

52. A capacitor is uncharged at t = 0. It is charged through a variable current I

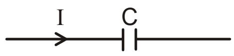
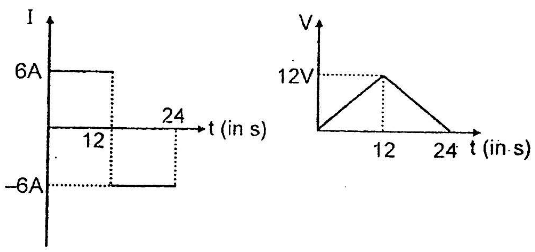


Figure shows variation of I with time and corresponding change in potential difference across capacitor with time



	Column I		**Column II**
(P)	Capacitance (in farad) of capacitor used in the circuit	(1)	16
(Q)	Time (in s) when charge on the capacitor is 48C	(2)	108
(R)	Energy stored (in Joule) in the capacitor at t = 12s	(3)	6
(S)	Energy stored (in Joule) in the capacitor at t = 18s	(4)	432

Codes :

	P	Q	R	S
(A)	1	3	2	4
(B)	3	1	3	4
(C)	3	1	4	2
(D)	4	3	1	2

53. A spherical metallic conductor has a spherical cavity. A positive charge is placed inside the cavity at its centre. Another positive charge is placed outside it. The conductor is initially electrically neutral

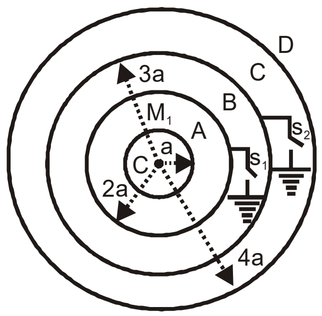
	Column I (Cause)		**Column II (Effect)**
(A)	If outside charge is shifted to other position	(p)	distribution of charge on inner surface of cavity changes
(B)	If inside charge is shifted to other position	(q)	distribution of charge on outer within cavity surface of conductor changes
(C)	If magnitude of charge inside cavity is increased	(r)	electric potential at centre of conductor due to charges present on outer surface of conductor changes
(D)	If conductor is earthed	(s)	force on the charge placed inside cavity changes

SECTION-E

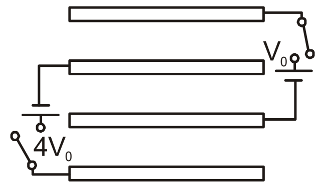
Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

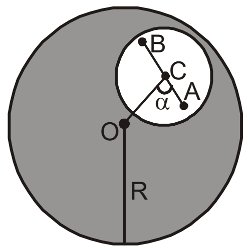
54. In the figure, A, B, C and D are four concentric spheres of radius a, 2a, 3a and 4a and contain, charges +3q, +6q, –9q and +12q respectively. In the beginning switches S_1 and S_2 are open. After earthing the sphere C, Δq_1 amount of charge flows from the sphere C to the earth. If the sphere B is subsequently earthed, then Δq_2 amount of charge flows from the sphere B to the earth, find the value of $\frac{|\Delta q_1|}{|\Delta q_2|}$



55. The figure shows four identical conducting plates each of area A. The separation between the consecutive plates is equal to L. When both the switches are closed, if charge present on the upper surface of the lowest plate from the top is written as $\frac{xV_0\varepsilon_0A}{L}$, then what is the value of x? Treat symbols as having usual meanings.



56. A sphere of radius R has uniformly distributed charge density ρ. There is a spherical cavity as shown in the figure has centre at C. It is given that AB = d, OC = ℓ and the angle between OC and AB is 60°. Find the potential difference in volt between A and B, if numerically $\rho\ell d = 54\varepsilon_0$.



57. Consider a uniformly charged non-conducting cube of volume charge density ρ. Potential at one of the corner is 4 volt, find the potential of centre of the cube (in volts)

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ANSWERS

LEVEL-1

1. (D)	2. (C)	3. (C)	4. (A)	5. (C)	6. (D)
7. (B)	8. (C)	9. (A)	10. (A)	11. (A,C)	12. (C)
13. (A,B,D)	14. (A,D)	15. (A,B,C,D)	16. (B)	17. (D)	18. (C)
19. (A)	20. (C)	21. (B)	22. (A-r, B-p,s ,C-q,t, D-r,s)		

23. (A-q,r, B-p,r,s ,C-p,q,r, D-r,s) 24. (A-p, B-r ,C-r) 25. (0)

LEVEL-2

1. (B)	2. (A)	3. (A)	4. (C)	5 (A)	6. (A)
7. (A)	8. (D)	9. (B)	10. (C)	11. (C)	12. (B)
13. (B)	14. (D)	15. (D)	16. (C)	17. (D)	18. (A)
19. (A)	20. (B)	21. (B)	22. (A)	23. (D)	24. (C)
25. (B,D)	26. (A,D)	27. (A,B)	28. (B,D)	29. (A,C,D)	30. (A,B,C)
31. (A,B)	32. (A,B)	33. (A,C)	34. (B,C)	35. (B)	36. (B)
37. (C)	38. (A)	39. (B)	40. (A)	41. (D)	42. (A)
43. (C)	44. (D)	45. (B)	46. (C)	47. (A)	48. (B)
49. (C)	50. (B)	51. (A)	52. (P-3, Q-1 ,R-4, S-2)	53. (A-q, B-p,s ,C-p,q,r, D-q,r)	
54. (3)	55. (3)	56. (9)	57. (8)		

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