Properties of charge

1. What is charge? Give its SI and CGS units. Is it a scalar or a vector?
2. What are major differences between mass and charge?
3. a. What do you understand by quantization of charge?
   b. What minimum magnitude of charge can be found independently in nature?
   c. Is fractional electronic charge possible? Explain.
4. What do you understand by conservation of charge and give two examples?
5. How is conservation of charge related to additive nature of charge?
6. How many electrons are there in
   (i) One coulomb of electric charge?
   (ii) One stat coulomb of electric charge?
7. A polythene piece rubbed with wool is found to have a negative charge of 3.2×10^{-7}C. Estimate the number of electrons transferred.

Objective Type Questions

8. Let 2×10^{15} electrons be added to a neutral body. Then charge on the body will become
   (1) 160 μC (2) -160 μC
   (3) 320 μC (4) -320 μC
9. If 10^9 electrons move out of a body every second. Time required to get a total charge of 1 C on this body is
   (1) 6.25 giga second (2) 6.25 kilo second
   (3) 6.25 tera second (4) 6.25 mega second
10. Which statement is correct w.r.t. properties of electric charge?
   (1) It is possible to create or destroy net charge carried by any isolated system.
   (2) Electric charge may not be an integral multiple of e^-
   (3) If a body contains n_1 electrons and n_2 protons, the total amount of charge on the body is $(n_1 + n_2)e/2$
   (4) none of these
11. A body is given $+1$ C charge. Its mass
   (1) increases by 5.7×10^{-12} kg
   (2) decreases by 5.7×10^{-12} kg
   (3) increases by 1.8×10^{-13} kg
   (4) decreases by 1.8×10^{-13} kg
12. Two conducting bodies with charges $+5$ C and -3C are brought in contact. Which of the following can not be the possible charges on them finally?
   (1) 1 C, 1C (2) 1.5C, 0.5C
   (3) 2C, 1C (4) 1.75C, 0.25C

Answers

7.	2×10^{12}	10.	(4)
8.	(4)	11.	(2)
9.	(1)	12.	(3)

Charging a body

1. What is the role of rubbing while charging a body by friction?
2. What is the major drawback of charging by conduction?
3. Explain the role of earthing a conductor in charging by induction. Can bodies be charged without using earth?
4. Is there always electrostatic repulsion between two similarly charged bodies? Will your answer remain same for similar point charges? Explain.
5. Repulsion is the true test of electrification. Explain.
6. A polythene piece rubbed with wool is found to have a negative charge of 3.2×10^{-7} C. Is there a transfer of mass from wool to polythene? If yes, find the mass transferred.
7. An electroscope initially has a net negative charge. Why do the foils come together when the electroscope is touched by a human hand?

Objective Questions

8. A body can be negatively charged by
   (1) Giving excess of electrons to it
   (2) Removing some electrons from it
   (3) Giving some protons to it
   (4) Removing some neutrons from it
9. In general, metallic ropes are suspended on the carriers which take inflammable material. The reason is
   (1) to control the speed
   (2) to keep the centre of gravity of the carrier nearer to the earth
   (3) to keep the body of the carrier in contact with the earth
   (4) nothing should be placed under the carrier
10. A glass rod rubbed with silk is used to charge a gold leaf electroscope having air inside the jar and the leaves are observed to diverge. The electroscope thus charged is exposed to X-rays for a short period. Then the leaves will
    (1) not be affected (2) diverge further
    (3) collapse (4) melt
11. When a glass rod is rubbed with silk, it
    (1) gains electrons from silk
    (2) gives electrons to silk
    (3) gains protons from silk
    (4) gives protons to silk
12. Five balls numbered 1 to 5 are suspended using separate threads. Pairs (1, 2), (2, 4) and (4, 1) show electrostatic attraction, while pair (2, 3) and (4, 5) show repulsion. Therefore ball 1 must be
    (1) positively charged
    (2) negatively charged
    (3) neutral
    (4) made of wood
13. Two identical conductors of copper and aluminium are placed in an identical electric fields. The magnitude of induced charge in the aluminium will be
    (1) zero
    (2) greater than in copper
    (3) equal to that in copper
    (4) less than in copper
14. When a body is connected to earth, electrons from the earth flow into the body. This means the body was most likely
    (1) uncharged (2) positively charged
    (3) negatively charged (4) an insulator

* * * *

Answers

6. 1.8×10^{-18} kg
7. The charges flows through the hand to the ground
8. (1)
9. (3)
10. (3)
11. (2)
12. (3)
13. (3)
14. (2)

Coulomb's law

1. State Coulomb's law. Give its form in both SI and CGS systems.
2. Define unit of charge using Coulomb's law.
3. Briefly explain various characteristics of Coulombic force. For what order of distance, the inverse square law is true?
4. A charge Q is to be divided in two parts. What should be values of charges on the two parts so that the force between two parts is maximum?
5. Two equal point charges separated by a certain distance repel each other by a force of 1000 N. If one of the charge is increased by 20% and other is reduced by 20%, find new force of interaction between them when placed at the same distance.
6. Two particles, each having a mass of 5g and charge 1.0×10^{-7}C, stay in limiting equilibrium on a horizontal table with a separation of 10 cm between them. The coefficient of friction between each particle and the table is the same. Find coefficient of friction.

Objective Type Questions

7. When the distance between the charged particles is halved, force between them becomes
   (1) One-fourth (2) Half
   (3) Double (4) Four times
8. There are two charges $+1$ microcoulombs and $+5$ microcoulombs. The ratio of the forces acting on them will be
   (1) 1 : 5 (2) 1 : 1
   (3) 5 : 1 (4) 1 : 25
9. F_g and F_e represents gravitational and electrostatic force respectively between electrons situated at a distance 10 cm. The ratio of F_g and F_e is of the order of
   (1) 10^{42} (2) 10
   (3) 1 (4) 10^{-43}
10. The ratio of the forces experienced by two small spheres with constant charge (a) in air (b) in a medium of dielectric constant K is
    (1) 1 : K (2) K : 1
    (3) 1 : K^2 (4) K^2 : 1
11. The dielectric constant of water is 80. Its permitivity is
    (1) 80 (2) $320 \pi \varepsilon_0$
    (3) $36 \pi \times 80 \varepsilon_0$ (4) $80 \varepsilon_0$
12. The ratio of acceleration of electron to that of proton due to the electrical force of their mutual attraction when they are 1 Å apart is ($m_P = 1.67 \times 10^{-27}$ kg, $m_E = 9.11 \times 10^{-31}$ kg).
    (1) 180 (2) 1834
    (3) 2500 (4) 1260

****

Answers

(4) Q/2 each
(5) 960 N
(6) 0.18
7. (4)
8. (2)
9. (4)
10. (2)
11. (4)
12. (2)

Coulomb's law (Super position), Electric field (Point charge)

1. What is meant by the principle of superpositon?
2. Two identical charges, Q each, are kept at a distance r from each other. A third charge q is placed on the line joining the above two charges such that all the three charges are in equilibrium. What is magnitude, sign and position of the charge q?
3. Four charges $q_A = 2\mu C$, $q_B = -5\mu C$, $q_C = 2\mu C$ and $q_D = 2\mu C$ are located at the corners of a square ABCD of side 10 cm. Find the force on a charge of 1 μC placed at the centre O of the square.
4. Two small spheres each of mass 'm' kg and having equal charge are suspended from a point by insulating threads each of length 'l' metre but negligible mass. If 'θ' is the angle which each string makes with vertical when equilibrium has been reached, find charge on one sphere.
5. a. Define electric field and intensity of electric field. Is it a scalar or a vector?
   b. An electron is released in an electric field. In which direction will it experience a force if any.
6. Write the expressions for electric field of a point charge in SI and CGS systems.
7. Two point charges $+q$ and $+4q$ are separated by a distance of 6a. Find the point on the line joining the two charges where electric field is zero.

Objective Type Questions

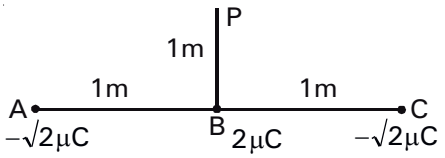
8. A charge q_1 exerts some force on a second charge q_2. If third charge q_3 is brought near, then the force on q_2
   (1) may increase
   (2) may become zero
   (3) may decrease
   (4) all of these
9. An electron is placed in an electric field of intensity E near the surface of earth. If net force experienced by the electron is zero, then E is
   (1) 5.57×10^{-11} N/C (2) 4.47×10^{-11} N/C
   (3) 10^{-11} N/C (4) 10 N/C
10. Three charges $+q$ each are placed at three corners of an equilateral triangle. The electric intensity at the centroid of the triangle is
   (1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$
   (3) Zero (4) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{r^2}$
11. Four particles, each having a charge q, are placed on the vertices of a regular pentagon. The distance of each corner from the centre is 'r'. The electric field at the centre of the pentagon is
   (1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$
   (3) Zero (4) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{r^2}$
12. Which statement is correct w.r.t. electric field?
   (1) If source charge is negative, the electric field vector, at each point, points radially outwards
   (2) Electric field due to a point charge does not necessarily have a spherical symmetry
   (3) Electric field is a characteristic of system of charges and is independent of the test charge
   (4) Electric field at a point due to a system of charges is the sum of the magnitudes of electric fields at the point due to individual charges

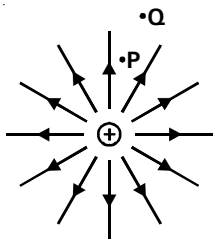
Answers

2. $-Q/4$
3. 12.6 N
7. 2a from $+q$
8. (4)
9. (1)
10. (3)
11. (1)
12. (3)

Electric line of forces

1. An infinite number of charges each equal to $6\,\mu C$ are situated along the x-axis at $x = 1$, $x = 2$, $x = 4$, $x = 8$ m and so on. Find the electric field at a point $x = 0$ due to the set of charges.
2. Calculate total electric field intensity at point P due to all three charges shown in the figure.

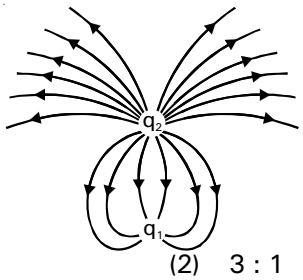


3. a. What are electric lines of force? How many lines of force originate from a charge q?
   b. Why electric lines of force never cross each other?
4. Draw electric lines of force for
   i. a point positive charge
   ii. a point negative charge
   iii. an electric dipole
   iv. a straight infinite uniformly charged wire
   v. a uniform electric field
5. 

Above figure shows the field lines of a point charge. At which of the two points P & Q electric field is stronger?

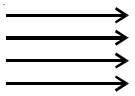
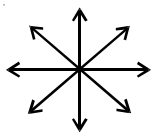
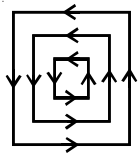
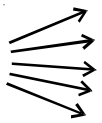
Objective Type Questions

6. What is the ratio of magnitude of q_1 to that of q_2?



(1) 1 : 3 (2) 3 : 1
(3) 1 : 1 (4) 1 : 2

7. Which of the following pattern of electric lines of force is not possible in an electrostatic field?

(1) 
(2) 
(3) 
(4) 

8. A charge particle is free to move in a uniform electric field. It will travel
   (1) Always along a line of force
   (2) Along a line of force, if its initial velocity is zero
   (3) Along a line of force, if it has some initial velocity in the direction of an acute angle with the line of force
   (4) None of the above
9. Which of the following is not true for electric lines of force
   (1) They start from and terminate on a charge
   (2) Their seperation is directly proportional to field strength
   (3) They cannot cross each other
   (4) They may be straight or curved
10. In a uniform field, lines of force are
   (1) straight (2) parallel
   (3) equidistant (4) all of these

(1) 7.2×10^4 N/C
(2) 9×10^3 N/C
6. (1)
7. (3)
8. (2)
9 (2)
10 (4)

Dipole, electric field of dipole, Torque ……..

1. a. Define electric dipole and dipole moment. Give its direction and SI units. What is an ideal dipole?
   b. Derive an expression for electric field on the axial line and equatorial line of a dipole.
2. A short electric dipole has dipole moment of 8×10^{-9} C-m. Determine the electric field due to the dipole at a distance of 0.2 m from the centre of the dipole situated on
   i. the axial line
   ii. on equatorial line
3. An electric dipole with moment $\vec{p}$ is placed in a uniform electric field of intensity $\vec{E}$. Derive the expression for the torque τ experienced by the dipole. Show diagramatically the orientation of the dipole in the field for which the torque is
   (i) maximum
   (ii) half the maximum value
   (iii) zero
4. A electric dipole with dipole moment 4×10^{-9} Cm is aligned at 30° with the direction of a uniform electric field of magnitude 5×10^4 NC^{-1}. Calculate the magnitude of torque acting on the dipole
5. An electric dipole is kept in uniform electric field. It experiences
   (1) A force and a torque
   (2) A force but not a torque
   (3) A torque but not a force
   (4) Neither a force nor a torque
6. Maximum torque experienced by an electric dipole consisting of two opposite charges of 1 μC each separated by a distance of 2 mm in uniform electric field E is 6×10^{-4} Nm. Then E is
   (1) 7.5×10^5 N/C (2) 3×10^5 N/C
   (3) 5×10^5 N/C (4) 6×10^5 N/C
7. Electric charges q, q, $-2q$ are placed at the corners of an equilateral triangle ABC of side L. The magnitude of electric dipole moment of the system is
   (1) qL (2) 2qL
   (3) $\sqrt{3}$ qL (4) 4qL
8. A charge 'Q' is placed on the axis of a short dipole of dipole moment 'p' at a distance 'r' from the dipole. Force experienced by the charge is given by
   (1) $\frac{pQ}{\pi\varepsilon_0 r^3}$ (2) $\frac{pQ}{4\pi\varepsilon_0 r^3}$
   (3) $\frac{2pQ}{\pi\varepsilon_0 r^3}$ (4) $\frac{pQ}{2\pi\varepsilon_0 r^3}$
9. The ratio of magnitudes of electric fields on the axis to that at the equator of an ideal dipole is
   (1) 1 : 1 (2) 2 : 1
   (3) 4 : 1 (4) 1 : 2
10. What is the angle between the electric dipole moment and the electric field strength due to it on the equatorial line
    (1) 0° (2) 90°
    (3) 180° (4) 270°
11. A diatomic molecule has an electric dipole moment of magnitude 6.4×10^{-30} C-m. How far apart are the centres of positive and negative charges assuming a transfer of one electron between atoms.
    (1) 4 pm (2) 4 mm
    (3) 4 μm (4) 40 pm
12. An electric dipole of moment p is placed at the origin along the x-axis. The electric field at a point P, whose position vector makes an angle with the x-axis, will make an angle ….. with the x-axis, where $\tan\alpha = \frac{1}{2}\tan\theta$
    (1) α (2) θ
    (3) $\theta + \alpha$ (4) $\theta + 2\alpha$

Answers

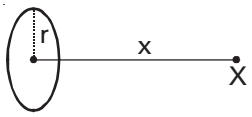
2 i. 18000 N/C
ii. 9000 N/C
4. 10^{-4} Nm
5. (3)
6. (2)
7. (3)
8. (4)
9. (2)
10. (3)
11. (4)
12. (3)

Dipole (..... Torque, Potential energy, Work done)

1. An electric dipole of moment $\vec{p}$ is placed in uniform electric field of intensity $\vec{E}$. Find the work done in rotating the dipole from an angle $_1$ to $_2$ with respect to the electric field. Derive the expression for potential energy of the dipole using the work done found above.
2. If $\sqrt{3}$ Joule of work is done by an external agent in rotating an electric dipole from the direction of uniform electric field to direction making an angle of 60° with it without acceleration, calculate torque required to hold dipole in same position.
3. Consider a permanent dipole of dipole moment p parallel to and in a non-uniform external field E. Then
   a. the net force on the dipole is zero.
   b. there will be a torque on the system
   c. the net force will be non-zero
   d. the net torque is zero
   (1) both a & b (2) both a & d
   (3) both b & c (4) both c & d
4. An electric dipole is placed in an electric field generated by a point charge
   (1) net electric force on the dipole must be zero
   (2) net electric force on the dipole may be zero
   (3) torque on dipole due to the field must be zero
   (4) torque on dipole due to the field may be zero
5. No work will be done in rotating a dipole in a uniform electric field from
   (1) 0° to 180° (2) 0° to 90°
   (3) 90° to 270° (4) 0° to 45°
6. Potential energy of an electric dipole in uniform electric field is zero, when angle between dipole moment and electric field is
   (1) 180° (2) 90°
   (3) 0° (4) 45°
7. An electric dipole of moment p is placed in the position of stable equilibrium in uniform electric field of intensity E. It is rotated through an angle θ from the initial position. The potential energy of electric dipole in the final position is
   (1) pE $\cos\theta$ (2) pE $\sin\theta$
   (3) pE$(1-\cos\theta)$ (4) $-$pE $\cos\theta$
8. An electric dipole has the magnitude of its charge as q and its dipole moment is p. It is placed in a uniform electric field E. If its dipole moment is along the direction of field, force on it and its potential energy are respectively
   (1) 2qE and minimum (2) qE and pE
   (3) Zero and minimum (4) qE and maximum
9. The work required to rotate a molecule with a dipole moment 'p' in uniform electric field E by 90° can not be
   (1) zero (2) $-$ pE
   (3) pE (4) 2pE

2. 3 Nm
3. (4)
4. (4)
5. (3)
6. (2)
7. (4)
8. (3)
9. (4)

Uniformly charged ring, Miscellaneous

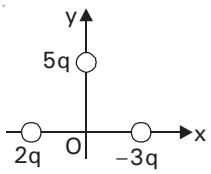
1. 

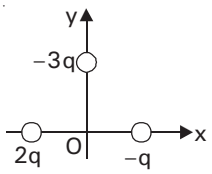
Find an expression for electric field intensity due to a uniformly charged ring of radius r, with charge per unit length λ, at a distance x from its centre. Discuss the following special cases

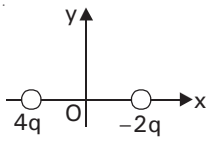
(i) $x = 0$

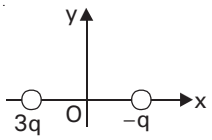
(ii) $x \gg r$

2. Find the point on the axis of a uniformly charged ring where strength of electric field is maximum.
3. A negatively charged particle is released from a point on the axis of a positively charged ring. Discuss its motion.
4. Two equal negative charge – q are fixed at the fixed points $(0, a)$ and $(0, -a)$ on the Y-axis. A positive charge Q is released from rest at the point $(2a, 0)$ on the X-axis. The charge Q will
   (1) Execute simple harmonic motion about the origin
   (2) Move to the origin and remain at rest
   (3) Move to infinity
   (4) Execute oscillatory but not simple harmonic motion
5. In the following four situations charged particles are at equal distance from the origin. Arrange them the magnitude of the net electric field at origin greatest first

(i) 

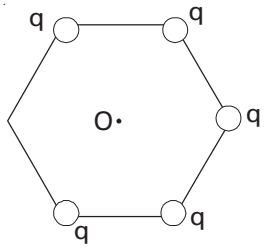
(ii) 

(iii) 

(iv) 

(1) (i) > (ii) > (iii) > (iv)
(2) (ii) > (i) > (iii) > (iv)
(3) (i) > (iii) > (ii) > (iv)
(4) (iv) > (iii) > (ii) > (i)

6. An electron falls through a small distance in a uniform electric field of magnitude $2 \times 10^4 NC^{-1}$. The direction of the field is reversed keeping the magnitude unchanged and a proton falls through the same distance. The time of fall will be
   (1) Same in both cases
   (2) More in the case of an electron
   (3) More in the case of proton
   (4) Independent of charge
7. Five point charge each having magnitude 'q' are placed at the corner of hexagon as shown in fig. Net electric field at the centre 'O' is $\vec{E}$. To get net electric field at 'O' be $6\vec{E}$, charge placed on the remaining sixth corner should be



(1) 6 q (2) – 6 q
(3) 5 q (4) – 5 q

8. Two point charge – q and $+q/2$ are situated at the origin and at the point (a, 0, 0) respectively. The point along the X-axis where the electric field vanishes is

(1) $x \frac{a}{\sqrt{2}}$ (2) $x = \sqrt{2}\, a$

(3) $x \frac{\sqrt{2}a}{\sqrt{2}-1}$ (4) $x = \frac{\sqrt{2}a}{\sqrt{2}+1}$

9. Two identical balls having like charges and placed at a certain distance apart repel each other with a certain force. They are brought in contact and then moved apart to a distance equal to half their initial separation. The force of repulsion between them increases 4.5 times in comparison with the initial value. The ratio of the initial charges of the balls is
   (1) 2 (2) 3
   (3) 4 (4) 6

Answers

4.	**(4)**	**7.**	**(4)**
5.	**(3)**	**8.**	**(3)**
6.	**(3)**	**9.**	**(1)**

Motion of charged particle

1. An electron moves a distance of 90 cm when accelerated from rest by an electric field of strength 2×10^{-4} NC^{-1}. Calculate the time of travel.
2. A particle of mass m and charge $-q$ enters the region between the two charged plates initially moving along x-axis with speed v_x. The length of plate is L and a uniform electric field E is maintained along y-axis between the plates. Show that the deflection of the particle along y direction at the far edge of the plate is $\frac{qEL^2}{2mv_x^2}$.

Objective Type Questions

3. Intensity of electric field required to keep a water drop of radius 10^{-5} cm just suspended in air when charged with one electron is approximately
   (1) 260 volt/cm (2) 260 N/C
   (3) 130 volt/cm (4) none of these
4. A particle A has charge $+q$ and a particle B has charge $+4q$ with each of them having the same mass m. When placed in the same uniform electric field, the ratio of acceleration of A to that of B will be
   (1) 2 : 1 (2) 1 : 2
   (3) 1 : 4 (4) 4 : 1
5. A mass $m = 20$ g has a charge $q = 3.0$ mC. It moves with a velocity of 20 m/s and enters a region of electric field of 80 N/C in the same direction as the velocity of the mass. The velocity of the mass after 3 seconds in this region is
   (1) 80 m/s (2) 56 m/s
   (3) 44 m/s (4) 40 m/s
6. A particle of mass m and charge q is placed at rest in a energy attained by the particle after moving a distance y is
   (1) q^2Ey (2) qEy
   (3) qE^2y (4) qEy^2

Answers

1. 2.25×10^{-4} **s** **5. (2)**
3. (2) **6. (2)**
4. (3)