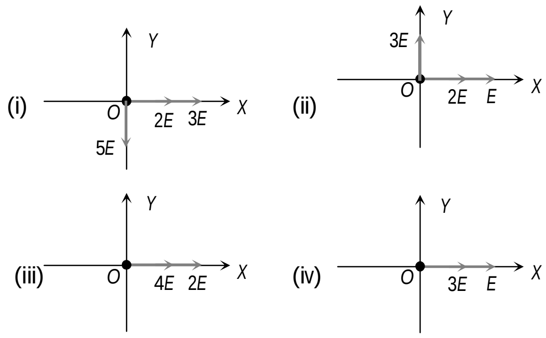
JEE (ADVANCED), PMT & FOUNDATIONS

PRACTICE TEST PHYSISCS SOLUTION ELECTROSTATICS 19 OCTOBER

1. (c) If electric field due to charge $|q|$ at origin is E then electric field due to charges $|2q|$, $|3q|$, $|4q|$ and $|5q|$ are respectively $2E$, $3E$, $4E$ and $5E$



$E_{(i)} = \sqrt{(5E)^2 + (5E)^2} = 5\sqrt{2}E$,

$E_{(ii)} = \sqrt{(3E)^2 + (3E)^2} = 3\sqrt{2}E$,

$E_{(iii)} = 4E + 2E = 6E$ and $E_{(iv)} = 3E + E = 4E$

$\Rightarrow E_{(i)} > E_{(iii)} > E_{(ii)} > E_{(iv)}$

2. (c) Flux coming out of the cube $\phi_1 = \dfrac{\lambda . a\sqrt{3}}{\varepsilon_0}$ ......(i)

and from sphere $\phi_2 = \dfrac{\lambda \cdot 2a}{\varepsilon_0}$ ......(ii)

$\therefore \dfrac{\phi_1}{\phi_2} = \dfrac{\sqrt{3}}{2}$

3. (c) $E_1 = \dfrac{\eta q}{4\pi\varepsilon_0 a^2}, E_2 = \dfrac{\eta q}{4\pi\varepsilon_0 a^2}$. Therefore $E = \vec{E}_1 + \vec{E}_2$

$= \sqrt{E_1^2 + E_2^2 + 2E_1E_2 \cos 60^o} = \dfrac{\sqrt{3}\eta q}{4\pi\varepsilon_0 a^2}$.

Since $\eta^{-1} < \sqrt{3}, 1 < \sqrt{3}\eta, \sqrt{3}\eta > 1$.

$\Rightarrow \dfrac{\sqrt{3}\eta q}{4\pi\varepsilon_0 a^2} > \dfrac{q}{4\pi\varepsilon_0 a^2} \Rightarrow E_3 > E_0 \left(E_0 = \dfrac{q}{4\pi\varepsilon_0 a^2}\right)$.

4. (c) The time required to fall through distance d is $d = \dfrac{1}{2}\left(\dfrac{qE}{m}\right)t^2$ or $t = \sqrt{\dfrac{2dm}{qE}}$

Since $t^2 \propto m,$ a proton takes more time.

5. (b) Total potential at the centre $V = \dfrac{6q}{4\pi\varepsilon_0 r}$

Required work done $= q.V = \dfrac{6q^2}{4\pi\varepsilon_0 r}$

6. (d) To obtained net field $6E$ at centre O, the charge to be placed at remaining sixth corner is $-5q$. (see following figure)

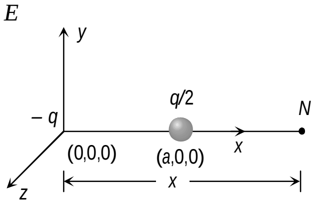
7. (c) $E = \dfrac{V}{d} \Rightarrow \dfrac{\sigma}{2\varepsilon_0} = \dfrac{V}{d} \Rightarrow d = \dfrac{V \times 2\varepsilon_0}{\sigma} = \dfrac{50 \times 2 \times 8.85 \times 10^{-12}}{0.1 \times 10^{-6}}$

$= 8.85 \times 10^{-3}$ $m = 8.88$ mm

8. (d) The surface of the conductor is an equipotential surface since there is free flow of electrons within the conductor. Thus potential at Q is the same as that at P. That is $V_P = V_Q = V.$ The electric field E at a point on the equipotential surface of the conductor is inversely proportional to the square of the radius of curvature r at that point. That is $E \propto r^{-2}$

Since point Q has a larger radius of curvature than that at point P, the electric field at Q is less than that at P. That is $E_Q < E_P = E$

9. (c)

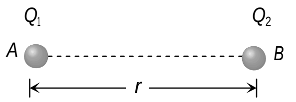


Suppose the field vanishes at a (distance x), we have $\frac{kq}{x^2} = \frac{kq/2}{(x-a)^2}$ or $2(x-a)^2 = x^2$ or $\sqrt{2}(x-a) = x$

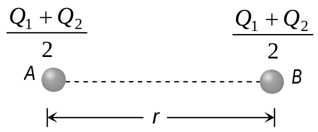
or $(\sqrt{2}-1)x = \sqrt{2}\,a$ or $x = \left(\frac{\sqrt{2}\,a}{\sqrt{2}-1}\right)$

10. (a) Suppose the balls having charges Q_1 and Q_2 respectively.

Initially :



Finally :



$$F' = \frac{k\left(\frac{Q_1+Q_2}{2}\right)^2}{\left(\frac{r}{2}\right)^2} = \frac{k(Q_1+Q_2)^2}{r^2}$$

It is given that $F' = 4.5F$ so $\frac{k\,(Q_1+Q_2)^2}{r^2} = 4.5\,k.\frac{Q_1Q_2}{r^2}$

$\Rightarrow (Q_1+Q_2)^2 = 4.5\,Q_1Q_2$. On solving it gives $\frac{Q_1}{Q_2} = \frac{2}{1}$.

11. (a) In the direction of electric field, potential decreases.

12. (b) Work done by the field $W = q(-dV) = -e(V_A - V_B)$

$= e(V_B - V_A) = e(V_C - V_A)$ $(\because V_B = V_C)$

$\Rightarrow (V_C - V_A) = \frac{W}{e} = \frac{6.4\times10^{-19}}{1.6\times10^{-19}} = 4\,V$

13. (d) Electric field is directed right ward (higher potential of – 200 V to lower potential of – 400 V). When electron left free in an electric it accelerates opposite to the electric field. Hence in the given case electron accelerates left ward.

14. (c) Point P lies at equatorial positions of dipole 1 and 2 and axial position of dipole 3.

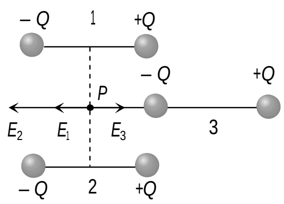
Hence field at P

due to dipole 1

$E_1 = \frac{k.p}{x^3}$ (towards left)

due to dipole 2

$E_2 = \frac{k.p}{x^2}$ (towards left)



due to dipole 3 $E_3 = \frac{k.(2p)}{x^3}$ (towards right)

So net field at P will be zero.

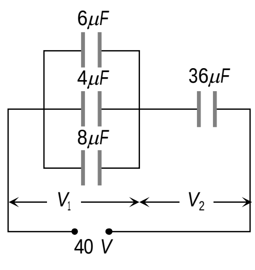
15. (c) Given circuit can be redrawn as follows capacitors, 9μF, 9μF and 7μF are short circuited. So they are deleted.

$V_1 + V_2 = 40\,V$

and $\frac{V_1}{V_2} = \frac{36}{18} = 2$

Hence $V_1 = \frac{80}{3}\,V$

and $V_2 = \frac{40}{3}\,V$



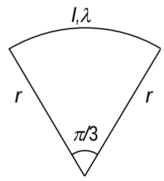
Charge on $8\mu F$ capacitor $= 8 \times \frac{80}{3} = 213.3\mu F \approx 214\,\mu F$

16. (d) Initial charge on sphere of radius $R = q$

Charge on this sphere after joining $q' = \frac{(q + (-2q)) \times R}{R + 2R} = \frac{-q \times R}{3R} = -\frac{q}{3}$

Now charge flowing between them $= q - \left(-\frac{q}{3}\right) = \frac{4q}{3}$

17. (c) Length of the arc $= r\theta = \frac{r\pi}{3}$



Charge on the arc $= \frac{r\pi}{3} \times \lambda$

$\therefore$ Potential at center $= \frac{kq}{r}$

$= \frac{1}{4\pi\varepsilon_0} \times \frac{r\pi}{3} \frac{\lambda}{r} = \frac{\lambda}{12\varepsilon_0}$

18. (c) There are 10 electrons and 10 protons in a neutral water molecule.
So it's dipole moment is $p = q\,(2l) = 10\,e\,(2l)$
Hence length of the dipole *i.e.* distance between centres of positive and negative charges is

$2\,l = \frac{p}{10e} = \frac{6.4 \times 10^{-20}}{10 \times 1.6 \times 10^{-19}} = 4 \times 10^{-12} m = 4\ pm$

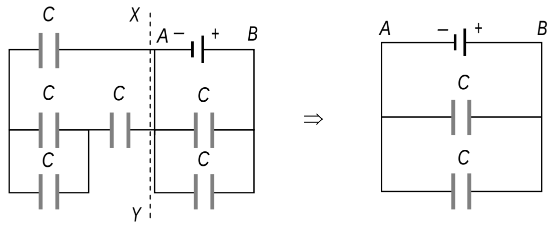
19. (a) Metal plate acts as an equipotential surface, therefore the field lines should enter normal to the surface of the metal plate.

20. (d) Charge required to reach the capacitor upto 10 V is

$Q = 500 \times 10^{-6} \times 10 = 5 \times 10^{-3} C$

Now required time $= \frac{5 \times 10^{-3}}{100 \times 10^{-6}} = 50\ sec$

21. (d) All capacitor lying in left side of line XY are short circuited so circuit can be reduced as follows



$C_{AB} = 2C$

22. (b) Given system is a spherical capacitor

So capacitance of system $C = K \times 4\pi\varepsilon_0 \left[\frac{r_1 r_2}{r_2 - r_1}\right]$

$= \frac{6}{9 \times 10^9} \left[\frac{9 \times 10}{1}\right] \times 10^{-2} = 6 \times 10^{-10}\ Farad$

Now potential of inner sphere will be equal to potential difference of the capacitor. So $V = \frac{q}{C} = \frac{18 \times 10^{-9}}{6 \times 10^{-10}} = 30V$

23. (d) In steady state current flows through 4Ω resistance only and it is $i = \frac{10}{(4+1)} = 2amp$. Potential difference across 4Ω resistance is

$V = 2 \times 4 = 8\ volt$

Hence, potential difference across each capacitor is $4V$
So charge on each capacitor $Q = 3 \times 4 = 12\mu C$.

24. (a) When key is open, charge in steady state will be $q_1 = CE$.

When key is closed, potential difference across capacitor will be $V = \frac{2R}{R + 2R} E = \frac{2}{3} R$

Charge in steady state will be $q_2 = \frac{2}{3} CE \Rightarrow \frac{q_1}{q_2} = \frac{3}{2}$.

25. (c) $K = \frac{t}{t - d'} \Rightarrow 2 = \frac{1}{1 - d'} \Rightarrow d' = \frac{1}{2} mm$

So new distance