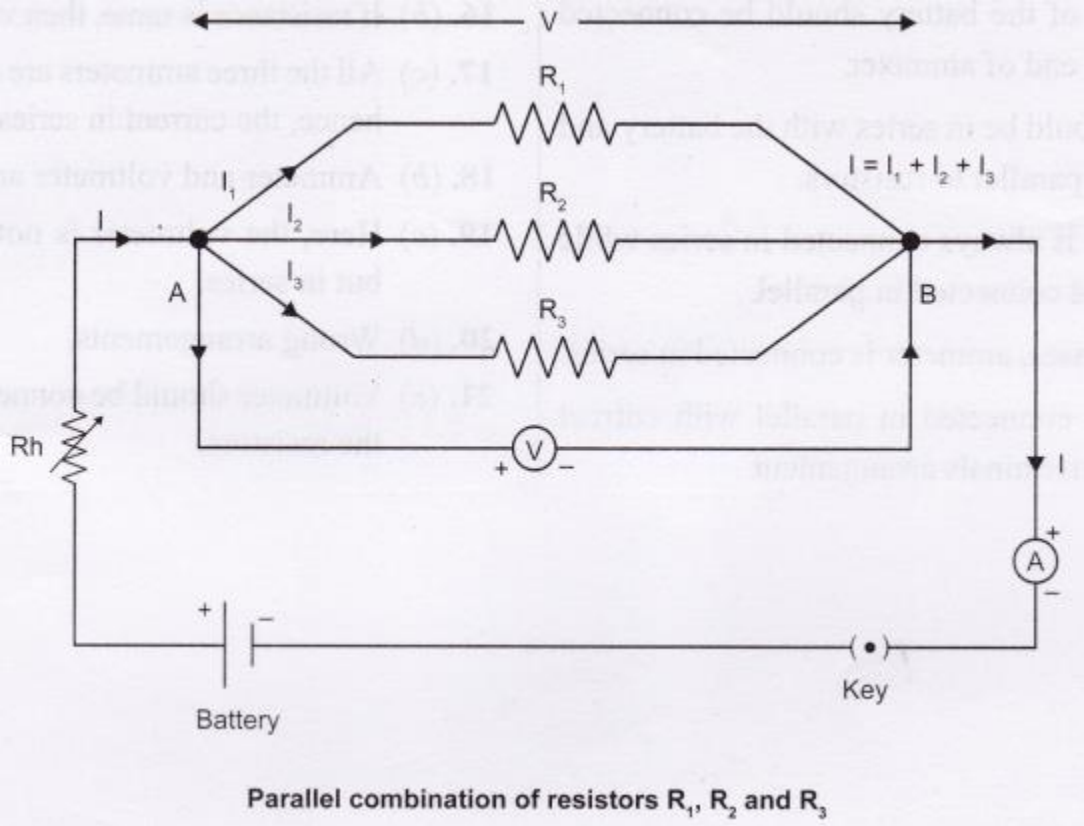
# Resistors in Parallel

## Introduction

- When resistors are connected such that they branch out from a single point and join up again in the circuit. This is known as a parallel connection.
- The three resistors in the figure given below shows that the path for current to flow through the circuit can be in three different routes.




Parallel combination of resistors $R_1$, $R_2$ and $R_3$

- **p.d. in parallel circuit:** The potential difference in the circuit across each resistor is the same.
- **Current in parallel circuit:** The current flowing through each resistor is not the same. It splits as it travels from the circuit.
- **Total current in parallel circuit:** The total current flowing through the circuit can be calculated by adding the values of current flowing through each resistor.
- **Application of parallel circuits connection:** Parallel circuits are preferred in household electric distribution. This is because the loss of current can be monitored and the short circuit can be avoided. The different devices need different voltage to function. For e.g. refrigerator, television and lamp have different voltage requirement. If they are connected in the series then the huge amount of current required by the refrigerator will flow through the other two

devices and can damage them. To overcome such a situation the parallel circuit is preferred.

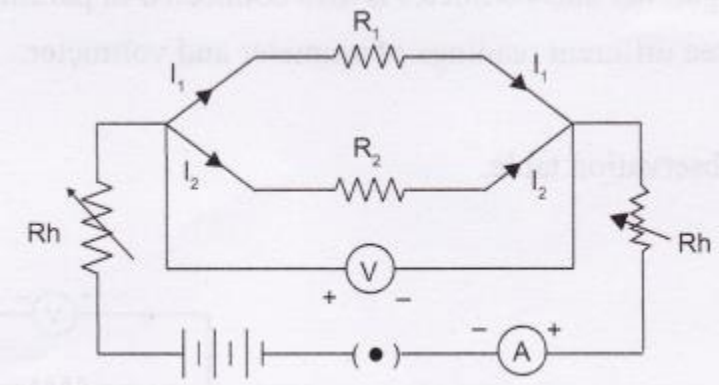
## Science lab manual Experiment – 3

**Aim**

To determine the equivalent resistance of two resistors when connected in parallel.

**Theory**

- When the resistors are connected in parallel with a combination of cells or battery, in such case the total current I, is equal to the sum of the separate value of current through each branch of the combination.
  i.e., $I=I_1+I_2+I_3+\ldots..$



Parallel combination of resistors $R_1$ and $R_2$

- In the above circuit let R be the equivalent resistance of the parallel combination of resistors.
  ∴ By applying Ohm's law we have
  $I=V/R_p$ ...(1)
- On applying Ohm's law to each resistor we get

$$I_1 = \frac{V}{R_1} \quad ...(2)$$

$$I_2 = \frac{V}{R_2} \quad ...(3)$$

But $I = I_1 + I_2$

$\therefore$ $\frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2}$ from equations (1), (2) and (3)

$\Rightarrow$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$

When resistors are connected in parallel combination the total resistance is reciprocal sum of the individual resistances.
i.e., $1/R_p = (1/R_1) + (1/R_2)$

- Current is constant in series circuit. Hence, we cannot connect bulb and room heater in series because their current requirement is different.

- Hence such devices are connected in parallel so that the current is divided through the different electrical gadgets.
- The total current is always decreased when resistors are connected in parallel.
- When the resistors are connected in parallel then the equivalent resistance of the parallel combination of the resistors is always low.

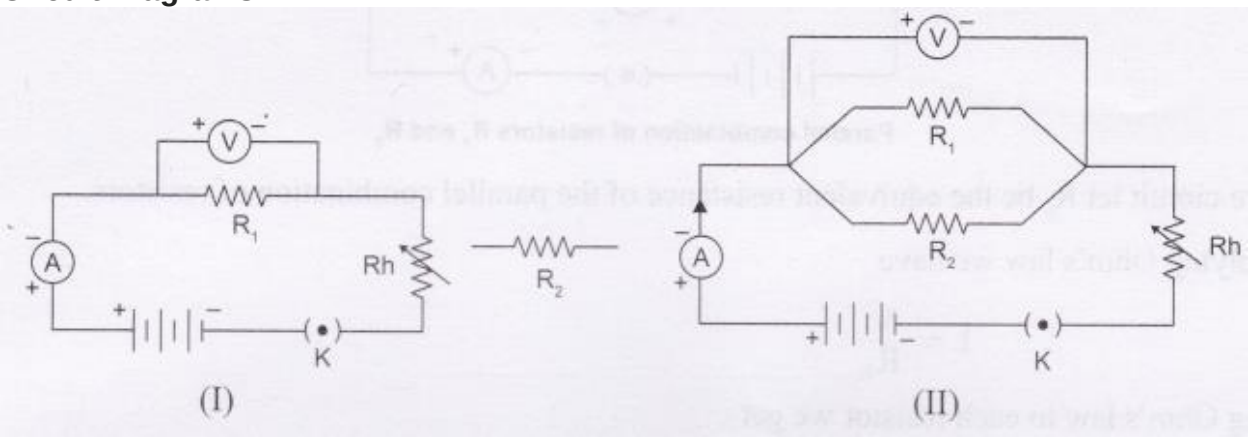
**Materials Required**

A battery, a plug key, connecting wires, an ammeter, a voltmeter, rheostat, a piece of sand paper and two resistors of different value.

**Procedure**

1. Keep the key off and make all the connections as shown in the given figure I.
2. When the circuit is connected appropriately insert the key.
3. Note three readings of ammeter and voltmeter for the resistors $R_1$ and $R_2$ separately.
4. Now connect the circuit as shown in figure II below.
5. The resistors are connected in parallel and voltmeter is also connected in parallel.
6. Use the rheostat and record three different readings of ammeter and voltmeter.
7. Remove the key.
8. Do the calculations from the observation table.

**Circuit Diagrams**




**Observation Table**

| Resistor Used | No. of Observations | Voltmeter Reading in Volts (V) | Ammeter Reading in Ampere (I) | R=V/I (in Ohm) | Mean Value of Resistance (Ohm) |
|---|---|---|---|---|---|
| R1 (Ist Resistor) | (a) | 0.01 | 0.01 | 1 | R1 = 1 Ohm |
| | (b) | 0.02 | 0.02 | 1 | |
| | (c) | 0.04 | 0.04 | 1 | |

| | | | | | |
|---|---|---|---|---|---|
| R2<br>(2nd Resistor) | (a) | 0.02 | 0.01 | 2 | R2 = 2 Ohm |
| | (b) | 0.06 | 0.03 | 2 | |
| | (c) | 0.08 | 0.04 | 2 | |
| 1/Rp= (1/R1)+ (1/R2)<br>(ParallelCombination) | (a) | 0.026 | 0.04 | 0.67 | Rp = 0.67 Ohm<br>1/Rp =1.5 Ohm |

**Result**

1. The calculated value of $1/R_p = (1/R_1) + (1/R_2) = 1.5\ \Omega$
2. The experimental value of $1/R_p = 1.5\ \Omega$
3. The equivalent resistance ($R_p$) is less than the individual resistance ($R_1$ or $R_2$)

**Precautions**

1. The connecting wires should be thick copper wires and the insulation of their ends should be removed using the sand paper.
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 current would cause unnecessary heating in the circuit. Heating may change the resistance of resistors.

## Lab Manual Science Viva Voce

**Question 1:**
When resistors are combined in parallel what would be total resistance?
**Answer:**
On combination of resistors in parallel the total resistance will be less.

**Question 2:**
When the resistors are connected in parallel what remains constant in the circuit, current I or potential difference V?
**Answer:**
When resistors are in parallel, potential difference (V) remains constant and not the current (I).

**Question 3:**
An electrician has to do wiring and gives circuit connections to all the rooms in a house. What type of connections will he do?
**Answer:**
The connections of all the circuits will be parallel.

**Question 4:**
Name the physical quantity which remains constant in parallel connection.
**Answer:**
Voltage remains unchanged when circuit has parallel connection.

## Science lab manual Activities Practical Based Questions

**Question 1:**
How will you calculate the equivalent resistance when three resistors are connected in parallel?
**Answer:**
Total resistance $R_p$ can be calculated using the following formula:

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

**Question 2:**
If two resistors are connected in parallel and their equivalent resistance is 2 ohm .What would be the value of each resistor if both have same value?
**Answer:**

$$\because \quad \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{and} \quad R_1 = R_2 \ [\text{Given}]$$

$$\therefore \quad \frac{1}{2} = \frac{2}{R_1} \quad \Rightarrow \quad \frac{1}{R_1} = \frac{1}{4} \quad \Rightarrow \quad R_1 = 4\,\Omega = R_2$$

**Question 3:**
Three resistors of 5 Ω, 2 Ω and 3 Ω are connected in parallel. What will be the total resistance?
**Answer:**
The total resistance of three resistors of 5 Ω, 2 Ω and 3 Ω when connected in parallel is given by

$$\frac{1}{R_p} = \frac{1}{5} + \frac{1}{2} + \frac{1}{3} = \frac{6+15+10}{30} = \frac{31}{30}$$

$$R_p = \frac{30}{31} = 0.96\,\Omega$$

**Question 4:**
Three resistances of 3 Ω each are connected in parallel. What will be the total resistance?
**Answer:**
$R_1$= 3 Ω, $R_2$ = 3 Ω and $R_3$ = 3 Ω

We have, $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\Rightarrow \quad \frac{1}{R_P} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{3}{3}$

$\Rightarrow \quad R_p = 1\Omega$

**Question 5:**
Three resistors of 1 Ω , 2 Ω and 3 Ω are connected in parallel, with potential difference of 2 V. What amount of current is drawn in the circuit?
**Answer:**
Three resistors are connected in parallel

$\therefore \quad \frac{1}{R_p} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} = \frac{6+3+2}{6} = \frac{11}{6}$

$\therefore \quad R_p = \frac{6}{11}, V = 2\ V, I = ?$

Now, $V = IR$

$\Rightarrow \quad I = \frac{V}{R} = \frac{2}{0.54}$

$\Rightarrow \quad I = 3.70\ A$

**Question 6:**
How is the fuse wire in household connected?
**Answer:**
A fuse wire in household is connected in series.

## Science Practicals Lab Manual Questions

**Question 1:**
If two resistors having resistances of 3 Ω, and 6 Ω, respectively are connected in parallel, what will be the net resistance in the circuit?
**Answer:**

The net resistance when the resistors are connected in parallel:

$$1/R_p = 1/R_1 + 1/R_2 = 1/3 + 1/6 = 3/6$$

$$\Rightarrow \quad R_p = \frac{6}{3} = 2\Omega$$

**Question 2:**
Two resistors having resistances of 4 Ω and 6 Ω, respectively are connected in a circuit. It was found that the total resistance in the circuit is less than 4 Ω. In what way the resistances would have been connected?
**Answer:**
The two resistors are connected in parallel because the overall resistance is less.

$$1/R_p = 1/R_1 + 1/R_2 = 1/4 + 1/6 = 5/12$$

$$\therefore \quad R_p = 12/5 = 2.4\ \Omega$$

**Question 3:**
Two resistors are connected in series and then in parallel. What effect will it have on the readings of voltmeter and ammeter?
**Answer:**
In series connection, the ammeter reading will remain the same but the voltmeter reading will decrease. But in parallel connection, the voltmeter reading will remain the same and the ammeter reading will be different.

**Question 4:**
In what way household appliances should be connected?
**Answer:**
The household appliances should be connected in parallel to get equal voltage for each

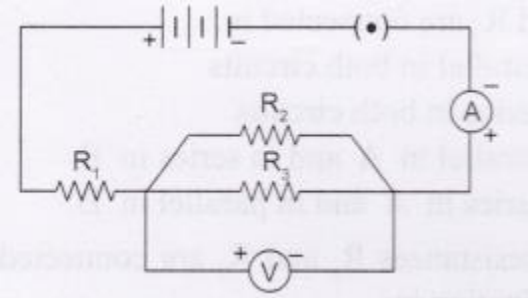
## Physics Lab Manual Multiple Choice Questions (MCQs)

**Questions based on Procedural and Manipulative Skills**
**Question 1:**
In our house circuit the electrical appliances are connected in:
**(a)** parallel
**(b)** series
**(c)** both (a) and (b)
**(d)** depends on power of device.
**Answer:**
**(a)**
**Explanation:**
To prevent the damage of appliances.

**Question 2:**
A circuit contains battery, 2 resistors of different value, ammeter and voltmeter. When resistors are connected in series and then in parallel, the device that will show same value in both the cases is:
**(a)** ammeter **(b)** voltmeter
**(c)** both (a) and (b) **(d)** none of these.
**Answer:**
**(d)**
**Explanation:**
The current changes in parallel and voltage changes in series.

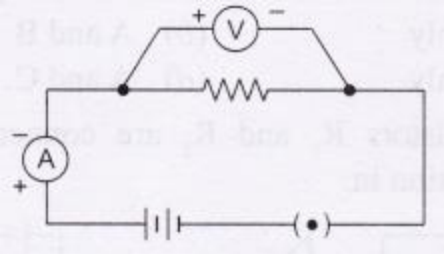
**Question 3:**
The physical quantity that remains unchanged in parallel combination is:
**(a)** voltage **(b)** current
**(c)** resistance **(d)** none of these.
**Answer:**
**(a)**
**Explanation:**
Voltage is same in parallel circuit.

**Questions based on Observational Skills**
**Question 4:**
In the circuit diagram, name the resistors which are in parallel connection.




**(a)** $R_1$ and $R_2$ **(b)** $R_2$ and $R_3$
**(c)** $R_1$ and $R_3$ **(d)** $R_1$ ,$R_2$ with $R_3$
**Answer:**
**(b)**
**Explanation:**
The current will be different but the voltage will be the same across $R_2$ and $R_3$.

**Question 5:**
The voltmeter, ammeter and resistance in the circuit shown below have been checked to be correct. On plugging the key, the ammeter reads 0.9 A, but the voltmeter reads zero. This could be because.




**(a)** The range of the voltmeter is more than twice the battery voltage.
**(b)** The least count of the voltmeter is too high.
**(c)** The wires joined to the voltmeter terminals are loose.
**(d)** The voltmeter is incorrectly placed in the circuit.

**Answer:**

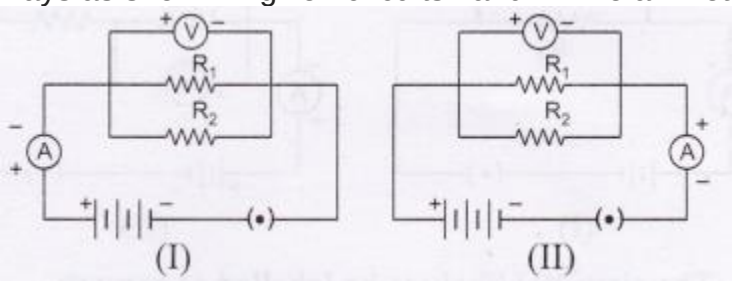
**(c)**

**Explanation:**

The circuit components are rightly arranged but if wires are loosely connected, the problem arises.

**Question 6:**

In parallel combination of resistors, two students connected the ammeter in two different ways as shown in given circuits I and II. The ammeter has been correctly connected in:




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

**Answer:**

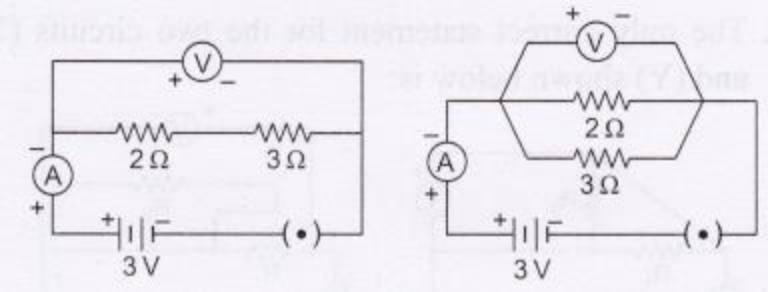
**(c)**

**Explanation:**

Ammeter is rightly connected in both the circuits and terminals are correct.

**Question 7:**

Two students are using two circuits shown below.
They are doing experiment to find the equivalent resistance of a:




**(a)** Series combination and parallel combination respectively of the two given resistors.
**(b)** Parallel combination and a series combination respectively of the two given resistors.
**(c)** Series combination of the two given resistors in both the cases.
**(d)** Parallel combination of the two given resistors in both the cases.

**Answer:**

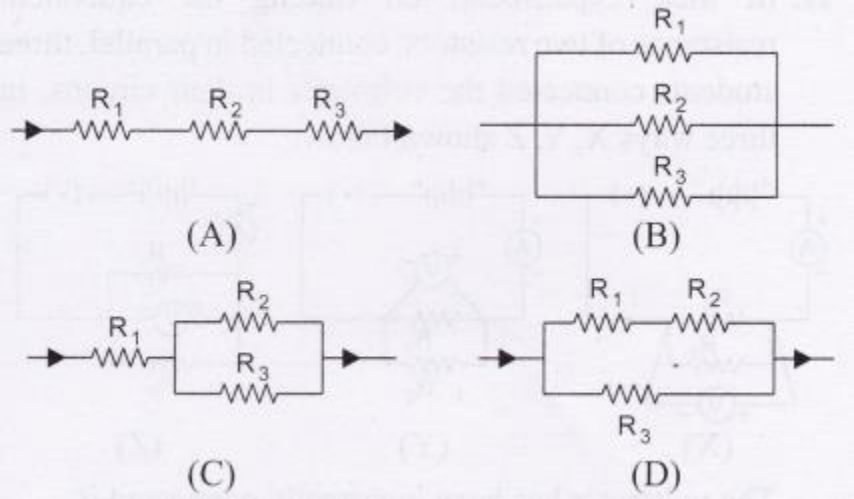
**(a)**

**Explanation:**

Given resistors are in series and parallel combinations respectively.

**Question 8:**

To determine the equivalent resistance of three resistors, when connected in a parallel arrangement four students connected the resistors as follows:




**(a)** A **(b)** B **(c)** C **(d)** D.

**Answer:**

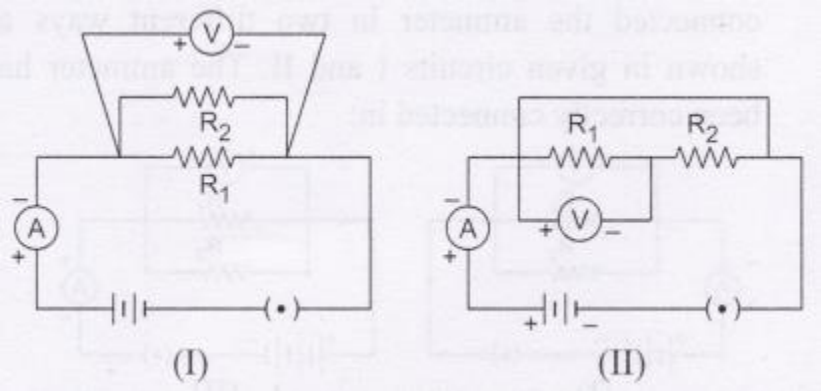
**(b)**

**Explanation:**

As per the arrangement, all the three resistors are connected in parallel.

**Question 9:**

Two students set up their circuits for finding the equivalent resistance of two resistors connected in parallel in two different ways as shown.
The circuit(s) likely to be labelled as correct:




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

**Answer:**

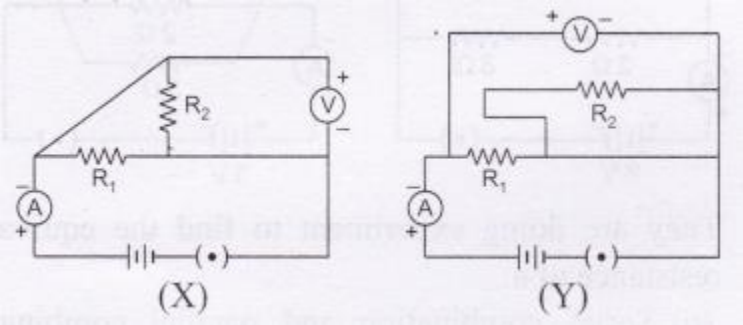
**(b)**

**Explanation:**

In circuit II, the resistors are connected in series and not in parallel.

**Question 10:**

The only correct statement for the two circuits (X) and (Y) shown below is:




**(a)** The resistors $R_1$ and $R_2$ have been connected in series in both the circuits.
**(b)** The resistors $R_1$ and $R_2$ have been connected in parallel in both the circuits.
**(c)** In the circuit (X) the resistors have been connected in parallel, whereas these are connected in series in circuit (Y)
**(d)** In the circuit (X) the resistors $R_1$ and $R_2$ are connected in series while these are connected in parallel in circuit (Y).

**Answer:**

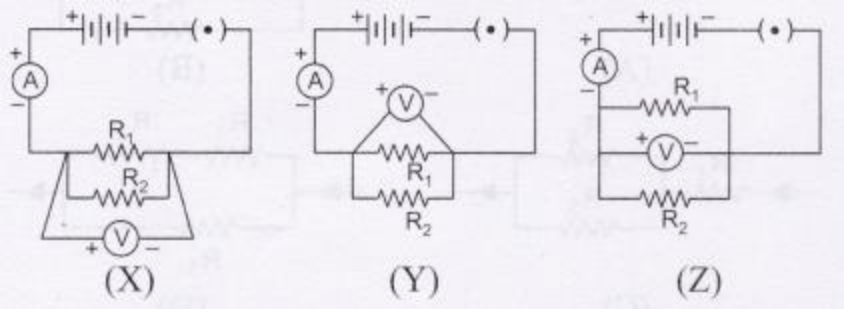
**(b)**

**Explanation:**

The series and parallel arrangements can be clearly identified from the figures.

**Question 11:**

In their experiment, on finding the equivalent resistance of two resistors, connected in parallel, three students connected the voltmeter in their circuits, in three ways X, Y, Z shown below:




The voltmeter has been incorrectly connected in

**(a)** case X only **(b)** case Y only

**(c)** case Z only **(d)** All the three cases.

**Answer:**

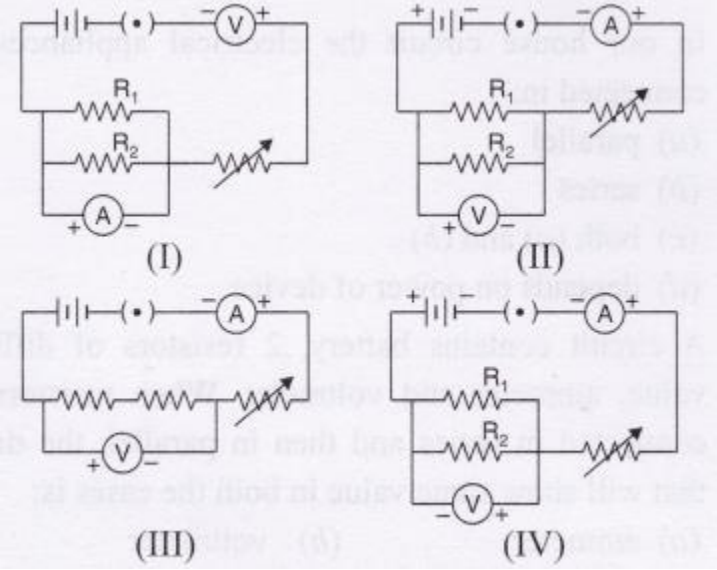
**(c)**

**Explanation:**

In circuit Z, voltmeter is connected in series with ammeter.

**Question 12:**

The correct set-up for determining the equivalent resistance of two resistors $R_1$ and $R_2$ when connected in parallel is:




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

**Answer:**

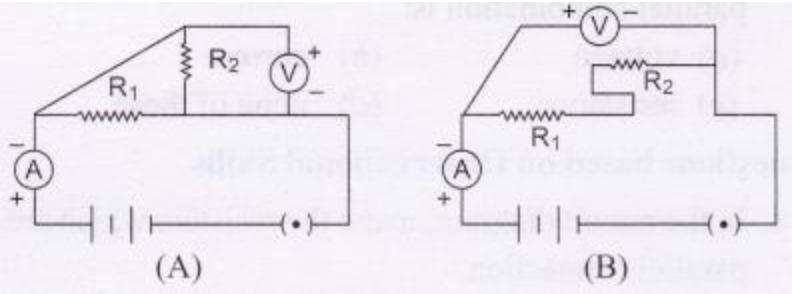
**(b)**

**Explanation:**

Ammeter is connected in series and voltmeter in parallel.

**Question 13:**

The resistors $R_1$ and $R_2$ are connected in circuits A and B.




$R_1$ and $R_2$ are connected in:

**(a)** parallel in both circuits

**(b)** series in both circuits

**(c)** parallel in A and in series in B

**(d)** series in A and in parallel in B.

**Answer:**

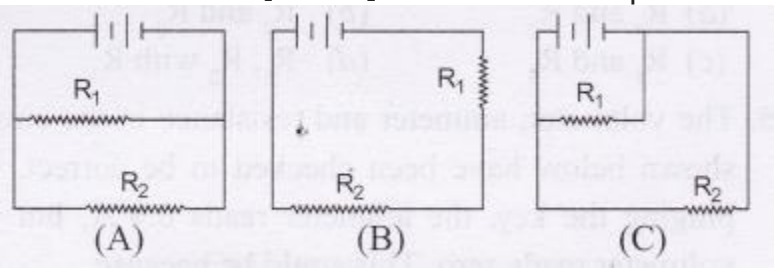
**(c)**

**Explanation:**

Given value resistors are connected in parallel in circuit A and in series in circuit B.

## Question 14:

Two resistances $R_1$ and $R_2$ are connected in parallel combination in:




The correct combination is shown in fig.

**(a)** A only **(b)** A and B

**(c)** C only **(d)** A and C.

**Answer:**

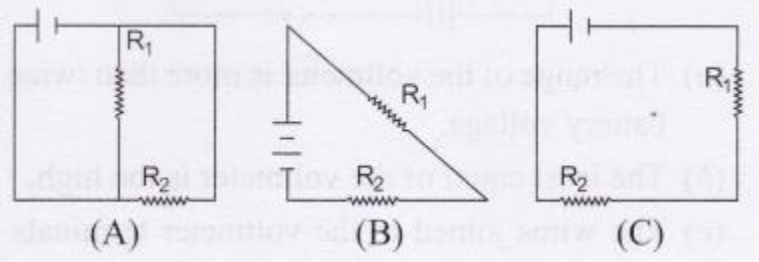
**(d)**

**Explanation:**

In circuit B, the resistors are connected in series.

## Question 15:

Two resistors $R_1$ and $R_2$ are connected in series combination in:




**(a)** A only **(b)** B only

**(c)** A and B **(d)** B and C.

**Answer:**

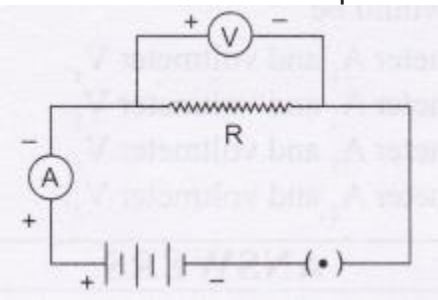
**(d)**

**Explanation:**

In circuit A, they are connected in parallel.

**Question 16:**

Which of the circuit components are connected in parallel in the given circuit diagram?




**(a)** key and ammeter

**(b)** ammeter and voltmeter

**(c)** voltmeter and resistor

**(d)** ammeter and resistor

**Answer:**

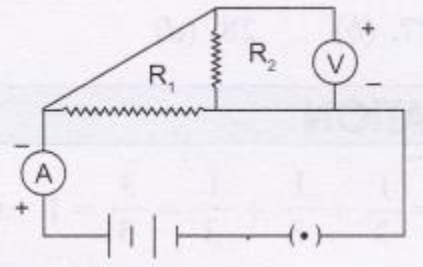
**(c)**

**Explanation:**

As per the circuit voltmeter V and resistor R are connected in parallel.

**Question 17:**

In the given circuit:




**(a)** $R_1$ and V are parallel

**(b)** $R_1$ and $R_2$ are parallel

**(c)** $R_1$, $R_2$ and V are parallel

**(d)** $R_2$ and V are parallel

**Answer:**

**(c)**

**Explanation:**

$R_1$ , $R_2$ and voltmeter V are connected in parallel as per the given figure.

**Questions based on Reporting and Interpretation Skills**

**Question 18:**

Three resistors of value 3 Ω are connected in parallel, the total resistance would be:
**(a)** 3 Ω **(b)** 9Ω **(c)** 6 Ω **(d)** 1 Ω.

**Answer:**

**(d)**

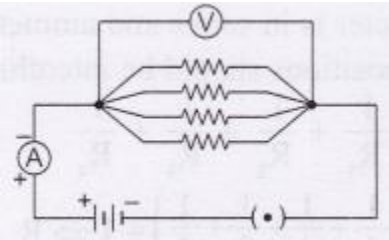
**Explanation:**

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_P} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{3}{3} = 1 \Rightarrow R_P = 1\ \Omega$$

**Question 19:**

Four resistors are connected in parallel. Each has a resistance 2 Ω. The effective resistance is:




**(a)** 8 Ω **(b)** 0.5 Ω **(c)** 4 Ω **(d)** 0.25 Ω.

**Answer:**

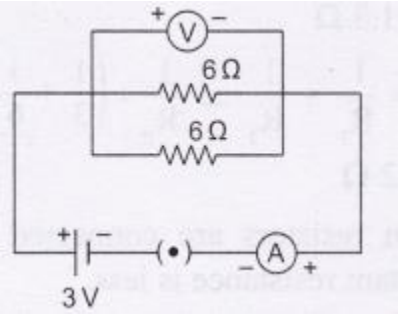
**(b)**

**Explanation:**

$$\frac{1}{R_p} = \left(\frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2}\right) = 2 \Rightarrow R_p = 0.5\ \text{ohm}$$

**Question 20:**

In the circuit below the voltmeter and ammeter readings would be respectively:




**(a)** 0 V and 0 A each **(b)** 3 V and 1 A
**(c)** I V and 3 A **(d)** 3 V and 3 A.

**Answer:**

**(b)**

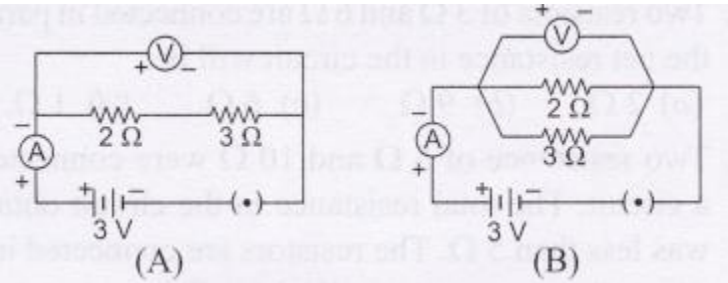
**Explanation:**

$$\frac{1}{R_p} = \left(\frac{1}{6} + \frac{1}{6}\right) = \frac{1}{3} \Rightarrow R_p = 3\ \Omega$$

$$I = \frac{3V}{3R} = 1\ A$$

**Question 21:**

For the circuits A and B shown below the voltmeter readings would be:




**(a)** 0.6 V in circuit A and 2.5 in B
**(b)** 0 V in both circuits
**(c)** 3 V in both circuits
**(d)** 0 V in circuit A and 3 V in circuit B

**Answer:**

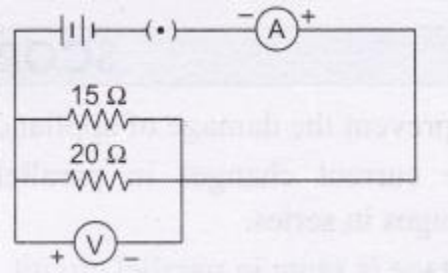
**(d)**

**Explanation:**

In circuit A, the key is open and in circuit B, the voltmeter V will show 3V reading.

**Question 22:**

The voltmeter, ammeter and the two resistors in the circuit have been checked and found correct. On inserting the key in the plug the voltmeter reads 3.0 V but the ammeter reads 150 mA. This could most likely be because the connecting wires joining the




**(a)** ammeter are loose
**(b)** 15 Ω resistor are loose
**(c)** 20 Ω resistor are loose
**(d)** voltmeter are loose.

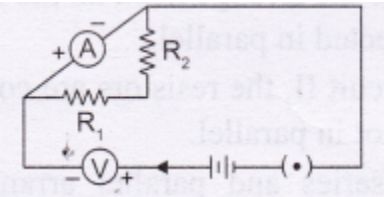
**Answer:**

**(b)**

**Explanation:**

The 15 ohm resistor is in parallel connection and with loose connections, the current may not flow through it.

**Question 23:**
For carrying out the experiment, on finding the equivalent resistance of two resistors connected in series, a student sets up the circuit as shown. On further verification he finds out that the circuit has one or more of the following faults:




(i) The resistors $R_1$ and $R_2$ have not been correctly connected in series.
(ii) The voltmeter has not been correctly connected in the circuit.
(iii) The ammeter has not been correctly connected in the circuit
Out of these three, the actual fault in the circuit is are:
**(a)** both (ii) and (iii)
**(b)** both (i) and (ii)
**(c)** only (i)
**(d)** only (ii).
**Answer:**
**(a)**
**Explanation:**
Voltmeter is in series and ammeter is in parallel, their positions should be interchanged.

**Question 24:**
Four resistors of 4 Ω each are connected in parallel. The resultant resistance will be:
**(a)** 4 Ω **(b)** 16 Ω **(c)** 64 Ω **(d)** 1 Ω.
**Answer:**
**(d)**
**Explanation:**

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

$$\frac{1}{R_p} = \left(\frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4}\right) = 1 \Rightarrow R_p = 1\ \Omega$$

**Question 25:**
Two resistors of 2 Ω and 4 Ω each are connected in parallel, the net resistance in the circuit will be:
**(a)** 6 Ω **(b)** 2 Ω **(c)** 1.3 Ω **(d)** 1 Ω.
**Answer:**
**(c)**

**Explanation:**

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{R_p} = \left(\frac{1}{2} + \frac{1}{4}\right) = \frac{3}{4}$$

$$R_p = 1.3\ \Omega$$

**Question 26:**

Two resistors of 3 Ω , and 6 Ω are connected in parallel, the net resistance in the circuit will be:

**(a)** 2 Ω **(b)** 9 Ω **(c)** 6 Ω **(d)** I Ω.

**Answer:**

**(a)**

**Explanation:**

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{R_p} = \left(\frac{1}{3} + \frac{1}{6}\right) = \frac{1}{2}$$

$$R_p = 2\ \Omega$$

**Question 27:**

Two resistance of 5 Ω and 10 Ω were connected in a circuit. The total resistance in the circuit obtained was less than 5 Ω. The resistors are connected in:

**(a)** series **(b)** parallel

**(c)** both (a) and (b) **(d)** can't say.

**Answer:**

**(b)**

**Explanation:**

When resistors are connected in parallel, the resultant resistance is less.

**Question 28:**

The following apparatus in a laboratory.

Cell: adjustable from 0 to 1.5 Ω

Resistor: 4 Ω and 12 Ω

Ammeter: $A_1$ of Range 0 to 3 A: Least Count 0.1 A

$A_2$ of Range 0 to 1 A: Least Count 0.05 A

Voltmeters: $V_1$ of Range 0 to 10 V: Least Count 0.5 V

$V_2$ of Range 0 to 5 V : Least Count 0.1 V

The best combination of voltmeter and ammeter for finding the equivalent resistance of the resistors in parallel would be

**(a)** ammeter $A_1$ and voltmeter $V_1$.

**(b)** ammeter $A_1$ and voltmeter $V_2$.

**(c)** ammeter $A_2$ and voltmeter $V_1$.

**(d)** ammeter $A_2$ and voltmeter $V_2$.

**Answer:**

**(d)**

**Explanation:**
The overall range of voltage is from 0 to 1.5 V and that of current is from 0 to 1.5/3 A = 0.5 A. We therefore prefer, instruments that cover these ranges and also have a better least count.