EXPERIMENT

AIM

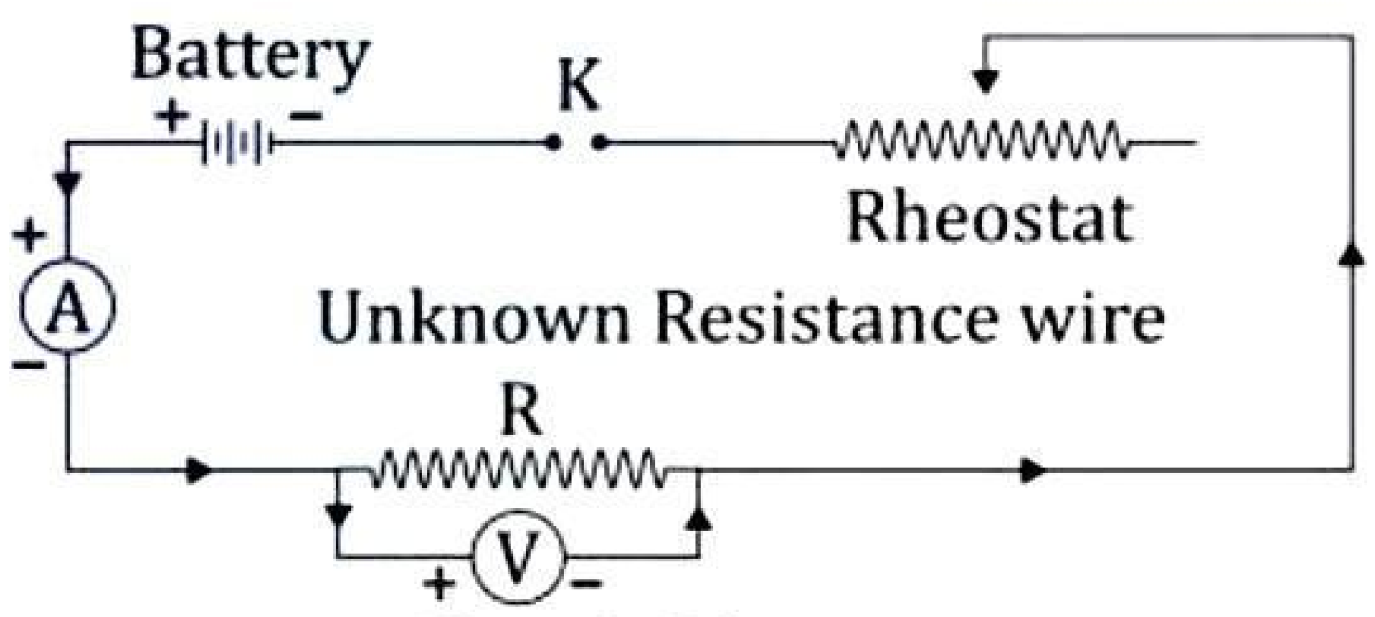
To determine resistivity of two/three wire by plotting a graph for potential difference versus current.

MATERIAL REQUIRED

A long uniform homogeneous resistance wire stretched between two points on an insulating board (say meter bridge) provided with terminals to make connections and a meter sealed laid alongside to measure its length a jockey, an acid accumulator, a voltmeter (0 – 3V), a rheostat (10Ω), an ammeter (0 – 100mA), a plug key (one way), connecting wires a piece of sandpaper, SWG plate and SWG table.

NOTE: The range of the ammeter should be judiciously decided following the resistance of the wire in use, for example, if you use a potentiometer of 10 wires instead of a meter bridge, the range of the ammeter should be (0 – 10mA), or otherwise correct measurement of current and hence that of resistance would not be possible.

DIAGRAM



Circuit Diagram

THEORY

1. **Ohm's Law:** The current flowing through a conductor is directly proportional to the applied voltage, provided that the temperature and other physical conditions of the conductor remain unchanged. If I is the current flowing through the wire and the potential difference across its ends is V then, according to Ohm's law;

$$V \propto I$$

$$\boxed{V = RI} \quad \text{.................................(i)}$$

   Here, the constant R is called the resistance of the conductor.

2. Resistance of a given wire is the opposition to the flow currently offered by the wire when connected across a source of potential difference.
3. It is a scalar quantity measured in ohm (Ω). The resistance of a wire is 1Ω, when 1A current flows through it on connecting a potential difference of 1 V across it. Resistance is the property of an object.
4. The resistance of a wire is given by,

$$\boxed{R = \rho\frac{l}{A}} \quad \text{...............................(ii)}$$

   Where,

ρ = Resistivity of the material of the wire
l = Length
A = Area of cross-section of the wire
S.I. unit of resistivity is ohm meter (Ωm). Resistivity is the property of a material.

5. From Ohm's Law

$$V = RI = \rho\frac{l}{A}I \quad \text{.........................(iii)}$$

$\frac{V}{l}$ = Potential gradient gives the magnitude of the electric field (E) developed in the conductor which forces the charge carriers in it to move.

$$E = \frac{V}{l} = \frac{R}{l}I = \frac{\rho}{A}I = \frac{J}{\sigma}$$

Where, $j = \frac{I}{A}$ is called current density and $\sigma = \frac{1}{\rho}$ is called the conductivity of the material of the condutor.

6. The constant, resistance per unit length of a conductor, is an important physical quantity. It is a scalar quantity measured in Ωm^{-1}.

$$\lambda = \frac{R}{l} = \frac{\rho}{A} = \text{constant} \quad \text{............................(iv)}$$

Wires of different SWG values have different resistance per unit length. Just by knowing λ, from SWG tables, we can know the length of the wire of a given material required for making the resistance of the desired value. From equations (iii) and (iv), we can write,

Potential gradient,

$$\frac{V}{l} = \lambda I$$

∴ If we plot a graph between the potential gradient and current, the slope of the graph will give us $\lambda = \frac{R}{l}$, i.e., the resistance per unit length.

PROCEDURE

1. Clean the ends of connecting wires by rubbing them with sandpaper.
2. Remove the plug from the single way plug key and arrange the apparatus.
3. Make connections as shown in figure taking care in connecting the positive terminals of the meters. Remember that current always enters a meter from its positive terminal.
4. See that pointer stays at the zero mark in a meter. If it is not so, adjust the position of the pointer at zero using a screwdriver and zero adjusting screw of the meter.
5. Read the maximum value marked on the scale of a meter (×) and count the total number of divisions on the scale (N). Then dividing x by N, you can find out the least count of the measuring device. Thus, find out the least count of the ammeter and voltmeter.
6. Adjust the sliding contact of the rheostat for the maximum resistance position of voltage across the resistance wire.
7. Insert the plug in the key and check those pointers in meters deflect in the clockwise direction. If it is not so, you may need to reverse the connections at the terminals of the meter. Placing the jockey at A, adjust the rheostat for maximum deflection within the range.
8. Place jockey at 20 cm mark, record ammeter and voltmeter reading.
9. Repeat the experiment atleast four more times placing the jockey at 40 cm, 60 cm, 80 cm and 100 cm.
10. Record observations in the table.
11. Plot a graph between potential gradient and ammeter readings taking potential gradient on the y-axis and ammeter readings on the x-axis.

OBSERVATIONS

1. SWG number of the wire = _______
2. Range of ammeter = _______ A to _____ A
3. Least count of ammeter = _______ mA = _____ A
4. Range of voltmeter = _______ V to _____ V
5. Least count of voltmeter = _______ V

FOR WIRE ONE; $l = 21$ cm

S. No.	Voltmeter reading - $n \times$ L.C. (in volt)	Ammeter reading- $n \times$ L.C. (in ampere)	Resistance of given wire, $(R=\frac{V}{I})$ Ω
1.	$2 \times \frac{1}{20}$	$1 \times \frac{1}{20}$	$\left(2 \times \frac{1}{20}\right) \div \left(1 \times \frac{1}{20}\right) = 2\Omega$
2.	$6 \times \frac{1}{20}$	$3 \times \frac{1}{20}$	$\left(6 \times \frac{1}{20}\right) \div \left(3 \times \frac{1}{20}\right) = 2\Omega$
3.	$8 \times \frac{1}{20}$	$4 \times \frac{1}{20}$	$\left(8 \times \frac{1}{20}\right) \div \left(4 \times \frac{1}{20}\right) = 2\Omega$
4.	$12 \times \frac{1}{20}$	$6 \times \frac{1}{20}$	$\left(28 \times \frac{1}{20}\right) \div \left(7 \times \frac{1}{20}\right) = 2\Omega$

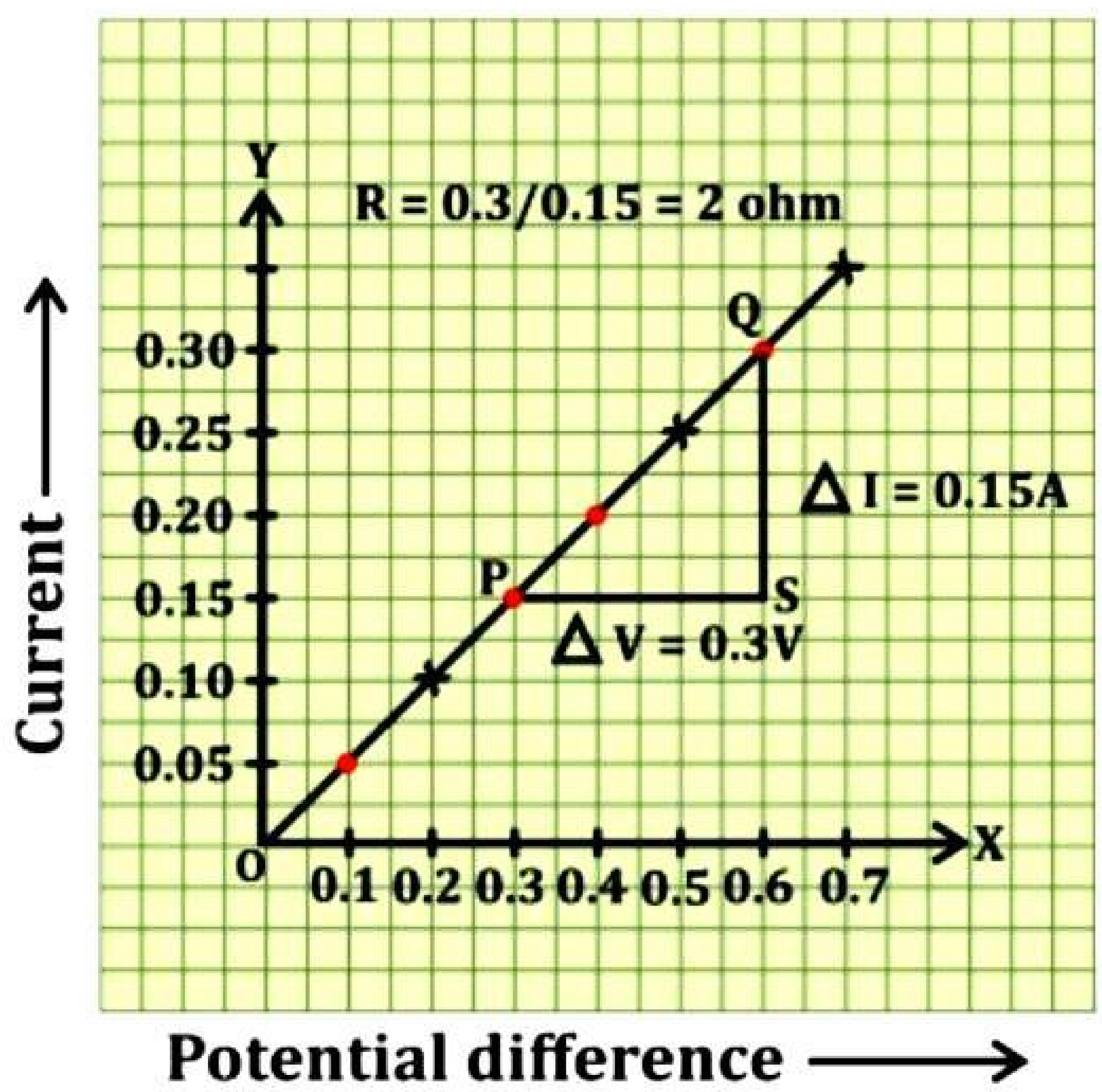
FOR WIRE TWO; $l = 42$ cm

S. No.	Voltmeter reading - $n \times$ L.C. (in volt)	Ammeter reading- $n \times$ L.C. (in ampere)	Resistance of given wire, $(R=\frac{V}{I})$ Ω
1.	$4 \times \frac{1}{20}$	$1 \times \frac{1}{20}$	$\left(4 \times \frac{1}{20}\right) \div \left(1 \times \frac{1}{20}\right) = 4\Omega$
2.	$12 \times \frac{1}{20}$	$3 \times \frac{1}{20}$	$\left(12 \times \frac{1}{20}\right) \div \left(3 \times \frac{1}{20}\right) = 4\Omega$
3.	$20 \times \frac{1}{20}$	$5 \times \frac{1}{20}$	$\left(20 \times \frac{1}{20}\right) \div \left(5 \times \frac{1}{20}\right) = 4\Omega$
4.	$28 \times \frac{1}{20}$	$7 \times \frac{1}{20}$	$\left(28 \times \frac{1}{20}\right) \div \left(7 \times \frac{1}{20}\right) = 4\Omega$

CALCULATIONS

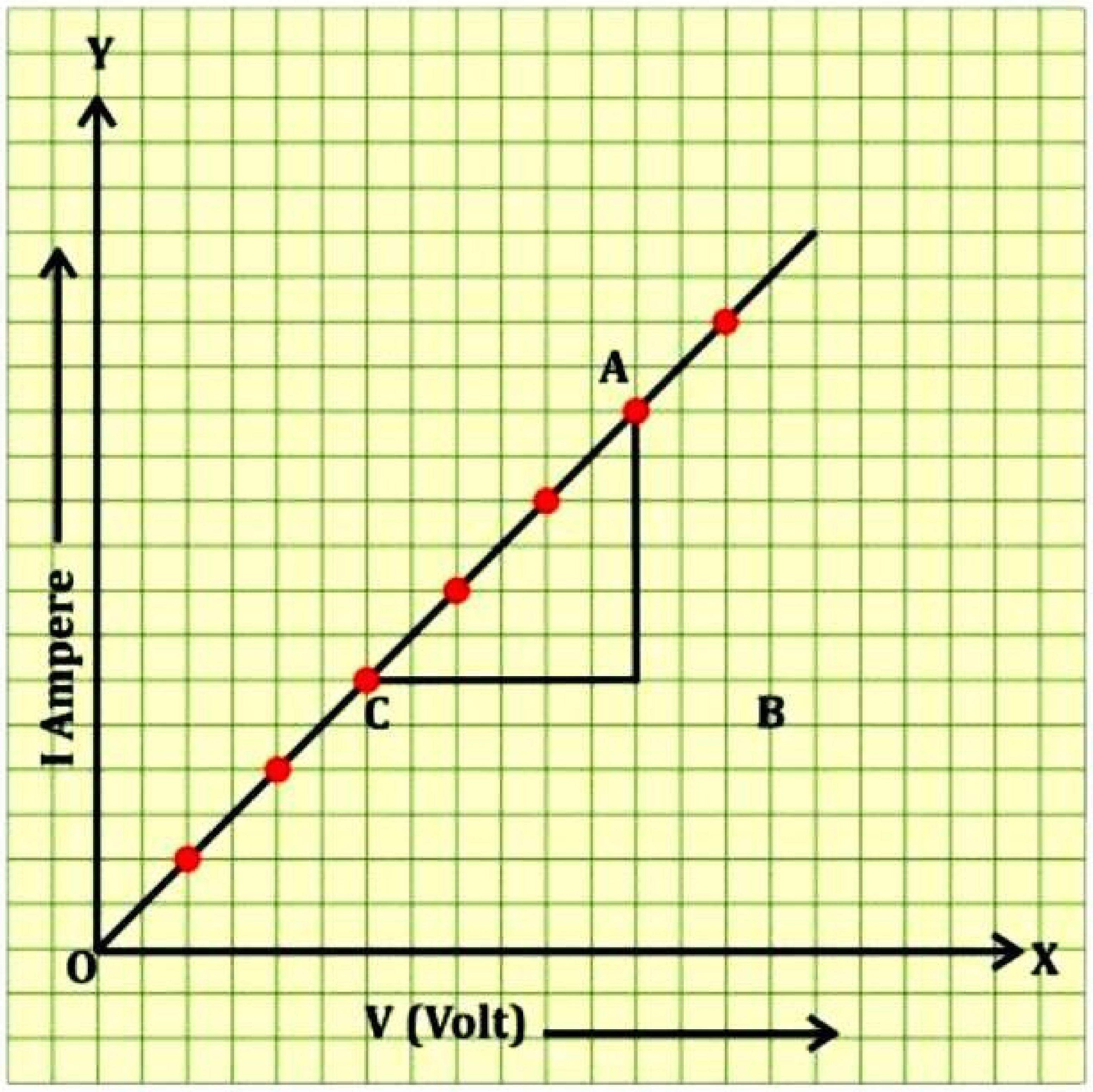
GRAPH FOR POTENTIAL VERSUS CURRENT:

GRAPH FOR WIRE ONE;



Resistance of wire one from the graph, $R = \frac{PS}{QS}$ (i.e. reciprocal of slope of the graph) $\approx 2\Omega$

GRAPH FOR WIRE TWO;



Resistance of wire two from the graph, $R = \frac{BC}{AB}$ (i.e. reciprocal of slope of the graph) $\approx 4\Omega$

Resistivity of wire one:- $\rho_1 = R_1 \frac{A}{l_1} = \frac{2 \times 3.14 \times (0.04)^2}{21 \times 4} \approx 1.19 \times 10^{-4} \Omega - cm$

Resistivity of wire two:- $\rho_2 = R_2 \frac{A}{l_2} = \frac{4 \times 3.14 \times (0.04)^2}{42 \times 4} \approx 1.19 \times 10^{-4} \Omega - cm$

RESULT

The value of resistivity of two given wires of different lengths is $\approx 1.19 \times 10^{-4} \Omega - cm$.

PRECAUTIONS

1. Measuring instruments of proper range and least count as per the requirement of the experiment should be selected.
2. The instruments you are using are normally quite delicate. Wrong connections and mishandling may damage some of them. So, draw the circuit diagram at the beginning of the experiment and get it checked by your teacher.
3. While making connections, keep the plug off the key, and insert the plug in the key only while taking observations.
4. Before plugging in the key make sure that all connections are right and tight - ammeter in series, voltmeter in parallel and current entering each terminal from its positive terminal.
5. The accumulator used should be fully charged and the unknown external resistance should have higher resistance than the internal resistance of the accumulator.

SOURCES OF ERROR

1. The wire may not be of uniform cross-section.
2. Connections may not be tight or contact resistance may vary.
3. Zero adjustments might not be proper.
4. Faults in the calibration of meters.
5. Human errors.

VIVA- VOCE

Q 1. What do we need to measure resistance per unit length of a wire?

Ans. It helps us to make the resistance of the desired value.

Q 2. On what factors does the resistance per unit length of a wire depend?

Ans. On resistivity of the material of the wire and the area of cross-section of the wire.

Q 3. If the radius of the wire is doubled, how will the resistance per unit length change?

Ans. Resistance per unit length will be $\frac{1}{4}$th the value of resistance of the thinner wire.

Q 4. Is the resistance per unit length of a wire constant?

Ans. Yes, provided the wire is of uniform cross-section, made of homogeneous material, and its temperature remains constant.

Q 5. Name the law you applied to determine the resistance of the given wire.

Ans. Ohm's law.

Q 6. State Ohm's law.

Ans. The potential difference across a conductor is directly proportional to the current flowing through it, provided that the temperature and other physical conditions of the conductor remain constant.

Q 7. What do you mean by other physical conditions?

Ans. Pressure on the conductor, or magnetic field around the conductor.

Q 8. Is Ohm's law universal?

Ans. No, Ohm's Law is applicable for conductors only that too for moderate values of potential difference.

Q 9. How do you make sure whether a certain circuit element is obeying Ohm's law or not?

Ans. By plotting its V-l graph. If the graph is a straight line, it obeys Ohm's law.