JEE MAIN ANSWER KEY & SOLUTIONS

SUBJECT :- PHYSICS
CLASS :- 12^{th} **PAPER CODE :- CWT-1**
CHAPTER :- ELECTROSTATICS

ANSWER KEY

1.	(D)	**2.**	(A)	**3.**	(D)	**4.**	(D)	**5.**	(C)	**6.**	(C)	**7.**	(B)
8.	(A)	**9.**	(C)	**10.**	(C)	**11.**	(A)	**12.**	(D)	**13.**	(C)	**14.**	(C)
15.	(B)	**16.**	(A)	**17.**	(A)	**18.**	(B)	**19.**	(A)	**20.**	(A)	**21.**	20
22.	10	**23.**	0	**24.**	8	**25.**	25	**26.**	20	**27.**	4	**28.**	7
29.	1	**30.**	0										

SOLUTIONS

1. (D)

Sol. By M.E. conservation between initial & final point :

$U_i + K_i = U_f + K_f$

$\therefore$ Answer is (D)

2. (A)

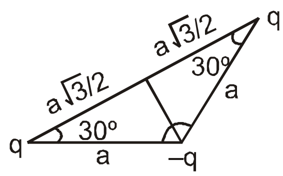
Sol. $\because E = \frac{F}{q}$ $\quad \therefore E = \frac{2000}{5} = 400$ N/C

Potential difference,

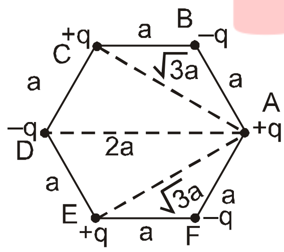
$\Delta V = E.\,d = 400 \times \frac{2}{100} = 8V.$

3. (D)

Sol.



$\Rightarrow$



(i) E.P.E. of charge +q at point A can be given as :

$E_A = \frac{-2kq^2}{a} + \frac{-2kq^2}{\sqrt{3}\,a} - \frac{kq^2}{2a}$ & E.P.E. of system

$\Rightarrow \quad E_S = \frac{E_A + E_B + E_C + E_D + E_E + E_F}{2}$

where $E_A = E_B = E_C = E_D = E_E = E_F$

$\therefore \quad E_S = 3\,E_A$

$\therefore \quad E_S = 6\left(-\frac{kq^2}{a}\right) + 6\left(\frac{kq^2}{a\sqrt{3}}\right) + 3$

$\left(-\frac{kq^2}{2a}\right) = \frac{q^2}{\pi \in_0 a}\left[\frac{\sqrt{3}}{a} - \frac{15}{8}\right]$

4. (D)

Sol. E = Field near sphere = $\frac{V}{R} = \frac{8000}{1\times10^{-2}}$

$= 8 \times 10^5$ V/m

$\therefore \quad$ Energy density$= \frac{1}{2}\varepsilon_0 E^2 = \frac{4\pi\varepsilon_0}{8\pi}$

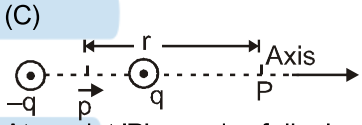
$E^2 = \frac{8\times8\times10^{10}}{8\pi\times9\times10^{9}} = \frac{80}{9\pi} = 2.83$ J/m^3.

5. (C)

Sol. Since P & Q are axial & equatorial points, so electric fields are parallel to axis at both points.

6. (C)

Sol.



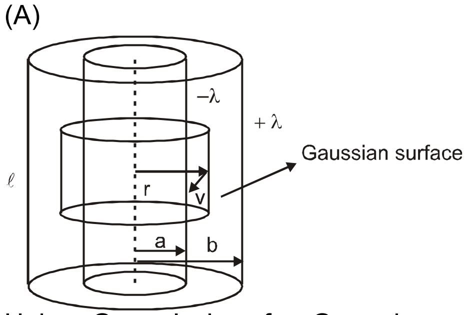
At a point 'P' on axis of dipole electric field E = $\frac{2kp}{r^3}$ and electric potential V = $\frac{kp}{r^2}$ both nonzero and electric field along dipole on the axis.

7. (B)

Sol. Density of electric field lines at a point i.e. no. of lines per unit area shows magnitude of electric field at that point.

8. (A)

Sol.



Using Gauss's law for Gaussian surface shown in figure. $\oint \vec{E}.d\vec{A} = \frac{q_{in}}{\varepsilon_0}$; $E.\,2\pi r\ell = \frac{\lambda\ell}{\varepsilon_0}$

$\therefore \quad E = \frac{\lambda}{2\pi\varepsilon_0 r}$

For circular motion.

$qE = \frac{mV^2}{r} = \frac{q\lambda}{2\pi\varepsilon_0 r}$

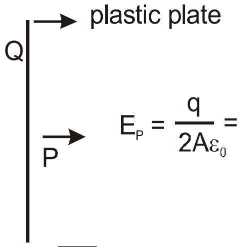
$\therefore \quad V = \sqrt{\frac{q\lambda}{2\pi\varepsilon_0 m}}$

9. (C)

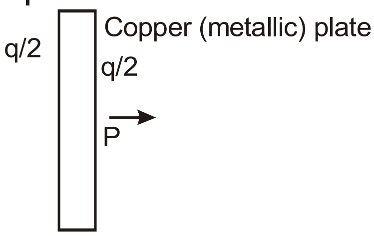
Sol. Induction takes place on outer surface of sphere producing non-uniform charge distribution & since external electric field can not enter the sphere, so interior remains charge free.

10. (C)

Sol.



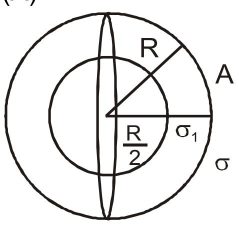
$E_P = \dfrac{q}{2A\varepsilon_0} = 50\ \text{V/m}$



$$E_P = \frac{q/2}{2A\varepsilon_0} + \frac{q/2}{2A\varepsilon_0} = \frac{q}{2A\varepsilon_0} = 50\text{V/m}$$

11. (A)

Sol.



Let surface charge density on inner shell is σ_1

Due to inner sphere, field at A = $\dfrac{1}{4} \times \dfrac{\sigma_1}{\varepsilon_0} = \dfrac{\sigma_1}{4\varepsilon_0}$,

and electrostatic pressure at point A.

$$= \frac{\sigma^2}{2\varepsilon_0} + \frac{\sigma_1\sigma}{4\varepsilon_0}$$

Net force one hemisphere

$$= \left(\frac{\sigma^2}{2\varepsilon_0} + \frac{\sigma_1\sigma}{4\varepsilon_0}\right)\pi R^2 = 0$$

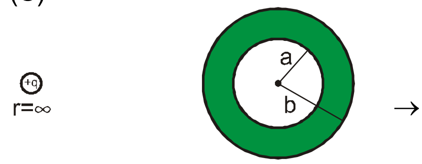
$\Rightarrow \quad \sigma^2 + \dfrac{\sigma_1\sigma}{2} = 0$, or $\sigma_1 = -2\sigma$

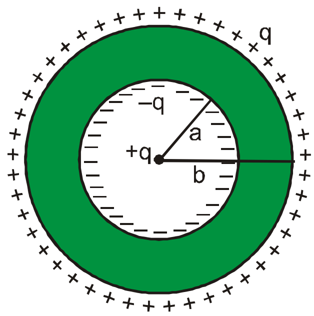
12. (D)

Sol. Force on Q due to E is QE. and not zero. Force on Q is zero due to E & electric field of induced outer charges on sphere.
Charge density on inner surface is not uniform therefore net force on charge Q is not zero.
Due to E, net force on shell is zero because net charge on shell is zero.

13. (C)

Sol.





Work done by external agent :

$W_{ext} = U_F - U_i$

$\therefore \quad W_{ext}$

$$= \left(\frac{Kq^2}{2a} + \frac{Kq^2}{2b} + \frac{K(+q)(-q)}{(a)} + \frac{K(-q)(+q)}{b} + \frac{K(+q)(+q)}{b}\right) - 0$$

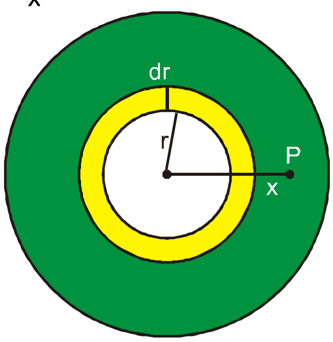
$$= \frac{Kq^2}{2b} - \frac{Kq^2}{2a}$$

14. (C)

Sol. Lets take a small spherical element of thickness dr.

Electric field at point P due to this element :

$$dE = \frac{K\,dq}{x^2}$$



$\therefore$ Total electric field :

$$E = \int \frac{K\,dq}{x^2}$$

$$E = \int \frac{K(\text{density})(\text{volume of the element})}{x^2}$$

$$E = \int_{r=\infty}^{r=x} \frac{K(\rho_0 r^2)(4\pi r^2 dr)}{x^2}$$

$$E = \frac{K\rho_0}{x^2}\left(\frac{x^5}{5}\right) = \frac{x\rho_0}{5}(x^3) \qquad \therefore \ (E \propto x^3)$$

15. (B)

Sol. Since, no external electric field can enter into a conductor so force experienced by Q = 0

16. (A)

Sol. $T = 2\pi\sqrt{\frac{\ell}{g_{eff}}}$; where, $g_{eff} = \frac{mg - qE}{m}$

$= g - \frac{qE}{m}$ $\quad\therefore$ Time period increases.

17. (A)

Sol. P.D, $= \int \vec{E}.\vec{dr}$ and E between spheres does not depend on charge on outer sphere.

18. (B)

Sol. In a conductor, potential is same everywhere

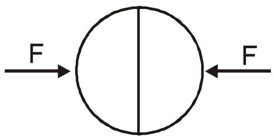
$\therefore$ Potential at A = potential at centre

$= V_{\text{due to p}} + V_{\text{due to induced charges}}$

$= \frac{kp}{(r\sec\phi)^2} + 0 \qquad = \frac{kp\cos^2\phi}{r^2}$

19. (A)

Sol.



Electrostatics repulsive force ;

$F_{ele} = \left(\frac{\sigma^2}{2\varepsilon_0}\right)\pi R^2$; $F = F_{ele} = \frac{\sigma^2\pi R^2}{2\varepsilon_0}$

20. (A)

Sol. According to option (A) the electric field due to P and S and due to Q and T add to zero. While due to U and R will be added up. Hence the correct option is (A).

21. 20

Sol. $W = Fr\cos\theta \Rightarrow \quad 4 = 0.2\ E\ 2\cos 60°$

$\Rightarrow \quad E = 20$ N/C.

22. 10

Sol. $E = \frac{F}{q} = \frac{3000}{3} = \frac{v}{d}$

$v = \frac{1000 \times 1}{100} = 10$

23. 0

Sol. $\omega = \vec{F}.\vec{r}$

$\omega = 0$

Angle between force and disp. = 90° or workdone by conservative force round the trip will always be zero.

24. 8

Sol. Let q is charge and a is racdius of single drop.

$U = \frac{3kq^2}{5a}$

charge on big drop = nq.

Let Radius of big drop is R.

$\Rightarrow \frac{4}{3}\pi R^3 = n.\frac{4}{3}\pi a^3 \quad \Rightarrow \quad R = an^{1/3}$.

P.E. of big drop $= \frac{3}{5}\frac{k(qn)^2}{R} = \frac{3}{5}\frac{k.q^2n^2}{an^{1/3}} = Un^{\frac{5}{3}}$

a + b = 5 + 3 = 8

25. 25

Sol. $K_i = \frac{kQ^2}{0.2} \quad \frac{kQ^2}{1} = 4\ kQ^2$

$K_f = \frac{1}{4} \times 4\ kQ^2 = \frac{kQ^2}{0.2} - \frac{kQ^2}{x}$

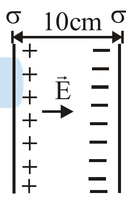
$1 = 5 - \frac{1}{x}$

$\frac{1}{x} = 4$

x = 25 cm

26. 20

Sol. $1.6 \times 10^{-19} \times E = 3.2 \times 10^{-17}$

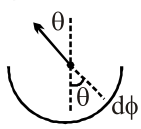


$E = \frac{3.2}{1.6} \times 100 = 200$ N/C

$\therefore$ Potential difference = (200) (0.1) = 20 volts.

27. 4

Sol.



$d\lambda = \sigma R d\phi$

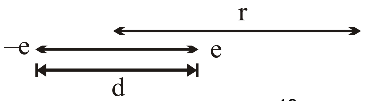
$\int_{-\pi/2}^{\pi/2} \frac{2kd\lambda}{R}\cos\phi$

$2k\sigma \int \cos\theta\, d\phi = 2k\sigma \left[\sin\phi \Big|_{-\pi/2}^{\pi/2}\right]$

$= \frac{\sigma}{\pi\epsilon_0} = \frac{4\pi\epsilon_0}{R\epsilon_0} = 4$

28. 7

Sol.



P = qd = ed = $1.6 \times 10^{-19} \times .20 = .32 \times 10^{-19}$

$$V = \frac{kP\cos\theta}{r^2} = \frac{kP\cos 0^\circ}{r^2} = \frac{kP\cos 0^\circ}{r^2}$$

$$= \frac{(9\times10^9)(.32\times10^{-19})}{r^2} = \frac{2.88\times10^{-10}}{r^2}$$

$$\therefore V_1 = \frac{2.88\times10^{-10}}{(1.4)^2} = 1.47\times10^{-10}$$

$\therefore$ 9 $(V_2 - V_1) = K_1 - K_2$

$$V_2 = \frac{2.88\times10^{-10}}{(1)^2} = 2.88\times10^{-10}$$

$$\Rightarrow -e\,(V_2 - V_1) = 0 - \frac{1}{2}mV^2$$

$\therefore$ $(1.6 \times 10^{-19})\,(1.41 \times 10^{-10})$

$$= \frac{1}{2}\times(9.1\times10^{31})V^2$$

$$\therefore V^2 = \frac{3.2\times1.41}{9.1}\times100 = 49.6$$

$\therefore$ V $\approx$ 7 m/s.

29. 1

Sol. $$\oint \vec{E}\cdot d\vec{A} = \frac{\int \rho dV}{\epsilon_0}$$

$$E \times 4\pi r^2 = \frac{k\int r^n \times 4\pi r^2 dr}{\epsilon_0}$$

$$= \frac{4\pi k}{\epsilon_0}\ \frac{r^{x+3}}{x+3}$$

$$E = \frac{k}{(n+3)\,\epsilon_0}(r^{n+1})$$

n + 1 = 2 $\Rightarrow$ n = 1

30. 0

Sol. Both point charges subtend equal solid angle at the given cross section, hence net flux is zero.