CONCEPTUAL QUESTIONS

Q. 1. *The two charged conductors are touched mutually and then separated. What will be the charge on them?*

Ans. The charge on them will be divided in the ratio of their capacitances. We know that $q = CV$. When the charged conductors touch, they acquire the same potential. Hence, $q \propto C$.

Q. 2. *The plates of a charged capacitor are connected to a voltmeter. If the plates of the capacitor are separated further, what will be the effect on the reading of the voltmeter?*

Ans. $V = \frac{q}{C}$ and $C = \frac{\varepsilon_0 A}{d}$

As the capacitor plates are separated, C decreases. Since charge on the plates remains the same, value of V increases. Hence, the reading of the voltmeter will increase.

Q. 3. *Any conducting object connected to earth is said to be grounded. Explain.*

Ans. The earth is an electron source or sink and is arbitrarily said to be at zero potential. A conducting body connected to earth is also at zero potential or "ground potential". Alternatively, the capacitance of earth is so large that removal of electrons from it or supply of electrons to it makes no difference either in the charge or potential of earth.

Q. 4. *How does a spark discharge occur between two charged objects?*

Ans. The air between the two charged objects is subjected to an electric field. If the potential gradient in the intervening air column becomes high enough, the air is ionised and conducting path is formed for free electrons which move across to discharge the surfaces. Stored electric potential energy is dissipated as heat, light and sound.

Q. 5. *If a solid dielectric is placed between the plates of a capacitor, its capacitance increases. Is there any other advantage of solid dielectric?*

Ans. There are other two advantages of a solid dielectric. First, it helps in keeping the plates close together without touching. Secondly, we can now charge the capacitor to a high potential ($V = q/C$).

Q.6. *Can you place a parallel plate capacitor (consisting of two plates) of 1 farad in your almirah?*

Ans. No. Suppose the two plates of the capacitor are separated by as small a distance as 1 mm.

$$C = \frac{\varepsilon_0 A}{d} \quad \text{or} \quad A = \frac{Cd}{\varepsilon_0} = (1) \times \frac{(1 \times 10^{-3})}{8.854 \times 10^{-12}} = 1.1 \times 10^8 \text{ m}^2$$

This area is equal to the area of a square having each side more than 10 km. Modern technology, however, has permitted the construction of 1F capacitors of very moderate size.

Q. 7. *Given a solid metal sphere and a hollow metal sphere. Which will hold more charge? Both spheres are of same radius.*

Ans. Both the spheres will hold the same charge. It is because charge remains on the outer surface of a charged conductor (whether solid or hollow) and the spheres have equal surface areas.

Q. 8. *Two capacitors of capacitances 1 μF and 0.01 μF are charged to the same potential. Which will give more intense electric shock if touched?*

Ans. $q = CV$. Since V is constant, $q \propto C$. It means that capacitor having large capacitance will store more charge. Hence, when 1μF capacitor is touched, the discharging current will be high and you will get more intense electric shock than in case of 0.01μF capacitor.

Q. 9. *Two spheres of different capacitances are charged to different potentials. They are then joined by a wire. Will total energy increase, decrease or remain the same?*

Ans. The two spheres are at different potentials. Therefore, when they are connected by a wire, there will be redistribution of charge (*i.e.*, flow of charge through wire) till the two spheres attain the same potential. Due to the flow of charge through the connecting wire, some energy will be lost as heat. Hence, the total energy after connecting the spheres will decrease.

Q. 10. *Can there be potential difference between two adjacent conductors which carry the same positive charge?*

Ans. Yes. We know that $V = q/C$. The capacitance depends upon the dimensions of the conductor. If the two conductors are of different shapes and sizes, they will be charged to different potentials when given the same charge.

Q. 11. *What are the differences between conductors and dielectrics?*

Ans. (*i*) Conductors have a large number of free electrons while dielectrics have practically no free electrons.

(*ii*) When a conductor is placed in an external electric field, there is no electric field inside the conductor. However, when a dielectric is placed in an electric field, its molecules are polarised. The effect of this polarisation is to weaken the applied electric field within the dielectric.

(*iii*) The dielectric constant of conductors is infinity while that of dielectrics is finite.

(*iv*) The dielectric strength of conductors is zero while that of dielectrics is finite.

(*v*) There is no limit to the current that a conductor can carry, provided that it can be kept cool enough. However, there is a limit to the electric flux that a dielectric will carry without breaking down.

Q. 12. *Show that capacitance of a metal plate A can be increased by bringing another metal plate B near A.*

Ans. The charge holding property of a conductor is called its capacitance. Fig. 5.47 shows an insulated metal plate *A*. Let positive charge be given to it till its potential becomes maximum. No further charge can be given to the plate as it would leak out. Now bring another insulated metal plate *B* near the plate *A* as shown in Fig. 5.47. The plate *A* will induce negative charge on the inner face of *B* and equal positive charge on the outer face. The induced positive charge tends to increase the potential of plate *A* while induced negative charge tends to decrease the potential of plate *A*. Since the induced negative charge is nearer to plate *A* than the induced positive charge, the net effect is that the potential of plate *A* decreases. Therefore, more charge can be given to plate *A* to raise its potential to maximum value. Thus the capacitance of conductor *A* is increased by bringing another uncharged conductor *B* near it.

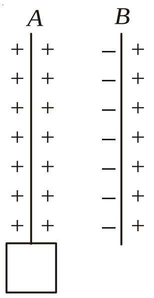

Fig. 5.47

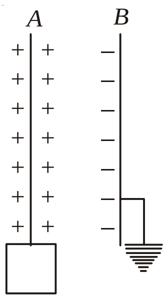

Fig. 5.48

Q. 13. *In the above question, show that capacitance of metal plate A can be further increased by earthing the plate B.*

Ans. If the plate *B* is earthed [See Fig. 5.48], the induced positive charge being free will flow to earth. However, induced negative charge remains since it is bound to the positive charge on plate *A*. As a result, the potential of plate *A* is sufficiently reduced. We can now give a large amount of charge to plate *A* to raise its potential to maximum value. We arrive at a very important conclusion that *capacitance of an insulated conductor is increased by bringing near it an uncharged earthed conductor.*

Q. 14. *Two identical metal plates are given charges q_1 and q_2 ($q_2 < q_1$) respectively. If they are now brought close to form a parallel-plate capacitor with capacitance C, what will be the potential difference between the plates ?*

Ans. Suppose *A* is the area of each plate. When the plates are held at a distance *d*, the capacitance of the parallel plate capacitor formed is

$$C = \frac{\varepsilon_0 A}{d}$$

If E_1 and E_2 are the electric fields due to two plates, then net electric field *E* between the two plates is

$$E = E_1 - E_2 = \frac{q_1 / A}{2\varepsilon_0} - \frac{q_2 / A}{2\varepsilon_0} = \frac{1}{2\varepsilon_0 A}(q_1 - q_2)$$

$\therefore$ P.D. between plates, $V = E\,d = \dfrac{1}{2\varepsilon_0 A}(q_1 - q_2) \times d = \dfrac{d}{2\varepsilon_0 A}(q_1 - q_2)$

$$= \frac{q_1 - q_2}{2C} \qquad \left[\because\ C = \frac{\varepsilon_0 A}{d}\right]$$

Q. 15. *A man fixes outside his house one evening a two metre high insulating slab carrying on its top a large aluminium sheet of area 1 m^2. Will he get electric shock if he touches the metal sheet next morning ?*

Ans. Yes, the man gets shock. The discharging current in the atmosphere will charge the aluminium sheet. When the man touches the sheet, the charge will flow to earth via the body of the man. Therefore, the man will get a shock.

Q. 16. *Capacitors P, Q and R have each a capacitance of C. A battery can charge the capacitor P to a potential difference of V. If after charging P, the battery is disconnected from it and the charged capacitor P is connected in the following separate instances to Q and R (i) to Q in parallel and (ii) to R in series, then what will be potential differences between the plates of P in the two instances ?*

Ans. When the capacitor P is charged to a potential difference V, it acquires charge $q = CV$.

(*i*) *When P is connected in parallel to Q*

Total capacitance = $C + C = 2C$

Total charge $= q + 0 = q$

$\therefore$ Potential difference V′ across each capacitor is

$$V' = \frac{q}{2C} = \frac{CV}{2C} = \frac{V}{2}$$

i.e. P.D. across $P = V/2$

(*ii*) *When P is connected to R in series*

When P is connected to R in series, the circuit is incomplete and no charge is transferred from capacitor P. Hence potential difference across the plates of P remains V.

Q. 17. *The safest way to protect yourself from lightning is to be inside a car. Comment.*

Ans. We know that electric field inside a conductor is zero. Since the body of the car is a metal, the electric field inside it is zero. The discharging current due to lightning passes to earth through the metallic body of the car.

Q.18. *Five identical capacitor plates each of area A are arranged such that the adjacent plates are at a distance d apart. The plates are connected to a battery of V volts as shown in Fig. 5.49. What is the magnitude and nature of charge on plates 1 and 4 ?*

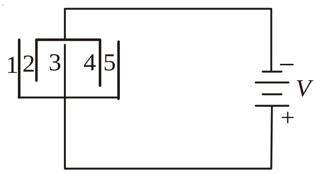

Fig. 5.49

Ans. The system constitutes 4 capacitors in parallel across V volts. Since area of each plate is A and the separation between adjacent plates is d, all the four capacitors have the same capacitance C. The plate 1 acts as a positive plate of capacitor C_1 (of capacitance C) formed between plates 1 and 2.

$$\therefore \quad \text{Charge on plate } 1 = +CV = \frac{\varepsilon_0 A}{d}V$$

The plate 4 acts as a negative plate of both the capacitors C_3 (between plates 3 and 4) and C_4 (between plates 4 and 5).

$$\therefore \quad \text{Charge on plate } 4 = -(C + C)V = \frac{-2\varepsilon_0 A}{d}V$$