D.C. Circuits

Current and Potential Difference in Circuits

Series and Parallel Circuits

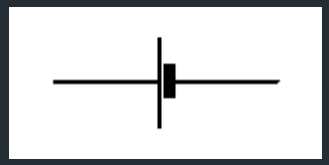
Draw circuit diagrams with power sources (cell, battery or a.c. mains), switches (closed and open), resistors (fixed and variable), light-dependent resistors, thermistors, lamps, ammeters, voltmeters, magnetising coils, bells, fuses, relays, diodes and light-emitting diodes.

Current and Potential Difference in Circuits

Electric Ciruit

- An electric circuit is a complete or closed path through which charge can flow from one terminal of an electrical source to the other.
- It consists of four main parts or components:
  - One that drives the electric charge round the circuit, e.g. a battery;
  - One on which the moving charge can do a useful job, e.g. a lamp;
  - Conductors to join them together, e.g. copper wire;
  - Switches to break or complete the circuit.

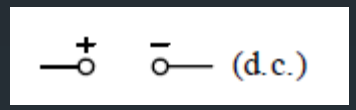
Symbols in Drawing Circuit



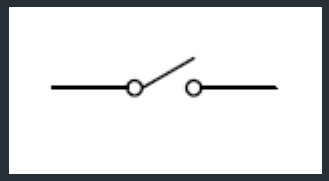
cell

battery

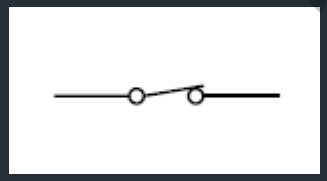
a.c. supply



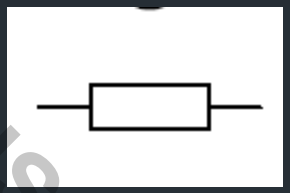
d.c. supply



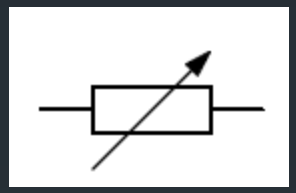
open switch



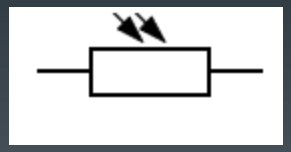
closed switch



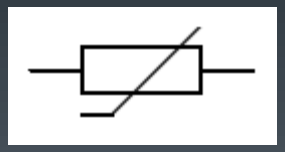
resistor



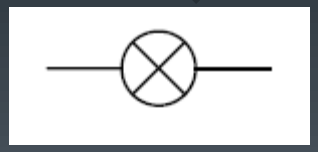
variable resistor



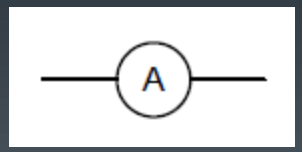
light dependent resistor (LDR)



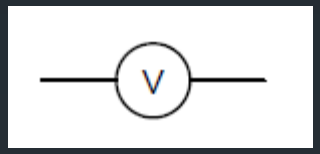
thermistor



lamp

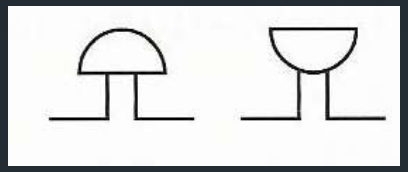


ammeter

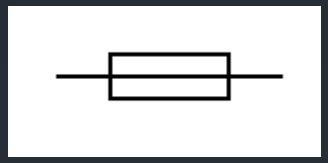


voltmeter

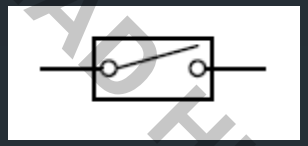
magnetising coil



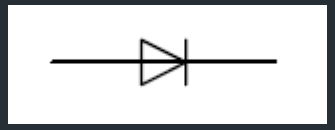
bell buzzer



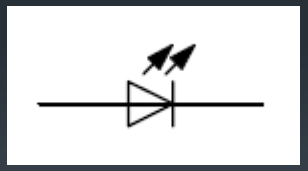
fuse



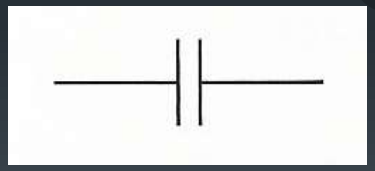
relay



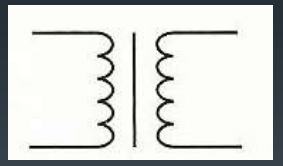
diode



light emitting diode



capacitor



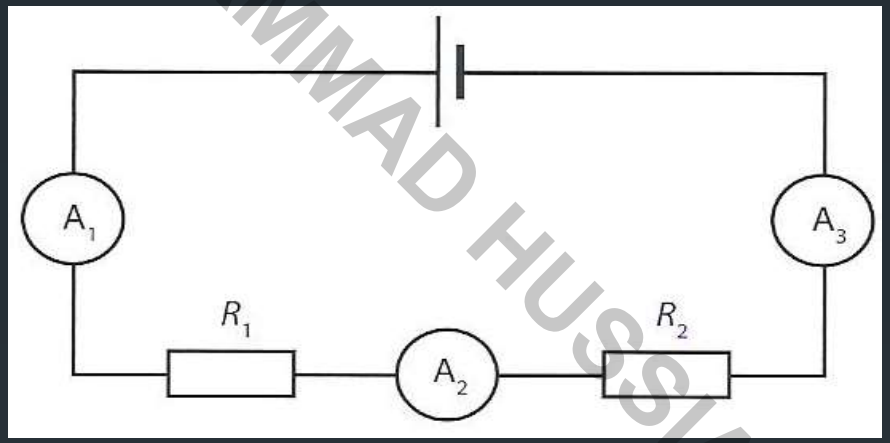
transformer

State that the current at every point in a series circuit is the same, and use this in calculations.

Current and Potential Difference in Circuits

Current in a Series Circuit

- In figure below, ammeters A_1, A_2 and A_3 measure the current at various points in the circuit.



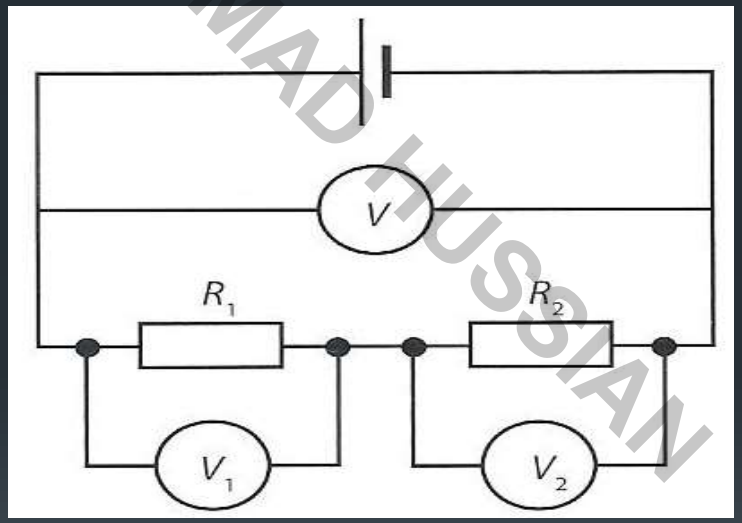
- All the ammeters record the same reading. This conclude that: The current at every point in a series circuit is the same.

State that the sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit and use this in calculations.

Current and Potential Difference in Circuits

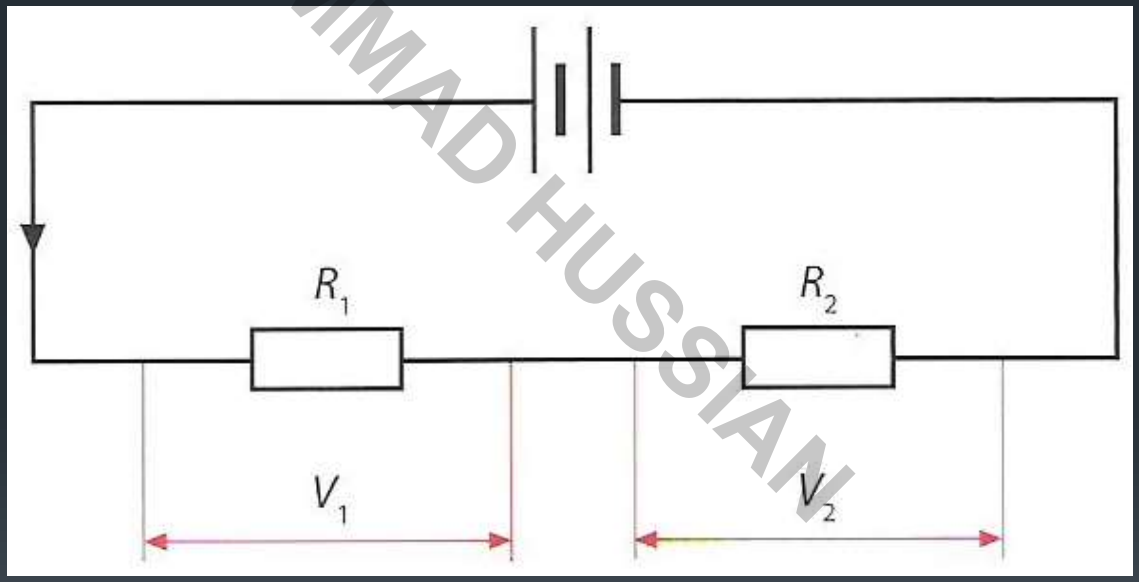
Potential Difference in a Series Circuit

- In figure below, voltmeters V_1 and V_2 measure the potential differences across R_1 and R_2 respectively. Voltmeter V measures the potential difference across the whole circuit.



- The sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit, i.e. $V = V_1 + V_2$.

- Figure below shows a simple circuit consisting of a battery connected by copper wires to two resistors having resistor R_1 and R_2.

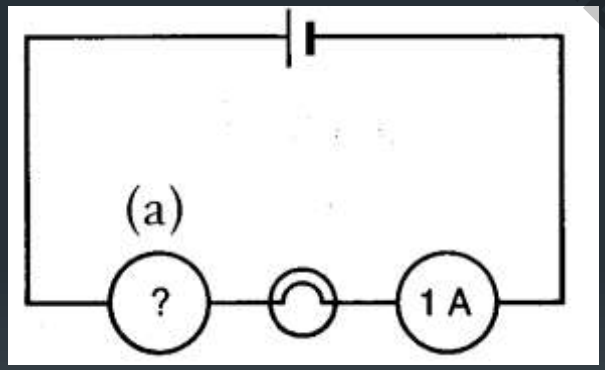


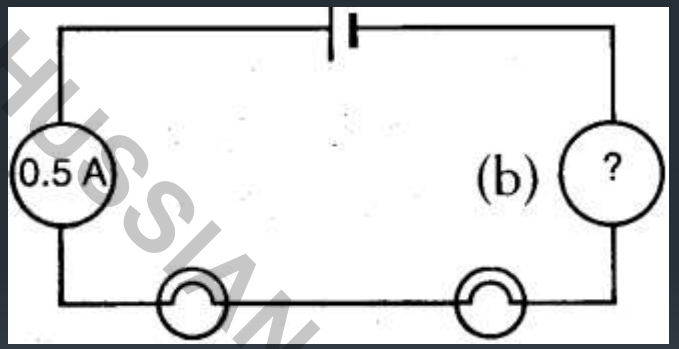
- For any individual resistor in the circuit, the current, potential difference and resistance are related by the equation V = IR
- Thus, $V_1 = IR_1$ and $V_2 = IR_2$.

- In a series circuit, the component with largest resistance has the highest potential difference across it.
- If the internal resistance of cell is neglected, the e.m.f. E of the cell equals to the potential difference across the whole circuit V.
- In series circuit, the current will cease to flow if there is a break anywhere in the circuit.

Problem Solving

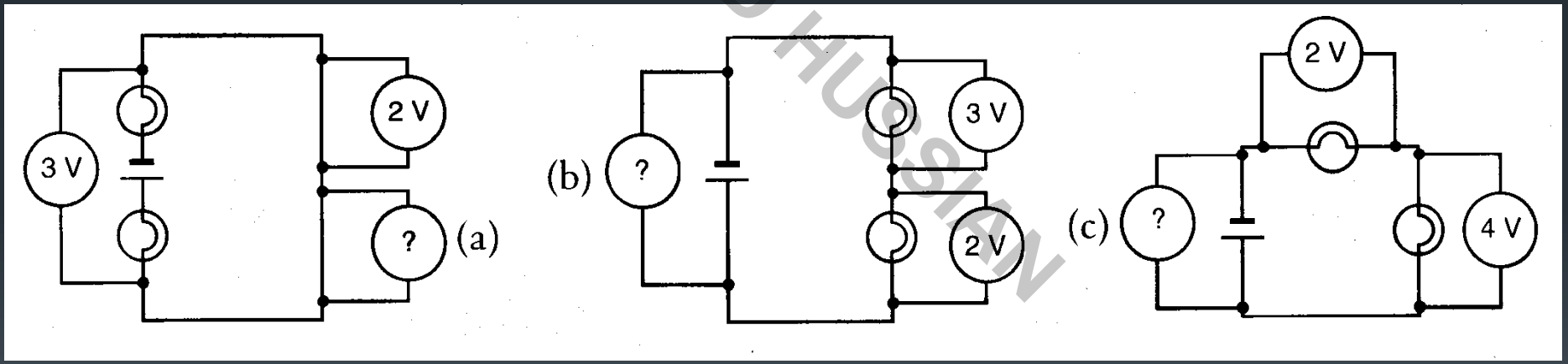
1. Determine the reading of the ammeter marked by '?'





Problem Solving

2. Determine the reading of the voltmeter marked by '?'



Problem Solving

3. Two resistors valued 30 Ω and 15 Ω are connected in series.
   a. Calculate its effective resistance.
   b. Calculate the current which a 4.5 V battery supplies to each combination.
   c. Calculate the potential difference across each separate resistor when the 4.5 V battery is connected across each combination.

Problem Solving

4. In a circuit four resistors valued 8 Ω, 20 Ω, 24 Ω and 30 Ω are connected in series to a 60 V cell. Find
   a. The combined resistance,
   b. The current ,
   c. The potential difference across the 20 Ω resistor.

Problem Solving

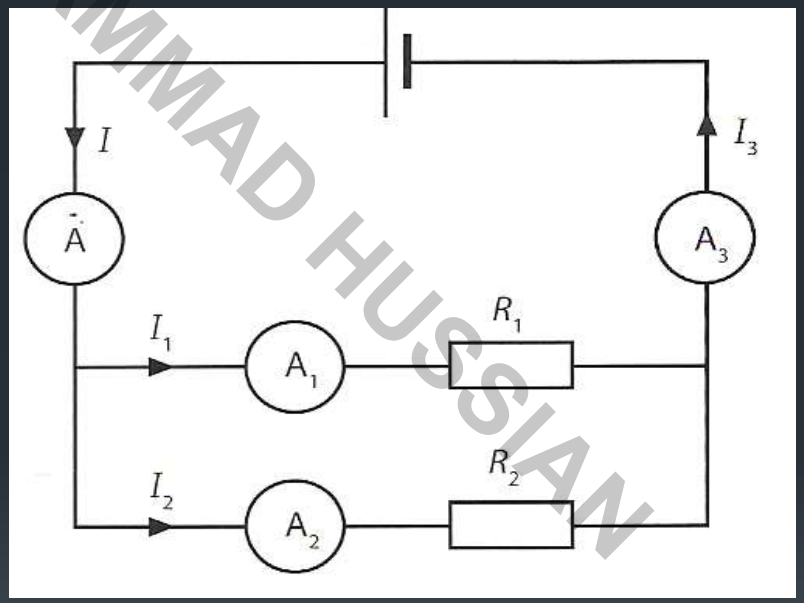
5. Three resistors are connected in series to a 24 V battery, and an ammeter in the circuit reads 0.5 A. The first resistor is rated at 22 Ω, and the second at 8 Ω. Find
   a. The total resistance,
   b. The resistance of the third resistor,
   c. The potential difference across the third resistor.

State that the current from the source is the sum of the currents in the separate branches of a parallel circuit.

Current and Potential Difference in Circuits

Current in a Parallel Circuit

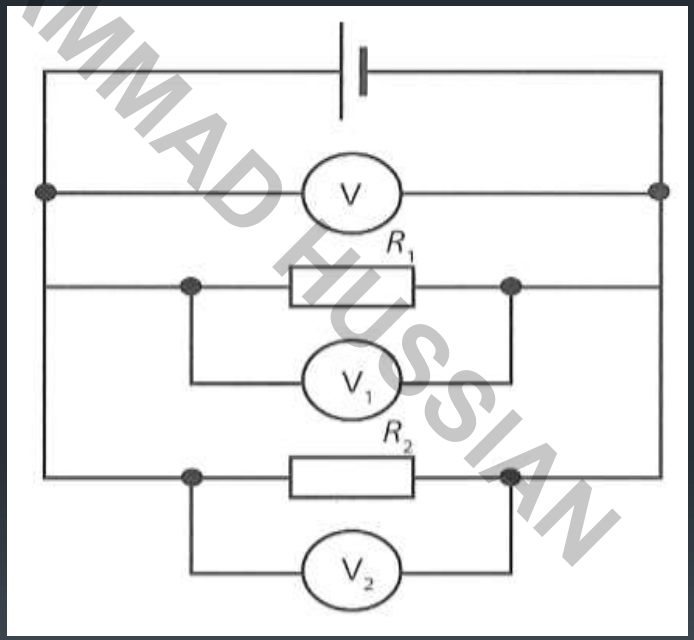
- Figure below shows how the current from dry cell is shared in the separate branches of a parallel circuit.



- The current from the source I the sum of the currents in the separate branches of a parallel circuit, i.e. $I = I_1 + I_2$.

Potential Difference in a Parallel Circuit

- Figure below shows a voltmeter V_1 and V_2 measure the potential differences across resistor R_1 and R_2 respectively.

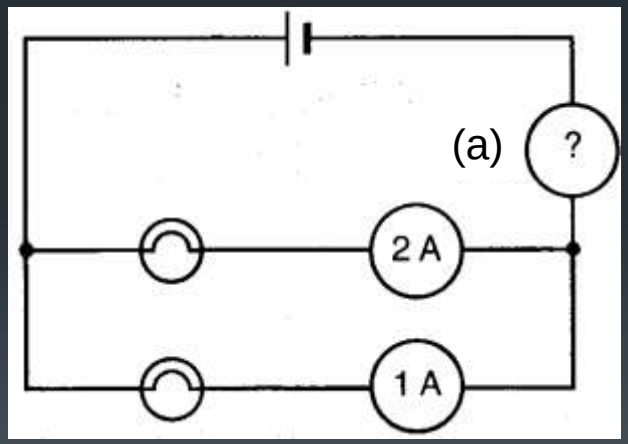


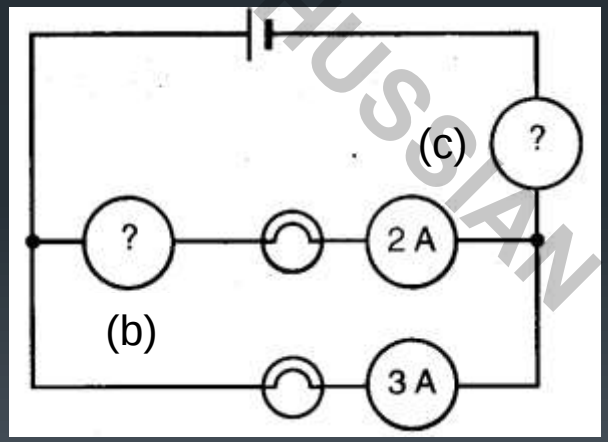
- All the voltmeters record the same reading. We can conclude that: ***the potential differences across the separate branches of a parallel circuit are the same***.

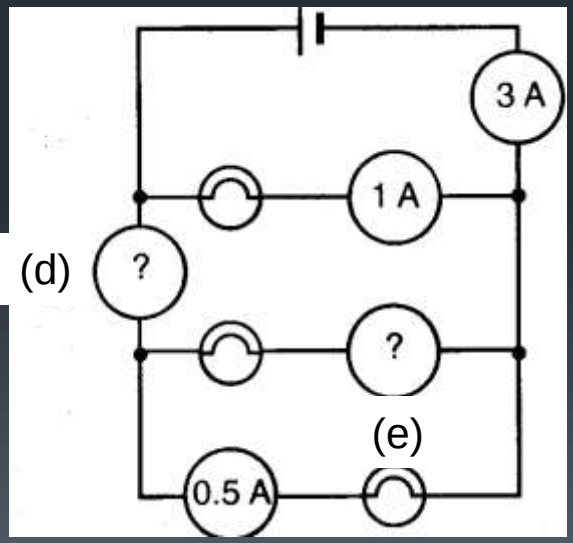
- In parallel circuit, the component with the smallest resistance has the highest current flowing through it.
- The current flowing out from the cell, I, is the same as the current flowing back to the cell, I_3.
- Any breakdown in one of the parallel branches does not affect the current flow in the other branches of the circuit.

Problem Solving

1. Determine the reading of the ammeter marked by '?'

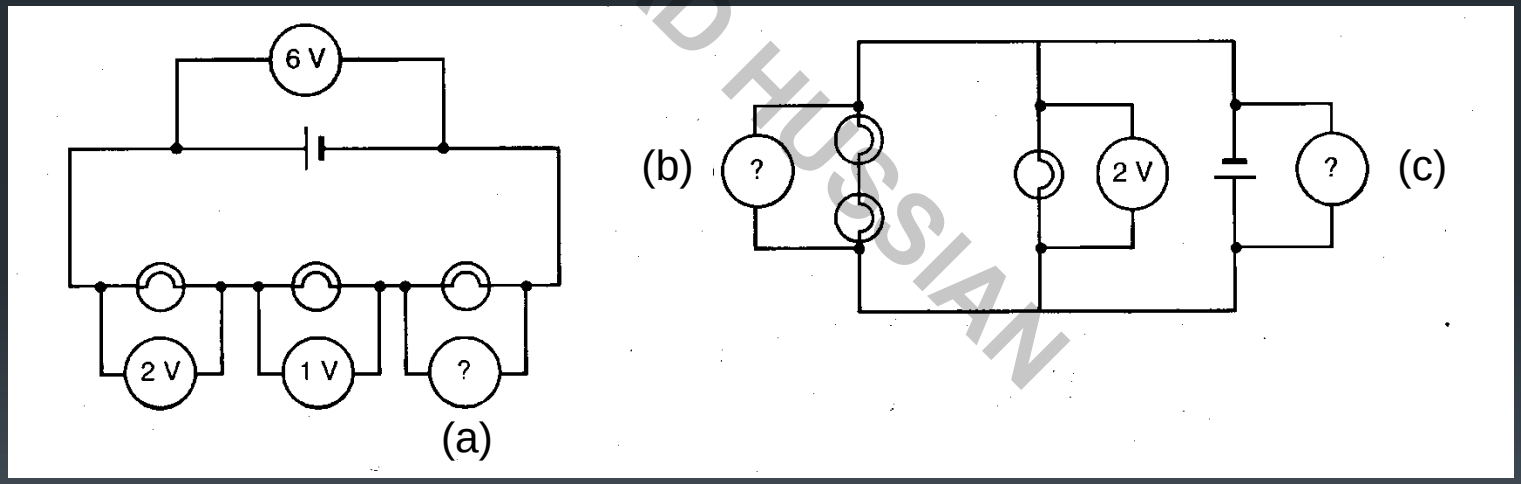






Problem Solving

2. Determine the reading of the voltmeter marked by '?'



Problem Solving

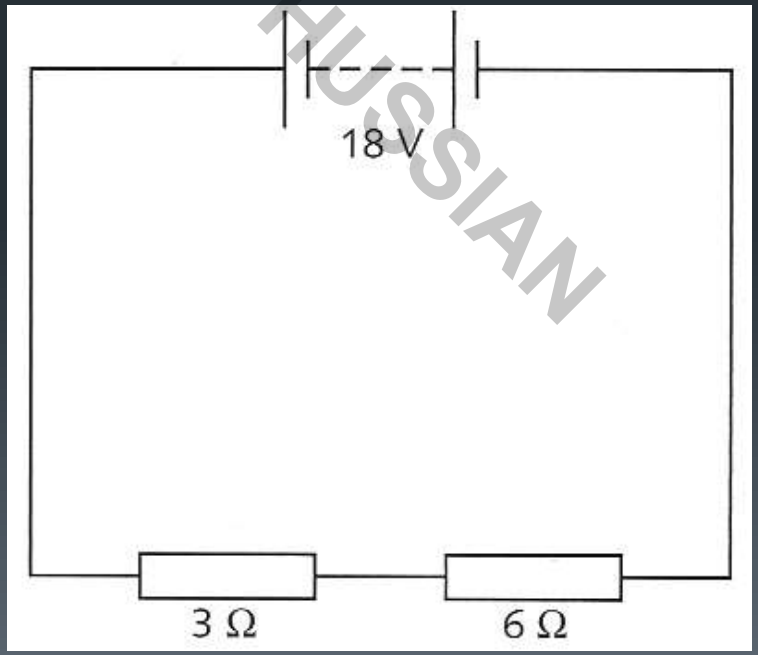
3. A 12 Ω and 4 Ω resistor is connected in parallel to a 12 V battery.
   a. Calculate the effective resistance.
   b. Calculate the current flowing through the 12 Ω resistor, the 4 Ω and the battery.
4. Four resistors with resistance 8 Ω, 20 Ω, 24 Ω and 30 Ω are connected in parallel to a 60 V dry cell. Find
   a. The combined resistance,
   b. The current in the battery,
   c. The current in the 8 Ω resistor.

Do calculations on the whole circuit, recalling and using formulae including $R = V/I$ and those for potential differences in series, resistors in series and resistors in parallel.

Series and Parallel Circuits

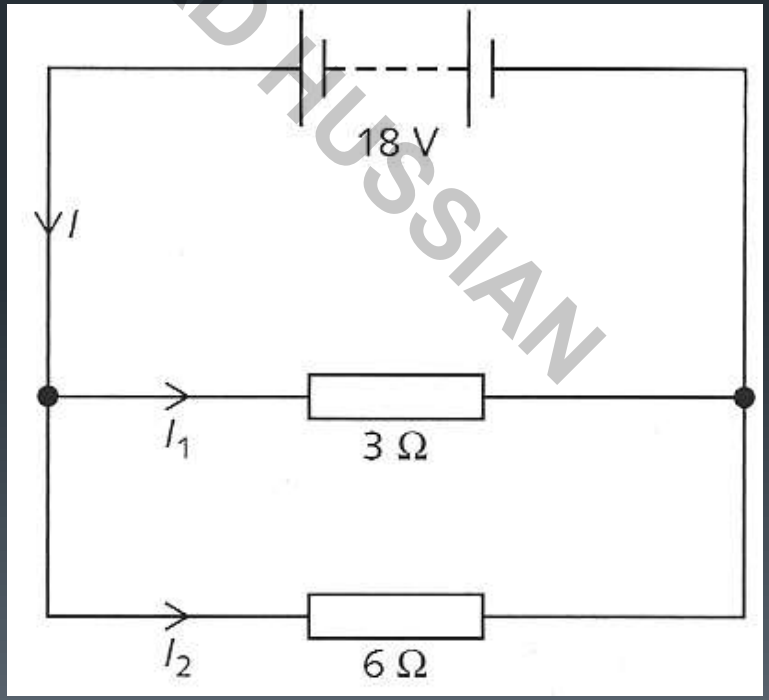
Problem Solving

1. Calculate the p.d.s across the 3 Ω resistors and the 6 Ω resistors in the circuit below.



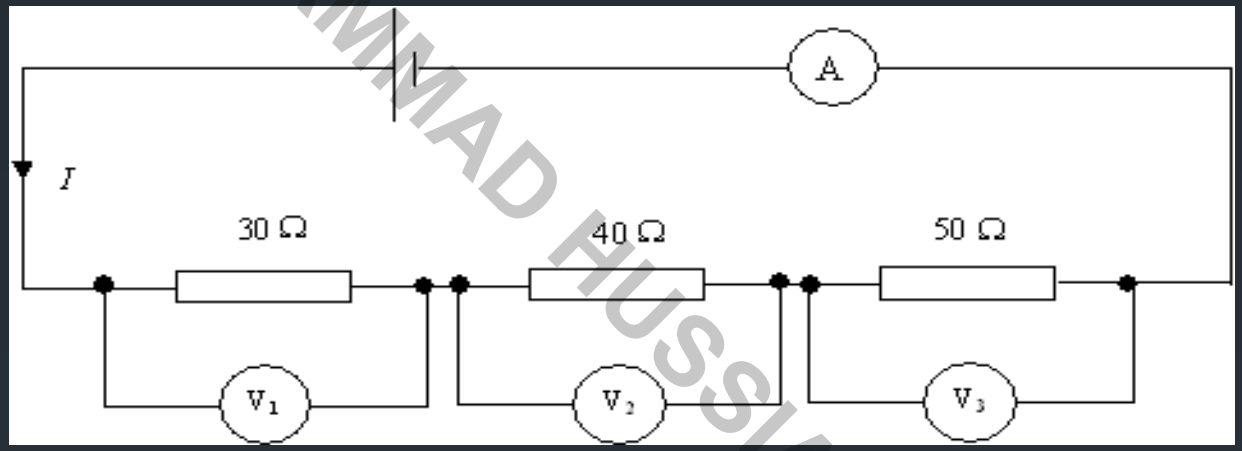
Problem Solving

2. Calculate the currents I, I_2 and I_3 in the circuit below.



Problem Solving

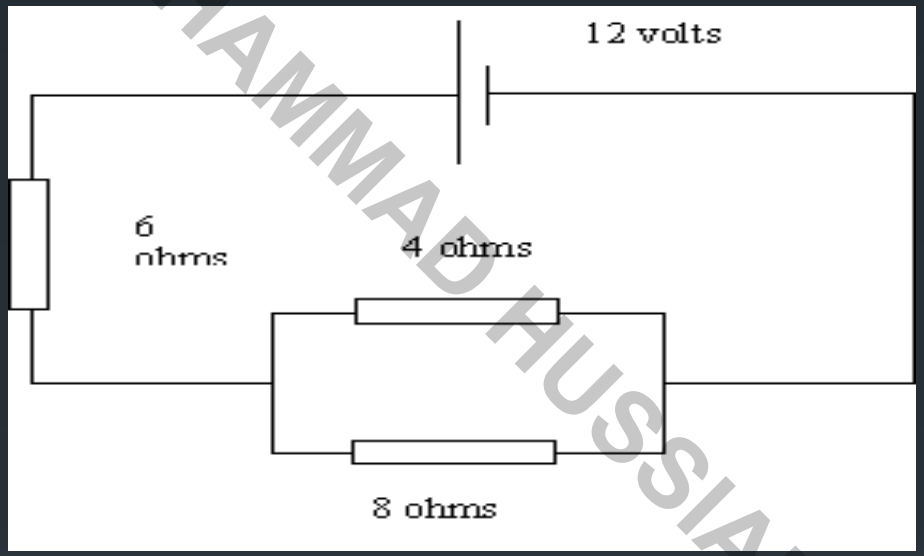
3. This question refers to the circuit below in which the current is 100 mA:



   a. What is 100 mA in amps?
   b. What is the current in each resistor?
   c. What is the voltage across each resistor?
   d. What is the total resistance?
   e. What is the battery voltage?

Problem Solving

4. Refer the circuit below

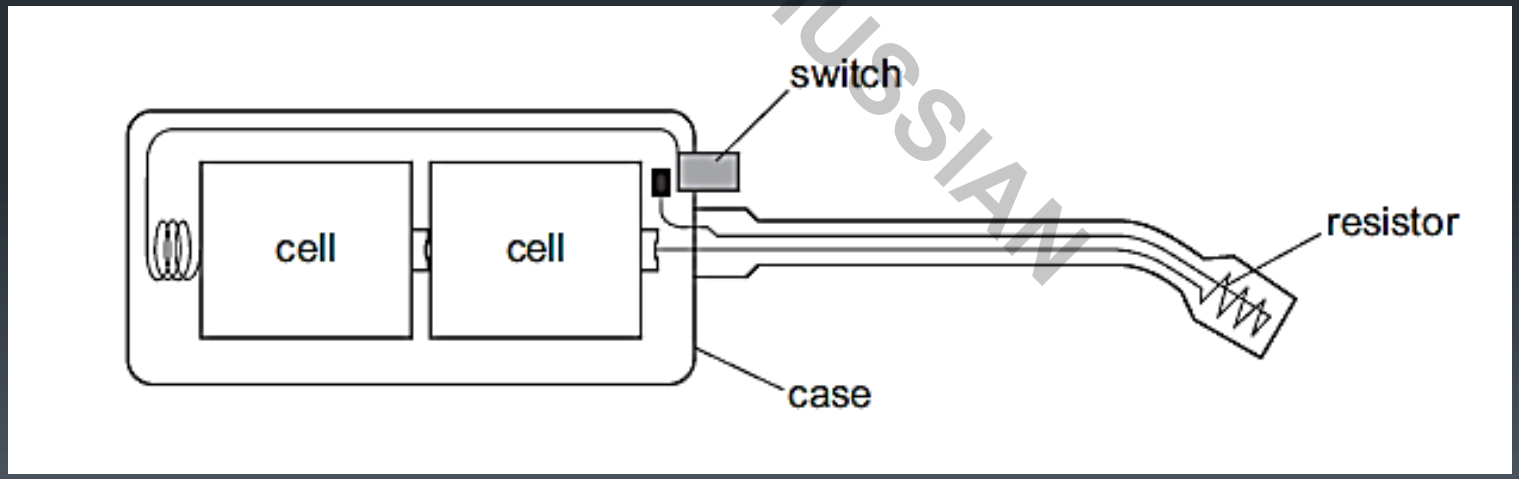


a. What is the single resistor equivalent?
b. What is the total current?
c. What is the voltage across the 6 ohm resistor?
d. What is the current in each resistor?

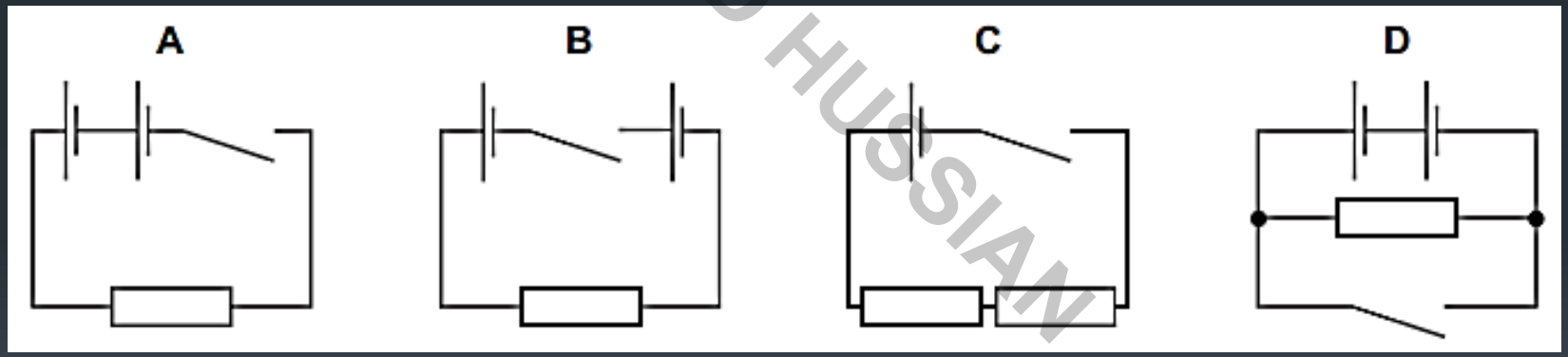
Problem Solving

5. The battery in a circuit has an e.m.f. of 6.0 V and negligible resistance. If two resistors R_1 and R_2 with resistance 12 Ω and 6 Ω are connected in parallel while resistance R_3 with resistance 8 Ω is connected in series with them.
   a. Calculate the combined resistance of the resistors connected in parallel.
   b. Calculate the current in the R_3.
6. Three resistors are connected in parallel to a 24 V battery, and the battery current is 3.0 A. The first resistor is rated 20 Ω and the second at 40 Ω. Find
   a. The total resistance,
   b. The resistance of the third resistor,
   c. The current in the third resistor.

1. The diagram shows the components of a lighter for a gas cooker.

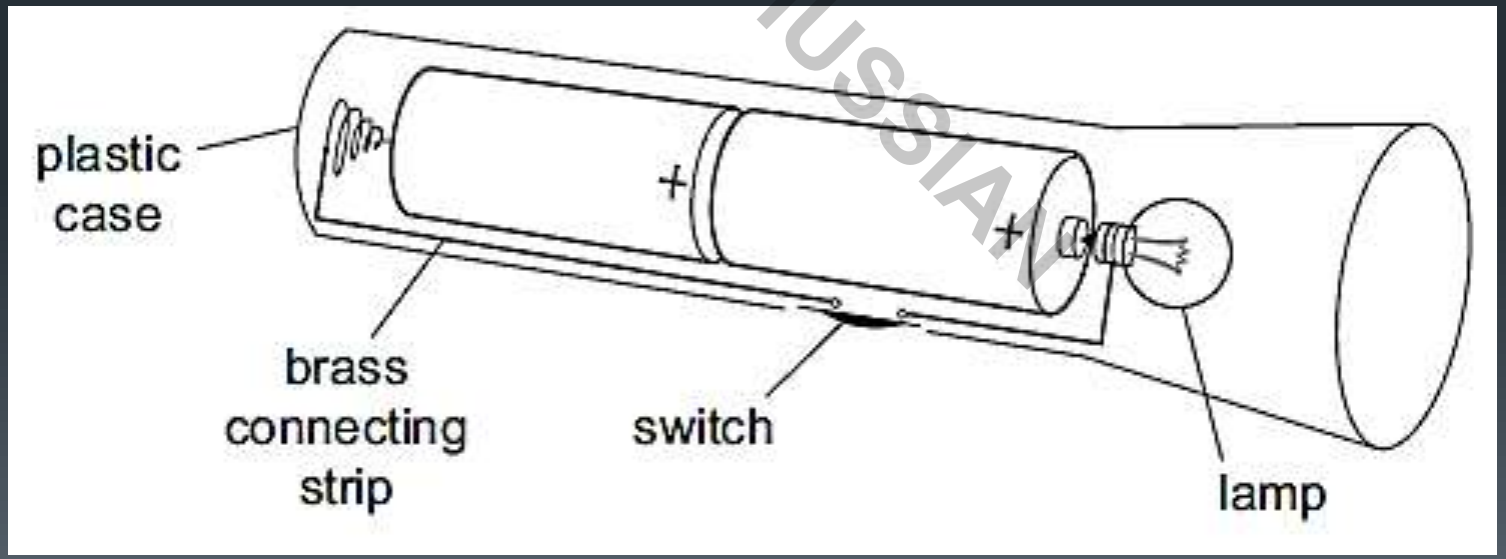


1. Which circuit diagram is correct for this lighter?

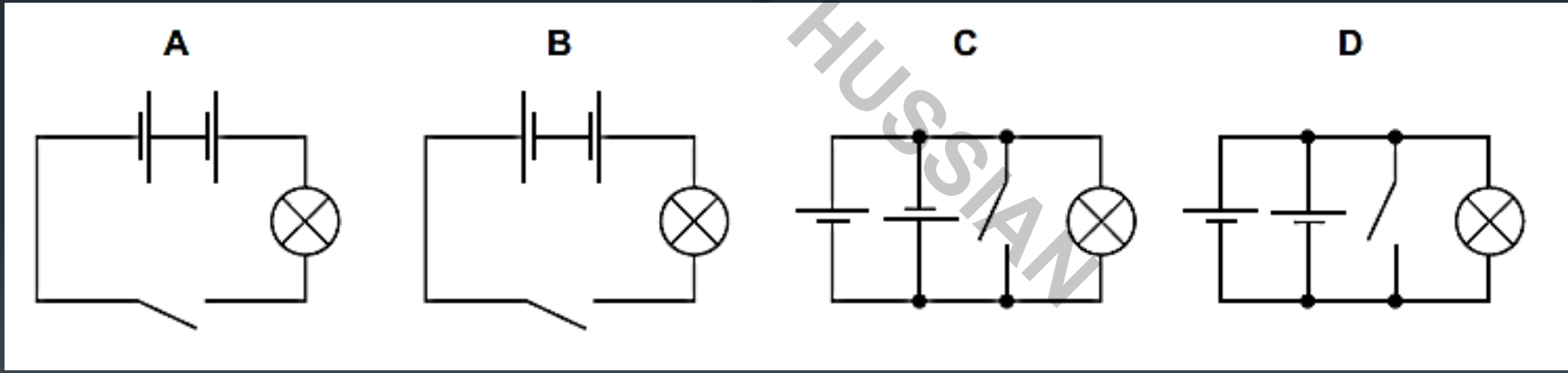


A

2. The diagram shows a torch containing two cells, a switch and a lamp.

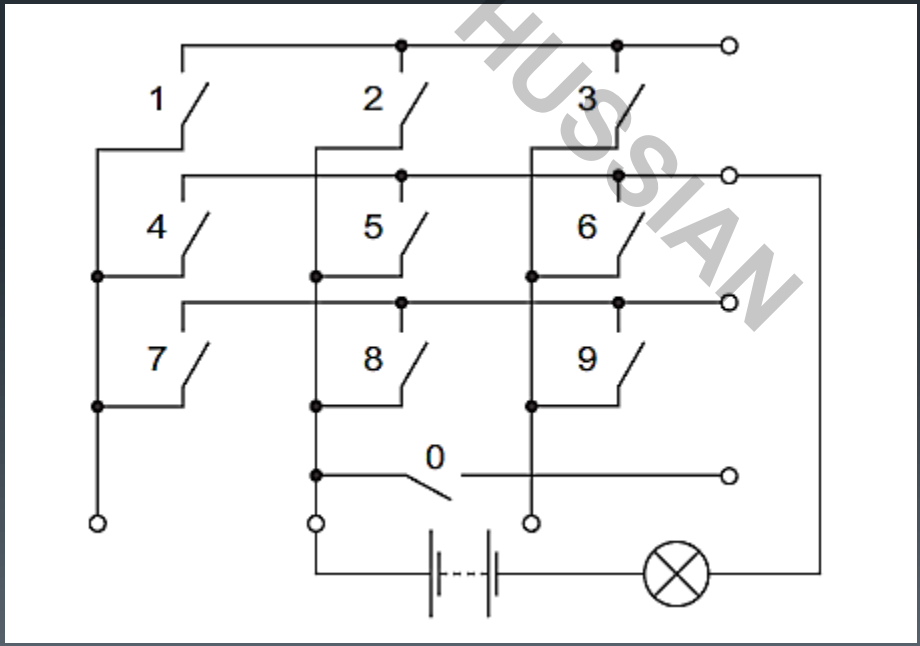


1. What is the circuit diagram for the torch?



A

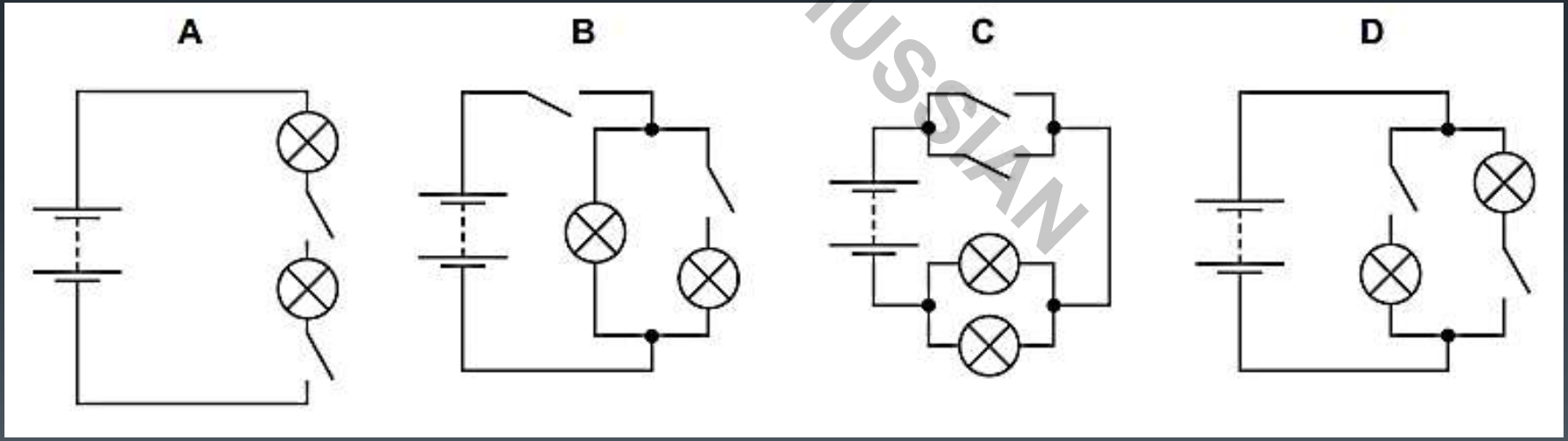
3. A student tests the circuit of a press-button telephone with a lamp and a battery.



1. Which single switch can be pressed to make the lamp light?

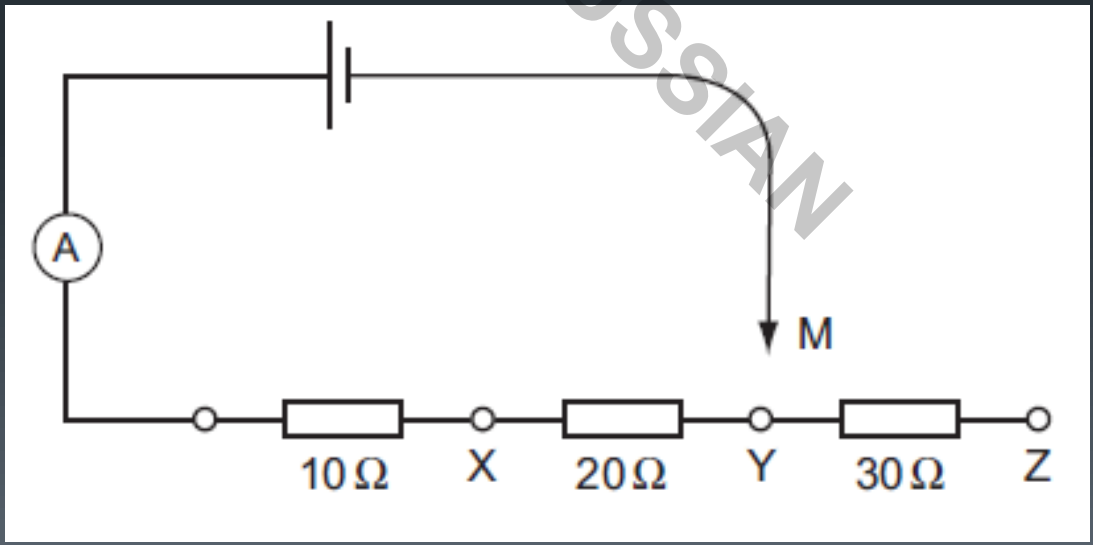
A. 0
B. 1
C. 5
D. 6

4. Which diagram shows a circuit that will allow the lamps to be switched on and off independently?



D

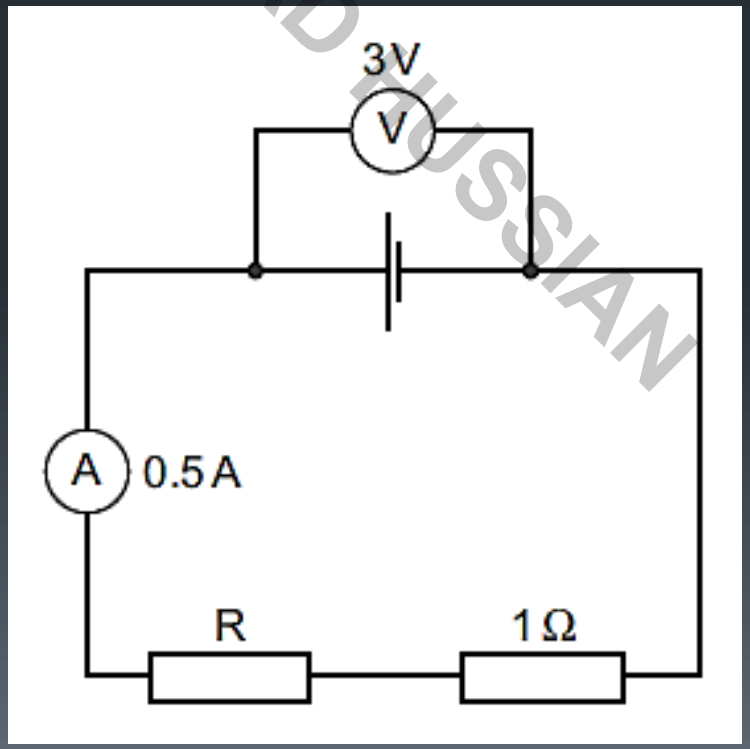
5. The diagram shows a cell connected in series with an ammeter and three resistors (10 Ω, 20 Ω, 30 Ω). The circuit can be completed by a moveable contact M.



1. When M is connected to X, the ammeter reads 0.6 A.
2. What is the ammeter reading when M is connected to Y?

A. 0.1 A
B. 0.2 A
C. 0.3 A
D. 0.6 A

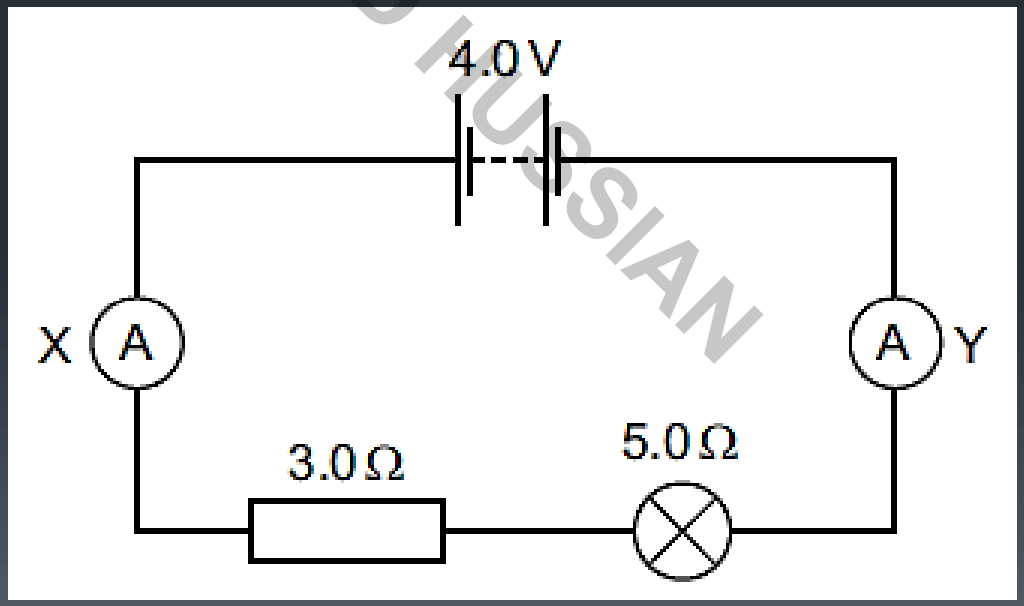
6. The diagram shows a circuit.



1. The ammeter has negligible resistance.
2. What is the resistance of the resistor R?

A. 0.5 Ω
B. 1.5 Ω
C. 5 Ω
D. 6 Ω

7. In the circuit shown, ammeter X reads 0.5 A.

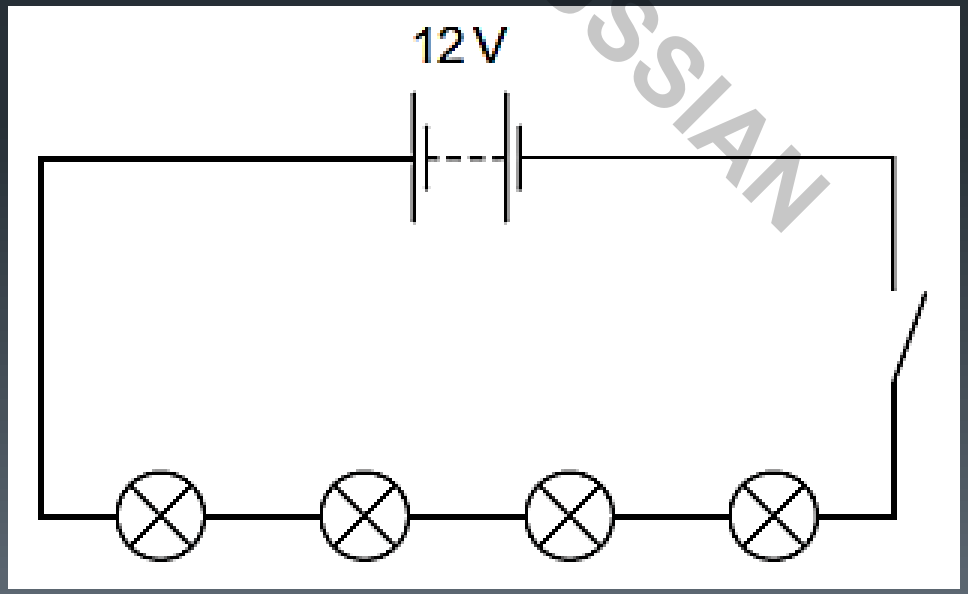


1. What does ammeter Y read?

A. 0
B. 0.5 A
C. 3.5 A
D. 4.0 A

8. Four lamps are connected in a circuit as shown in the diagram.

   Each lamp is designed to operate at 12 V.

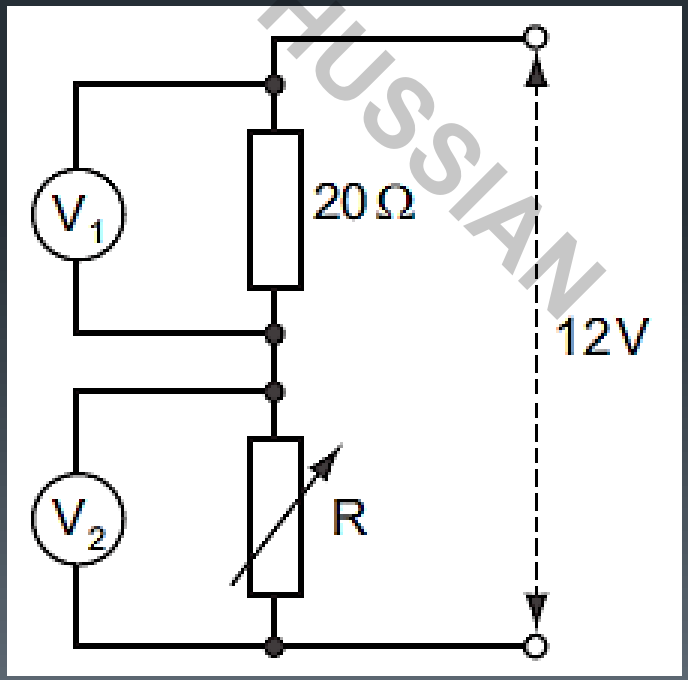


The circuit is now switched on.

Which statement is correct?

A. Each lamp can be switched off independently.
B. If one lamp breaks all the others will stay alight.
C. The current is the same in all the lamps.
D. The lamps will all light at normal brightness.

9. The potential divider shown is connected across a constant 12 V supply.



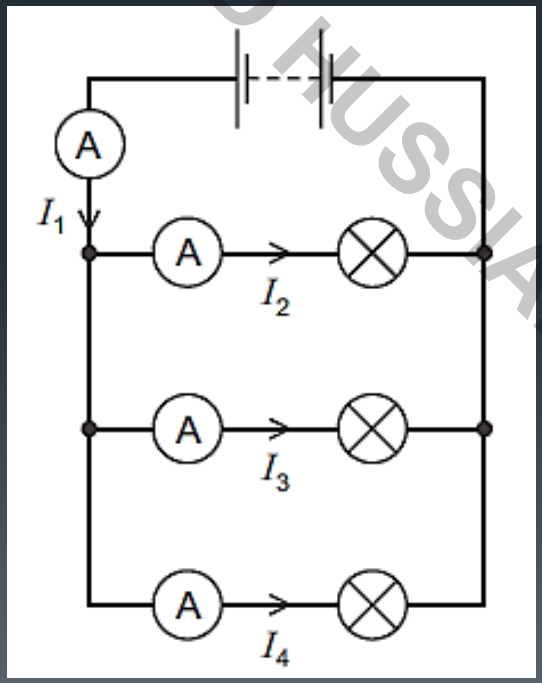
When R has a value of 20 Ω, the voltmeter readings are equal.

How do these readings change when the value of R is reduced to 10 Ω?

	reading on V_1	reading on V_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

C

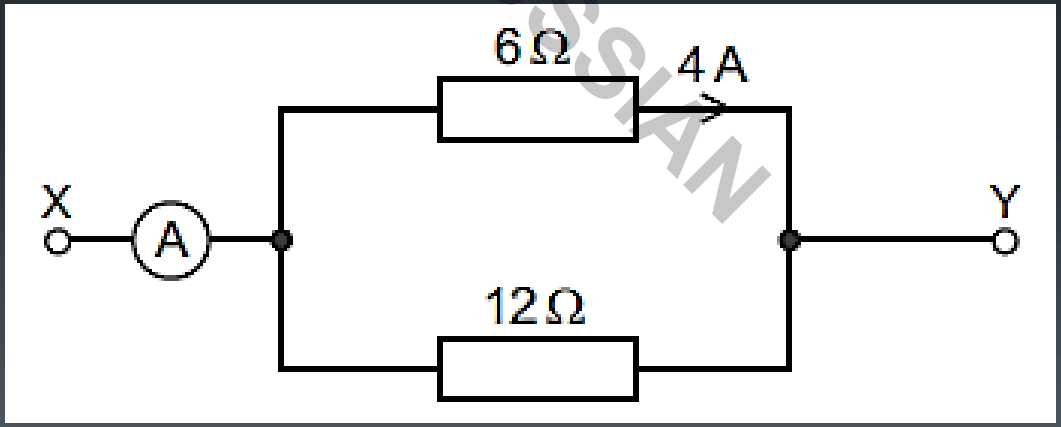
10. A student sets up the circuit shown.



1. The currents measured with the ammeters are shown.
2. Which equation is correct?

A. $I_1 = I_2 + I_3 + I_4$
B. $I_1 = I_2 = I_3 = I_4$
C. $I_2 + I_3 = I_4 + I_1$
D. $I_4 = I_3 + I_2 + I_1$

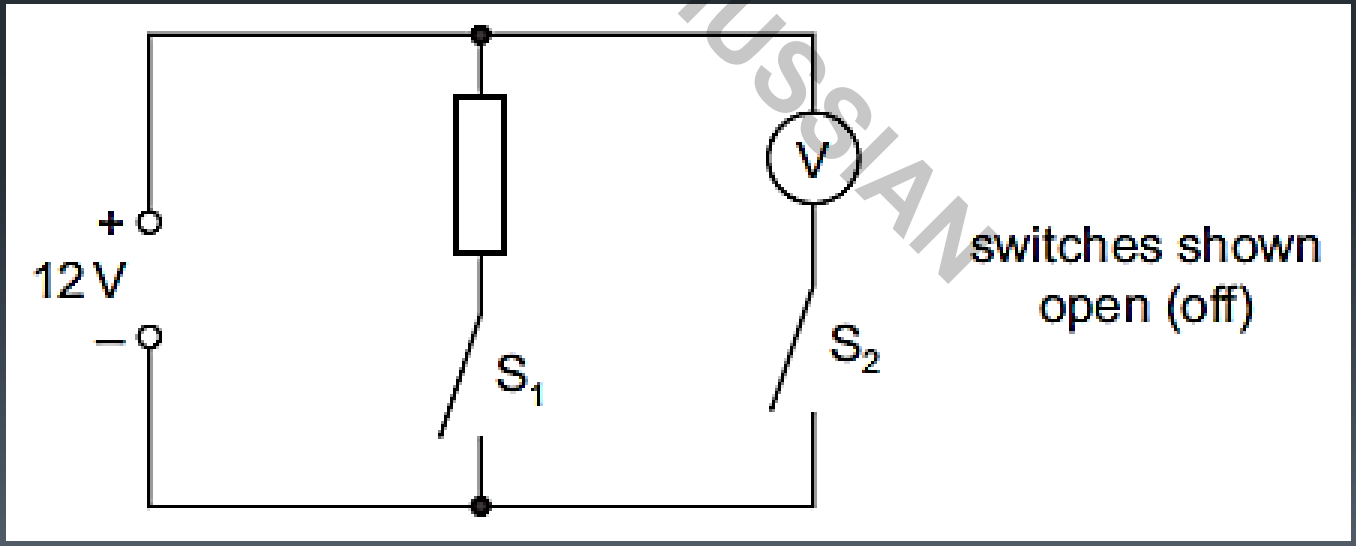
11. Two resistors of 6 Ω and 12 Ω are arranged in parallel. A potential difference is connected across the terminals X and Y. The current in the 6 Ω resistor is 4 A.



1. What is the current in the ammeter?

A. 4 A
B. 6 A
C. 8 A
D. 12 A

12. In the circuit shown, the switches S1 and S2 may be open (off) or closed (on).



11. Which line in the table shows the voltmeter reading for the switch positions given?

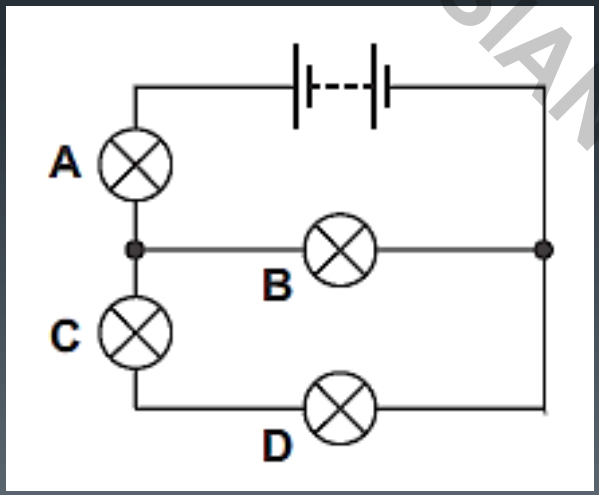
	S_1	S_2	voltmeter reading / V
A	open	open	12
B	closed	closed	12
C	open	closed	0
D	closed	open	12

B

13. In the circuit shown, the battery lights up all four lamps.

When one of the lamp filaments melts, the other three lamps stay on.

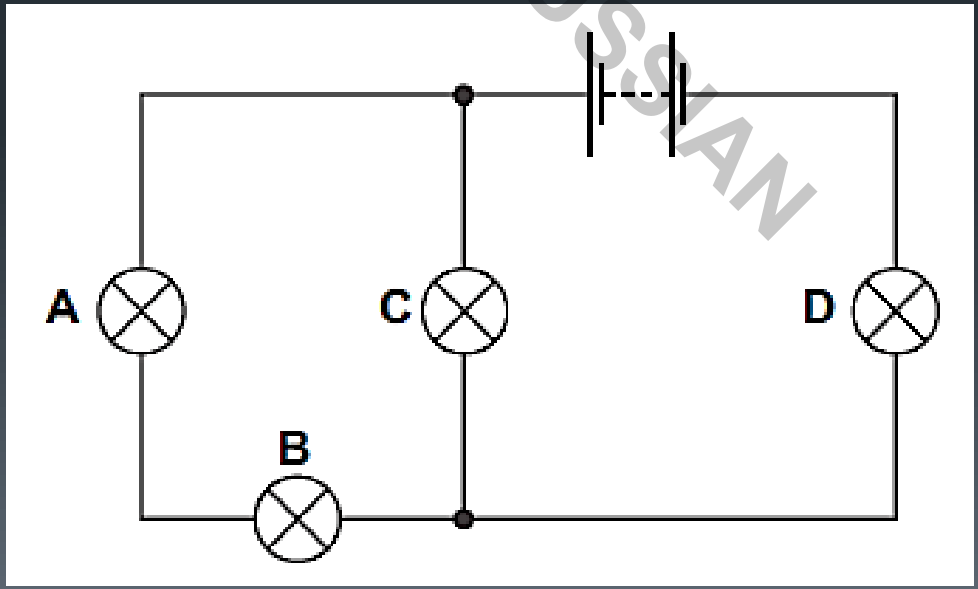
Which lamp filament melts?



B

14. In the circuit below, one of the lamps breaks, causing all the other lamps to go out.

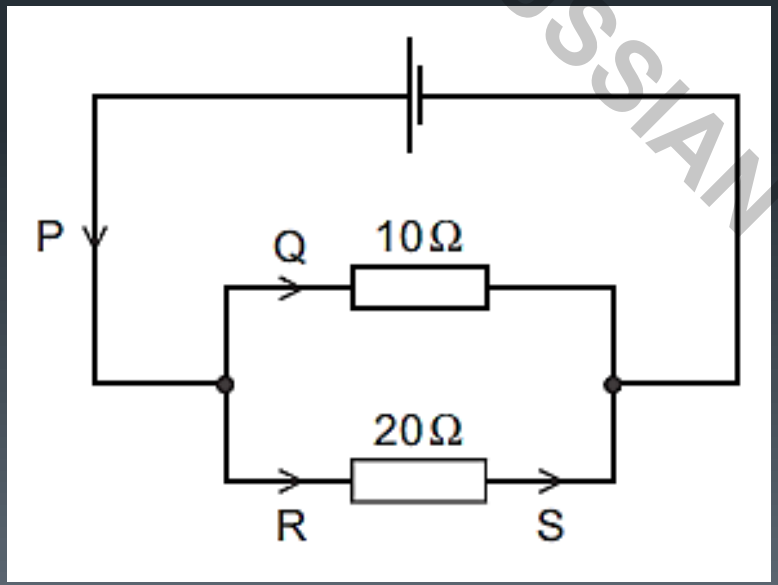
    Which lamp breaks?



D

15. The circuit diagram shows a parallel arrangement of resistors.

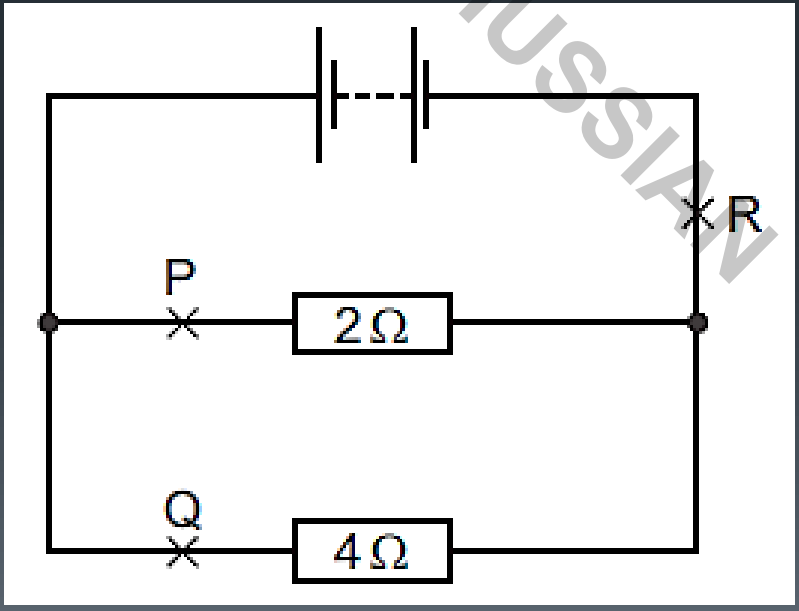
    P, Q, R and S represent the current at the points shown.



1. Which statement is correct?

A. P is greater than Q.
B. Q is equal to R.
C. R is greater than S.
D. S is equal to P.

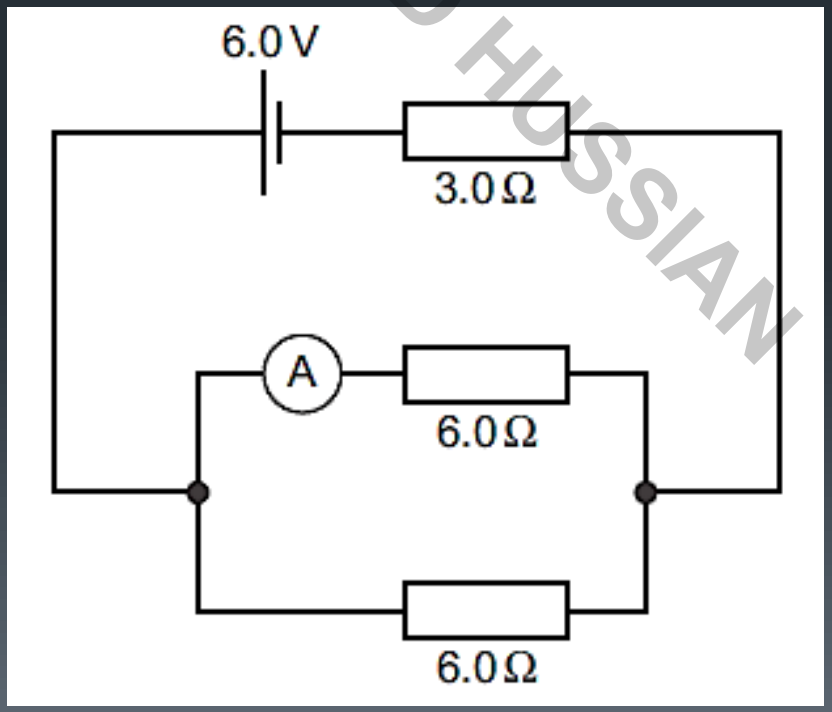
16. A circuit contains two resistors connected in parallel with a battery.



1. Which of the following statements about the currents at P, Q and R is true?

A. The current at P is the greatest.
B. The current at Q is the greatest.
C. The current at R is the greatest.
D. The current is the same at points P, Q and R.

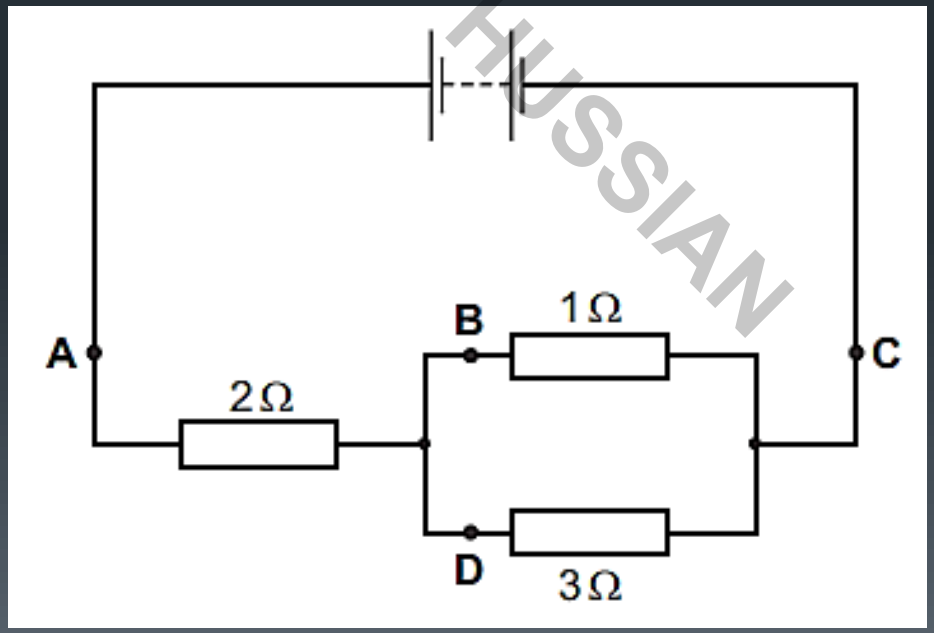
17. The following circuit is set up.



1. What is the reading on the ammeter?

A. 0.33 A
B. 0.50 A
C. 0.67 A
D. 1.0 A

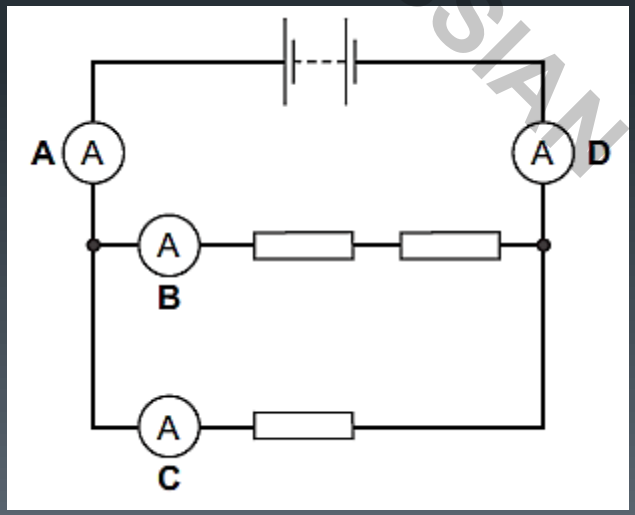
18. At which point in the circuit is the current the smallest?



D

19. The diagram shows a battery connected to three identical resistors. Four ammeters A, B, C and D are connected in the circuit.

20. Which ammeter shows the smallest reading?



B