REVIEW QUESTIONS

13.1 How can you show by simple experiments that there are two types of electric charges?

Ans: See Questions 1

13.2 What is the method of charging bodies by electrostatic induction?

See Questions 2

13.3 How does electrostatic induction differ from charging by friction?

Ans. During the process of charging by friction, we rub a neutral body with another neutral body. But in the process of electrostatic induction. We charge a conductor without making any contact with the charging body.

13.4 What is gold leaf electroscope? Discuss its working principle with a label diagram.

Ans. See Questions 3

13.5 Suppose you have a glass rod which becomes positively charged when you rub it with wool. Describe how would you charge the electroscope (i) negatively (ii) Positively.

Ans. See Questions 3

13.6 With the help of electroscope how you can find presence of charge on a body.

Ans. See Questions 3

13.7 **Describe how you would determine the nature of the charge on a body by using electroscope.**

Ans. See Questions 3

13.8 **Explain Coulomb's law of electrostatic and write its mathematical from?**

Ans. See Questions 4

13.9 **What is meant by electric field and electric intensity?**

Ans. See Questions 5

13.10 **Is electric intensity a vector Quantity? What will be its direction?**

Ans. See Questions 5

13.11 **Find the electric intensity due to a point charge q.**

Ans. See Questions 5

13.12 **How would you define potential difference between two points? Define its unit.**

Ans. See Questions 7

13.13 **Show that potential difference can be described as energy transfer per unit charge between the two points.**

Ans. See Questions 7

13.14 **Describe capacitor as an energy strong device?**

Ans. See Questions 9

13.15 **What do you men by the capacitance of a capacitor? Define units of capacitance.**

Ans. See Questions 8

13.16 **Derive the formula for the effective capacitance for a series combination of a number of capacitors.**

Ans. See Questions 11

13.17 **Discuss different types of capacitors.**

Ans. See Questions 12

13.18 **What is difference between variable and fixed type capacitor?**

Ans. See Questions 12

13.19 **Enlist some uses of capacitors.**

Ans. See Questions 13

13.20 **Discuss one application of static electricity.**

Ans. See Questions 14

13.21 **What are hazards of static electricity?**

Ans. See Questions 15

CONCEPTUAL QUESTIONS

13.1 An electrified rod attracts pieces of paper. After a while these pieces fly away! Why?

Ans. When a glass rod is rubbed with a silk cloth, it is positively charged. This electrified rod attracts pieces of paper. When the pieces of paper touch the rod, they give up some electrons to the glass rod and become positively charged. They are then flown away by the rod due to force of repulsion form the positive charge remaining on the rod.

13.2 How much negative charge has been removed from a positively charged electroscope if it has a charge of 7.5×10^{-11}C?

Ans. A charge of -75×10^{-11} C has been removed from a positively charged electroscope which has a charge of 7.5×10^{-11}C.

13.3 In what direction will a positively charged particle move in an electric field?

Ans. A positive charge released in an electric field will move along the direction electric field i.e. from higher potential to the lower potential.

13.4 Does each capacitor carry equal charge in series combination? Explain.

Ans. As in series combination each capacitor is connected side by side, so each capacitor carries equal magnitude of charge due to electrostatic induction.

13.5 Each capacitor in parallel combination has equal potential difference between its two plates. Justify the statement.

Ans. In a parallel combination of capacitors, two plates of each capacitor are connected to the positive and negative terminals of a battery between the same two points. Hence potential difference between two plates of each capacitor is equal i.e equal to the potential difference of the battery.

13.6 Is the presence of charge necessary for the existence of electrostatic potential?

Ans. Electrostatic potential is a characteristic of the field charge and independent of the existence of test charge

13.7 Rubber tires get charged from friction with the road. What is the polarity of the charge?

Ans. During the process of rubbing, electrons form road surface (make of black pitch) are transferred to rubber tyres to make them negatively charged.

13.8 Perhaps you have seen a gasoline truck trailing a metal chain beneath it. What purpose does the chain serve?

Ans. This metal charging is used of the purpose of earthling. The static charge accumulated on the body of truck during transportation are discharged to the ground through this metal chain. This may avoid any chance of explosion or fire during filling or otherwise.

13.9 If a high-voltage power line fell across your car while you were in the car, why should you not come out of the car?

Ans. Similar to Faraday's cage, inside the car you are safe from the influence of external field. The charge is evenly distributed on the surface of the car and the electric field inside the car is zero. But if we touch the ground. While coming out of the car, the charge will be discharged to the ground through our body. Hence it may be fatal.

13.10 **Explain why, a glass rod can be charged by rubbing when held by hand but an iron rod cannot be charged by rubbing, if held by hand?**

Ans. Because glass rod is an insulator, so charge developed on it during rubbing does not flow to the ground through the hand holding it. However, iron rod is a conductor and charge developed on it during rubbing can easily flow to the ground through the hand holding it. For this reason all metal objects used in electrostatic have insulating handles or stands.

Information based Questions and their Answers

Point to Ponder (Page 77)

Q.1 **Why leaves of charged electroscope diverge if we touch its disk with a metal rod but they do not diverge if we touch the disk with a rubber rod?**

Ans. If we touch the disk of a charged electroscope with a conductor, electrons will flow from electroscope to the ground or from ground or the electroscope. It depends upon the type charge on the disk of the electroscope. Due to this transfer of charges, divergence of leaves will decrease or increase accordingly. As in case of an insulator, there is not any flow of charges (as insulators are bad conductors) , so there is not any change in the position of leaves of the electroscope.

Point to Ponder (Page 78)

Q.2 **In a dry day, if we walk in a carpeted room and then touch some conductor, we will get a small electric shock! Can you tell why does it happen?**

Ans. It is caused by static electric charges accumulated on our body due to friction while walking on a carpet.

Quick Quiz (Page 80)

Q.3 **If we double the distance between the two charges, what will be the change in the force between the charges:**

Ans. If we double the distance between two charges, force between them decreases by a factor of $\frac{1}{4}$ according to Coulomb's law.

$$F = \frac{kq_1q_2}{r^2} \quad \text{where } r = 2r$$

Then, $F' = \frac{kq_1q_2}{(2r)^2}$ or $F' = \frac{kq_1q_2}{4r^2} = \frac{1}{4}F$

Point Ponder (Page 81)

Q.4 **A strong electric field exists in the vicinity of the "Faraday cage". Yet the person inside the cage is not affected. Can you tell why?**

Ans. A Faraday's cage is an enclosure made of a conducting material to block internal electric fields. In the presence of internal electric field, the electric charges on the surface of cage are redistributed in such a way so that electric field becomes zero inside the interior of Faraday's cage.

Quick Quiz (Page 85)

Q.5 **is the equivalent capacitance of parallel capacitors larger or smaller than the capacitance of any individual capacitor in the combination?**

Ans. In parallel combination of capacitors, equivalent capacitance is the sum of the individual capacitances. Hence, equivalent capacitance will be larger than the capacitance of any individual capacitor in the combination.

Quick Quiz (Page 86)

Q.6 **Is the equivalent capacitance of series capacitors larger or smaller than the capacitance of any individual capacitor in the combination?**

Ans. In series combination of capacitors, The equivalent capacitance is equal the sum of the reciprocal of the individual capacitances. Hence, equivalent capacitance is smaller than the capacitance of any individual capacitor in the combination.

Point to Ponder (Page 89)

Q.7 **Capacitor blocks d.c current but allows a.c. current to pass through a circuit. How does this happen?**

Ans. D.C current flows only in one direction. When capacitor connected' to any D.C source (e.g battery) is fully charged there is no further flow of current in the circuit. In case of A.C the polarity of A.C. source changes again and again due to which charge polarity on the plates of capacitor also changes. Due to this reason. A.C. is not stopped or blocked through the circuit.

MULTIPLE CHOICE QUESTIONS

(i) **A Positive electric charge**

(a) attracts other positive charge (b) repels other positive charge

(c) attracts a neutral charge (d) repels a neutral charge

(ii) **An object gains excess negative charge after being rubbed against another object**

(a) neutral (b) negatively charged (c) positively charged (d) either a, b or c

(iii) **Two uncharged objects A and B are rubbed against each other when object B is placed near a negatively charged object C, the two objects repel each other which of the following statements is true about object A?**

(a) remains uncharged (b) becomes positively charged

(c) becomes negatively charged (d) unpredictable

(iv) **When you rub a plastic rod against your hair several times and put it near some bits of paper the pieces of papers are attracted towards it. What does this observation indicates?**

(a) the rod and the paper are oppositely charged

(b) the rod acquires a positive charge

(c) the rod and the paper have the same charges

(d) the rod acquires a negative charge

(v) **According to coulomb's law, what happens to the attraction of two oppositely charged objects as their distance of separation increases?**

(a) increase (b) decreases

(c) remains unchanged (d) cannot be determined

(vi) **The coulomb's law is valid for the charges which are**

(a) moving and point charges (b) moving and non-point charges

(c) stationary and point charges (d) stationary and large size charges

(vii) **A positive and a negative charge are initially 4 cm apart. When they are moved closer together so that they are now only 1 cm apart, the force between them is**

(a) 4 times smaller than before (b) 4 times larger than before

(c) 8 times larger than before (d) 16 times larger than before

(viii) **Five joules of work is needed to shift 10C is charge form one place to antoher. The potential difference between the places is**

(a) 0.5 V (b) 2 V (c) 5V (d) 10V

(ix) **Two charged spheres are separated by 2mm. Which of the following would produce the greatest attractive force?**

(a) + 1q and +4q (b) – 1q and – 4q (c) +2q and +2q (d) +2q and -2q

(x) **Electric field lines**

(a) always cross each other (b) never cross each other

(c) cross each other in the region of strong field

(d) cross each other in the region of weak field

(xi) **Capacitance is defined as**

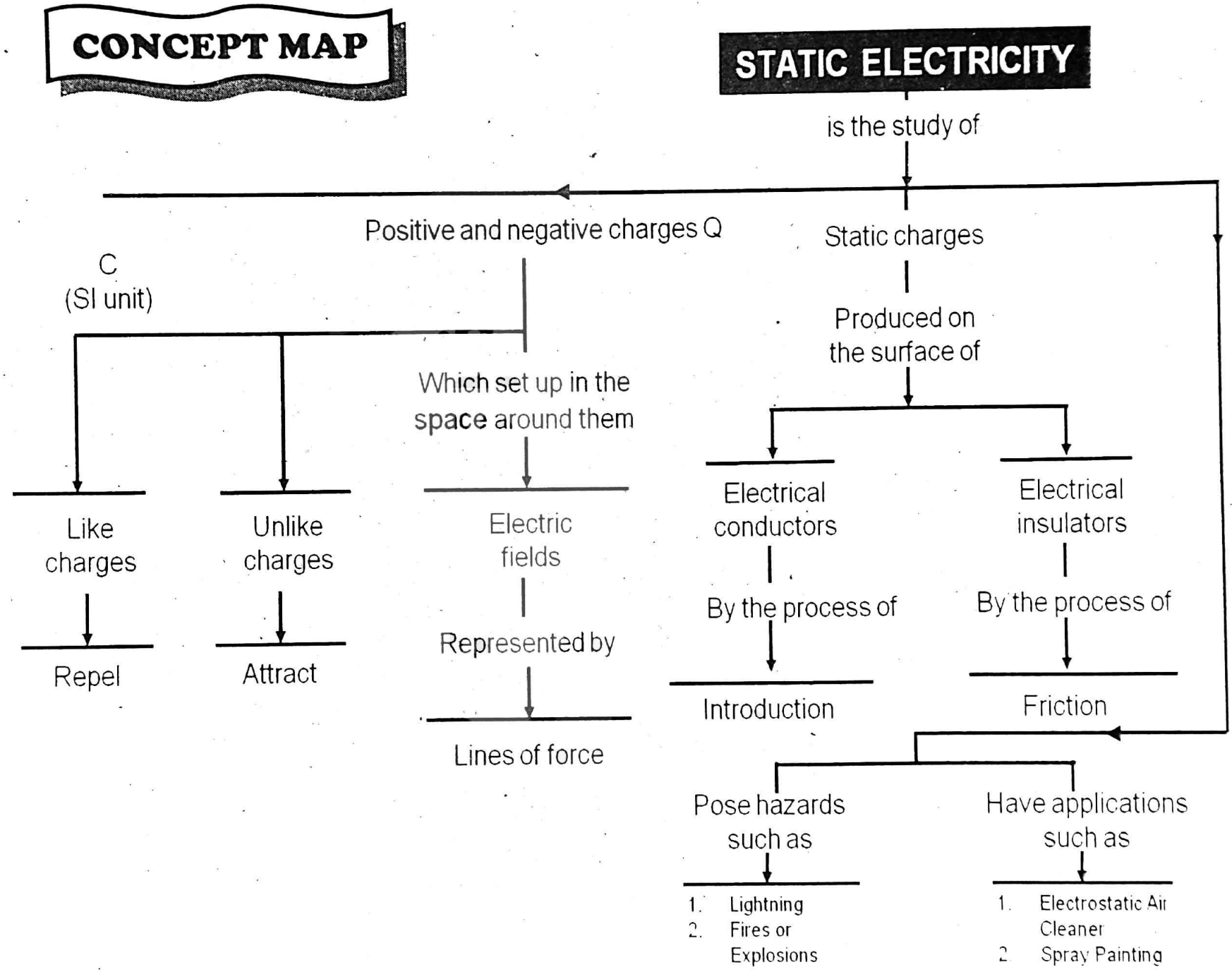
(a) VC (b) Q/V (c) QV (d) V/Q

1	2	3	4	5	6	7	8	9	10	11
b	a	b	a	c	c	d	a	d	b	b

CHAPTER 13

ELECTROSTATICS

CONCEPT MAP



TOPICAL MULTIPLE CHOICE QUESTIONS

13.1 and 13.2 Production of Electric Charges and Electrostatic Induction

1. **Study of charges at rest is called _____**
   (a) Electrostatics (b) Magnetism (c) Electrochemistry (d) Electric Current
2. **An insulating rod is charged positively by rubbing. This is due to**
   (a) Deficiency of protons (b) Excess of protons
   (c) Deficiency of electrons (d) Excess of electrons
3. **When an insulating rod is charged negatively, this is due to**
   (a) Deficiency of protons (b) Excess of protons
   (c) Deficiency of electrons (d) Excess of electrons
4. **If we run a plastic comb through hair and then bring it near shell pieces of paper. The comb _____**
   (a) Attract them (b) repel them (c) Both a and b (d) None of these
5. **Electric charges can be produced by rubbing a neutral body with**
   (a) Charged body (b) Another neutral body (c) Both a and b (d) None of these
6. **SI unit of electric charge is _____**
   (a) Coulomb (b) Ampere (c) Volt (d) Watt
7. **A positive charge**
   (a) Attract other positive (b) Repel other positive charge
   (c) Attract the natural charge (d) Repels a neutral charge
8. **An object gain excess negative charge after being rubbed against another object**
   (a) Neutral (b) Negative charged (c) positively charge (d) Object
9. **A body can be charged by**
   (a) Rubbing with another body (b) Conduction
   (c) Electrostatic induction (d) All of these
10. **Only _____ type charges exist**
    (a) One (b) Two (c) Three (d) Four
11. **When a glass rod is rubbed with a silk cloth, then**
    (a) Glass rod acquires negative charge while silk acquires positive charge
    (b) Glass rod acquires positive charge while silk acquires negative charge
    (c) Both glass rod and silk acquire negative charge
    (d) Both glass rod and silk acquire positive charge
12. **If a glass rod is rubbed with a silk cloth, it receives charge by the process of:**
    (a) Heating (b) Separation of change
    (c) Rubbing (d) electric force
13. **Which one of the following statements is correct?**
    (a) Similar charges attract each other
    (b) Similar charges repel each other
    (c) Similar charges attract and repel each other
    (d) Similar charges hither attract nor repel each other
14. **Which one of the following statements is correct?**
    (a) Opposite charges attract each other
    (b) Opposite charges repel each other
    (c) Opposite charges attract and repel each other
    (d) Opposite charges neither attract nor repel each other.

15. **Metals are good conductors of electricity, because they have**
(a) Large number of bounded electrons (b) Small number of bounded electrons
(c) Large number of free electrons (d) Small number of free electrons

16. **Free electrons are**
(a) Tightly bound (b) Fixed
(c) Loosely bound (d) strongly fixed

17. **The number of electrons in one coulomb charge is equal to**
(a) 6.25×10^{19} (b) 1.6×10^{-19}
(c) Zero (d) 6.2×10^{21}

18. **Like charges always _____ each other**
(a) Attract (b) Repel (c) Attract and repel (d) None of these

19. **In the presence of a charged body an insulated inductor develops positive charge at one end and negative charges at other end, this process is called the _____**
(a) Electrostatic induction (b) Conduction (c) Friction (d) All of these

13.2,13.3 and 13.4 Electroscope ,Coulomb's Law and Electric Field

20. **Electroscope is an instrument used for**
(a) Detecting presence of charge (b) To detect the type of charges
(c) To identify conductor and insulator (d) All of these

21. **Force of attraction or repulsion acts between**
(a) Two charged bodies (b) Neutral bodies (c) Non charged bodies (d) All of these

22. **Who established fundamental law of electric force between two stationary charged particles?**
(a) Planks (b) Faraday (c) Quantum (d) Coulomb

23. **According to Coulomb's law**
(a) $F=K\frac{q_1 r^2}{q_2}$ (b) $F=\frac{kr_1 r_2}{(q)^2}$ (c) $F=\frac{kq_1 q_2}{r^2}$ (d) $F=k\frac{q_1 q_2}{r}$

24. **K is constant of proportionality given by**
(a) $K=\frac{1}{4\pi \in_o}$ (b) $K=\frac{\in}{4\pi}$ (c) $K=\frac{4\pi}{\in_o}$ (d) None of these

25. **SI unit of K**
(a) Nm^2C (b) Nm^2C^{-2} (c) $N^2m^2C^{-1}$ (d)

26. **The value of K**
(a) $8.85 \times 10^9\ Nm^2C^{-2}$ (b) $9 \times 10^9\ Nm^2C^{-2}$ (c) $6.67 \times 10^9\ Nm^2C^{-2}$ (d)none of these

27. **A region around the charge in which it exerts electrostatic force on another charge is called**
(a) Gravitational field (b) Magnetic field (c) Electric field (d) All of these

28. **SI unit of electric intensity is**
(a) Nm^{-1} (b) NC^{-1} (c) Nm^{-2} (d) Nm

29. **The spacing between the field lines shows the**
(a) Strength of electric field (b) Direction of electric field
(c) Both a and b (d) None of these

30. **Electroscope can be charge by the process**
(a) Magnetism (b) Internal reflection
(c) Electrostatic induction (d) Electromagnetic tension

31. **The value of Coulomb's constant K depends upon**
(a) The system of units used
(b) Medium between the charges
(c) Quantity of the charges
(d) The system of units and the medium between the charges

32. **If the distance between the two charged bodies is halved, the force between them becomes**
(a) Doubled (b) Half
(c) Four times (d) One half

33. **If the distance between two charges is doubled, the electric force between them will become**
(a) Four times (b) Twice
(c) Half (d) One fourth

34. **Electric charge of 100μC is 13 m apart from another charge 16.9μC. The force between them in Newton is**
(a) 9×10^{7} (b) 0.09
(c) 90 (d) 9×10^{5}

35. **The electric force of repulsion between two electrons at a distance of 1 m is**
(a) 1.8 N (b) 1.5×10^{-9}N
(c) 2.30×10^{-27}N (d) 2.30×10^{-27}N

36. **The magnitude of the charge on the electron is**
(a) 1.2×10^{-19}C (b) 1.6×10^{-19}C
(c) 2.6×10^{-19}C (d) 1.81×10^{-19}C

37. **The space around the charge within which other charges are influenced by it is called**
(a) electric intensity (b) Electric field
(c) Electric flux (d) Electric potential

38. **Force experienced by a unit positive charge placed at a point in the electric field is known as**
(a) Electric field intensity (b) Magnetic field intensity
(c) Electric potential (d) Capacity

39. **The force per unit charge is known as**
(a) Electric flux (b) Electric intensity
(c) Electric potential (d) Electric volt

40. **SI unit of electric field intensity is**
(a) Coulomb (b) Volt
(c) Newton/coulomb (d) Ampere

41. **Electric field intensity is a vector quantity and its direction is**
(a) Perpendicular to the direction of field (b) Opposite to the direction of force
(c) Along the direction of force (d) At a certain angle

42. **The electric intensity at infinite distance from the point charge is**
(a) Zero (b) Infinite
(c) 1 Volt – m^{-1} (d) Positive

13.6 and 13.7 Electric potential , capacitor and capacitance :

43. **Work done in bringing a unit positive charge from infinity to that point in an electric field is called**
(a) potential difference (b) Resistance
(c) Capacitance (d) **Electric** potential

44. **Electric field is strong when liens are**
(a) Separated (b) Closer (c) Smaller (d) Larger

45. **_____ at a point in an electric field is equal to amount of work done in bringing unit positive charge from infinity to that point**
(a) Electric intensity (b) Potential difference (c) Electric potential (d) Volt

46. **Which statement is true about electrical potential**
(a) Its SI unit is volt (b) It is scalar quantity (c) At any point $v = \frac{w}{q}$ (d) all of these

47. **In order to store the charge a device is used which is called**
(a) Potential (b) Capacitor (c) Momentum (d) Voltage

48. **SI unit of capacitance**
(a) Farad (F) (b) Coulomb (c) Newton (d) Voltage

49. **Parallel plate capacitor consist of two metal plates separated by**
(a) Metal (b) Insulator (c) Conductor (d) all of these

50. **Which is incorrect for parallel capacitor?**
(a) $v_1 = v_2 = v_3 = v$ (b) $Q = Q_1 + Q_2 + Q_3$ (c) $C_e = C_1 + C_2 + C_3$ (d) $Q_1 = Q_2 = Q_3 = Q$

51. **The work done in moving a unit positive charge form one point to another against the eclectic field is a measure of**
(a) Intensity of electric field (b) Resistance between two points
(c) Capacitance (d) Potential difference between two points

52. **The potential difference between two points is one volt. The amount of work done in moving a charge of one coulomb from one point to another is**
(a) One erg (b) One Joule
(c) One electron volt (d) one coulomb

53. **Electron volt is the unit of**
(a) Potential difference (b) Electric energy
(c) Electric current (d) Capacitance

54. **The electron energy is one electron – volt when it is accelerated through a potential difference of**
(a) One volt (b) One joule
(c) One Coulomb (d) One erg

55. **Electric potential is a**
(a) Vector quantity (b) Scalar quantity
(c) Neither scalar nor vector (d) Sometimes scalar and sometimes vector

56. **One electron volt is equal to**
(a) 1.6×10^{-19}J (b) 1.6×10^{19}J
(c) 6.25×10^{-18}J (d) 6.25×10^{18}J

57. **The capacitance C of a capacitor is given by the relation**
(a) C = QV/2 (b) C = QV
(c) C = Q/V (d) C = V/Q

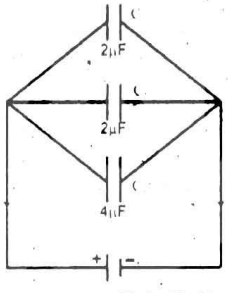
58. **A capacitor is a perfect insulator for**
(a) Direct current (b) Alternating current
(c) Both for the direct and alternating current (d) Electric charge

59. **Which one of the following is correct?**
(a) 1 $\mu F = 10^{-6} F$ (b) 1$\rho F = 10^{-13} F$
(c) 1$\rho F = 10^{-6} \mu$ F (d) All of the above

60. **When capacitors are connected in parallel, their equivalent capacitance is equal to**
(a) The product of their individual capacitances
(b) The sum of their individual capacitances
(c) The product of their individual reciprocal capacitances
(d) The sum of the reciprocals of the individual capacitances

61. **When capacitors are connected in series, their equivalent capacitance is equal to**
(a) The product of their individual capacitances
(b) The sum of their individual capacitance
(c) The sum of the reciprocals of the individual capacitances
(d) The product of their individual reciprocal capacitances

62. **Three capacitors C_1, C_2 and C_3 are connected in parallel as in the Fig. Their equivalent capacitance will be**



(a) 8μF (b) 0.8μF
(c) 1μF (d) 16μF

63. **Tick the correct statement**
(a) Capacitance decreases in parallel combination
(b) Capacitance decreases in series combination
(c) Capacitance is the same in both combinations
(d) All of the above

64. **If 4μF and 2μF capacitors are connected in series, the equivalent capacitance is given by**
(a) 6μF (b) 2μf
(c) 1.3μF (d) 8Fμ

65. **Two 50μF capacitors are connected in parallel. The equivalent capacitance of the combination is**
(a) 1μF (b) 100μF
(c) 50μF (d) 25μF

13.9 and 13.10 Types of capacitor and some hazards of electricity:

66. **In variable capacitors**
(a) Both the sets of plates are fixed
(b) Both the sets of plates are moveable
(c) One set of plates is fixed and the other is moveable
(d) Both the sets of plates are neither fixed not moveable

67. Variable capacitors are used in
(a) Radio only (b) Television only
(c) Radio and television (d) None of the above

68. A radio tuning capacitor is a
(a) Variable parallel plate capacitor (b) Variable cylindrical capacitor
(c) Spherical capacitor (d) Tubular capacitor

69. Which of the following is commercial type capacitor
(a) Tubular capacitor (b) Electrolytic capacitor
(c) Miniature capacitors (d) All of the above

70. The equivalent capacitance is greater than individual capacitance in
(a)Series combination (b) Parallel combination
(c) Series and parallel combination (d) All of them

71. Farad is defined as
(a) Coulomb/Volt (b) Ampere/Volt
(c) Coulomb/Joule (d) Joule/coulomb

72. Capacitor have different types depending upon
(a) Their construction (b) Nature of dielectric (c) Both A and B (d) None of above

73. In variable capacitors, the value of capacitance can be
(a) Decrease (b) Increased (c) Both a and B (d) Fixed

74. In fixed type of capacitors, the value of capacitance
(a) Increase (b) Decrease (c) Can not be changed (d) All given ture

75. It is a fixed capacitor
(a) Paper capacitor (b) Mica capacitor (c) Both a and b (d) Capacitors in radio sets

76. In Mica capacitors the dielectric is
(a) Aluminum foils (b) Mica (c) Copper (d) Polythene paper

77. Capacitors are used in
(a) Tuning Transmitters (b) Receiver (c) Transistor radio (d) All of these

78. Capacitors are used in resonant circuit that tune radios to particular frequency
(a) Electrostatic air cleaner (b) Spray painting (c) Car washing (d) None of these

79. Application of electrostatic is
(a) Photocopying (b) Car painting (c) Extracting Dust (d) All of these

ANSWER KEY

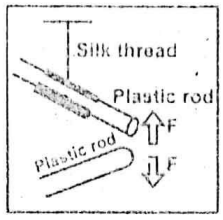
Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans
1	a	11	b	21	a	31	d	41	c	51	d	61	c	71	a
2	c	12	c	22	d	32	c	42	a	52	b	62	a	72	c
3	d	13	b	23	c	33	d	43	d	53	b	63	b	73	c
4	a	14	a	24	a	34	b	44	b	54	a	64	c	74	c
5	b	15	c	25	b	35	c	45	c	55	a	65	b	75	c
6	a	16	c	26	b	36	b	46	d	56	a	66	c	76	b
7	b	17	a	27	c	37	b	47	b	57	c	67	c	77	d
8	b	18	b	28	b	38	a	48	a	58	c	68	a	78	d
9	d	19	a	29	a	39	b	49	b	59	a	69	d	79	d
10	b	20	d	30	c	40	c	50	d	60	b	70	b		

SHORT QUESTIONS

13.1 And 13.2 Production of Electric Charges and Electrostatic Induction

(1) **How can we produce a charge in neutral body?**

Ans: We can produce a charge in neutral body by rubbing it with another neutral body e.g plastic rod rub with per or silk.



(2) **What is electrostatics?**

Ans: Study of charges at rest is called electrostatics or static electricity.

(3) **What is meant by electrostatic induction, for which purpose it is used?**

Ans: In the presence of a charged body, an insulated conductor develops positive charge at one end and negative charge at the other end. This process is called the electrostatic induction. This method is used for charging body.

(4) **Why is electric charge produced in bodies by friction?**

Ans: When we rub two bodies, we provide external force by rubbing. Then the loosely bound electrons in one body are transferred to the other body. As electrons carry negative charge, therefore, a negative charge is developed on the body which gets electrons and positive charge is developed on that body which looses electrons.

(5) **What is purpose electrostatic used?**

Ans: Electrostatic is used in everyday lives which includes photocopying, car painting extracting dust from carpets and form chimneys of industrial machinery.

13.3,13.4 and 13.5 Electroscope, Coulomb's Law and Electric Field

(6) **How electroscope can be charged?**

Ans: Electroscope can be charge by the process of electrostatic induction. It can also be chare by process of conduction.

(7) **Which type of instrument gold leaf electroscope is?**

Ans: The gold leaf electroscope is sensitive instrument for detecting charges. It consists of a brass rod with a brass disk at the top and two thin leaves of gold foil hanging at the bottom. The rod passes through an insulator that keep the rod in place and also remains the charges. Charges can move freely from the disk to leaves through the rod. A thin aluminum foil is attached on the lower portion of the inside of the jar.

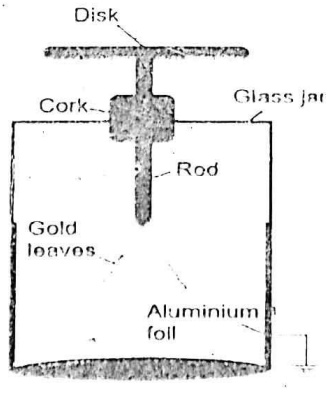


Fig. 1Uncharged electroscope

(8) **How can we detect with electroscope that body is conductor or insulator?**

Ans: Electroscope can also be used to distinguish between insulator and conductors. Touch the disk of a charged electroscope with martial under test. If the leaves collapse from their diverged position the body would be a good conductor. If thee is no change in the divergence of the leaves, it will show that the body under test is insulator.

(9) **Defined electric field intensity?**

Ans: "The strength of electric field at any point in space is known as electric field intensity"

Formula:

$$E = \frac{F}{q^o}$$

Thus the electric field intensity at any point is defined as the force acting on a unit positive charge place at that point.

Unit:

Its SI unit is NC^{-1}

(10) **State the Coulomb's law.**

Ans: The force of attraction or repulsion between two points charges is directly proportional to the product of the quantity of charges and inversely proportional to the square of the distance between them

Mathematically:

$$F \propto q_1 q_2$$

$$F \propto \frac{1}{r^2}$$

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

Where F is coulomb's force, q_1, q_2, are charges and K is called coulomb's constant

(11) **Who introduce the electric lines of force?**

Ans: The direction of electric liens filed intensity in an electric field can also be represented by drawing lines these lines are known as electric lines of force introduced by Michael Faraday.

(12) **What is meant by point charges?**

Ans: If the distance between two charged bodies is much greater as compared to their size. the bodies are considered as point charges.

(13) **What will happen to Coulomb's force, if the distance between two point charges becomes double?**

Ans: According to coulomb's law

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

When r = 2r

Then $F' = k\frac{q_1 q_2}{(2r)^2}$ Or $F' = k\frac{q_1 q_2}{4r^2}\ \frac{1}{4}$

Thus if the distance between two point charges is doubled, the coulomb's force between them reduces to one fourth.

(14) **In which direction Coulomb's force act between the two charges?**

Ans: The Coulomb's forces have equal magnitude but always act in opposite directions.

(15) **What is SI unit of electric intensity?**

Ans: SI unit of electric intensity is NC^{-1}.

(16) **What is work of Charles Coulomb?**

Ans: A French scientist Charles Coulomb (1736 – 1806) in 1785 experimentally established the fundamentals law of electric force between two stationary charged particles.

(17) **What is direction of electric intensity?**

Ans: Electric intensity being a force is a vector quantity. Its direction is the same as that of the force acting on the positive test charge.

(18) **On which factors the value of K depends?**

Ans: The value of the k depends upon the medium between the two charges and the system of units in which F, q and r are measured $\in_0$ is the permittivity of free space.

13.6,13.7 and 13.8 Electric potential , capacitor and capacitance, difference types of capacitors:

(19) **What is meant by electric potential?**

Ans: Electric potential at a point in an electric field is equal to the amount of work done in bringing a unit positive charge form infinity to that point

Formula:

$$V = \frac{W}{q}$$

Unit:

Its unit is volt.

(20) **Defined fared?**

Ans: If one Coulomb of charge given to the plates of a capacitor produces a potential difference of one volt between the plates of the capacitor then its capacitance would be one farad.

$$1F = \frac{1C}{1V}$$

(21) **What is meant by Capacitance?**

Ans: Capacitance is the ability of the capacitor to store charge. It is given by the ratio of charge and the electric potential as

Formula:

$$C = \frac{Q}{V}$$

Unit:

SI unit of capacitance is fared (F) fared is a large unit, usually we use a smaller unit called micro fared (μF) and pico forced (pF).

(22) **Define potential difference between two points.**

Ans: "The potential difference between two points can be defined as the energy supplied by a unit charge as it moves from one point to the other."

(23) **What is electron volt? Also find its energy in joules.**

Ans: Electron volt [eV] is the unit of energy used to measure the energy supplied by the movement of charges. This is a small unit of energy and is often used in atomic and nuclear physics. It is defined as under:

Definition

"It is equal to the amount of energy supplied by an electron as it moves between two points having a potential difference of one volt."

Mathematically

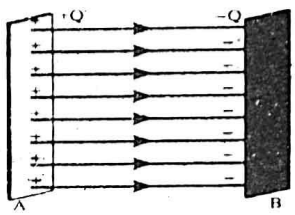
Charge on an electron = $q = 1.6 \times 10^{-19}$ C.

Potential difference = $V_A - V_B = 1$ V

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ C} \times 1 \text{ V}$$
$$= 1.6 \times 10^{-19} \text{ J}$$

(24) How does capacitor store charge?

Ans:



If +Q amount of charge is transferred to its one plate, due to electrostatic induction it would induce -Q charge on the inner surface of other plate. There exists a force of attraction between the charges +Q stored on the first plate and the charge -Q induced on the inner surface of other plate.

Due to this force of attraction, the charges are bound with the plate and remain stored for long periods.

(25) Why charge can not be stored on capacitor for a long time?

Ans: Charge cannot be stored on a conductor for a long period of time because the stored charges mutually repel each other due to which they spread on the whole surface of the conductor and also tend to leak out from there.

13.8 and 13.9 Types of capacitor and some hazards of electricity:

(26) How static electricity can be generated?

Ans: Static electricity can be generated by the frictions of the gasoline being pumped into a vehicle or container. It can also be produced when we get out of the car or remove an article of clothing static electric charge build up during transport.

(27) What do you know about paper capacitor?

Ans: Paper capacitor is an example of fixed capacitors. The paper capacitor has a cylindrical shape. Usually an oiled or greased paper or a thin plastic sheet is used as a dielectric between two aluminum foils. The papers or plastic sheet is firmly rolled in the form of a cylinder and is then enclosed into a plastic case.

(28) How the phenomenon of lightening occurs?

Ans: The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunder clouds. The thunderclouds are charged by friction between the water molecules in the thunder clouds and the air molecules. When the charge on the thunder clouds is sufficiently high, it can produce positive and negative charges in the air. The huge amount of negative charge is discharged to the highest object on the ground and can harm them.

(29) How static charges are dangerous?

Ans: If static charges are allowed to discharge through the area where there is petrol vapour a fire can occur. The results are frightening and may be devastating.

(30) **What is difference between variable and fixed capacitors?**

Ans: Capacitors are either variable or fixed. In variable capacitors the value of capacitance can be increased or decreased. In fixed type capacitors, the value of capacitance cannot be changed.

(31) **How electrolytic capacitor is important?**

Ans: An electrolytic capacitors in important because it is often used to store large amounts of charge at relatively law voltages.

(32) **Why parallel plate capacitors are not commonly used.**

Ans: Parallel plate capacitors are not commonly used in most devices because in order to store enough charger, their size must be large which is not desirable.

(33) **Why it is very dangerous to swim in the open sea, play in an open field or hide under a tree during a thunderstorm?**

Ans :The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunderclouds. The thunderclouds are charged by friction between the water molecules in the thunderclouds and the air molecules. When the charge on the thunderclouds is sufficiently high, it can produce positive and negative charges in the air. The he amount of negative charge is discharged to the highest object on the ground and can harm them.

This explains why it is very dangerous to swim in the open sea, play in an open field or hide under a tree during a thunderstorm.

(34) **How is Static electricity a major cause of fires and explosions at many places**

Ans Static electricity is a major cause of fires and explosions at many places. A fire or an explosion may occur due to excessive build-up of electric charges produced by friction.

(35) **What is capacitor and at what principle it work?**

Ans: Capacitor is a device that is used to store charges. It works on the principle of electrostatic induction.

(36) **What is the purpose of parallel combination of capacitors?**

Ans: If 'n' capacitors are combined in parallel, then their equivalent capacitance is given by:

$$C_e = C_1 + C_2 + C_3 + \ldots\ldots + C_n$$

Generally capacitors are connected in parallel combination to increase the value of capacitance.

(37) **How can we determine that an electric field is strong or weak in a certain region?**

Ans: The number of lines of force is related with the strength of the field. If in a certain region, lines of force are close to each other, the field is strong there. And if lines of force are far apart from each other, the field is weaker there. Thus by seeing the lines of force, we can get information about the magnitude and direction of electric field intensity.

(38) **Enlist few uses of capacitors.**

Ans: They are used in:

(i) tuning transmitters (2) receiver and transistor radios

(3) table fans, exhaust fans (4) Coolers, air conditioners (5) motors, washing machines

(39) **For what purpose electrostatics is used in everyday life?**

Ans: Electrostatics is used in everyday lives which includes photocopying, car painting, extracting dust from dirty carpets and from chimneys of industrial machinery.

(40) **How automobile manufactures use statics electricity to paint new cars?**

Ans: The body of car is charged and then the paint is given the opposite charge by charging the nozzle of the sprayer. Due to mutual repulsion charge particles coming out of the nozzle form a fine mist and are evenly distributed on the surface of the object.

(41) **How the phenomenon of lightening occurs?**

Ans: The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunderclouds. The thunderclouds are charged by friction between the water molecules in the thunderclouds and the air molecules. When the charge on the thunderclouds is sufficiently high, it can produce positive and negative charges in the air. The huge amount of negative charge is discharged to the highest object on the ground and can harm it.

(42) **Why lightening conductors are used in tall buildings?**

Ans: The purpose of the lightening conductor is to provide a steady discharge path for the large amount of negative charge in the air to flow form the top of the building to the earth. In this way, the chances of lightening damage due to sudden discharge can be minimized.

(43) **How static electricity can be generated?**

Ans: Static electricity can be generated by the friction of the gasoline being pumped into a vehicle or container. It can also be produced when we get out of the car or remove an article of clothing. Portable oil containers can also build up a static electric charge during transport.

(44) **How static charges are dangerous?**

Ans: If static charges are allowed to discharge though the areas where there is petrol vapour a fire can occur. The results are frightening and may be devastating.

(45) **Write any two examples of practical application of electrostatic induction?**

Ans: The applications of electrostatic induction are given as under:

i. Separation of particles from smoke

ii. Electro painting

LONG QUESTIONS

13.1 Production of electric charges:

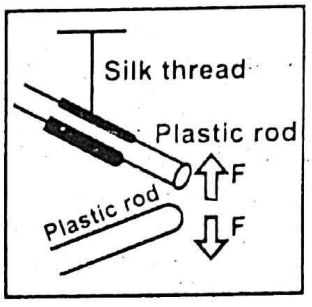
Q.1What is electrostatic? How electric charges be produced? Explain it with activities.

Electrostatics:

"Study of charges at rest is called electrostatics or static electricity."

Production of electric charges:

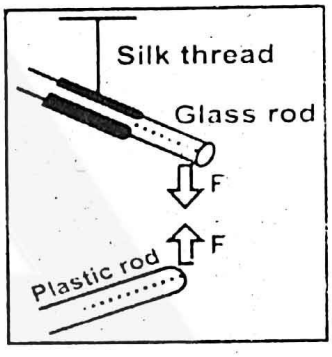
We can produce electric charge by rubbing a neutral body with another neutral body. The following activates show that we can produce two types of electric charges through the process of rubbing.



Activity 1: Take a plastic rod. Rub it with fur and suspend it horizontally by a silk thread (as shown Fig. 1). Now take another plastic rod and rub it with fur and bring near to the suspended rod

Observation:

We will observation that both the rods will repel each other. It means during the rubbing both the rods were charged both rods have same charge.



Activity 2: Now take a glass rod and rub it with slide and suspend it horizontally. When we bring the plastic rod rubbed with fur near to the suspended glass rod as shown fig. 2.

Observation:

We observe that both the rods attract each other.

Conclusions:

- In the above activity, rods are unlike and their attraction imply that charge on the two rods are not of the same kind but of opposite nature.

These apposite charges are conventionally called positive and negative charge. During the process of rubbing negative charge is transferred from one object to another object from these activities we conclude that:

Conclusion:

1. Charge is a basic property of a material body due to which it attracts or repels another object.
2. Friction produces two different types of charge on different material 9such as glass and plastic).
3. Like charges always repel each other.
4. Unlike charges always attract each other.
5. Repulsion is the sure test of charge on a body.

13.2 Electrostatic Induction:

Q.2 What is meant by electrostatic induction? Explain it with the help of experiments or activities.

Definition:

In the presence of a charged body, an insulated conductor develops positive charge at one end and negative charge at the other end. This process is called the electrostatic induction.

Explanation with the help of the activities

Activity 1:

If we bring charged plastic rod near neutral aluminium rod, both rods attract each other as shown in Fig. 13.4. This attraction between the charged and uncharged rods shows as if both rods have different charged. But this is not true. Charged plastic rod produces displacement of positive and negative charges on the neutral aluminium rod which is the cause of attraction between them. But total charge on aluminium rod is still zero. It implies that attraction is not the sure test of charge on a body.

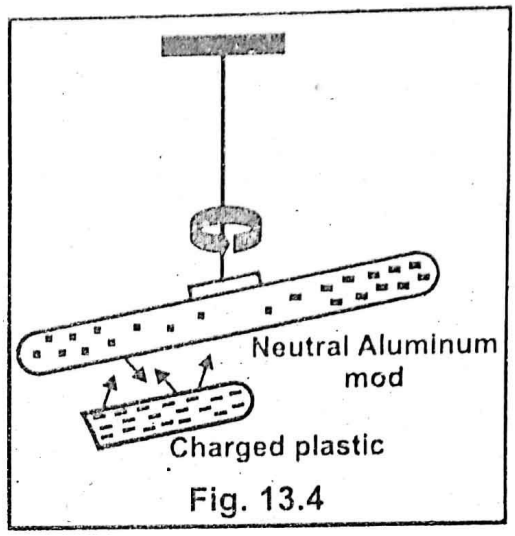


Fig. 13.4

It also shows that electrostatic induction is another method of charging a body and is described below.

Method of Charging a bodies by electrostatic induction

Consider a metallic sphere placed on an insulated stand Fig. (13.5a), The sphere is neutral as it carries equal number of positive and negative charges. Now bring a negatively charged rubber rod near the conducting sphere. As shown in Fig. (13.5.b) left part of the sphere that is close to the rod becomes positively charged while the right part that is away form the rod becomes negatively charged. Negative charge in the rod repels the negative charge of the sphere and shifts it to the opposite region of the sphere that is away form the rod. Thus there is excess of positive charge in the region of sphere close to the rod while there is excess of negative charge in the region of the sphere away form the rod. But as a whole the sphere is still neutral, since no charge has been added or subtracted.

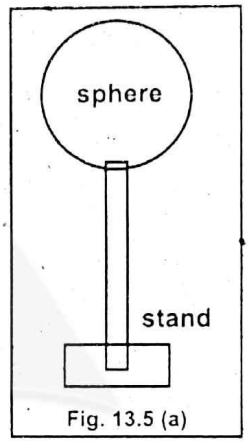


Fig. 13.5 (a)

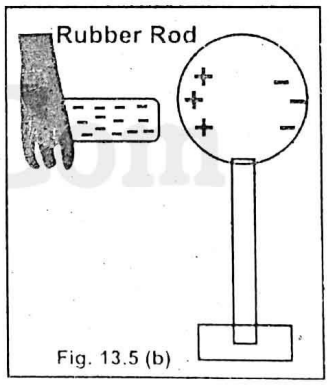


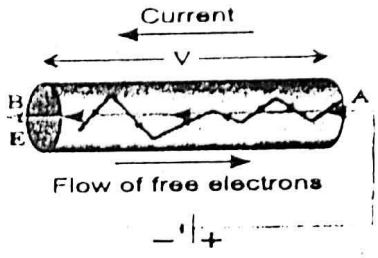
Fig. 13.5 (b)

Now if we remove the rod away form the sphere, the charged again will spread uniformly on the whole surface of the sphere.

Now earth the sphere through a conducting wire in the presence of the rod (Fig. 13.6-a) The negative charge will flow to the earth an leaves the sphere with net positive charge Now if we first break the earth connection and then remove the rod form the sphere it will get positive charge permanently (Fig. 13.6-b).

Explanation

When the ends of a copper wire are at different temperatures, heat energy flows from one end of higher temperature to the end of lower temperature. The flow stops when both ends reach the same temperature. Water in pipe also flows in a pipe from high level to low level. Similarly when a conductor is connected to a battery, it pushes positive charges to flow current from high potential to low potential as shown in fig.



The flow of current continues as long as there is a potential difference. Conventional current produces the same effect as the current flowing from negative terminal to the positive terminal due to flow of negative charges.

Q.4 **How we can detect and measure the electric current (14.1)?**

Ans: We use different electrical instruments which can detect and measure the current in the circuit.

1. **Galvanometer:**

"Galvanometer is a device which is used to detect the presence of electric current in any circuit."

ii. **Ammeter:**

"Ammeter is a device which is used to measure the current in any circuit."

Importance of Galvanometer

Galvanometer is very sensitive instruments and can detect small current. A current of few milli amperes is sufficient in it. Ideal galvanometer should have very small resistance to pass the maximum current in the circuit.

Polarity of galvanometer

While making the connections polarity of the terminals of the galvanometer should be taken into consideration. Generally the terminal of the galvanometer with red colour shows the positive polarity while that of with black colour shows negative polarity.

How Ammeter is formed?

After suitable modification galvanometer can converted into an ammeter. A suitable but small resistance is connected in parallel to the galvanometer, this circuit is called ammeter. A large current of the range such as 1A or 10 A can be measured by means of ammeter, like galvanometer ammeter is also connected in series, so that the current flowing in the circuit also passes through the ammeter.

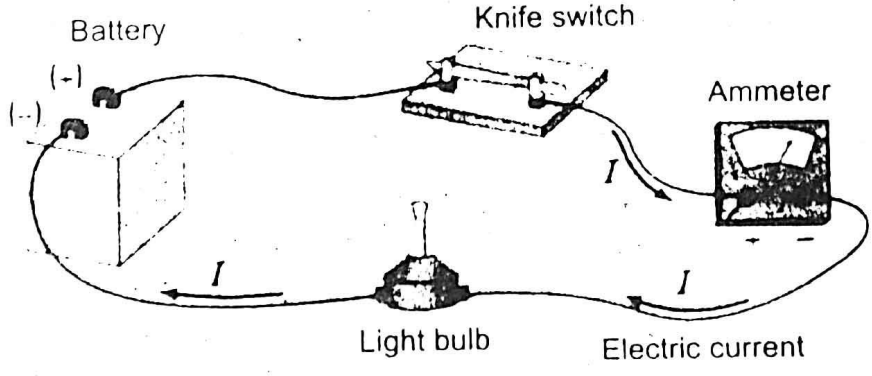


Fig. 14.5: Schematic diagram showing the measurement of current

14.2 and 14.3 Potential Difference and e.m.f

Q.5: **Define and explain the potential difference (14.2).**

Ans: **Definition:**

"Potential difference across the two ends of a conductor causes the dissipation of electrical energy into other forms of energy as charges flow through the circuit.

Charging the Electroscope by Electrostatic induction:

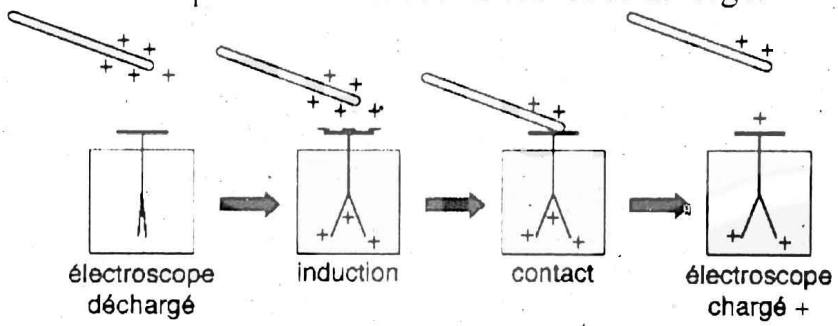
Electroscope can be charged by the process of electrostatic induction. In order to produce positive charge on the electroscope, bring a negatively charged body near the disk of the electroscope (Fig. 3-a). Positive charge will appear on the disk of the electroscope while negative charges will shift to the leaves. Now connect the disk of electroscope to the earthed aluminium foil by a conducting wire (Fig. 3-b). Charge of the leaves will flow to the earth through the wire. Now if we first beak the earth connection and then remove the rod the electroscope will be left with positive charge. Similarly electroscope can be charged negatively with the help of a positively charged rod.



Charging the electroscope positively

By Conduction:

Electroscope can also be charged by the process of conduction. Touch a negatively charged rod with the disk of a neutral electroscope. Negative charge from the rod will transfer to the electroscope and will cause its leaves to diverge.



(ii)

Detecting the Type of Charge:

For the detection of type of charge on a body, electroscope is first charged either positively or negatively. Suppose the electroscope is positively charged as explained before. Now in order to detect the type of charge on a body. Bring the charged body near the disk of the positively charged electroscope. If the divergence of the leaves increases, the body carries positive charge (Fig. 4-a). On the other hand if the divergence decreases, the body has negative charge (Fig 4-b)

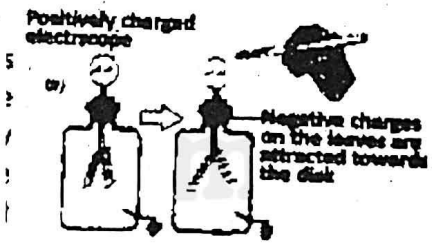


Fig. 4-a detecting positive charge on body

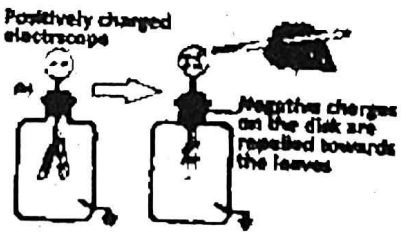


Fig. 4-b detecting negative charge on body

(iii) **Identifying conductors and insulators:**

Electroscope can also be used to distinguish between insulators and conductors. Touch the disk of a charged electroscope with material under test. If the leaves collapse from their diverged position the body would be a good conductor. If there is no change in the divergence of the leaves. It will show that the body under test is an insulator.

13.4 Coulomb's Law:

Q.4 State and explain Coulomb's law and write its mathematical form.

Introduction:

We know that a force of attraction or repulsion acts between two charged bodies. How is this force affected when the quantity of the charge on the two bodies or the distance between them is changed? In order to find the answers of these question, a French scientist charges coulomb (1736-1806) in 1785 experimentally established the fundamental law of electric force between two stationary charged particles.

Coulomb's Law:

Statement:

"The force of attraction or repulsion between two point charges is directly proportional to the product of the quantity of charges and inversely proportional to the square of the distance between them."

Mathematically:

$$F \propto q_1 q_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

$$F \propto \frac{1}{T^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Combining Eqs. (i) and (ii) we get

$$F = k\frac{q_1 q_2}{r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

Equation (iii) is known as coulomb's law. Where F is the force between the two charges and is called the coulomb force, q_1 and q_2 are the quantities of two charges and r is the distance between the centre of two charges (Fig. 1-a-b) K is the constant of proportionality given by

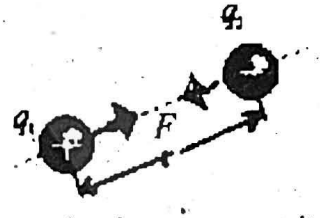


Fig. 1-a attraction between oppsite charges



Fig. 1-b Repulasion between similar charges

$$K = 1/4\pi\varepsilon_0$$

Dependence of value of K

The value of K depends upon the medium between the two charges and the system of units in which F, q, and r are measured, ε_0 is the permittivity of free space.

Now if the medium between the two charges is air then the value of K in SI units will be $9 \times 10^9 Nm^2C^{-2}$.

Final form of Coulomb's force is

$$F = \frac{1}{4\pi\in_0} \times \frac{q_1 q_2}{(r)^2}$$

Point Charges:

Coulomb's law is true only for point charges whose sizes are very smallest compared to the distance between them. Like other forces, electric forces also obey Newton's third law.

13.5 Electric Field And Electric Field Intensity:

Q.5 **Define electric field and electric intensity also explain electric intensity?**

OR

What is meant by electric field and electric intensity? Find the electric intensity due to point charge

Electric field

Definition:

"The region of space surrounding the charge q in which it exerts a force on the charge q_0 is known as electric field of the charge q."

OR

"The electric field is a region around a charge in which it exerts electrostatic force on another charges."

Explanation:

According to Coulomb's law if a unit positive charge q_0 (call it the test charge) is brought near a charge q (call it the field charge) placed in space, the charge q_0 will experience a force. The value of this force would depend upon the distance between the two charges. If the charge q_0 is moved away form q this force would decrease till at a certain distance the force would practically reduce to zero. Now the charge q_0 is out of the influence of charge q.

Electric Filed Intensity

"The strength of electric field at any point in space is known as electric field intensity"

Explanation:

In order to find the value of electric intensity at a point in the field, of charge + q, we place a test charge q_0 at that point Fig. 13.13. If F is the force acting on the test charge q_0 the electric field intensity would be given by

$$E \frac{F}{q_0} \text{.....(13.4)}$$

Thus the electric field intensity at any point is defined as the force acting on a unit positive charge place at that point.

SI Unit:

SI unit of electric intensity is NC^{-1}

If the electric field due to a given arrangement of charges is known at some point, the force on any particle with charge q placed that point can be calculated by using the formula

$F = qE$ .....(13.5)

Quantity:

Electric intensity being a force is a vector quantity. It direction is the same as that of the force acting on the positive test charge. If the test charge is free to move, it will always move in the direction of electric intensity.

Q.6 **What is meant by electric lines of force? Explain**

Electric Filed Lines:

Definition:

The direction of electric field intensity in an electric field can also be represented by drawing lines. These lines are known as electric lines of force.

Explanation:

These lines were introduced by Michael Faraday. The field lines are imaginary line around a field charge with an arrow head indicating the direction of force. Field lines always move away form positive charge but toward negative charge. The spacing between the field lines shows the strength of electric field (Fig 1)

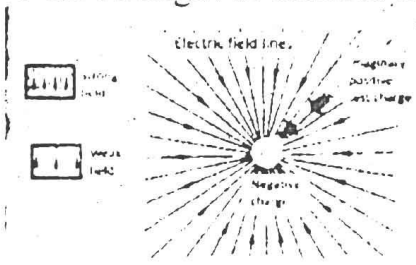
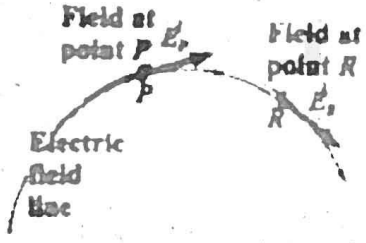


Fig. 1

Relation of field line with the electric field intensity

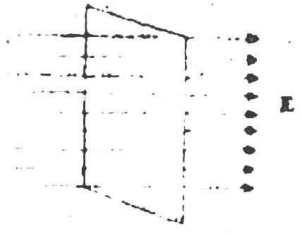
Field lines are related to the electric field intensity in any region of space in the following way

1. The electric field intensity is tangent to the electric field lines at each point (Fig. 2-a).



(Fig. 2-a)

2. The number of lines per unit area through a surface perpendicular to the lines is proportional to the electric field strength in a given region (Fig. 2-b)

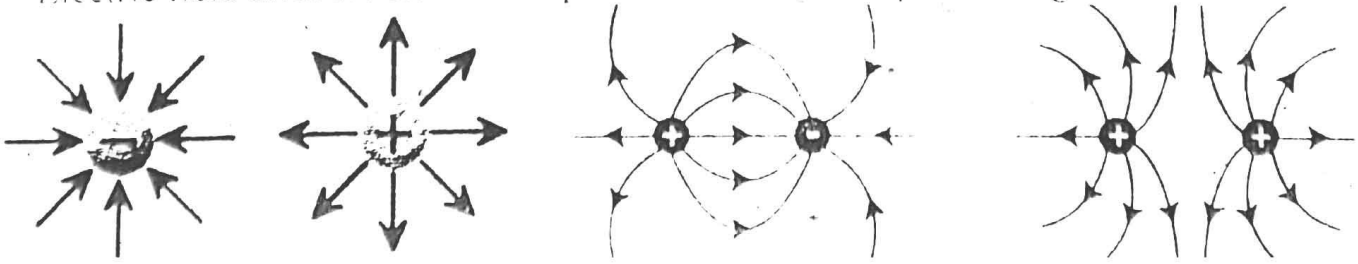


(Fig. 2-b)

3. Electric field is strong when the field lines are close together and weak when the lines are for apart.

4. No, two field lines cross each other.

Electric field lines for an isolated positive and negative point charges are shown below:



13.6 Electrostatic Potential:

Q.7 What is meant by electric potential? Explain

Electric potential:

"Electric potential at a point in an electric field is equal to the amount of work done in bringing a unit positive charge form infinity to that point."

Mathematically:

If W is the work done in moving a unit positive charge from infinity to a certain point in the field, the electric potential V at this point would be given by

$$V = \frac{W}{q} \quad \text{.....(13.6)}$$

It implies that electric potential is measured relative to some reference point and like potential energy we can measure only the change in potential between two points.

Quantity:

Electric potential is a scalar quantity.

Unit:

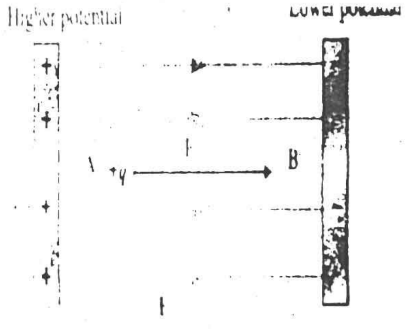
It SI unit is volt which is equal to JC^{-1}

Definition of volt:

If one joule of work is done against the electric field in bringing one coulomb positive charge form infinity to a point in the electric field then the potential at that point will be one volt. Or if the potential energy of one coulomb of charge at a point in the electric field is one joule, the potential of the point will be one volt.

Potential Difference:

A body in gravitational field always tends to move form a point of higher potential energy to a point of lower potential energy. Similarly, when a charge is released in a electric field, it moves form a point of higher potential say A to appoint a lower potential say B(Fig. 13.16). If the potential of point A is V_A and that of point B is V_B the potential energy of the charge at these points will be qv_A and qv_B respectively. The change in potential energy of the charge when it moves from point A to B will be equal to qv_A-qv_B. This energy is utilized in doing some useful work.



Thus Energy supplied by the charge = $q(v_A-V_B)$ ..... (13.7)

If q is equal to one unit, then the potential difference between two points becomes equal to the energy supplied by the charge. Thus, we define potential difference between two points as

Potential difference:

"The energy supplied by a unit charge as it moves form one point to the other in the direction of the field."

- If a positive charge is transferred form a point of lower potential to a point of higher potential i.e. against the field direction, energy would have to be supplied to it.
- When we release a negative charge in an electric field, its behaviour will be opposite to that of positive charge. A more useful unit for the electrical energy is electron volt (eV).

13.7 Capacitors and Capacitance:

Q.8 What is meant by capacitance of the conductor? Explain.

Capacitance:

"The ability of a capacitor to store charge is known as capacitance. It is the ratio of charge and electric potential".

Explanation:

When we charge a conductor, some work has to be done during the process of transferring the charge to the conductor. This raises the potential of the conductor. Experiments show that the charge Q on the conductor is directly proportional to its potential V,

$$Q \propto V$$

Or $$Q = CV \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$C = Q/V$$

Where C is a constant whose value depends upon the size of the conductor. It is known as capacitance of the conductor. In Equation [1], if V= 1 volt, then Q = C i.e., the capacitance of a conductor is equal to the amount of charge which raises the potential of the conductor by one volt.

Unit

The unit of capacitance is known as farad. It can be defined as:

Farad

"It is the capacity of that conductor the potential of which rises by one volt when one coulomb charge is given to it."

Q.9 Describe a capacitor. How does it store charge?

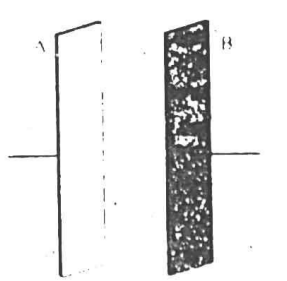
OR

Describe capacitor as an energy storing device?

Ans: "The device that is used to store electric charge is known as Capacitor"

Construction

It consists of two thin metal plates, parallel to each other with a very small distance between them. The medium between the two plates is air or a sheet of some insulator. This medium is known as dielectric. A plane parallel plate capacitor has been shown in Figure.



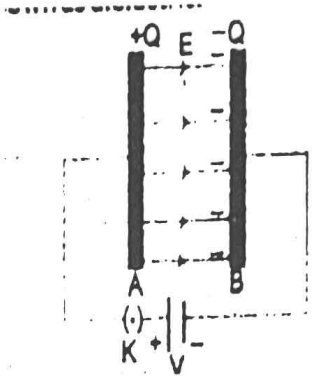
Parallel plate capacitor

Storage of charge on metals

Charge cannot be stored on a conductor for a long period of time because the stored charges mutually repel each other due to which they spread on the whole surface of the conductor and also tend to leak out from there.

Process of storing charges on capacitor

If +Q amount of charge is transferred to its plate A, due to electrostatic induction it would induce -Q charge on the inner surface of the plate B and +Q charge on its outer plate as shown in the figure. The lines offered between the plates have been shown. There exists a force of attraction between the charges +Q stored on the plate and the charge -Q induced on the inner surface of plate B. Due to this force of attraction, the charges are bound with the plate and remain stored for long periods.



Mathematical form

Due to presence of the charges on the plate, a potential difference V is created between them which is directly proportional to the charge Q given to the plate 'A'.

$$Q \propto V$$

Or $$Q = CV$$

Here C is the constant of proportionality, known as the capacitance of the capacitor.

Combination of Capacitors

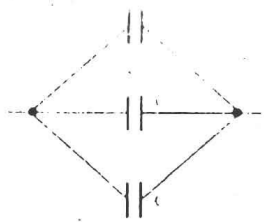
Q.10 How are the capacitors are connected in parallel? Describe the characteristics features of this combination.

OR

Derive the formula for the effective capacitance for a parallel combination of a number of capacitors.

Ans:

In this method the left plate of each capacitor is connected to the positime terminal of battery by a connecting wire. In the same way the right plate of each capacitor is connected to negative terminal of the battery.



Characteristics of parallel combination

1. Each capacitor connected to a battery of voltage V has the same potential difference V across it.
   i.e $V_1 = V_1 = V_2 = V$
2. The charge developed across the plates of each capacitor will be different due to different value of capacitances.
3. The total charge Q supplied by the battery is divided among the various capacitors. Hence

$$Q = Q_1 + Q_2 + Q_3$$

$$\text{or } Q = C_1V + C_2V + C_3V$$

$$\text{or } \frac{Q}{V} = V_1 + V_2 + C_3$$

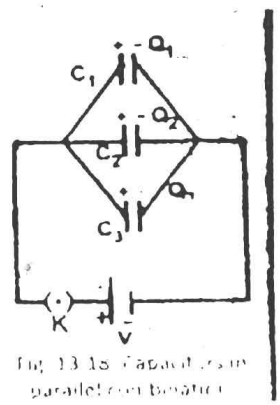


Fig. 13.18 Capacitors in parallel combination

4. Thus, we can replace the parallel combination of capacitors with one equivalent capacitor having capacitance C_{eq} (Fig. 13.19), such that

   $C_{eq} = C_1 + C_2 + C_3$

   In the case of n capacitors connected in parallel, the equivalent capacitance is given by

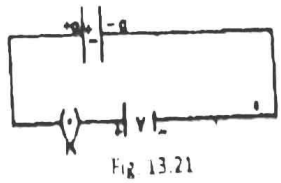


Fig. 13.21

$C_{eq} = C_1 + C_2 + C_3 + \ldots\ldots\ldots\ldots + C_n$

5. The equivalent capacitance of a parallel combination of capacitors is greater than any of the individual capacitances.

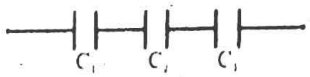
Q.11 How are the capacitors are connected in series? Describe the characteristics features of this combination.

OR

Derive the formula for the effective capacitance for a series combination of a number of capacitors.

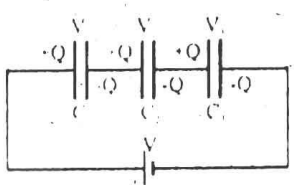
Ans:

In this method the capacitors are connected side by side. The right plate of one capacitor is connected to the left plate the next capacitor as shown in figure.



Characteristics of series combination

1. Each capacitor has the same charge across it. IF the battery supplies + Q charge to the left plate of the capacitor C_1 due to induction -Q charge is induced on the right plate of the capacitor and + Q charge on the left plate of the capacitor C_2 i.e.



$Q_1 = Q_2 = Q_3 = Q$

2. The potential difference across each capacitor is different due to different values of capacitances.

3. The voltage of the battery has been divided among the various capacitors. Hence

$$V = V_1 + V_2 + V_3$$

$$= \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$= Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

$$\frac{V}{Q} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right).$$

4. Thus, we can replace series combination of capacitors wit one equivalent capacitor having capacitance C eq i.e.,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

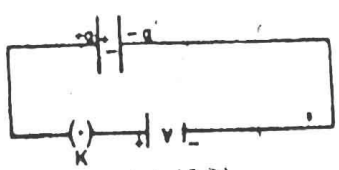


Fig. 13.21

5.In the case of n capacitors connected in series. We have

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots\ldots\ldots + \frac{1}{C_n}$$

13.8 Different Types Of Capacitors:

Q.12 Discuss the different types of capacitors.

Parallel plate capacitors are not commonly used in most devices because in order to store enough charge their size must be large which is not desirable. A parallel plate capacitor has a dielectric between its plates and is made of a flexible material that can be rolled into the shape of a cylinder. In this way, we can increase the area of each plate while the capacitor can fit into a small space. Some other types of capacitors use chemical reactions to store charge, like tiny batteries.

Types of capacitor:

Capacitors have different types depending upon their construction and the nature of dielectric used in them. Capacitors are either variable or fixed. In variable capacitors,

Definition:

Fixed capacitor

If the capacitor is such that its plates are immovable, it is known as a fixed capacitor. Its value does not change.

TYPES OF FIXED CAPACITOR:

- Paper capacitor
- Mica capacitor

Paper capacitors:

The paper capacitor has a cylindrical shape. Usually an oiled or greased paper or a thin plastic sheet is used as a dielectric between two aluminium foils. The paper or plastic sheet firmly rolled in the form of a cylinder and is then enclosed into a plastic case.

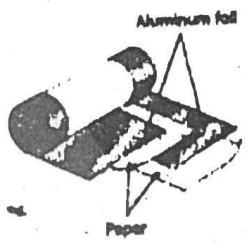
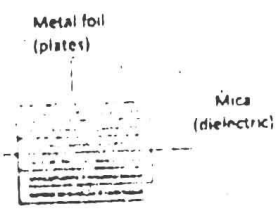


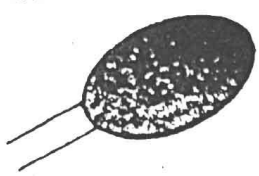
Fig. 13.22: Paper capacitor

Mica capacitor:

Capacitor another example of fixed capacitors. In these capacitors, mica is used as dielectric between the two metal plates (Fig. 13.23-a). For convenience and safety purposes it is enclosed in a plastic case or in a case of some insulator. Wires attached to plates project out of the case for making connections (Fig. 13.23-b).



If the capacitance is to be increased, large number of plates is piled up, one over the other with layers of dielectric in between and alternative plates are connected with each other.



Variable capacitor:

In variable type of capacitors some arrangement is made to change the area of the plates facing each other (Fig. 13.24). It is generally a combination of many capacitors with air as electric. It consists of two sets of plates.



One set remains fixed while the other set can rotate so the distance between the plates does not change and they do not touch each other . The common area of the plates of the two sets which faces each other, determines the value of capacitance. Thus the capacitance of the capacitor can be increased or decreased by turning the rotatable plates in or out of the space between the static plates such capacitors are usually utilized for tuning in radio sets.

AN ELECTROLYTIC

An electrolytic capacitor is often used to store large amounts of charge at relatively low voltages (Fig. 13.25). It consists of a metal foil in contact with an electrolyte –a solution that conducts charge by virtue of the motion of the ions contained In it.

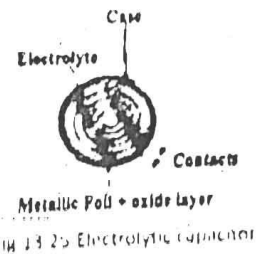


Fig 13.25 Electrolytic Capacitor

When a voltage is applied between the foil and the electrolyte, a thin layer of metal oxide (an insulator) is formed on the foil, and this layer serves as the dielectric. Enormous capacitances can be attained because the dielectric layer is very thin.

Q.13 Write down few uses of capacitors.

Uses of Capacitors:

Capacitors have wide range of applications in different electrical and electronic circuits.

For Tuning some appliance:

They are used for turning transmitters, receivers and transistor radios.

For Home appliance:

They are also used for table fans, celling fans, exhaust fans, fan motors in air conditioners; coolers, motors washing machines, air conditioners and many other appliances for their smooth working.

In electronic circuses:

Capacitors are also used in electronic circuits of computers etc.

To differentiate between Low and high frequency:

Capacitors can be used to differentiate between high frequency and low frequency signal which make them useful in electronic circuits.

A so filter circuit:

Capacitors are used in the resonant circuits that tune radios to particular frequencies. Such circuits are called filter circuit.

Ceramic:

Capacitors are generally superior to other types and therefore can be used in vast ranges of application.

13.9 Applications of Electrostatics:

Q.14 Discuss in detail important application of electrostatic.

OR

Write a note on the following

(a) Electrostatic air cleaner

(b) Spray Painting

Static electricity has an important place in our everyday lives which include photocopying, car painting, extracting dust from dirty carpets and from chimneys of industrial machinery.

Electrostatic Air Cleaner:

An electrostatic air cleaner is used in homes to relieve that discomfort of allergy sufferers.

Working of electric static Air cleaner:

Air mixed with dust and pollen enters the device across a positively charged mesh screen. The airborne particles become positively charged when they make contact with the screen. Then they pass through a second, negatively charged mesh screen. The electrostatic force of attraction between the positively charged particles in the air and the negatively charged screen cases the particles to precipitate out on the surface of the screen.

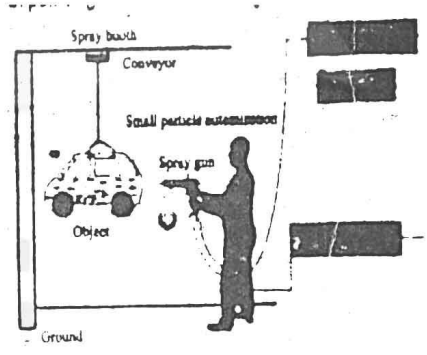
Through this process we can removes a very high percentage of contaminants form the air stream.

Spray painting;

Automobile manufacturers use static electricity to paint new cars.

Working of electrostatic spray painting:

The body of car is charged and then the paint is given the opposite charge by charging the nozzle of the sprayer (Fig.13.26) Due to mutual repulsion charge particles coming out of the nozzle form a fine mist and are evenly distributed on the surface of the object. The charged paint particles are attracted to the car and stick to the body, just like a charged balloon sticks to a wall. Once the paint dries, sticks much better to the car and is smoother because is the uniformly distributed. This is a very effective, efficient and economical way of painting automobiles on large scale.



13.26 Schematic diagram of electrostatic spray painting system. The object is charged and spray paint is positively charged. As the paint leaves the charged nozzle it repels and gives a fine mist of paint

13.10 Some Hazards of Static Electricity Lightening:

Q.15 What are the hazards of static electricity? Explain them.

There are so many hazards of static electricity. We are discussing only two of them.

(i) Lightening (ii) Fires or Explosions

(i) **Lightening**

The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunderclouds. The thunderclouds are charged by friction between the water molecules in the thunderclouds and the air molecules. When the charge on the thunderclouds is sufficiently high, it can produce positive and negative charges in the air. The he amount of negative charge is discharged to the highest object on the ground and can harm them.

This explains why it is very dangerous to swim in the open sea, play in an open filed or hide under a tree during a thunderstorm.

Precaution or prevention:

To prevent lightening from damaging tall buildings, lightening conductors are used. The purpose of the lightening conductor is to provide a steady discharge path for the large amount of negative charge in the air to flow form the top of the building to the Earth. In this way the chances of lightening damage due to sudden discharge can be minimized.

(ii) **Fires or Explosions:**

Static electricity is a major cause of fires and explosions at many places. A fire or an explosion may occur due to excessive build-up of electric charges produced by friction.

Production of static electricity:

Static electricity can be generated by the friction of the gasoline being pumped into a vehicle or container. It can also be produced when we get out of the car or remove an article of clothing. Static charge are dangerous. If static charges are allowed to discharge though the areas where there is petrol vapour a fire can occur.

The results are frightening and may be devastating.

Portable oil containers can build up a static electric charge during transport. Consequently, when the container is not placed on the ground for filling, its static electricity could be discharged and result in a fire when filling begins.

Precaution or prevention

Precaution or prevention containers should be placed on the ground during filling and the nozzle should be kept in contact with the container. Containers should not to be filled while inside a vehicle.

NUMERICAL PROBLMES

13.1.1 The charge of how many negatively charged particles would be equal to $100\mu C$. Assume charge on one negative particle is $1.6\times10^{-19}C$?

Solution: Given that,

Total Charge $Q = 100\ \mu C = 100 \times 10^{-6} C$

Charge on an electron $e = 1.6 \times 10^{-19} C$

To find: No. of negatively charged particles $n = ?$

Calculations: Using the formula

$$Q = ne$$

Or $$n = \frac{Q}{e}$$

By putting the values

$$n = \frac{100\times10^{-6}C}{1.6\times10^{-19}C}$$

$$= \frac{10^{2}\times10^{-6}\times10^{19}}{1.6}$$

$$= \frac{10^{0} \times 10^{21}}{1.6}$$

$$= \frac{1}{1.6} \times 10^{15}$$

$$= \frac{1}{16} \times 10^{16} = 0.0625 \times 10^{16}$$

$$n = 6.25 \times 10^{13}$$ **Ans**

13.1.2 Two point charges $q_1 = 10\mu C$ and $q_2 = 5\mu C$ are placed at a distance of 150 cm. What will be the Coulomb's force between them? Also find the direction of the force.

Solution: Given that

First point charge = $q_1 = 10\mu C = 10 \times 10^{-6} = 1 \times 10^{-5} C$

Second point charge = $q_2 = 5\ \mu C = 5 \times 10^{-6}\ C$

Distance r = 150 cm = $\frac{150cm}{100} = 1.5$ m

Proportionality constant = k = $9 \times 10^{9}\ Nm^2\ C^{-2}$

To Find

(i) Magnitude of Coulomb's force F = ?

(ii) Direction of Coulomb's force = ?

Calculations: According to Coulomb's law

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

By putting the values

$$F = \frac{9 \times 10^{9} Nm^2 C^{-2} \times 1 \times 10^{-5} C \times 5 \times 10^{-6} C}{(1.5m)^2}$$

$$= \frac{9 \times 10^{9} Nm^2 \times 10^{-5} \times 5 \times 10^{-6}}{2.25m^2}$$

$$= \frac{45 \times 10^{-2} N}{2.25}$$

$$= \frac{45}{225} N$$

F = 0.2 N **Ans**

The direction of coulomb's force is direction of repulsion

13.1.3 The force of repulsion between two identical positive charges is 0.8 N, when the charges are 0.1 m part. Find the value of each charge.

Solution: Given that,

Force = F = 0.8 N

Distance between the charges r = 0.1 m

Proportionality constant = $k = 9 \times 10^9\ Nm^2C^{-2}$

To Find: Value of each charger = q = ?

Calculations: Using Coulomb's law

$$F = \frac{kq_1q_2}{r^2}$$

Since the charges are identical, therefore, $q_1 = q_2 = q$, thus

$$F = k\frac{q^2}{r^2}$$

Or $\quad F \times r^2 = 9 \times 10^9\ Nm^2\ C^{-2} \times q^2$

Or $\quad q^2 = \frac{F \times r^2}{9 \times 10^9\ Nm^2C^{-2}}$

By putting the values

$$q^2 = \frac{0.8N \times (0.1m)^2}{9 \times 10^9\ Nm^2\ C^{-2}}$$

$$= \frac{0.8 \times 0.01}{9 \times 10^9}\ C^2$$

$$= \frac{0.008}{9 \times 10^9}\ C^2$$

$$q = \sqrt{\frac{0.008 \times 10^{-9}}{9}}\ C$$

$$q = 9.4 \times 10^{-7}\ C \text{ Ans}$$

13.1.4 Two charges repel each other with a force of 0.1 N when they are 5cm apart. Find the forces between the same charges when they are 2 cm apart.

Solution: Given that,

Force F $= 0.1$ N

Distance between the charges r = 5 cm = $\frac{5}{100}$ m = 0.05 m

To Find: Forces between the charge when they are 2 cm or 0.02 m apart F = ?

Calculations: According to coulomb's law,

$$F = K\frac{q.q}{r^2}$$

By putting the values

$$0.1\ N = 9 \times Nm^2\ C^{-2} \times \frac{q.q}{(0.05m)^2}$$

Or $q_1q_2 = \frac{0.1\times(0.05)^2}{9\times10^9} C^2$

Now force between the charges

$$F = k\frac{q_1q_2}{r^2}$$

By putting the values

$$F = 9\times10^9\ Nm^2C^{-2} \times \frac{(0.1)\times(0.05)^2\ C^2}{9\times10^9} \times \frac{1}{(0.02m)^2}$$

$$= \frac{(0.1)\times(0.05)^2}{(0.02)^2} N$$

F = 0.62 N **Ans.**

13.1.5 The potential lat a point in an electric field is 10^4 V. If a charge of $+100\mu C$ is brought from infinity to this point. What would be the amount of work done on it?

Solution: Given that,

Electric potential V = 10^4 V

Charge q = $+100\ \mu C = 100\times10^{-6}\ C = 1\times10^{-4}\ C$

To Find: Work done W = ?

Calculations: Using the formula

$$V = \frac{W}{q}$$

Or $W = qV$

By putting the values

$W = 10^{-4}\ C \times 10^4\ C$

W = 1J **Ans.**

13.1.6 A point charge of +2C is transferred from a point at potential 100V to a point at potential 50V, what would be the energy supplied by the charge?

Solution: Given that,

Charge q = +2C

Potential at point A V_A = 100 V

Potential at point B V_B = 50 V

To Find: Energy supplied by the charge E = ?

Calculations

Using the formula

$$E = q(V_A - V_B)$$

By putting the values

E = 2C(100V – 50V)

E = 100 J **Ans.**

13.1.7 A capacitor holds 0.06 coulombs of charge when fully charged by a 9 volt battery. Calculate capacitance of the capacitor.

Solution: Given that,

Charge Q = 0.06 C

Voltage V = 9V

To Find: Capacitance C = ?

Calculations: Using the formula

$$Q = CV$$

Or $$C = \frac{Q}{V}$$

By putting the values

$$C = \frac{0.06C}{9v}$$

$$C = 6.67 \times 10^{-3} \text{ F}$$ **Ans.**

13.1.8 A capacitor holds 0.03 coulombs of charge when fully charged by a 6 volt battery. How much voltage would be required for it to hold 2 coulombs of charge?

Solutions: Given that

Charge = Q = 0.03 C

Voltage V = 6V

To Find: Voltage to hold 2C of charge V = ?

Calculations: Since

$$0.03\ C = 6V$$

Or $$1C = \frac{6V}{0.03}$$

Therefore,

$$2C = \frac{6V}{0.03} \times 2$$

$$= \frac{1200V}{3}$$

$$V = 400 \text{ V}$$ **Ans.**

13.1.9 Two capacitors of $6\mu F$ and $12\mu F$ are connected in series with 12V battery. Find the equivalent capacitance of the combination. Find the charge and potential difference across each capacitor.

Solution: Given that,

Capacitance = $C_1 = 6\ \mu F = 6 \times 10^{-6} F$

Capacitance = $C_2 = 12\ \mu F = 12 \times 10^{-6} F$

Voltage = $V = 12\ V$

To Find

(i) Equivalent capacitance $C_{eq} = ?$

(ii) Charge on each capacitor $Q = ?$

(iii) Potential difference across one capacitor $V_1 = ?$

Potential difference across second capacitor = $V_2 = ?$

Calculations: (i) Since the capacitors are connected in series, therefore, equivalent capacitance will be

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

By putting the values

$$\frac{1}{C_{eq}} = \frac{1}{6\mu F} + \frac{1}{12\mu F} = \frac{2+1}{\mu F}$$

$$\frac{1}{C_{eq}} = \frac{3}{12\mu F}$$

Or $$C_{eq} = \frac{12\mu F}{3}$$

$$C_{eq} = 4\mu F \text{ Ans.}$$

(ii) Since the capacitor are connected in series, therefore, charge on capacitor will be

$$Q = CV$$

Or $$Q = 4 \times 10^{-6}\ F \times 12V$$

$$Q = 48 \times 10^{-6}\ FV$$

$$Q = 48\ \mu C \text{ Ans.}$$

(iii) Potential difference across capacitor of capacitance C_1 will be

$$Q = C_1 V_1$$

Or $$V_1 = \frac{Q}{C_1}$$

Or $V_1 = \frac{48\mu C}{6\mu F} = 8V$ **Ans.**

Similarly, potential difference across capacitor of capacitance C_2 will be

$$Q = C_2V_2$$

Or $$V_2 = \frac{Q}{C_2}$$

Or $$V_2 = \frac{48\mu C}{12\mu F} = 4V$$ **Ans.**

13.1.10 Tow capacitors of capacitances $6\mu F$ and $12\mu F$ are connected in parallel with a 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

Solution: Given that,

Capacitance $= C_1 = 6\mu F$

Capacitance $= C_2 = 12\mu F$

Voltage $= V = 12V$

To Find

(i) Equivalent capacitance $C_{eq} = ?$

(ii) Charge on one capacitor $Q_1 = ?$

(iii) Charge on second capacitor $= Q_2 = ?$

(iv) Potential difference across each capacitor $V = ?$

Calculations: (i) Since the capacitors are connected in parallel, therefore, equivalent capacitance will be

$$C_{eq} = C_1 + C_2$$
$$= 6\mu F + 12\mu F$$
$$C_{eq} = 18\mu F$$ **Ans.**

(ii) Charge on capacitor C_1 will be

$$Q_1 = C_1V$$

Or $$Q_1 = 6\mu F \times 12V$$

$$Q_1 = 72\mu C$$ **Ans.**

(iii) Charge on capacitor C_2 will be

$$Q_2 = C_2V$$

$$Q_2 = 12\ \mu F \times 12\ V$$

$$Q_2 = 144\mu\ C$$ Ans.

(iv) Since the capacitors are connected in parallel, therefore, potential difference across each capacitor will be 12V.