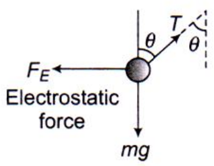
WEEKLY TEST RANKER'S BATCH TEST - 18 RAJPUR
SOLUTION Date 02-02-2020

[PHYSICS]

1. **(c)** We put a unit positive charge at O. Resultant force due to the charge placed at A and C is zero and resultant charge due to B and D is towards D along the diagonal BD

2. A

3. Since both the small spheres are at same horizontal level, the electrostatic forces on both spheres are in horizontal direction. The FBD of left sphere is shown in figure



The sphere is in equilibrium

$T \cos\theta = mg$ .... (i)

and $T \cos\theta = F_E$ .... (ii)

from (i) and (ii), $\tan\theta = \dfrac{F_E}{mg}$

The magnitude of electrostatic force on each sphere is same irrespective of its charge

for $\theta_1 = \theta_2$ the necessary condition is $m_1 = m_2$

4. **(b)** $\vec{F}_{DO} = \dfrac{q^2}{4\pi\varepsilon_0 a^2}$ and $\angle DOC = \theta_2 - \theta_1$

But $\vec{F}_{DO}\cos(\theta_2 - \theta_1) = \dfrac{q^2\sqrt{3}}{8\pi\varepsilon_0 a^2}$ (given)

So, $\cos(\theta_2 - \theta_1) = \dfrac{\sqrt{3}}{2}$

$\theta_2 - \theta_1 = 30°$

$\vec{F}_{BO} = \dfrac{q^2}{4\pi\varepsilon_0 a}$ and $\angle COB = \theta_3 - \theta_2$

But $\vec{F}_{BO}\cos(\theta_3 - \theta_2) = \dfrac{q^2\sqrt{3}}{8\pi\varepsilon_0 a^2}$ (given)

So, $\cos(\theta_3 - \theta_2) = \dfrac{\sqrt{3}}{2}$

$\theta_3 - \theta_2 = 30°$

From (i) and (ii)

$\theta_2 - \theta_1 = \theta_3 - \theta_2$ or $2\theta_2 = \theta_1 + \theta_3$

5. **(c)** Electric field at a distance R is only due to sphere because electric field due to shell inside it is always zero. Hence electric field = $\frac{1}{4\pi\varepsilon_0}\cdot\frac{3Q}{R^2}$

6. **(c)** The dipole is inclined at an angle $\tan^{-1}(\sqrt{3}) = 60°$ to x-axis whereas the given point lies on x-axis. Also, $p = 2$.

$$E = \frac{kp}{r^3}\sqrt{1+3\cos^2\theta} = k\frac{\sqrt{7}}{8}$$

7. The radius of the sphere = r

Volume charge density = ρ

The total charge on the sphere,

$$Q = \frac{4}{3}\pi r^3 \rho$$

$\therefore$ Electric field intensity on the surface of the solid sphere,

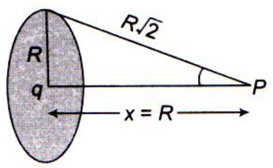
$$E = \frac{1}{4\pi\varepsilon_0}\times\frac{Q}{r^2}$$

$$= \frac{1}{4\pi\varepsilon_0}\times\frac{\frac{4}{3}\pi r^3\rho}{r^2} = \frac{\rho r}{3\varepsilon_0}$$

8. **(b)** Electric field at point P due to charge of ring is

$$E = \frac{kQx}{(R^2+x^2)^{3/2}}$$

At $x = R$: $E = \frac{kQ}{2\sqrt{2}R^2}$ directed towards the centre.



Electric field at P due to centre charge: $\frac{kq}{R^2}$

For net field to be zero at P:

$$\frac{kq}{R^2} = \frac{kQ}{2\sqrt{2}R^2} \Rightarrow q = \frac{Q}{2\sqrt{2}} = \frac{Q}{4}\sqrt{2}$$

9. Let ϕ_A, ϕ_B, and ϕ_C are the electric flux linked with A, B and C

According to Gauss theorem, $\phi_A + \phi_B + \phi_C = \frac{q}{\varepsilon_0}$

Since, $\phi_A = \phi_C$

$\therefore$ $2\phi_A + \phi_B = \frac{q}{\varepsilon_0}$ or $2\phi_A = \frac{q}{\varepsilon_0} - \phi_B$

or $2\phi_A = \frac{q}{\varepsilon_0} - \phi$ (Given $\phi_B = \phi$)

$\therefore \phi_A = \frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right)$

10. **(a)** When dipole is given a small angular displacement θ about its equilibrium position, the restoring torque will be

$\tau = -pE\sin\theta = -pE\theta$ (as $\sin\theta = \theta$)

or $I\frac{d^2\theta}{dt^2} = -pE\theta$ (as $\tau = I\alpha = I\frac{d^2\theta}{dt^2}$)

or $\frac{d^2\theta}{dt^2} = -\omega^2\theta$ with $\omega^2 = \frac{pE}{I} \Rightarrow \omega = \sqrt{\frac{pE}{I}}$

11. **(d)** According to Gauss' theorem, electric flux:

$$\phi_E = \frac{q}{\varepsilon_0} = \int \vec{E}.d\vec{S}$$

The surface integral in the above equations contains six terms - the surface integral over the bottom surface, the surface integral over the top surface and surface integral over the four vertical faces.

For the bottom surface, both the vectors $\vec{E}$ and $d\vec{S}$ are in the same direction. For the top surface, they act in opposite directions while for the vertical faces, they are perpendicular to each other.

Hence, $\phi_E = \int_{\text{bottom}} \vec{E}_1.d\vec{S} + \int_{\text{top}} \vec{E}_2.d\vec{S} + 4\int_{\text{faces}} \vec{E}.d\vec{S}$

$$= \int_{\text{bottom}} E_1.dS\cos 0^\circ + \int_{\text{top}} E_2.dS\cos 180^\circ + 4\int_{\text{faces}} E\,dS\cos 90^\circ$$

$$= \int_{\text{bottom}} E_1.dS - \int_{\text{top}} E_2.dS = E_1S - E_2S = (E_1 - E_2)S$$

Also, $\phi_E = \frac{q_{\text{enclosed}}}{\varepsilon_0}$

$q = \varepsilon_0(E_1 - E_2)S = \varepsilon_0(100\,\text{Vm}^{-1} - 60\,\text{Vm}^{-1})(100\text{ m})^2$

$= 4 \times 10^5 \varepsilon_0$ C

12. **(c)** Electric field is perpendicular to the equipotential surface and is zero everywhere inside the metal.

13. Given that V = 6xy – y + 24z

Now, $\vec{E} = -\left(\hat{i}\frac{\partial V}{\partial x} + \hat{j}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$

$= -[(6y)\hat{i} + (6x - 1 + 2z)\hat{j} + (2y)\hat{k}]$

$\therefore \quad \vec{E} \text{ at } (1,1,0) = -(6\hat{i} + 5\hat{j} + 2\hat{k})$

14. Net electric flux emitted from a spherical surface of radius a is :

$\phi_{net} = \frac{q_m}{\epsilon_0}$ [Accoding to Gauss's law]

or $ES = (Aa)(4\pi a^2) = \frac{q_m}{\epsilon_0}$, hence $q_{in} = 4\pi\epsilon_0 Aa^3$

15. **(a)** If portion outside the cylinder is removed, electric field at points on curved surface will decrease.

16. According to Gauss's law,

Electric flux, $\phi_E = \frac{q_{inside}}{\varepsilon_0}$

Charge on α-particle = 2e

$\therefore \quad \phi_E = \frac{2e}{\varepsilon_0}$

17. $E = 10^7$ V/m

$r = 0.10$ m

$E = \frac{V}{r}$

$V = Er = 10^7 \times \frac{10}{100}$

$V = 10^6$ V

18. $V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2}$

Here, $V = 1.8 \times 10^5$ V, $\theta = 60^o$,

$r = 50 \times 10^{-2} = 0.5$ m

$\therefore \quad 1.8 \times 10^5 = 9 \times 10^9 \times \frac{p\cos 60^o}{(0.5)^2}$

or $p = \frac{1.8 \times 10^5 \times 0.25 \times 2}{9 \times 10^9} = 10^{-5}\,C - m$

19. d
20. a
21. c
22. The points R and S are placed on the same perpendicular line to the lines of force.
23. b
24. c
25. d
26. $V_1 = V_2$

$\frac{q_1}{4\pi\varepsilon_0 a} = \frac{q_2}{4\pi\varepsilon_0 b}, \frac{q_1}{q_2} = \frac{a}{b}$

$\therefore \quad \frac{\sigma_1}{\sigma_2} = \frac{q_1 / 4\pi a^2}{q_2 / 4\pi b^2} = \frac{q_1}{q_2} \times \frac{b^2}{a^2} = \frac{a}{b} \times \frac{b^2}{a^2} = \frac{b}{a}$

27. b

28. b

29. $q_1 = Q$, $q_2 = -2Q$, $E_1 = E$

We know that electric field at the location of Q,

$$E_1 = K\frac{q_2}{d^2} \qquad E_1 \propto q_2$$

Therefore, $\frac{E_1}{E_2} = \frac{q_2}{q_1} = \frac{-2Q}{Q} = -2$

$\therefore$ $E_2 = -\frac{E_1}{2} = -\frac{E}{2}$

$\Delta\phi = 4 \times 10^3 - 8 \times 10^3$

$= -4 \times 10^3$ N-m²/coulomb

30. The line process from the positive charge and will reach B, if B is negative

The number of lines/unit area, i.e., the density of A is + ve, B is – ve and |A| > |B|

31. When joined by a wire, the two spheres attain a common potential V.

Intensity, $E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{R_1^2}$

$$= \frac{1}{4\pi\varepsilon_0}\frac{(\text{capacity } C_1) \times V}{R_1^2}$$

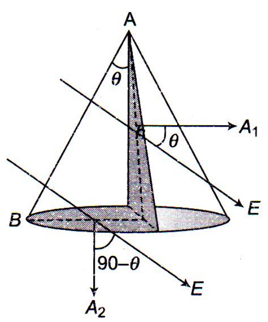
$$= \frac{4\pi\varepsilon_0 R_1 V}{4\pi\varepsilon_0 R_1^2} = \frac{V}{R_1}$$

Similarly, $E_2 = \frac{V}{R_2}$

$\therefore$ $\frac{E_1}{E_2} = \frac{R_2}{R_1}$

32. At equatorial point, $E_e = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$

33. **(a)** Flux entering the cone from side AB will ultimately also pass through area A_1 and A_2.



So, $\phi = EA_1\cos\theta + EA_2\cos(90-\theta)$

$$= E\left(\frac{1}{2}2Rh\cos\theta + \frac{\pi}{2}R^2\sin\theta\right)$$

$$= ER\left(h\cos\theta + \pi(R/2)\sin\theta\right)$$

34. **(B)**

$dV = -\vec{E}.d\vec{r} = -(-2x^3 \times 10^3 \hat{i}).(dx\hat{i} + dy\hat{j} + dz\hat{k}) = 2x^3 \times 10^3\, dx$

$\Rightarrow \int_0^V dV = -\int_2^1 (2x^3) \times 10^3\, dx \Rightarrow V = 7.5 \times 10^3\ V$

35. **(A)**

Potential difference due to inner 10C charge

$= K\,10\left(\frac{1}{\cdot 1} - \frac{1}{\cdot 2}\right) = 9 \times 10^{10}\,(5) = 45 \times 10^{10} = 4.5 \times 10^{11} V$

Potential difference due to outer charge $= \left(\frac{K \times 20}{0.2} - \frac{K \times 20}{0.2}\right) = 0\ V$

$\therefore$ P.d. $= 4.5 \times 10^{11} V$

36. **(D)**

Interaction energy of system of charges is $= \frac{1}{2}[U_1 + \ldots\ldots + U_6] = \frac{1}{2}[6U_1] = 3U_1$

$= 3kq^2\left(-\frac{2}{a} + \frac{2}{a\sqrt{3}} - \frac{1}{2a}\right) = \frac{q^2}{\pi \epsilon_0 a}\left(\frac{\sqrt{3}}{2} - \frac{15}{8}\right)$

37. **(A)**

The distribution of charge on the outer surface, depends only on the charges outside, and it distributes itself such that the net, electric field inside the outer surface due to the charge on outer surface and all the outer charges is zero. Similarly the distribution of charge on the inner surface, depends only on the charges inside the inner surface, and it distributes itself such that the net, electric field outside the inner surface due to the charge on inner surface and all the inner charges is zero.

Also the force on charge inside the cavity is due to the charge on the inner surface. Hence answer is option

38. **(C)**

Using the formula for electric field produced by large sheet $E = \frac{Q}{2A\epsilon_0}$

We get ;

$E_A = \frac{4Q}{2A\varepsilon_0}(-\hat{i})$; $E_B = \frac{2Q}{2A\varepsilon_0}.(-\hat{i})$; $E_C = \frac{4Q}{2A\varepsilon_0}.(+\hat{i})$

39. **(B)**

Speed will be maximum when acceleration becomes zero. ie when Kx = EQ $\Rightarrow$ $x = \frac{EQ}{K}$

By work–energy theorem : $w_{all} = \Delta KE$ $\Rightarrow$ $EQX - \frac{1}{2}KX^2 = \frac{1}{2}mv^2$

Substituting x = EQ/K, $V_{max} = QE/\sqrt{mK}$

Compression will be maximum when velocity becomes zero.

$W_{all} = \Delta KE$ $\Rightarrow$ $EQX - \frac{1}{2}KX^2 = 0$; $X_{max} = \frac{2EQ}{K}$

40. **(A)**

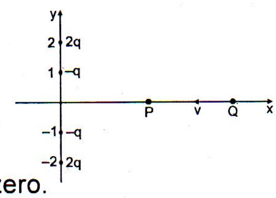
The potential at centre of sphere in which q charge is uniformly distributed throughout the volume is -

$$V_C = \frac{1}{4\pi\varepsilon_O}\frac{3q}{2R}$$

By symmetry the potential at centre due to half sphere will be half of the complete sphere.

$$\therefore \quad V_C = \frac{1}{4\pi\varepsilon_O}\frac{3q/2}{2R} = \frac{1}{4\pi\varepsilon_O}\frac{3Q}{2R} \quad [\because \frac{q}{2} = Q]$$

41. **(B)**



There exists a point P on the x-axis (other than the origin), where net electric field is zero.Once the charge Q reaches point P, attractive forces of the two –ve charge will dominate and automatically cause the charge Q to cross the origin.

Now if Q is projected with just enough velocity to reach P, its K.E. at P is zero.

But while being attracted towards origin it acquires K.E. & hence its net energy at the origin is positive. (P.E. at origin = zero).

42. **(a)** Electric field lines of force can never intersect each other, because if they do so then at the point of intersection two tangents can be drawn which would mean two directions of force at that point which is impossible.

If there are n point charges $q_1, q_2 \ldots. q_n$, then each of them will produce the same intensity at any point which it would have produced in the absence of other point charges. Hence, intensity of $\vec{E}$ is resultant of $\vec{E}_1, \vec{E}_2 \ldots.. \vec{E}_n$ as $\vec{E} = \vec{E}_1 + \vec{E}_2 + \cdots + \vec{E}_n$.

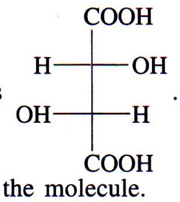
43. **(d)** The electrostatic force between the two protons is nearly 10^{36} times the gravitational force between them.

The electrostatic force between the two electrons is nearly 10^{43} times the gravitational force between them. The electrostatic force between a proton and an electron is nearly 10^{39} times the gravitational force between them. Gravitational force is the dominating force in nature and not Coulomb's force. Gravitational force is the weakest force. Also, Coulomb's force>> gravitational force.

44. (c) If electric lines of forces cross each other, then the electric field at the point of intersection will have two direction simultaneously which is not possible physically.

45. (b) Electron and proton have same amount of charge so they have same Coulomb force. They have different accelerations because they have different masses $\left(a = \frac{F}{m}\right)$.
Therefore, both assertion and reason are true and reason is the correct explanation of the assertion.

[CHEMISTRY]

46. Starch is a natural polymer.
47. A
48. Orlon is a chain-growth polymer.
49. B
50. Isoprene (2-methyl-1, 3-butadiene) is the monomer of natural rubber.
51. B
52. Saran is a copolymer.
53. C
54. B
55. Terylene has ester linkages.
56. A
57. Polymerization of caprolactam yields nylon-6.
58. D
59. B
60. Natural rubber is an elastomer. The irregular geometry of the molecules involves weak van der Waals force of attraction.
61. C
62. A
63. B
64. B
65. For monosaccharides, the value of n in $C_nH_{2n}O_n$ varies from 3 to 7.
66. The number of monosaccharides in oligosaccharides varies from 2 to 10.
67. The prefix L in L-glyceraldehyde implies the absolute configuration of asymmetric carbon.
68. The number of optical isomers in an aldose containing n asymmetric carbon atoms is 2^n.
69. Both glucose and fructose are reducing sugars. Sucrose is a non-reducing sugar.
Pentanal contains —CHO group. it shows the test. Acetophenone does not contain —CHO group. it does not show the test.
70. A
71. L-Tartaric acid is 

. The L isomer has —OH on the left of the last asymmetric carbon placed at the bottom of the molecule.
72. An amino acid contains an amino group attached to α-carbon atom.
73. The amino acids are basic units of protei

74. The number of amino acids commonly found in proteins is 20.

75. The number of essential amino acids is 10.

76. Isoleucine contains nonpolar $—CH(CH_3)CH_2CH_3$ group.

77. Zwitterion is a doubly-charged species.

78. At low pH, an amino acid exists as $H_3\overset{+}{N}CHRCOOH$.

79. At high pH, an amino acid exists as $H_2NCHRCOO^-$.

80. Glycine does not contain chiral carbon atom. Hence, it is not optically active.

81. Proteins contains exclusively L isomers of amino acids.

82. The amino acid $H_2N\underset{\underset{COOH}{|}}{CH}(CH_2)_4NH_2$ at low pH exists as $H_3\overset{+}{N}\underset{\underset{COOH}{|}}{CH}(CH_2)_4NH_3$.

83. The pH of the solution at which amino acids exist as Zwetterion follows the order
acidic side chain < neutral chain < basic side chain.

84. The amino acid $H_2N\underset{\underset{COOH}{|}}{CH}(CH_2)_2COOH$ at low pH exists as $H_3\overset{+}{N}\underset{\underset{COOH}{|}}{CH}(CH_2)_2COOH$.

85. The amino acid $H_2N\underset{\underset{COOH}{|}}{CH}(CH_2)_2COOH$ at high pH exists as $H_2N\underset{\underset{COO^-}{|}}{CH}(CH_2)_2COO^-$.

86. In the representation of a dipeptide, amino group is present at the left end.

87. At pH = 2, alanine is protonated to NH_2 and at pH = 10, —COOH group ionizes to $—COO^-$

88. Initial amount of $H^+ = VM = (0.06025\ dm^3)\ (0.1\ mol\ dm^{-3}) = 0.006025\ mol$
Remaining amount of $H^+ = (0.01625\ dm^3)\ (0.1\ mol\ dm^{-3}) = 0.00125\ mol$
Amount of H^+ reacted $= (0.006025 - 0.001625)\ mol = 0.0044\ mol$
Mass of NH_3 produced $= (\text{Amount of } H^+)\ (M_{NH_3}) = (0.0044\ mol)\ (17\ g\ mol^{-1}) = 0.0748\ g$

$$\text{Per cent of nitrogen} = \left(\frac{M_N}{M_{NH_3}}\right)(m_{NH_3})\left(\frac{100}{m_{compound}}\right) = \left(\frac{14}{17}\right)(0.0748)\left(\frac{100}{0.156}\right) = 39.5$$

89. $$\text{Per cent of sulphur} = \left(\frac{M_S}{M_{BaSO_4}}\right)(m_{BaSO_4})\left(\frac{100}{m_{compound}}\right) = \left(\frac{32}{233}\right)(0.9336)\left(\frac{100}{0.244}\right) = 52.5$$

90. C