CONCEPTUAL QUESTIONS

Q 1. Why it is not possible to measure the drift speed for electron by timing their travel along a conductor?

Ans: First reason is that when a conductor is connected to a voltage source, the randomly moving electrons get a net direction to travel in the presence of electric field produced due to source voltage (E=V/d). These electrons when move, also collide with the atoms of conductor. Due to this collision, their velocity changes and the electrons do not move straight rather they make a zigzag shaped motion with increasing and decreasing speed. Thus they do not travel appreciable distance so that their time of travel can be measured to calculate drift velocity. This is the reason that we cannot measure the value of drift velocity for electrons.

Second reason is that the electrons are identical particles and in order to find out which electron is moving, we have to assign it a number so that we can concentrate on any one electron to time its travel and calculate drift velocity. But electrons cannot be distinguished from each other.

Q 2. Relationship $R = \frac{V}{i}$ tells us that the resistance of a conductor is directly proportional to the P.D applied to it. What do think of this proportion?

Ans: The relation $R = \frac{V}{i}$ is mathematical form of Ohm's law in which R is the resistance and it is a constant of proportionality subject to the condition that physical state (temperature) of the system remains same while the current i is proportional to the applied potential difference V. When voltage is changed, the current also changes proportionally and their ratio $\frac{V}{i}$ remains the same. So R is not proportional to potential difference V.

Q 3. A heavy duty battery of a truck maintains a current of 3A for 24 hours. How much charge flows from the battery during this time?

Ans: In the given question current i = 3 A and its time of travel t = 24 hrs is given. In order to find the charge q flowing during the given time, we use equation q = i t but time t needs to be converted in SI unit (second). So with this conversion, putting the values in equation we get

$$q = 3\ A \times (24 \times 60 \times 60)\ s$$

$$q = 259200\ C = 0.26\ \mu C$$

Q 4. While analyzing circuit internal resistance of emf sources are ignored why?

Ans: Internal resistance is in fact, the resistance offered by emf source to the flow of charges. In the normal conditions, the load resistor R (one or more), connected across an emf source are very large in magnitude whereas the resistance of the emf

source (r) is very small and consequently the potential drop (ir) across it is also very small. Therefore, in analyzing a circuit we usually ignore this small resistance.

Q 5. Under what circumstances can terminal P.D. of a battery exceed its emf?

Ans: Whenever a source of emf ε is being charged, its terminal potential difference V_t exceeds the emf. In a closed circuit, having source of emf ε connected, the terminal potential difference V_t is lesser than emf itself due to potential drop (i r) across internal resistor of emf source. The equation for terminal potential difference is;

$$V_t = \varepsilon - ir$$

Now if an emf source in this state is charged, then its current reverses in direction making terminal potential difference greater than the emf ε of the circuit.

$$V_t = \varepsilon - (-ir) = \varepsilon + ir$$

$$V_t = \varepsilon + ir$$

Last equation shows that during charging of an emf source, its terminal potential difference exceeds the emf ε.

Q 6. What is the difference between an emf and a P.D?

e.m.f	Potential Difference
1. e.m.f ε of the cell is potential difference between terminals of a cell (or emf source) when no current flows through it or even when it is an open circuit.	1. When circuit is closed and current i starts flowing through load R, then the product of current and resistance R is called as terminal potential difference V_t
2. Emf ε of the cell is usually greater than the terminal potential difference.	2. Usually terminal potential difference V_t is lesser than emf ε of the cell due to the potential drop across the internal resistor (ir) of the emf source
3. Emf causes the flow of the current as a result of which potential difference is developed across any two points in the circuit. So, emf is regarded as the cause.	3. Terminal potential difference is regarded as the effect of electromotive force (emf).
4. If emf ε and current i are known, we can measure total electrical power of the source.	4. If potential difference V_t and current i are given, we can calculate power dissipated across the load resistor R.
5. The emf of a source is given as; $\varepsilon = V_t + ir$	5. The terminal potential difference across a load is measured as; $V_t = \varepsilon - i$

Q 7. The loop rule is based on the conservation of energy principle and the junction rule on conservation of charge principle. Explain just how these are based on these principles?

Ans: Starting with the loop rule (KVL), which says that in a closed circuit or loop, sum of all potential drops across load resistors is equal to the sum of all emf sources. It means that total energy supplied by all emf sources to each coulomb of charge is equal to the total energy consumed by resistors which is in accordance with the law of conservation of energy.

Now junction rule (KCL) says that at a junction, sum of all the currents entering is equal to the sum of all the currents leaving it. It means that at a junction, total charges entering per unit time is equal to total charges leaving the junction at the same time. Charges cannot accumulate at the junction. Thus we can say that loop rule is based on the conservation of energy principle and the junction rule on conservation of charge principle.

8. Why rise in temperature of conductor is accompanied by rise in resistance

Ans: Resistance of a conductor arises due to the collision of charges with the atoms of the conductor. These atoms are vibrating about their mean position with a particular amplitude. When temperature increases, thermal motion of atoms of the conductor also increases. This increases the amplitude of vibration of the lattice atoms. Therefore, more collisions of electrons occur with lattice atoms during their passage and hence resulting in increase in resistance. Equation shows resistance for a conductor at a temperature "T"

$$R_T = Ro\,(1 + \alpha\, T)$$

Q 9. Does the direction of emf provided by a battery depend on the direction of current flow through the battery?

Ans: No, the direction of emf provided by a battery does not depend on the direction of current flow through the battery. An emf source has two terminals; a positive at higher potential and the other negative terminal at lower potential. It is the intrinsic property of a battery that direction of emf within it is always from lower potential to higher potential. However terminal potential difference V_t in the outside circuit depends upon the direction of current through it.