CBSE Test Paper-04

Class - 12 Physics (Electric Charges and Fields)

1. Positive and negative point charges of equal magnitude are kept at $\left(0,0,\frac{a}{2}\right)$ and $\left(0,0,\frac{-a}{2}\right)$ respectively. The work done by the electric field when another positive point charge is moved from (-a,0,0) to (a,0,0) is
   a. zero
   b. depends on the path connecting the initial and final positions
   c. negative
   d. positive
2. Electrostatic force is
   a. force exerted by one charge on another when the two are at rest in a given frame of reference
   b. force exerted by an electron on a neutron
   c. force exerted by one charge on another when the two are accelerating in a given frame of reference
   d. force exerted by one charge on another when the two are moving in a given frame of reference
3. Conductors are materials
   a. that allow movement of protons
   b. that allow movement of electrons
   c. that allow movement of neutrons
   d. that allow only random movement of electrons
4. Ionization of a neutral atom is the
   a. only gain of one or more neutrons
   b. gain or loss of one or more electrons
   c. only gain of one or more electrons
   d. only gain of one or more protons
5. Consider a uniform electric field $\mathrm{E}=3\times10^{3}\mathrm{N/C}$.
   (a) What is the flux of this field through a square of 10 cm on a side whose plane is parallel to the yz plane?
   (b) What is the flux through the same square if the normal to its plane makes a 60°

angle with the x-axis?

a. $30\mathrm{Nm}^2/\mathrm{C}, 15\mathrm{Nm}^2/\mathrm{C}$
b. $20\mathrm{Nm}^2/\mathrm{C}, 15\mathrm{Nm}^2/\mathrm{C}$
c. $40\mathrm{Nm}^2/\mathrm{C}, 15\mathrm{Nm}^2/\mathrm{C}$
d. $40\mathrm{Nm}^2/\mathrm{C}, 25\mathrm{Nm}^2/\mathrm{C}$

6. < p>How does the electric flux due to a point charge enclosed by a spherical Gaussian surface get affected when its radius is increased?
7. Is the Coulomb force that one charge exerts on another changes if other charges are brought nearby?
8. What is the electric flux through a cube of side 1 cm which encloses an electric dipole?
9. Why do the electrostatic field lines not form closed loop?
10. Given a uniform electric field $E = 5 \times 10^3 \hat{\mathbf{i}}$ NC^{-1}, find the flux of this field through a square of 10cm on a side whose plane is parallel to the YZ-plane. What would be the flux through the same square if the plane makes an angle of 30^0 with the X-axis?
11. What is the dimensional formula for ε_0?
12. It is now believed that protons and neutrons (which constitute nuclei of ordinary matter) are themselves built out of more elementary units called quarks. A proton and a neutron consists of three quarks each. Two types of quarks, the so called 'up' quark (denoted by u) of charge + (2/3) e, and the 'down' quark (denoted by d) of charge , together with electrons build up ordinary matter. (Quarks of other types have also been found which give rise to different unusual varieties of matter). Suggest a possible quark composition of a proton and a neutron.
13. Point charges having values $= 0.1\mu C + 0.2\mu C - 0.3\mu C$ and $-0.2\mu C$ are placed at the corners A, B, C and D respectively of a square of side one meter. Calculate the magnitude of the force on a charge of $+1\mu C$ placed at the centre of the square.
14. A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of $80.0\mu C/m^2$.
    a. Find the charge on the sphere.
    b. What is the total electric flux leaving the surface of the sphere?
15. A $12\mu C$ charge is placed at the distance of 10 cm from a linear charge of $100\mu C$ uniformly distributed once the length of 10 cm as shown in figure. Find the force on $12\mu C$ charge.

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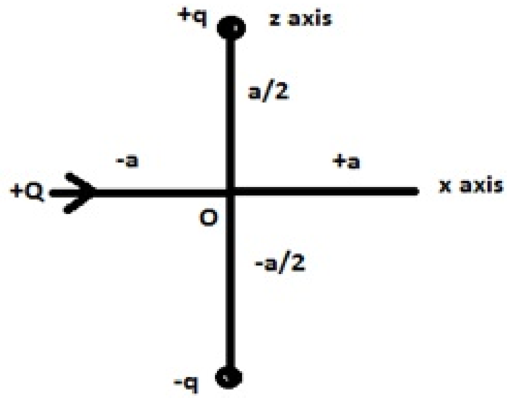
Answers

1. a. zero

   Explanation: +Q charge is moving on equatorial line of dipole as shown in figure, since on equatorial line V=0 So W = QV = 0



2. a. force exerted by one charge on another when the two are at rest in a given frame of reference

   Explanation: Electrostatics means charges at rest,or relatively at rest so this force can be applicable only when charge produce electric field which is constant which is possible only when charges at rest or relatively at rest.

3. b. that allow movement of electrons

   Explanation: Conductors are materials that permit electrons to flow freely from particle to particle. An object made of a conducting material will permit charge to be transferred across the entire surface of the object.
   In conductors some electrons are unpaired so these electrons can move freely.

4. b. gain or loss of one or more electrons

   Explanation: It is not possible to remove or add protons to atom, but electron can be added or removed by an atom easily so charge can be developed on an atom by removing or adding electrons, by adding electrons it becomes negative charged, by removing electrons it becomes positive charged.

5. a. $30Nm^2/C$, $15Nm^2/C$

   Explanation:

   i. Electric field intensity, = 3×10^3 î N/C

Magnitude of electric field intensity, = 3 × 10^3 N/C

Side of the square, s = 10 cm = 0.1 m

Area of the square, A = s^2 = 0.01 m^2

The plane of the square is parallel to the y-z plane.

Hence, angle between the unit vector normal to the plane and electric field, θ = 0° Flux (Φ) through the plane is given by the relation, ϕ = $\vec{E}.\vec{A} = EA\ Cos\theta$ =3 × 10^3 × 0.01 × cos0° = 30 N m^2/C

ii. Electric field intensity, = 3 × 10^3 î N/C

Magnitude of electric field intensity, = 3 × 10^3 N/C

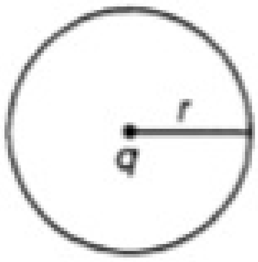
Side of the square, s = 10 cm = 0.1 m

Area of the square, A = s^2 = 0.01 m^2.

Angle between the unit vector normal to the plane and electric field, θ = 60°

Flux (Φ) through the plane is given by the relation, ϕ = $\vec{E}.\vec{A} = EA\ Cos\theta$ = 3 × 10^3 × 0.01 × cos60° = 15 N m^2/C

6. According to question, Electric flux (ϕ) due to a point charge enclosed by a spherical Gaussian surface is q given by



$\phi = \mathbf{E} \cdot \mathbf{A}$

where E is the electric field and A is the area vector

$\phi = \frac{kq}{r^2} \cdot 4\pi\ r^2 = kq \cdot 4\pi \left(\because E = \frac{kq}{r^2} \text{ and } A = 4\pi r^2\right)$

So, there is no effect of change in radius on the electric flux as charge enclosed by the surface is same in both the cases so electric flux will remain same even the shape is of non symmetrical one.

7. No, the Coulomb force due to one charge is not changed.

8. $\phi_E = \oint E \cdot dS = q/\varepsilon_0$ ...... (i)

where, E = electrostatic field due to all the charges

q = total charge enclosed by the surface
ε_0 = absolute electric permittivity of free space
So, in the given case, cube encloses an electric dipole. Therefore, the total charge enclosed by the cube is zero as +q - q = 0
So from Equation (i), we have $\phi_E = \frac{q}{\varepsilon_0} = 0$
so we can conclude that electric flux through the cube will be zero.

9. The electrostatic field lines do not form a closed loop because electric field lines can not reside under the conductor. If they form close loop like magnetic field there must be existence of another pole which is not the case with the electric charges.

10. Given, electric field intensity
$\mathbf{E} = 5 \times 10^3 \mathrm{iNC}^{-1}$
Magnitude of electric field intensity
$|\mathbf{E}| = 5 \times 10^3 \mathrm{NC}^{-1}$
Side of square, S = 10 cm = 0.1 m
Area of square, A= $(0.1)^2$ = 0.01 m^2
The plane of the square is parallel to the YZ-plane.
Hence, the angle between the unit vector normal to the plane and electric field is zero.
i.e., $\theta = 0^\circ$
$\therefore$ Flux through the plane is the scalar product of Electric field vector and Area vector.
$\phi = |E| \times A \cos\theta \Rightarrow \phi = 5 \times 10^3 \times 0.01 \cos 0^\circ$
$\phi = 50 \mathrm{Nm}^2 \mathrm{C}^{-1}$
If the plane makes an angle of 30^0 with the X-axis, then angle between area vector and electric field will be , $\theta = 60^\circ$
$\therefore$ Flux through the plane,
$\phi = |\mathbf{E}| \times A \times \cos 60^\circ$
$= 5 \times 10^3 \times 0.01 \times \cos 60^\circ = 25 \mathrm{Nm}^2 \mathrm{C}^{-1}$

here positive value of electric flux denotes that electric field lines are coming out of the loop and can also be stated as 25 Weber. Above example shows that when orientation of loop changes so does the electric flux through the loop because angle between Electric field vector and area vector changes continuously due to which flux is coming different in both the cases.

11. $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$

or, $[\varepsilon_0] = \frac{[q_1q_2]}{[Fr^2]} = \frac{[A^2T^2]}{[MLT^{-2}][L^2]}$

= $[M^{-1}L^{-3}T^4A^2]$

12. Charge on 'up' quark $(u) = +\frac{2}{3}e$

Charge on 'down' quark $(d) = -\frac{1}{3}e$

Charge on a proton = e

Charge on a neutron = 0

Let a proton contains x 'up' quarks and (3 - x) 'down' quarks. Then total charge on a proton is,

ux + d(3 - x) = e

or, $+\frac{2}{3}ex - \frac{1}{3}e(3 - x) = e$

or, $+\frac{2}{3}x - 1 + \frac{x}{3} = 1$

or, x = 2

and 3 - x = 3 - 2 = 1

i.e. proton contains 2 'up' quarks and 1 'down' quark. Its quarks composition should be uud.

Let a neutron contains y 'up' quarks and (3 - y) 'down' quarks.

Then total charge on a neutron is:

ny + d(3 - y) = 0

or, $+\frac{2}{3}ey - \frac{1}{3}e(3 - y) = 0$

or, $+\frac{2}{3}y - 1 + \frac{y}{3} = 1$

or, y = 1

and 3 - y = 3 - 1 = 2

i.e. neutrons contain 1 'up' quark and 2 'down' quarks. Its quark composition should be udd.

13. $AC^2 = AB^2 + BC^2 = 1 + 1 = 2$

or $AC = \sqrt{2}m$

$AO = \frac{1}{2}\sqrt{2}m = 0.5\sqrt{2}m$

Also, AO = CO = BO = DO = $0.5\sqrt{2}m$

Let F_A be the force exerted by the charge of $' + 0.1\mu C'$ at A on the charge of $' + 1\mu C'$ at the centre O of the square.

Then $F_A = 9 \times 10^9 Nm^2C^{-2} \; \frac{(0.1\times10^{-6}C)(1\times10^{-6}C)}{2(0.5)^2m^2}$

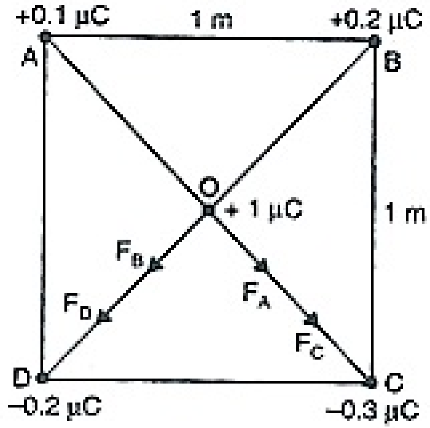
or, $F_A = \frac{9\times10^9\times\times0.1\times10^{-12}}{2\times0.25}N$ = 0.0018 N

If F_C is the force exerted by charge at C on charge at O, then

$$F_C = 9 \times 10^9 \frac{(0.3\times10^{-6})(1\times10^{-6})}{2(0.5)^2}N$$

$= \frac{9\times0.3\times10^{-3}}{2\times0.25}N$ = 0.0054 N

Both F_A and F_C act in the same direction. The resultant of F_A and F_C



F_1 = (0.0018 + 0.0054)N = 0.0072 N

Force exerted by the charge at B on the charge at O,

$$F_B = 9 \times 10^9 \frac{(0.2\times10^{-6})(1\times10^{-6})}{2(0.5)^2}N$$

$= 3.6 \times 10^{-3}N$ = 0.0036 N

Force exerted by the charge at D on the charge at O,

$F_D = 9 \times 10^9 \frac{(0.2\times10^{-6})(1\times10^{-6})}{2(0.5)^2}N$ = 0.0036 N

Both F_B and F_D act in the same direction. Resultant of F_B and FD'

F_2 = (0.0036 + 0.0036)N = 0.0072 N

The angle between F_1 and F_2 is clearly 90°. So, the resultant F of F_1 and $F_2$is given by

$$F = \sqrt{(0.0072)^2 + (0.0072)^2N} = 0.0072\sqrt{2}N$$

$= 0.0072 \times 1.414N$ = 0.01018 N

14. Given, $r = \frac{2.4}{2} = 1.2m$
    $\sigma = 80 \times 10^{-6}C/m^2$

    a. Charge on sphere
       $q = \sigma \cdot A = \sigma \cdot 4\pi r^2$

or, $q = 80 \times 10^{-6} \times 4 \times 3.14 \times (1.2)^2$

$q = 1.45 \times 10^{-3} C$

b. The total electric flux leaving the surface of the sphere

$\phi = \frac{q}{E_0}$

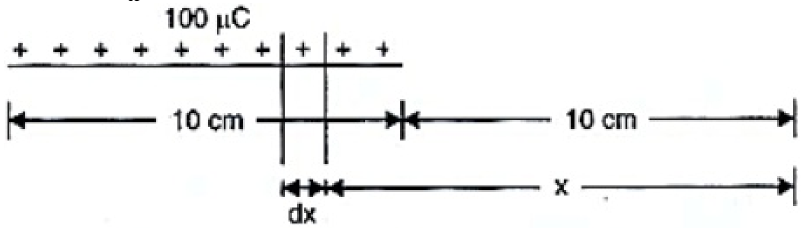
$= \frac{1.45 \times 10^{-3}}{9 \times 10^{-12}} = 1.6 \times 10^8 Nm^2/C$

15. Force on $12\mu C$ charge due to an elementary part of the linear charge,

$dF = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(\lambda dx) 12 \times 10^{-6}}{x^2}$

$= 9 \times 10^9 \times \frac{100 \times 10^{-6}}{10 \times 10^{-2}} \times 12 \times 10^{-6} \times \frac{dx}{x^2}$

$= 1.08 \frac{dx}{x^2}$



Net force on $12\mu C$ charge

$F = \int dF = 1.08$

$\int_{0.10}^{0.20} \frac{dx}{x^2} = 1.08 \left[-\frac{1}{x}\right]_{0.01}^{0.20}$

$= 1.08 \left[\frac{1}{0.10} - \frac{1}{0.20}\right] = 10.8 \left[1 - \frac{1}{2}\right] = 5.4N$