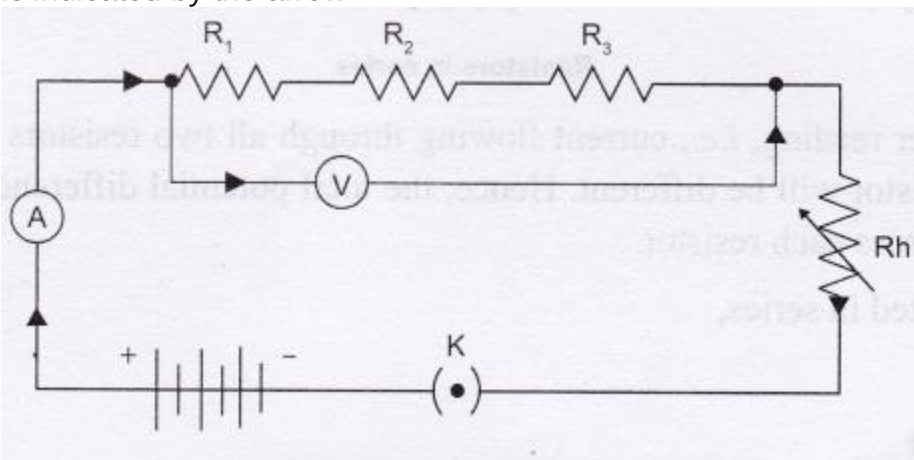
Resistors in Series

Introduction

- Resistors can be connected in series or in parallel.
- In series connection the current flows through them one after another. The circuit given below shows three resistors connected in series, and the direction of current is indicated by the arrow.



Circuit diagram for resistors in series

- Since the current travels through only one path/route hence the current flowing through each of the resistors is the same. The total current flowing through the circuit is always the same in series.
- Also, the voltage drops across the resistors must add up to the total voltage supplied by the battery. The voltage
  across each resistor would be V_1 , V_2, and V_3 . Hence the total voltage is:
  $V_{total} = V_1 + V_2 + V_3$
- The total number of electrons moving from one end of the battery and reaching the other end of the battery is same. But the speed with which the electrons are flowing from each resistor would be different. Depending on the path the electrons get to flow through each resistor.

Drawbacks of series circuit connections

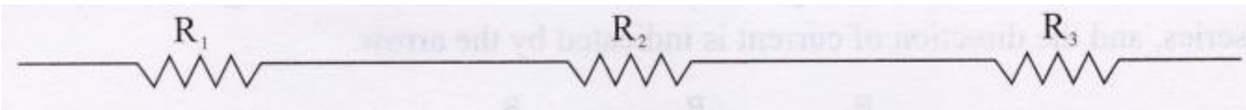
- When the current flows through the wire, the flow of electrons are obstructed by the atoms of the wire and the friction produced causes the loss of energy in the form of heat energy.
- In series connection, if two bulbs are connected then both the bulbs will be dimmer as compared to their original voltage.
- In series connection, we cannot switch off only one device without turning both off.
- There will be chances of short circuiting because loss of current or overflowing of current.

- Series connection can damage the electrical appliance due to flow of huge amount of current which may be not required by that appliance.

EXPERIMENT – 2

Aim
To determine the equivalent resistance of two resistors when connected in series.
Theory

- Resistance of a wire can be increased or decreased depending on its combinations and connections in a circuit.
- Resistors are joined in the circuit in two different methods, i.e., in series and in parallel.
- If two resistors named as R_1 and R_2 are joined end to end they are said to be connected in series.



Resistors in series

- In such a case the ammeter reading, i.e., current flowing through all two resistors will be same but the potential difference across each resistor will be different. Hence, the total potential difference V is the combination of two different volts obtained across each resistor.

.’. If R_1 and R_2 are connected in series,
$R = R_1 + R_2$
Where current I = constant
But potential difference $V = V_1 + V_2$
∴ On applying Ohm's law to the three resistors separately, we get

$V_1 = IR_1$ …(1)
$V_2 = IR_2$ …(2)
Total $V = V_1 + V_2$
$V = IR_1 + IR_2$
$V = I(R_1 + R_2)$

This proves that total resistance R for connection in series combination is:
$R = R_1 + R_2$

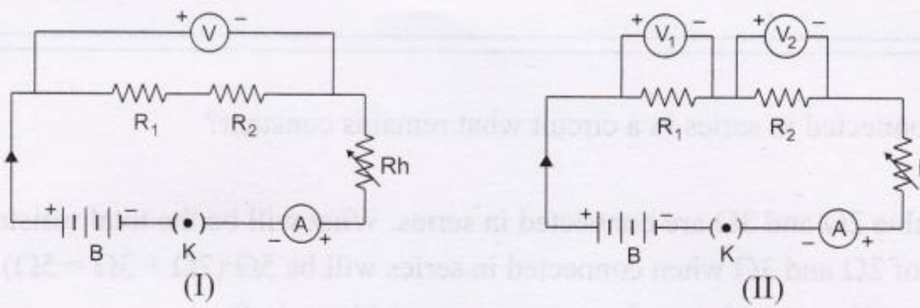
Materials Required

- Two resistors of different values for example,
  R, = 1 Ω, R, = 2Ω.
- Battery of 6 volt.

- Ammeter, plug key, connecting wires, a piece of sand paper, voltmeter and rheostat.

Procedure

1. Make the connections according to the diagram given below.
2. Do not ‘on’ the key.
3. Connect ammeter in series and voltmeter in parallel and rheostat in series in the circuit.
4. Carefully check the +ve and -ve terminals of the battery, voltmeter and ammeter, and the connections as shown in Fig. I.
5. Record the ammeter reading and the voltmeter reading by inserting the key.
6. By adjusting rheostat note three readings.
7. Now connect voltmeter in parallel one by one to individual resistance as shown in Fig. II and note down the readings.
8. Plug the key. Measure the potential difference across the first resistor. Let it be V_1 .
9. Similarly, measure the potential difference across the second resistor, separately. Let the value be V_2.
10. Calculate the relationship between V, V_1, and V_2.



B = battery (6V)
K = key
A = ammeter
V = voltmeter
$R_1 = 1\,\Omega$
$R_2 = 2\,\Omega$
Rh = Rheostat
V_1, V_2 = voltmeter readings for individual resistors.

Observation Table

Resistor Used	No. of Observations	Voltmeter Reading in Volts (V)	Ammeter Reading in Ampere (I)	$R = \frac{V}{I}$ (in Ohm)	Mean Value of Resistance (Ohm)
R_1 (1st Resistor)	(a)	0.01	0.01	1	$R_1 = \frac{1+1+1}{3}\,\Omega\,\frac{3}{3} = 1$ Ohm
	(b)	0.02	0.02	1	
	(c)	0.04	0.04	1	
R_2 (2nd Resistor)	(a)	0.02	0.01	2	$R_2 = \frac{2+2+2}{3}\,\Omega\,\frac{6}{3} = 2$ Ohm
	(b)	0.06	0.03	2	
	(c)	0.08	0.04	2	
$R_S = R_1 + R_2$ (Series Combination)	(a)	0.03	0.01	3	$R_S = \frac{3+3+3}{3}\,\Omega\,\frac{9}{3} = 3$ Ohm
	(b)	0.06	0.02	3	
	(c)	0.09	0.03	3	

Result

1. The calculated value of $R_s = R_1 + R_2 = 3\,\Omega$
2. The experimental value of $R_s = 3\,\Omega$
   The above two values are close to each other.
   Hence, $R_s = R_1 + R_2$ is verified.

Precautions

1. The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sandpaper.
2. Connections should be tight otherwise some external resistance may introduce in the circuit.
3. Connections should be made as per the circuit.

4. The ammeter should be connected in series with the resistor such that the current enters at the positive terminal and leaves at the negative terminal of the ammeter.
5. Voltmeter should always be connected in parallel to resistor.
6. Calculate the least count of voltmeter and ammeter correctly.
7. The pointers of the ammeter and voltmeter should be at zero mark when no current flows through the circuit.
8. Current should be passed through the circuit for a short time while taking observations; otherwise a current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

Viva Voce

Question 1:
If the resistors are connected in series in a circuit what remains constant?
Answer:
Current.

Question 2:
Two resistance of value 2Ω and 3Ω are connected in series. What will be the total resistance?
Answer:
The total resistance of 2Ω and 3Ω when connected in series will be 5Ω (2Ω + 3Ω = 5Ω).

Question 3:
What is the potential difference when resistors are connected in series?
Answer:
The potential difference V for the series of resistors in a circuit will be the sum of all the potential differences.
$V = V_1 + V_2 + V_3$ ….

Question 4:
How do we connect the voltmeter in a circuit where resistors are in series?
Answer:
The voltmeter is connected parallel in a circuit where resistors are in series.

Question 5:
When several resistors are joined in series what is the total resistance in combination?
Answer:
The total resistance R is equal to the sum of their individual resistance R_1, R_2, R_3,…
∴ $R = R_1 + R_2 + R_3 +$…………..

Practical Based Questions

Question 1:
How will you connect the three resistors given to you so that the resultant resistance is increased?
Answer:
The resistors should be connected in series to get the resultant resistance maximum.

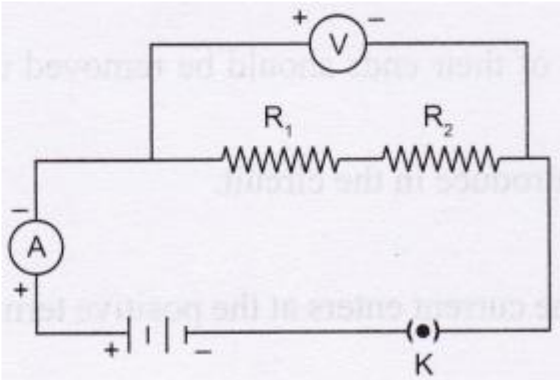
Question 2:
When three resistors of different resistance are connected in series, what will be the current flowing through each resistor?
Answer:
The current will be the same in all the three resistors when connected in series. But the potential difference will be different.

Question 3:
Two equal resistors are connected in series. What will be the total resistance?
Answer:
If two equal resistors of resistance R each, when connected in series the total resistance will be R + R = 2R

Question 4:
What will be the voltmeter reading when 5A current is flowing through 2Ω and 3Ω resistors connected in series?
Answer:
The voltmeter reading across 2Ω resistor will be
$V = IR$
$V_1 = 5 \times 2 = 10$ V
and across 3Ω resistor will be
$V_2 = 5 \times 3 = 15$ V.
$V_1 + V_2 = V$
So, $V = 10 + 15 = 25$ V

Question 5:
Draw a circuit diagram to show the two resistors of equal resistance connected in series.

Answer:



NCERT Lab Manual Questions

Question 1:

If two resistors having resistances of 2Ω and 4Ω, respectively are connected in a series combination in an electric circuit, what will be the net resistance in the circuit?

Answer:

The net resistance when the resistors are connected in series is calculated by:

$R_s = R_1 + R_2$

Resistance is series = 2 + 4 = 6Ω

Question 2:

In an electric circuit, a resistor of 5 Ω resistance is connected to a battery (5 V) through an ammeter and a plug key. Now in this circuit an another resistor of 10 Ω is connected in series with the 5 Ω resistor. Will there be any change in the ammeter reading? How much?

Answer:

The current in the electric circuit when 5 ohm resistance and 5 V potential difference is connected:

I = V/R, 5/5 = 1 A

When 10 ohm resistor is connected in series with 5 ohm, the equivalent resistance is:

$R_s = R_1 + R_2$= 5 + 10=15 ohm.

The current will be: I = V/R, 1 = 5/15 = 1/3 A

The overall change in the ammeter reading will be: 1 – 1/3 = 2/3A

Question 3:

In the above question, what is the potential difference across the two ends of the resistor of 5 Ω resistance, when it is alone in the circuit? What is the potential difference across the two ends of resistor of 5 Ω resistance when it is connected in series with the resistor of 10 Ω resistance? What is the potential difference across the series combination?

Answer:

The potential difference across the resistor of 5 ohm resistance is:

$V_1 = I_1R_1$ = 1 x 5 = 5V

Potential difference across the resistor of 5 ohm resistance when it is connected in series with the resistor of 10 ohm resistance is:
$V_2 = I_2 R_1 = 1/3 \times 5 = 5/3$ V ($I_2 = 1/3$A, from Q.2)
Potential difference across the series combination is:
$V_3 = I_2(R_1 + R_2) = 1/3 \times (5 + 10) = 1/3 \times 15 = 5$ V

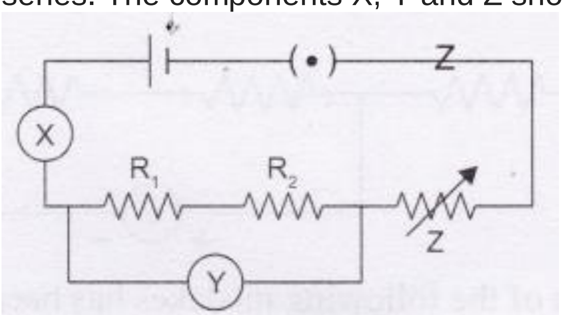
Multiple Choice Questions (MCQs)

Questions based on Procedural and Manipulative Skills

Question 1:
A piece of wire of resistance R is cut into 3 equal parts and then connected in series. The formula used to find the equivalent resistance R will be:

(a) $\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
(b) $R_1 + R_2 + R_3$
(c) $R + \frac{1}{R_2} + \frac{1}{R_3}$
(d) $R_1 + R_2 + \frac{1}{R_3}$

Question 2:
The given circuit diagram shows the experiment arrangement of different circuit components for determination of equivalent resistance of two resistors connected in series. The components X, Y and Z shown in the circuit respectively represent

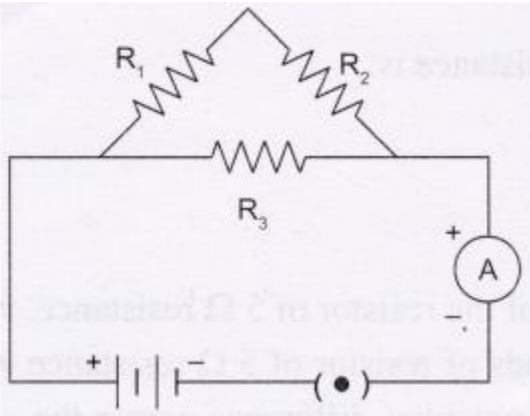


(a) Rheostat, Resistor, Ammeter
(b) Voltmeter, Ammeter, Rheostat
(c) Ammeter, Voltmeter, Rheostat
(d) Rheostat, Ammeter, Voltmeter.

Question 3:
You are given four resistors. If the resistance is to be increased then the resistors are to be connected in:
(a) series
(b) parallel
(c) mixed arrangement
(d) none of these.

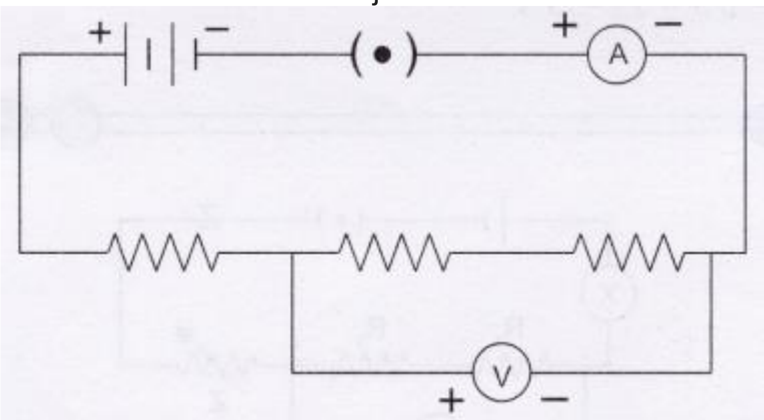
Question 4:
In an experiment on finding the equivalent resistance of two resistors, connected in series, a student connects the terminals of the voltmeter as:
(a) one terminal of each of the two resistors and these terminals are not interconnected
(b) one terminal of each of the two resistors and these terminals are also interconnected
(c) both the terminals of each of the two resistors
(d) both the terminals of one resistor and one terminal of the other resistor.

Questions based on Observational Skills
Question 5:



In the above circuit diagram, the resistance connected in series are:
(a) R_1 R_2 and R_3
(b) R_1 and R_2
(c) R_1 and R_3
(d) only R_3

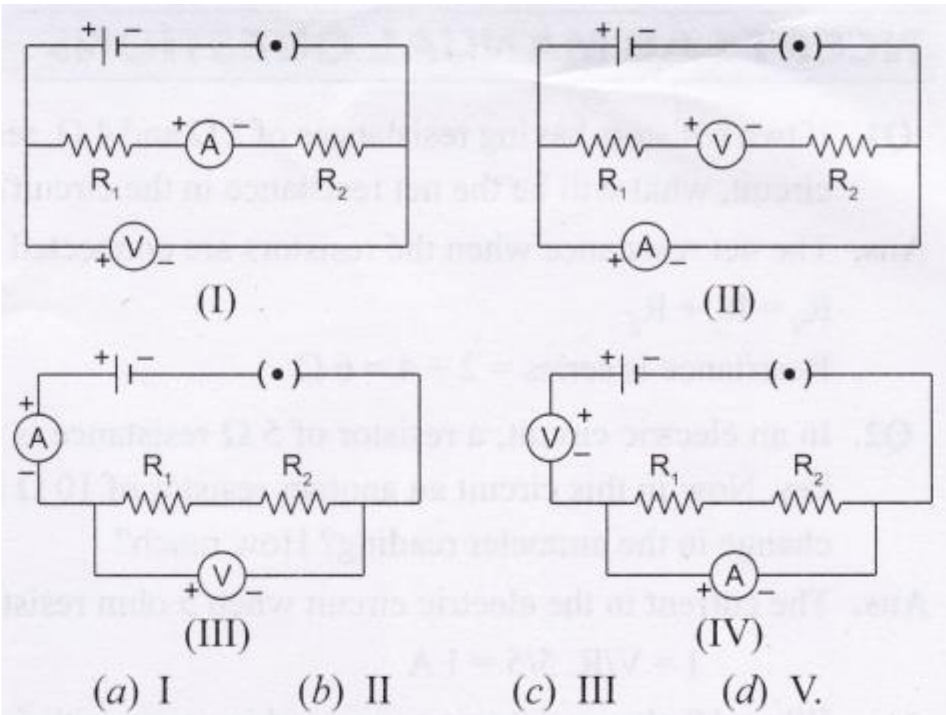
Question 6:
To determine the equivalent resistance of two resistors when connected in series, a student arranged the circuit components as shown in the diagram. But he did not succeed to achieve the objective.



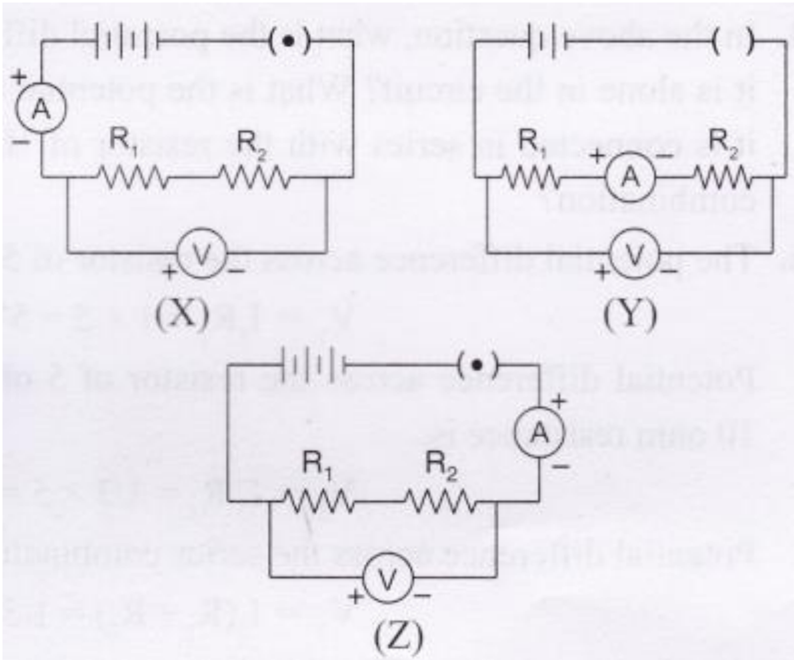
Which of the following mistakes has been committed by him in setting up the circuit?
(a) Position of voltmeter is incorrect.

(b) Position of ammeter is incorrect.
(c) Terminals of voltmeter are wrongly connected.
(d) Terminals of ammeter are wrongly connected.

Question 7:
In an experiment to determine the equivalent resistance of two resistors R_1 and R_2 in series which one of the following circuit diagram shows the correct way of connecting the voltmeter in the circuit?

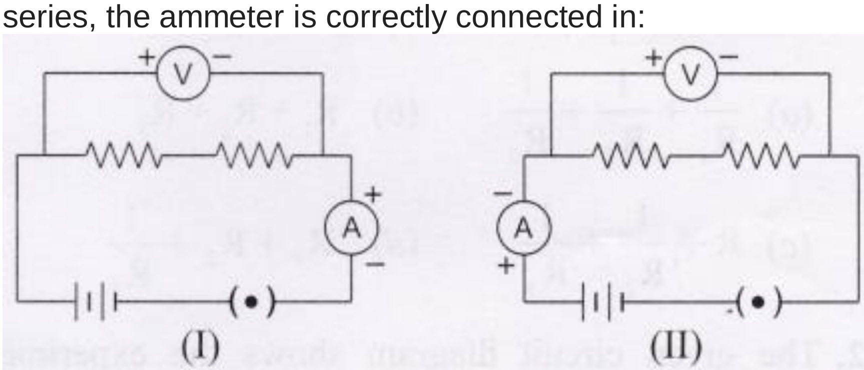


Question 8:
In an experiment of finding the equivalent resistance of two resistors connected in series, three students connected the ammeter in their circuits in three ways X, Y and Z shown here.



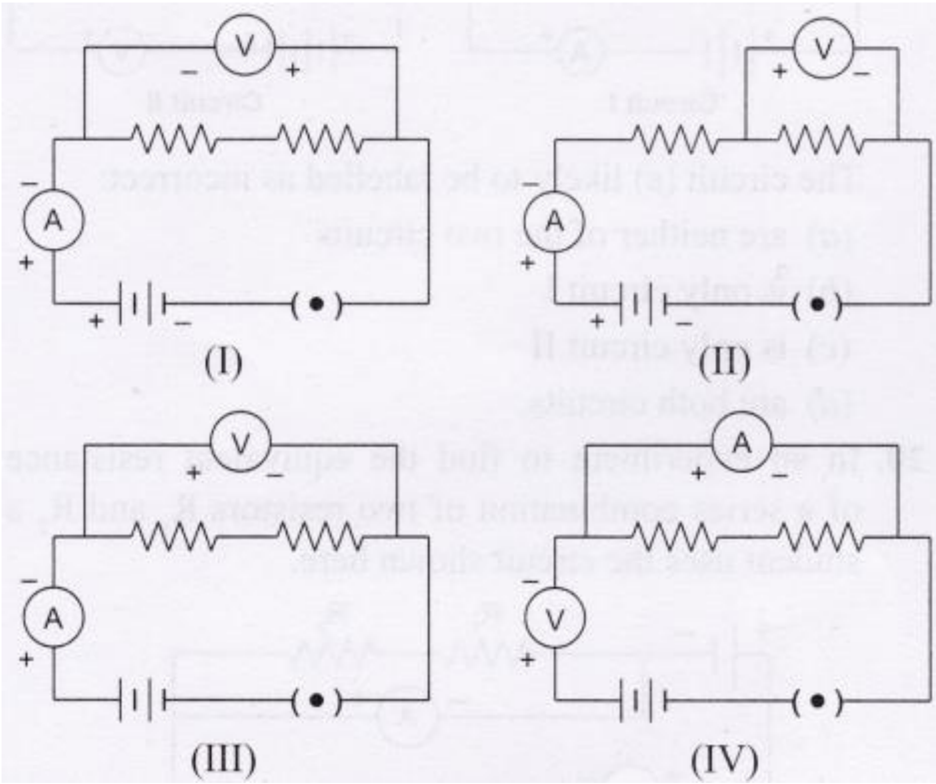
Assuming their ammeters to be ideal, the ammeter have been correctly connected in
(a) Cases X and Y only
(b) Cases Y and Z only
(c) Cases Z and X only
(d) All the three cases.

Question 9:
In an experiment on finding the equivalent resistance of two resistors connected in series, the ammeter is correctly connected in:



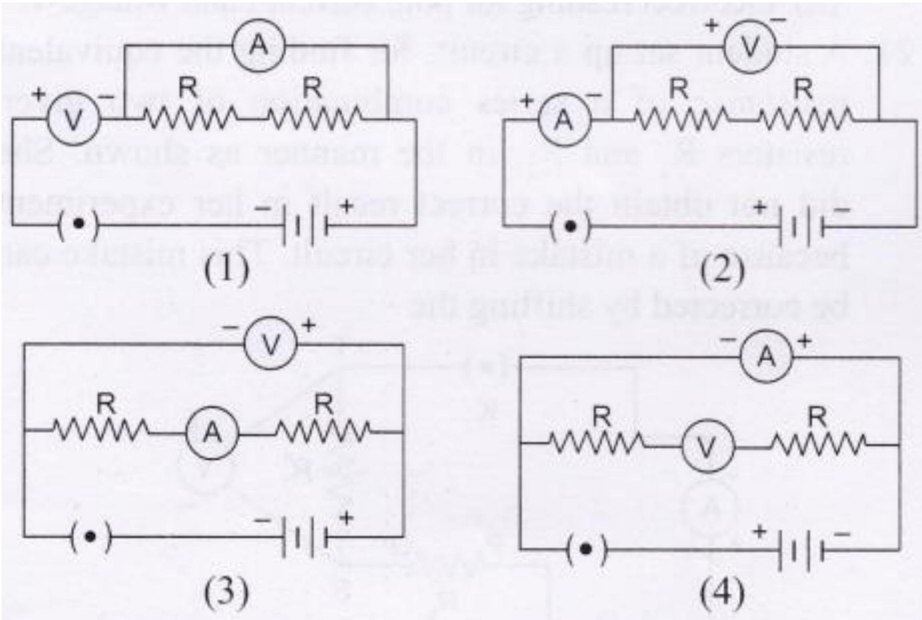
(a) circuit (I) only
(b) circuit (II) only
(c) both circuits (I) and (II)
(d) neither of the two circuits.

Question 10:
In an experiment of finding the equivalent resistance of two resistors connected in series the voltmeter is correctly connected only in circuit



(a) I
(b) II
(c) III
(d) IV

Question 11:
The correct way of connecting the ammeter and voltmeter with a series combination of two resistors in a circuit for finding their equivalent resistance, is shown in diagram



(a) 1 (b) 2 (c) 3 (d) 4

Questions based on Reporting and Interpretation Skills

Question 12:

A battery of 9 V is connected in series with resistors of 0.2 Ω, 0.3 Ω, 0.4 Ω, 0.5 Ω, and 12 Ω respectively. The current flowing through 12 Ω resistor is:

(a) 1A
(b) 1.3 A
(c) 0.67 A
(d) none of these.

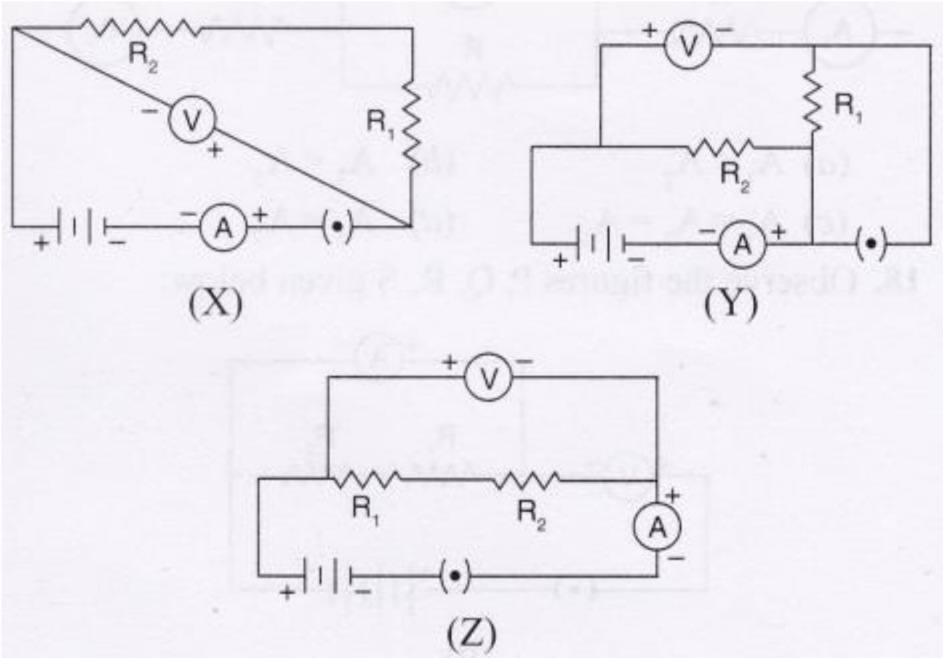
Question 13:

If four resistors, each of 1Ω are connected in series the effective resistance will be:

(a) 1 Ω
(b) 2 Ω
(c) 0.5 Ω
(d) 4 Ω.

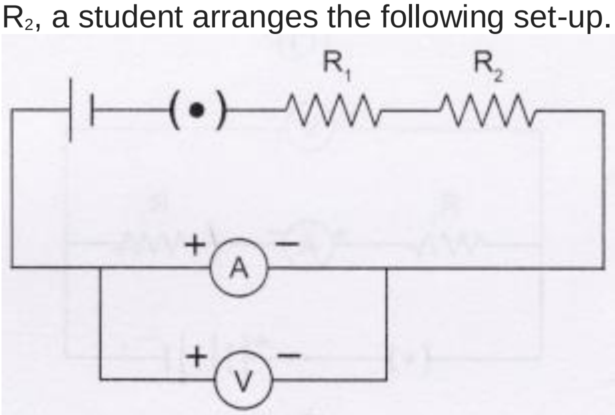
Question 14:

For determining the equivalent resistance of two resistors Rj and connected in series, three students X, Y and Z set up their circuits as shown below:



The correct set-up is that of
(a) student X only
(b) student Y only
(c) student Z only
(d) students X and Z

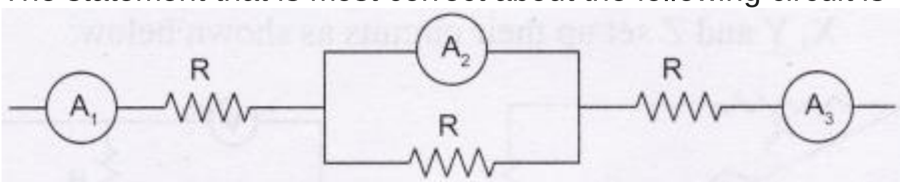
Question 15:
To determine the equivalent resistance of a series combination of two resistors R_1 and R_2, a student arranges the following set-up.



Which one of the following statements will be true for this circuit? It'gives
(a) incorrect reading for current I and potential difference V both
(b) correct reading for current I, but incorrect reading for p.d. V.
(c) correct reading for p.d. V but incorrect reading for current I
(d) correct reading for both V and I.

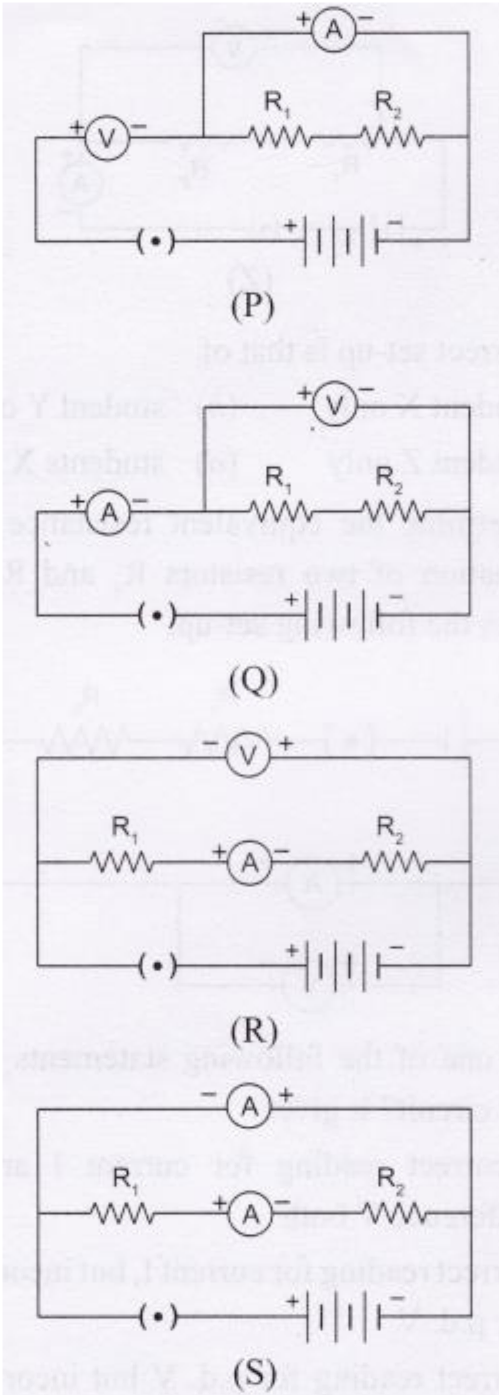
Question 16:
In the electric circuit, three resistors R_1, R_2 and R_3 are connected in series such that R_2 =

R_3 If V_1, V_2 and V_3 are the voltages across R_1, R_2, and R_3 respectively then.
(a) $V_1=V_2$
(b) $V_2 = V_3$
(c) $V_1 = V_3$
(d) $V_1 = V_2 = V_3$.

Question 17:
The statement that is most correct about the following circuit is


(a) $A_1<A_2$
(b) $A_3<A_2$
(C) $A_1=A_2 = A_3$
(d) $A_1=A_3$

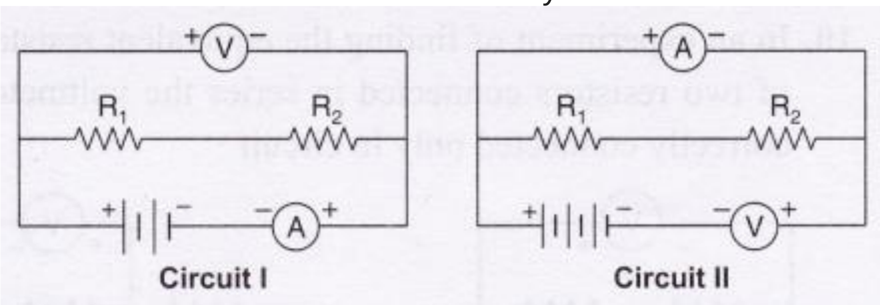
Question 18:
Observe the figures P, Q, R, S given below:



The correct way of connecting the ammeter and voltmeter with a series combination of two resistors in a circuit for finding their equivalent resistance, is shown in diagram

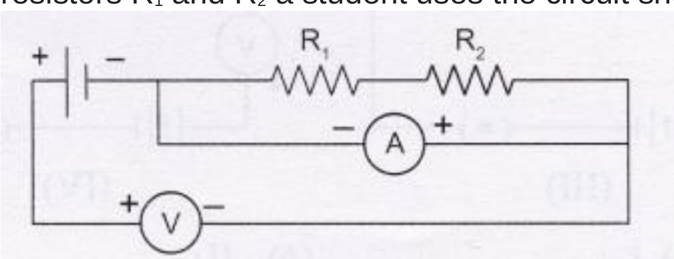
(a) P
(b) Q
(c) R
(d) S

Question 19:
Two students set up their circuits for finding the equivalent resistance of two resistors connected in series in two different ways as shown.



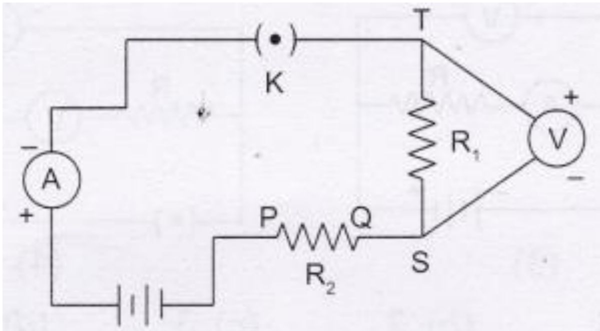
The circuit (s) likely to be labelled as incorrect:
(a) are neither of the two circuits
(b) is only circuit I
(c) is only circuit II
(d) are both circuits.

Question 20:
In an experiment to find the equivalent resistance of a series combination of two resistors R_1 and R_2 a student uses the circuit shown here.



(a) correct reading for voltage V but incorrect reading for current 1
(b) correct reading for current I but incorrect reading for voltage V
(c) correct reading for both current I and voltage V
(d) incorrect reading for both current I and voltage V.

Question 21:
A student set up a circuit, for finding the equivalent resistance of a series combination of two given resistors R_1 and R_2, in the manner as shown. She did not obtain the correct result in her experiment because of a mistake in her circuit. This mistake can be corrected by shifting the



(a) voltmeter and connecting it across P and Q
(b) ammeter and connecting it between K and T
(c) voltmeter and connecting it across T and P with correct polarity
(d) ammeter and connecting it across P and Q.

Answers:

1. (b)	2. (c)	3. (a)	4. (a)	5. (b)
6. (d)	7. (c)	8. (a)	9. (c)	10. (c)
11. (b)	12. (c)	13. (d)	14. (c)	15. (b)
16. (b)	17. (c)	18. (b)	19. (c)	20. (d)
21. (c)				

Scoring Key With Explanation

1. (b) In series, all the resistances are added.
2. (c) As per the arrangement, X is connected in series so it is an ammeter. Y is connected in parallel, so it is a voltmeter and Z is a symbol of rheostat.
3. (a) In series, the overall resistance is summed up and increases.
4. (a) Resistors are connected in series and hence should avoid the interconnection.
5. (b) R_1 and R_2 are in same line.
6. (d) Ammeter should be connected in series. Also, the +ve end of the battery should be connected with the +ve end of ammeter.
7. (c) Ammeter should be in series with the battery and voltmeter in parallel to resistors.
8. (a) An ammeter is always connected in series while a voltmeter is connected in parallel.
9. (c) In both the cases, ammeter is connected in series.
10. (c) Voltmeter is connected in parallel with correct +ve and -ve terminals arrangement.
11. (b) The ammeter must be connected in series, between the battery and the series combination of the two resistors, and the voltmeter should be put in parallel across the series combination of the two resistors. All the polarities must also be correct.
12. (c) I = V/R = 9V/13.4 ohm = 0.67 A
13. (d) All four resistors are added in series.

14. (c) +ve of ammeter is connected to -ve of common point of resistors and voltmeters.
15. (b) Voltmeter is not correctly arranged, it will give the potential difference of ammeter.
16. (b) If resistance is same, then voltage will be the same.
17. (c) All the three ammeters are connected in series and hence, the current in series is same e., constant.
18. (b) Ammeter and voltmeter are correctly arranged.
19. (c) Here, the voltmeter is not connected in parallel but in series.
20. (d) Wrong arrangements.
21. (c) Voltmeter should be connected in parallel to both the resistors.