EXPERIMENT (A)

AIM

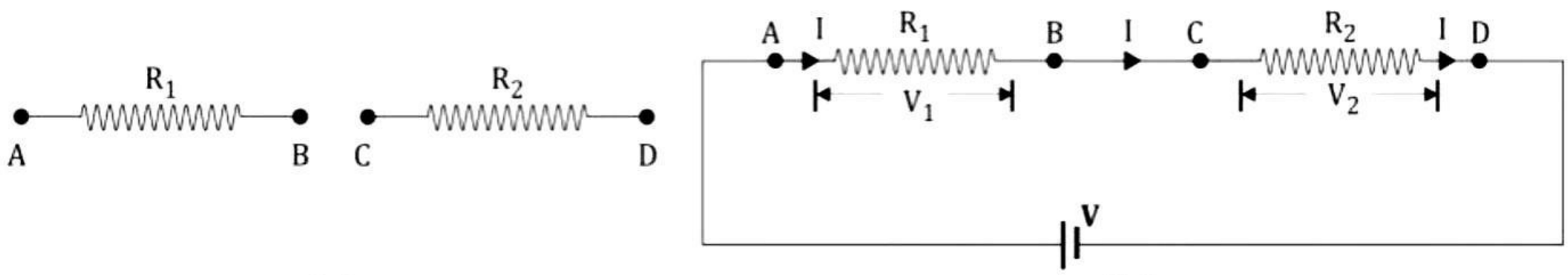
Determination of the equivalent resistance of two resistors, when connected in series.

MATERIALS REQUIRED

Two standard resistance coils (or resistors), ammeter (0 - 1.5A), voltmeter (0 - 1.5V), one-way key, low resistance rheostat, connecting wires, a piece of sandpaper and ceil or battery eliminator.

THEORY

The end-to-end connection of two or more resistors is said to be series combination, if they provide only one path to the flow of current, i.e., same current would be flown through each resistor. Consider V be the potential difference by one DC source across the combination of unknown resistances R_1 and R_2 [as shown in Fig. 1(b)].



(a) Two resistors AB and CD are placed one after the other
(b) Two resistors AB and CD are connected in a series combination

Fig.1

If V_1 and V_2 be the potential differences measured by the voltmeter across each resistor, then

$$V = V_1 + V_2 \text{ .....(i)}$$

According to Ohm's law,

$$V_1 = IR_1,\ V_2 = IR_2$$

$$\text{and } V = IR_s \text{ ..... (ii)}$$

Where, R_s = Equivalent resistance of R_1 and R_2 in series combination.

From Eqs. (i) and (ii), we get

$$IR_s = IR_1 + IR_2$$

$$R_s = R_1 + R_2$$

Thus, the equivalent resistance of the series combination is equal to the sum of the individual resistances connected in the series circuit.

PROCEDURE

(i) Note the least count and the zero error (if any) of the given ammeter and voltmeter.

(ii) Clean the ends of connecting wires using a sandpaper.

(iii) Find the values of two given resistances R_1 and R_2 by the procedure given in Experiment 5.

(iv) Connect the resistances in series as shown in block diagram or circuit diagram given in Fig. 2.

(v) Put the plug in the key and take the readings of ammeter and voltmeter (as done in Experiment v).

(vi) Repeat the step v three times by changing the position of the sliding contact of the rheostat (as done in Experiment 5).

(vii) Tabulate the readings and find the ratio of V and I. It will give the equivalent resistance of the combination.

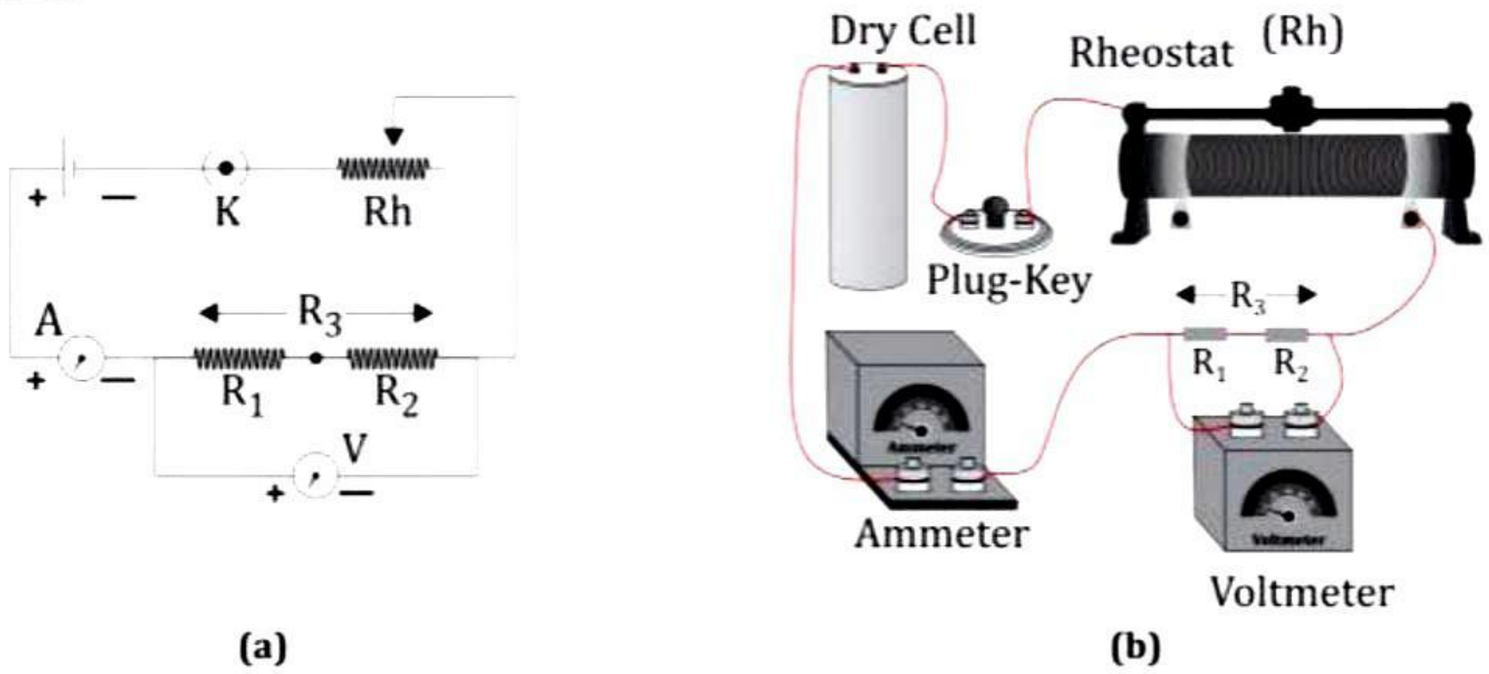


Fig.2

OBSERVATION

(i) Least count of ammeter = ... A

(ii) Zero error of ammeter = ... A

(iii) Least count of voltmeter = ... V

(iv) Zero error of voltmeter = ... V

(v) Zero correction in ammeter reading = ... A

(vi) Zero correction in voltmeter reading = ... V

Resistor used	Observations	Voltmeter reading (volt)	Ammeter Reading (ampere)	R=V/I (ohm)	Mean value of resistance (ohm)
R_1	(a) (b) (c)				
R_1	(a) (b) (c)				
$R_s = R_1+R_2$	(a) (b) (c)				

CALCULATIONS

1. Mean value of R_1 = ... Ω
2. Mean value of R_2 = ... Ω
3. Equivalent value of series combination,
   (i) By calculation, $R'_s = R_1 + R_2$ = ... Ω

(ii) By experiment, R_s = ... Ω
Difference in both values, $R_s - R'_s$ = ... Ω

RESULT

(i) There is a close agreement between the calculated value and the value obtained by the experiment. Hence, $R_s = R_1 + R_2$ is verified.

(ii) Equivalent resistance, R_s = ... Ω

PERCENTAGE ERROR

It can be found by using the following relation:

$$\text{Percentage Error} = \left[\frac{(\text{Approximate Value} - \text{Exact Value})}{\text{Exact Value}}\right] \times 100$$

It shows that the percentage error is within the experimental error.

PRECAUTIONS

(i) Remove the dust and other insulating particles from the ends of connecting wire, by rubbing it with sandpaper.

(ii) All the connections should be tight and properly done as per the circuit diagram.

(iii) Take out the plug from the plug key in between the two observations.

(iv) A low resistance rheostat should be used in the circuit to obtain a large variation in the current.

(v) The thick copper connecting wires should be used in the circuit.

(vi) The positive terminal of the ammeter and voltmeter must be connected to the positive terminal of the battery or battery eliminator.

(vii) Never connect the two terminals of the cell without any resistance.

(viii) The pointers of the ammeter and voltmeter should be at zero mark when no current flows through them.

(ix) Current should be passed through the circuit for a short time while taking observations; otherwise, current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

(x) The ammeter should be connected in series with the combination of resistors such that the current enters at the positive terminal and leaves at the negative terminal of the ammeter.

(xi) Voltmeter should always be connected in parallel to the combination of resistors.

SOURCES OF ERROR

(i) Reading error may be possible while observing the pointer of ammeter and voltmeter.

(ii) Thick connecting wires may not be available at the time of performing the experiment.

(iii) Area of cross-section of resistance may not be uniform across the length of the wire.

(iv) The high resistance rheostat may be used.

(v) Current may be allowed for the longer period through the circuit.

(vi) The terminal screws of the given instruments may not be tightened properly.

VIVA VOCE

Q 1. What is the relationship between V and R for the series combination?

Ans. The total equivalent resistance of a series circuit is equal to the sum of the individual resistances.

Q 2. What happens to the resistance of the resistor, if the current through it increases?

Ans. It remains unchanged because the resistance does not depend on the current flowing through it.

Q 3. When two unequal resistances are connected in series, what will be the potential difference across each resistor?

Ans. When two unequal resistances are connected in series, the potential difference across each resistor will be different.

Q 4. What happens to the ammeter reading if two resistors of the same value are connected in series in the circuit?

Ans. The deflection in ammeter is reduced to half of the previous value, i.e., ammeter shows half of the previous reading.

Q 5. Why resistance becomes more in series combination?

Ans. The effective length of all the resistors in series combination increases. Hence, equivalent resistance of the combination increases as $R \propto I$.

Q 6. When do we put the resistances in series combination?

Ans. A, when we have the smaller value of resistance and need the greater value of resistance, we put them in series combination.

Q 7. In a circuit, if two resistors of resistances 5Ω and 10Ω are connected in series. Compare the current passing through the two resistors.

Ans. In a series combination, same current passes through all the resistors. Thus, the ratio of current will be 1:1.

Q 8. Why current should be passed for a short time through the circuit while taking observations?

Ans. Current passed through the circuit for longer time while taking observations, can cause unnecessary heating in the circuit, which may change the resistance of resistors.

Q 9. Mention the use of rheostat in the circuit.

Ans. To change the current in the circuit which can be done by changing the sliding contact of the rheostat.

Q 10. Can you mention one disadvantage of series connection?

Ans. In series connection, if any one component fails to work, the circuit breaks and none of the components work.

Q 11. If two resistors having resistances of 2 Ω and 4 Ω, respectively are connected in a series combination in an electric circuit, what will be the next resistance in the Circuit?

Ans. According to series combination, $R_{net} = R_1 + R_2$

$\Rightarrow R_{net} = (2 + 4)\ \Omega\ \{\because R_1 = 2\ \Omega, R_2 = 4\Omega\}$

$\Rightarrow R_{net} = 6\ \Omega$

EXPERIMENT (B)

AIM

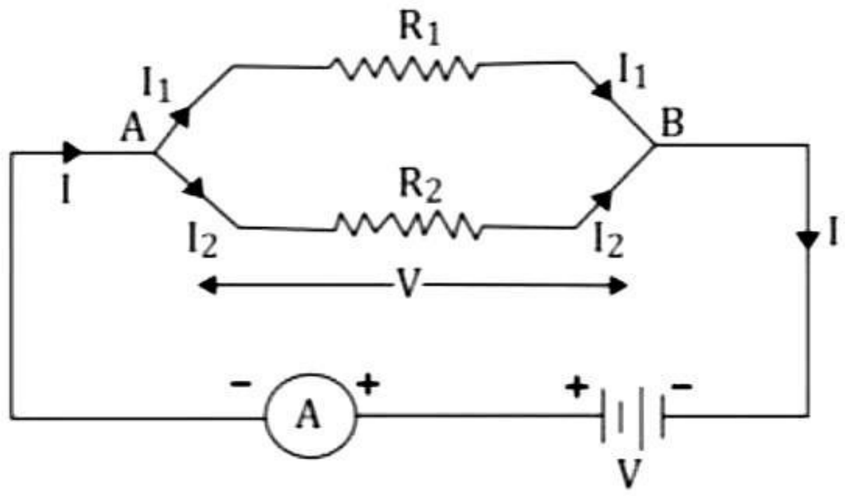
Determination of the equivalent resistance of two resistors, when connected in parallel.

MATERIALS REQUIRED

Two standard resistance coils (or resistors), ammeter (0-1.5 A), voltmeter (0-1.5 V), one-way plug key, a low resistance rheostat, connecting wires, a piece of sandpaper and cell or battery eliminator.

THEORY

An arrangement of resistors in which number of resistors are connected between two common points in such a way that the potential difference across each resistor is equal to the applied voltage is called parallel combination of resistances.



Two resistors are connected in a parallel combination

Fig.1

As shown in Fig. 1, two resistors of resistances R_1 and R_2 are connected between two points A and B in parallel combination. Let the potential difference applied by the DC source to this combination be V.

Let I_1 and I_2 be the currents measured by an ammeter, connected in series with each resistor R_1 and R_2 respectively, then,

$$I = I_1 + I_2 \ldots\ldots (i)$$

According to Ohm's law,

$$I_1 = \frac{V}{R_1} \text{ and } I_2 = \frac{V}{R_2} \ldots\ldots (ii)$$

If R_p is the equivalent resistance of the given parallel combination, having the same potential difference as the applied potential, then

$$I = \frac{V}{Rp} \ldots\ldots\ldots (iii)$$

From Eqs. (i), (ii) and (iii), we get

$$\frac{V}{Rp} = \frac{V}{R_1} + \frac{V}{R_2}$$

or

$$\frac{1}{Rp} = \frac{V}{R_1} + \frac{V}{R_2}$$

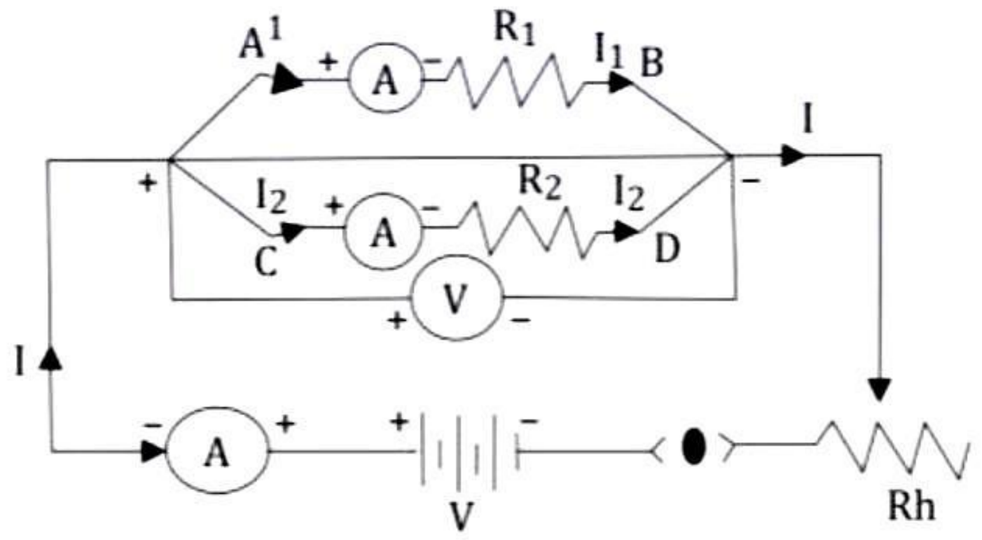
or

$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$

Therefore, when number of resistances are connected in a parallel combination, the reciprocal of the equivalent resistance is equal to the sum of the reciprocals of the individual resistances.

PROCEDURE

(i) Note down the least count and zero error (if any) of the given ammeter and voltmeter.
(ii) Clean the ends of connecting wires using sandpaper.
(iii) Find the values of two given resistances R_1 and R_2 by the procedure given in Experiment 5.



Parallel Combination

Fig.2

Connect the given resistors in parallel combination between the two terminals of the voltmeter (as shown in Fig. 3).

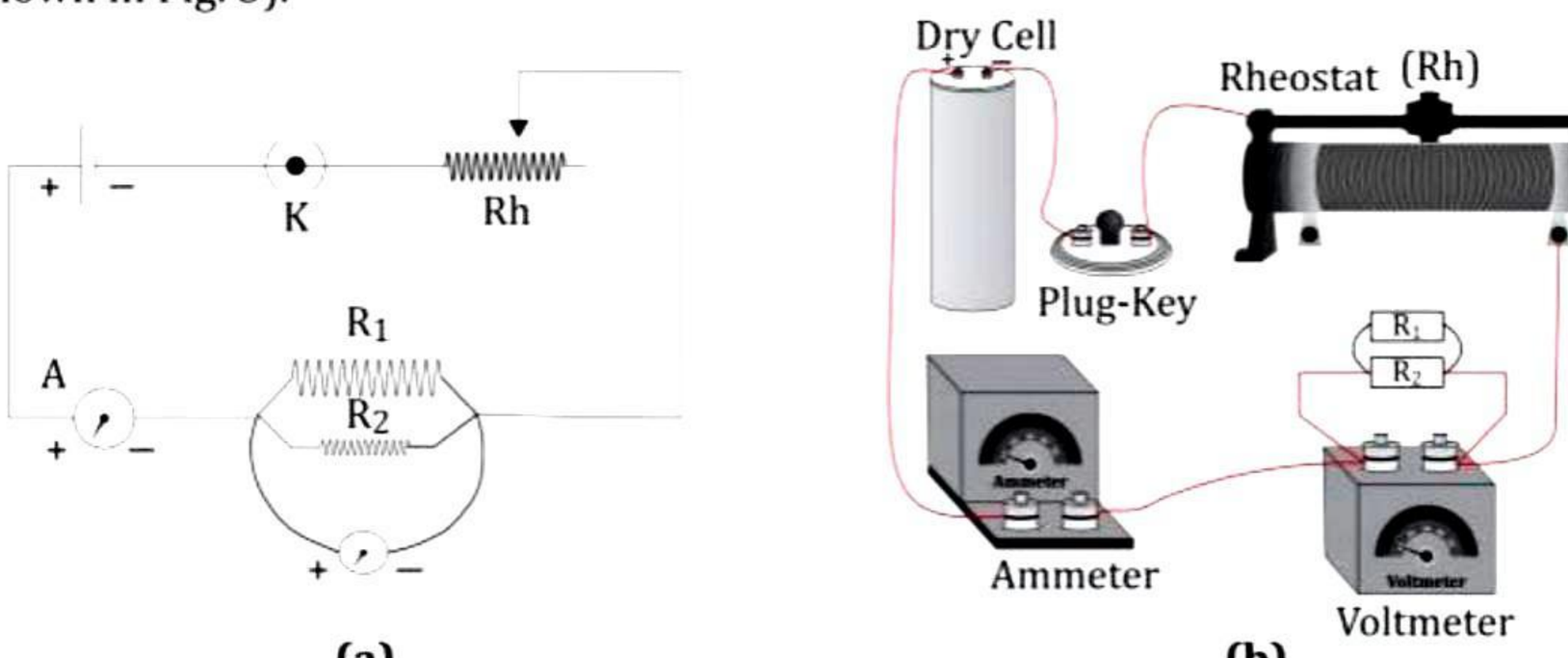


Fig. 3

(iv) Put the plug in the key and take the readings of ammeter and voltmeter (as done in Experiment 5).
(v) Repeat the step v three times by changing the position of the sliding contact of the rheostat (as done in Experiment 5).

Resistor used	Observations	Voltmeter reading (volt)	Ammeter reading (ampere)	R = V/I (ohm)	Mean value of resistance (Ohm)
R_1	(a) (b) (c)				
R_2	(a) (b) (c)				
$R_p = \frac{R_1 R_2}{R_1 + R_2}$	(a) (b) (c)				

CALCULATIONS

1. Mean value of R_1 = ... Ω
2. Mean value of R_2 = ... Ω
   Equivalent value of parallel combination,
   (i) By calculations, $R'_p = \frac{R_1 R_2}{R_1 + R_2}$ ..... Ω
   (ii) By experiment, R_p = ... Ω

RESULT

1. The equivalent resistance of parallel combination, R_p = ... Ω
2. There is close agreement between the calculated value and the value obtained by the experiment. Hence, $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ is verified.

PERCENTAGE ERROR

$$\text{Percentage Error} = \left[\frac{(\text{Approximate Value} - \text{Exact Value})}{\text{Exact Value}}\right] \times 100$$

It shows that percentage error is within the experimental error.

PRECAUTIONS

(i) It is to be properly checked that ammeter is connected in series and voltmeter is connected in parallel.
(ii) The connecting wires should be thick and must have tight connection at joints.
(iii) The ends of connecting wires should be cleaned properly using sandpaper.
(iv) The ammeter and voltmeter must be of proper range and of less least count.
(v) Current should be passed for very short time; otherwise, heating effect can change the actual result.

SOURCES OF ERROR

(i) Reading error may be possible while observing the pointer of ammeter and voltmeter.
(ii) Thick connecting wires may not be available at the time of performing the experiment.
(iii) Area of cross-section of resistance may not be uniform across the length of wire.
(iv) The high resistance rheostat may be used.
(v) Current may be allowed for longer period.
(vi) The terminal screws of the instruments may not be tightened properly.

VIVA VOCE

Q 1. State the law for the equivalent resistance, when resistors are in parallel combination.
Ans. Law states that the reciprocal of equivalent resistance is equal to the sum of the reciprocal of individual resistances.

Q 2. Name the type of connection used in house wiring.
Ans. In our house wiring, parallel connection of appliances is used.

Q 3. What is the ratio in which current divides itself in the parallel combination?
Ans. The current divides itself in the inverse ratio of resistance in parallel combination (i.e., $I \propto R$).

Q 4. Can you explain why voltmeter is connected in parallel across the conductor?
Ans. It is connected in parallel across the conductor to measure the maximum potential drop.

Q 5. Define range of an ammeter.
Ans. Range of an ammeter is defined as the maximum and minimum values of current that can be measured through an ammeter without any damage.

Q 6. Name the quantity which remains same in parallel combination of resistors.

Ans. In parallel combination of resistors, voltage (V) remains same.

Q 7. State some disadvantages of parallel circuit.

Ans. As one fuse controls all light, fans, and other electric appliances of a single room, circuit all of them will be put off when the fuse blows off.
It is difficult to install a new circuit for new installation of electrical appliances.

Q 8. If two resistors of resistances R_1 and R_2 respectively are connected in parallel. How will you find the equivalent resistance?

Ans. If two resistors of resistances R_1 and R_2 respectively are connected in parallel, then equivalent resistance can be given as $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$

Q 9. Suppose in a combination, we find that the equivalent resistance is smaller than the smallest resistance used in the circuit. Which type of combination is present in the circuit?

Ans. It is a parallel combination.

Q 10. What is the effect of temperature on the value of resistance of a conductor?

Ans. The resistance of conductor increases with increase in temperature.

Q 11. What do you mean by the range of voltmeter?

Ans. The maximum and minimum values of potential difference that can be measured through a voltmeter without any damage defines the range of voltmeter.

Q 12. Two resistors having resistances of 4Ω and 6Ω respectively are connected in a circuit. It was found that the total resistance in the circuit is less than 4Ω. In what way the resistances would have been connected?

Ans. As we know that, for parallel combination, net resistance is less than that of individual resistance. So, they are connected in parallel with each other.

Q 13. Two resistors are connected in series and then in parallel. What effect will it have on the readings of voltmeter and ammeter?

Ans. As the applied voltage remains same, so there will be no change in the reading of voltmeter. Ammeter reading will be less in case of series and more in case of parallel.

Q 14. In what way, household appliances should be connected?

Ans. Household appliances must be connected in parallel.