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Topic covered:

- **Electrostatics (Session - 1)**

Worksheet

1. Three equal charges are placed on the three corners of a square. If the force between q_1 and q_2 is F_{12} and that between q_1 and q_3 is F_{13}, the ratio of magnitudes $\frac{F_{12}}{F_{13}}$ is
   a. $\frac{1}{2}$
   b. 2
   c. $\frac{1}{\sqrt{2}}$
   d. $\sqrt{2}$

2. When 10^{14} electrons are removed from a neutral metal sphere, the charge on the sphere becomes
   a. $16\ \mu C$
   b. $-16\ \mu C$
   c. $32\ \mu C$
   d. $-32\ \mu C$

3. A metallic sphere A is given positive charge whereas another identical metallic sphere B of exactly same mass as of A is given an equal amount of negative charge then,
   a. Mass of A and mass of B will remain equal
   b. Mass of A increases
   c. Mass of B decreases
   d. Mass of B increases

4. The force between two charges $0.06\ m$ apart is $5\ N$ if each charge is moved towards the other by $0.01\ m$ then the force between them will become
   a. $7.20\ N$
   b. $11.25\ N$
   c. $22.50\ N$
   d. $45.00\ N$

5. Two point charges $+3\ \mu C$ and $+8\ \mu C$ repel each other with a force of $40\ N$. If a charge of $-5\ \mu C$ is added to each of them, then the force between them will become
   a. $-10\ N$
   b. $+10\ N$
   c. $+20\ N$
   d. $-20\ N$

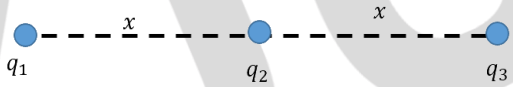
6. Three charges each of magnitude q are placed at the corners of an equilateral triangle, the electrostatic force on the charge placed at the center is(each side of the triangle is L)
   a. Zero
   b. $\frac{1}{4\pi\varepsilon_o}\frac{q^2}{L^2}$
   c. $\frac{1}{4\pi\varepsilon_o}\frac{3q^2}{L^2}$
   d. $\frac{1}{12\pi\varepsilon_o}\frac{q^2}{L^2}$

7. Two charges placed in air repel each other by a force of $10^{-4}\ N$. When oil is introduced between the charges, the force becomes $2.5\times 10^{-5} N$. The dielectric constant of oil is
   a. 2.5
   b. 0.25
   c. 2.0
   d. 4.0

8. Initially a body was neutral, after getting 80 micro coulombs of charge. The number of additional electrons in it will be
   a. 8×10^{-5}
   b. 80×10^{-17}
   c. 5×10^{14}
   d. 1.28×10^{-17}

9. Two point charges repel each other with a force of 100 N. One of the charges is increased by 10% and the other is reduced by 10%. The new force of repulsion at the same distance would be
   a. 100 N
   b. 121 N
   c. 99 N
   d. None of these

10. Three charged particles are placed on a straight line as shown in the given figure. q_1 and q_2 are fixed, but q_3 can be moved. Under the action of the forces from $q_1$and q_2, q_3 is in equilibrium. What is the relation between q_1 and q_2?



   a. $q_1 = 4q_2$
   b. $q_1 = -q_2$
   c. $q_1 = -4q_2$
   d. $q_1 = q_2$

11. What happens to the radius of a soap bubble if the charge of the soap bubble is negative?

12. If a negatively charged rod touches a conductor, the conductor will be charged by which method
   a. Friction
   b. Conduction
   c. Induction
   d. Convection

13. A neutral metal sphere is touched by a negatively charged metal rod. During the process, electrons are transferred from the _____ to the _____ and the sphere acquires a _____ charge.
   a. neutral sphere, charge rod, negative
   b. neutral sphere, charged rod, positive
   c. charged rod, neutral sphere, negative
   d. charged rod, neutral sphere, positive

14. Calculate the number of electrons constitute one coulomb of charge.

15. When air is replaced by a dielectric medium of constant K, the maximum force of attraction between two charges separated by a distance
    a. increases K times
    b. remains unchanged
    c. decreases K times
    d. increases K^{-1} times

16. Two metallic spheres of radii 1 cm and 3 cm are given charges $-1 \times 10^{-2}\ C$ and $5 \times 10^{-2}\ C$, respectively. If these are connected by a conducting wire, the final charge on the bigger sphere is
    a. $2 \times 10^{-2}\ C$
    b. $3 \times 10^{-2}\ C$
    c. $4 \times 10^{-2}\ C$
    d. $1 \times 10^{-2}\ C$

17. Two positive ions, each carrying a charge q, are separated by a distance d. If F is the force of repulsive between the ions, the number of electrons missing from each ion will be (e being the charge on an electron)
    a. $\frac{4\pi\varepsilon_o F d^2}{e^2}$
    b. $\sqrt{\frac{4\pi\varepsilon_o F e^2}{d^2}}$
    c. $\sqrt{\frac{4\pi\varepsilon_o F d^2}{e^2}}$
    d. $\frac{4\pi\varepsilon_o F d^2}{q^2}$

18. There are two metallic spheres of same radii but one is solid and the other is hollow, then
    a. Solid sphere can be given more charge
    b. Hollow sphere can be given more charge
    c. They can be charged equally(maximum)
    d. None of the above.

19. Two small spheres each having $+Q$ are suspended by insulating threads of length L from a hook. This arrangement is taken in space where there is no gravitational effect, then angle between the two suspensions and the tension in each will be
    a. $180°, \frac{1}{4\pi\varepsilon_o}\frac{Q^2}{(2L)^2}$
    b. $90°, \frac{1}{4\pi\varepsilon_o}\frac{Q^2}{L^2}$
    c. $180°, \frac{1}{4\pi\varepsilon_o}\frac{Q^2}{2L^2}$
    d. $180°, \frac{1}{4\pi\varepsilon_o}\frac{Q^2}{L^2}$

20. Two similar spheres having $+Q$ and $-Q$ charge are kept at a certain distance. F force acts between the two. If at the midpoint of the line joining the two spheres, another similar sphere having $+Q$ charge is kept, then it experiences a force in magnitude and direction as
    a. Zero having no direction
    b. $8F$ towards $+Q$ charge
    c. $8F$ towards $-Q$ charge
    d. $4F$ towards $+Q$ charge

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Answer Key

Question Number	1	2	3	4	5
Answer Key	(b)	(a)	(d)	(b)	(b)

Question Number	6	7	8	9	10
Answer Key	(a)	(d)	(c)	(c)	(c)

Question Number	11	12	13	14	15
Answer Key	Increase	(b)	(c)	625×10^{16}	(c)

Question Number	16	17	18	19	20
Answer Key	(b)	(c)	(c)	(a)	(c)

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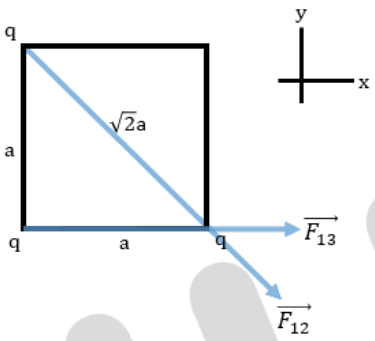
Solutions

1. (b)

$F_{12} = \frac{1}{4\pi\varepsilon_o}\frac{q^2}{a^2}$ and $F_{13} = \frac{1}{4\pi\varepsilon_o}\frac{q^2}{(a\sqrt{2})^2}$

$\frac{F_{12}}{F_{13}} = 2$



2. (a)

Electrons are removed, so the charge will be positive.

$q = ne \Rightarrow q = 10^{14} \times 1.6 \times 10^{-19}\ C \Rightarrow q = 1.6 \times 10^{-5}\ C = 16\ \mu C$

3. (d)

Negative charge means excess of electrons, which increases the mass of sphere B.

4. (b)

We know that $F \propto \frac{1}{r^2} \Rightarrow \frac{F_1}{F_2} = \left(\frac{r_2}{r_1}\right)^2 \Rightarrow \frac{5}{F_2} = \left(\frac{0.04}{0.06}\right)^2$

$F_2 = 11.25\ N$

Two point charges $+3\ \mu C$ and $+8\ \mu C$ are of same sign so they will repel each other.

5. (b)

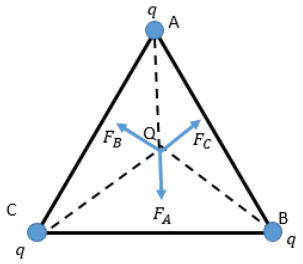
After a charge of $-5\ \mu C$ is added to both the point charges, the new charges will be, $-2\ \mu C$ and $+3\ \mu C$

Since, $F \propto Q_1\ Q_2$

$\frac{F}{F'} = \frac{Q_1 Q_2}{Q'_1 Q'_2} \Rightarrow \frac{40}{F'} = \frac{3\times8}{-2\times3} \Rightarrow F' = 10\ N$

6. (a)

The magnitude of the forces are equal to each other in the given situation and they are equally inclined with each other. Therefore, their resultant will be zero.



7. (d)

Using $K = \frac{F_a}{F_m} \Longrightarrow K = \frac{10^{-4}}{2.5\times10^{-5}} = 4$

8. (c)

Using $q = ne$

$$n = \frac{Q}{e} = \frac{80\times10^{-6}}{1.6\times10^{-19}} = 5 \times 10^{14}$$

9. (c)

Points repelling each other by a force $=100\ N$ initially

$$\therefore \frac{k\ q_1\ q_2}{r^2} = 100$$

One of the charge is increased by 10% and the other is reduced by 10%

Therefore, new force $F = \frac{k(1.1q_1)\ (0.9q_2)}{r^2}$

$$\frac{F}{100} = 0.99 \Longrightarrow F = 99\ N$$

10. (c)

Total force on q_3 is $F_1 + F_2 = 0$

$$\Longrightarrow \frac{k\ q_1\ q_3}{(2x)^2} + \frac{k\ q_2\ q_3}{(x)^2} = 0$$

$$\Longrightarrow q_1 = -4q_2$$

11.

The radius of the soap bubble increases due to repulsive force of the charges.

12. (b)

Electrostatic induction is a redistribution of charges in an object, caused by the influence of nearby charges. Charging by induction involves transfer of charges from one part to the other of the body.

13. (c)

During charging by conduction, both objects acquire the same type of charge. If a negative object is used to charge a neutral object, then both objects become charged negatively. In order for the neutral sphere to become negative, it must gain electrons from the negatively charged rod.

14.

$$q = ne$$

where, $q \longrightarrow$ charge, $n \longrightarrow$ number of electrons, $e \longrightarrow$ charge on an electron

$$1C = n(1.6 \times 10^{-19})$$

$$n = \frac{10^{19}}{1.6} = 625 \times 10^{16} \text{ electrons}$$

15. (c)

The maximum force, $F_m = \frac{F_o}{K}$

The maximum forces decrease K times

16. (b)

When the given metallic spheres are connected by conducting wire, charge will flow till both the spheres acquire a common potential which is given by common potential,

$$V = \frac{q_1 + q_2}{C_1 + C_2} = \frac{-1 \times 10^{-2} + 5 \times 10^{-2}}{4\pi\varepsilon_o R_1 + 4\pi\varepsilon_o R_2}$$

$$= \frac{4 \times 10^{-2}}{4\pi\varepsilon_o(1 \times 10^{-2} + 3 \times 10^{-2})}$$

$$= \frac{4 \times 10^{-2}}{4\pi\varepsilon_o(4 \times 10^{-2})} = \frac{1}{4\pi\varepsilon_o}$$

$\therefore$ Final charge on the bigger sphere $= 4\pi\varepsilon_o \times 3 \times 10^{-2} \times \frac{1}{4\pi\varepsilon_o} = 3 \times 10^{-2}\ C$

17. (c)

According to Coulomb's law, the force of repulsion between the two positive ions each of charge q, separated by a distance d is given by

$$F = \frac{1}{4\pi\varepsilon_o}\frac{(q)(q)}{d^2}$$

$$q^2 = 4\pi\varepsilon_o F d^2$$

$$q = \sqrt{4\pi\varepsilon_o F d^2}$$

Since, $q = ne$

Where $n =$ number of electrons missing from each ion

$e =$ magnitude of charge on electron

$$n = \frac{\sqrt{4\pi\varepsilon_o F d^2}}{e}$$

$$= \sqrt{\frac{4\pi\varepsilon_o F d^2}{e^2}}$$

18. (c)

In case of metallic sphere (solid or hollow), the charge will reside on the surface of the sphere. Since both spheres have same surface area, they can hold equal number of maximum charges.

19. (a)

The position of the balls in the satellite will become as shown below

Thus the angle=180°

And force $=\frac{1}{4\pi\varepsilon_o}\frac{Q^2}{(2L)^2}$ (using Coulomb's law)

20. (c)

Initially the force between spheres A and C is $F = \frac{kQ^2}{r^2}$

The net force after a similar sphere B is placed at the midpoint is $F_{net} = F_A + F_C$

$$F_{net} = \frac{kQ^2}{\left(\frac{r}{2}\right)^2} + \frac{kQ^2}{\left(\frac{r}{2}\right)^2} = 8\frac{kQ^2}{r^2} = 8F$$

The net force acts towards $-Q$