Conceptual questions

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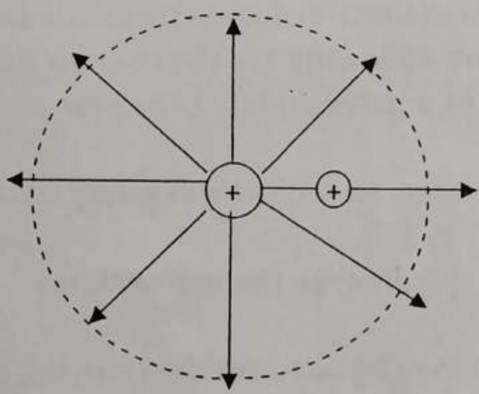
1. The electric potential is constant through a given region of space. Is the electric field zero or non-zero in this region? Explain. $E = -\frac{\Delta V}{\Delta r}$ As $\Delta V = 0$ So $E = 0$
2. If a point charge (+a) q of mass m is released in a non-uniform electric field with field lines pointing in the same direction, will it make a rectilinear motion? Yes
3. What is the relationship between voltage and energy? More precisely, what is the relationship between potential difference and electric potential energy? $U = q \times V$
4. Voltages (Potential Difference) are always measured between two points. Why? $1eV = 1V \times 1e$
5. How are units of volts and electron volts related? How do they differ?
6. In what region of space is the potential due to a uniformly charged sphere the same as that of a point charge? In what region does it differ from that of a point charge?

7. Can the potential of a non-uniformly charged sphere be the same as that of a point charge? Explain.
8. What is an equipotential line and equipotential surface?
9. Can different equipotential lines cross each other ? Explain. No
10. Water has a large dielectric constant, but it is rarely used in capacitors. Explain why?
11. A capacitor is connected in series with a resistor and charged. Explain why the potential difference across the resistor decreases with time during the charging.
12. Sketch the graphs of potential difference against time for (a) a discharging capacitor (b) a charging capacitor.
13. Compare the formula for capacitors in series and parallel with those for resistors in series and parallel. Explain why the pattern is different.
14. Explain why capacitors are of little use for storage of energy for normal domestic purposes of lighting heating and so on.

Conceptual Questions or Short Answer Questions

1. **Answer: The E.F. Intensity may or may not be zero in a region of space where electric** potential remains constant. Following cases or examples may prove helpful to explain.
   Case – 1: The region in which electric field is completely absent then electric potential will also be zero. As a special case we can say that electric potential is constant as zero. Thus in this case electric field intensity will be zero.
   Case – 2: For an equipotential surface electric potential has same value at every point but E.F. intensity is not zero at those points because equipotential surface lie within electric field.
   Case – 3: Within a charged conducting spherical shell electric potential remains constant everywhere but electric field intensity inside a conductor is zero.

2. **Yes, a point charge will follow a straight path if we release it in such a non-uniform electric field whose each electric field line points in a specific direction.**
   Consider figure – 1. In this case the charge will move along a straight line.

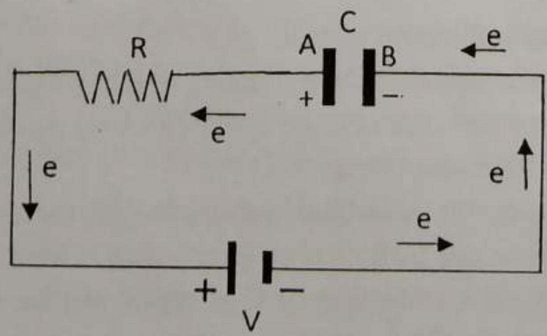


3. **Answer: Already explained in the notes.**
4. **Voltage is a general term by which we usually mean potential difference. P.d is the** magnitude of work done per unit charge between two points. Thus the concept of voltage is associated with two points.
5. **Volt is the S.I. unit of electric potential, whereas electron-volt is the unit of energy.** By definition if work done per unit charge in moving it from infinity to a field point is equal to 1 J then the electric potential of that point will be 1 V. Whereas electron-volt is the amount of K.E. when an electron moves through a p.d. of 1 V. K.E. = 1 eV = 1.6×10^{-19} J

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

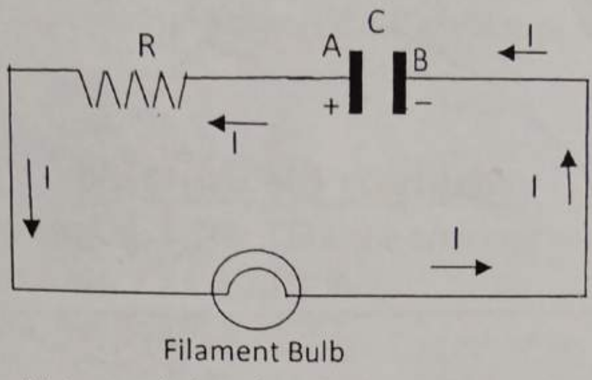
6. According to one of the applications of Gauss's law a uniformly charged conducting sphere behaves like a point charge for the region which exists outside it. Thus Outside the charged conducting sphere the formula to calculate the electric potential at some distance r (r is measured from its centre) is identical to that of point charge i.e.
$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$
But inside a charged conductor electric potential remains same everywhere i.e. inside the conductor V is independent of r, thus in the interior region a uniformly charged conducting sphere behaves differently than that of a point charge.
7. **In case of non-uniform charge on a sphere, the surface charge density will be different** at different point on its surface, as a result the contour – map of equipotential surfaces will not result concentric circles. It means that the magnitude of electric potential will not be the same at same distance from the centre of this sphere like point charge.
8. **Already explained in notes**
9. **No, different equipotential lines will not intersect because, if they do so then at the point of intersect there will be two value of electric potential which is physically not possible, because** $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$
10. **The capasitance of a parallel plate capacitor is,**
$$C = \frac{A\,\epsilon_0}{d}$$
Without changing the shape and size of the capacitor, we can increase it capacitance by introducing a non-polar dielectric of large dielectric constant. Water has a large value of dielectric constant. Following are the reasons due to which water cannot be filled between the plates of a parallel plate capacitor.
1. It is non.polar
2. Only pure water is insulator. An impurity in a very small fraction can make it conducting.
3. It causes rusting which can damage the metal plates.

11. **Consider the circuit which may be used for the charging of a capacitor.**

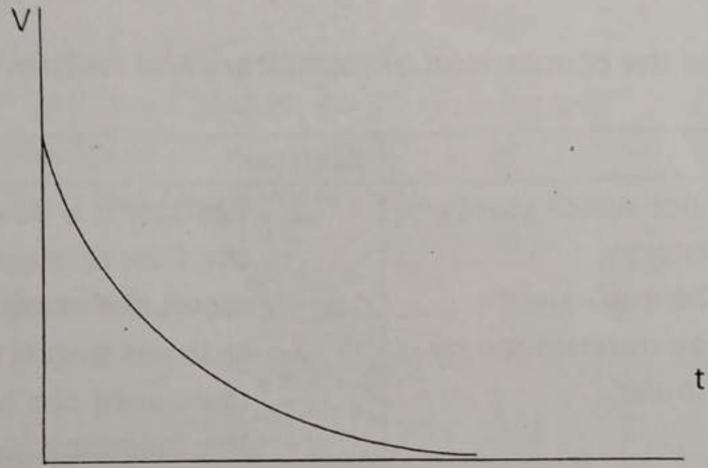


From the circuit, $V = V_R + V_C \rightarrow (1)$. Initially the charge on the capacitor is zero therefore, $V_C = Q/C$, will be zero and the whole voltage of the source will be available across resistor only. But gradually when the capacitor charges V_C will increase. As V (source voltage) remains constant therefore, according to eq.1 V_R will decrease.

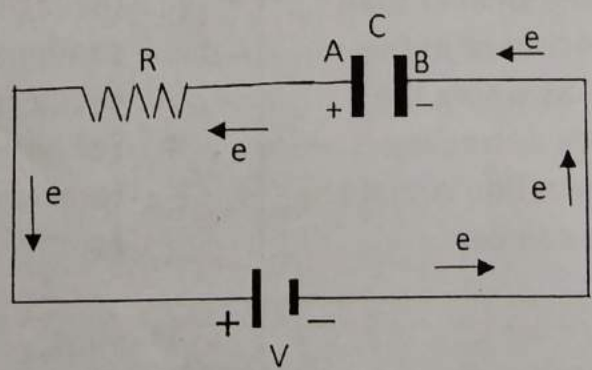
12. The circuit used for the discharging of a capacitor may look like fig.1.



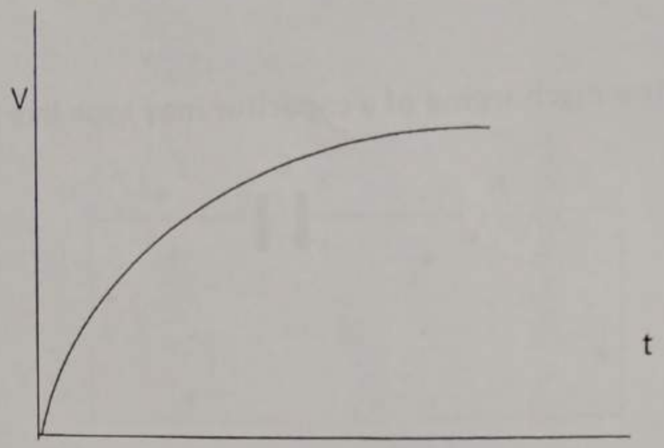
As Q$\propto$ V, therefore, the V-t graph for the discharging process will look like fig.2



Similarly, the circuit used for the charging of a capacitor may look like fig.3.



As $Q \propto V$, therefore, the V-t graph for the discharging process will look like fig.4



13. The following table gives the comparison of capacitors and resistors in parallel and series combination.

Capacitor	Resistor
1. Capacitor is a device which stores electric charge/ energy. 2. In series circuit the equivalent capacitance can be determined by the following formula: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ 3. When capacitors are connected in series then the equivalent capacitance is even smaller than the smallest capacitance in the combination. i.e. as whole the circuit capacitance decreases. 4. For parallel combination circuit the total capacitance can be determined as: $C_{eq} = C_1 + C_2 + C_3$ 5. In parallel combination the total capacitance will be even greater than the highest capacitance in the combination. i.e. as a whole the circuit capacitance increases.	1. Resistor is a device which opposes the flow of electric charge. As a result the charge loses energy. 2. In series circuit the equivalent resistance can be determined by the following formula: $R_{eq} = R_1 + R_2 + R_3$ 3. In series combination the total resistance will be even greater than the highest capacitance in the combination. i.e. as a whole the circuit resistance increases. 4. For parallel combination circuit the total resistance can be determined as: $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ 5. When resistors are connected in parallel then the equivalent resistance is even smaller than the smallest resistance in the combination. i.e. as whole the circuit resistance decreases.

14. Following are some of the common reasons due to which capacitors cannot be used as alternate power source.

1. The amount of energy/charge that is stored in a capacitor is very small.
2. The value of time constant (RC) is very small due to which the capacitor discharges quickly.
3. During discharging process the potential difference does not remain constant.