

12th Science Lesson 6 Questions in English

6] Electrostatics

1. The forces we experience in everyday life are electromagnetic in nature except ____

- a) Friction
- b) Gravity**
- c) Repulsion
- d) All the above

Explanation

The technological developments of the modern 21st century are primarily due to our understanding of electromagnetism. The forces we experience in everyday life are electromagnetic in nature except gravity. It is now understood that except gravity, all forces which we experience in every day life (tension in the string, normal force from the surface, friction etc.) arise from electromagnetic forces within the atoms.

2. Which among the following statement is correct

- 1) When an object is pushed, the atoms in our hand interact with the atoms in the object and this interaction is basically electromagnetic in nature. When we stand on Earth's surface, the gravitational force on us acts downwards and the normal force acts upward to counter balance the gravitational force.
 - 2) It arises due to the electromagnetic interaction of atoms on the surface of the Earth with the atoms present in the feet of the person. Though, we are attracted by the gravitational force of the Earth, we stand on Earth only because of electromagnetic force of atoms.
 - 3) When an object is moved on a surface, static friction resists the motion of the object. This static friction arises due to electromagnetic interaction between the atoms present in the object and atoms on the surface. Kinetic friction also has similar origin. This branch of electricity which deals with stationary charges is called Electrostatics.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3**

3. Two millenniums ago, Who, noticed that amber after rubbing with animal fur attracted small pieces of leaves and dust?

- a) Aryans
- b) Greeks**
- c) Romans
- d) None of the above

Explanation

Two millenniums ago, Greeks noticed that amber (a solid, translucent material formed from the resin of a fossilized tree) after rubbing with animal fur attracted small pieces of leaves and dust. The amber possessing this property is said to be 'charged'.

4. Which among the following statement is correct

- 1) Consider a charged rubber rod hanging from a thread. Suppose another charged rubber rod is brought near the first rubber rod; the rods repel each other. Now if we bring a charged glass rod close to the charged rubber rod, they attract each other.
 - 2) At the same time, if a charged glass rod is brought near another charged glass rod, both the rods repel each other. From these observations, the following inferences are made (i) The charging of rubber rod and that of glass rod are different from one another. (ii) The charged rubber rod repels another charged rubber rod, which implies that 'like charges repel each other'.
 - 3) We can also arrive at the same inference by observing that a charged glass rod repels another charged glass rod. (iii) The charged rubber rod attracts the charged glass rod, implying that the charge in the glass rod is same kind of charge present in the rubber. Thus, like charges attract each other
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

We can also arrive at the same inference by observing that a charged glass rod repels another charged glass rod. (iii) The charged rubber rod attracts the charged glass rod, implying that the charge in the glass rod is not the same kind of charge present in the rubber. Thus unlike charges attract each other.

5. In the 18th century, who called one type of charge as positive (+) and another type of charge as negative (-)?

- a) J. J. Thomson
- b) Benjamin Franklin
- c) Rutherford
- d) John Dalton

Explanation

In the 18th century, Benjamin Franklin called one type of charge as positive (+) and another type of charge as negative (-). Based on Franklin's convention, rubber and amber rods are negatively

charged while the glass rod is positively charged. If the net charge is zero in the object, it is said to be electrically neutral.

6. Charging the objects through rubbing is called _____

- a) Cosmoelectric charging
- b) Triboelectric charging**
- c) Neoelectric charging
- d) Hostelectric charging

Explanation

When an object is rubbed with another object (for example rubber with silk cloth), some amount of charge is transferred from one object to another due to the friction between them and the object is then said to be electrically charged. Charging the objects through rubbing is called triboelectric charging.

7. The SI unit of charge is _____

- a) Newton
- b) Joule
- c) Coulomb**
- d) Pascal

Explanation

Most objects in the universe are made up of atoms, which in turn are made up of protons, neutrons and electrons. These particles have mass, an inherent property of particles. Similarly, the electric charge is another intrinsic and fundamental property of particles. The SI unit of charge is coulomb.

8. Which among the following statement is correct

- 1) Benjamin Franklin argued that when one object is rubbed with another object, charges get transferred from one to the other. Before rubbing, both objects are electrically neutral and rubbing simply transfers the charges from one object to the other.
 - 2) He concluded that charges are neither created or nor destroyed but can only be transferred from one object to other. This is called conservation of total charges and is one of the fundamental conservation laws in physics.
 - 3) It is stated more generally in the following way. The total electric charge in the universe is constant and charge can neither be created nor be destroyed. In any physical process, the net change in charge will always be zero.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3**

9. Who in n his famous experiment found that the value of $e = 1.6 \times 10^{-19}$ C?

- a) James Chadwick
- b) Harvey Fletcher
- c) **Robert Millikan**
- d) Rutherford

Explanation

Robert Millikan in his famous experiment found that the value of $e = 1.6 \times 10^{-19}$ C. The charge of an electron is -1.6×10^{-19} C and the charge of the proton is $+1.6 \times 10^{-19}$ C.

10. Calculate the number of electrons in one coulomb of negative charge?

- a) $n = 1.38 \times 10^{18}$ electrons
- b) $n = 3.18 \times 10^{18}$ electrons
- c) **$n = 6.25 \times 10^{18}$ electrons**
- d) $n = 9.18 \times 10^{18}$ electrons

Explanation

According to the quantisation of charge, $q = ne$

Here $q = 1\text{C}$. So, the number of electrons in 1 coulomb of charge is $n = q / e$.

$$n = 1\text{C} / 1.6 \times 10^{-19}$$

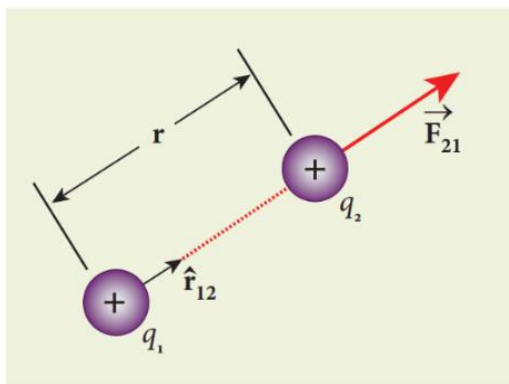
$$n = 6.25 \times 10^{18} \text{ electrons.}$$

11. Which among the following statement is correct regarding coulomb's law?

- 1) In the year 1786, Coulomb deduced the expression for the force between two stationary point charges in vacuum or free space. Consider two-point charges q_1 and q_2 at rest in vacuum, and separated by a distance of r . According to Coulomb, the force on the point charge q_1 exerted by another point charge q_2 is $F_{21} = K \frac{q_1 + q_2}{r^2} r_{12}$.
 - 2) Coulomb's law states that the electrostatic force is directly proportional to the product of the magnitude of the two-point charges and is inversely proportional to the square of the distance between the two-point charges.
 - 3) The force on the charge q_2 exerted by the charge q_1 always lies along the line joining the two charges. r_{12} is the unit vector pointing from charge q_1 to q_2 . Likewise, the force on the charge q_1 exerted by q_2 is along r_{12} (i.e., in the direction opposite to r_{12}). The magnitude of the electrostatic force between two charges each of one coulomb and separated by a distance of 1 m is calculated as follows: $|F| = 9 \times 10^9 \text{ N}$.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) **Both 2 and 3**

d) All 1, 2 and 3

Explanation



In the year 1786, Coulomb deduced the expression for the force between two stationary point charges in vacuum or free space. Consider two-point charges q_1 and q_2 at rest in vacuum, and separated by a distance of r . According to Coulomb, the force on the point charge q_2 exerted by another point charge q_1 is $F_{21} = K \frac{q_1 q_2}{r^2} \hat{r}_{12}$.

12. By Coulomb's law, in S.I units, $k = \frac{1}{4\pi\epsilon_0}$ and its value is -----

- a) $9 \times 10^9 \text{ N m C}$
- b) $9 \times 10^9 \text{ N m}^2 \text{ C}$
- c) $9 \times 10^9 \text{ N m C}^2$
- d) $9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$

Explanation

By Coulomb's law, in S.I units, $k = \frac{1}{4\pi\epsilon_0}$ and its value is $9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$.

13. Which among the following statement is correct regarding coulombs law?

- 1) Coulomb's law has same structure as Newton's law of gravitation. Both are inversely proportional to the square of the distance between the particles. The electrostatic force is directly proportional to the product of the magnitude of two-point charges and gravitational force is directly proportional to the product of two masses.
- 2) But there are some important differences between these two laws. The gravitational force between two masses is always attractive but Coulomb force between two charges can be attractive or repulsive, depending on the nature of charges.
- 3) The gravitational force between two masses is dependent of the medium. For example, if 1 kg of two masses are kept in air or inside water, the gravitational force between two masses remains different. Thus, electrostatic force between the two charges depends on nature of the medium in which the two charges are kept at rest.

a) Both 1 and 2

- b) Both 1 and 3
- c) Both 2 and 3
- d) All 1, 2 and 3

Explanation

The gravitational force between two masses is independent of the medium. For example, if 1 kg of two masses are kept in air or inside water, the gravitational force between two masses remains the same. But the electrostatic force between the two charges depends on nature of the medium in which the two charges are kept at rest.

14. What is the value of Gravitational constant?

- a) $G = 4.91 \times 10^{-8} \text{ N m}^2 \text{ kg}^{-2}$
- b) $G = 5.82 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
- c) **$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$**
- d) $G = 7.83 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$

Explanation

The value of the gravitational constant $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$. The value of the constant k in Coulomb law is $k = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$. Since k is much greater than G , the electrostatic force is always greater in magnitude than gravitational force for smaller size objects.

15. Which principle explains the interaction between multiple charges?

- a) Multitude principle
- b) **Superposition principle**
- c) Nanoconduction principle
- d) Compressive principle

Explanation

Coulomb's law explains the interaction between two-point charges. If there are more than two charges, the force on one charge due to all the other charges needs to be calculated. Coulomb's law alone does not give the answer. The superposition principle explains the interaction between multiple charges.

16. Which among the following statement is correct regarding superposition principle?

- 1) According to this superposition principle, the total force acting on a given charge is equal to the vector sum of forces exerted on it by all the other charges. Consider a system of n charges, namely $q_1, q_2, q_3, \dots, q_n$. The force on q_1 exerted by the charge q_2 ,
- 2) $F_{12} = K \frac{q_1 q_2}{r^2} \hat{r}_{21}$. where $\hat{r}_{21}$ is the unit vector from q_2 to q_1 along the line joining the two charges and r_{21} is the distance between the charges q_1 and q_2 . The electrostatic force between two charges is not affected by the presence of other charges in the neighbourhood.

- a) Only 1
- b) Only 2
- c) **Both 1 and 2**
- d) None

17. Consider a point charge kept at a point in space. If another point charge is placed at some distance from the first point charge, it experiences either an attractive force or repulsive force. This is called ____

- a) Consideration at a distance
- b) **Action at a distance**
- c) Motion at a distance
- d) Flexible at a distance

Explanation

Consider a point charge kept at a point in space. If another point charge is placed at some distance from the first point charge, it experiences either an attractive force or repulsive force. This is called 'action at a distance'.

18. Who introduced the concept of field?

- a) James Maxwell
- b) Heinrich Hertz
- c) Humphry Davy
- d) **Michael Faraday**

Explanation

Michael Faraday introduced the concept of field.

19. Which among the following statement is correct

- 1) According to Faraday, every charge in the universe creates an electric field in the surrounding space, and if another charge is brought into its field, it will interact with the electric field at that point and will experience a force. It may be recalled that the interaction of two masses is similarly explained using the concept of gravitational field.
- 2) Both the electric and gravitational forces are contact forces, hence the field concept is required to explain action at a distance. Consider a source point charge q located at a point in space. Another point charge q_0 (test charge) is placed at some point P which is at a distance r from the charge q .
- 3) The electrostatic force experienced by the charge q_0 due to q is given by Coulomb's law. $F = \frac{1}{4\pi\epsilon_0} \frac{q q_0}{r^2}$, where $K = \frac{1}{4\pi\epsilon_0}$. The charge q creates an electric field in the surrounding space within which its effect can be felt by another charge. It is measured in terms of a quantity called electric field intensity or simply called electric field E .

- a) Both 1 and 2
- b) Both 1 and 3**
- c) Both 2 and 3
- d) All 1, 2 and 3

Explanation

Both the electric and gravitational forces are non-contact forces, hence the field concept is required to explain action at a distance. Consider a source point charge q located at a point in space. Another point charge q_0 (test charge) is placed at some point P which is at a distance r from the charge q .

20. The electric field at the point P at a distance r from the point charge q is given by ----

- a) $E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \mathbf{r}$
- b) $E = \frac{1}{2\pi\epsilon_0} \frac{q}{r^2} \mathbf{r}$
- c) $E = \frac{1}{4\pi\epsilon_0} \frac{r}{q^2} \mathbf{r}$
- d) $E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^r} \mathbf{q}^r$

Explanation

The electric field at the point P at a distance r from the point charge q is defined as the force that would be experienced by a unit positive charge placed at that point P and is given by $E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \mathbf{r}$.

21. Which among the following statement is correct regarding electric field?

- 1) If the charge q is positive then the electric field points away from the source charge and if q is negative, the electric field points towards the source charge q . If the electric field at a point P is ρE , then the force experienced by the test charge q_0 placed at the point P is $F = q_0 E$.
 - 2) The equation $E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \mathbf{r}$ implies that the electric field is independent of the test charge q_0 and it depends only on the source charge q . Since the electric field is a vector quantity, at every point in space, this field has unique direction and magnitude.
 - 3) In the definition of electric field, it is assumed that the test charge q_0 is taken sufficiently small, so that bringing this test charge will not move the source charge. In other words, the test charge is made sufficiently small such that it will not modify the electric field of the source charge.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3**

22. How many kinds of electric field are there?

- a) Three
- b) Four

- c) Six
- d) **Two**

Explanation

There are two kinds of the electric field: uniform (constant) electric field and non-uniform electric field. Uniform electric field will have the same direction and constant magnitude at all points in space. Non-uniform electric field will have different directions or different magnitudes or both at different points in space.

23. The electric field at an arbitrary point due to a collection of point charges is simply equal to the vector sum of the electric fields created by the individual point charges. This is called ____

- a) Superposition of electric pulse
- b) Superposition of electric currents
- c) **Superposition of electric fields**
- d) Superposition of electro magnets

Explanation

Suppose a number of point charges are distributed in space. To find the electric field at some point P due to this collection of point charges, superposition principle is used. The electric field at an arbitrary point due to a collection of point charges is simply equal to the vector sum of the electric fields created by the individual point charges. This is called superposition of electric fields.

24. Which among the following statement is correct regarding Electric field due to continuous charge distribution?

- 1) The electric charge is quantized microscopically. While dealing with the electric field due to a charged sphere or a charged wire etc., it is very difficult to look at individual charges in these charged bodies.
 - 2) Therefore, it is assumed that charge is distributed continuously on the charged bodies and the discrete nature of charges is not considered here. The electric field due to such continuous charge distributions is found by invoking the method of calculus.
- a) Only 1
 - b) Only 2
 - c) **Both 1 and 2**
 - d) None

25. Which among the following statement is correct

- 1) Electric field vectors are visualized by the concept of electric field lines. They form a set of continuous lines which are the visual representation of the electric field in some region of space. The following rules are followed while drawing electric field lines for charges.

- 2) The electric field lines start from a positive charge and end at negative charges or at infinity. For a positive point charge the electric field lines point radially outward and for a negative point charge, the electric field lines point radially inward.
- 3) Note that for an isolated negative point charge the electric field line starts from the charge and ends only at infinity. For an isolated positive point charge the electric field lines start at infinity and end at the negative charge.
 - a) **Both 1 and 2**
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

Note that for an isolated positive point charge the electric field line starts from the charge and ends only at infinity. For an isolated negative point charge the electric field lines start at infinity and end at the negative charge. The electric field vector at a point in space is tangential to the electric field line at that point.

26. Which among the following statement is correct regarding electric field lines?

- 1) The electric field lines are denser (more closer) in a region where the electric field has small magnitude and high dense in a region where the electric field is of large magnitude. In other words, the number of lines passing through a given surface area perpendicular to the lines is proportional to the magnitude of the electric field in that region.
- 2) The magnitude of the electric field for a point charge decreases as the distance increases ($|E| \propto \frac{1}{r^2}$). So the electric field has greater magnitude at the surface A than at B. Therefore, the number of lines crossing the surface A is greater than the number of lines crossing the surface B. Note that at surface B the electric field lines are farther apart compared to the electric field lines at the surface A.
- 3) No two electric field lines intersect each other. If two lines cross at a point, then there will be two different electric field vectors at the same point. As a consequence, if some charge is placed in the intersection point, then it has to move in two different directions at the same time, which is physically impossible. Hence, electric field lines do not intersect.
 - a) Both 1 and 2
 - b) Both 1 and 3
 - c) **Both 2 and 3**
 - d) All 1, 2 and 3

Explanation

The electric field lines are denser (more closer) in a region where the electric field has larger magnitude and less dense in a region where the electric field is of smaller magnitude. In other words, the number of lines passing through a given surface area perpendicular to the lines is proportional to the magnitude of the electric field.

27. Two equal and opposite charges separated by a small distance constitute an _____

- a) Electric potential
- b) Electric dipole**
- c) Electric constant
- d) Electric volt

Explanation

Two equal and opposite charges separated by a small distance constitute an electric dipole. In many molecules, the centres of positive and negative charge do not coincide. Such molecules behave as permanent dipoles. Examples: CO, water, ammonia, HCl etc.

28. Which among the following statement is correct

- 1) Consider two equal and opposite point charges (+q, -q) that are separated by a distance 2a. The electric dipole moment is defined as $p = qr_+ + (-q)r_-$, where r_+ is the position vector of +q from the origin and r_- is the position vector of -q from the origin.
 - 2) The electric dipole moment vector lies perpendicular to the line joining two charges and is directed from +q to -q. The electric field lines for an electric dipole. For simplicity, the two charges are placed on the y-axis. If the two charges are placed on x or z-axis, dipole moment will point from -q to +q.
 - 3) The magnitude of the electric dipole moment is equal to the product of the magnitude of one of the charges and the distance between them, $|p| = 2qa$. Though the electric dipole moment for two equal and opposite charges is defined, it is possible to define and calculate the electric dipole moment for a collection of point charges. The electric dipole moment for a collection of n point charges is given by $p = \sum_{i=1}^n q_i r_i$.
- a) Both 1 and 2
 - b) Both 1 and 3**
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

The electric dipole moment vector lies along the line joining two charges and is directed from -q to +q. The electric field lines for an electric dipole. For simplicity, the two charges are placed on the x-axis. Even if the two charges are placed on y or z-axis, dipole moment will point from -q to +q.

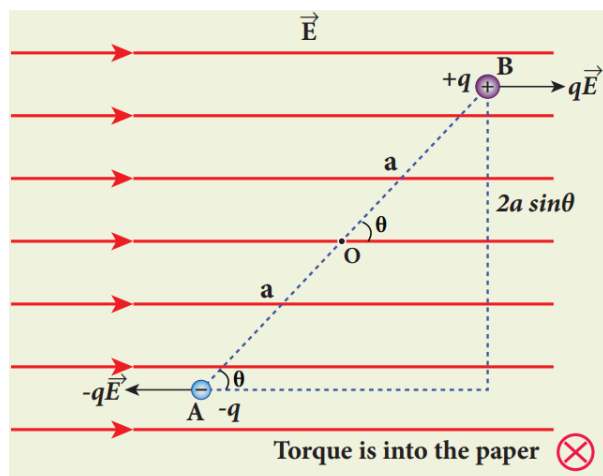
29. What is the S.I. unit of dipole moment?

- a) Newton metre
- b) Newton / metre
- c) Coulomb metre**
- d) Coulomb / metre

Explanation

The SI unit of dipole moment is coulomb metre (Cm).

30. Which among the following statement is correct regarding Torque experienced by an electric dipole in the uniform electric field?



- 1) Consider an electric dipole of dipole moment p placed in a uniform electric field E whose field lines are equally spaced and point in the same direction. The charge $+q$ will experience a force qE in the direction of the field and charge $-q$ will experience a force $-qE$ in a direction opposite to the field.
- 2) Since the external field E is uniform, the total force acting on the dipole is zero. These two forces acting at different points will constitute a couple and the dipole experience a torque. This torque tends to rotate the dipole. The total torque on the dipole about the point O
- 3) Using right-hand corkscrew rule, it is found that total torque is perpendicular to the plane of the paper and is directed into it. The magnitude of the total torque $\tau = qE \cdot 2a \sin \theta$, where θ is the angle made by p with E . Since $p = 2aq$, the torque is written in terms of the vector product as $\tau = pE \sin \theta$ and is maximum when $\theta = 90^\circ$.
 - a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

31. A sample of HCl gas is placed in a uniform electric field of magnitude $3 \times 10^4 \text{ N C}^{-1}$. The dipole moment of each HCl molecule is $3.4 \times 10^{-30} \text{ Cm}$. Calculate the maximum torque experienced by each HCl molecule?

- a) $\tau_{\max} = 8.19 \times 10^{-26} \text{ Nm}$
- b) $\tau_{\max} = 10.2 \times 10^{-26} \text{ Nm}$
- c) $\tau_{\max} = 12.7 \times 10^{-26} \text{ Nm}$
- d) $\tau_{\max} = 15.6 \times 10^{-26} \text{ Nm}$

Explanation

The maximum torque experienced by the dipole is when it is aligned perpendicular to the applied field

$$\tau_{\max} = pE \sin 90^\circ = 3.4 \times 10^{-30} \times 3 \times 10^4$$

$$\tau_{\max} = 10.2 \times 10^{-26} \text{ Nm.}$$

32. Which among the following is not the conservative forces?

- a) Gravitational force
- b) Coulomb force
- c) **Frictional force**
- d) None of the above

Explanation

In mechanics, potential energy is defined for conservative forces. Since gravitational force is a conservative force, its gravitational potential energy. Since Coulomb force is an inversesquare-law force, its also a conservative force like gravitational force. Therefore, we can define potential energy for charge configurations.

33. Which among the following statement is correct

- 1) Consider a positive charge q kept fixed at the origin which produces an electric field ρE around it. A positive test charge q' is brought from point R to point P against the repulsive force between q and q' . Work must be done to overcome the repulsion between the charges and this work done is stored as potential energy of the system.
 - 2) The test charge q' is brought from R to P with constant velocity which means that external force used to bring the test charge q' from R to P must be equal and opposite to the coulomb force ($F_{\text{ext}} = -F_{\text{coulomb}}$). The work done is $W = \int_R^P F_{\text{ext}} \cdot dr$.
 - 3) Since coulomb force is conservative, work done is dependent of the path and it is independent of on the initial and final positions of the test charge. If potential energy associated with q' at P is U_P and that at R is U_R , then difference in potential energy is defined as the work done to bring a test charge q' from point R to P and is given as $U_P - U_R = W = \Delta U$.
- a) **Both 1 and 2**
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

Since coulomb force is conservative, work done is independent of the path and it depends only on the initial and final positions of the test charge. If potential energy associated with q' at P is U_P and that at R is U_R , then difference in potential energy is defined as the work done to bring a test charge q' from point R to P and is given as $U_P - U_R = W = \Delta U$.

34. The electric potential at a point P is equal to the work done by an external force to bring a unit positive charge with constant velocity from infinity to the point P in the region of the external electric field E. Mathematically this is written as _____

- a) $V_P = - \int_{\infty}^P E \cdot dr$
- b) $V_P = - \int_{\infty}^P E \cdot dr^2$
- c) $V_P = - \int_{\infty}^P E + dr$
- d) $V_P = - \int_{\infty}^P E + dr^2$

Explanation

The electric potential at a point P is equal to the work done by an external force to bring a unit positive charge with constant velocity from infinity to the point P in the region of the external electric field E. Mathematically this is written as $V_P = - \int_{\infty}^P E \cdot dr$. The electric potential energy difference can be written as $\Delta U = q' \Delta V$. P

35. Which among the following statement is correct regarding Electric potential due to a point charge?

- 1) Consider a positive charge q kept fixed at the origin. Let P be a point at distance r from the charge q. The electric potential at the point P is $V = - \int_{\infty}^r E \cdot dr$. The electric potential due to a point charge q at a distance r is $V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$.
 - 2) If the source charge q is positive, $V > 0$. If q is negative, then V is negative and equal to $V = - \frac{1}{4\pi\epsilon_0} \frac{q}{r}$. It is clear that the potential due to positive charge decreases as the distance increases, but for a negative charge the potential increases as the distance is increased. At infinity ($r = \infty$) electrostatic potential is zero ($V = 0$).
 - 3) In the case of gravitational force, mass moves from a point of lower gravitational potential to a point of higher gravitational potential. Similarly, a positive charge moves from a point of lower electrostatic potential to a point of higher electrostatic potential. However, a negative charge moves from lower electrostatic potential to higher electrostatic potential.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

In the case of gravitational force, mass moves from a point of higher gravitational potential to a point of lower gravitational potential. Similarly, a positive charge moves from a point of higher electrostatic potential to a point of lower electrostatic potential. However, a negative charge moves from lower electrostatic potential to higher electrostatic potential.

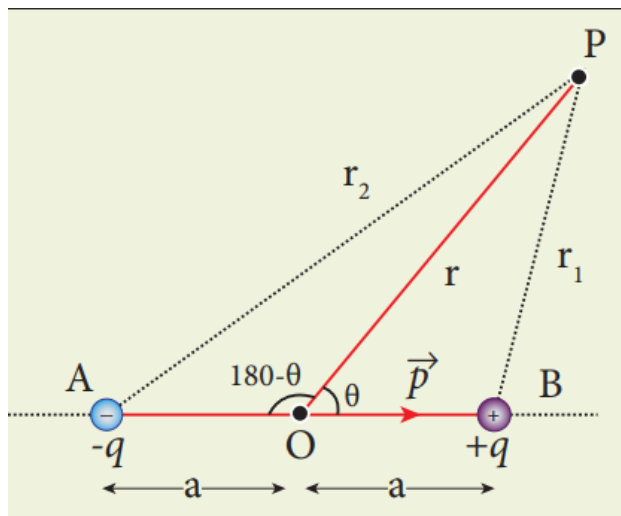
36. What is the S.I unit of electric field?

- a) Newton coulomb
- b) Newton / coulomb**
- c) Newton metre
- d) Newton / metre

Explanation

The electric field is a vector quantity and its SI unit is newton per coulomb (NC^{-1}).

37. Which among the following statement is correct regarding Electrostatic potential at a point due to an electric dipole?



- 1) Consider two equal and opposite charges separated by a small distance $2a$. The point P is located at a distance r from the midpoint of the dipole. Let θ be the angle between the line OP and dipole axis AB. Total potential at the point P, $V = \frac{1}{4\pi\epsilon} q \left(\frac{1}{r_1} - \frac{1}{r_2} \right)$.
- 2) Now we can write $p \cos\theta = p \times r$, where r is the unit vector from the point O to point P. Hence the electric potential at a point P due to an electric dipole is given by $V = \frac{1}{4\pi\epsilon} \frac{p \cdot r}{r^2}$ ($r \gg a$). This is valid for distances very large compared to the size of the dipole. But for a point dipole, the equation is valid for any distance.
- 3) The potential due to an electric dipole falls as $1/r^2$ and the potential due to a single point charge falls as $1/r$. Thus, the potential due to the dipole falls faster than that due to a monopole (point charge). As the distance increases from electric dipole, the effects of positive and negative charges nullify each other.
 - a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3**

38. Which among the following statement is correct regarding Equi-potential Surface?

- 1) Consider a point charge q located at some point in space and an imaginary sphere of radius r is chosen by keeping the charge q at its centre. The electric potential at all points on the surface of the given sphere is the same. Such a surface is called an equipotential surface.
- 2) An equipotential surface is a surface on which all the points are at the different electric potential. For a point charge the equipotential surfaces are concentric spherical surfaces. Each spherical surface is an equipotential surface but the value of the potential is same for different spherical surfaces.
- 3) For a uniform electric field, the equipotential surfaces form a set of planes normal to the electric field E . The work done to move a charge q between any two points A and B, $W = q(V_B - V_A)$. If the points A and B lie on the same equipotential surface, work done is zero because $V_A = V_B$.
 - a) Both 1 and 2
 - b) Both 1 and 3**
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

An equipotential surface is a surface on which all the points are at the same electric potential. For a point charge the equipotential surfaces are concentric spherical surfaces. Each spherical surface is an equipotential surface but the value of the potential is different for different spherical surfaces. The electric field is normal to an equipotential surface. If it is not normal, then there is a component of the field parallel to the surface.

39. Which among the following equation gives Relation between electric field and potential?

- a) $E = -\frac{dV}{dx}$
- b) $E = -\frac{dV}{dx^2}$
- c) $E = -\frac{dV^2}{dx}$
- d) $E = -\frac{dV}{dx^2}$

Explanation

Consider a positive charge q kept fixed at the origin. To move a unit positive charge by a small distance dx towards q in the electric field E , the work done is given by $dW = -E dx$. The minus sign implies that work is done against the electric field. This work done is equal to electric potential difference. Therefore, $E = -\frac{dV}{dx}$.

40. Which among the following statement is correct regarding Electrostatic potential energy for collection of point charges?

- 1) The electric potential at a point at a distance r from point charge q_1 is given by $V = \frac{1}{4\pi\epsilon} \frac{q_1}{r}$. This potential V is the work done to bring a unit negative charge from infinity to the point.

Now if the charge q_2 is brought from infinity to that point at a distance r from q_1 , the work done is the product of q_2 and the electric potential at that point. Thus, we have $W = q_2 V$.

- 2) This work done is stored as the electrostatic potential energy U of a system of charges q_1 and q_2 separated by a distance r . Thus, we have $U = q_2 V = \frac{1}{4\pi\epsilon} \frac{q_1 q_2}{r}$. The electrostatic potential energy depends only on the distance between the two-point charges. In fact, the expression is derived by assuming that q_1 is fixed and q_2 is brought from infinity.
- 3) The equation holds true when q_2 is fixed and q_1 is brought from infinity or both q_1 and q_2 are simultaneously brought from infinity to a distance r between them. Since the Coulomb force is a conservative force, the electrostatic potential energy is independent of the manner in which the configuration of charges is arrived at.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) **Both 2 and 3**
 - d) All 1, 2 and 3

Explanation

The electric potential at a point at a distance r from point charge q_1 is given by $V = \frac{1}{4\pi\epsilon} \frac{q_1}{r}$. This potential V is the work done to bring a unit positive charge from infinity to the point. Now if the charge q_2 is brought from infinity to that point at a distance r from q_1 , the work done is the product of q_2 and the electric potential at that point. Thus, we have $W = q_2 V$.

41. Which among the following work on the principle of torque acting on an electric dipole?

- a) Air cooler
- b) **Microwave**
- c) Turbine
- d) All the above

Explanation

Microwave oven works on the principle of torque acting on an electric dipole. The food we consume has water molecules which are permanent electric dipoles. Oven produces microwaves that are oscillating electromagnetic fields and produce torque on the water molecules.

42. Which among the following statement is correct regarding Electrostatic potential energy of a dipole in a uniform electric field?

- 1) Consider a dipole placed in the uniform electric field ρE as shown in the Figure 1.29. A dipole experiences a torque when kept in an uniform electric field ρE . This torque rotates the dipole to align it with the direction of the electric field. To rotate the dipole (at constant angular velocity) from its initial angle θ' to another angle θ against the torque exerted by the electric field, an equal and opposite external torque must be applied on the dipole.

- 2) The work done by the external torque to rotate the dipole from angle θ' to θ at constant angular velocity is $W = \int_{\theta'}^{\theta} \tau_{ext} d\theta$. Since τ_{ext} is equal and opposite to $\tau_E = p \times E$, we have $W = pE(\cos\theta' - \cos\theta)$. The potential energy stored in the system of dipole kept in the uniform electric field is given by $U = -pE \cos\theta$
- 3) In addition to p and E , the potential energy also depends on the orientation θ of the electric dipole with respect to the external electric field. The potential energy is maximum when the dipole is aligned parallel ($\theta = \pi$) to the external electric field and minimum when the dipole is aligned anti-parallel ($\theta = 0$) to the external electric field.
- Both 1 and 2
 - Both 1 and 3
 - Both 2 and 3
 - All 1, 2 and 3

Explanation

In addition to p and E , the potential energy also depends on the orientation θ of the electric dipole with respect to the external electric field. The potential energy is maximum when the dipole is aligned anti-parallel ($\theta = \pi$) to the external electric field and minimum when the dipole is aligned parallel ($\theta = 0$) to the external electric field.

43. The number of electric field lines crossing a given area kept normal to the electric field lines is called _____

- Electric conductor
- Electric magnitude
- Electric flux**
- Electric vector

Explanation

The number of electric field lines crossing a given area kept normal to the electric field lines is called electric flux.

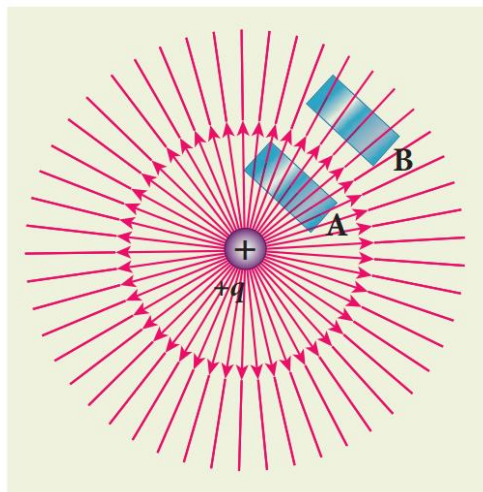
44. Electric flux is usually denoted by the Greek letter _____

- μ_E
- Θ_E
- Φ_E**
- ϵ_E

Explanation

Electric flux is usually denoted by the Greek letter Φ_E .

45. Which among the following statement is correct



- 1) The electric field of a point charge is drawn in this figure. Consider two small rectangular area elements placed normal to the field at regions A and B. Even though these elements have the same area, the number of electric field lines crossing the element in region A is more than that crossing the element in region B.
 - 2) Therefore, the electric flux in region A is more than that in region B. Since electric field strength for a point charge decreases as the distance increases, electric flux also decreases as the distance increases. The above discussion gives a qualitative idea of electric flux. However, a precise definition of electric flux is needed.
- a) Only 1
 - b) Only 2
 - c) **Both 1 and 2**
 - d) None

46. What is the unit of Electric flux?

- a) N m C
- b) N m C^2
- c) **$\text{N m}^2 \text{C}^{-1}$**
- d) $\text{N m}^{-2} \text{C}^{-1}$

Explanation

The unit of Electric flux $\text{N m}^2 \text{C}^{-1}$. Electric flux is a scalar quantity and it can be positive or negative.

47. Which among the following statement is correct regarding Electric flux for uniform Electric field?

- 1) Consider a uniform electric field in a region of space. Let us choose an area A normal to the electric field lines. The electric flux for this case is $\Phi_E = EA$. Suppose the same area A is kept parallel to the uniform electric field, then no electric field lines pass through the area A. The electric flux for this case is zero. $\Phi_E = 0$

- 2) If the area is inclined at an angle θ with the field, then the component of the electric field perpendicular to the area alone contributes to the electric flux. The electric field component parallel to the surface area will not contribute to the electric flux. For this case, the electric flux, $\Phi_E = (E \cos\theta) A$.
- 3) Further, θ is also the angle between the electric flux and the direction normal to the area. Hence in general, for uniform electric field, the electric flux is defined as $\Phi_E = E A = EA \cos\theta$. If $\theta = 90^\circ$. Therefore $\Phi_E = E A \cos 90^\circ = E A$
- Both 1 and 2
 - Both 1 and 3
 - Both 2 and 3
 - All 1, 2 and 3

Explanation

Further, θ is also the angle between the electric field and the direction normal to the area. Hence in general, for uniform electric field, the electric flux is defined as $\Phi_E = E A = EA \cos\theta$. If $\theta = 90^\circ$. Therefore, $\Phi_E = E A \cos 90^\circ = 0$.

48. The total electric flux over the closed surface is written as _____

- $\Phi_E = \oint E + dA$
- $\Phi_E = \oint E \cdot dA$
- $\Phi_E = E \oint dA$
- $\Phi_E = \oint E \cdot dA^2$

Explanation

The total electric flux over this closed surface is written as $\Phi_E = \oint E \cdot dA$. The total electric flux over a closed surface can be negative, positive or zero.

49. In general, the electric flux is negative if the electric field lines _____

- Enters the closed surface
- Leaves the closed surface
- Both entered and leaves the closed surface
- None of the above

Explanation

In general, the electric flux is negative if the electric field lines enter the closed surface and positive if the electric field lines leave the closed surface.

50. Which law states that if a charge Q is enclosed by an arbitrary closed surface, then the total electric flux Φ_E through the closed surface is $\Phi_E = \oint E \cdot dA = \frac{Q_{encl}}{\epsilon_0}$.

- Pascal law

- b) Joules law
- c) **Gauss law**
- d) Coulomb law

Explanation

Gauss's law states that if a charge Q is enclosed by an arbitrary closed surface, then the total electric flux Φ_E through the closed surface is $\Phi_E = \oint E \cdot dA = \frac{Q_{\text{encl}}}{\epsilon_0}$.

51. Which among the following statement is correct regarding Gauss law?

- 1) The total electric flux through the closed surface depends only on the charges enclosed by the surface and the charges present outside the surface will not contribute to the flux and the shape of the closed surface which can be chosen arbitrarily. The total electric flux is independent of the location of the charges inside the closed surface.
 - 2) To arrive at equation $\Phi_E = \frac{Q_{\text{encl}}}{\epsilon_0}$, we have chosen a spherical surface. This imaginary surface is called a Gaussian surface. The shape of the Gaussian surface to be chosen depends on the type of charge configuration and the kind of symmetry existing in that charge configuration.
 - 3) The electric field is spherically asymmetric for a point charge, therefore spherical Gaussian surface is chosen. Cylindrical and planar Gaussian surfaces also be chosen for same kinds of charge configurations. The electric field E is due to charges present inside the Gaussian surface not for outside but the charge Q_{encl} denotes the charges which lie both inside and outside the Gaussian surface
- a) **Both 1 and 2**
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

The electric field is spherically symmetric for a point charge, therefore spherical Gaussian surface is chosen. Cylindrical and planar Gaussian surfaces can be chosen for other kinds of charge configurations. The electric field E is due to charges present inside and outside the Gaussian surface but the charge Q_{encl} denotes the charges which lie only inside the Gaussian surface.

52. Electric field due to any arbitrary charge configuration cannot be calculated using which among the following law?

- a) Gauss law
- b) Coulomb law
- c) **Pascal law**
- d) None of the above

Explanation

Electric field due to any arbitrary charge configuration can be calculated using Coulomb's law or Gauss law. If the charge configuration possesses some kind of symmetry, then Gauss law is a very efficient way to calculate the electric field.

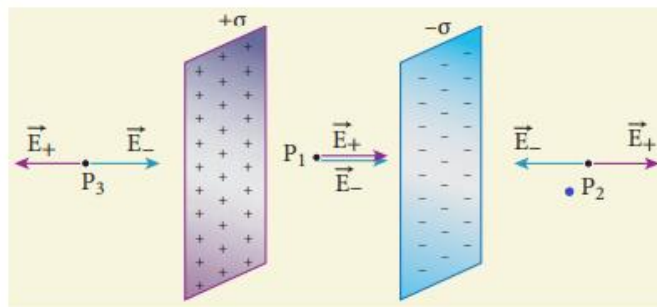
53. Which among the following statement is correct regarding application of Gauss law on Electric field due to charged infinite plane sheet?

- 1) Consider an infinite plane sheet of charges with uniform surface charge density σ (charge present per unit area). Let P be a point at a distance of r from the sheet. Since the plane is infinitely large, the electric field should be same at all points equidistant from the plane and radially directed outward at all points.
 - 2) A cylindrical Gaussian surface of length 2r and two flat surfaces each of area A is chosen such that the infinite plane sheet passes perpendicularly through the middle part of the Gaussian surface. Total electric flux linked with the cylindrical surface, $\Phi_E = \oint E \cdot dA = \frac{Q_{encl}}{\epsilon_0}$.
 - 3) Since the magnitude of the electric field at these two equal flat surfaces is uniform, E is taken out of the integration and Q_{encl} is given by $Q_{encl} = \sigma A$, we get $2E \int_p dA = \frac{\sigma A}{\epsilon_0}$. The total area of surface either at P or P', $\int_p dA = A$. Hence $E = \frac{\sigma}{2\epsilon_0}$.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) **All 1, 2 and 3**

54. Which among the following statement is correct regarding Electric field due to two parallel charged infinite sheets?

- 1) Consider two infinitely large charged plane sheets with equal and opposite charge densities $+\sigma$ and $-\sigma$ which are placed parallel to each other. The electric field between the plates and outside the plates is found using Gauss law. The magnitude of the electric field due to an infinite charged plane sheet is $\frac{\sigma}{2\epsilon_0}$ and it points perpendicularly outward if $\sigma > 0$ and points inward if $\sigma < 0$.
 - 2) At the points P_2 and P_3 , the electric field due to both plates are unequal in magnitude and same in direction. As a result, electric field at a point outside the plates is infinite. But between the plates, electric fields are in the same direction i.e., towards the right and the total electric field at a point P_1 is $E_{inside} = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon_0}$.
- a) **Only 1**
 - b) Only 2
 - c) Both 1 and 2
 - d) None

Explanation



At the points P_2 and P_3 , the electric field due to both plates are equal in magnitude and opposite in direction. As a result, electric field at a point outside the plates is zero. But between the plates, electric fields are in the same direction i.e., towards the right and the total electric field at a point P_1 is $E_{\text{inside}} = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon_0}$.

55. Gauss law is a powerful technique whenever a given charge configuration possesses ____

- a) Spherical symmetry
- b) Cylindrical symmetry
- c) Planar symmetry
- d) **All the above**

Explanation

Gauss law is a powerful technique whenever a given charge configuration possesses spherical, cylindrical or planar symmetry, then the electric field due to such a charge configuration can be easily found. If there is no such symmetry, the direct method (Coulomb's law and calculus) can be used. For example, it is difficult to use Gauss law to find the electric field for a dipole since it has no spherical, cylindrical or planar symmetry.

56. Which among the following statement is correct

- 1) An electrical conductor has a minimum number of mobile charges which are free to move in the material. In a metallic conductor, these mobile charges are free electrons which are bound to many atoms and therefore are restricted to move on the surface of the conductor.
 - 2) When there is no external electric field, the free electrons are in continuous random motion in all directions. As a result, there is no net motion of electrons along any particular direction which implies that the conductor is in electrostatic equilibrium. Thus, at electrostatic equilibrium, there is no net current in the conductor.
- a) Only 1
 - b) **Only 2**
 - c) Both 1 and 2
 - d) None

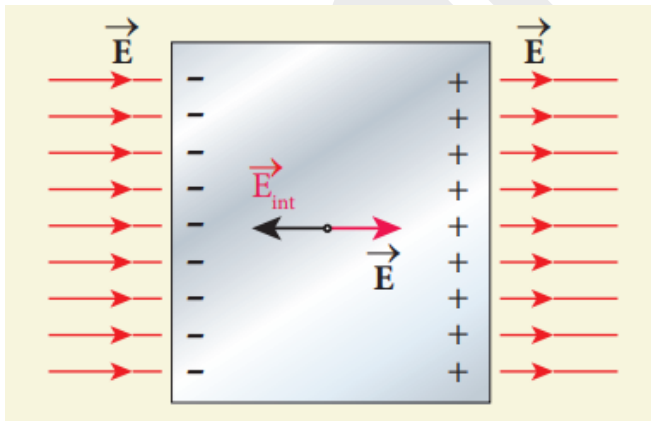
Explanation

An electrical conductor has a large number of mobile charges which are free to move in the material. In a metallic conductor, these mobile charges are free electrons which are not bound to any atom and therefore are free to move on the surface of the conductor.

57. Which among the following statement is correct

- 1) The electric field is zero everywhere inside the conductor. This is true regardless of whether the conductor is solid or hollow. This is an experimental fact. Suppose the electric field is not zero inside the metal, then there will be a force on the mobile charge carriers due to this electric field.
 - 2) As a result, there will be a net motion of the mobile charges, which contradicts the conductors being in electrostatic equilibrium. Thus the electric field is zero everywhere inside the conductor. We can also understand this fact by applying an external uniform electric field on the conductor. Before applying the external electric field, the free electrons in the conductor are uniformly distributed in the conductor.
 - 3) When an electric field is applied, the free electrons accelerate to the right causing the right plate to be negatively charged and the left plate to be positively charged. Due to this realignment of free electrons, there will be an internal electric field created inside the conductor which decrease until it nullifies the external electric field. Once the external electric field is nullified the conductor is said to be in electrostatic equilibrium.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation



When an electric field is applied, the free electrons accelerate to the left causing the left plate to be negatively charged and the right plate to be positively charged. Due to this realignment of free electrons, there will be an internal electric field created inside the conductor which increases until it nullifies the external electric field. Once the external electric field is nullified the conductor is said to be in electrostatic equilibrium.

58. Which among the following statement is correct

- 1) There is more net charge inside the conductors. The charges must reside on both the surface of the conductors. We can prove this property using Gauss law. Consider an arbitrarily shaped conductor. A Gaussian surface is drawn inside the conductor such that it is very close to the surface of the conductor.
- 2) Since the electric field is zero everywhere inside the conductor, the net electric flux is also zero over this Gaussian surface. From Gauss's law, this implies that there is no net charge inside the conductor. Even if some charge is introduced inside the conductor, it immediately reaches the surface of the conductor.
 - a) Only 1
 - b) Only 2**
 - c) Both 1 and 2
 - d) None

Explanation

There is no net charge inside the conductors. The charges must reside only on the surface of the conductors. We can prove this property using Gauss law. Consider an arbitrarily shaped conductor. A Gaussian surface is drawn inside the conductor such that it is very close to the surface of the conductor.

59. Which among the following statement is correct

- 1) The electric field outside the conductor is perpendicular to the surface of the conductor and has a magnitude of σ / ϵ_0 where σ is the surface charge density at that point. If the electric field has components parallel to the surface of the conductor, then free electrons on the surface of the conductor would experience acceleration.
- 2) This means that the conductor is in equilibrium. Therefore, at electrostatic equilibrium, the electric field must be parallel to the surface of the conductor. We now prove that the electric field has magnitude σ / ϵ_0 just inside the conductor's surface. Consider a small cylindrical Gaussian surface. One half of this cylinder is embedded inside the conductor.
- 3) Since electric field is normal to the surface of the conductor, the curved part of the cylinder has zero electric flux. Also, inside the conductor, the electric field is zero. Hence the bottom flat part of the Gaussian surface has no electric flux. Therefore, the top flat surface alone contributes to the electric flux. The electric field is parallel to the area vector and the total charge inside the surface is σA . By applying Gauss's law $EA = \frac{\sigma A}{\epsilon}$.
 - a) Both 1 and 2
 - b) Both 1 and 3**
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

This means that the conductor is not in equilibrium. Therefore, at electrostatic equilibrium, the electric field must be perpendicular to the surface of the conductor. We now prove that the electric field has magnitude σ / ϵ_0 just outside the conductor's surface. Consider a small cylindrical Gaussian surface. One half of this cylinder is embedded inside the conductor.

60. Which among the following statement is correct

- 1) The electrostatic potential has the same value on the surface and inside of the conductor. We know that the conductor has no parallel electric component on the surface which means that charges can be moved on the surface without doing any work.
 - 2) This is possible only if the electrostatic potential is constant at end points on the surface and there is potential difference between any two points on the surface. Since the electric field is zero inside the conductor, the potential is maximum at the surface of the conductor. Thus, at electrostatic equilibrium, the conductor is always at equipotential.
- a) **Only 1**
 - b) Only 2
 - c) Both 1 and 2
 - d) None

Explanation

This is possible only if the electrostatic potential is constant at all points on the surface and there is no potential difference between any two points on the surface. Since the electric field is zero inside the conductor, the potential is the same as the surface of the conductor. Thus, at electrostatic equilibrium, the conductor is always at equipotential.

61. Charging a conductor without actual contact is called _____

- a) Electrostatic potential
- b) Electrostatic resistant
- c) **Electrostatic induction**
- d) Electrostatic convection

Explanation

Whenever a charged rod is touched by another conductor, charges start to flow from charged rod to the conductor. Is it possible to charge a conductor without any contact? yes. This type of charging a conductor without actual contact is called electrostatic induction.

62. Which among the following statement is correct regarding electrostatic induction

- 1) Consider an uncharged (neutral) conducting sphere at rest on an insulating stand. Suppose a negatively charged rod is brought near the conductor without touching it. The negative charge of the rod repels the electrons in the conductor to the opposite side. As a result,

positive charges are induced near the region of the charged rod while negative charges on the farther side.

- 2) Before introducing the charged rod, the free electrons were distributed uniformly on the surface of the conductor and the net charge is zero. Once the charged rod is brought near the conductor, the distribution is no longer uniform with more electrons located on the farther side of the rod and positive charges are located closer to the rod. But the total charge is zero.
- 3) Now the conducting sphere is connected to the ground through a conducting wire that removes the electron from the conducting sphere. Note that positive charges will not flow to the ground because they are attracted by the negative charges of the rod. When the grounding wire is removed from the conductor, the positive charges remain near the charged rod. Now the positive charge gets distributed uniformly on the surface of the conductor. By this process, the neutral conducting sphere becomes positively charged.
 - a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) **All 1, 2 and 3**

63. A sensitive electrical instrument which is to be protected from external electrical disturbance can be kept inside this cavity. This is called _____

- a) Electrostatic capacitor
- b) Electrostatic receiver
- c) **Electrostatic shielding**
- d) Electrostatic potential

Explanation

Consider a cavity inside the conductor. Whatever be the charges at the surfaces and whatever be the electrical disturbances outside, the electric field inside the cavity is zero. A sensitive electrical instrument which is to be protected from external electrical disturbance can be kept inside this cavity. This is called electrostatic shielding.

64. Which is an instrument used to demonstrate Electrostatic shielding?

- a) Maxwell cage
- b) **Faraday cage**
- c) Coulomb cage
- d) Thomson cage

Explanation

Faraday cage is an instrument used to demonstrate Electrostatic shielding. It is made up of metal bars. If an artificial lightning jolt is created outside, the person inside is not affected. During lightning accompanied by a thunderstorm, it is always safer to sit inside a bus than in open ground.

or under a tree. The metal body of the bus provides electrostatic shielding, since the electric field inside is zero.

65. Which is a non-conducting material and has no free electrons?

- a) Bipolar
- b) Transmitter
- c) Dielectric
- d) **All the above**

Explanation

A dielectric is a non-conducting material and has no free electrons. The electrons in a dielectric are bound within the atoms.

66. Which among the following is not the example of dielectrics?

- a) Ebonite
- b) **Tin**
- c) Glass
- d) Mica

Explanation

Ebonite, glass and mica are some examples of dielectrics. When an external electric field is applied, the electrons are not free to move anywhere but they are realigned in a specific way. A dielectric is made up of either polar molecules or non-polar molecules.

67. Which is one in which centres of positive and negative charges coincide?

- a) Polar molecule
- b) **Non-polar molecule**
- c) Both polar molecule and Non-polar molecule
- d) None of the above

Explanation

A non-polar molecule is one in which centres of positive and negative charges coincide. As a result, it has no permanent dipole moment. When an external electric field is applied, the centres of positive and negative charges are separated by a small distance which induces dipole moment in the direction of the external electric field. Then the dielectric is said to be polarized by an external electric field.

68. Which among the following is not the example of Non-polar molecule?

- a) H_2
- b) O_2

- c) HCL
- d) None of the above

Explanation

Examples of non-polar molecules are hydrogen (H_2), oxygen (O_2), and carbon dioxide (CO_2) etc.

69. Which among the following is not the example of Polar molecule?

- a) H_2O
- b) N_2O
- c) NH_3
- d) **None of the above**

Explanation

Examples of polar molecules are H_2O , N_2O , HCl , NH_3 .

70. Which among the following statement is correct regarding polar molecules?

- 1) In polar molecules, the centres of the positive and negative charges are separated even in the absence of an external electric field. They have a permanent dipole moment. Due to thermal motion, the direction of each dipole moment is oriented randomly.
 - 2) Hence the net dipole moment is maximum in the absence of an external electric field. When an external electric field is applied, the dipoles inside the material tend to align in the opposite direction of the electric field. Hence a net dipole moment is induced in it. Then the dielectric is said to be polarized by an external electric field.
- a) Only 1
 - b) **Only 2**
 - c) Both 1 and 2
 - d) None

Explanation

Hence the net dipole moment is zero in the absence of an external electric field. When an external electric field is applied, the dipoles inside the material tend to align in the direction of the electric field. Hence a net dipole moment is induced in it. Then the dielectric is said to be polarized by an external electric field.

71. Which is defined as the total dipole moment per unit volume of the dielectric?

- a) Capacitance
- b) Conductance
- c) **Polarisation**
- d) Alignment

Explanation

In the presence of an external electric field, the dipole moment is induced in the dielectric material. Polarisation ρP is defined as the total dipole moment per unit volume of the dielectric. For most dielectrics (linear isotropic), the Polarisation is directly proportional to the strength of the external electric field. $P = X_e E_{ext}$.

72. In $P = X_e E_{ext}$, X_e is a constant called _____

- a) **Electric susceptibility**
- b) Electric alignment
- c) Electric conductance
- d) Electric orientation

Explanation

In $P = X_e E_{ext}$, X_e is a constant called the electric susceptibility which is a characteristic of each dielectric.

73. Which among the following statement is correct regarding Induced Electric field inside the dielectric?

- 1) When an external electric field is applied on a conductor, the charges are aligned in such a way that an internal electric field is created which tends to cancel the external electric field. But in the case of a dielectric, which has no free electrons, the external electric field only realigns the charges so that an internal electric field is produced.
 - 2) The magnitude of the internal electric field is smaller than that of external electric field. Therefore, the net electric field inside the dielectric is not zero but is parallel to an external electric field with magnitude less than that of the external electric field. For example, let us consider a rectangular dielectric slab placed between two oppositely charged plates.
 - 3) The uniform electric field between the plates acts as an external electric field E_{ext} which polarizes the dielectric placed between plates. The positive charges are induced on one side surface and negative charges are induced on the other side of surface. But inside the dielectric, the net charge is zero even in a small volume.
- a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) **All 1, 2 and 3**

74. When the external electric field applied to a dielectric is very large, it tears the atoms apart so that the bound charges become free charges. Then the dielectric starts to conduct electricity. This is called _____

- a) Dielectric resistance
- b) Dielectric strength
- c) **Dielectric breakdown**
- d) All the above

Explanation

When the external electric field applied to a dielectric is very large, it tears the atoms apart so that the bound charges become free charges. Then the dielectric starts to conduct electricity. This is called dielectric breakdown.

75. The maximum electric field the dielectric can withstand before it breaks down is called ___

- a) **Dielectric strength**
- b) Dielectric capacitance
- c) Dielectric resistance
- d) Dielectric potential

Explanation

The maximum electric field the dielectric can withstand before it breaks down is called dielectric strength. For example, the dielectric strength of air is $3 \times 10^6 \text{ V m}^{-1}$. If the applied electric field increases beyond this, a spark is produced in the air.

76. Which is a device used to store electric charge and electrical energy?

- a) Inductor
- b) Resistor
- c) **Capacitor**
- d) None of the above

Explanation

Capacitor is a device used to store electric charge and electrical energy. It consists of two conducting objects (usually plates or sheets) separated by some distance. Capacitors are widely used in many electronic circuits and have applications in many areas of science and technology.

77. Which among the following substance has highest Dielectric strength?

- a) Teflon
- b) **Mica**
- c) Paper
- d) Air

Explanation

Mica - $100 \times 10^6 \text{ Vm}^{-1}$, Teflon - $60 \times 10^6 \text{ Vm}^{-1}$, Paper - $16 \times 10^6 \text{ Vm}^{-1}$, Air - $3 \times 10^6 \text{ Vm}^{-1}$, Pyrex glass - $14 \times 10^6 \text{ Vm}^{-1}$.

78. Which among the following statement is correct?

- 1) A simple capacitor consists of two parallel metal plates separated by a small distance. When a capacitor is connected to a battery of potential difference V , the electrons are transferred from one plate to the other plate by battery so that one plate becomes negatively charged with a charge of $-Q$ and the other plate positively charged with $+Q$.
 - 2) The potential difference between the plates is equivalent to the battery's terminal voltage. If the battery voltage is increased, the amount of charges stored in the plates decrease. In general, the charge stored in the capacitor is inverse to the potential difference between the plates. $Q = C/V$.
 - 3) where the C is the proportionality constant called capacitance. The capacitance C of a capacitor is defined as the ratio of the magnitude of charge on either of the conductor plates to the potential difference existing between them. $C = \frac{Q}{V}$.
- a) Both 1 and 2
 - b) Both 1 and 3**
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

The potential difference between the plates is equivalent to the battery's terminal voltage. If the battery voltage is increased, the amount of charges stored in the plates also increase. In general, the charge stored in the capacitor is proportional to the potential difference between the plates. $Q = C/V$.

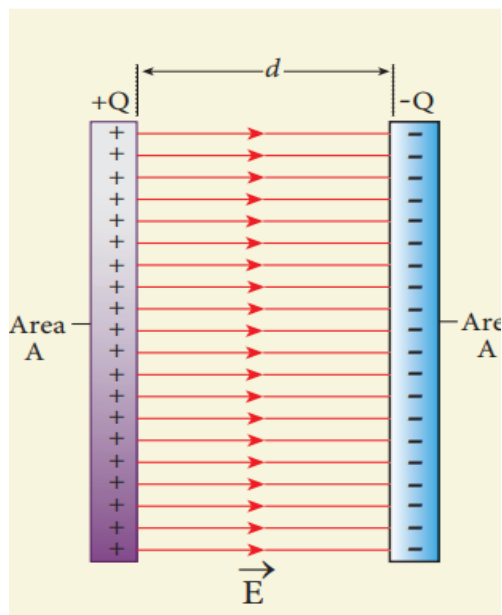
79. What is the S.I unit of capacitance?

- a) Farad**
- b) Joule
- c) Coulomb
- d) Weber

Explanation

The SI unit of capacitance is coulomb per volt or farad (F) in honour of Michael Faraday. Farad is a larger unit of capacitance. In practice, capacitors are available in the range of microfarad ($1\mu F = 10^{-6} F$) to picofarad ($1pF = 10^{-12} F$). Note that the total charge stored in the capacitor is zero ($Q - Q = 0$). When we say the capacitor stores charges, it means the amount of charge that can be stored in any one of the plates.

80. Which among the following statement is correct regarding Capacitance of a parallel plate capacitor?



- 1) Consider a capacitor with two parallel plates each of cross-sectional area A and separated by a distance d . The electric field between two infinite parallel plates is uniform and is given by $E = \sigma / \epsilon_0$ where σ is the surface charge density on either plates ($\sigma = \frac{Q}{A}$).
- 2) If the separation distance d is very much smaller than the size of the plate ($d^2 \ll A$), then the above result can be used even for finite-sized parallel plate capacitor. The electric field between the plates is $E = Q / A\epsilon_0$.
- 3) Since the electric field is uniform, the electric potential difference between the plates having separation d is given by $V = Ed = \frac{Qd}{A\epsilon}$. Therefore, the capacitance of the capacitor is given by $C = \frac{Q}{V} = \frac{\epsilon_0 A}{d}$. From the equation it is evident that capacitance is directly proportional to the area of cross section and is inversely proportional to the distance between the plates.
 - a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

81. The energy stored per unit volume of space is defined as _____

- a) Energy resistance
- b) Energy potential
- c) **Energy density**
- d) Energy potential

Explanation

The energy stored per unit volume of space is defined as energy density $u_E = \frac{U}{\text{volume}}$. From equation we get $u_E = \frac{1}{2} \epsilon_0 E^2$.

82. Which among the following statement is correct

- 1) Capacitor not only stores the charge but also it stores energy. When a battery is connected to the capacitor, electrons of total charge $-Q$ are transferred from one plate to the other plate. To transfer the charge, work is done by the battery. This work done is stored as electrostatic potential energy in the capacitor.
- 2) To transfer an infinitesimal charge dQ for a potential difference V , the work done is given by $dW = V dQ$. Where $V = \frac{Q}{C}$. The total work done to charge a capacitor is $W = \int_0^Q \frac{Q}{C} dQ = \frac{Q^2}{2C}$. It is important to note that the energy density depends only on the electric field and not on the size of the plates of the capacitor.
 - a) Only 1
 - b) Only 2
 - c) **Both 1 and 2**
 - d) None

83. Which among the following statement is correct regarding applications of capacitors?

- 1) Flash capacitors are used in digital cameras for taking photographs. The flash which comes from the camera when we take photographs is due to the energy released from the capacitor, called a flash capacitor.
- 2) During cardiac arrest, a device called heart defibrillator is used to give a sudden surge of a large amount of electrical energy to the patient's chest to retrieve the normal heart function.
- 3) Capacitors are used in the ignition system of automobile engines to increase sparking. Capacitors are used to increase power fluctuations in power supplies and to increase the efficiency of power transmission.
 - a) **Both 1 and 2**
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

Capacitors are used in the ignition system of automobile engines to eliminate sparking. Capacitors are used to reduce power fluctuations in power supplies and to increase the efficiency of power transmission. However, capacitors have disadvantage as well. Even after the battery or power supply is removed, the capacitor stores charges and energy for some time.

84. Which among the following statement is incorrect

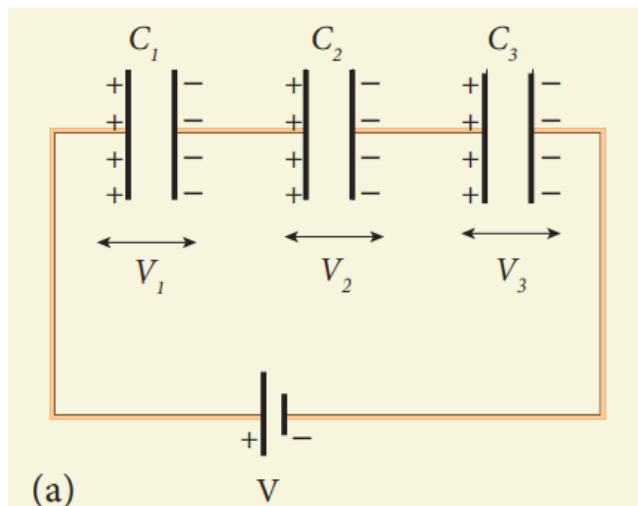
- 1) Effect of dielectrics in capacitors when the battery is disconnected charge (Q) is constant, voltage (V), electric field (E) and energy (U) decreases while capacitance (C) increases.
- 2) Effect of dielectrics in capacitors when the battery is connected charge (Q) is constant, voltage (V), electric field (E) and energy (U) increase while capacitance (C) decrease.
 - a) Only 1

- b) Only 2
- c) Both 1 and 2
- d) None

Explanation

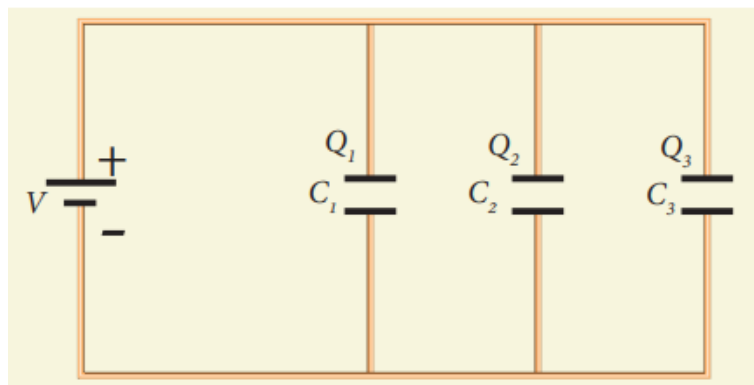
Effect of dielectrics in capacitors when the battery is connected charge (Q) is increased, voltage (V), electric field (E) are constant while capacitance (C) and Energy (U) increase.

85. Which among the following statement is correct regarding Capacitor in series?



- 1) Consider three capacitors of capacitance C_1 , C_2 and C_3 connected in series with a battery of voltage V . As soon as the battery is connected to the capacitors in series, the electrons of charge $-Q$ are transferred from negative terminal to the right plate of C_3 which pushes the electrons of same amount $-Q$ from left plate of C_3 to the right plate of C_2 due to electrostatic induction.
- 2) Similarly, the left plate of C_2 pushes the charges of $-Q$ to the right plate of C_1 which induces the positive charge $+Q$ on the left plate of C_1 . At the same time, electrons of charge $-Q$ are transferred from left plate of C_1 to positive terminal of the battery. By these processes, each capacitor stores the same amount of charge Q .
- 3) The capacitances of the capacitors are in general different, so that the voltage across each capacitor is also different and are denoted as V_1 , V_2 and V_3 respectively. The sum of the voltages across the capacitor must be equal to the voltage of the battery $V = V_1 + V_2 + V_3$. If three capacitors in series are considered to form an equivalent single capacitor C_s , $(1/C_s) = (1/C_1) + (1/C_2) + (1/C_3)$.
 - a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

86. Which among the following statement is correct regarding Capacitance in parallel



- 1) Consider three capacitors of capacitance C_1 , C_2 and C_3 connected in parallel with a battery of voltage V . Since corresponding sides of the capacitors are connected to the same positive and negative terminals of the battery, the voltage across each capacitor is equal to the battery's voltage. Since capacitances of the capacitors are different the charge stored in each capacitor is not the same.
- 2) Let the charge stored in the three capacitors be Q_1 , Q_2 , and Q_3 respectively. According to the law of conservation of total charge, the sum of these three charges is equal to the charge Q transferred by the battery, $Q = Q_1 + Q_2 + Q_3$. Since $Q = CV$, we have $Q = C_1 V + C_2 V + C_3 V$.
- 3) If these three capacitors are considered to form a single equivalent capacitance C_P which stores the total charge Q , then we can write $Q = C_P V$. Substituting this in equation we get, $1/(C_P V) = 1/C_1 V + 1/C_2 V + 1/C_3 V$. Thus, $1/C_P = 1/C_1 + 1/C_2 + 1/C_3$. Thus, the equivalent capacitance of capacitors connected in parallel is equal to the sum of the reciprocal of individual capacitances. The equivalent capacitance C_P in a parallel connection is always smaller than the largest individual capacitance.
 - a) Both 1 and 2
 - b) Both 1 and 3
 - c) Both 2 and 3
 - d) All 1, 2 and 3

Explanation

If these three capacitors are considered to form a single equivalent capacitance C_P which stores the total charge Q , then we can write $Q = C_P V$. Substituting this in equation, we get $C_P V = C_1 V + C_2 V + C_3 V$. Thus, $C_P = C_1 + C_2 + C_3$. the equivalent capacitance of capacitors connected in parallel is equal to the sum of the individual capacitances. The equivalent capacitance C_P in a parallel connection is always greater than the largest individual capacitance.

87. Which among the following statement is correct regarding Distribution of charges in a conductor

- 1) Consider two conducting spheres A and B of radii r_1 and r_2 respectively connected to each other by a thin conducting wire. The distance between the spheres is much smaller than the radii of either spheres. If a charge Q is introduced into any one of the spheres, this charge Q

is redistributed into both the spheres such that the electrostatic potential is different in both the spheres.

- 2) They are now uniformly charged and attain electrostatic equilibrium. Let q_1 be the charge residing on the surface of sphere A and q_2 is the charge residing on the surface of sphere B such that $Q = q_1 + q_2$. The charges are distributed only on the surface and there is no net charge inside the conductor
- 3) The electrostatic potential at the surface of the sphere A is given by $V_A = \frac{1}{4\pi\epsilon_0} \frac{q_1}{r_1}$. The electrostatic potential at the surface of the sphere B is given by $V_B = \frac{1}{4\pi\epsilon_0} \frac{q_2}{r_2}$. The surface of the conductor is an equipotential. Since the spheres are connected by the conducting wire, the surfaces of both the spheres together form an equipotential surface. This implies that $V_A = V_B$. we know $q = 4\pi r \sigma$. Thus, $\sigma_1 r_1 = \sigma_2 r_2$, from which we conclude that $\sigma r = \text{constant}$
 - a) Both 1 and 2
 - b) Both 1 and 3
 - c) **Both 2 and 3**
 - d) All 1, 2 and 3

Explanation

Consider two conducting spheres A and B of radii r_1 and r_2 respectively connected to each other by a thin conducting wire. The distance between the spheres is much greater than the radii of either spheres. If a charge Q is introduced into any one of the spheres, this charge Q is redistributed into both the spheres such that the electrostatic potential is same in both the spheres.

88. Lightning arrester or lightning conductor works on the principle of _____

- a) Resistance discharge
- b) Capacitance discharge
- c) **Corona discharge**
- d) Potential discharge

Explanation

Lightning arrester or lightning conductor is a device used to protect tall buildings from lightning strikes. It works on the principle of action at points or corona discharge.

89. Which among the following statement is incorrect regarding Action of points?

- 1) Consider a charged conductor of irregular shape. We know that smaller the radius of curvature, the larger is the charge density. The end of the conductor which has larger curvature (smaller radius) has a large charge accumulation.
- 2) As a result, the electric field near this edge is very low and it deionizes the surrounding air. The positive ions are attracted at the sharp edge and negative ions are repelled towards the sharper edge. This reduces the total charge of the conductor near the sharp edge. This is called action of points or corona discharge.

- a) Only 1
- b) Only 2**
- c) Both 1 and 2
- d) None

Explanation

As a result, the electric field near this edge is very high and it ionizes the surrounding air. The positive ions are repelled at the sharp edge and negative ions are attracted towards the sharper edge. This reduces the total charge of the conductor near the sharp edge. This is called action of points or corona discharge.

90. Who in the year 1929, designed a machine which produces a large amount of electrostatic potential difference, up to several million volts (10^7 V)?

- a) Robert Van de Graaff**
- b) Nikola Tesla
- c) Albert Einstein
- d) Benjamin Franklin

Explanation

In the year 1929, Robert Van de Graaff designed a machine which produces a large amount of electrostatic potential difference, up to several million volts (10^7 V). This Van de Graff generator works on the principle of electrostatic induction and action at points. The high voltage produced in this Van de Graaff generator is used to accelerate positive ions (protons and deuterons) for nuclear disintegrations and other applications.