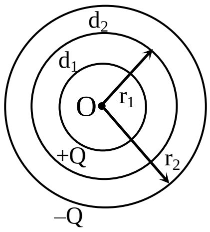
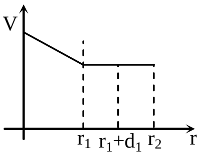
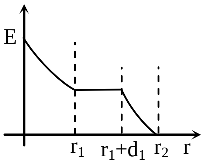
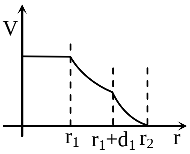
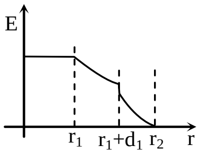
1. Two concentric conducting spheres of radii r_1 and r_2 ($r_1 < r_2$) carry electric charges of + Q and – Q respectively. The region between the sphere is filled with two insulating layers of dielectric constant ε_1 and ε_2 and width d_1 and d_2 respectively. Variation of potential and electric field with radial distance from O is given. Select the correct one. (assume Vat $r_2 = 0$)



(a) 

(b) 

(c) 

(d) 

2. An electric charge $10^{-3}\mu C$ is placed at the origin (0, 0) of X-Y co-ordinate system. Two points A and B are situated at $(\sqrt{2}, \sqrt{2})$ and (2, 0) respectively. The potential difference between the points A and B will be-

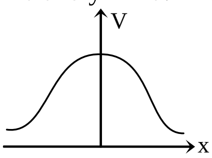
(a) 4.5 volt (b) 9 volt (c) Zero (d) 2 volt

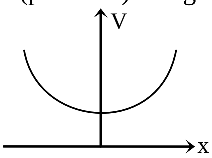
3. Two point charges q and – q are at positions (0, 0, d) and (0, 0, – d) respectively. What is the electric field at (a, 0, 0)?

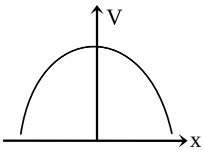
(a) $\frac{2qd}{4\pi\varepsilon_0(d^2+a^2)^{3/2}}\hat{k}$ (b) $\frac{qd}{4\pi\varepsilon_0(d^2+a^2)^{3/2}}\hat{k}$

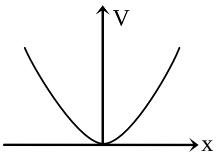
(c) $\frac{-2qd}{4\pi\varepsilon_0(d^2+a^2)^{3/2}}\hat{k}$ (d) $\frac{-qd}{4\pi\varepsilon_0(d^2+a^2)^{3/2}}\hat{k}$

4. Two identical positive charges are placed on the y-axis at y = – a and y = + a. The variation of V (potential) along x-axis is shown by graph -

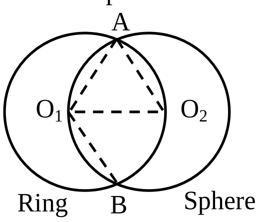
(a) 

(b) 

(c) 

(d) 

5. A charge q is distributed uniformly on a ring of radius r. A sphere of equal radius r is constructed with its centre at the periphery of the ring (see Fig.). The electric flux through the surface of the sphere is -



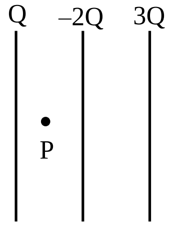
(a) $\frac{q}{\varepsilon_0}$ (b) $\frac{2q}{\varepsilon_0}$ (c) $\frac{q}{2\varepsilon_0}$ (d) $\frac{q}{3\varepsilon_0}$

6. Three points A, B and C are at a distance of 1m, 2m and 1m from an infinitely long charged wire of linear charge density λ C/m. A charge q is taken from A to B, B to C and finally C to A. Which of the following is/are correct about the work done in the above process -

(a) $W_{AB} = 2W_{BC}$ (b) $W_{AB} = -W_{BC}$

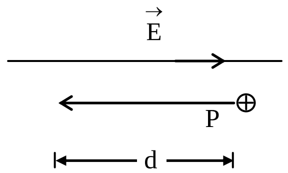
(c) $W_{BC} = 0$ (d) $W_{AB} = 0$

7. Three large identical conducting sheets placed parallel to each other at finite distance contains charges Q, – 2Q and 3Q respectively. If surface area of sheet is A, then magnitude of electric field at point P is -



(a) Zero (b) $\frac{2Q}{A\in_0}$ (c) $\frac{Q}{A\in_0}$ (d) $\frac{4Q}{A\in_0}$

8. A proton moves a distance d in a uniform electric field $\vec{E}$ as shown in the figure. Does the electric field do a positive or negative work on the proton? Does the electric potential energy of the proton increase or decrease?



(a) Negative, increase (b) Positive, decrease

(c) Negative, decrease (d) Positive, increase

9. A charge +q is fixed at each of the points $x = x_0$, $x = 3x_0$, $x = 5x_0$,… upto∞ on X-axis and charge –q is fixed on each of the points $x = 2x_0$, $x = 4x_0$, $x = 6x_0$, …upto∞. Here x_0 is a positive constant. Take the potential at a point due to a charge Q at a distance r from it to be $\frac{Q}{4\pi\varepsilon_0 r}$. Then the potential at the origin due to above system of charges will be-

(a) zero (b) $\frac{q}{8\pi\varepsilon_0 x_0 \log_e 2}$ (c) ∞ (d) $\frac{q\log_e 2}{4\pi\varepsilon_0 x_0}$

10. The electric potential V is given as a function of distance x (metre) by
$V = (5x^2 + 10x - 4)$ volt. Value of electric field at x = 1 m is

(a) –23 V/m (b) 11V/m (c) 6V /m (d) –20V/m

11. What is not true for equipotential surface for uniform electric field?

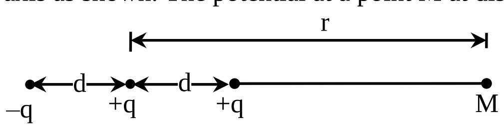
(a) Equipotential surface is flat

(b) Equipotential surface is spherical

(c) Electric lines are perpendicular to equipotential surface

(d) Work done is zero

12. Three charges are located on a horizontal axis as shown. The potential at a point M at distance r is - (r >> d)



(a) $\frac{kq}{r^2}(2d+r)$ (b) $\frac{kq}{r}(2d-r)$

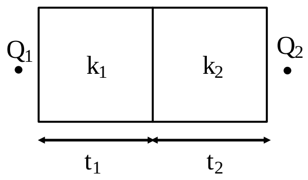
(c) $\frac{kq}{r}(2d+r)$ (d) $\frac{kq}{r^2}(d+r)$

13. Work done by an external agent to move slowly a charge Q from rim of a uniformly charged horizontal disc of radius a and charge per unit area σ, to center of this disc is-

(a) $\frac{\sigma aQ}{\varepsilon_0}\left(\frac{2}{\pi}-\frac{1}{2}\right)$ (b) $\frac{\sigma aQ}{\varepsilon_0}\left(\frac{1}{2}-\frac{1}{\pi}\right)$

(c) $\frac{\sigma aQ}{\varepsilon_0}\left(\frac{1}{\pi}-\frac{1}{2}\right)$ (d) $\frac{\sigma aQ}{\varepsilon_0}\left(\frac{1}{2}-\frac{2}{\pi}\right)$

14. Two charges Q_1 and Q_2 are distance d apart. Two dielectrics of thickness t_1 and t_2 and dielectric constant k_1 and k_2 are introduced as shown. Find the force between the charges -



(a) $\frac{Q_1Q_2}{4\pi\varepsilon_0[d-(t_1+t_2)+k_1t_1+k_2t_2]^2}$

(b) Zero

(c) $\frac{Q_1Q_2}{4\pi\varepsilon_0[d+\sqrt{k_1}\,t_1+\sqrt{k_2}\,t_2]^2}$

(d) $\frac{Q_1Q_2}{4\pi\varepsilon_0[\sqrt{k_1}\,t_1+\sqrt{k_2}\,t_2+d-(t_1+t_2)]^2}$

15. An electric dipole is fixed at the origin of coordinates. Its moment is directed in the positive x-direction. A positive charge is moved from the point (r, 0) to the point (–r, 0) by an external agent. In this process, the work done by the agent is -

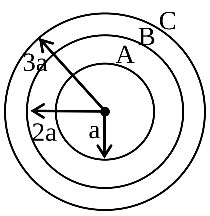
(a) Positive and inversely proportional to r

(b) Positive and inversely proportional to r^2

(c) Negative and inversely proportional to r

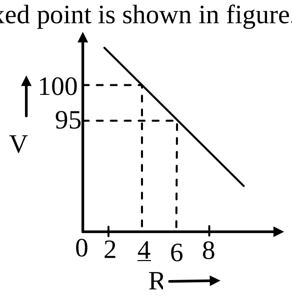
(d) Negative and inversely proportional to r^2

16. Three concentric spherical shells A, B and C having uniformly distributed total charges + Q, – 2Q and +Q respectively are placed as shown. The potential at the centre will be-



(a) $\frac{-Q}{4\pi\epsilon_0 a}$ (b) $\frac{-Q}{12\pi\epsilon_0 a}$ (c) $\frac{Q}{12\pi\epsilon_0 a}$ (d) Zero

17. The variation of potential with distance R from a fixed point is shown in figure. The electric field at R = 5 m is–

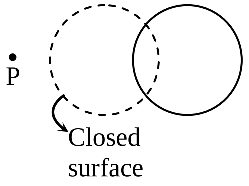


(a) 2.5 V m^{-1} (b) – 2.5 V m^{-1}

(c) (2/5) V m^{-1} (d) – (2/5) V m^{-1}

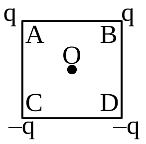
18. A particle of mass 2g and charge 1 μC is held at a distance of 1 metre from a fixed charge of 1 mC. If the particle is released, it will be repelled. The speed of the particle when it is at a distance of 10 metres from the fixed charge is-
(a) 100 m/s (b) 90 m/s (c) 60 m/s (d) 45 m/s

19. Figure shows a closed surface which intersects a conducting sphere. If a positive charge is placed at point P, the flux through the closed surface will become



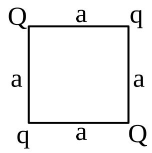
(a) Still zero (b) Positive (c) Negative (d) Indefined

20. Charges are placed at the vertices of square as shown in diagram. If charge at A and B are interchanged with C and D respectively then-



(a) Only magnitude of electric field will change at the centre
(b) Both magnitude and direction of electric field will change at the centre
(c) Only direction of electric field at centre will change
(d) Both magnitude and direction of electric field will remain unchanged

21. Point charge are placed the corners of square of side 'a'. The value and nature of q can be best represented, to make the net force on Q zero as –



(a) $-2\sqrt{2}\,Q$ (b) $2\sqrt{2}Q$
(c) $\frac{-Q}{2\sqrt{2}}$ (d) $\frac{Q}{2\sqrt{2}}$

22. An insulated conductor initially free from charge is charged by repeated contacts with a plate which after each contact is replenished to a charge Q. If q is the charge on the conductor after first operation then the maximum charge which can be given to the conductor is-
(a) $\frac{Qq}{Q-q}$ (b) $\frac{Qq}{Q+q}$ (c) Q (d) q

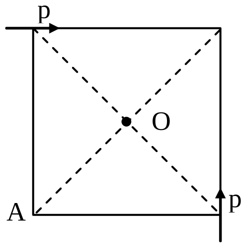
23. Two similar very small conducting spheres having charges 40 μC and – 20 μC are some distance apart. Now they are touched and kept at same distance. The ratio of the initial to the final force between them is
(a) 8 : 1 (b) 4 : 1 (c) 1 : 8 (d) 1 : 1

24. A hollow uniformly charged sphere has radius r. If the potential difference between its surface and a point at a distance 3r from the centre is V then the electric field intensity at a distance 3r form centre is-
(a) V/6r (b) V/4r (c) V/3r (d) V/2r

25. A little charged bead is inside the hollow frictionless sphere manufactured from the insulating material. Sphere has a diameter of 50 cm. The mass of the bead is 90 mg, its charge is 0.5 μC. What minimum charge must carry on object at the bottom of the sphere to keep hold the charged bead at the vertex of the sphere in stable equilibrium-
(a) 4.9×10^{-8}C (b) 9.8×10^{-8}C

(c) 19.6×10^{-8}C (d) 30.2×10^{-8}C

26. Two short dipole of dipole moment p are placed at two corners of a square as shown in figure. What is the ratio of magnitudes of electric field intensity at two points O & A i.e. $E_{at\ O} : E_{at\ A}$?



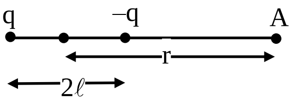
(a) 2 (b) $2\sqrt{2}$ (c) 4 (d) $\sqrt{2}$

27. Eight charges, each of magnitude q are placed at the vertices of a cube placed in vacuum. Electric potential at the centre of the cube due to this system of charges is :
(ε_0 is permittivity of vacuum and a is length of each side of the cube)-

(a) $\frac{2q}{\pi\varepsilon_0 a}$ (b) $\frac{4q}{\sqrt{3}\pi\varepsilon_0 a}$ (c) Zero (d) $\frac{\sqrt{3}q}{\pi\varepsilon_0 a}$

28. The potential of the electric field produced by a point charge at any point (x, y, z) is given by ; $V = 3x^2 + 5$, where x, y, z are in metres and V is in volts. The intensity of the electric field at (–2, 1, 0) is-
(a) +17 Vm^{-1} (b) –17 Vm^{-1} (c) +12 Vm^{-1} (d) –12 Vm^{-1}

29. In given dipole, for $r >> 2\ell$, electric potential at A will be –



(a) 0 (b) $\frac{1}{4\pi\varepsilon_0}\frac{(-q\times 2\ell)}{r^2}$

(c) $\frac{1}{4\pi\varepsilon_0}\frac{q\times 2\ell}{r^2}$ (d) $\frac{1}{4\pi\varepsilon_0}\frac{q\ell}{r^2}$

30. Two parallel plate capacitors have the same separation $d = 8.85 \times 10^{-4}$ m between the plates. The plate areas of A and B are 0.04 m^2 and 0.02 m^2 respectively. A slab of dielectric constant K = 9 has dimensions such that it can exactly fill space between the plates of capacitor B. The slab is placed inside A as shown in figure (a). A is then charged to a potential difference of 110 volt.

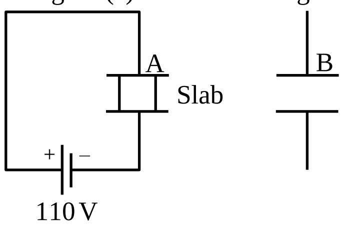


Fig.(a)

The battery is disconnected and then the dielectric slab is removed from A. The same dielectric slab is now placed inside B filling it completely. The two capacitors are then connected as shown in figure (b). Then:

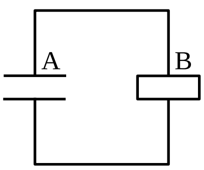
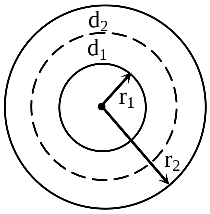


Fig.(b)

(a) The work done by an external agency in removing the slab from A is 4.84×10^{-5} J
(b) The work done on an external agency in removing the slab from A is 4.84×10^{-5} J
(c) The energy stored in the system in figure is 1.1×10^{-6} J

(d) The energy stored in the system in figure is 11×10^{-6} J

1. (c)



Electric field

$r < r_1$, $E = 0$

$r_1 < r < r_1 + d$, $E = \dfrac{Q}{4\pi\varepsilon_0 r^2 \varepsilon_1}$

$r_1 + d < r < r_2$, $E = \dfrac{Q}{4\pi\varepsilon_0 \varepsilon_2 r^2}$

$r > r_2$, $E = 0$

$\therefore$ (B) and (D) is wrong

Potential can be find out by integrating

i.e. $V = -\int_{\infty}^{r} E.dr = 0$

2. (c)

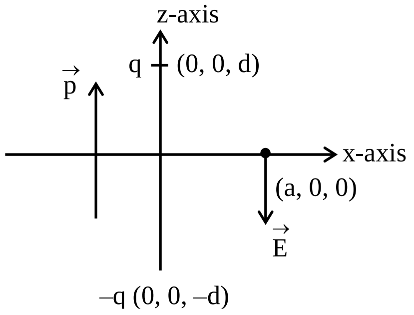
$V_A = \dfrac{kQ}{r_A}$, $V_B = \dfrac{kQ}{r_B}$

$r_A = \sqrt{(\sqrt{2}-0)^2 + (\sqrt{2}-0)^2} = 2$

$r_B = \sqrt{(2-0)^2 + (0-0)^2} = 2$

$\therefore \boxed{V_A - V_B = 0}$

3. (c)

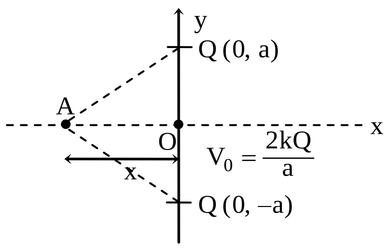


Use formula $E = \dfrac{kp}{(r^2 + \ell^2)^{3/2}}$

$\therefore E = \dfrac{1}{4\pi\varepsilon_0} \dfrac{q \times 2d}{(a^2 + d^2)^{3/2}}$

$\therefore \vec{E} = \dfrac{1}{4\pi\varepsilon_0} \dfrac{2qd}{(a^2 + d^2)^{3/2}} (-\hat{k})$

4. (a)



Potential at centre is

$V_0 = \frac{2kQ}{a}$

Potential at axis

$V_A = \frac{2kQ}{\sqrt{a^2 + x^2}}$

At $x = \infty$, $V_\infty = 0$

$\therefore$ Graph will be O at $x = \pm \infty$ and will be maximum at $x = 0$

5. (d)

Angle at O, is 120^0 $\therefore$ $\frac{1}{3}$ part of ring is inside the sphere

$\therefore$ Σ q inside the sphere = $\frac{q}{3}$

6. (b)

$W_{AB} = q(V_B - V_A)$

$V_{BC} = q(V_C - V_B)$

$V_A = V_C$

$\therefore W_{AB} = -W_{BC}$

7. (a)

$E_P = \frac{Q}{2\epsilon_0 A} + \frac{2Q}{2\epsilon_0 A} - \frac{3Q}{2\epsilon_0 A} = 0$

8. (a)

+ve charge moves in the direction of field, but here it is moved opposite to the field, $\therefore$ work is to be done by external source.

$\mathbf{W}_{electric}$ = – ve, Potential energy increase.

9. (d)

$V = \frac{kq}{x_0} - \frac{kq}{2x_0} + \frac{kq}{3x_0} - \frac{kq}{4x_0} + \ldots\ldots\ \infty$

$V = \frac{kq}{x_0}\left(1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} \ldots\infty\right) = \frac{kq}{x_0}(\log_e 2)$

10. (d)

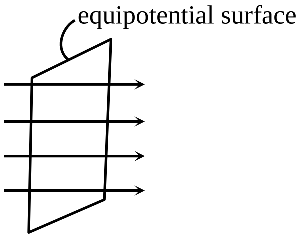
$\frac{\partial V}{\partial x} = 10x + 10 \Rightarrow \left(\frac{\partial V}{\partial x}\right)_{x=1} = 20$

$\vec{E} = -[i(20)] = -20 V/m$

11. (b)

$\because$ Field is uniform

$\therefore$ equipotential surface can't be spherical



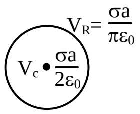
12. (a)

$V_M = -\frac{kq}{r+d} + \frac{kq}{r} + \frac{kq}{r-d}$

$= kq\left(\frac{1}{r-d} - \frac{1}{r+d}\right) + \frac{kq}{r}$

$= kq\left(\frac{2d}{r^2-d^2}\right) + \frac{kq}{r} \; \frac{600}{x^2} \; \frac{kq2d}{r^2} + \frac{kq}{r} = \frac{kq}{r^2}(2d+r)$

13. (b)



14. (d)

Effective distance in vacuum

$= \sqrt{k_1}\; t_1 + \sqrt{k_2}\; t_2 - (t_1 + t_2)$.

15. (d)

The potential due to the dipole is positive at

A(r, 0) and negative at B(–r, 0). Also this potential is inversely proportional to r^2. Work is done by agent is also inversely proportional to r^2 $W_{ext.\, A \to B} = q\,(V_B - V_A) = -ve$

↓ ↓

–ve +ve

16. (c)

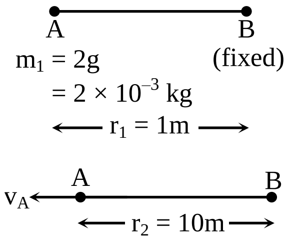
$V_{centre} = \frac{KQ}{a} + \frac{K(-2Q)}{2a} + \frac{KQ}{3a} = \frac{KQ}{3a}$

17. (a)

At r = 5 m $E = -\frac{dV}{dr} = -\left(\frac{-5}{2}\right) = 2.5\ \frac{V}{m}$

18. (b)

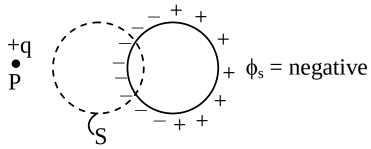
$q_1 = 1\mu C = 10^{-6}$ C $q_2 = 1mC = 10^{-3}$ C



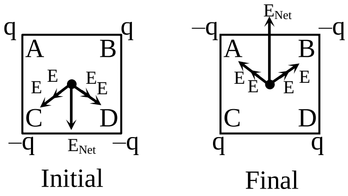
Conserving energy

$k\,\frac{q_1q_2}{r_1} = \frac{1}{2}\,m_1 v_A^2 + k\,\frac{q_1q_2}{r_2}$

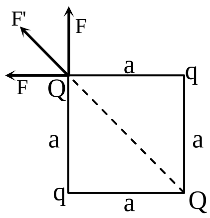
19. (c)



20. (c)



21. (c)



Resultant of F and F = F" = $2F\cos\frac{90}{2} = \sqrt{2}\,\frac{kQq}{a^2}$

To make force of Q zero : F' + F" = 0

$\Rightarrow \frac{kQ^2}{(\sqrt{2}a)^2} + \frac{\sqrt{2}kQq}{a^2} = 0 \left(q = \frac{-Q}{2\sqrt{2}}\right)$

22. (a)

Let $C_1 \to$ Capacitance of plate and C_2 that of the conductor, then $\frac{Q-q}{q} = \frac{C_1}{C_2}$

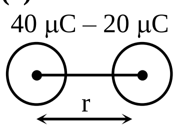
Let $q_{max} \to$ max. charge

Then flow of charge from the plate to the conductor will stop, when

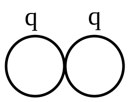
$V_{conductor} = V_{plate}$

$\frac{q_{max}}{C_2} = \frac{Q}{C_1} \quad \therefore q_{max} = \frac{C_2}{C_1}\,Q = \frac{qQ}{Q-q}$

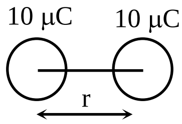
23. (a)



$F_i = \frac{k(40)(20)}{r^2}$,



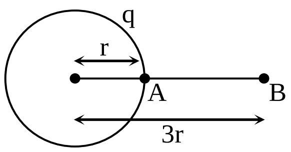
$40 - 20 = 2q \Rightarrow q = 10\ \mu C$



$F_f = \frac{k(10)(10)}{r^2}$

$\frac{F_i}{F_f} = \frac{40\times 20}{10\times 10} = \frac{8}{1} = 8 : 1$

24. (a)



$V_A = \frac{kq}{r}$

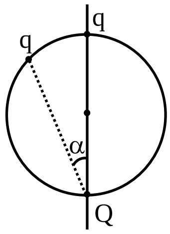
$V_B = \frac{kq}{3r}$

$V = V_A - V_B = \frac{kq}{r}\left(1 - \frac{1}{3}\right) = \frac{2kq}{3r}$

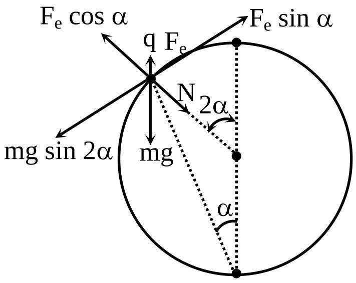
$E_B = \frac{kq}{(3r)^2} = \frac{k(3r)V}{9r^2(2k)} = \frac{V}{6r}$

25. (b)

Let give small displacement to q.



The equilibrium will be stable if net force after giving displacement will be in direction of position of equilibrium.



$F_e \sin\alpha \geq mg\sin 2\alpha$. then net force will be directed toward vertex in initial equilibrium position

$\frac{kqQ}{d^2}\sin\alpha \geq mg\sin 2\alpha$

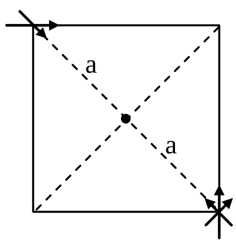
d-diameter of sphere and α is very small

$\frac{kqQ}{d^2} \times \alpha \geq mg \times 2\alpha$

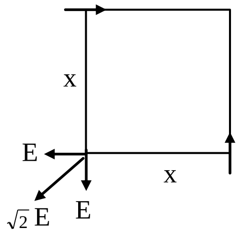
$Q \geq \frac{2mgd^2}{kq} = 9.8 \times 10^{-8}$ C

26. (b)

$E_{at\ o} = 2\frac{KP}{a^3}$



$E_{at\ A} = \sqrt{2}\ \frac{KP}{x^3}$



$x^2 + x^2 = 4a^2 \qquad \frac{E_{ato}}{E_{at_A}} = \frac{2 \times x^3}{a^3 \times \sqrt{2}}$

$x^2 = 2a^2 \qquad = \frac{4}{1}\, x = \sqrt{2}\, a$

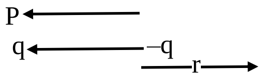
27. (b)

$$V_{centre} = \frac{k\,Q_{Total}}{r} = \frac{1}{4\pi\varepsilon_0} \frac{(8q)}{\left(\frac{a\sqrt{3}}{2}\right)} = \frac{4q}{\sqrt{3}\pi\varepsilon_0 a}$$

28. (c)

$$E_x = -\frac{dV}{dx}$$

29. (b)



$V = \frac{KP\cos\theta}{r^2}$ here $\theta = 180°$

$\therefore\ V = \frac{KP\cos 180°}{r^2} = -\frac{KP}{r^2}$

30. (d)

The capacitance of A without dielectric is

$C_0 = \frac{8.85 \times 10^{-12} \times 0.04}{8.85 \times 10^{-4}} = 0.4 \times 10^{-9}$ F

The energy present in A after removal of the slab is, therefore, $U_f = \frac{q^2}{2C} = 605 \times 10^{-7}$ J where $q = CV = 2 \times 10^{-9} \times 110 = 22 \times 10^{-8}$ coulomb. The increase in energy is, therefore, $\Delta U = 605 \times 10^{-7} - 121 \times 10^{-7} = 484 \times 10^{-7}$ J. This is the required work done. The option (A) is correct. Now, the capacitance of A without dielectric is

$C_A = 0.4 \times 10^{-9}$ F

The capacitance of B with dielectric is

$C_B = \frac{8.85 \times 10^{-12} \times 9 \times 0.02}{8.85 \times 10^{-4}}$

$= 1.8 \times 10^{-9}$ F

The total capacitance of the system is

$C_{eff} = 0.4 \times 10^{-9} + 1.8 \times 10^{-9}$

$= 2.2 \times 10^{-9}$ F

The charge on the system has already been obtained. It is $q = CV = 22 \times 10^{-8}$ coulomb. So, the energy stored on the system is:

$U = \frac{q^2}{2C} = \frac{1}{2} \times \frac{(22 \times 10^{-8})^2}{2.2 \times 10^{-9}}$ J

$= 11 \times 10^{-6}$ J

Therefore, the option (D) is also correct.