Physics · Electric Current and Electromagnetism · Electric Current, Ohm's Law and Kirchhoff's Laws

Ohm's Law for a Closed Circuit

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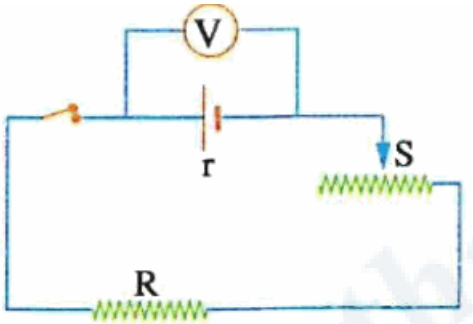
Multiple choice questions — 87 questions

1 An electric source has an emf of 8 V and an internal resistance r. The potential difference between its terminals while a current flows in its circuit is .....

(A) equal to 8 V
(B) less than 8 V
(C) greater than 8 V
(D) impossible to determine without knowing r

---

2 In the opposite circuit, when the variable resistance (S) is increased, the voltmeter reading .....



(A) increases
(B) decreases until it becomes zero
(C) stays the same
(D) decreases but does not become zero

---

3 When a battery of emf 6 V is connected to a 10 Ω resistance, a current of 0.5 A flows. The internal resistance of the battery is .....

(A) 0.5 Ω (B) 1 Ω (C) 1.5 Ω (D) 2 Ω

---

4 Three resistances 3 Ω, 6 Ω and 4 Ω are connected in series to a battery of emf 30 V and internal resistance 2 Ω, so:
The total resistance of the circuit is .....

(A) 11 Ω (B) 13 Ω (C) 15 Ω (D) 19 Ω

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5 Three resistances 3 Ω, 6 Ω and 4 Ω are connected in series to a battery of emf 30 V and internal resistance 2 Ω, so:
The current flowing in the circuit is .....

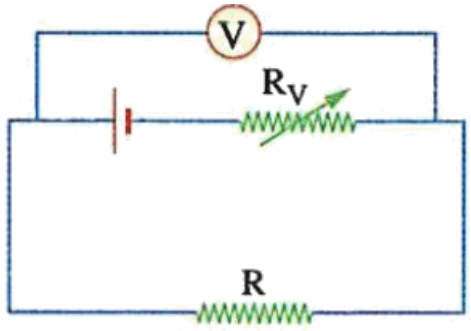
(A) 0.5 A (B) 1 A (C) 1.5 A (D) 2 A

6 Three resistances 3 Ω, 6 Ω and 4 Ω are connected in series to a battery of emf 30 V and internal resistance 2 Ω, so:

The potential difference across the 6 Ω resistance is .....

(A) 6 V (B) 8 V (C) 12 V (D) 18 V

7 In the circuit shown, when R_V is decreased, the reading of the voltmeter (V) .....



(A) increases (B) decreases until it becomes zero

(C) stays constant (D) decreases but does not become zero

8 When the external circuit of a battery is closed, the current flowing through it is inversely proportional to .....

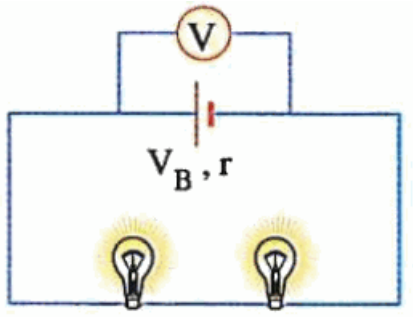
(A) the emf of the battery

(B) the internal resistance of the battery

(C) the external equivalent resistance of the circuit

(D) the total resistance of the circuit

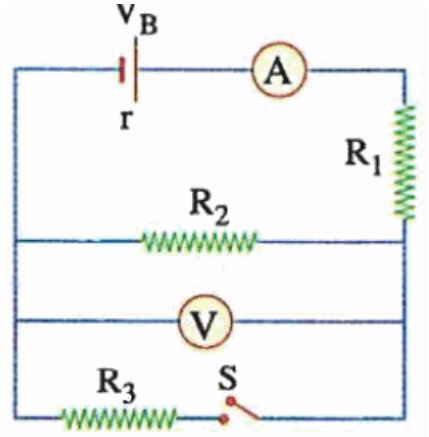
9 In the circuit shown in the figure, if the filament of one of the two lamps burns out, the voltmeter reading .....



(A) increases (B) decreases but is not zero

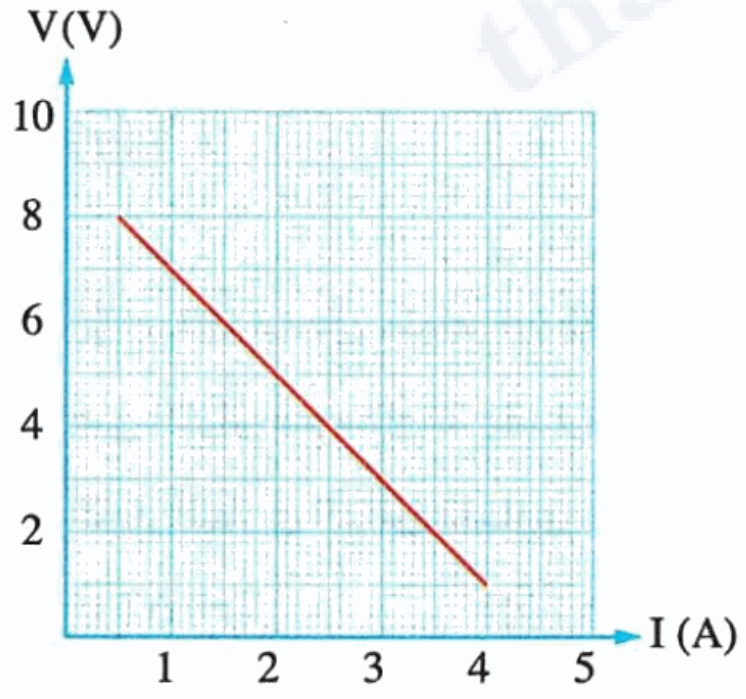
(C) does not change (D) becomes zero

10 In the circuit shown, when the switch S is closed, the readings of the voltmeter and the ammeter respectively .....



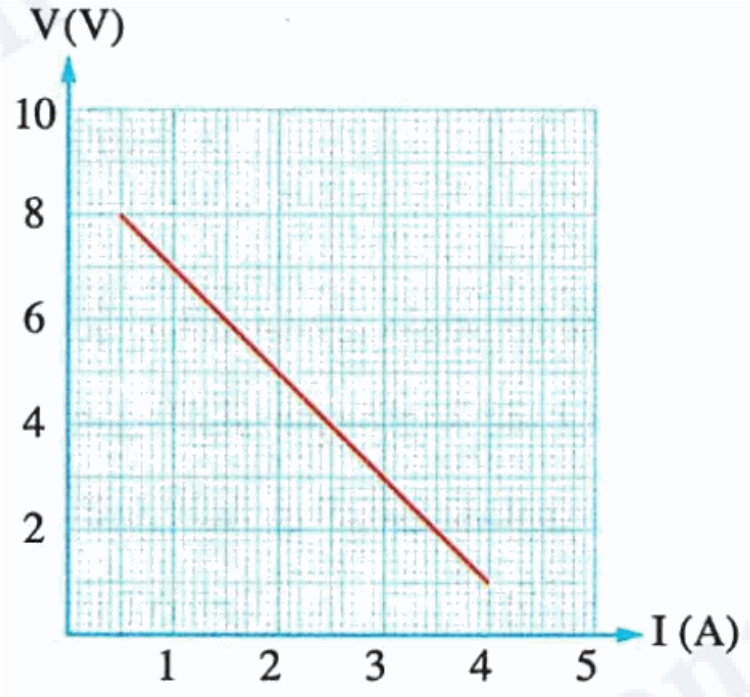
(A) decrease, decrease
(B) decrease, increase
(C) increase, decrease
(D) increase, increase

11 The opposite graph represents the relation between the potential difference between the terminals of a battery (V) and the current flowing through it (I), so:
The internal resistance of the battery is .....



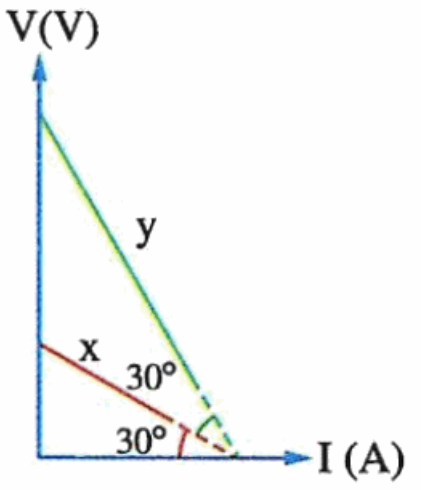
(A) 1 Ω
(B) 2 Ω
(C) 0.45 Ω
(D) 0.9 Ω

12 The opposite graph represents the relation between the potential difference between the terminals of a battery (V) and the current flowing through it (I), so:
The emf of the battery is .....



(A) 7 V (B) 7.5 V (C) 8 V (D) 9 V

13 The opposite graph represents the relation between the potential difference between the terminals of two cells (x) and (y) and the current flowing in the circuit of each. The ratio between their internal resistances (r_x/r_y) is .....



(A) $1/2$ (B) $1/3$ (C) $(\sqrt{3})/2$ (D) $\sqrt{3/2}$

14 Figure (1) is a graph of the relation between the voltmeter reading (V) and the ammeter reading (A) when the resistance (R) is changed in the circuit shown in figure (2).
If the internal resistance of the battery is 0.25 Ω, which of the following represents two possible values for the points (x) and (y) shown on the graph?

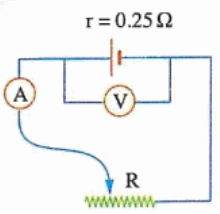


Figure (2)

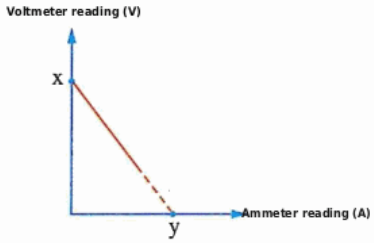
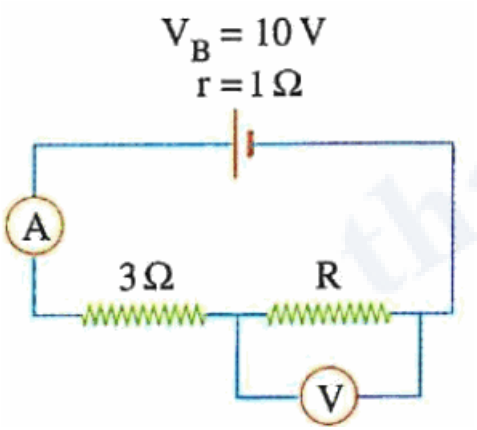


Figure (1)

(A) x = 8 V, y = 8 A (B) x = 8 V, y = 2 A (C) x = 2 V, y = 8 A (D) x = 2 V, y = 4 A

15 In the circuit shown in the figure, if the ammeter reads 1 A, the voltmeter reads .....



(A) 3 V (B) 6 V (C) 7 V (D) 9 V

16 A metal wire of length 30 m, cross-sectional area 0.3 cm² and resistivity 5×10^{-7} Ω.m is connected in series with a resistance of 8.5 Ω and a battery of emf 18 V and internal resistance 1 Ω. The current flowing in the circuit is .....

(A) 0.9 A (B) 1.8 A (C) 3.6 A (D) 4.2 A

17 A battery of emf 6 V and internal resistance 1 Ω, an ammeter of negligible resistance, a fixed resistance R and a rheostat are connected in series. When the slider is at the start of the rheostat, a current of 0.6 A flows in the circuit, and when the slider is at the end of the rheostat, a current of 0.1 A flows, so:
The resistance R is .....

(A) 3 Ω (B) 6 Ω (C) 9 Ω (D) 12 Ω

18 A battery of emf 6 V and internal resistance 1 Ω, an ammeter of negligible resistance, a fixed resistance R and a rheostat are connected in series. When the slider is at the start of the rheostat, a current of 0.6 A flows in the circuit, and when the slider is at the end of the rheostat, a current of 0.1 A flows, so:

The maximum resistance of the rheostat is .....

(A) 15 Ω (B) 27 Ω (C) 38 Ω (D) 50 Ω

19 Two resistances $R_1 = 6\ \Omega$ and $R_2 = 4\ \Omega$ are connected in parallel between the terminals of an electric source of emf 6 V and internal resistance 0.1 Ω, so:

The current flowing in the circuit is .....

(A) 1.3 A (B) 2.4 A (C) 3.6 A (D) 4 A

20 Two resistances $R_1 = 6\ \Omega$ and $R_2 = 4\ \Omega$ are connected in parallel between the terminals of an electric source of emf 6 V and internal resistance 0.1 Ω, so:

The electric power consumed in the circuit (inside and outside the source) is .....

(A) 14.4 W (B) 15 W (C) 18.3 W (D) 21.9 W

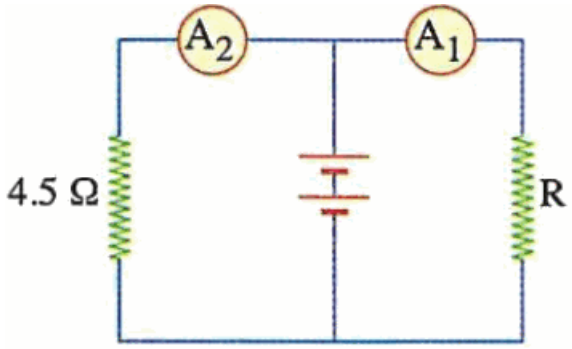
21 Two resistances $R_1 = 6\ \Omega$ and $R_2 = 4\ \Omega$ are connected in parallel between the terminals of an electric source of emf 6 V and internal resistance 0.1 Ω, so:

The electric power consumed in R_1 is .....

(A) 12.2 W (B) 9.3 W (C) 6.1 W (D) 5.53 W

22 In the opposite circuit, if the reading of ammeter A_1 is 1 A, the reading of ammeter A_2 is 2 A and the internal resistance of the battery (r) is 1 Ω, so:

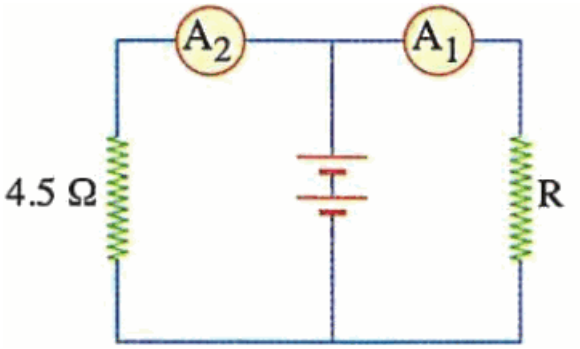
The value of the resistance R is .....



(A) 2 Ω (B) 4.5 Ω (C) 9 Ω (D) 13 Ω

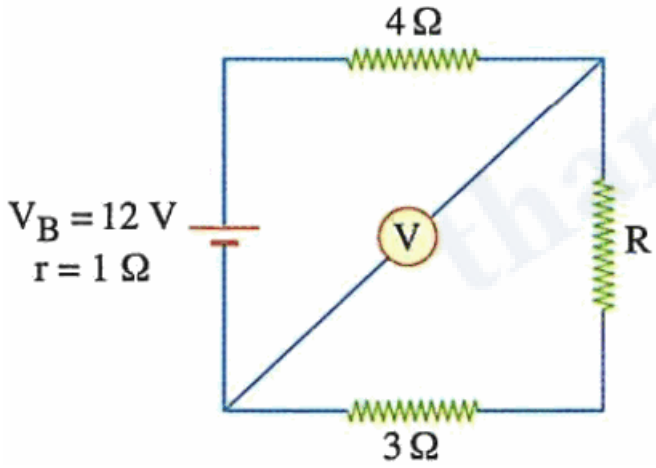
23 In the opposite circuit, if the reading of ammeter A_1 is 1 A, the reading of ammeter A_2 is 2 A and the internal resistance of the battery (r) is 1 Ω, so:

The emf of the battery is .....



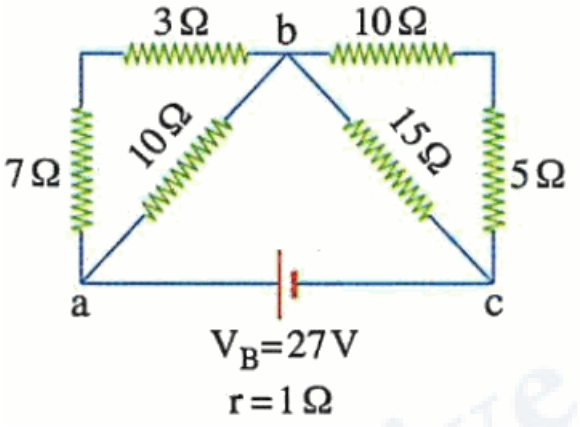
(A) 14 V (B) 12 V (C) 9 V (D) 8 V

24 In the circuit shown in the figure, if the voltmeter reads 6 V, the resistance R is .....



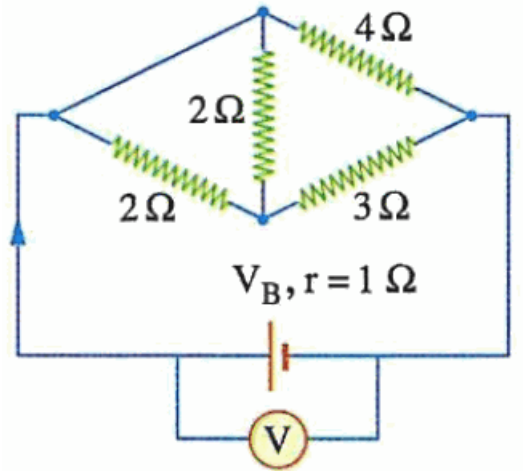
(A) 2 Ω (B) 3 Ω (C) 4.8 Ω (D) 6 Ω

25 In the circuit shown, the potential difference between b and c is .....



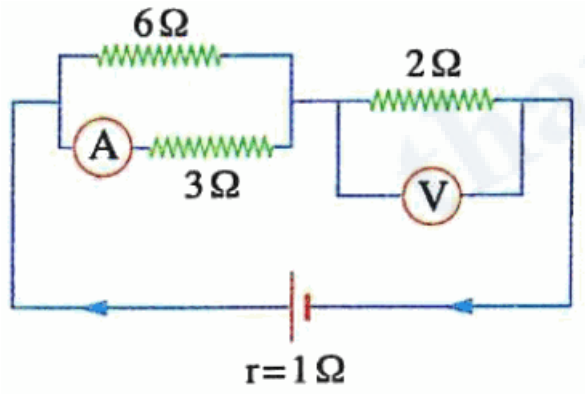
(A) 5 V (B) 10 V (C) 15 V (D) 20 V

26 In the opposite circuit, if the voltmeter reads 8 V, the emf of the battery (V_B) is .....



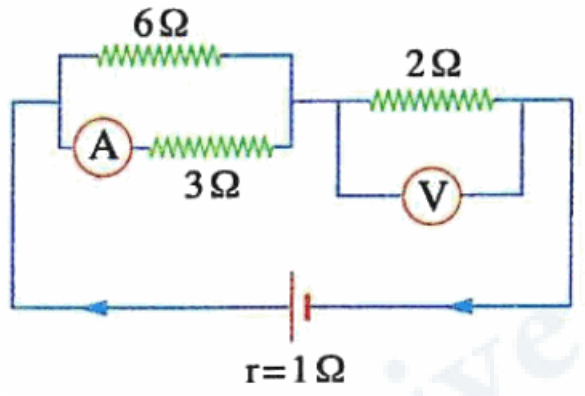
(A) 8 V (B) 10 V (C) 12 V (D) 14 V

27 In the opposite figure, if the current flowing in the 6 Ω resistance is 1 A, so:
The reading of the ammeter (A) is .....



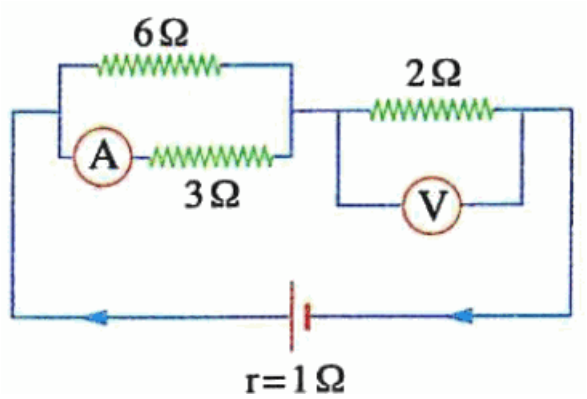
(A) 3.4 A (B) 3 A (C) 2.8 A (D) 2 A

28 In the opposite figure, if the current flowing in the 6 Ω resistance is 1 A, so:
The reading of the voltmeter (V) is .....



(A) 1 V (B) 3 V (C) 6 V (D) 9 V

29 In the opposite figure, if the current flowing in the 6 Ω resistance is 1 A, so:
The emf of the battery is .....

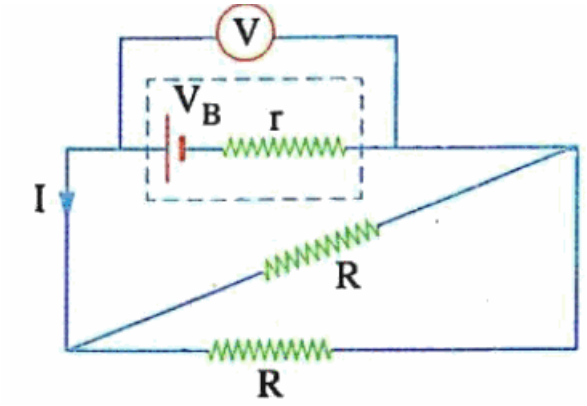


(A) 11 V (B) 13 V (C) 15 V (D) 19 V

30 Three resistances 8 Ω, 6 Ω and 16 Ω are connected together in a certain way, then the group is connected to a current source of internal resistance 1.2 Ω. When the circuit is closed, the p.d. across the 8 Ω resistance is 2 V, across the 6 Ω resistance is 6 V and across the 16 Ω resistance is 4 V. The emf of the source is .....

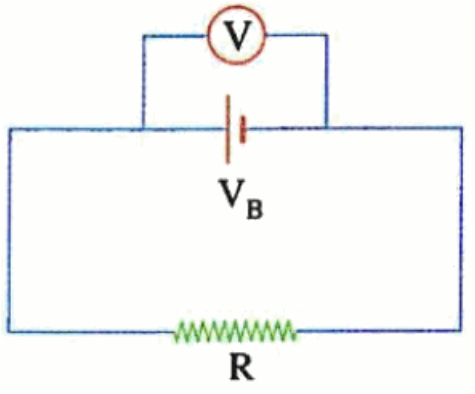
(A) 6 V (B) 7.5 V (C) 9 V (D) 12 V

31 In the opposite circuit, the voltmeter reading is .....



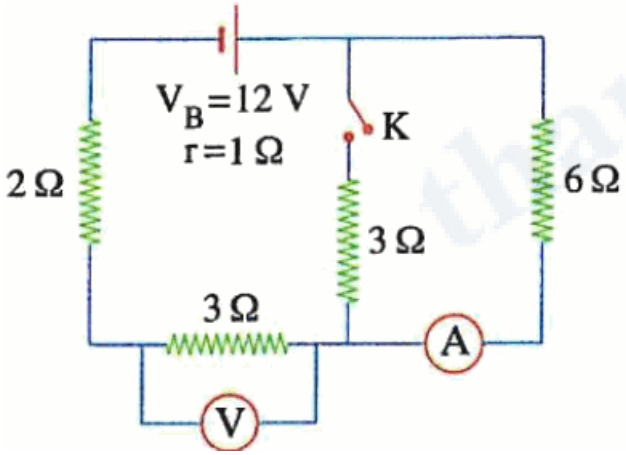
(A) $V_B - 2Ir$ (B) $V_B + Ir$ (C) $IR/2$ (D) $2IR$

32 In the opposite circuit, if the internal resistance of the battery is *1/4*R, the voltmeter reading is .....



(A) *2/3* V_B (B) *5/4* V_B (C) *1/5* V_B (D) *4/5* V_B

33 In the circuit shown in the figure, when the switch K is closed, the readings of the ammeter (A) and the voltmeter (V) .....



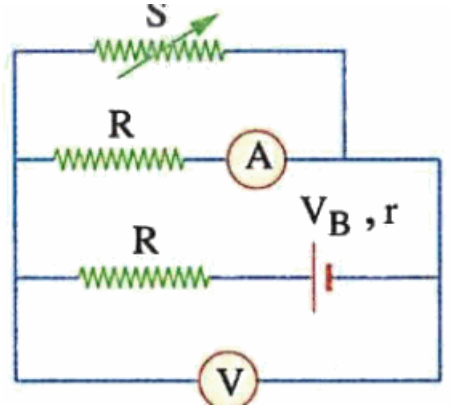
(A) ammeter reading increases, voltmeter reading decreases

(B) ammeter reading decreases, voltmeter reading increases

(C) ammeter reading increases, voltmeter reading increases

(D) ammeter reading decreases, voltmeter reading decreases

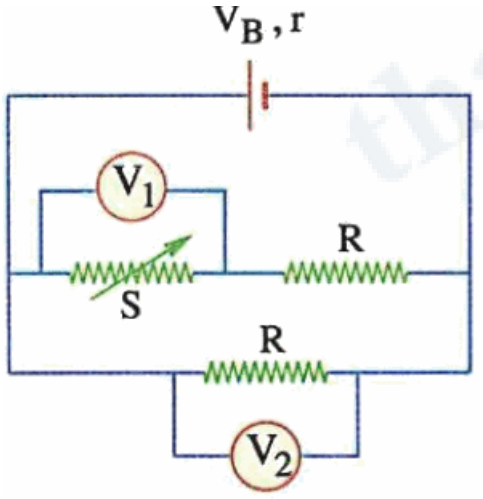
34 What happens to the readings of the ammeter and the voltmeter respectively when the variable resistance S in the opposite circuit is increased?



(A) increase, increase
(B) increase, decrease
(C) decrease, increase
(D) decrease, decrease

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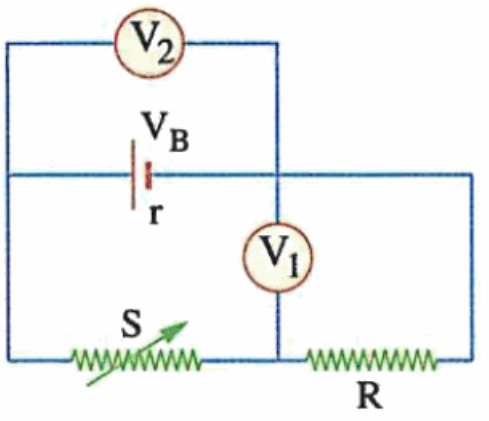
35 The opposite figure shows a closed circuit. When the variable resistance (S) is increased, the readings of the two voltmeters V_1 and V_2 respectively .....



(A) increase, increase
(B) decrease, decrease
(C) increase, decrease
(D) decrease, increase

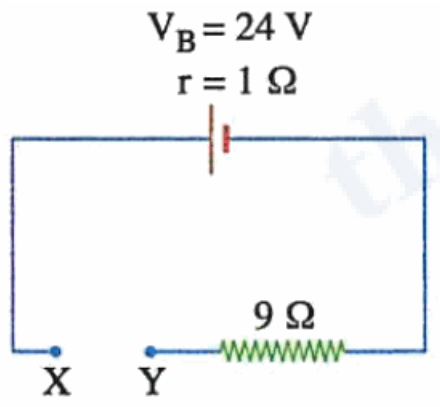
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36 In the circuit shown, if the value of the variable resistance (S) is decreased, which of the following ratios decreases?



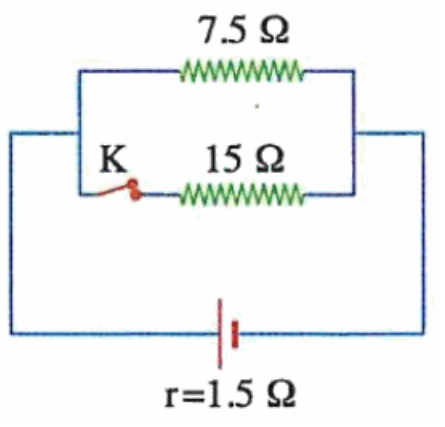
(A) V_1/V_B (B) V_2/V_1 (C) V_B/V_2 (D) V_1/V_2

37 You have a group of resistances, each of 8 Ω. How many of them are needed, and how should they be connected between the points X and Y, so that a current of 2 A flows in the circuit?



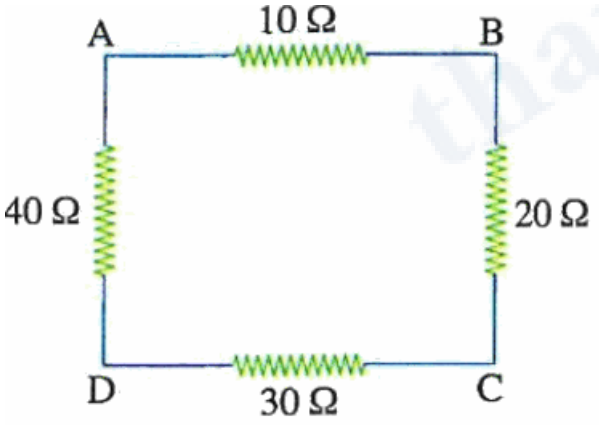
(A) two resistances, in series (B) three resistances, in series
(C) four resistances, in parallel (D) six resistances, in parallel

38 In the circuit shown in the figure, if the current flowing in the circuit when the switch K is closed is 0.5 A greater than when it is open, the emf of the battery is .....



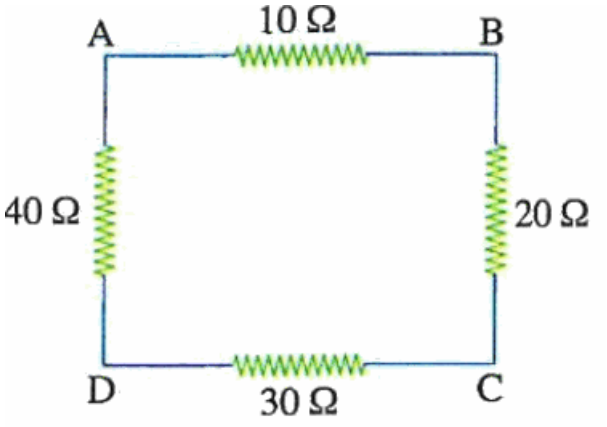
(A) 8.2 V (B) 9.4 V (C) 10.3 V (D) 11.7 V

39 The opposite figure shows four resistances connected in the shape of a square ABCD, so: The two points to which a battery of internal resistance 1 Ω must be connected so that a current of 0.25 A flows in all the resistances are .....



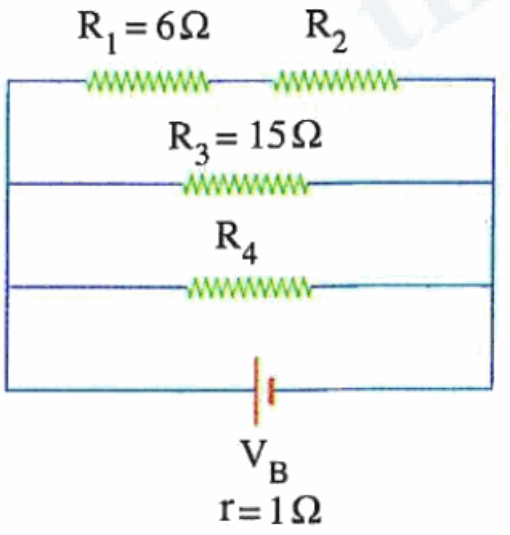
(A) A, B (B) B, D (C) C, D (D) A, C

40 The opposite figure shows four resistances connected in the shape of a square ABCD, so:
If a battery of internal resistance 1 Ω is connected between the two points that make the current in all the resistances 0.25 A, the emf of this battery is .....



(A) 13 V (B) 26 V (C) 35 V (D) 40 V

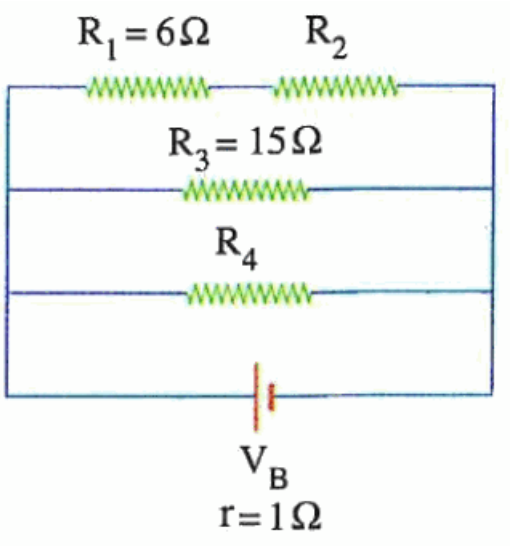
41 The opposite figure shows a circuit consisting of a battery V_B of internal resistance 1 Ω connected to four resistances R_1, R_2, R_3 and R_4. A current of 0.3 A flows in R_1, 0.3 A in R_2, 0.4 A in R_3 and 0.2 A in R_4, so:
The emf V_B of the source is .....



(A) 5.4 V (B) 6.9 V (C) 7.13 V (D) 9.51 V

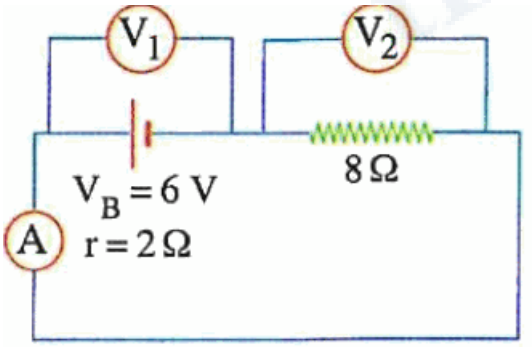
42 The opposite figure shows a circuit consisting of a battery V_B of internal resistance 1 Ω connected to four resistances R_1, R_2, R_3 and R_4. A current of 0.3 A flows in R_1, 0.3 A in R_2, 0.4 A in R_3 and 0.2 A in R_4, so:

The total resistance of the circuit is .....



(A) 30 Ω (B) 14 Ω (C) 7.67 Ω (D) 13.34 Ω

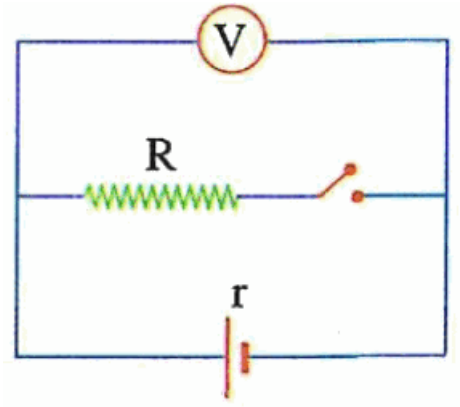
43 In the circuit shown in the figure, the readings of the two voltmeters V_1 and V_2 are .....



(A) V_1 = 2.25 V, V_2 = 5.5 V (B) V_1 = 4.8 V, V_2 = 4.8 V

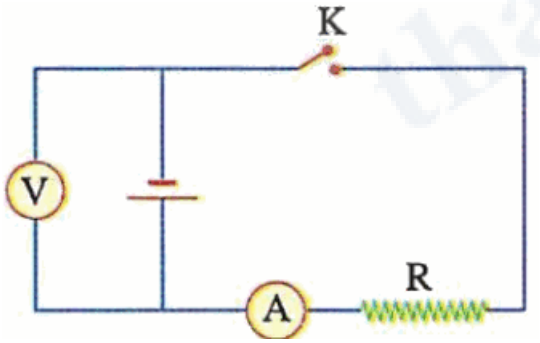
(C) V_1 = 2.25 V, V_2 = 2.25 V (D) V_1 = 4.8 V, V_2 = 2.4 V

44 A resistance (R) is connected to a battery of internal resistance (r) and a switch, as in the opposite circuit. If the voltmeter reads (V_o) when the switch is open, and its reading becomes $0.8\ V_o$ when the switch is closed, the ratio (R/r) is .....



(A) 1 (B) 2 (C) 4 (D) 8

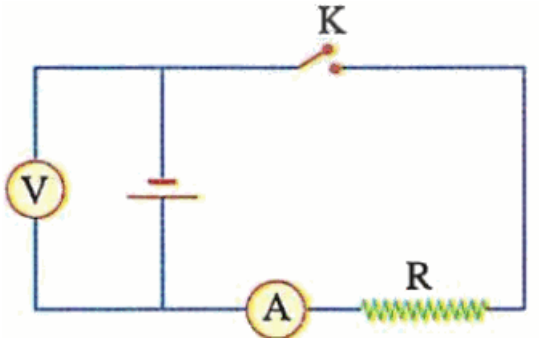
45 In the opposite circuit, when the switch K is open the voltmeter reads 12 V, and when the switch K is closed the voltmeter reads 9 V and the ammeter reads 1.5 A, so:
The internal resistance of the battery is .....



(A) 0.5 Ω (B) 1 Ω (C) 1.5 Ω (D) 2 Ω

46 In the opposite circuit, when the switch K is open the voltmeter reads 12 V, and when the switch K is closed the voltmeter reads 9 V and the ammeter reads 1.5 A, so:

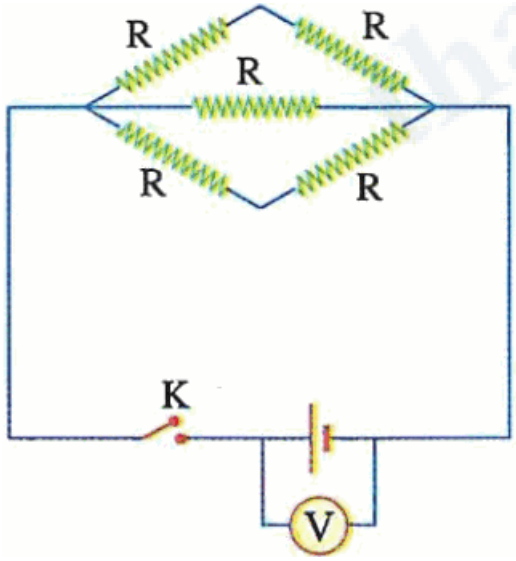
The value of the resistance R is .....



(A) 2 Ω (B) 4 Ω (C) 6 Ω (D) 8 Ω

47 In the circuit shown in the figure, the internal resistance of the battery is 2 Ω. The voltmeter reads 12 V when the switch K is open, and its reading becomes 10 V when the switch K is closed, so:

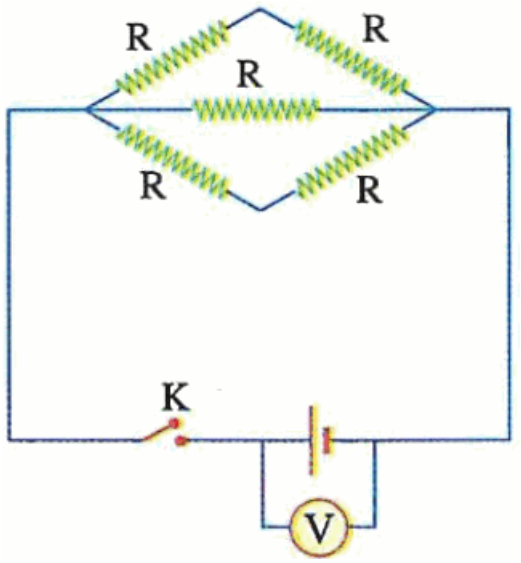
The current flowing in the circuit when the switch K is closed is .....



(A) 4 A (B) 3 A (C) 2 A (D) 1 A

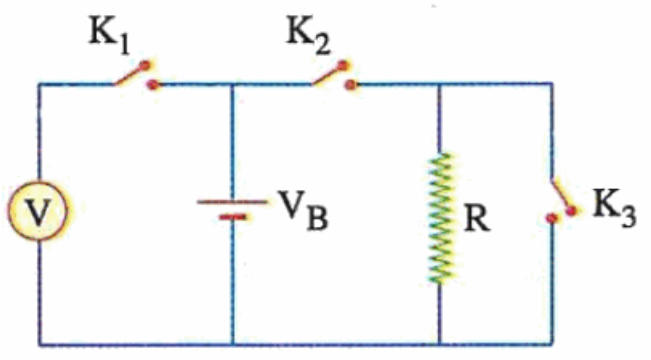
48 In the circuit shown in the figure, the internal resistance of the battery is 2 Ω. The voltmeter reads 12 V when the switch K is open, and its reading becomes 10 V when the switch K is closed, so:

The value of the resistance R is .....



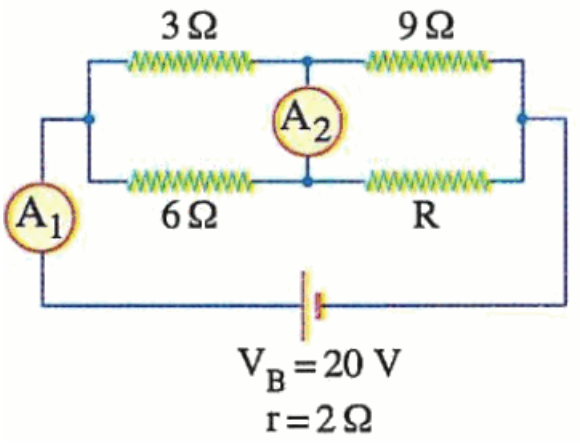
(A) 5 Ω (B) 10 Ω (C) 15 Ω (D) 20 Ω

49 In the opposite circuit, a voltmeter is connected across a battery of emf (V_B) and internal resistance (r). The voltmeter reads zero when ..... is closed.



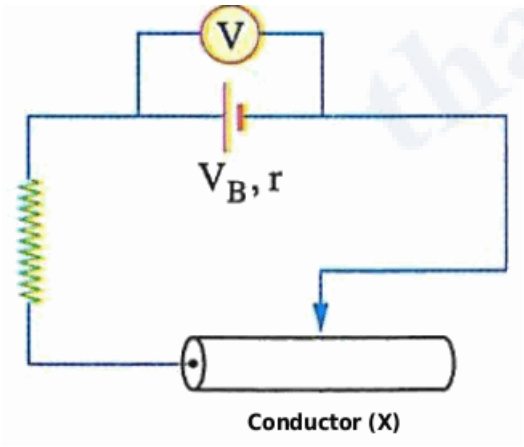
(A) the switch K_1 only
(B) the two switches K_1 and K_2 only
(C) the two switches K_1 and K_3 only
(D) all three switches K_1, K_2 and K_3

50 In the opposite circuit, if the pointer of the ammeter (A_2) stays at zero, the reading of the ammeter (A_1) is .....



(A) 3.5 A (B) 2.5 A (C) 2 A (D) 1.5 A

51 An electric source is connected to a uniform conductor (x) through a slider, as in the opposite circuit. What happens to the voltmeter reading (V) when the length of the part of the conductor that carries the current is increased?



(A) increases (B) decreases
(C) does not change (D) cannot be determined

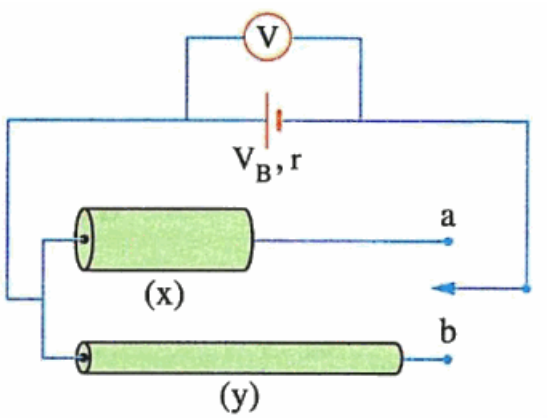
52 In the circuit shown, two uniform conductors (x) and (y) of the same metal, of lengths (ℓ) and (2ℓ) and cross-section diameters (d) and $(d/2)$ respectively, can be connected through a two-way switch to a battery of internal resistance (r). The following table records the voltmeter reading as the switch contact point is changed:

The switch is not connected to either point (a) or (b): V_1

The switch is connected to point (a): V_2

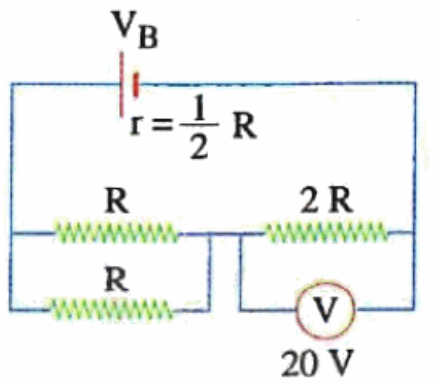
The switch is connected to point (b): V_3

The correct order of the three voltmeter readings is .....



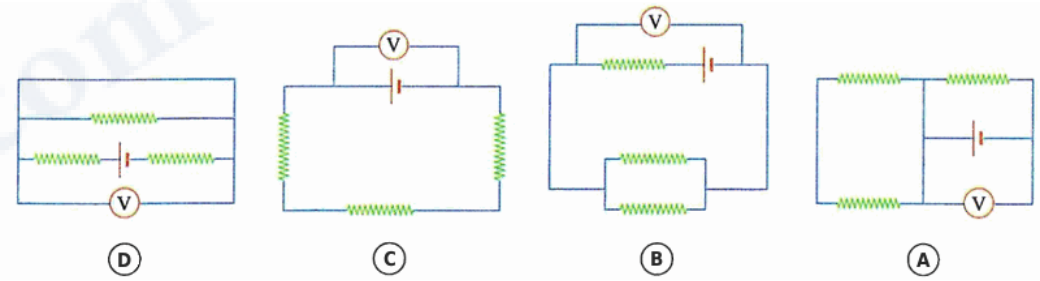
(A) $V_1 = V_2 = V_3$ (B) $V_1 > V_2 > V_3$ (C) $V_1 > V_3 > V_2$ (D) $V_3 > V_2 > V_1$

53 In the opposite circuit, the emf of the battery is .....

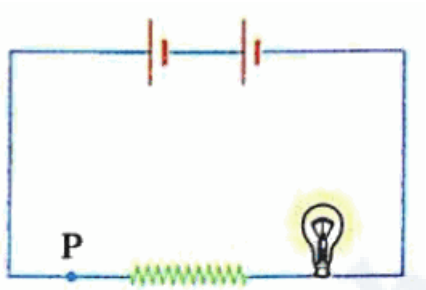


(A) 25 V (B) 30 V (C) 35 V (D) 45 V

54 Three identical resistances are connected to a battery of internal resistance (r) in four different ways, as shown in the following circuits. In which of these circuits is the voltmeter reading the greatest?



55 What change should be made in the opposite circuit to increase the current flowing in the lamp?



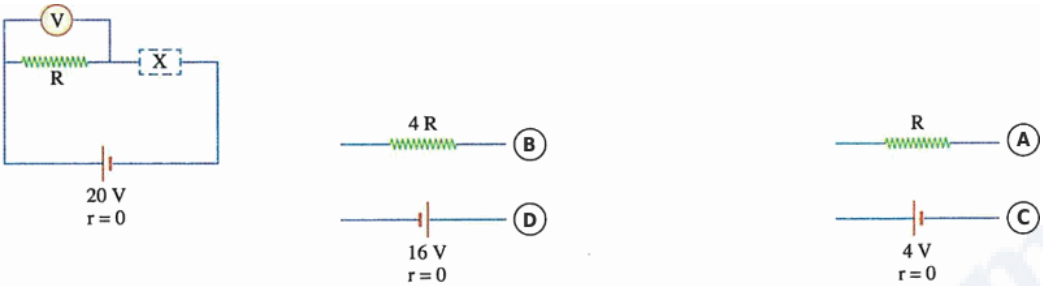
(A) Adding a resistance in parallel with the resistance in the circuit

(B) Adding a resistance in series with the resistance in the circuit

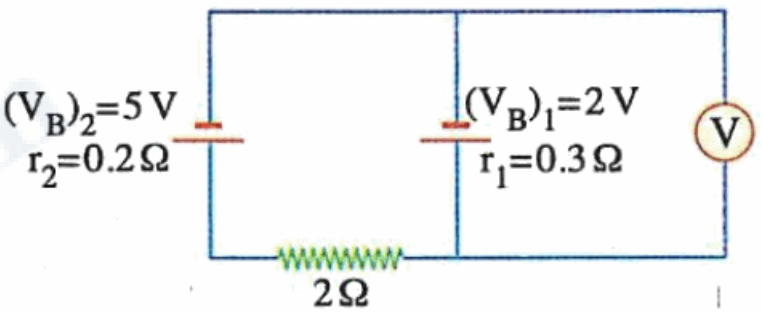
(C) Removing one of the two cells

(D) Moving the lamp to point P

56 The opposite figure represents a closed circuit. Which of the following components represents the element X that makes the voltmeter pointer deflect to 4 V?

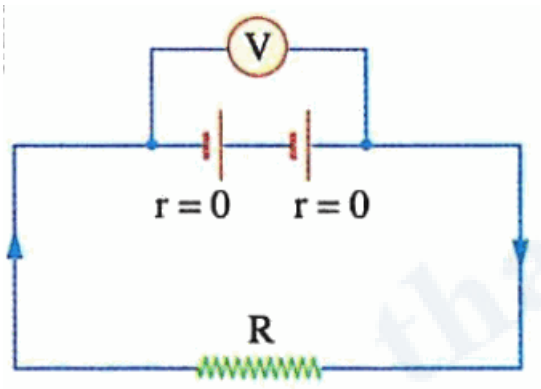


57 In the circuit in front of you, the voltmeter reading is .....



(A) 7.64 V (B) 2.36 V (C) 2 V (D) 1.64 V

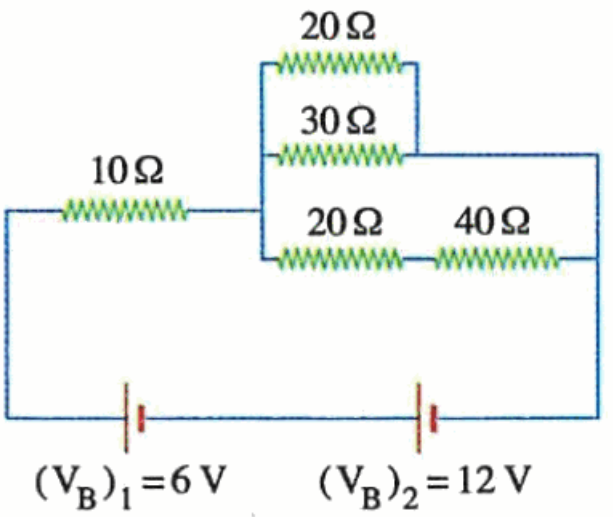
58 In the opposite circuit, if we remove one of the two cells of the battery and connect another resistance in series with the resistance R, the voltmeter reading .....



(A) increases (B) decreases

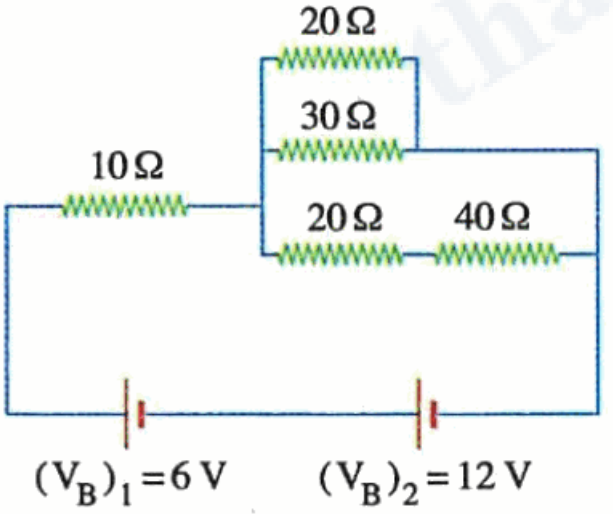
(C) stays the same (D) cannot be determined

59 In the circuit shown in the figure, if the internal resistance of each cell is 2 Ω, so:
The total external resistance of the circuit is .....



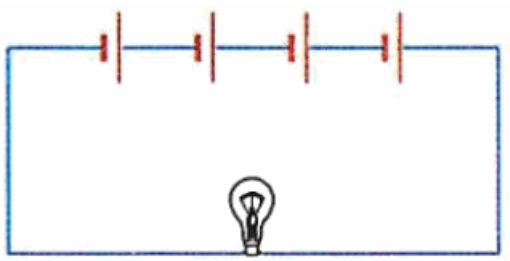
(A) 5 Ω (B) 10 Ω (C) 20 Ω (D) 25 Ω

60 In the circuit shown in the figure, if the internal resistance of each cell is 2 Ω, so:
The total current flowing in the circuit is .....



(A) 0.25 A (B) 0.5 A (C) 0.75 A (D) 1 A

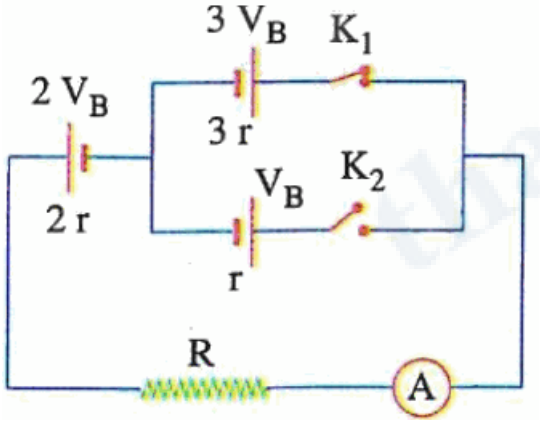
61 The opposite figure shows four identical cells, each of emf 12 V, connected to an electric lamp. If the current flowing in the circuit is 0.5 A and the power consumed in the lamp is 23 W, the internal resistance of each cell is .....



(A) 0.5 Ω (B) 1 Ω (C) 1.5 Ω (D) 2 Ω

---

62 In the circuit shown, when the switch K_1 is opened and the switch K_2 is closed, which of the following choices shows what happens to both the direction of the current in the resistance R and the ammeter reading?



(A) the current direction stays the same, the ammeter reading increases

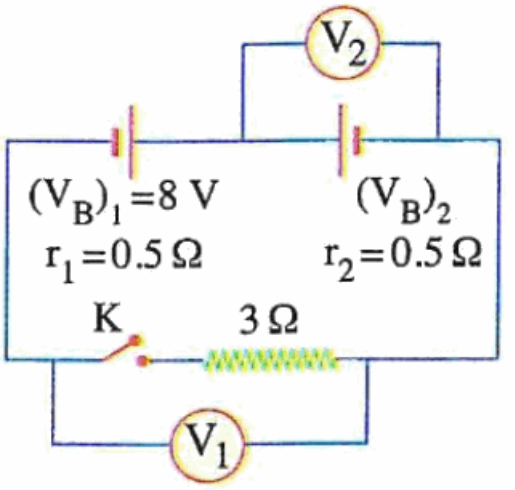
(B) the current direction is reversed, the ammeter reading decreases

(C) the current direction stays the same, the ammeter reading decreases

(D) the current direction is reversed, the ammeter reading increases

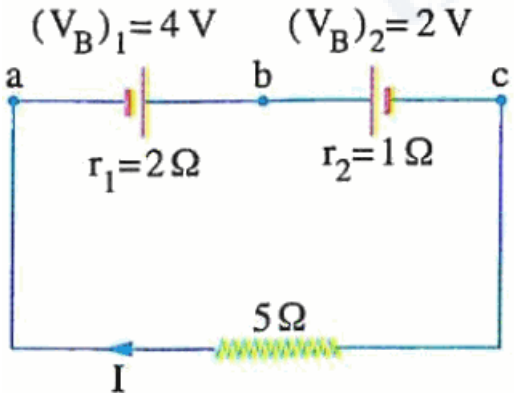
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63 In the opposite circuit, the reading of voltmeter V_1 is 4 V while the switch K is open. Given that $(V_B)_2 > (V_B)_1$, the readings of the two voltmeters V_1 and V_2 after closing the switch K are .....



(A) V_1 = 3 V, V_2 = 11.5 V
(B) V_1 = 3 V, V_2 = 8 V
(C) V_1 = 4.5 V, V_2 = 11.5 V
(D) V_1 = 4.5 V, V_2 = 8 V

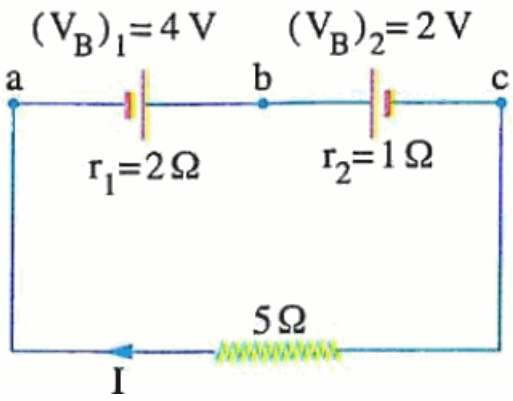
64 From the opposite circuit:
The current flowing in the circuit is .....



(A) *2/3* A
(B) *3/2* A
(C) *1/2* A
(D) *1/4* A

65 From the opposite circuit:

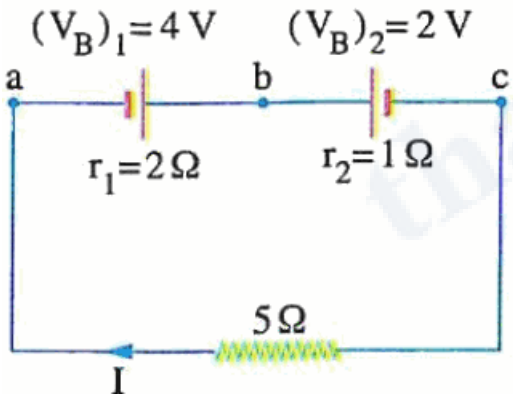
The potential difference between the points a and b is .....



(A) *7/2* V (B) *5/3* V (C) *4/9* V (D) *2/3* V

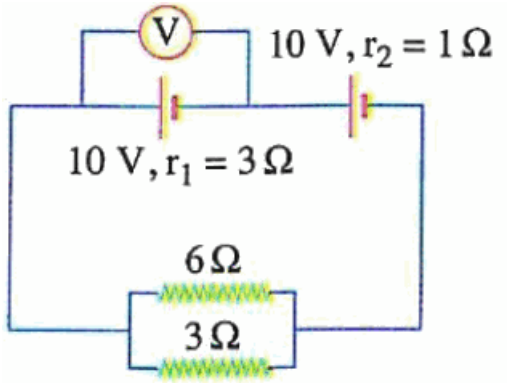
66 From the opposite circuit:

The potential difference between the points b and c is .....



(A) 0.4 V (B) 2.25 V (C) 0.625 V (D) 1.6 V

67 In the opposite circuit, the voltmeter reading is .....

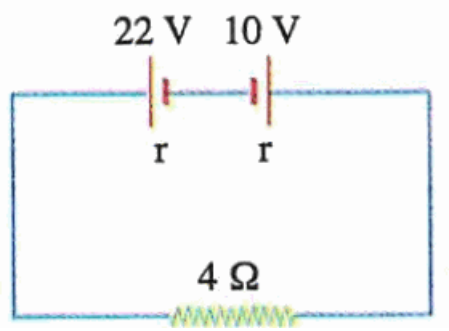


(A) 20 V (B) 10 V (C) 5 V (D) 0

68 A battery of emf 8 V and internal resistance 0.4 Ω is charged by a source of internal resistance 0.4 Ω, and a current of 2.5 A flows in the circuit. Neglecting the resistance of the connecting wires, the emf of the source used to charge the battery is .....

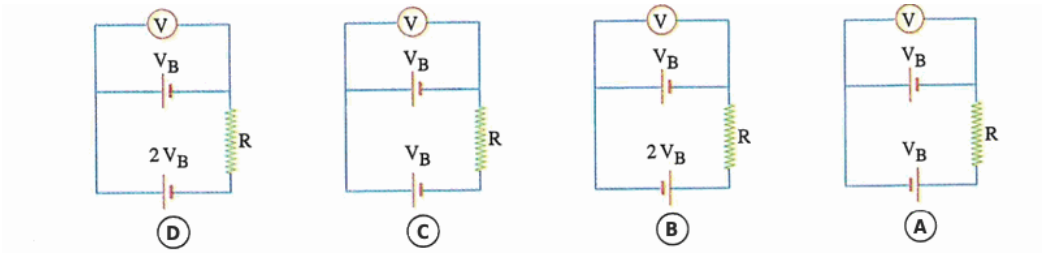
(A) 12 V (B) 11 V (C) 10 V (D) 6 V

69 In the circuit shown, if the power consumed in the 4 Ω resistance is 16 W, the value of r is .....

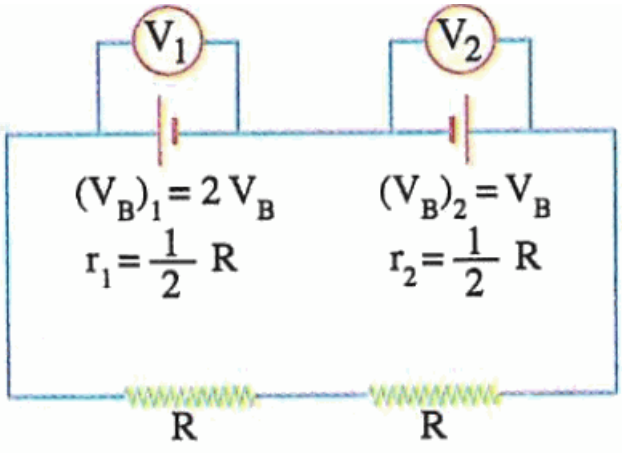


(A) 0.25 Ω (B) 0.5 Ω (C) 1 Ω (D) 2 Ω

70 Each of the following circuits consists of a voltmeter, an ohmic resistance (R) and two batteries, each with an internal resistance (r). In which of these circuits is the voltmeter reading greater than the emf (V_B)?



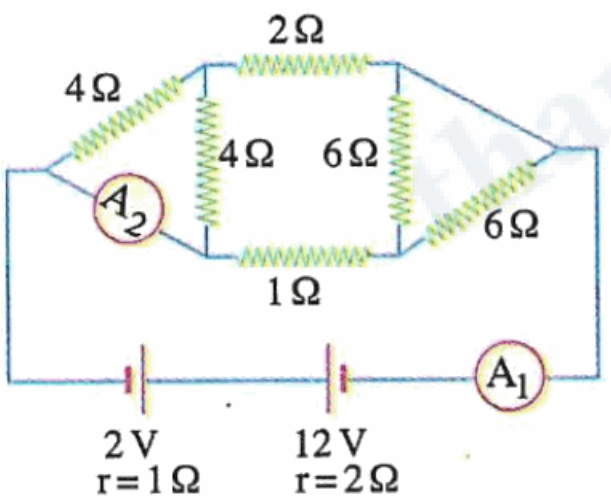
71 In the opposite circuit, the ratio V_2/V_1 is .....



(A) *5/11* (B) *2/3* (C) *7/11* (D) *1/1*

72 From the circuit shown in the figure:

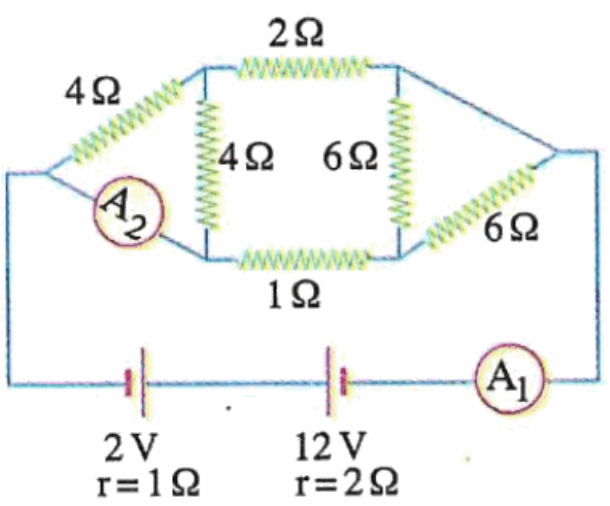
The reading of ammeter A_1 is .....



(A) 2 A (B) 5 A (C) 7 A (D) 10 A

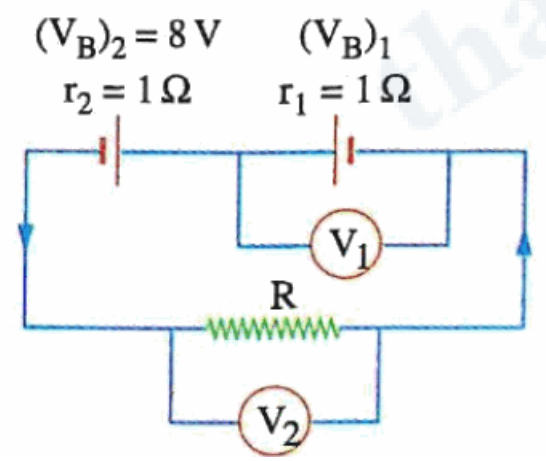
73 From the circuit shown in the figure:

The reading of ammeter A_2 is .....



(A) 0.5 A (B) 1 A (C) 1.5 A (D) 2 A

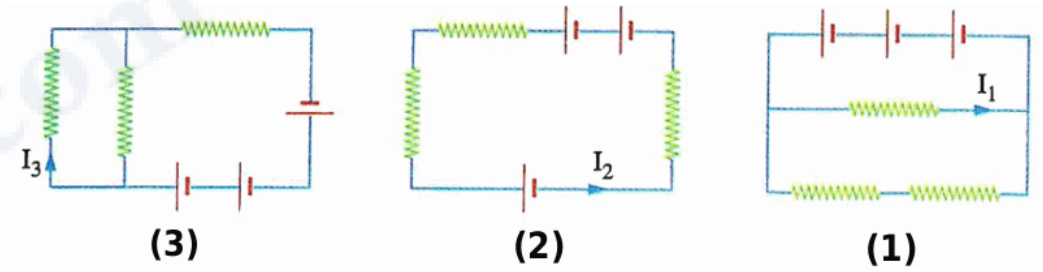
74 In the opposite circuit, if the readings of the two voltmeters (V_1) and (V_2) are 16 V and 6 V respectively, the value of the resistance (R) and the emf $(V_B)_1$ respectively are .....



(A) R = 3 Ω, $(V_B)_1$ = 16 V (B) R = 4 Ω, $(V_B)_1$ = 10 V

(C) R = 3 Ω, $(V_B)_1$ = 18 V (D) R = 4 Ω, $(V_B)_1$ = 18 V

75 Each of the following figures represents a circuit of three identical resistances connected to three identical cells of negligible internal resistance, in three different ways.
The ratio between the currents $I_1 : I_2 : I_3$ is .....



(A) $9 : 1 : 3$ (B) $2 : 3 : 1$ (C) $3 : 6 : 2$ (D) $1 : 4 : 9$

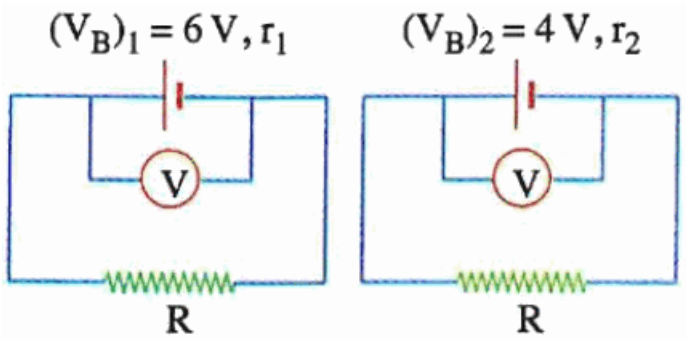
76 A cell is connected to a resistance of 1.9 Ω and a current of 0.5 A flows. When this resistance is replaced by another of 10.6 Ω, the current drops to 0.125 A. The emf of the cell is .....

(A) 5.3 V (B) 3.31 V (C) 2.7 V (D) 1.45 V

77 A cell is connected to a resistance R and the current flowing in it is I. When another resistance $R/2$ is connected in parallel with the first one, the current in the circuit doubles. The internal resistance of the cell is .....

(A) 3R (B) $R/3$ (C) 6R (D) $R/6$

78 An ohmic resistance R is connected to two different batteries, each on its own, as shown in the two opposite circuits. If the two voltmeter readings are equal, each 3 V, the ratio between the internal resistances of the two batteries (r_1/r_2) is .....



(A) $2/3$ (B) $3/2$ (C) $1/3$ (D) 3

79 Two identical wires made of the same material, each 50 cm long with a cross-sectional area of 2 mm², are connected in series in a circuit with a cell of internal resistance 0.5 Ω, and the current in the circuit is 2 A. When the same two wires are connected in parallel to the same cell, the total current in the circuit is 6 A, so:

The emf of the cell used is .....

(A) 3 V (B) 6 V (C) 9 V (D) 12 V

80 Two identical wires made of the same material, each 50 cm long with a cross-sectional area of 2 mm², are connected in series in a circuit with a cell of internal resistance 0.5 Ω, and the current in the circuit is 2 A. When the same two wires are connected in parallel to the same cell, the total current in the circuit is 6 A, so:

The electrical conductivity of the wire material is .....

(A) $125 \times 10^3\ \Omega^{-1}.m^{-1}$ (B) $250 \times 10^4\ \Omega^{-1}.m^{-1}$

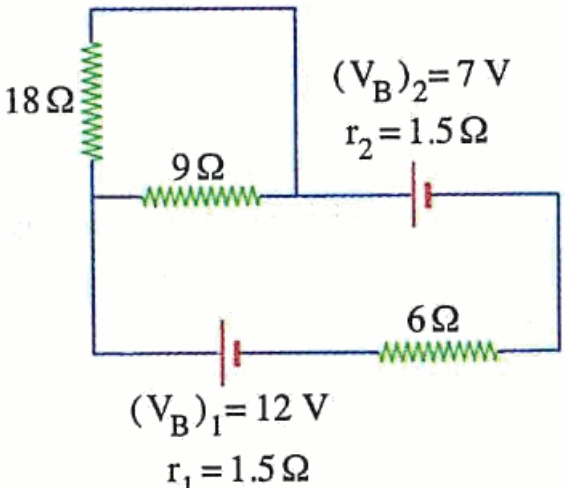
(C) $396 \times 10^6\ \Omega^{-1}.m^{-1}$ (D) $431 \times 10^8\ \Omega^{-1}.m^{-1}$

81 A battery of emf 12 V is connected to two identical lamps connected in parallel. The p.d. between the terminals of the battery becomes 10.8 V and the power consumed in each lamp is 12 W. The internal resistance of the battery is .....

(A) 0.25 Ω (B) 0.54 Ω (C) 0.72 Ω (D) 1 Ω

82 From the opposite circuit:

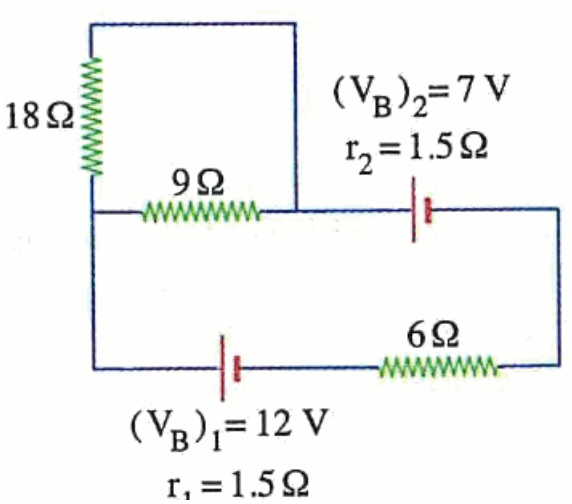
The current flowing through the 12 V battery is .....



(A) 3/5 A (B) 1/3 A (C) 4/9 A (D) 7/8 A

83 From the opposite circuit:

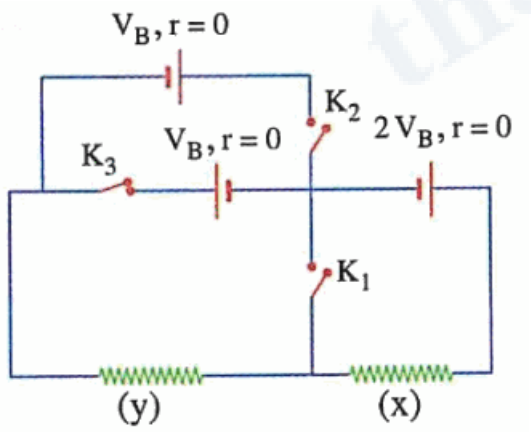
The power consumed in the 9 Ω resistance is .....



(A) *5/4* W (B) *3/7* W (C) *6/5* W (D) *4/9* W

84 Two identical resistances x and y, connected as in the opposite circuit, each consume a power P_w. What power do the resistances x and y consume respectively when:

the switch K_1 is closed?



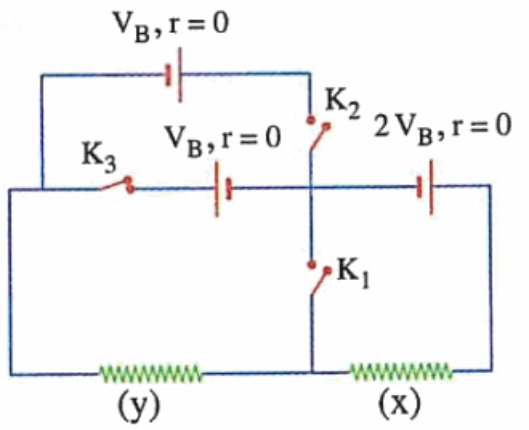
(A) x: *4* P_w, y: *2* P_w

(B) x: *16* P_w, y: *4* P_w

(C) x: $P_w/4$, y: $P_w/2$

(D) x: $P_w/16$, y: $P_w/4$

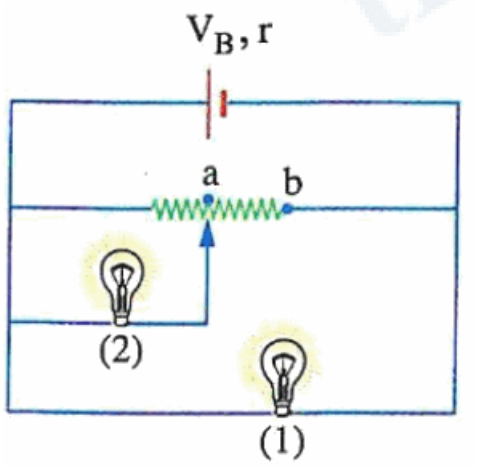
85 Two identical resistances x and y, connected as in the opposite circuit, each consume a power P_w. What power do the resistances x and y consume respectively when:
the switch K_3 is opened and the switch K_2 is closed?



(A) x: $3/2\ P_w$, y: $2\ P_w$
(B) x: $P_w/4$, y: $P_w/8$
(C) x: $9\ P_w$, y: $9\ P_w$
(D) x: $(2\ P_w)/3$, y: $(2\ P_w)/3$

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86 The opposite circuit contains two identical lamps (1) and (2). When the slider is moved from position a to position b, what happens to the brightness of:
lamp (1)?

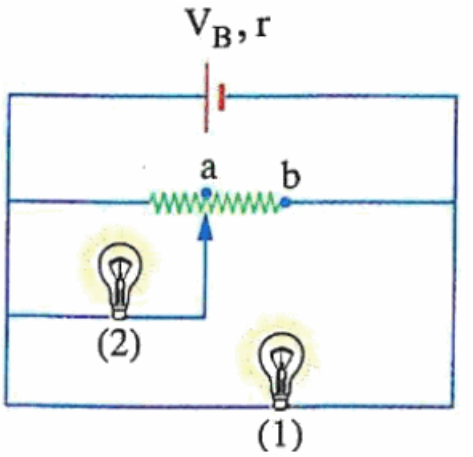


(A) decreases
(B) increases
(C) does not change
(D) becomes zero

---

87 The opposite circuit contains two identical lamps (1) and (2). When the slider is moved from position a to position b, what happens to the brightness of:

lamp (2)?



(A) decreases (B) increases (C) does not change (D) becomes zero

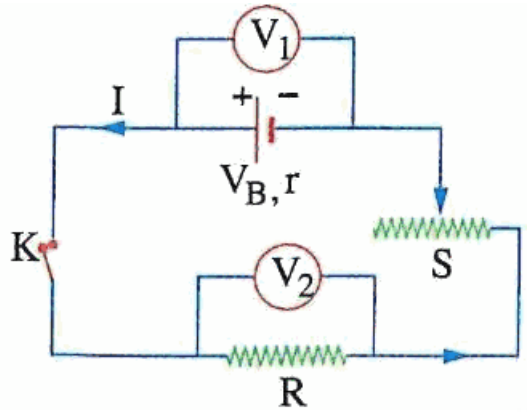
Essay questions — 15 questions

1 In the circuit shown in the figure:

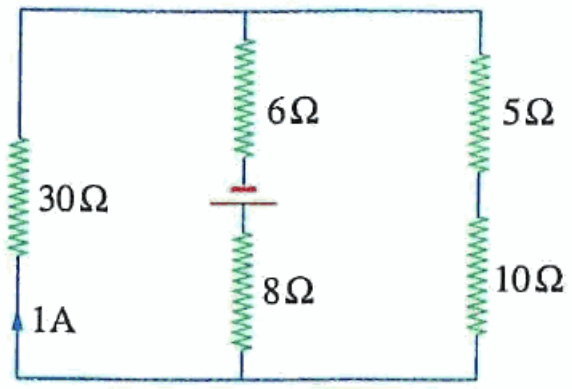
(1) Write the relation between each of the readings V_1 and V_2 and the current I flowing in the circuit.

(2) Deduce what happens to the readings V_1 and V_2 when the resistance of the rheostat S is increased.

(3) What are the readings of V_1 and V_2 when the switch K is opened?

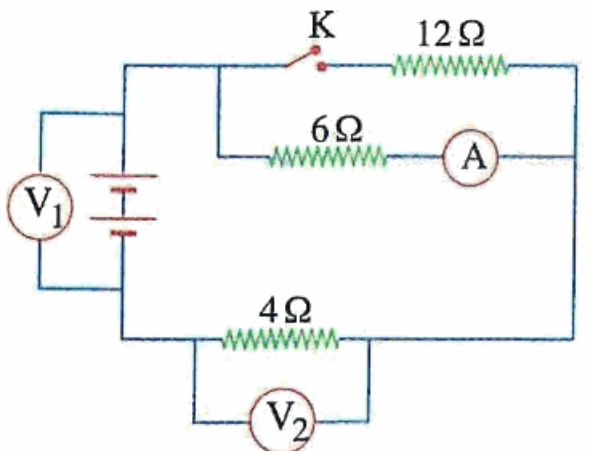


2 In the circuit shown in the figure, calculate the emf of the source if its internal resistance is 2 Ω

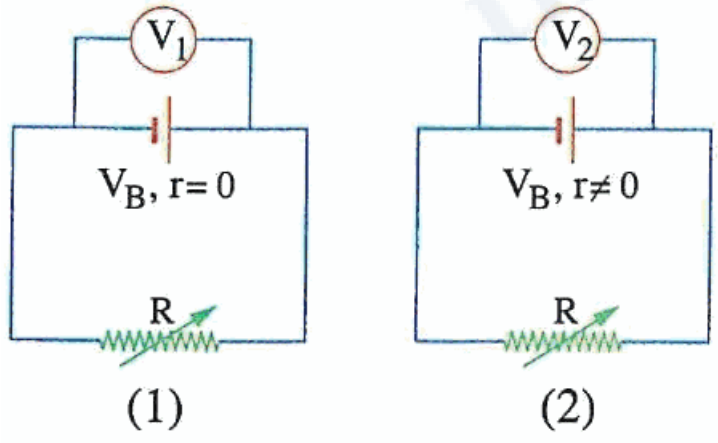


3 In the circuit shown, if the emf of the battery is 12 V and its internal resistance is $2\ \Omega$, find the readings of the ammeter (A), the voltmeter (V_1) and the voltmeter (V_2) when the switch K is:

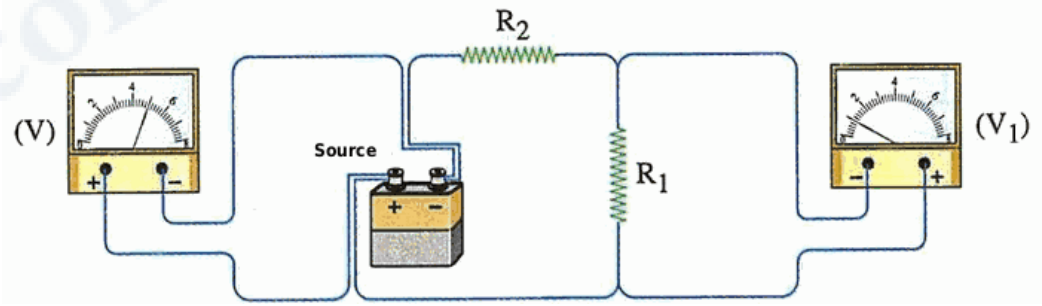
(1) open. (2) closed.



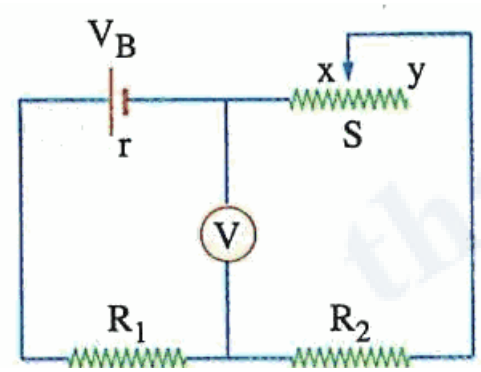
4 In the two opposite circuits (1) and (2), a variable resistance R is connected once to a source of emf V_B with negligible internal resistance, and once to a source of emf V_B and internal resistance r. When R is increased in both circuits, the reading of voltmeter V_1 stays constant while the reading of voltmeter V_2 increases. Explain why.



5 In the circuit shown in the following figure, the resistance R_1 is twice the internal resistance (r) of the source, and the reading of voltmeter (V) across the source is five times the reading of voltmeter (V_1) across R_1. Find the resistance R_2 in terms of the internal resistance (r) of the source.

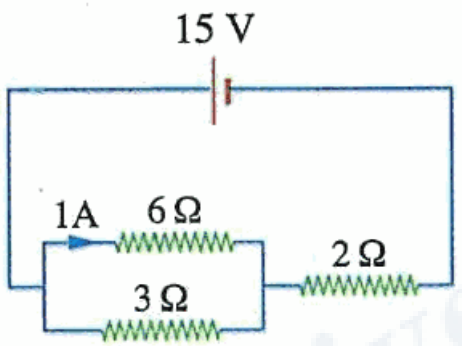


6 In the circuit shown, what happens to the voltmeter reading when the slider is moved from point x to point y?

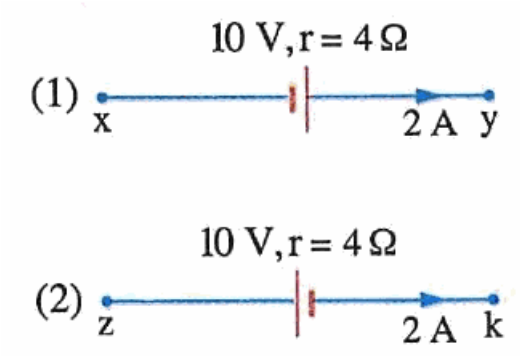


7 A closed circuit consists of a battery of emf V_B and internal resistance r, a variable resistance R and an ammeter. When R was doubled, the ammeter reading did not drop to half. Does this agree with Ohm's law or not? Explain your answer.

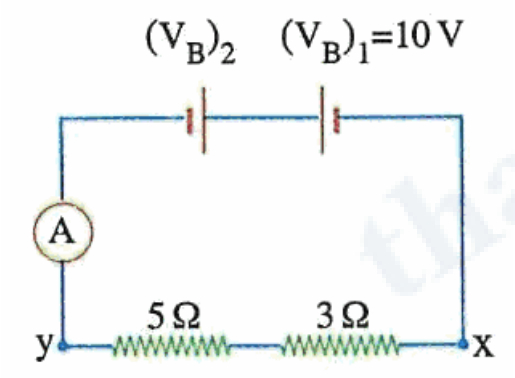
8 From the data of the opposite circuit, is the internal resistance of the battery significant or negligible? Explain your answer.



9 Figures (1) and (2) each represent part of a different circuit. Find the ratio between the potential differences $(V_{xy})/(V_{zk})$



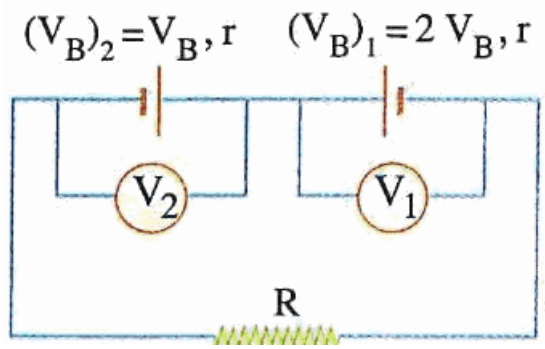
10 In the opposite circuit, the potential of point x is higher than the potential of point y, the ammeter reads 2 A and the internal resistance of each battery is *1* Ω. Calculate the emf of the battery $(V_B)_2$



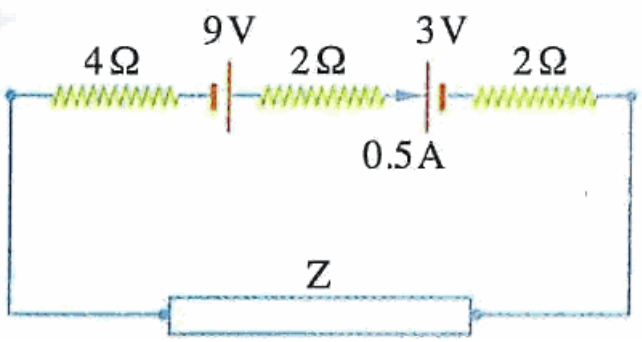
11 In the opposite figure, which is greater? Explain.

(1) The emf of the battery $(V_B)_1$ or the reading of voltmeter V_1?

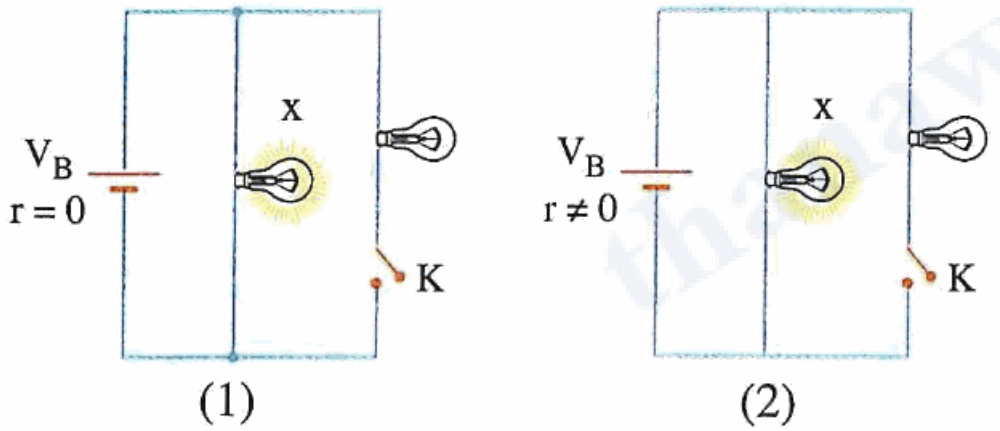
(2) The emf of the battery $(V_B)_2$ or the reading of voltmeter V_2?



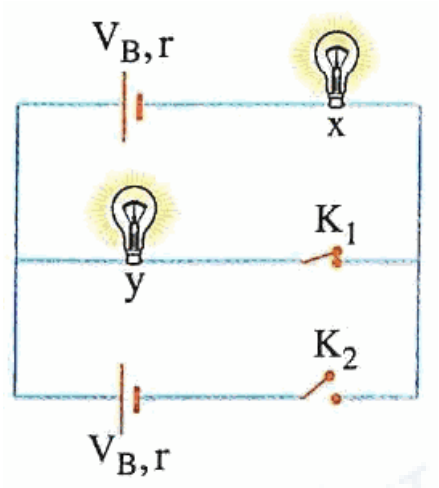
12 The opposite figure shows a closed circuit containing an unknown element Z. Given that the internal resistances of the sources in the circuit are negligible, suggest two possibilities for the unknown element Z that give the values shown in the figure.



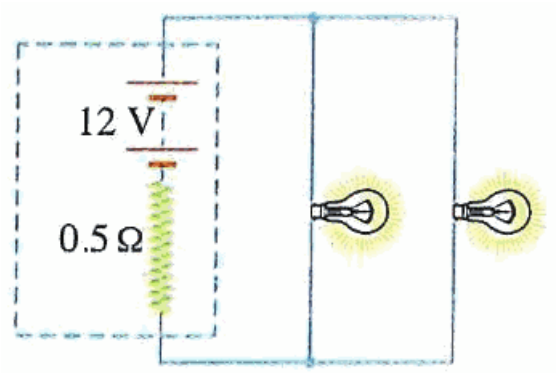
13 In the two opposite circuits (1) and (2), what is the effect of closing the switch K on the brightness of lamp x?



14 In the circuit shown in the figure, explain what happens to the brightness of lamp x when the switch K_1 is opened and the switch K_2 is closed.

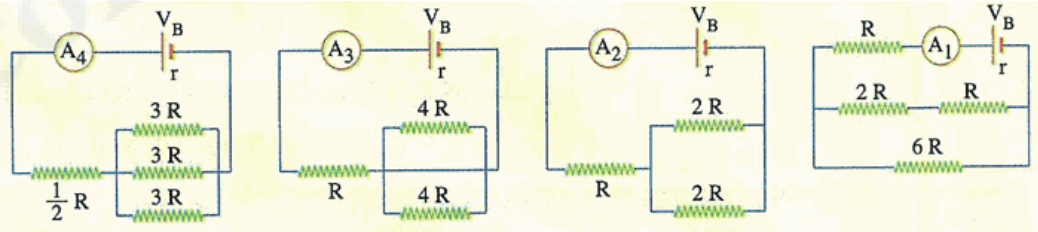


15 Two identical lamps, each marked (60 W, 12 V), are connected to a battery of emf 12 V and internal resistance $0.5\ \Omega$ as in the opposite figure. Explain why the power consumed by each lamp is not 60 W



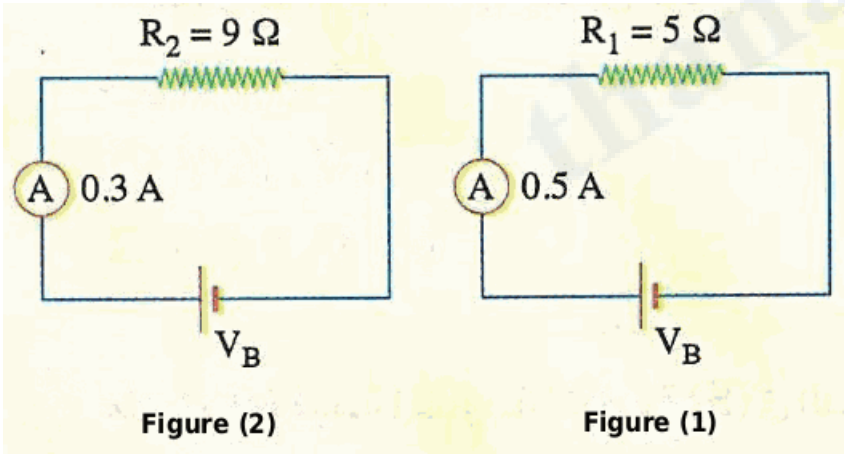
Past exam questions — 31 questions

1 The following figures show four circuits, each containing an ammeter. What is the correct order of the readings of the ammeters A_1, A_2, A_3 and A_4? (Trial exam / May 2021)



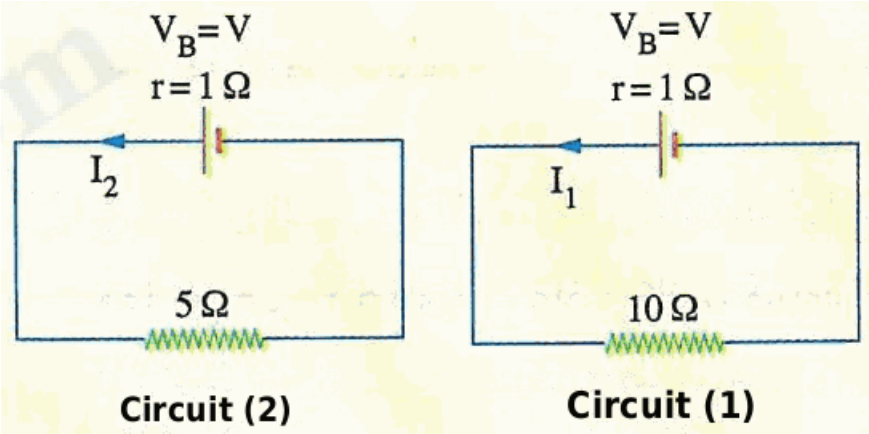
(A) $A_3 > A_1 > A_2 > A_4$
(B) $A_2 > A_1 > A_3 > A_4$
(C) $A_1 > A_2 > A_4 > A_3$
(D) $A_3 > A_4 > A_2 > A_1$

2 A cell is connected to a resistance R_1 and the current in the circuit is 0.5 A, as in figure (1). When R_1 is replaced by a resistance R_2, the current in the circuit becomes 0.3 A, as in figure (2). The emf of the cell is ..... (Trial exam / May 2021)



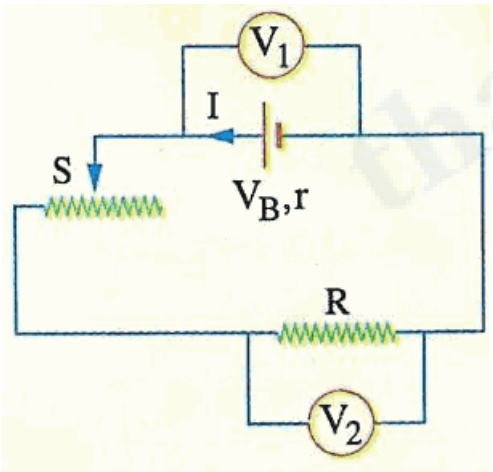
(A) 1.2 V
(B) 1.5 V
(C) 2 V
(D) 3 V

3 The opposite figure represents two circuits. The ratio I_1/I_2 is ..... (Trial exam / June 2021)



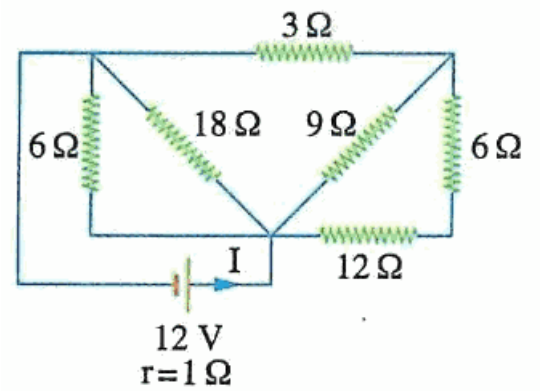
(A) *6/11* (B) *11/6* (C) *1/2* (D) *1/1*

4 From the circuit in front of you, the ratio between the readings of the two voltmeters V_1/V_2 = ... (1st session 2021)



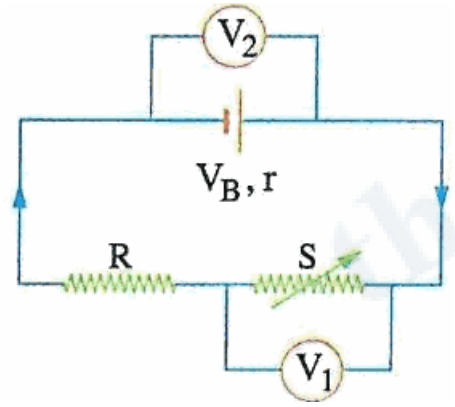
(A) $(V_B + Ir)/IR$ (B) $IR/(V_B + V_2)$
(C) $(IR - Ir)/(V_2 - V_B)$ (D) $(V_B - Ir)/IR$

5 In the circuit in front of you, the current I is ..... (1st session 2021)



(A) 0.76 A (B) 0.83 A (C) 3 A (D) 4 A

6 In the closed circuit shown in the figure, when the value of the variable resistance (S) is increased, ... (2nd session 2021)



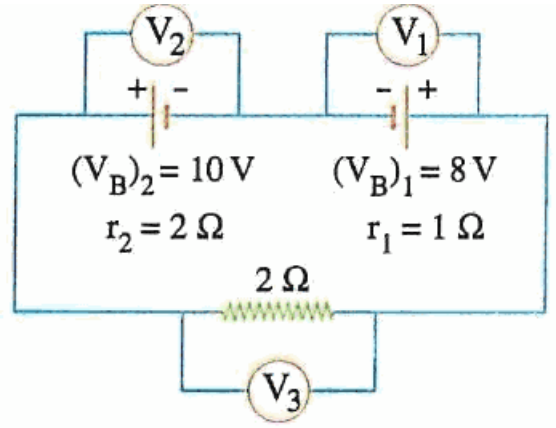
(A) the readings of both V_1 and V_2 increase

(B) the reading of V_1 increases and the reading of V_2 decreases

(C) the reading of V_1 decreases and the reading of V_2 increases

(D) the readings of both V_1 and V_2 decrease

7 In the circuit shown in the figure, if the reading of V_3 is 0.8 V, which of the following choices correctly gives the readings of V_1 and V_2 respectively? (2nd session 2021)



(A) V_1 = 10 V , V_2 = 6 V

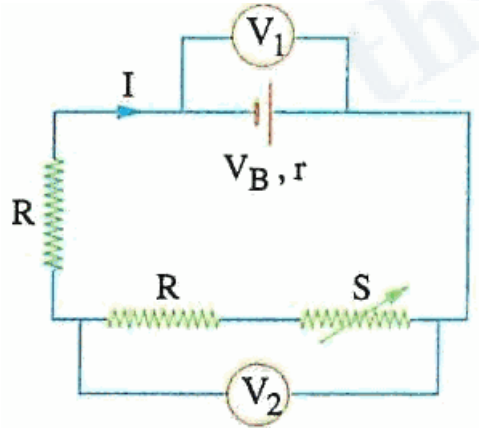
(B) V_1 = 8.4 V , V_2 = 9.2 V

(C) V_1 = 7.6 V , V_2 = 9.2 V

(D) V_1 = 4 V , V_2 = 8 V

---

8 When the value of the variable resistance (S) in the circuit shown is increased, which choice correctly describes the change in the readings of voltmeter (V_1) and voltmeter (V_2) respectively? (1st session 2022)



(A) V_1 increases , V_2 increases

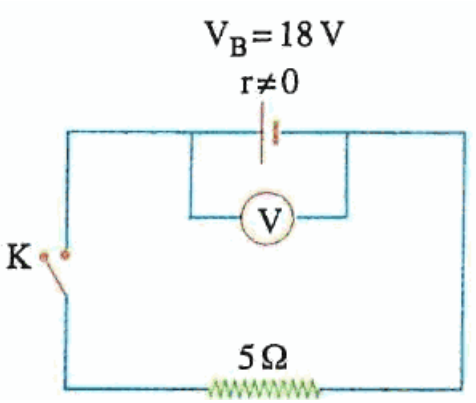
(B) V_1 stays constant , V_2 increases

(C) V_1 decreases , V_2 stays constant

(D) V_1 decreases , V_2 decreases

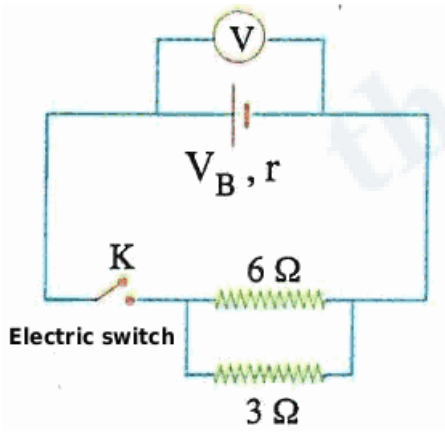
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9 In the circuit shown, if the voltmeter reads 18 V while the switch (K) is open, and 15 V when it is closed, the internal resistance of the battery is ..... (1st session 2022)



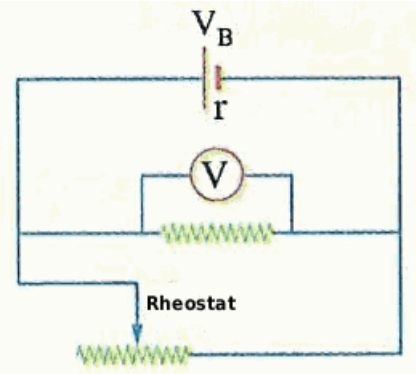
(A) 3 Ω (B) 2 Ω (C) 4 Ω (D) 1 Ω

10 In the circuit shown in the figure, the voltmeter read 14 volts while the switch K was open, and when K was closed its reading became 8 volts. The internal resistance of the battery is ..... (2nd session 2022)



(A) 1.25 Ω (B) 0.5 Ω (C) 1.5 Ω (D) 0.25 Ω

11 In the circuit shown in the figure, what happens to the voltmeter reading when the resistance taken from the rheostat is changed? (Trial exam 2023)



(A) Decreasing the rheostat resistance: the voltmeter reading decreases

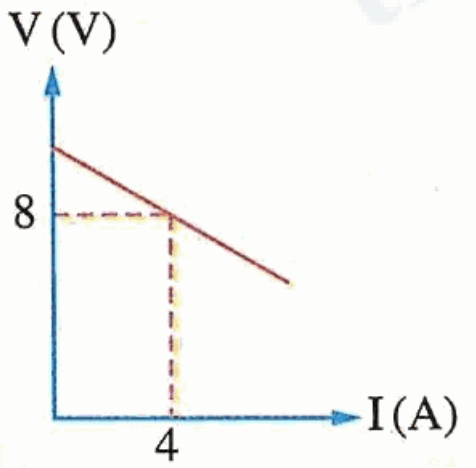
(B) Decreasing the rheostat resistance: the voltmeter reading increases

(C) Increasing the rheostat resistance: the voltmeter reading decreases

(D) Increasing the rheostat resistance: the voltmeter reading does not change

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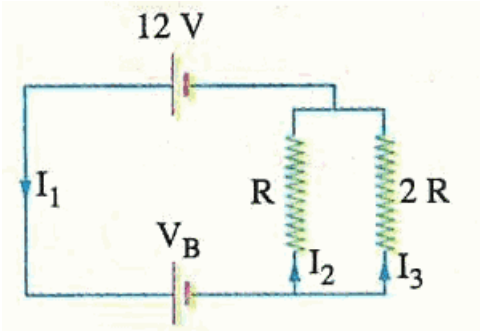
12 The graph shows the relation between the potential difference (V) between the terminals of a battery of internal resistance *0.5* Ω, connected in a closed circuit, and the current (I) in the circuit. The emf of the battery is ..... (Trial exam 2023)



(A) 8 V (B) 10 V (C) 9 V (D) 12 V

---

13 In the circuit shown in the figure, which choice correctly gives the values of V_B, I_1 and I_2 respectively? (Trial exam 2023)



(A) $V_B = 6$ V , $I_1 = 2$ A , $I_2 = 1$ A

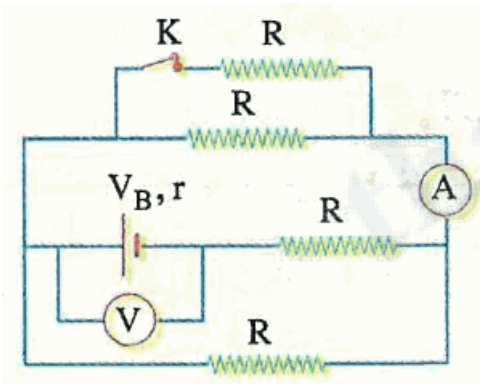
(B) $V_B = 18$ V , $I_1 = 3$ A , $I_2 = 1$ A

(C) $V_B = 18$ V , $I_1 = 1$ A , $I_2 = 2$ A

(D) $V_B = 6$ V , $I_1 = 3$ A , $I_2 = 2$ A

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14 The figure represents a closed circuit. When the switch (K) is opened, ... (1st session 2023)



(A) the ammeter reading decreases and the voltmeter reading increases

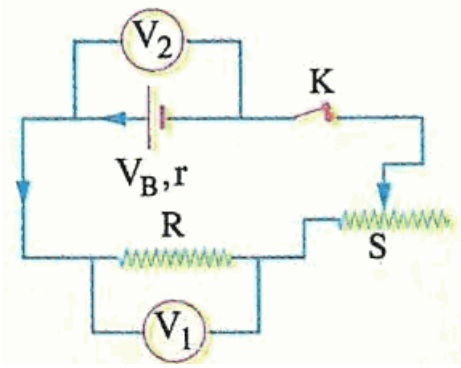
(B) the ammeter reading increases and the voltmeter reading decreases

(C) the readings of both the ammeter and the voltmeter decrease

(D) the readings of both the ammeter and the voltmeter increase

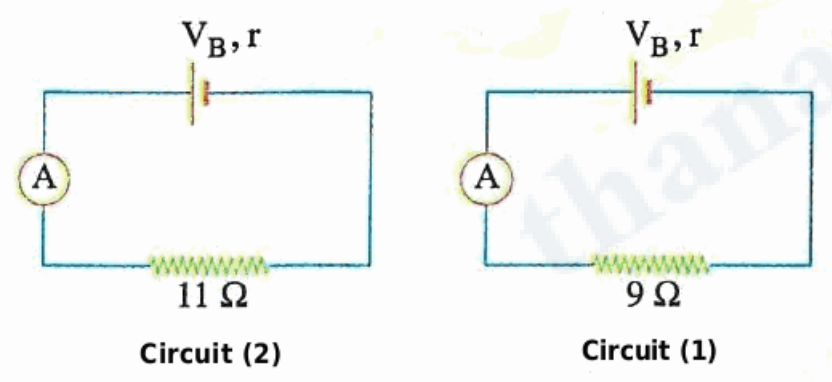
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15 From the figure in front of you, we find that ..... (2nd session 2023)



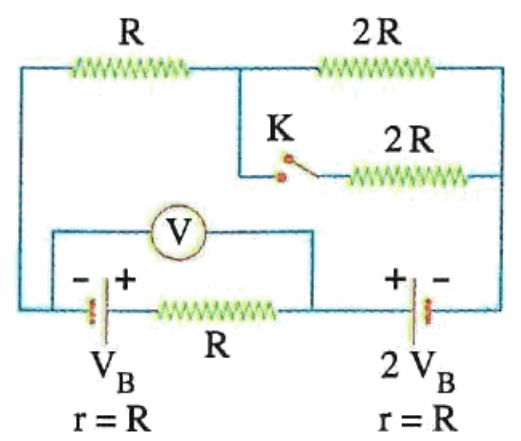
(A) $V_2 < V_B$ (B) $V_1 > V_B$ (C) $V_2 = V_B$ (D) $V_1 = V_2$

16 The opposite figure shows a certain battery connected in two different circuits. If the ammeter reads 1.2 A in the first circuit and 1 A in the second circuit, the internal resistance of the battery (r) is ..... (2nd session 2023)



(A) *1.5* Ω (B) *2* Ω (C) *0.5* Ω (D) *1* Ω

17 You have a circuit as in the figure. Which of the following choices for the voltmeter reading is correct? (1st session 2024)



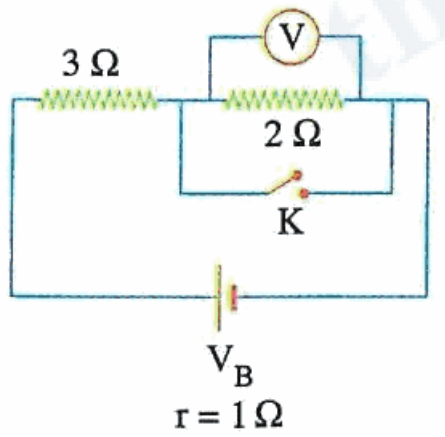
(A) K open: $4/3\ V_B$, K closed: $6/5\ V_B$

(B) K open: $4/3\ V_B$, K closed: $7/5\ V_B$

(C) K open: $7/6\ V_B$, K closed: $6/5\ V_B$

(D) K open: $7/6\ V_B$, K closed: $7/5\ V_B$

18 The opposite figure represents a circuit. If the voltmeter reads 4 V when the switch K is open, the potential difference across the $3\ \Omega$ resistance when K is closed is ..... volts. (2nd session 2024)



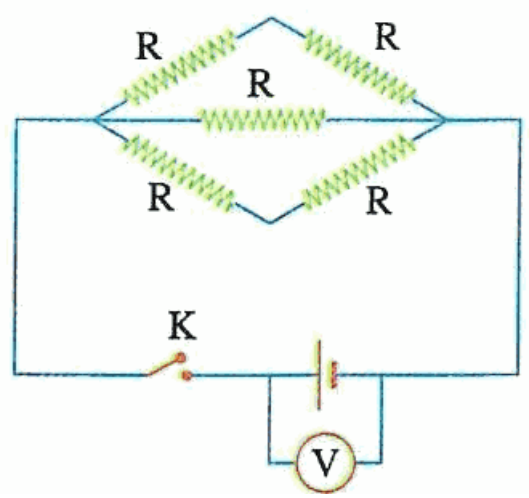
(A) 4

(B) 8

(C) 6

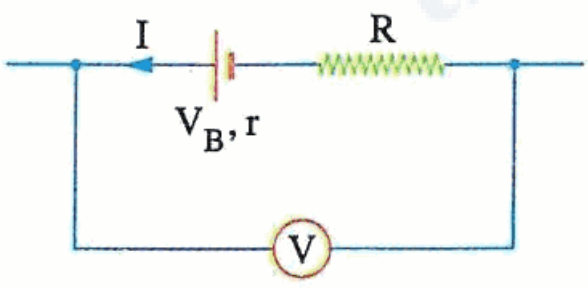
(D) 9

19 In the circuit shown in the figure, the internal resistance of the battery is $0.5\ \Omega$, the voltmeter reads 21 V while the switch K is open and 19.5 V when K is closed. The current in the circuit and the value of the resistance R respectively are ..... (Sample exam 2025)



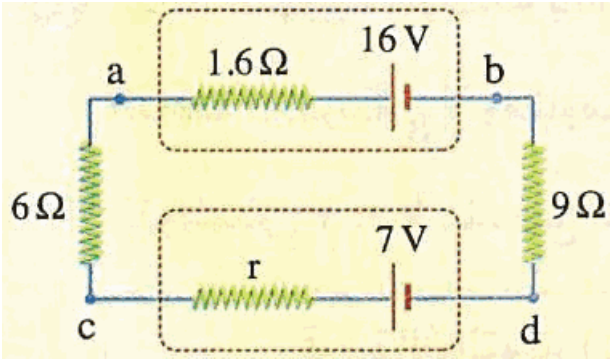
(A) I = 2 A , R = $10\ \Omega$
(B) I = 2 A , R = $13\ \Omega$
(C) I = 3 A , R = $10\ \Omega$
(D) I = 3 A , R = $13\ \Omega$

20 The opposite figure shows part of a circuit. The voltmeter reading (V) is calculated from the relation ..... (Sample exam 2025)



(A) $V = V_B - I(R + r)$
(B) $V = V_B - I(R - r)$
(C) $V = V_B + I(R + r)$
(D) $V = V_B + I(R - r)$

21 In the circuit in the opposite figure, if the potential difference between the points a and b is 15.2 V, the value of r and the potential difference between the points (c) and (d) respectively are ..... (Sample exam 2025)



(A) r = *1.4* Ω , V_{cd} = 7.7 V

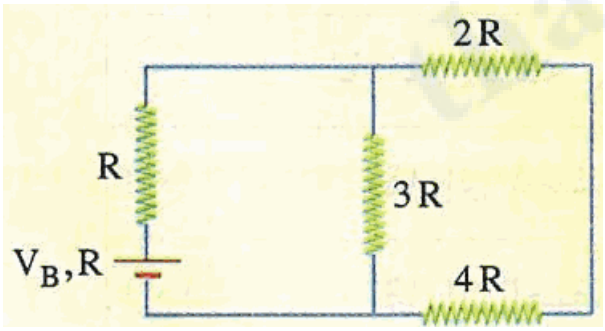
(B) r = *1.4* Ω , V_{cd} = 7.8 V

(C) r = *0.7* Ω , V_{cd} = 7.7 V

(D) r = *2.8* Ω , V_{cd} = 8.4 V

---

22 In the opposite circuit, a group of different resistances is connected to a battery of internal resistance R. Which of the following relations between the potential differences across the external resistances is correct? (Sample exam 2025)



(A) $V_{3R} = 3\,V_R = 3\,V_{2R} = 1.5\,V_{4R}$

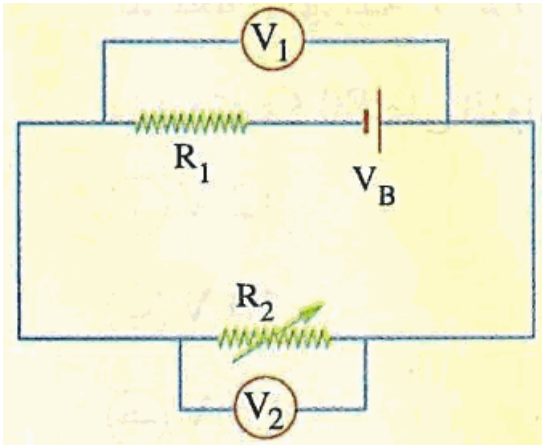
(B) $V_{3R} = 3\,V_R = 1.5\,V_{2R} = 0.75\,V_{4R}$

(C) $V_{3R} = 2\,V_R = V_{2R} = V_{4R}$

(D) $V_{3R} = 2\,V_R = 3\,V_{2R} = 1.5\,V_{4R}$

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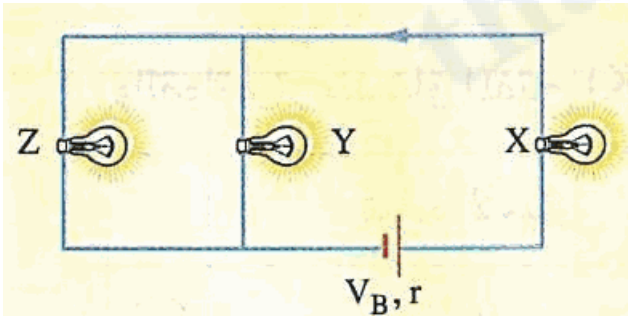
23 In the circuit shown in the figure, what happens to the readings of the two voltmeters (V_1) and (V_2) when the value of the variable resistance (R_2) is increased? (1st session 2025)



(A) V_1 decreases , V_2 decreases
(B) V_1 decreases , V_2 increases
(C) V_1 increases , V_2 decreases
(D) V_1 increases , V_2 increases

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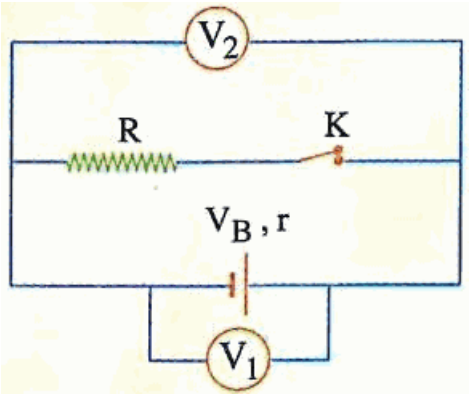
24 Three identical lamps, each of resistance (R), are connected to a battery of emf (V_B) and internal resistance $(0.5\ R)$ as in the figure. When the filament of lamp (Y) burns out, what happens to the brightness of lamps (X) and (Z)? (1st session 2025)



(A) X increases , Z increases
(B) X increases , Z decreases
(C) X decreases , Z increases
(D) X decreases , Z decreases

---

25 The circuit shown in the figure contains a resistance R connected to a battery of emf V_B and internal resistance r. What happens to the readings of the two voltmeters V_1 and V_2 when the switch K is opened? (2nd session 2025)



(A) V_1 increases to V_B , V_2 increases to V_B

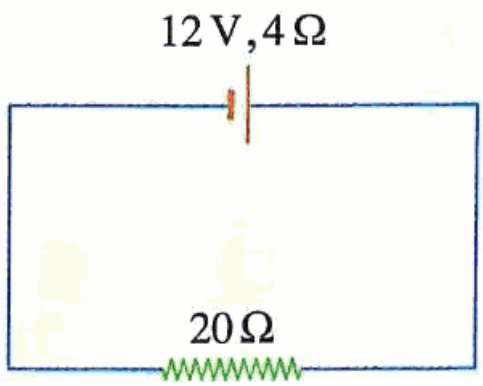
(B) V_1 increases to V_B , V_2 decreases to zero

(C) V_1 decreases to zero , V_2 increases to V_B

(D) V_1 decreases to zero , V_2 decreases to zero

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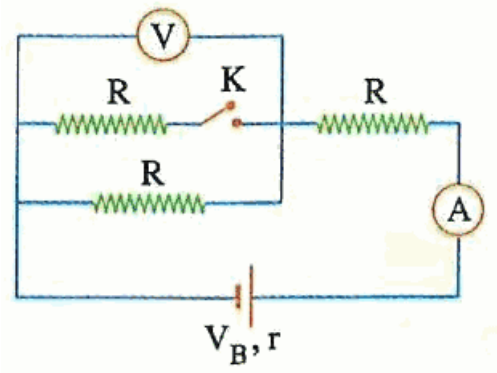
26 The figure shows a resistance of $20\ \Omega$ connected across the terminals of a battery of emf 12 V and internal resistance $4\ \Omega$. If a voltmeter of resistance $80\ \Omega$ is connected in parallel across this resistance, what is the voltmeter reading? (2nd session 2025)



(A) 12 V (B) 10 V (C) 9.6 V (D) 2.4 V

---

27 In the circuit shown in the figure, the ammeter reading is (I), the voltmeter reading is (V) and the internal resistance of the battery is (r = 0.5 R). What happens to the readings of the ammeter and the voltmeter when the switch (K) is closed? (2nd session 2025)



(A) ammeter increases , voltmeter decreases

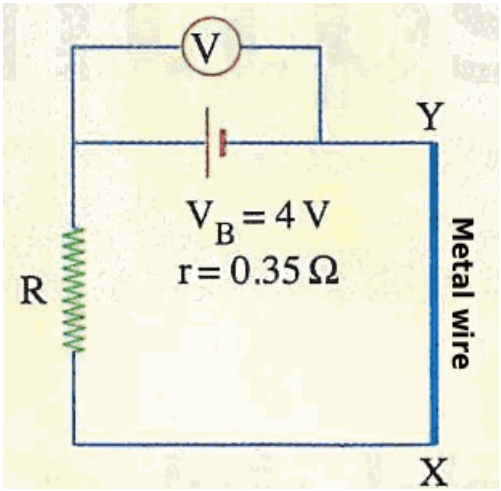
(B) ammeter increases , voltmeter increases

(C) ammeter decreases , voltmeter decreases

(D) ammeter decreases , voltmeter increases

---

28 The figure shows a circuit consisting of a battery of emf 4 V and internal resistance $0.35\ \Omega$ connected to a fixed resistance (R) and a metal wire (XY) 90 cm long with a cross-sectional area of $3 \times 10^{-8}\ m^2$. If the voltmeter reads 3.3 V while the p.d. between point (X) and point (Y) is 1.8 V, then ..... (Sample exam 2026)



(A) external equivalent resistance $1.65\ \Omega$, conductivity $33.33 \times 10^6\ \Omega^{-1}\ m^{-1}$

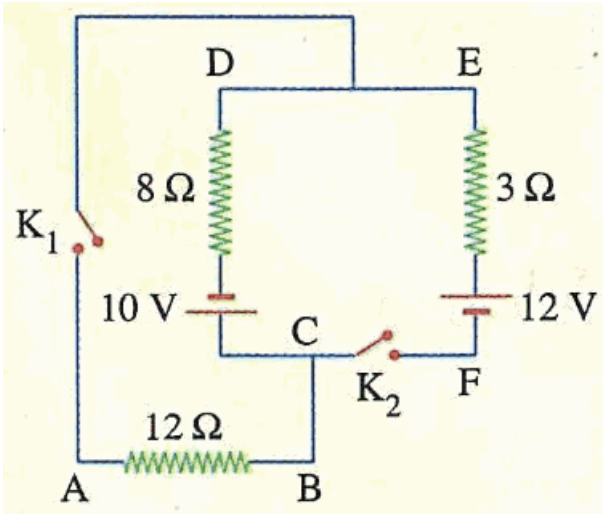
(B) external equivalent resistance $0.9\ \Omega$, conductivity $33.33 \times 10^6\ \Omega^{-1}\ m^{-1}$

(C) external equivalent resistance $1\ \Omega$, conductivity $3 \times 10^8\ \Omega^{-1}\ m^{-1}$

(D) external equivalent resistance $0.75\ \Omega$, conductivity $3 \times 10^8\ \Omega^{-1}\ m^{-1}$

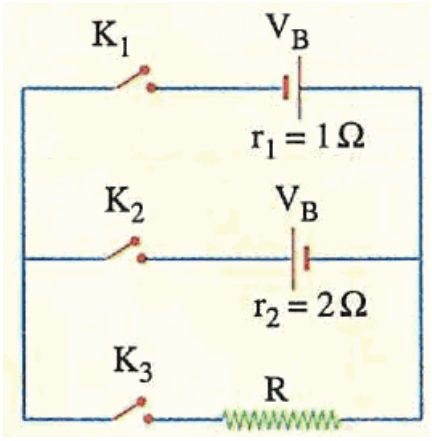
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29 Using the data on the opposite circuit, when only the switch (K_1) is closed, the p.d. between the points B and D is ..... while when only the switch (K_2) is closed, the p.d. between the points D and F is ..... (Sample exam 2026)



(A) V_{BD} = 14 V , V_{DF} = 6 V
(B) V_{BD} = 6 V , V_{DF} = 16 V
(C) V_{BD} = 6 V , V_{DF} = 6 V
(D) V_{BD} = 26 V , V_{DF} = 18 V

30 The opposite figure represents a circuit. When only K_1 and K_3 are closed, a current of 0.8 A flows, and when only K_2 and K_3 are closed, a current of 0.6 A flows. Calculate the value of V_B (1st session 2024)



31 A battery of emf 18 V and internal resistance 2 Ω is connected to a resistance R, and the p.d. between the terminals of the battery is 12 V. If another resistance of 12 Ω is connected in parallel with R, calculate the current in the circuit in the second case. (2nd session 2024)

Answer key and solutions

Multiple choice questions

1 B	2 A	3 D	4 C	5 D	6 C	7 A	8 D	9 A	10 B
11 B	12 D	13 B	14 C	15 B	16 B	17 C	18 D	19 B	20 A
21 D	22 C	23 B	24 A	25 C	26 C	27 D	28 C	29 C	30 B
31 C	32 D	33 B	34 A	35 A	36 B	37 C	38 D	39 B	40 A
41 B	42 C	43 B	44 C	45 D	46 C	47 D	48 D	49 D	50 C
51 A	52 C	53 B	54 C	55 A	56 B	57 B	58 B	59 C	60 C
61 B	62 D	63 A	64 D	65 A	66 B	67 D	68 C	69 C	70 D
71 C	72 A	73 C	74 C	75 A	76 D	77 B	78 D	79 C	80 A
81 B	82 B	83 D	84 B	85 C	86 A	87 B			

1 **Answer (B)**

When a current flows, the p.d. between the terminals is less than the emf.

$V = V_B - Ir$

2 **Answer (A)**

Increasing the variable resistance decreases the current, so the voltage lost inside the battery decreases.

$V = V_B - Ir$

So the reading increases.

3 **Answer (D)**

$I = V_B/(R + r)$

$0.5 = 6/(10 + r)$

$r = 2\ \Omega$

4 **Answer (C)**

$R_t = 3 + 6 + 4 + 2 = 15\ \Omega$

5 **Answer (D)**

$I = 30/15 = 2\ A$

6 **Answer (C)**

$V = 2 \times 6 = 12\ V$

7 **Answer (A)**

The voltmeter measures the p.d. across the resistance R.

Decreasing the variable resistance increases the current.

$V = IR$

8 **Answer (D)**

$I = V_B/(R + r)$

The current is inversely proportional to the total resistance.

9 **Answer (A)**

The two lamps are in series, so a burnt filament makes the circuit open, as if it had an open switch.

The current becomes zero.

$V = V_B\text{-}Ir = V_B$

So the reading increases and becomes equal to the emf.

10 **Answer (B)**

Closing S adds a branch in parallel, so the total resistance decreases.

The total current increases (ammeter).

$V = V_B\text{-}I(r + R_1)$

So the voltmeter reading decreases.

11 **Answer (B)**

$r = |(\Delta V)/(\Delta I)| = (8\text{-}1)/(4\text{-}0.5) = 2\ \Omega$

12 **Answer (D)**

$V_B = V + Ir$

$V_B = 8 + 0.5 \times 2 = 9\ V$

13 **Answer (B)**

The slope represents the internal resistance.

$r_x/r_y = fractan30°tan60° = 1/3$

14 **Answer (C)**

Point x is the emf and point y is the short-circuit current.

$I_{sc} = V_B/r = 2/0.25 = 8\ A$

15 **Answer (B)**

$V_B = I(3 + R + r)$

$10 = 1 \times (3 + R + 1)$

$R = 6\ \Omega$

$V = 1 \times 6 = 6\ V$

16 **Answer (B)**

$R_w = (\rho\ L)/A$

$R_w = (5 \times 10^{-7} \times 30)/(0.3 \times 10^{-4})$

$R_w = 0.5\ \Omega$

$I = 18/(0.5 + 8.5 + 1) = 1.8\ A$

17 **Answer (C)**

At the start of the rheostat its resistance is zero.

$6 = 0.6(R + 1)$

$R = 9\ \Omega$

18 **Answer (D)**

At the end of the rheostat its resistance is the largest.

$6 = 0.1(9 + R_{max} + 1)$

$R_{max} = 50\ \Omega$

19 **Answer (B)**

$R_p = (6 \times 4)/10 = 2.4\ \Omega$

$I = 6/(2.4 + 0.1) = 2.4\ A$

20 **Answer (A)**

$P = V_B I = 6 \times 2.4 = 14.4\ W$

21 **Answer (D)**

$V = 2.4 \times 2.4 = 5.76\ V$

$P_1 = (V^2)/R_1 = (5.76^2)/6 = 5.53\ W$

22 **Answer (C)**

The two branches have the same p.d. (the p.d. of the battery).

$V = 2 \times 4.5 = 9\ V$

$R = 9/1 = 9\ \Omega$

23 **Answer (B)**

$V = 2 \times 4.5 = 9\ V$

$I = 1 + 2 = 3\ A$

$V_B = V + Ir$

$V_B = 9 + 3 \times 1 = 12\ V$

24 **Answer (A)**

The voltmeter is connected across R and the 3 Ω resistance together.

$6 = (12(R + 3))/(R + 3 + 4 + 1)$

$R = 2\ \Omega$

25 **Answer (C)**

$R_{ab} = ((7 + 3) \times 10)/20 = 5\ \Omega$

$R_{bc} = ((10 + 5) \times 15)/30 = 7.5\ \Omega$

$I = 27/(5 + 7.5 + 1) = 2\ A$

$V_{bc} = 2 \times 7.5 = 15\ V$

26 **Answer (C)**

The voltmeter measures the p.d. of the battery.

$R_{bottom} = (2 \times 2)/4 + 3 = 4\ \Omega$

$R_{ext} = (4 \times 4)/8 = 2\ \Omega$

$I = 8/2 = 4\ A$

$V_B = 8 + 4 \times 1 = 12\ V$

27 **Answer (D)**

The 6 Ω and 3 Ω resistances are in parallel.

$V = 1 \times 6 = 6\ V$

$I_A = 6/3 = 2\ A$

28 **Answer (C)**

$I = 1 + 2 = 3\ A$

$V = 3 \times 2 = 6\ V$

29 **Answer (C)**

$R_p = (6 \times 3)/9 = 2\ \Omega$

$V_B = 3 \times (2 + 2 + 1) = 15\ V$

30 **Answer (B)**

The 8 Ω and 16 Ω resistances are in series, and together they are in parallel with 6 Ω.

$I_1 = 2/8 = 0.25\ A$

$I_2 = 6/6 = 1\ A$

$I = 1.25\ A$

$V_B = 6 + 1.25 \times 1.2 = 7.5\ V$

31 **Answer (C)**

The voltmeter measures the p.d. of the battery.

The two resistances R are in parallel.

$V = ItimesR/2$

32 **Answer (D)**

$V = V_B R/(R + r) = V_B R/(R + R/4)$

$V = 4/5 V_B$

33 **Answer (B)**

Closing K adds a branch in parallel, so the total resistance decreases.

The total current increases, so the p.d. across the 3 Ω resistance (voltmeter) increases.

The p.d. across the parallel group decreases, so the ammeter current decreases.

34 **Answer (A)**

Increasing the variable resistance increases the external resistance, so the total current decreases.

So the voltage lost inside the battery decreases and the voltmeter reading increases.

$I_A = V/R$

So the ammeter current increases.

35 **Answer (A)**

Increasing the variable resistance increases the external resistance.

The p.d. of the battery (V2) increases.

$V_1 = VS/(S+R)$

So V1 increases too.

36 **Answer (B)**

Decreasing the variable resistance increases the current.

$V_1 = IR\uparrow$, $V_2 = V_B\text{-}Ir\downarrow$

The ratio that decreases is

V_2/V_1

37 **Answer (C)**

$R_t = 24/2 = 12\ \Omega$

$R_{XY} = 12\text{-}9\text{-}1 = 2\ \Omega$

$8/n = 2 \Rightarrow n = 4$

Four resistances in parallel.

38 **Answer (D)**

$R_{closed} = (7.5 \times 15)/22.5 = 5\ \Omega$

$V_B/(5+1.5)\text{-}V_B/(7.5+1.5) = 0.5$

$V_B = 11.7\ V$

39 **Answer (B)**

For equal currents, the battery is connected between two points with two equal paths between them.

$R_{BAD} = 10+40 = 50\ \Omega$

$R_{BCD} = 20+30 = 50\ \Omega$

40 **Answer (A)**

$I = 0.25+0.25 = 0.5\ A$

$R_{BD} = (50 \times 50)/100 = 25\ \Omega$

$V_B = 0.5 \times (25+1) = 13\ V$

41 **Answer (B)**

R1 and R2 are in series, so they carry the same current.

$I = 0.3 + 0.4 + 0.2 = 0.9\ A$

$V = 0.4 \times 15 = 6\ V$

$V_B = 6 + 0.9 \times 1 = 6.9\ V$

42 **Answer (C)**

$R_t = V_B / I = 6.9 / 0.9 = 7.67\ \Omega$

43 **Answer (B)**

The circuit is a series circuit.

$I = 6/(8+2) = 0.6\ A$

$V_2 = 0.6 \times 8 = 4.8\ V$

$V_1 = 6\text{-}0.6 \times 2 = 4.8\ V$

44 **Answer (C)**

Switch open: the reading is the emf.

Switch closed: the reading is the p.d. across R.

$0.8V_0 = V_0 R/(R+r)$

$R/r = 4$

45 **Answer (D)**

Switch open: the reading is the emf.

$V_B = 12\ V$

Switch closed: the difference is the voltage lost inside the battery.

$12\text{-}9 = 1.5 \times r$

$r = 2\ \Omega$

46 **Answer (C)**

$R = 9/1.5 = 6\ \Omega$

47 **Answer (D)**

Switch open: the reading is the emf.

$I = (12\text{-}10)/2 = 1\ A$

48 **Answer (D)**

$R_{ext} = 10/1 = 10\ \Omega$

$R_{ext} = R/2$

$R = 20\ \Omega$

49 **Answer (D)**

Closing all three switches short-circuits the resistance R, so the external resistance is zero.

$V = V_B\text{-}Ir = 0$

50 **Answer (C)**

Ammeter A2 reads zero, so the bridge is balanced.

$3/6 = 9/R \Rightarrow R = 18\ \Omega$

$R_{ext} = (12 \times 24)/36 = 8\ \Omega$

$I = 20/(8+2) = 2\ A$

51 **Answer (A)**

Increasing the length increases the resistance of the conductor, so the current decreases.

$V = V_B\text{-}Ir$

So the reading increases.

52 **Answer (C)**

V1 is in the open circuit: the reading is the emf.

$RproptoL/(d^2)$

$R_y/R_x = 2/1 \times (d^2)/((d/2)^2) = 8$

The greater the external resistance, the greater the reading.

$V_1 > V_3 > V_2$

53 **Answer (B)**

$R_{ext} = R/2 + 2R = 2.5R$

$I = 20/2R = 10/R$

$V_B = I(2.5R + 0.5R) = 30\ V$

54 **Answer (C)**

The reading is the p.d. of the battery.

$V = V_B(R_{ext})/(R_{ext} + r)$

The greatest reading is with the greatest external resistance.

55 **Answer (A)**

To increase the current, we decrease the total resistance.

A resistance connected in parallel decreases the equivalent resistance.

56 **Answer (B)**

$V_X = 20-4 = 16\ V$

$R_X/R = 16/4 = 4$

$R_X = 4R$

57 **Answer (B)**

The two batteries oppose each other in the loop.

$I = (5-2)/(0.2+2+0.3) = 1.2\ A$

The second battery is being charged.

$V = 2 + 1.2 \times 0.3 = 2.36\ V$

58 **Answer (B)**

The internal resistance is zero, so the reading is the total emf.

Removing a cell decreases it, so the reading decreases.

59 **Answer (C)**

The three branches are in parallel.

$1/R_p = 1/20 + 1/30 + 1/60$

$R_p = 10\ \Omega$

$R_{ext} = 10 + 10 = 20\ \Omega$

60 **Answer (C)**

$V_B = 6 + 12 = 18\ V$

$r = 2 + 2 = 4\ \Omega$

$I = 18/(20+4) = 0.75\ A$

61 **Answer (B)**

$V_B = 4 \times 12 = 48\ V$

$V_{lamp} = P/I = 23/0.5 = 46\ V$

$48-46 = 0.5 \times r_t$

$r_t = 4\ \Omega \Rightarrow r = 1\ \Omega$

62 **Answer (D)**

63 **Answer (A)**

In the open circuit, V1 reads the difference between the two emfs.

$V_{B2} = 8 + 4 = 12\ V$

$I = (12\text{-}8)/(0.5 + 0.5 + 3) = 1\ A$

V1 is connected across the switch and the 3 Ω resistance together.

$V_1 = 1 \times 3 = 3\ V$

The second battery is discharging.

$V_2 = 12\text{-}1 \times 0.5 = 11.5\ V$

64 **Answer (D)**

The two batteries oppose each other.

$I = (4\text{-}2)/(2 + 1 + 5) = 1/4\ A$

65 **Answer (A)**

The first battery is discharging.

$V_{ab} = 4\text{-}Ir_1$

$V_{ab} = 4\text{-}1/4 \times 2 = 7/2\ V$

66 **Answer (B)**

The second battery is being charged (the current enters its positive terminal).

$V_{cb} = 2 + Ir_2$

$= 2 + 1/4 \times 1 = 2.25\ V$

67 **Answer (D)**

The two batteries are in series in the same direction.

$R_{ext} = (6 \times 3)/9 = 2\ \Omega$

$I = 20/(2 + 3 + 1) = 10/3\ A$

$V = 10\text{-}10/3 \times 3 = 0$

68 **Answer (C)**

The battery is being charged.

$V_{source} = V_B + I(r_1 + r_2)$

$= 8 + 2.5 \times 0.8 = 10\ V$

69 **Answer (C)**

The two batteries oppose each other.

$I = \sqrt{(P/R)} = \sqrt{(16/4)} = 2\ A$

$22\text{-}10 = 2(4 + 2r)$

$r = 1\ \Omega$

70 **Answer (D)**

The reading is greater than the emf only for a battery that is being charged.

$V = V_B + Ir$

71 **Answer (C)**

The two batteries oppose each other.

$I = (2V_B\text{-}V_B)/(R/2 + R/2 + 2R) = V_B/3R$

$V_1 = 2V_B\text{-}IR/2 = 11/6V_B$

The second battery is being charged.

$V_2 = V_B + IR/2 = 7/6V_B$

$V_2/V_1 = 7/11$

72 **Answer (A)**

The two batteries oppose each other.

$V_B = 12\text{-}2 = 10\ V$

$r = 1 + 2 = 3\ \Omega$

The equivalent resistance of the group is 2 Ω.

$I_1 = 10/(2 + 3) = 2\ A$

73 **Answer (C)**

The p.d. across the group:

$V = 2 \times 2 = 4\ V$

The potential of the upper point is 2 V because the two resistances are equal.

$I_{bottom} = 4/(1 + 3) = 1\ A$

$I_{vertical} = (4\text{-}2)/4 = 0.5\ A$

$I_{A_2} = 1 + 0.5 = 1.5\ A$

74 **Answer (C)**

$I = 6/R$, $V_{B1} = 16 + I$

$V_{B1} - 8 = I(2 + R)$

$8 + 6/R = 12/R + 6$

$R = 3\ \Omega$, $V_{B1} = 18\ V$

75 **Answer (A)**

Figure (1): three batteries in series.

$I_1 = 3E/R$

Figure (2): one opposes two, so the resultant is E.

$I_2 = E/3R$

$I_3 = 1/2 \times 3E/1.5R = E/R$

$I_3 : I_2 : I_1 = 3 : 1 : 9$

76 **Answer (D)**

The emf is the same in both cases.

$0.5(1.9 + r)$

$= 0.125(10.6 + r)$

$r = 1\ \Omega$

$V_B = 0.5 \times 2.9 = 1.45\ V$

77 **Answer (B)**

$R_p = (R \times R/2)/(R + R/2) = R/3$

$2(R/3 + r) = R + r$

$r = R/3$

78 **Answer (D)**

$V = V_B R/(R + r)$

$3 = 6R/(R + r_1) \Rightarrow r_1 = R$

$3 = 4R/(R + r_2) \Rightarrow r_2 = R/3$

$r_1/r_2 = 3$

79 **Answer (C)**

$V_B = 2(2R_w + 0.5)$

$V_B = 6(R_w/2 + 0.5)$

$R_w = 2\ \Omega$

$V_B = 2(4 + 0.5) = 9\ V$

80 **Answer (A)**

The resistance of each wire from the previous part:

$R_w = 2\ \Omega$

$\rho = R_w A/L = (2 \times 2 \times 10^{-6})/0.5$

$\rho = 8 \times 10^{-6}\ \Omega.m$

$\sigma = 1/(\rho) = 125 \times 10^{3}\ \Omega^{-1}.m^{-1}$

81 **Answer (B)**

$R_{lamp} = (V^2)/P$

$R_{lamp} = (10.8^2)/12 = 9.72\ \Omega$

$I = 2 \times 10.8/9.72 = 2.22\ A$

$r = (12\text{-}10.8)/2.22 = 0.54\ \Omega$

82 **Answer (B)**

The 18 Ω and 9 Ω resistances are in parallel.

$R_p = (18 \times 9)/27 = 6\ \Omega$

The two batteries oppose each other.

$I = (12\text{-}7)/(6 + 6 + 1.5 + 1.5) = 1/3\ A$

83 **Answer (D)**

$I_9 = 1/3 \times 18/27 = 2/9\ A$

$P = I^2R = 4/81 \times 9 = 4/9\ W$

84 **Answer (B)**

85 **Answer (C)**

86 **Answer (A)**

Lamp (1) is connected across the terminals of the battery.

Moving the slider towards b increases the total current.

$V = V_B\text{-}Ir$

So the p.d. of the battery decreases and the brightness of the lamp decreases.

87 **Answer (B)**

The part of the rheostat connected in series with lamp (2) decreases.

So the lamp's share of the voltage increases and its brightness increases.

Essay questions

1 **Model answer**

(1) $V_1 = V_B - Ir$, $V_2 = IR$

(2) When S increases, the total resistance $R_t = S + R + r$ increases, so the current $I = V_B/R_t$ decreases.

So the reading of V_1 increases since $V_1 = V_B - Ir$, and the reading of V_2 decreases since $V_2 = IR$

(3) When the switch K is opened: $V_1 = V_B$, $V_2 = 0$

2 **Model answer**

$10\ \Omega$ and $5\ \Omega$ in series = $15\ \Omega$, and with $30\ \Omega$ in parallel = $10\ \Omega$

$R' = 10 + 6 + 8 = 24\ \Omega$

$I_1 \times 15 = 1 \times 30$, $I_1 = 2\ A$, $I = 2 + 1 = 3\ A$

$V_B = I(R' + r) = 3 \times (24 + 2) = 78\ V$

3 **Model answer**

(1) K open: $R' = 6 + 4 = 10\ \Omega$, $I = 12/(10 + 2) = 1\ A$

$V_1 = 12 - 1 \times 2 = 10\ V$, $V_2 = 1 \times 4 = 4\ V$

(2) K closed: $R' = 4 + (12 \times 6)/18 = 8\ \Omega$, $I = 12/(8 + 2) = 1.2\ A$

Ammeter reading: $1.2 \times 4 = I_A \times 6$, $I_A = 0.8\ A$

$V_1 = 12 - 1.2 \times 2 = 9.6\ V$, $V_2 = 1.2 \times 4 = 4.8\ V$

4 **Model answer**

In circuit (1) the internal resistance of the battery is negligible, so always $V_1 = V_B$ and the reading of voltmeter V_1 does not change.

In circuit (2) the battery has an internal resistance, and according to $V_2 = V_B - Ir$, increasing R decreases the current, so Ir decreases and the reading of V_2 increases.

5 **Model answer**

$R_1 = 2r$, $V = 5V_1$, $V = V_1 + V_2$

$V_2 = 4V_1 = 4IR_1 = 8Ir$

$V_2 = IR_2$, $R_2 = 8r$

6 **Model answer**

When the slider is moved from x to y, the resistance taken from S increases, so the total resistance increases and the current decreases.

So the voltmeter reading increases according to $V = V_B - I(R_1 + r)$

7 **Model answer**

Yes, because the current in a closed circuit is given by $I = V_B/(R + r)$, so it is not inversely proportional to the external resistance R alone, because the battery has an internal resistance; it is inversely proportional to the total resistance.

8 **Model answer**

$V_6 = V_3 : 1 \times 6 = I_3 \times 3 , I_3 = 2\ A , I = 3\ A$

$V_{battery} = IR' = 3 \times (2 + (6 \times 3)/9) = 12\ V$

$V_B \neq V_{battery}$, so the battery has a significant internal resistance.

9 **Model answer**

The battery in figure (2) is being charged: $V = V_B + Ir$, and in figure (1) it is discharging: $V = V_B - Ir$

$(V_{xy})/(V_{zk}) = (10 - 2 \times 4)/(10 + 2 \times 4) = 1/9$

10 **Model answer**

The potential of x is higher than that of y, so the current flows from x to y through the two resistances, so $(V_B)_2 > (V_B)_1$

$(V_B)_2 - (V_B)_1 = I(R' + r')$

$(V_B)_2 - 10 = 2 \times (3 + 5 + 1 + 1) , (V_B)_2 = 30\ V$

11 **Model answer**

$(V_B)_1 > (V_B)_2$, so battery $(V_B)_1$ is discharging and battery $(V_B)_2$ is being charged.

$(1)\ V_1 = (V_B)_1 - Ir$, so $(V_B)_1 > V_1$

$(2)\ V_2 = (V_B)_2 + Ir$, so $V_2 > (V_B)_2$

12 **Model answer**

The unknown element must satisfy: $(V_B)_t = IR_t$

$(V_B)_t = 9 - 3 = 6\ V , IR_t = 0.5 \times (2 + 2 + 4) = 4\ V$

So Z can be:

1- a cell of emf 2 V with negligible internal resistance, whose positive terminal is connected to the negative terminal of the 3 V cell.

2- a resistance of $4\ \Omega$

13 **Model answer**

In circuit (1) the p.d. across lamp (x) stays constant and equal to V_B, because it is connected across a battery of negligible internal resistance, so the brightness of lamp (x) does not change.
In circuit (2) the total resistance decreases, so the current increases and the internal voltage drop (Ir) increases. So the p.d. across the source, and across the lamp, decreases and the brightness of lamp (x) decreases.

14 **Model answer**

Lamp x goes out, because when K_1 is opened and K_2 is closed, the two cells of equal emf oppose each other, so their total emf is zero and no current flows in the lamp.

15 **Model answer**

Because the battery has an internal resistance, which makes the p.d. across each lamp less than 12 V when the current flows.

Past exam questions

1	2	3	4	5	6	7	8	9	10
D	D	A	D	C	A	B	A	D	C
11	12	13	14	15	16	17	18	19	20
A	B	D	A	A	D	B	D	D	A
21	22	23	24	25	26	27	28	29	30
A	D	D	C	A	C	A	A	C	—
31									
—									

1 **Answer (D)**

$A_1 : R + (3R \times 6R)/9R = 3R$, $A_2 : R + 2R/2 = 2R$

A_3 : the two $4R$ resistances are short-circuited by a wire: R , $A_4 : R/2 + 3R/3 = 1.5R$

Least resistance, greatest current: $A_3 > A_4 > A_2 > A_1$

2 **Answer (D)**

$V_B = I_1(R_1 + r) = I_2(R_2 + r)$

$0.5(5 + r) = 0.3(9 + r)$, $r = 1\ \Omega$

$V_B = 0.5 \times 6 = 3\ V$

3 **Answer (A)**

$I_1 = V/(10 + 1) = V/11$, $I_2 = V/(5 + 1) = V/6$

$I_1/I_2 = 6/11$

4 **Answer (D)**

$V_1 = V_B - Ir$, $V_2 = IR$

$V_1/V_2 = (V_B - Ir)/IR$

5 **Answer (C)**

$9\ \Omega$ with $(6 + 12)\ \Omega$ in parallel = $6\ \Omega$, and with $3\ \Omega$ in series = $9\ \Omega$

With $6\ \Omega$ and $18\ \Omega$ in parallel: $1/(R') = 1/6 + 1/18 + 1/9 = 1/3$, $R' = 3\ \Omega$

$I = 12/(3 + 1) = 3\ A$

6 **Answer (A)**

When S increases, the current decreases.

$V_2 = V_B - Ir$ increases , $V_1 = V_B - I(R + r)$ increases

7 **Answer (B)**

$I = V_3/2 = 0.4\ A$, and the two batteries oppose each other: $(10 - 8)/(2 + 1 + 2) = 0.4\ A$

The 10 V battery is discharging: $V_2 = 10 - 0.4 \times 2 = 9.2\ V$

The 8 V battery is being charged: $V_1 = 8 + 0.4 \times 1 = 8.4\ V$

8 **Answer (A)**

When S increases, the current decreases.

$V_1 = V_B - Ir$ increases , $V_2 = V_B - I(R + r)$ increases

9 **Answer (D)**

Switch open: $V_B = 18\ V$

Closed: $I = 15/5 = 3\ A$, $r = (18 - 15)/3 = 1\ \Omega$

10 **Answer (C)**

Switch open: $V_B = 14\ V$

Closed: $R' = (6 \times 3)/9 = 2\ \Omega$, $I = 8/2 = 4\ A$

$r = (14 - 8)/4 = 1.5\ \Omega$

11 **Answer (A)**

Decreasing the rheostat resistance decreases the total resistance, so the current increases and the internal voltage drop Ir increases.

So the p.d. between the terminals of the battery (the voltmeter reading) decreases.

12 **Answer (B)**

$V = V_B - Ir$, $8 = V_B - 4 \times 0.5$

$V_B = 10\ V$

13 **Answer (D)**

14 **Answer (A)**

The upper group (through the ammeter) and the lower resistance are in parallel, and they are connected in series with R and the battery.

Opening K increases the total resistance, so the total current decreases and the ammeter reading decreases, and the voltmeter reading $V = V_B - Ir$ increases.

15 **Answer (A)**

The switch K is open, so no current flows.

$V_1 = 0$, $V_2 = V_B$, so the correct statement is $V_2 = V_B$

16 **Answer (D)**

$V_B = 1.2(9 + r) = 1 \times (11 + r)$

$r = 1\ \Omega$

17 **Answer (B)**

The two batteries oppose each other, so the resultant is V_B, and the battery V_B is being charged.

K open: $I = V_B/6R$, $V = V_B + I(r + R) = V_B + 2V_B/6 = 4/3\ V_B$

K closed: $I = V_B/5R$, $V = V_B + 2V_B/5 = 7/5\ V_B$

18 **Answer (D)**

K open: $I = 4/2 = 2\ A$, $V_B = 2 \times (3 + 2 + 1) = 12\ V$

K closed: the $2\ \Omega$ resistance is short-circuited: $I = 12/(3 + 1) = 3\ A$

$V_3 = 3 \times 3 = 9\ V$

19 **Answer (D)**

K open: $V_B = 21\ V$, closed: $Ir = 21 - 19.5 = 1.5$, $I = 3\ A$

External resistance = $19.5/3 = 6.5\ \Omega$

The bridge is balanced: $1/(R') = 1/2R + 1/R + 1/2R = 2/R$, $R/2 = 6.5$, $R = 13\ \Omega$

20 **Answer (A)**

The current leaves the positive terminal, so the battery is discharging, and it flows through R in the same direction.

$V = V_B - Ir - IR = V_B - I(R + r)$

21 **Answer (A)**

The 16 V battery is discharging: $15.2 = 16 - 1.6I$, $I = 0.5\ A$

$16 - 7 = 0.5 \times (1.6 + 6 + 9 + r)$, $r = 1.4\ \Omega$

The 7 V battery is being charged: $V_{cd} = 7 + 0.5 \times 1.4 = 7.7\ V$

22 **Answer (D)**

$3R$ with $(2R + 4R)$ in parallel = $2R$, $R_t = R + R + 2R = 4R$, $I = V_B/4R$

$V_R = V_B/4$, $V_{3R} = V_B/2$, $V_{2R} = V_B/6$, $V_{4R} = V_B/3$

$V_{3R} = 2V_R = 3V_{2R} = 1.5V_{4R}$

23 **Answer (D)**

Both V_1 and V_2 measure the p.d. across R_2: $V = (V_B\ R_2)/(R_1 + R_2 + r)$

When R_2 increases, this p.d. increases, so both readings increase.

24 **Answer (C)**

Before: $R_t = R + R/2 + 0.5R = 2R$, current of X = $V_B/2R$, current of Z = $V_B/4R$

After Y burns out: $R_t = 2.5R$, current of X = current of Z = $V_B/2.5R$

So the brightness of X decreases and the brightness of Z increases.

25 **Answer (A)**

Opening K stops the current in the circuit.

$V_1 = V_B - Ir = V_B$, and voltmeter V_2 is connected through the resistance to the battery terminals, so it reads V_B

26 **Answer (C)**

$R' = (20 \times 80)/100 = 16\ \Omega$, $I = 12/(16 + 4) = 0.6\ A$

$V = 0.6 \times 16 = 9.6\ V$

27 **Answer (A)**

The voltmeter measures the p.d. across the parallel group.

Before closing: $I = V_B/2.5R$, $V = 0.4\ V_B$

After closing: $I = V_B/2R$, $V = V_B/2R \times R/2 = 0.25\ V_B$

So the ammeter reading increases and the voltmeter reading decreases.

28 **Answer (A)**

$Ir = 4 - 3.3 = 0.7$, $I = 2\ A$, external resistance = $3.3/2 = 1.65\ \Omega$

$R_{XY} = 1.8/2 = 0.9\ \Omega$

$\sigma = (\ell)/RA = 0.9/(0.9 \times 3 \times 10^{-8}) = 33.33 \times 10^6\ \Omega^{-1}\ m^{-1}$

29 **Answer (C)**

K_1 only: $I = 10/(8 + 12) = 0.5\ A$, $V_{BD} = 0.5 \times 12 = 6\ V$

K_2 only: the two batteries act in the same direction: $I = (10 + 12)/(8 + 3) = 2\ A$

$V_{DF} = 12 - 2 \times 3 = 6\ V$

30 **Model answer**

$V_B = I(R + r)$

When K_1 and K_3 are closed: $V_B = 0.8(R + 1)$

When K_2 and K_3 are closed: $V_B = 0.6(R + 2)$

$0.8R + 0.8 = 0.6R + 1.2$, $R = 2\ \Omega$

$V_B = 0.8 \times 3 = 2.4\ V$

31 **Model answer**

$I_1 = (V_B - V)/r = (18 - 12)/2 = 3\ A$

$R_t = 18/3 = 6\ \Omega$, $R = 6 - 2 = 4\ \Omega$

When $12\ \Omega$ is connected in parallel with R: $R' = (4 \times 12)/16 = 3\ \Omega$

$I_2 = 18/(3 + 2) = 3.6\ A$