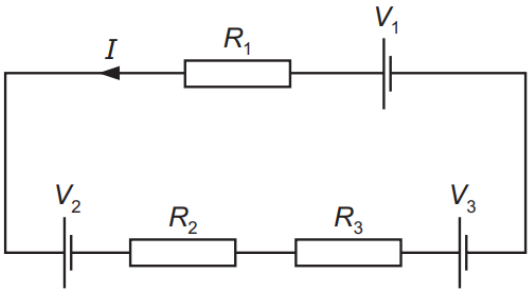
1. 9702/12/F/M/16 Q34

Three cells with e.m.f.s V_1, V_2 and V_3, have negligible internal resistance. These cells are connected to three resistors with resistances R_1, R_2 and R_3, as shown.



The current in the circuit is I.

Which equation is correct?

A $V_1 + V_2 + V_3 = I(R_1 + R_2 + R_3)$

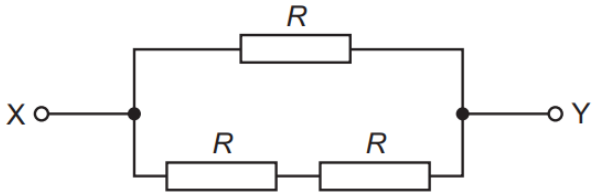
B $V_1 + V_2 - V_3 = I(R_1 + R_2 + R_3)$

C $V_1 - V_2 + V_3 = I(R_1 + R_2 + R_3)$

D $V_1 - V_2 - V_3 = I(R_1 + R_2 + R_3)$

2. 9702/12/F/M/16 Q35

Three resistors, each of resistance R, are connected in a network, as shown.



The total resistance between points X and Y is 8.0 Ω.

What is the value of R?

A 2.7 Ω **B** 4.0 Ω **C** 5.3 Ω **D** 12 Ω

3. 9702/12/F/M/16 Q36

In deriving a formula for the combined resistance of three different resistors in series, Kirchhoff's laws are used.

Which physics principle is involved in this derivation?

A the conservation of charge

B the direction of the flow of charge is from negative to positive

C the potential difference across each resistor is the same

D the current varies in each resistor, in proportion to the resistor value

4. 9702/12/F/M/16 Q37

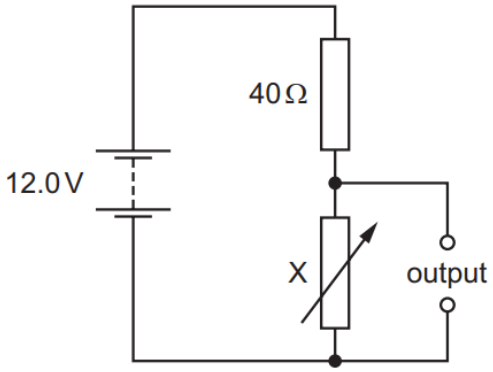
The battery of a car has an internal resistance of 0.10 Ω and an electromotive force of 12 V. When the battery is connected to the starter motor, the potential difference across the battery terminals is 7.0 V.

What is the current supplied to the starter motor?

A 50 A **B** 70 A **C** 120 A **D** 190 A

5. 9702/11/M/J/16 Q34

In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0 Ω to 500 Ω. The e.m.f. of the battery is 12.0 V. It has negligible internal resistance.



What is the maximum range of values of potential difference across the output?

A 1.3 V to 11.1 V

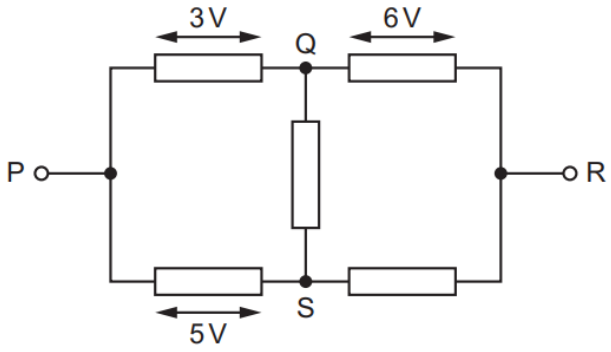
B 1.3 V to 12.0 V

C 1.5 V to 11.1 V

D 1.5 V to 12.0 V

6. 9702/11/M/J/16 Q35

There is a current from P to R in the resistor network shown.



The potential difference (p.d.) between P and Q is 3 V.

The p.d. between Q and R is 6 V.

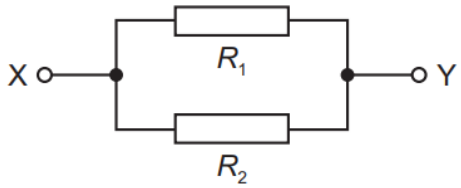
The p.d. between P and S is 5 V.

Which row in the table is correct?

	p.d. between Q and S	p.d. between S and R
A	2 V	4 V
B	2 V	10 V
C	3 V	4 V
D	3 V	10 V

7. 9702/11/M/J/16 Q36

Two resistors of resistances R_1 and R_2 are connected in parallel.



What is the combined resistance between X and Y?

A $R_1 + R_2$ **B** $\frac{R_1 R_2}{R_1 + R_2}$ **C** $\frac{R_1 + R_2}{R_1 R_2}$ **D** $\frac{R_1}{R_2}$

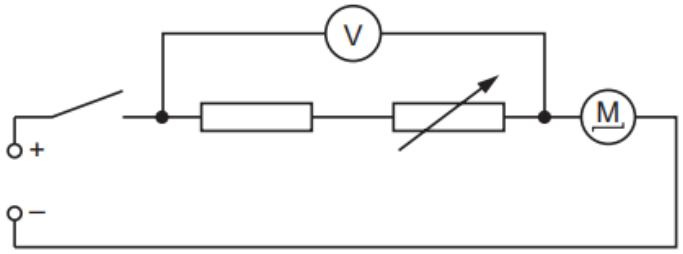
8. 9702/11/M/J/16 Q37

A voltmeter is used to monitor the operation of an electric motor. The motor speed is controlled by a variable resistor. A fixed resistor is used to limit the speed.

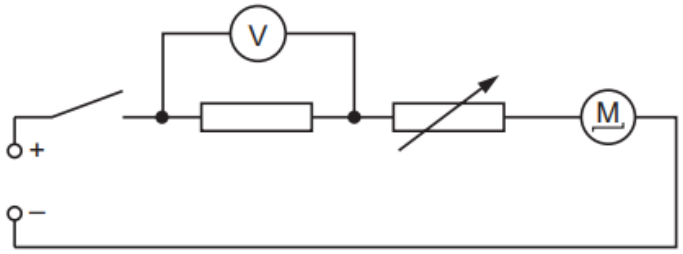
The current in the motor is gradually changed.

In which circuit is the voltmeter reading proportional to the current in the motor?

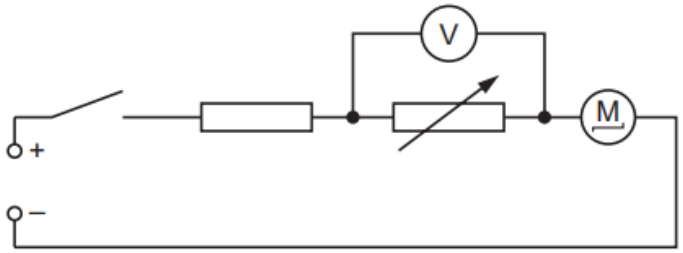
A



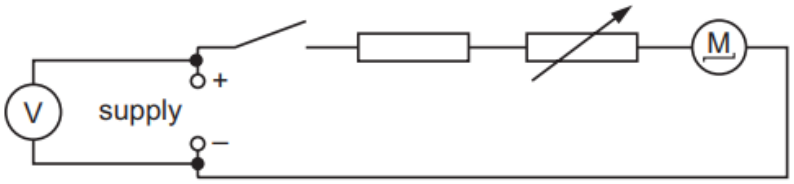
B



C

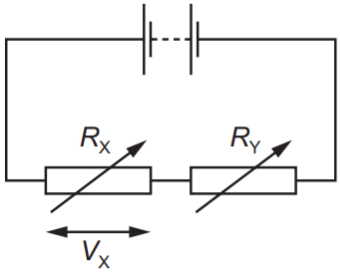


D



9. 9702/12/M/J/16 Q36

A potential divider circuit is formed by connecting a battery of negligible internal resistance in series with two variable resistors, as shown.



The variable resistors have resistances R_X and R_Y.
V_X is the potential difference across resistance R_X.

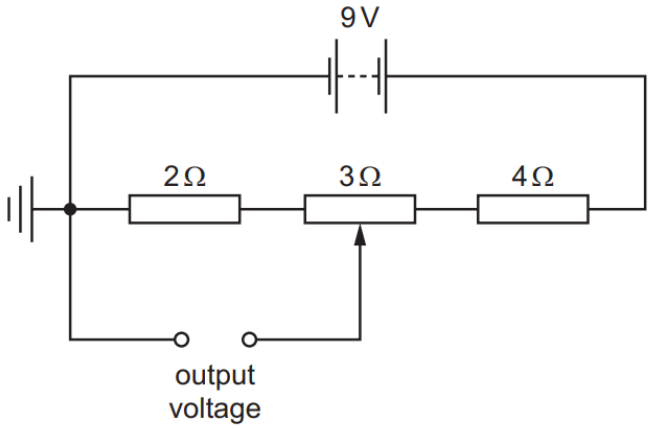
R_X and R_Y are both changed at the same time.

Which combination of changes **must** cause V_X to increase?

	R_X	R_Y
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

10. 9702/12/M/J/16 Q37

In the circuit shown, contact may be made at any point along the 3 Ω resistor (potentiometer).



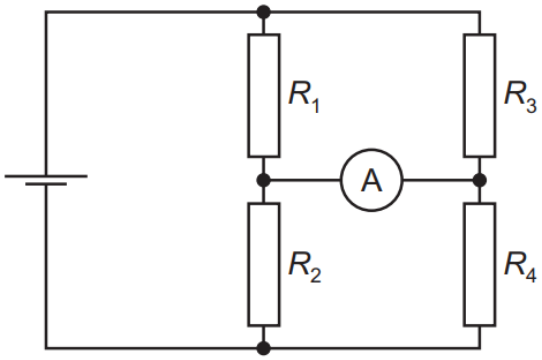
The battery has e.m.f. 9 V and negligible internal resistance.

What is the maximum range of the output voltage?

A 0–2 V **B** 0–5 V **C** 2–3 V **D** 2–5 V

11. 9702/11/O/N/16 Q36

In the circuit shown, the reading on the ammeter is zero.



The four resistors have different resistances R_1, R_2, R_3 and R_4.

Which equation is correct?

A $R_1 - R_3 = R_2 - R_4$

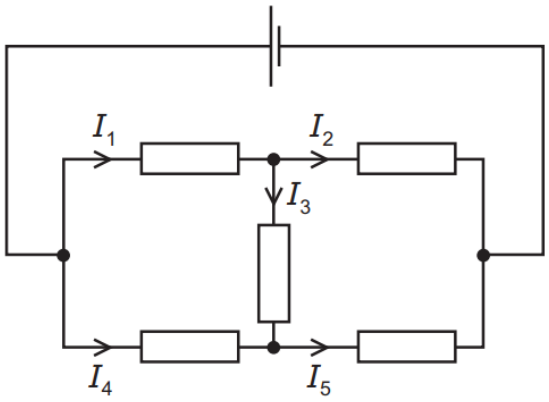
B $R_1 \times R_3 = R_2 \times R_4$

C $R_1 - R_4 = R_2 - R_3$

D $R_1 \times R_4 = R_2 \times R_3$

12. 9702/11/O/N/16 Q37

The diagram shows currents I_1, I_2, I_3, I_4 and I_5 in different branches of a circuit.



Which equation is correct?

A $I_1 = I_2 + I_3$

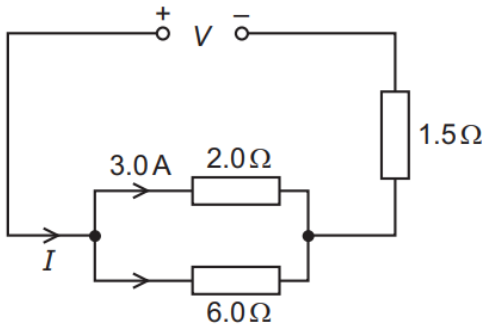
B $I_2 = I_1 + I_3$

C $I_3 = I_4 + I_5$

D $I_4 = I_5 + I_3$

13. 9702/12/O/N/16 Q37

In the circuit shown, there is a current of 3.0 A in the 2.0 Ω resistor.

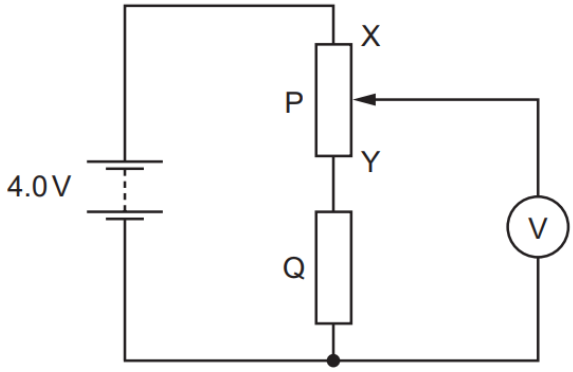


What are the values of the current I delivered by the power supply and the voltage V across it?

	I/A	V/V
A	3.0	10.5
B	4.0	9.0
C	4.0	12
D	12	18

14. 9702/12/O/N/16 Q38

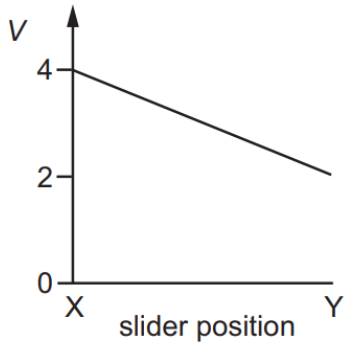
In the circuit below, P is a potentiometer of total resistance 10 Ω and Q is a fixed resistor of resistance 10 Ω. The battery has an e.m.f. of 4.0 V and negligible internal resistance. The voltmeter has a very high resistance.



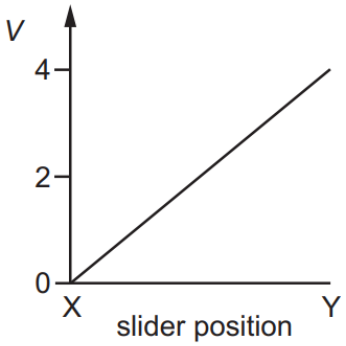
The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading V is plotted against slider position.

Which graph is obtained?

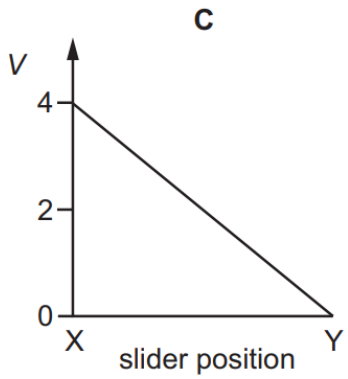
A



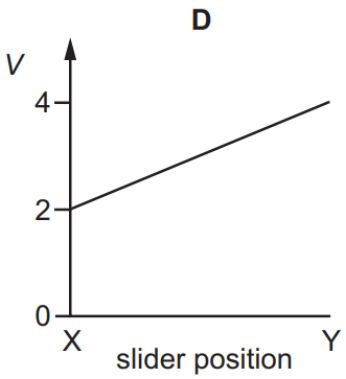
B



C

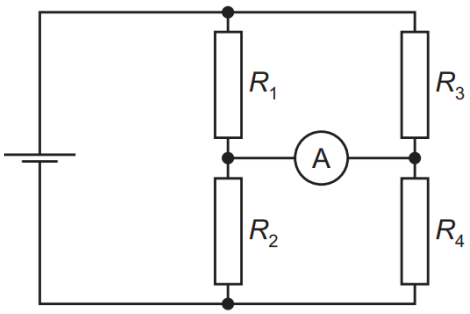


D



15. 9702/13/O/N/16 Q36

In the circuit shown, the reading on the ammeter is zero.



The four resistors have different resistances R_1, R_2, R_3 and R_4.

Which equation is correct?

A $R_1 - R_3 = R_2 - R_4$

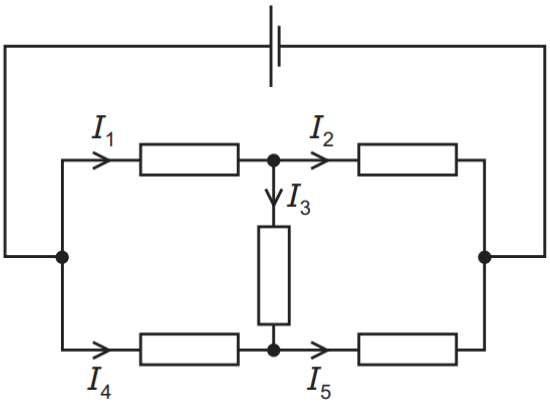
B $R_1 \times R_3 = R_2 \times R_4$

C $R_1 - R_4 = R_2 - R_3$

D $R_1 \times R_4 = R_2 \times R_3$

16. 9702/13/O/N/16 Q37

The diagram shows currents I_1, I_2, I_3, I_4 and I_5 in different branches of a circuit.



Which equation is correct?

A $I_1 = I_2 + I_3$

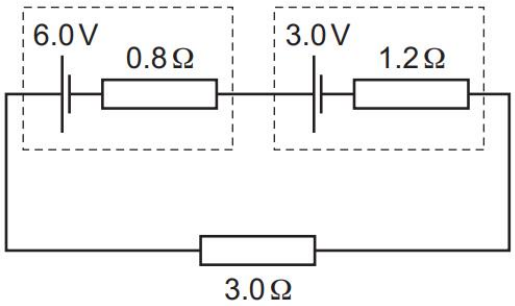
B $I_2 = I_1 + I_3$

C $I_3 = I_4 + I_5$

D $I_4 = I_5 + I_3$

17. 9702/12/F/M/17 Q35

Two cells are connected to a load resistor of resistance 3.0Ω. The electromotive force (e.m.f). and the internal resistance of each of the cells is shown.

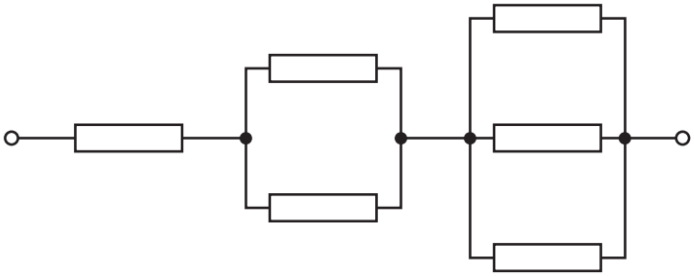


What is the current in the load resistor?

A 0.60A **B** 1.2A **C** 1.8A **D** 3.0A

18. 9702/12/F/M/17 Q36

Six resistors, each of resistance R, are connected as shown.



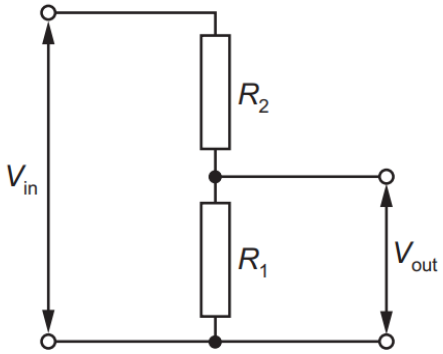
The combined resistance is 66 kΩ.

What is the value of R?

A 11 kΩ **B** 18 kΩ **C** 22 kΩ **D** 36 kΩ

19. 9702/12/F/M/17 Q37

A potential divider consists of two resistors of resistances R_1 and R_2 connected in series across a source of potential difference (p.d.) V_{in}. The p.d. across R_1 is V_{out}.

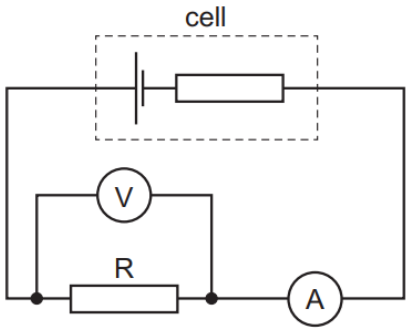


Which changes to R_1 and to R_2 will increase the value of V_{out}?

	R_1	R_2
A	doubled	doubled
B	doubled	halved
C	halved	doubled
D	halved	halved

20. 9702/11/M/J/17 Q35

The circuit shown includes a cell of constant internal resistance and an external resistor R.



A student records the ammeter and voltmeter readings. She then connects a second identical external resistor in parallel with the first external resistor.

What happens to the ammeter reading and to the voltmeter reading?

	ammeter reading	voltmeter reading
A	decreases	decreases
B	decreases	stays the same
C	increases	decreases
D	increases	stays the same

21. 9702/11/M/J/17 Q36

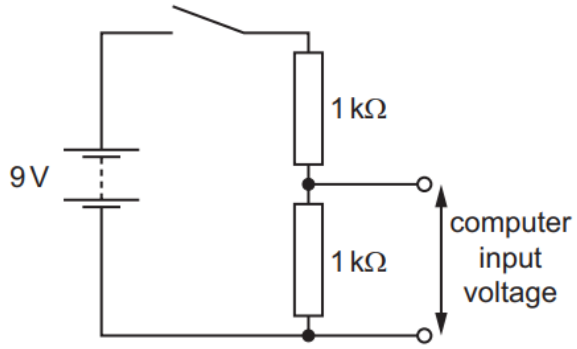
A computer is used to detect the change of position of a switch.

To detect the change of position, the computer requires a potential difference (p.d.) of 0 V to its input at one switch position and a p.d. of between 5 V and 7 V at the other switch position.

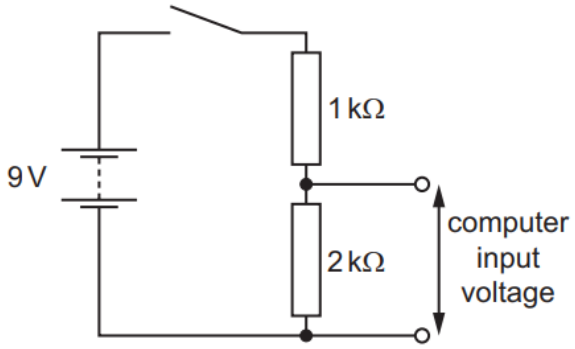
For each of the circuits, assume the battery has negligible internal resistance.

Which circuit provides an input voltage to the computer that enables it to detect the change of position of the switch?

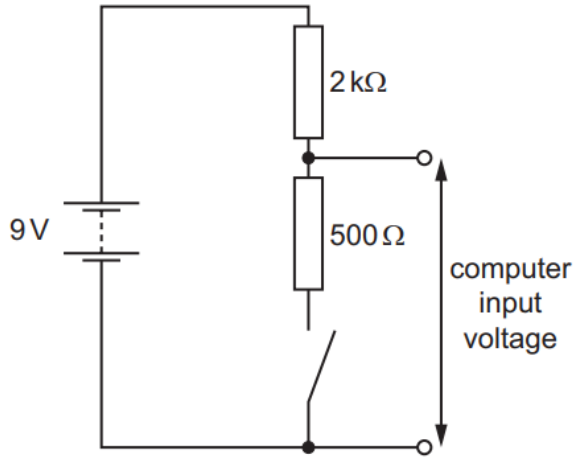
A



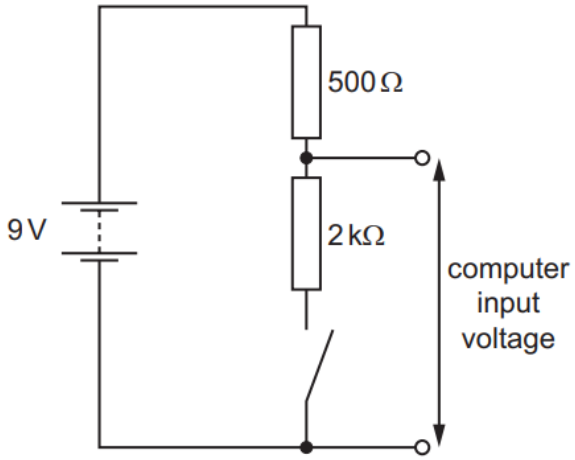
B



C

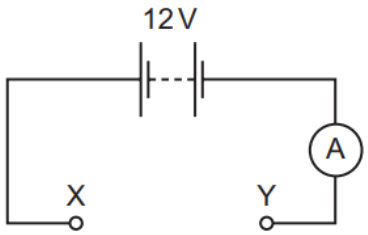


D



22. 9702/11/M/J/17 Q37

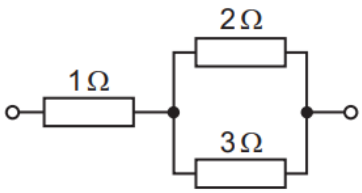
In the circuit shown, the battery and ammeter have negligible resistance.



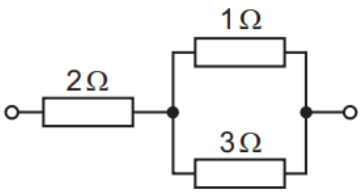
The following combinations of resistors are each separately placed between the terminals X and Y of the circuit.

Which combination would give an ammeter reading of 8 A?

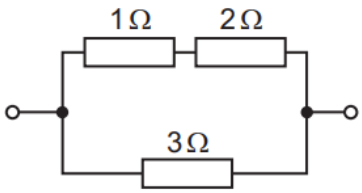
A



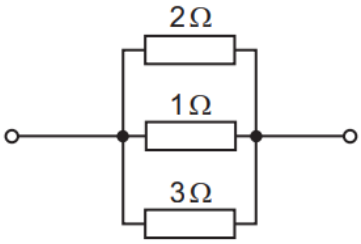
B



C



D



23. 9702/12/M/J/17 Q35

A cell has a constant electromotive force.

A variable resistor is connected between the terminals of the cell.

The resistance of the variable resistor is decreased.

Which statement about the change of the cell's terminal potential difference (p.d.) is correct?

A The terminal p.d. is decreased because more work is done moving unit charge through the internal resistance of the cell.

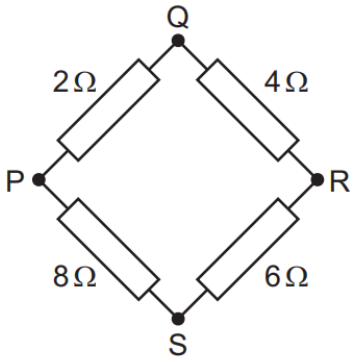
B The terminal p.d. is decreased because the current in the variable resistor is decreased.

C The terminal p.d. is increased because more work is done moving unit charge through the variable resistor.

D The terminal p.d. is increased because the current in the variable resistor is increased.

24. 9702/12/M/J/17 Q36

Four resistors are connected in a square as shown.



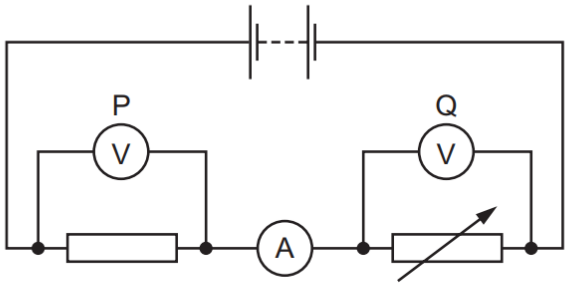
The resistance may be measured between any two junctions.

Between which two junctions is the measured resistance greatest?

A P and Q **B** Q and S **C** R and S **D** S and P

25. 9702/12/M/J/17 Q37

A circuit is set up as shown.



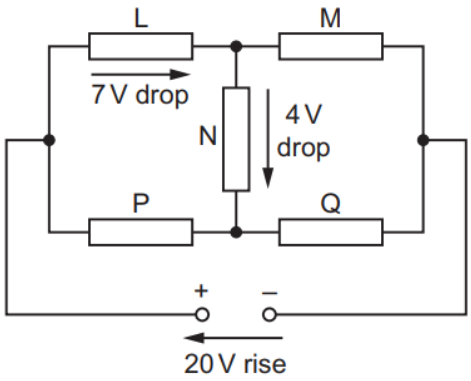
The variable resistor is adjusted so that the ammeter reading decreases.

How do the readings of the voltmeters change?

	reading on voltmeter P	reading on voltmeter Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

26. 9702/13/M/J/17 Q35

A 20 V d.c. supply is connected to a circuit consisting of five resistors L, M, N, P and Q.



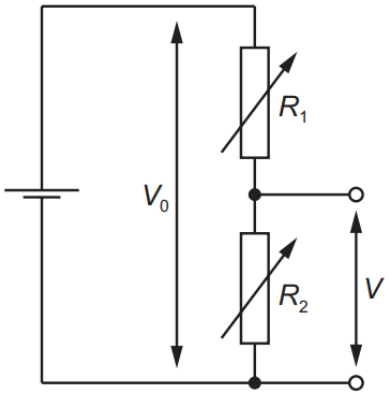
There is a potential drop of 7 V across L and a further 4 V potential drop across N.

What are the potential drops across M, P and Q?

	potential drop across M / V	potential drop across P / V	potential drop across Q / V
A	9	7	13
B	13	7	13
C	13	11	9
D	17	3	17

27. 9702/13/M/J/17 Q36

A potential divider circuit consists of a cell of negligible internal resistance in series with two variable resistors of resistances R_1 and R_2. The potential difference (p.d.) across the cell is V_0. The p.d. at the output is V.



Which statement is correct?

A When R_1 increases, it takes a greater proportion of V_0, so V decreases.

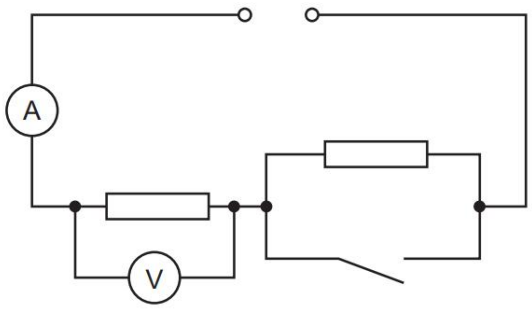
B When R_1 increases, the current through R_1 and R_2 decreases, so V increases.

C When R_2 decreases, it takes a smaller proportion of V_0, so V increases.

D When R_2 increases, the current through R_1 and R_2 decreases, so V decreases.

28. 9702/11/O/N/17 Q36

In the circuit shown, the ammeter reading is I and the voltmeter reading is V.

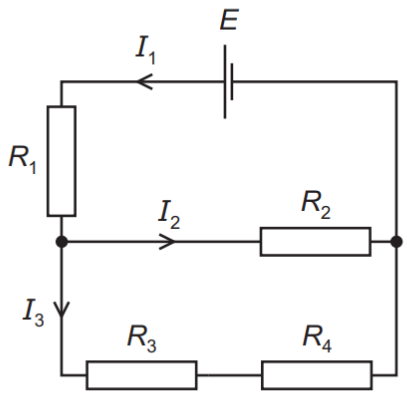


When the switch is closed, which row describes what happens to I and to V?

	I	V
A	decreases	decreases
B	increases	increases
C	increases	stays the same
D	stays the same	increases

29. 9702/11/O/N/17 Q37

A cell of electromotive force E and negligible internal resistance is connected to a network of resistors of resistances R_1, R_2, R_3 and R_4 as shown.



The branches of the circuit have currents I_1, I_2 and I_3.

Which equation is correct?

A $I_1R_1 + I_2R_2 = I_3R_3 + I_3R_4$

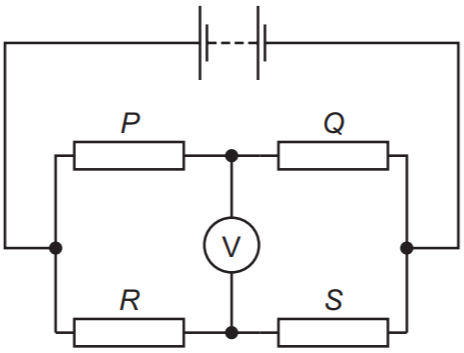
B $I_2R_2 - I_3R_4 - I_3R_3 = 0$

C $E = I_1R_1 + I_2R_2 + I_3R_3 + I_3R_4$

D $E = I_1R_1 + I_2R_2 - I_3R_3 - I_3R_4$

30. 9702/11/O/N/17 Q38

The circuit diagram shows four resistors of different resistances *P*, *Q*, *R* and *S* connected to a battery.



The voltmeter reading is zero.

Which equation is correct?

A $P - Q = R - S$

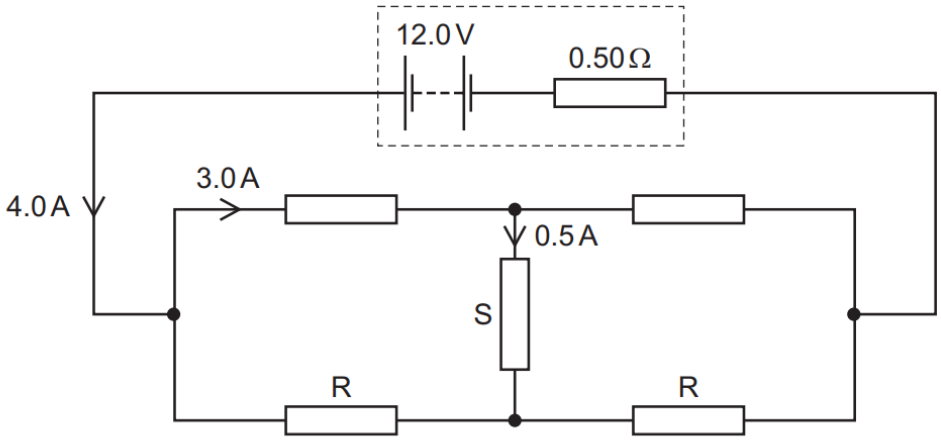
B $P - S = Q - R$

C $PQ = RS$

D $PS = QR$

31. 9702/12/O/N/17 Q37

The circuit shown contains a resistor S that is neither in series nor in parallel with the other resistors.



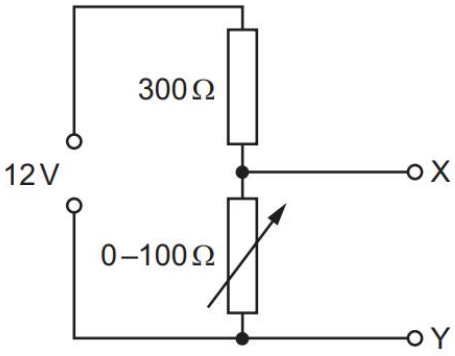
Kirchhoff's laws can be used with the data in the diagram to deduce the resistance of each of the two identical resistors labelled R.

What is the resistance of each resistor R?

A 3.0 Ω **B** 4.0 Ω **C** 4.8 Ω **D** 5.0 Ω

32. 9702/12/O/N/17 Q38

The diagram shows a potential divider connected to a 12 V supply of negligible internal resistance.

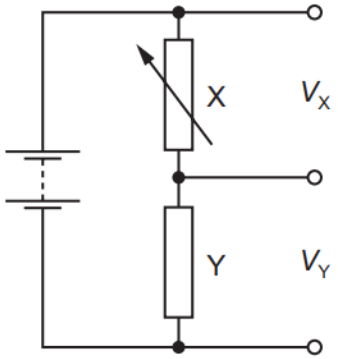


Which range of voltages can be obtained between X and Y?

A 0 to 3 V **B** 0 to 4 V **C** 0 to 8 V **D** 0 to 9 V

33. 9702/12/F/M/18 Q36

A potential divider circuit is constructed with one variable resistor X and one fixed resistor Y, as shown.



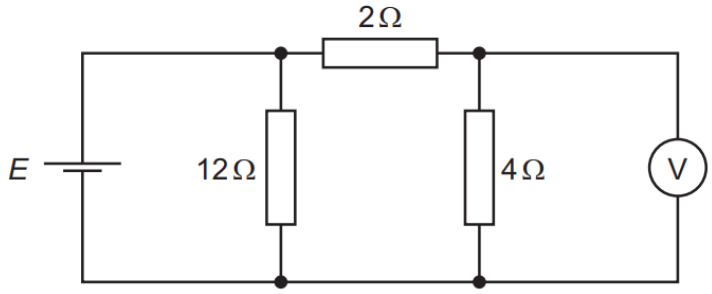
The potential difference across resistor X is V_X and the potential difference of resistor Y is V_Y.

As the resistance of X is increased, what happens to V_X and to V_Y?

	V_X	V_Y
A	falls	rises
B	falls	stays the same
C	rises	falls
D	rises	stays the same

34. 9702/12/F/M/18 Q37

A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected into a circuit, as shown.



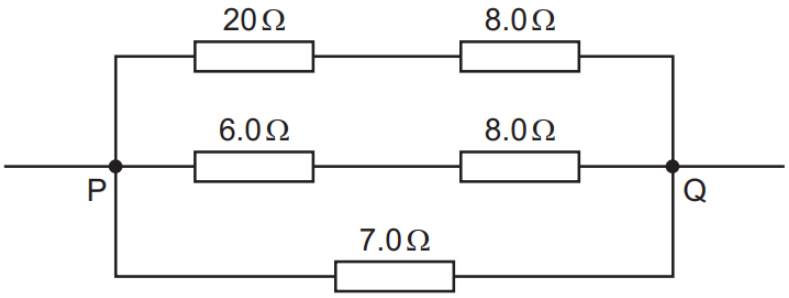
The voltmeter has a very high resistance and reads a potential difference V_{out}.

What is the ratio $\frac{V_{out}}{E}$?

A $\frac{1}{6}$ **B** $\frac{1}{3}$ **C** $\frac{1}{2}$ **D** $\frac{2}{3}$

35. 9702/12/F/M/18 Q38

Five resistors are connected as shown.



What is the total resistance between points P and Q?

A 0.25Ω **B** 0.61Ω **C** 4.0Ω **D** 16Ω

36. 9702/11/M/J/18 Q33

The sum of the electrical currents into a point in a circuit is equal to the sum of the currents out of the point.

Which statement is correct?

A This is Kirchhoff's first law, which results from the conservation of charge.

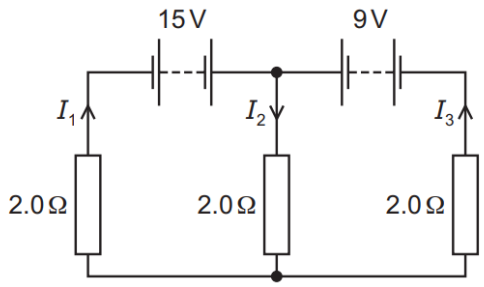
B This is Kirchhoff's first law, which results from the conservation of energy.

C This is Kirchhoff's second law, which results from the conservation of charge.

D This is Kirchhoff's second law, which results from the conservation of energy.

37. 9702/11/M/J/18 Q34

In the circuit shown, the batteries have negligible internal resistance.

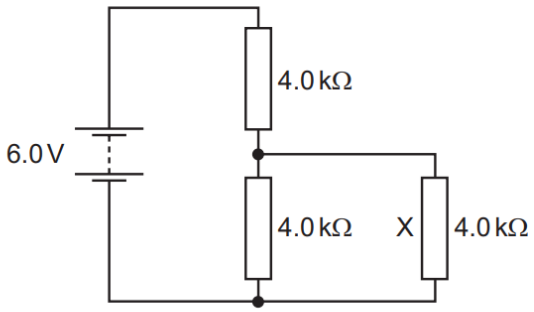


What are the values of the currents I_1, I_2 and I_3?

	I_1 / A	I_2 / A	I_3 / A
A	–5.5	1.0	6.5
B	0.5	4.0	3.5
C	3.5	4.0	0.5
D	6.5	1.0	–5.5

38. 9702/11/M/J/18 Q35

A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to three resistors as shown.



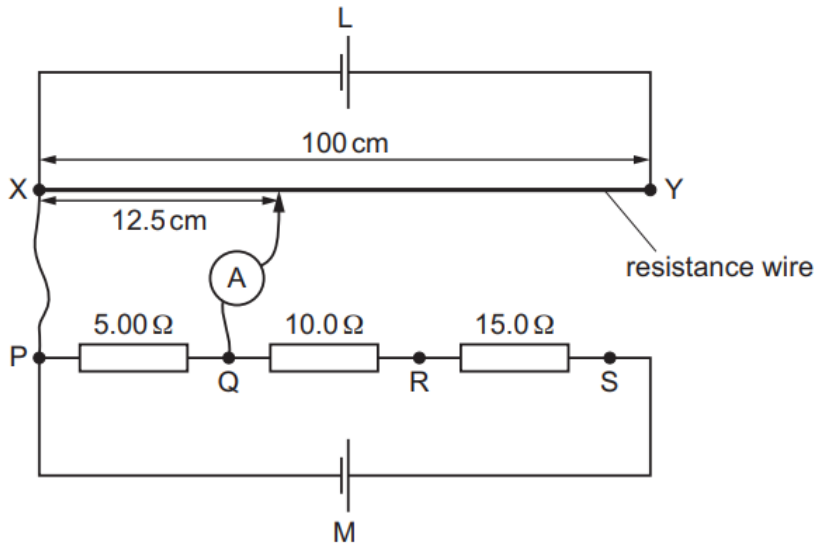
Each resistor has a resistance of 4.0 kΩ.

What is the current in resistor X?

A 0.25 mA **B** 0.50 mA **C** 0.75 mA **D** 1.0 mA

39. 9702/11/M/J/18 Q36

A uniform resistance wire XY of length 100 cm is connected in series with a cell L. Another cell M is connected in series with resistors of resistances 5.00 Ω, 10.0 Ω and 15.0 Ω.



The potential difference (p.d.) between P and Q is balanced against 12.5 cm of the resistance wire, so that the ammeter reads zero.

The p.d. across the other resistors is then balanced against other lengths of the resistance wire.

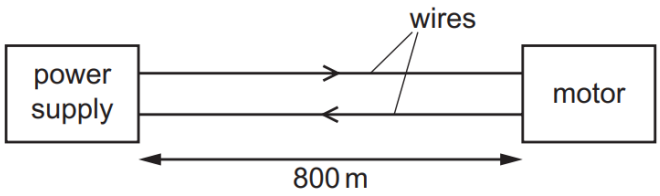
Which balanced lengths of resistance wire correspond to the connection points given in the table?

connection points	balanced length / cm			
	A	**B**	**C**	**D**
Q and R	12.5	25.0	25.0	25.0
Q and S	62.5	62.5	75.0	62.5
P and R	37.5	37.5	37.5	12.5

40. 9702/11/M/J/18 Q37

A motor is required to operate at a distance of 800 m from its power supply. The motor requires a potential difference (p.d.) of 16.0 V and a current of 0.60 A to operate.

Two wires are used to supply power to the motor as shown.



The resistance of each of these wires is 0.0050 Ω per metre.

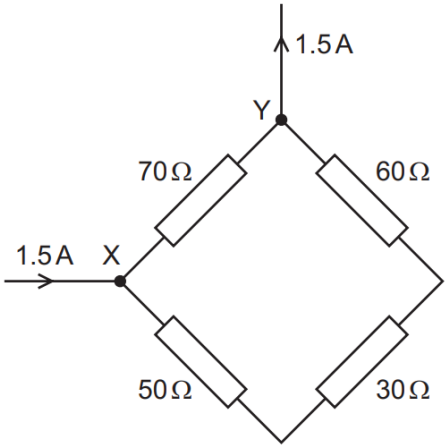
What is the minimum output p.d. of the power supply?

A 11.2 V **B** 16.0 V **C** 18.4 V **D** 20.8 V

41. 9702/12/M/J/18 Q34

Four different resistors are arranged as shown.

A current of 1.5 A enters the network at junction X and leaves through junction Y.

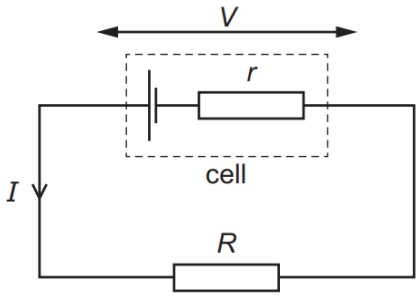


What is the current in the resistor of resistance 30 Ω?

A 0.21 A **B** 0.50 A **C** 0.75 A **D** 1.0 A

42. 9702/12/M/J/18 Q35

A cell of constant electromotive force drives a current I through an external resistor of resistance R. The terminal potential difference (p.d.) across the cell is V.



When the internal resistance r of the cell increases, what is the effect on V and on I?

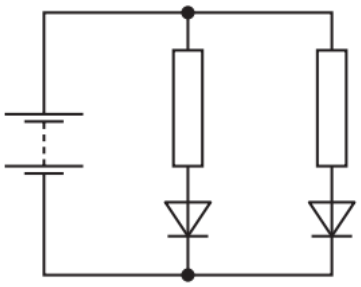
	V	I
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

43. 9702/12/M/J/18 Q36

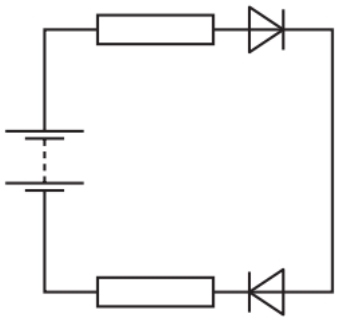
In the circuits shown, the batteries are identical and all have negligible internal resistance. All of the resistors have the same resistance. The diodes have zero resistance when conducting and infinite resistance when not conducting.

In which circuit is the current in the battery greatest?

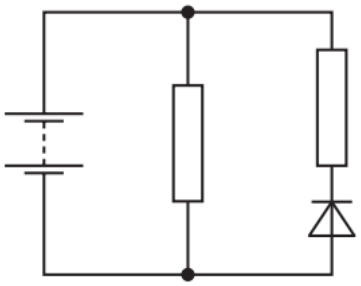
A



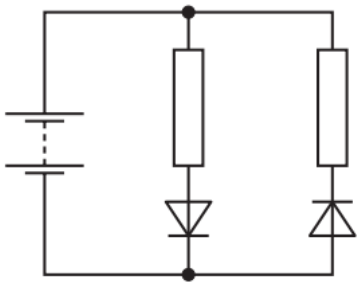
B



C

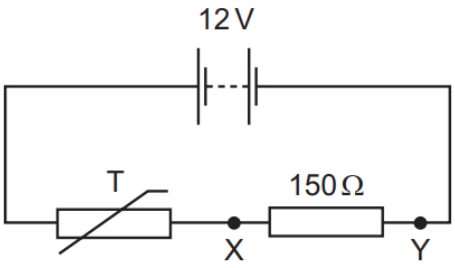


D



44. 9702/12/M/J/18 Q37

A thermistor is an electrical component with a resistance that varies with temperature. A thermistor T is used in a fire alarm system. The alarm is triggered when the potential difference between X and Y is 4.5 V.



What is the resistance of T when the alarm is triggered?

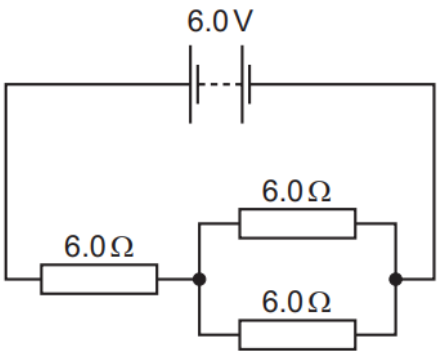
A 90 Ω **B** 150 Ω **C** 250 Ω **D** 400 Ω

45. 9702/13/M/J/18 Q34

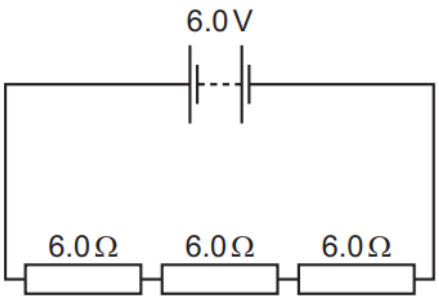
A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to three resistors each of resistance 6.0 Ω.

Which circuit will produce a current through the battery of 0.67 A?

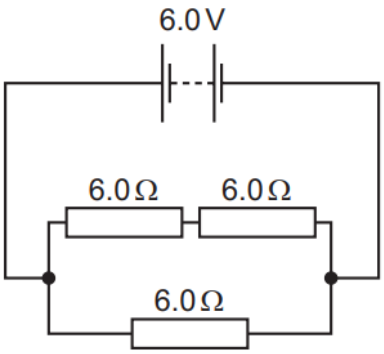
A



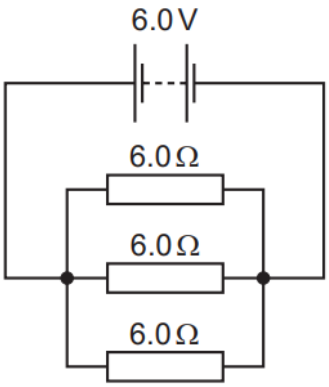
B



C

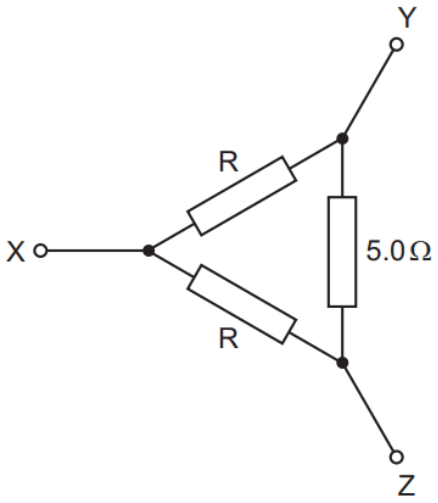


D



46. 9702/13/M/J/18 Q35

The diagram shows a network of three resistors. Two of these, marked R, are identical. The other resistor has a resistance of 5.0 Ω.



The resistance between Y and Z is found to be 2.5 Ω.

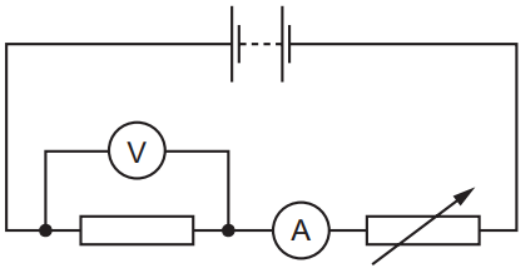
What is the resistance between X and Y?

A 0.30 Ω **B** 0.53 Ω **C** 1.9 Ω **D** 3.3 Ω

47. 9702/13/M/J/18 Q36

The diagram shows a battery, a fixed resistor, an ammeter and a variable resistor connected in series.

A voltmeter is connected across the fixed resistor.



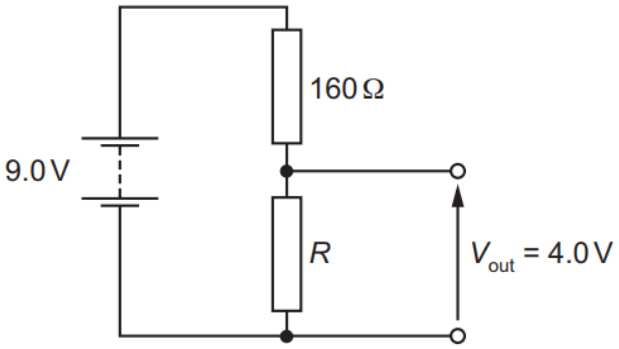
The resistance of the variable resistor is reduced.

Which row describes the changes in the readings of the ammeter and of the voltmeter?

	ammeter	voltmeter
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

48. 9702/13/M/J/18 Q37

The circuit diagram shows a battery of electromotive force (e.m.f.) 9.0 V and negligible internal resistance. It is connected to two resistors of resistances 160 Ω and R. The output potential difference V_{out} is 4.0 V.

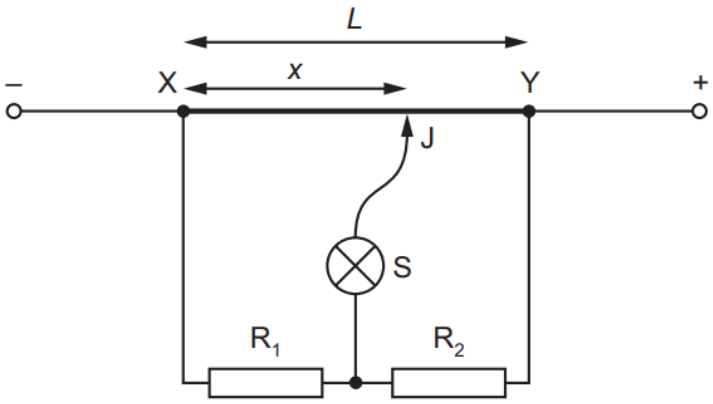


What is the resistance R?

A 32 Ω **B** 49 Ω **C** 71 Ω **D** 128 Ω

49. 9702/13/M/J/18 Q38

In the circuit shown, XY is a length L of uniform resistance wire. A potential difference is applied across XY. R_1 and R_2 are unknown resistors. J is a sliding contact that joins the junction of R_1 and R_2 to points on XY through a lamp S.



J is moved along XY to a point at which the lamp is off. This point is at a distance x from X.

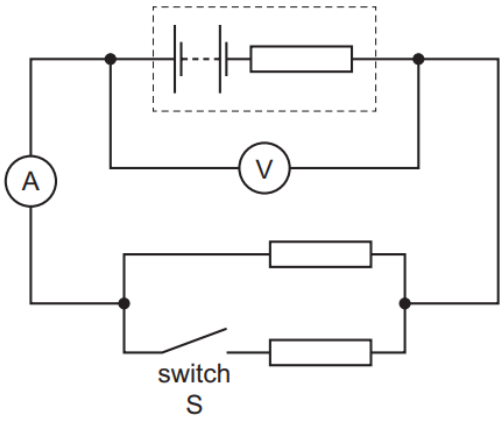
The potential difference across R_1 is V_1 and the potential difference across R_2 is V_2.

What is the value of the ratio $\frac{V_1}{V_2}$?

A $\frac{L}{x}$ **B** $\frac{x}{L}$ **C** $\frac{L-x}{x}$ **D** $\frac{x}{L-x}$

50. 9702/11/O/N/18 Q36

A battery, with internal resistance, is connected to a parallel arrangement of two resistors and a switch S, as shown.



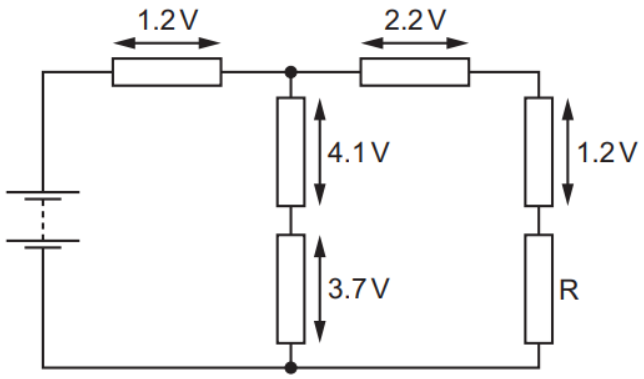
Initially switch S is open.

What happens to the voltmeter and ammeter readings when switch S is closed?

	voltmeter reading	ammeter reading
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

51. 9702/11/O/N/18 Q37

A battery is connected to a network of six resistors, as shown.



The potential differences across five of the resistors are labelled on the diagram.

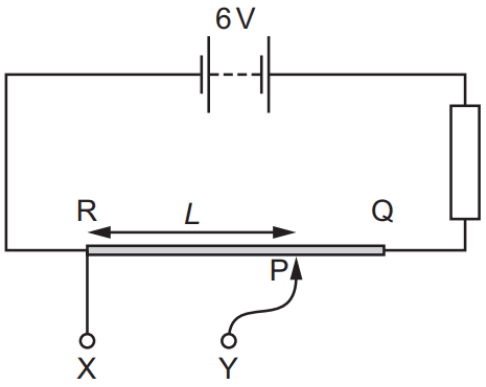
What is the potential difference across resistor R?

A 4.4V **B** 4.6V **C** 6.6V **D** 11.2V

52. 9702/11/O/N/18 Q38

The diagram shows a battery of electromotive force (e.m.f.) 6 V, connected in series with a resistor and a uniform resistance wire RQ of length 60 cm.

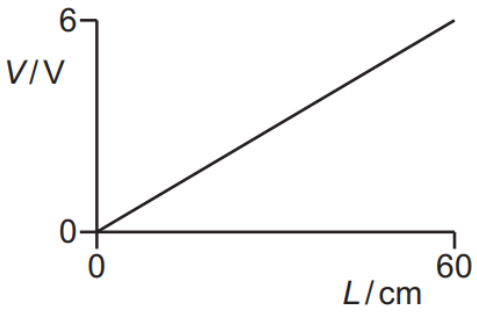
The resistance of RQ is equal to the resistance of the resistor.



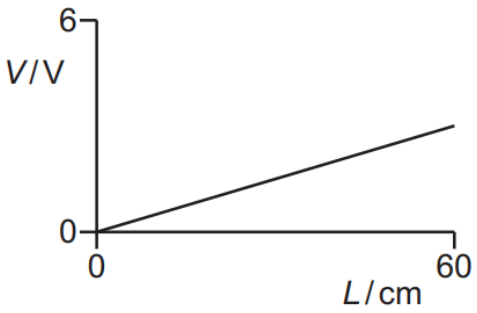
Terminal X is connected to fixed point R. Terminal Y is connected to point P, a connection that may be made at any position along the wire. *L* is the distance between R and P.

Which graph shows the variation with *L* of the potential difference (p.d.) *V* across XY?

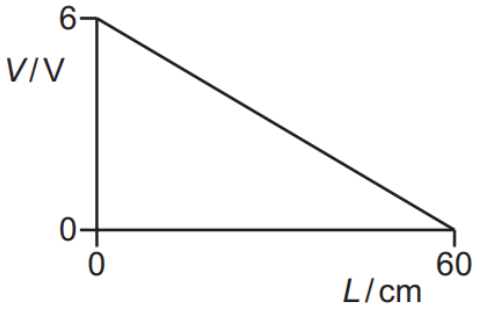
A



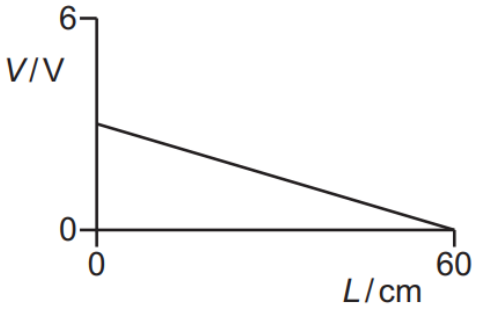
B



C

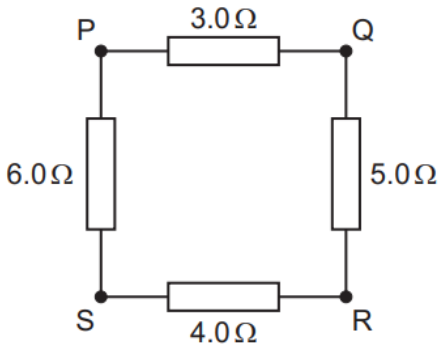


D



53. 9702/12/O/N/18 Q36

A battery of negligible internal resistance may be connected between any two points P, Q, R and S of the network of resistors shown.



Which connections will give the largest current and the smallest current in the battery?

	largest current	smallest current
A	PQ	PR
B	PQ	QS
C	RS	PR
D	RS	QS

54. 9702/12/O/N/18 Q37

Kirchhoff's second law is a consequence of a basic principle.

What is this principle?

A The charge flowing in an electric circuit is conserved.

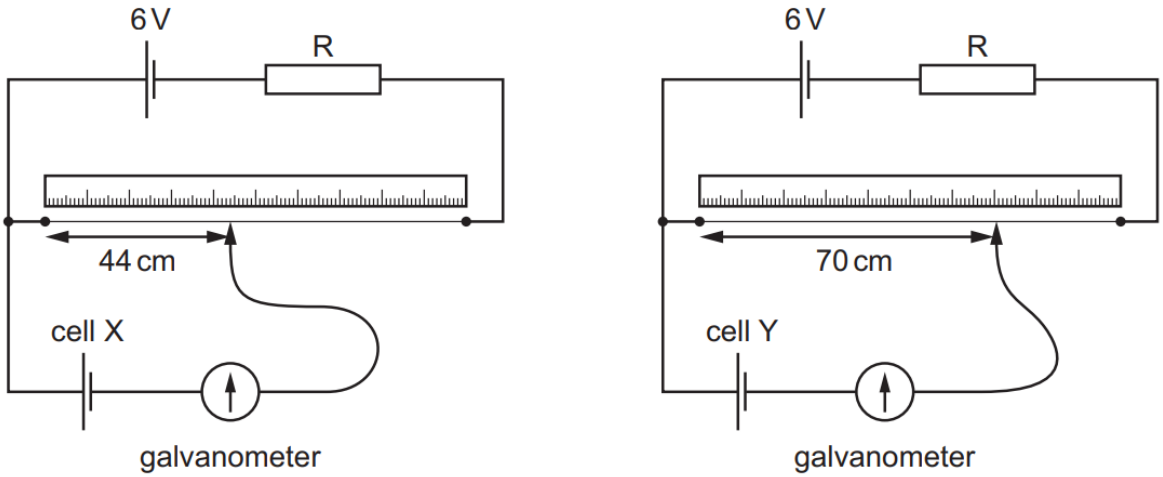
B The energy in an electric circuit is conserved.

C The sum of the electric currents entering a point in an electrical circuit is equal to the sum of the electric currents leaving that point.

D The sum of the potential differences in a circuit is equal to the sum of the products of the current and resistance.

55. 9702/12/O/N/18 Q38

Two cells are investigated using a potentiometer. At the balance point, cell X gives a reading of 44 cm and cell Y gives a reading of 70 cm.



Which statement is **not** correct?

A A potentiometer balance point results in zero current through the galvanometer.

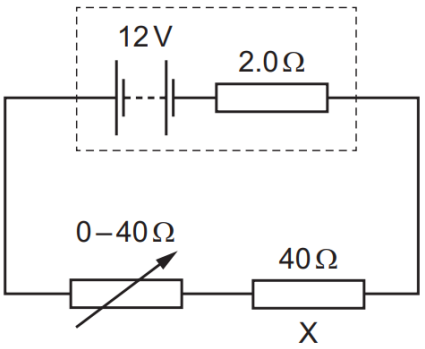
B At the balance point, the current through resistor R in both circuits is the same.

C The electromotive force (e.m.f.) of cell X is larger than that of cell Y.

D The value of the e.m.f. of each of the cells X and Y is less than 6 V.

56. 9702/13/O/N/18 Q35

A resistor X of resistance 40 Ω and a variable resistor are connected to a battery of electromotive force (e.m.f.) 12 V and internal resistance 2.0 Ω, as shown.



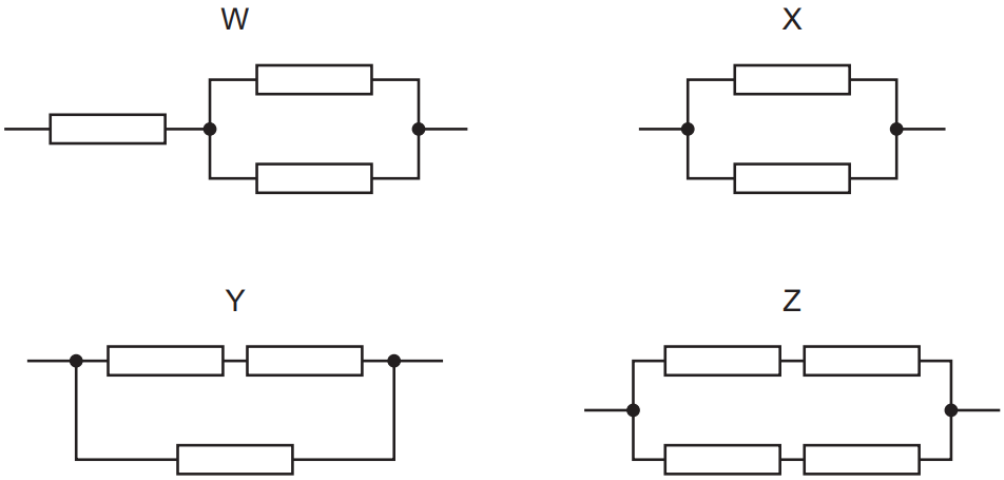
The resistance of the variable resistor is changed from 0 to 40 Ω.

What is the change in power dissipated in resistor X?

A 2.4 W **B** 2.7 W **C** 3.6 W **D** 5.6 W

57. 9702/13/O/N/18 Q36

All the resistors shown in the resistor networks W, X, Y and Z have the same resistance.



Which list gives the networks in order of increasing total resistance?

A W → Z → Y → X

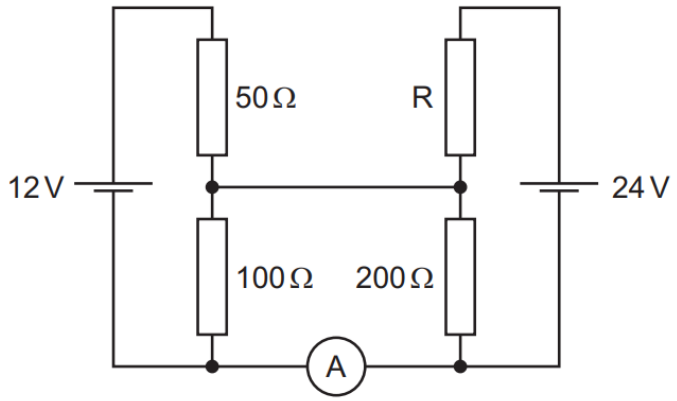
B X → W → Y → Z

C X → Y → W → Z

D X → Y → Z → W

58. 9702/13/O/N/18 Q37

In the circuit shown, the ammeter reading is zero.

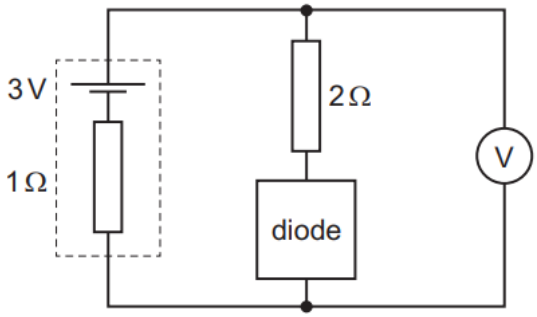


What is the resistance of resistor R?

A 100 Ω **B** 200 Ω **C** 400 Ω **D** 600 Ω

59. 9702/13/O/N/17 Q35

An ideal diode has zero resistance when forward biased and infinite resistance when reverse biased. The diode is connected in series with a 2Ω resistor across the terminals of a source having electromotive force (e.m.f.) 3V and internal resistance 1Ω, as shown.



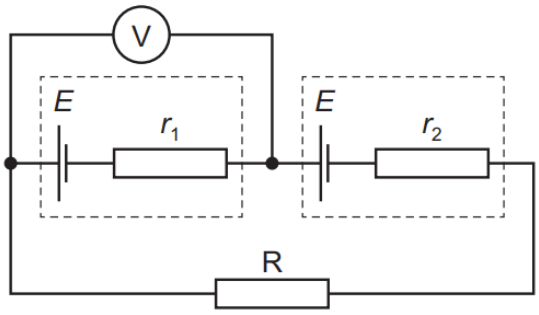
A high-resistance voltmeter is connected across the diode and resistor.

Which row gives the readings of the voltmeter for the two ways of connecting the diode?

	forward biased	reverse biased
A	1V	3V
B	2V	0V
C	2V	3V
D	3V	0V

60. 9702/13/O/N/17 Q36

Two cells, each with electromotive force (e.m.f.) E, but different internal resistances r_1 and r_2, are connected in series to a resistor R. The reading on the voltmeter is 0V.

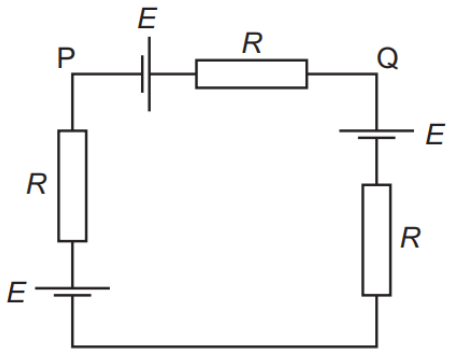


What is the resistance of R?

A 0 **B** $r_1 - r_2$ **C** $r_1 + r_2$ **D** $\frac{r_1 r_2}{r_1 + r_2}$

61. 9702/13/O/N/17 Q37

Three identical cells each have electromotive force (e.m.f.) E and negligible internal resistance. The cells are connected to three identical resistors, each of resistance R, as shown.



What is the potential difference between P and Q?

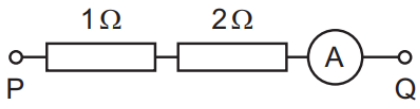
A 0 **B** $\frac{E}{3}$ **C** $\frac{2E}{3}$ **D** E

62. 9702/13/O/N/17 Q38

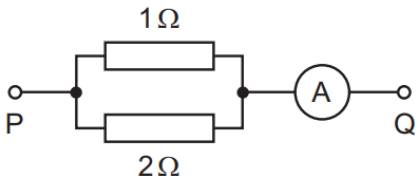
In each arrangement of resistors, the ammeter has a resistance of 2 Ω.

Which arrangement gives the largest reading on the ammeter when the same potential difference is applied between points P and Q?

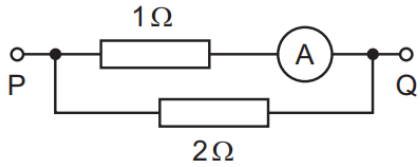
A



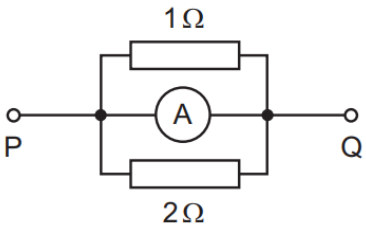
B



C

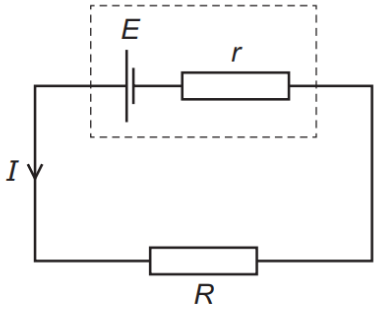


D



63. 9702/12/F/M/19 Q36

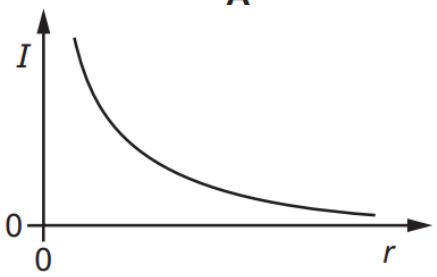
A cell of internal resistance r and electromotive force (e.m.f.) E is connected in series with a resistor of resistance R.



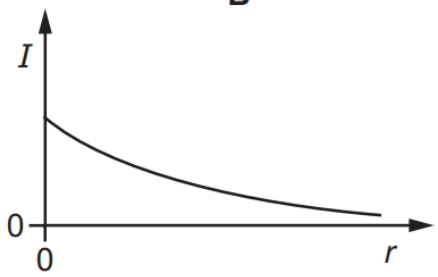
The resistance R and the e.m.f. E remain fixed. The internal resistance r of the cell changes over time.

Which graph best shows the variation of the current I in the circuit with the internal resistance r?

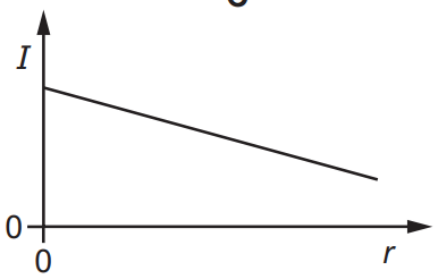
A



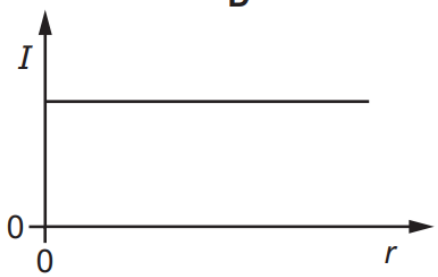
B



C

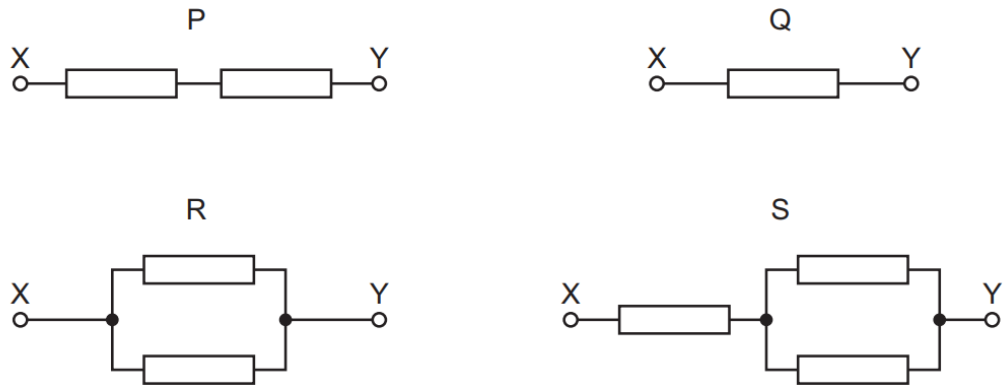


D



64. 9702/12/F/M/19 Q37

Identical resistors are connected in four combinations P, Q, R and S between terminals X and Y.



What is the order of decreasing combined resistance between X and Y (largest first)?

A P → S → Q → R

B P → S → R → Q

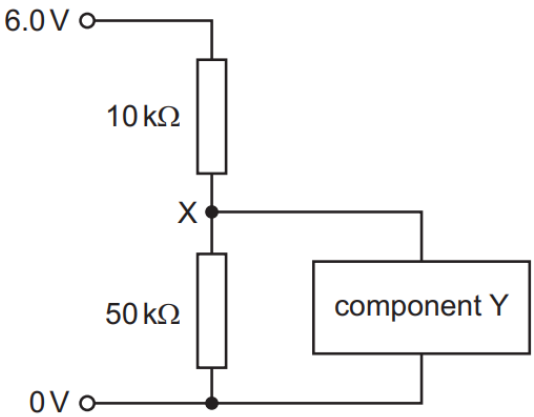
C Q → R → S → P

D S → P → Q → R

65. 9702/12/F/M/19 Q38

The circuit shown consists of two resistors of resistances 10 kΩ and 50 kΩ and a component Y.

A 6.0 V supply is provided. The electric potential of the bottom wire is 0 V.



The current in component Y is negligible.

What is the electric potential at junction X?

A 1.0 V **B** 1.2 V **C** 4.8 V **D** 5.0 V

66. 9702/11/M/J/19 Q35

When a battery is connected to a resistor, the battery gradually becomes warm. This causes the internal resistance of the battery to increase whilst its electromotive force (e.m.f.) stays unchanged.

As the internal resistance of the battery increases, how do the terminal potential difference and the output power change, if at all?

	terminal potential difference	output power
A	decreases	decreases
B	decreases	unchanged
C	unchanged	decreases
D	unchanged	unchanged

67. 9702/11/M/J/19 Q36

A cell is connected to a resistor of resistance 3.00 Ω. The current in the resistor is 1.00 A.

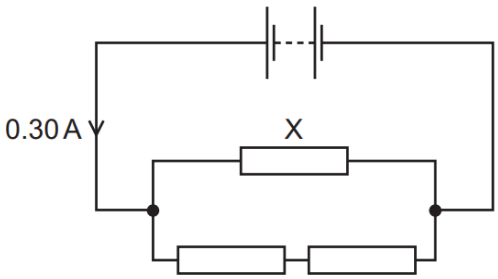
A second identical resistor is added in parallel. The current becomes 1.93 A.

What are the e.m.f. E and internal resistance r of the cell?

	E/V	r/Ω
A	0.113	3.11
B	3.04	0.0358
C	3.11	0.113
D	9.34	6.34

68. 9702/11/M/J/19 Q37

A battery with negligible internal resistance is connected to three resistors, as shown.



All three resistors have the same resistance.

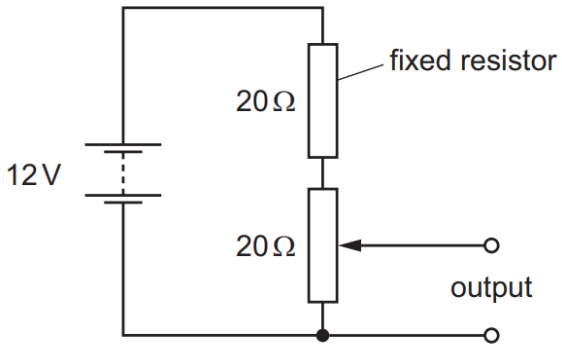
The current in the battery is 0.30 A.

What is the current in resistor X?

A 0.10 A **B** 0.15 A **C** 0.20 A **D** 0.30 A

69. 9702/11/M/J/19 Q38

The diagram shows a potentiometer and a fixed resistor connected across a 12 V battery of negligible internal resistance.



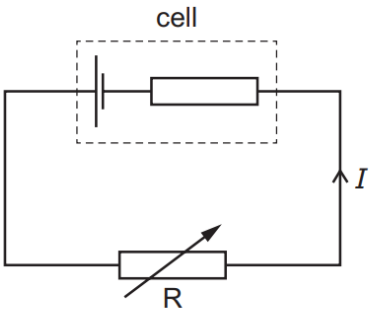
The fixed resistor and the potentiometer each have resistance 20 Ω. The circuit is designed to provide a variable output voltage.

What is the range of output voltages?

A 0 – 6 V **B** 0 – 12 V **C** 6 – 12 V **D** 12 – 20 V

70. 9702/12/M/J/19 Q35

A cell with internal resistance is connected to a variable resistor R as shown.



The resistance of R is gradually decreased.

How do the current I and the terminal potential difference across the cell change?

	current I	terminal potential difference across cell
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

71. 9702/12/M/J/19 Q36

Kirchhoff's first law states that the sum of the currents entering a junction in a circuit is equal to the sum of the currents leaving it.

The law is based on the conservation of a physical quantity.

What is this physical quantity?

A charge

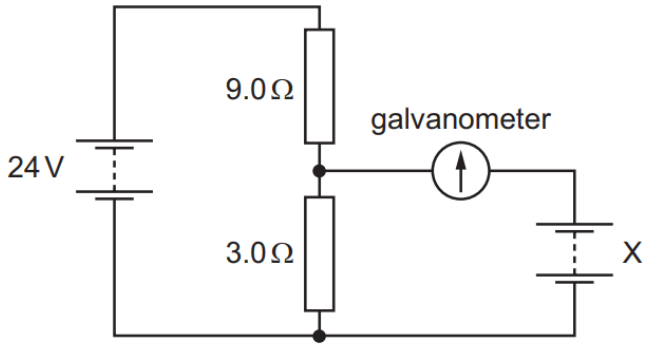
B energy

C mass

D momentum

72. 9702/12/M/J/19 Q37

A circuit contains two batteries, each of negligible internal resistance, and two resistors as shown.



The galvanometer has a current reading of zero.

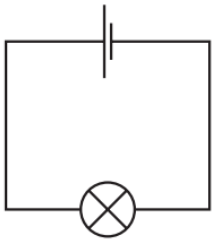
What is the electromotive force (e.m.f.) of battery X?

A 6.0 V **B** 8.0 V **C** 16.0 V **D** 18.0 V

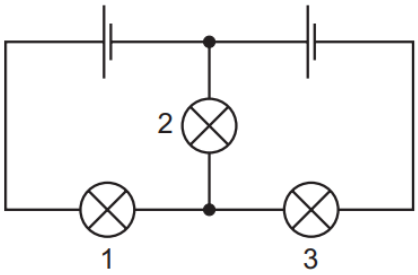
73. 9702/13/M/J/19 Q36

A student has a set of identical cells and identical lamps. The cells have negligible internal resistance.

A lamp connected to a cell lights with normal brightness.



What happens when the student connects the lamps and the cells as shown?



A All three lamps light with normal brightness.

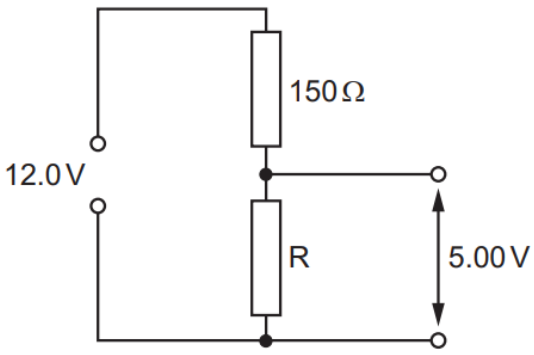
B Only lamp 2 lights with normal brightness.

C Only lamps 1 and 3 light with normal brightness.

D None of the lamps light with normal brightness.

74. 9702/13/M/J/19 Q37

A potential divider circuit is shown.

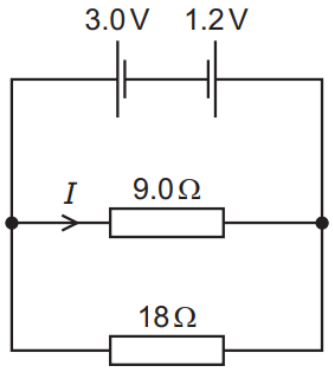


What is the resistance of resistor R in the potential divider circuit?

A 62.5 Ω **B** 107 Ω **C** 210 Ω **D** 360 Ω

75. 9702/13/M/J/19 Q38

Two cells of electromotive force (e.m.f.) 3.0 V and 1.2 V and negligible internal resistance are connected to resistors of resistance 9.0 Ω and 18 Ω as shown.



What is the current I in the 9.0 Ω resistor?

A 0.10 A **B** 0.20 A **C** 0.30 A **D** 0.47 A

76. 9702/11/O/N/19 Q34

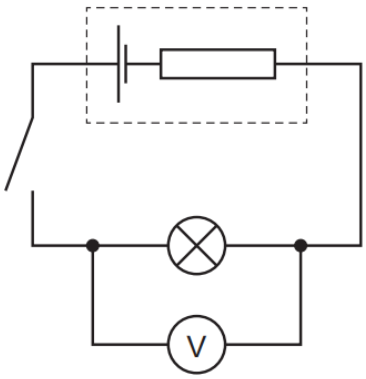
Kirchhoff's two laws for electric circuits can be derived by using conservation laws.

On which conservation laws do Kirchhoff's laws depend?

	Kirchhoff's first law	Kirchhoff's second law
A	charge	current
B	charge	energy
C	current	mass
D	energy	current

77. 9702/11/O/N/19 Q35

The diagram shows a circuit.



Which statement about the circuit is **not** correct?

A Electromotive force is the energy transferred per unit charge.

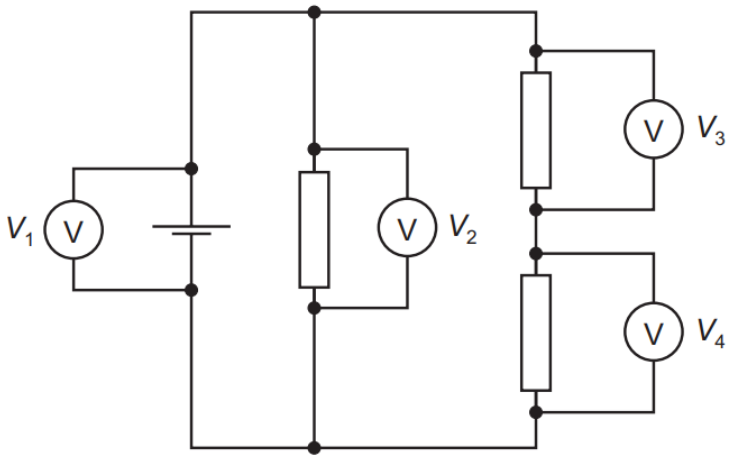
B Energy is transferred from chemical potential energy in the cell to other forms when the switch is closed.

C The electromotive force of the cell is greater than the terminal potential difference when the switch is closed.

D When the switch is open, the voltmeter measures the electromotive force of the cell.

78. 9702/11/O/N/19 Q36

The diagram shows a circuit containing four voltmeters. The readings on the voltmeters are V_1, V_2, V_3 and V_4. All the readings are positive.



Which equation relating the voltmeter readings is correct?

A $V_1 = V_2 + V_4$

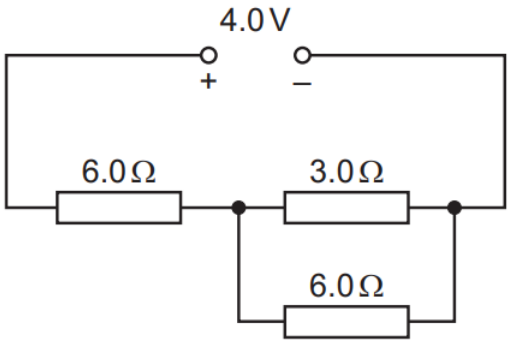
B $V_1 = V_2 + V_3 + V_4$

C $V_2 + V_3 = V_4$

D $V_3 + V_4 - V_2 = 0$

79. 9702/11/O/N/19 Q37

A network consists of a 3.0 Ω resistor and two 6.0 Ω resistors, as shown.



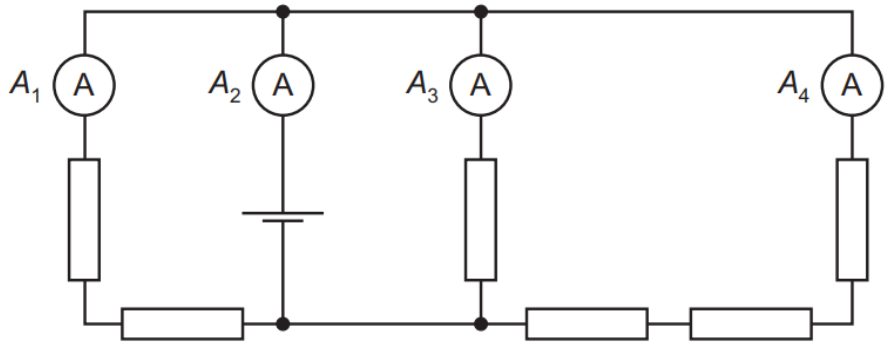
The potential difference (p.d.) across the network is 4.0 V.

What is the current through the 3.0 Ω resistor?

A 0.17 A **B** 0.25 A **C** 0.33 A **D** 1.3 A

80. 9702/11/O/N/19 Q38

In the circuit shown, all the resistors are identical and all the ammeters have negligible resistance.



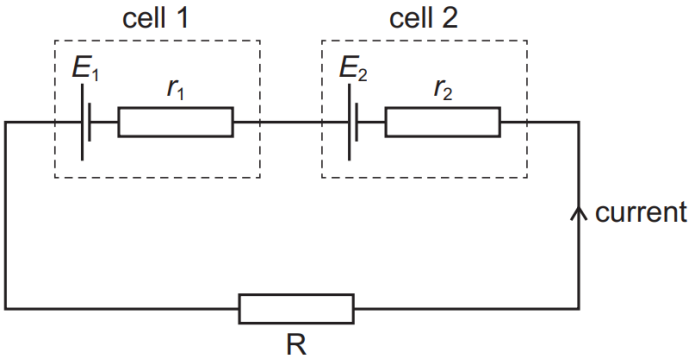
The reading A_1 is 0.6 A.

What are the readings on the other ammeters?

	A_2 / A	A_3 / A	A_4 / A
A	1.0	0.3	0.1
B	1.4	0.6	0.2
C	1.8	0.9	0.3
D	2.2	1.2	0.4

81. 9702/12/O/N/19 Q34

Two cells with electromotive forces E_1 and E_2 and internal resistances r_1 and r_2 are connected to a resistor R as shown.



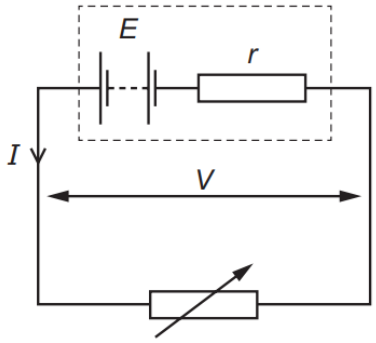
The terminal potential difference across cell 1 is zero.

Which expression gives the resistance of resistor R?

A $\frac{E_2r_1 - E_1r_2}{E_1}$ **B** $\frac{E_2r_1 - E_1r_2}{E_2}$ **C** $\frac{E_1r_2 - E_2r_1}{E_1}$ **D** $\frac{E_1r_2 - E_2r_1}{E_2}$

82. 9702/12/O/N/19 Q35

A battery has an electromotive force (e.m.f.) E and internal resistance r. The battery delivers a current I to a variable resistor and the potential difference (p.d.) across its terminals is V.



The variable resistor is adjusted so that I increases.

Why does V decrease?

A The e.m.f. E decreases.

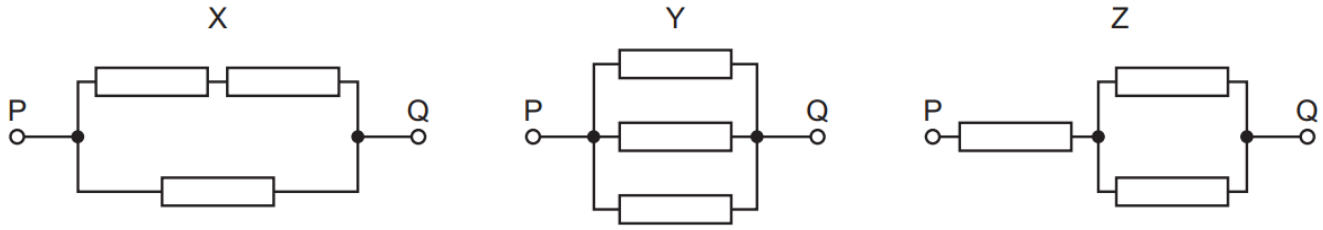
B The internal resistance r increases.

C The p.d. across r increases.

D The resistance of the variable resistor increases.

83. 9702/12/O/N/19 Q36

Three identical resistors are connected between terminals P and Q in different networks X, Y and Z as shown.



What is the order of increasing combined resistance between P and Q (lowest first)?

A X → Y → Z

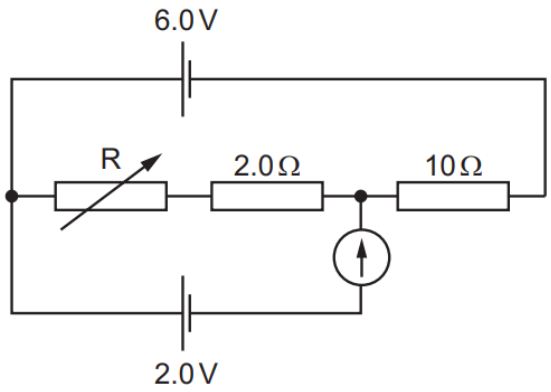
B X → Z → Y

C Y → X → Z

D Y → Z → X

84. 9702/12/O/N/19 Q37

The diagram shows a variable resistor R and two fixed resistors connected in series in a circuit to act as a potential divider.



The cell of electromotive force (e.m.f.) 6.0 V has negligible internal resistance. A cell of e.m.f. 2.0 V and a galvanometer are connected into the potential divider. The resistance of R is varied until the galvanometer reads zero.

What is the resistance of resistor R?

A 3.0 Ω **B** 5.0 Ω **C** 8.0 Ω **D** 18 Ω

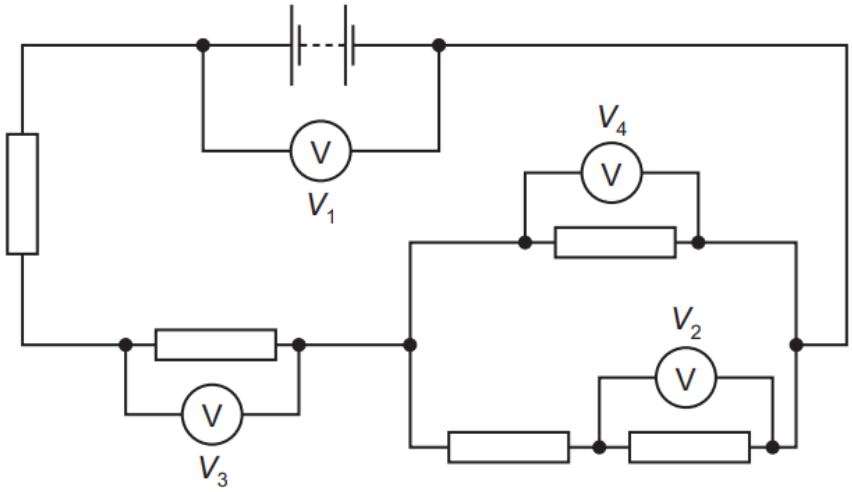
85. 9702/13/O/N/19 Q37

Which row correctly describes Kirchhoff's laws?

	Kirchhoff's first law	physics principle applied for first law	Kirchhoff's second law	physics principle applied for second law
A	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy
B	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge
C	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge
D	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy

86. 9702/13/O/N/19 Q38

In the circuit shown, all the resistors are identical.



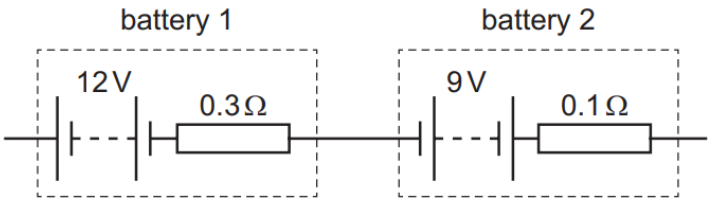
The reading V_1 is 8.0 V and the reading V_2 is 1.0 V.

What are the readings on the other voltmeters?

	V_3/V	V_4/V
A	1.5	1.0
B	3.0	2.0
C	4.5	3.0
D	6.0	4.0

87. 9702/12/F/M/20 Q35

Two batteries are connected together, as shown.



Battery 1 has electromotive force (e.m.f.) 12 V and internal resistance 0.3 Ω.

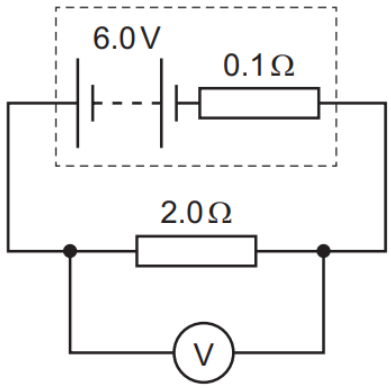
Battery 2 has e.m.f. 9 V and internal resistance 0.1 Ω.

What are the e.m.f. and the internal resistance of a single battery that has the same effect as the combination?

	e.m.f. / V	internal resistance / Ω
A	3	0.2
B	3	0.4
C	21	0.2
D	21	0.4

88. 9702/12/F/M/20 Q36

The diagram shows a circuit.



What is the reading on the voltmeter?

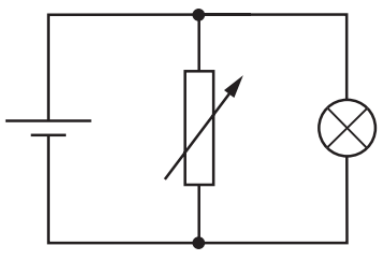
A 0.3 V **B** 5.7 V **C** 6.0 V **D** 6.3 V

89. 9702/12/F/M/20 Q37

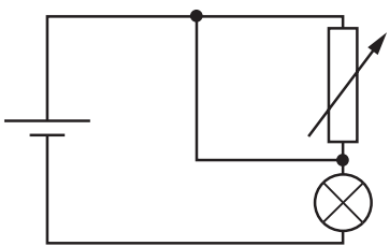
In the circuits shown, the cell has negligible internal resistance.

Which diagram shows a potential divider circuit that can vary the potential difference (p.d.) across the lamp?

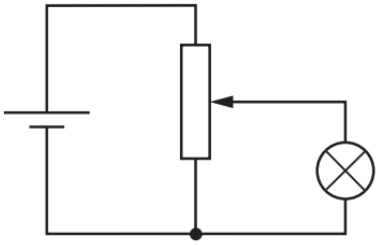
A



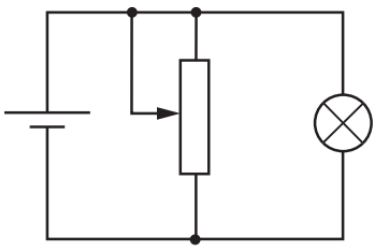
B



C



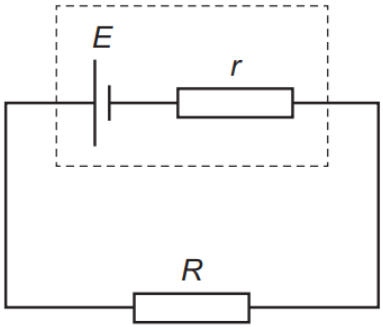
D



90. 9702/11/M/J/20 Q36

A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a resistor of resistance R.

A maximum power P can be dissipated by the resistor without overheating.



What is the maximum value of E if the resistor does not overheat?

A $R\sqrt{\dfrac{P}{(R-r)}}$ **B** $R\sqrt{\dfrac{P}{(R+r)}}$ **C** $(R-r)\sqrt{\dfrac{P}{R}}$ **D** $(R+r)\sqrt{\dfrac{P}{R}}$

91. 9702/11/M/J/20 Q37

Three identical resistors can be connected together in four different ways.

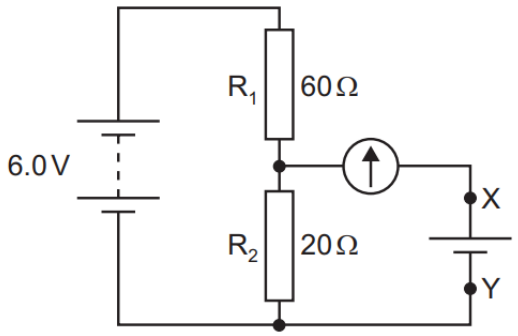
The resistances of two of these combinations are 4.0 Ω and 9.0 Ω.

What is the resistance of each individual resistor?

A 3.0 Ω **B** 6.0 Ω **C** 12 Ω **D** 18 Ω

92. 9702/11/M/J/20 Q38

In the circuit shown, a battery of negligible internal resistance is connected in series with a pair of fixed resistors R_1 and R_2.



The circuit is to be used to test whether the electromotive force (e.m.f.) of a particular cell is 1.5 V. The cell is connected between terminals X and Y in parallel with R_2 and in series with a galvanometer.

Which statement about the test is correct?

A Any non-zero reading on the galvanometer means the cell has an e.m.f. of 1.5 V.

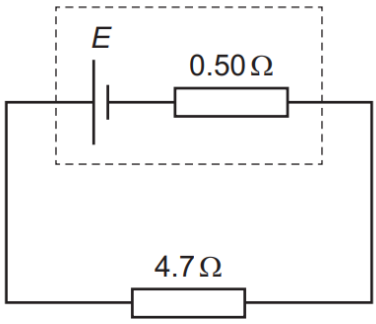
B The battery does not need to have an e.m.f. of 6.0 V.

C The cell may be connected either way round between X and Y.

D The galvanometer does not need a scale calibrated in amperes.

93. 9702/12/M/J/20 Q36

A cell of electromotive force (e.m.f.) E and internal resistance $0.50\,\Omega$ is connected to a resistor of resistance $4.7\,\Omega$.



The maximum power that can be dissipated by the resistor without overheating is 0.50 W.

What is the maximum value of E for the resistor **not** to overheat?

A 1.4 V **B** 1.5 V **C** 1.7 V **D** 2.9 V

94. 9702/12/M/J/20 Q37

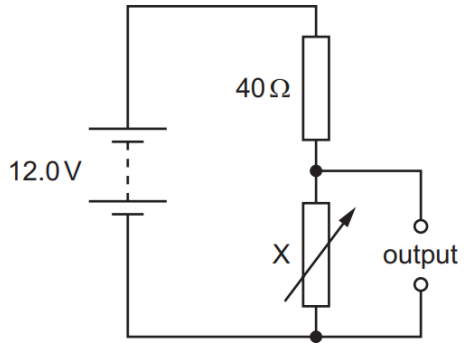
Kirchhoff's first and second laws link to the conservation of physical quantities.

Which quantities do they link to?

	first law	second law
A	charge	energy
B	charge	momentum
C	energy	charge
D	energy	momentum

95. 9702/12/M/J/20 Q38

In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0 Ω to 500 Ω. The electromotive force (e.m.f.) of the battery is 12.0 V. It has negligible internal resistance.



What is the maximum range of values of potential difference across the output?

A 1.3 V to 11.1 V

B 1.3 V to 12.0 V

C 1.5 V to 11.1 V

D 1.5 V to 12.0 V

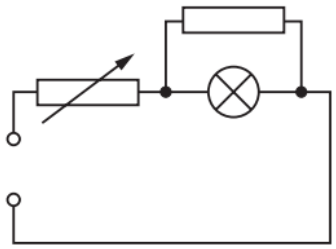
96. 9702/11/O/N/20 Q35

In the circuits shown, the power supply has an electromotive force (e.m.f.) greater than the normal operating voltage of the lamp. The internal resistance of the power supply is negligible.

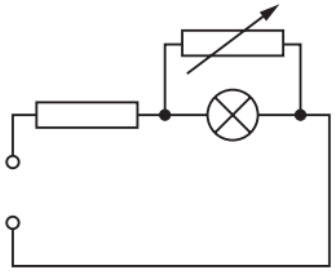
The resistance of the variable resistor is adjusted from zero to its maximum value.

In which circuit could the voltage across the lamp change from zero to its normal operating voltage and **not** exceed its normal operating voltage?

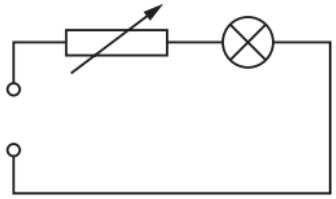
A



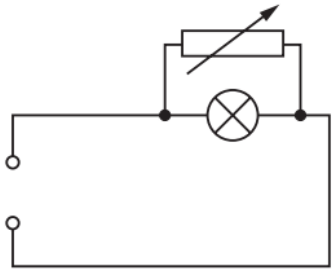
B



C

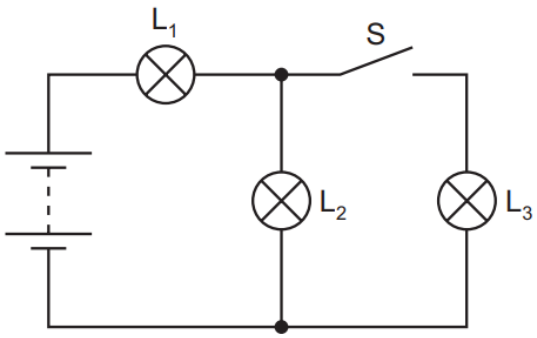


D



97. 9702/11/O/N/20 Q36

Three identical lamps L_1, L_2 and L_3 are connected to a battery with negligible internal resistance, as shown.

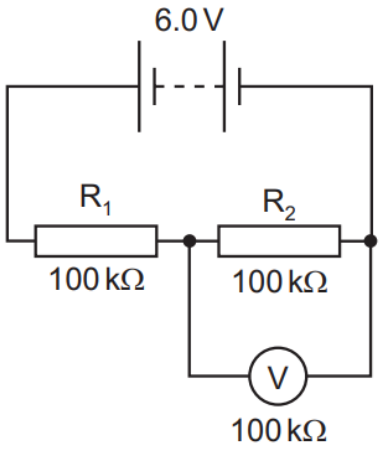


What happens to the brightness of lamps L_1 and L_2 when the switch S is closed?

	lamp L_1	lamp L_2
A	brighter	brighter
B	brighter	dimmer
C	dimmer	brighter
D	dimmer	dimmer

98. 9702/11/O/N/20 Q37

In the circuit shown, the 6.0 V battery has negligible internal resistance. Resistors R_1 and R_2 and the voltmeter each have a resistance of 100 kΩ.

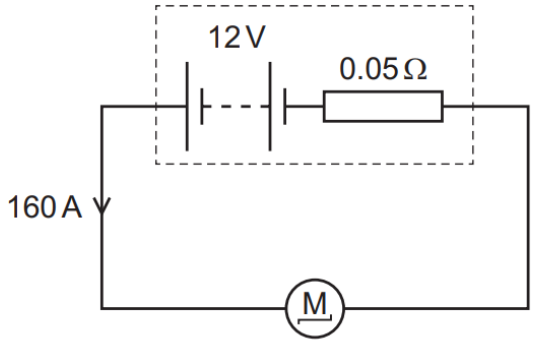


What is the current in the resistor R_2?

A 20 μA **B** 30 μA **C** 40 μA **D** 60 μA

99. 9702/12/O/N/20 Q36

A car battery has an electromotive force (e.m.f.) of 12 V and an internal resistance of 0.05 Ω. The battery is connected to the starter motor of a car. The current in the motor is 160 A.

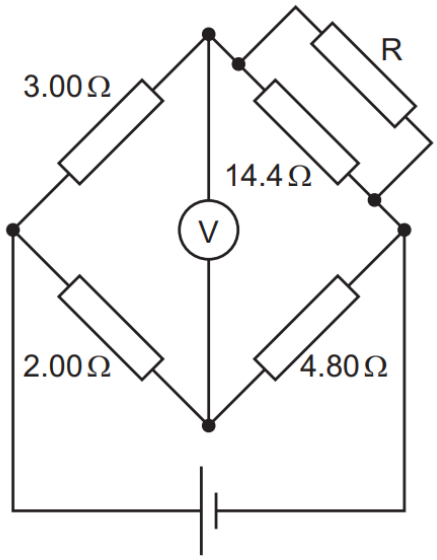


What is the terminal p.d. across the battery?

A 0 V **B** 4 V **C** 8 V **D** 12 V

100. 9702/12/O/N/20 Q37

A cell of negligible internal resistance is connected to a network of resistors and a voltmeter, as shown.



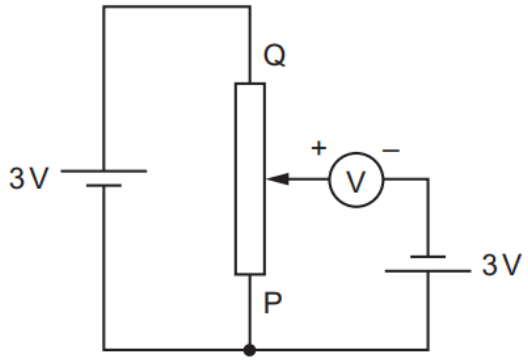
The reading on the voltmeter is zero.

What is the resistance of resistor R?

A 1.20 Ω **B** 1.80 Ω **C** 7.20 Ω **D** 14.4 Ω

101. 9702/12/O/N/20 Q38

A voltmeter is connected into a circuit with the polarity shown in the diagram.



The sliding contact is moved to end P of the potentiometer and then to end Q.

What are the two readings of the voltmeter?

	sliding contact at end P	sliding contact at end Q
A	0 V	3 V
B	0 V	6 V
C	3 V	3 V
D	3 V	6 V

102. 9702/13/O/N/20 Q36

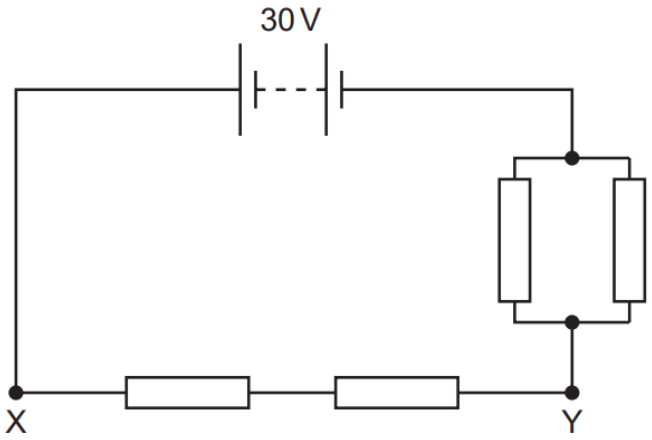
A cell is connected to a fixed resistor. Over a long period of time, the internal resistance of the cell increases.

What is the effect of the increase in internal resistance on the electromotive force (e.m.f.) of the cell and on the power dissipated by the fixed resistor?

	e.m.f.	power dissipated
A	decreases	decreases
B	decreases	no change
C	no change	decreases
D	no change	no change

103. 9702/13/O/N/20 Q37

Four identical resistors are connected in a circuit, as shown.



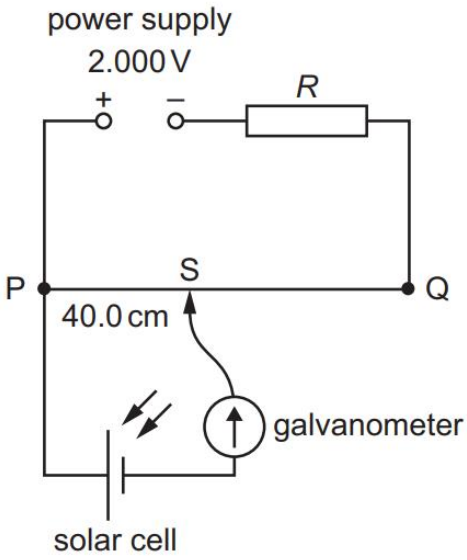
The battery has negligible internal resistance and an e.m.f. of 30 V.

What is the potential difference between the two points X and Y?

A 6.0 V **B** 15 V **C** 20 V **D** 24 V

104. 9702/13/O/N/20 Q38

A power supply and a solar cell are compared using the potentiometer circuit shown.



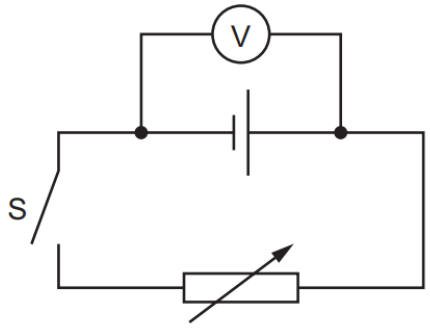
The potentiometer wire PQ is 100.0 cm long and has a resistance of 5.00 Ω. The power supply has an e.m.f. of 2.000 V and the solar cell has an e.m.f. of 5.00 mV.

Which resistance *R* must be used so that the galvanometer reads zero when PS = 40.0 cm?

A 395 Ω **B** 405 Ω **C** 795 Ω **D** 805 Ω

105. 9702/12/F/M/21 Q36

A cell that has internal resistance is connected to a switch S and a variable resistor. A voltmeter is connected between the terminals of the cell, as shown.



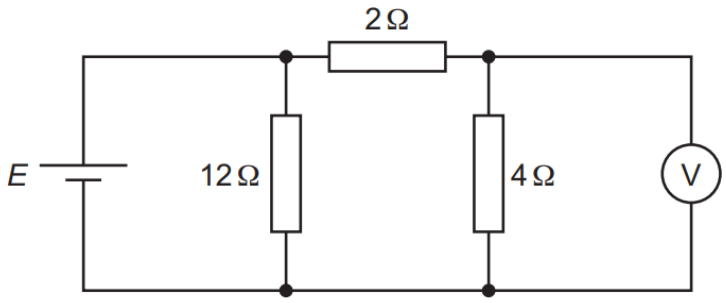
When switch S is open, the voltmeter reads 1.5 V. The switch is then closed and the variable resistor is adjusted to have a resistance of 4.0 Ω. The voltmeter now reads 0.75 V.

What is the internal resistance of the cell?

A 1.0 Ω **B** 2.0 Ω **C** 4.0 Ω **D** 8.0 Ω

106. 9702/12/F/M/21 Q37

A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected into a circuit, as shown.



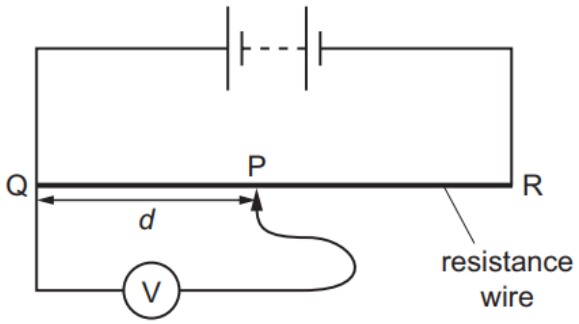
The voltmeter has a very high resistance and reads a potential difference V_{out}.

What is the ratio $\frac{V_{out}}{E}$?

A $\frac{1}{6}$ **B** $\frac{1}{3}$ **C** $\frac{1}{2}$ **D** $\frac{2}{3}$

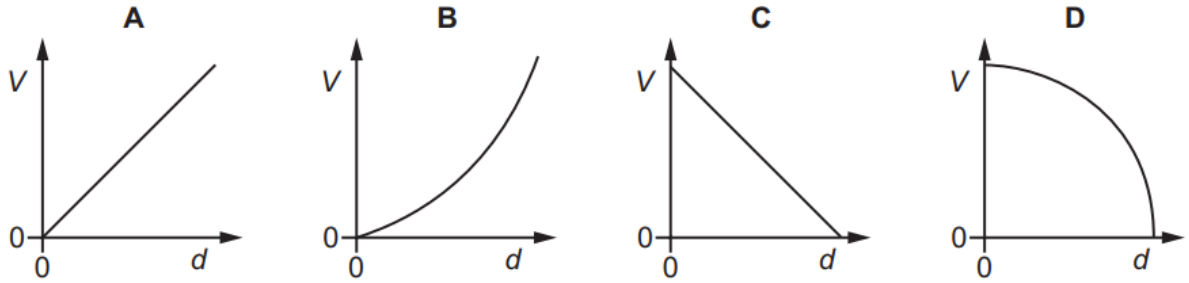
107. 9702/12/F/M/21 Q38

A battery is connected to a potentiometer. The potentiometer consists of a uniform resistance wire and a sliding contact P.



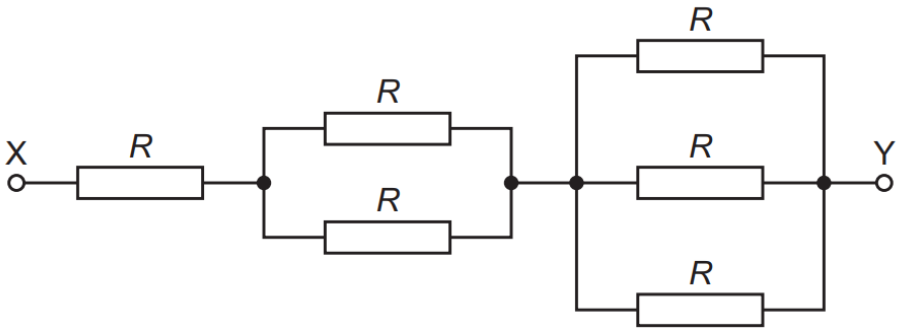
The potential difference (p.d.) *V* between the sliding contact P and end Q of the wire is measured using a voltmeter. The sliding contact P is moved from end Q to end R of the wire. Sliding contact P is distance *d* from Q.

Which graph shows the variation with distance *d* of the p.d. *V*?



108. 9702/11/M/J/21 Q36

The diagram shows a network of resistors. Each resistor has resistance *R*.

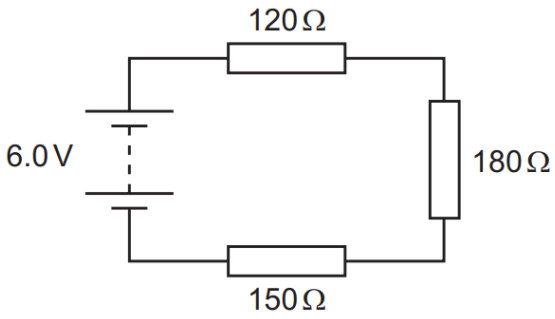


What is the total resistance of the network between points X and Y?

A $\frac{R}{6}$ **B** $\frac{6R}{11}$ **C** $\frac{11R}{6}$ **D** $6R$

109. 9702/11/M/J/21 Q37

Three resistors are connected in series with a battery, as shown. The battery has negligible internal resistance.



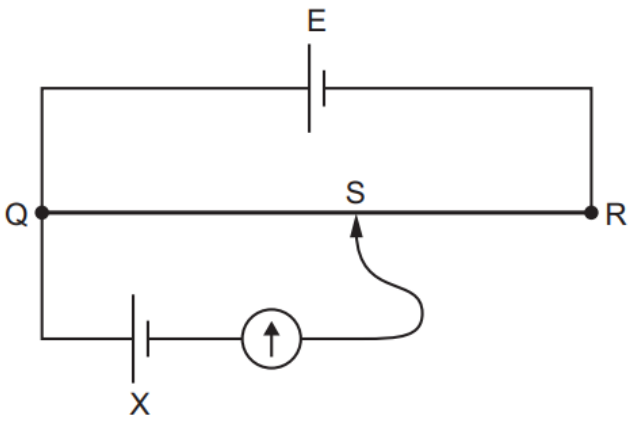
What is the potential difference across the 180 Ω resistor?

A 1.6 V **B** 2.4 V **C** 3.6 V **D** 4.0 V

110. 9702/11/M/J/21 Q38

A potentiometer circuit is used to determine the unknown electromotive force (e.m.f.) of a cell X.

In the circuit shown, E is a cell with an e.m.f. that is known accurately. QR is the potentiometer wire, which has a movable contact S. Contact S is connected to a galvanometer and to cell X.



What is **not** a necessary requirement to determine the e.m.f. of X from the circuit?

A The e.m.f. of cell X must be lower than the e.m.f. of cell E.

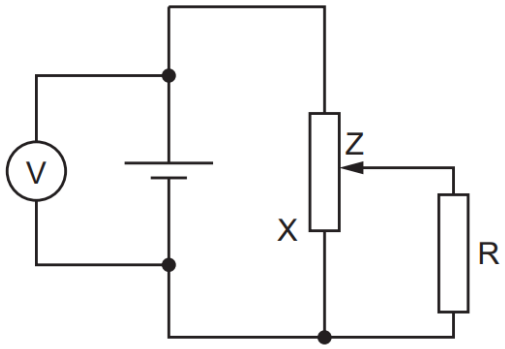
B The internal resistance of cell X must be known.

C The lengths QS and QR must be determined accurately.

D The resistance of the wire QR must be proportional to its length.

111. 9702/12/M/J/21 Q36

A cell of constant electromotive force (e.m.f.) but with internal resistance is connected to a fixed resistor R using a potentiometer. A voltmeter measures the potential difference (p.d.) between the terminals of the cell.



Which statement explains the change to the reading of the voltmeter as contact Z is moved towards end X of the potentiometer?

A The voltmeter reading decreases because the current through the cell decreases.

B The voltmeter reading decreases because the current through the cell increases.

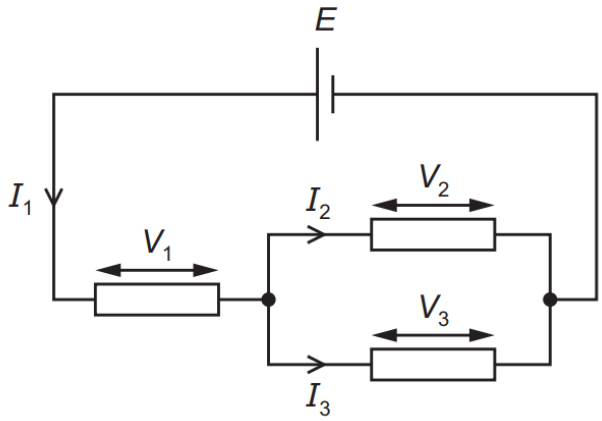
C The voltmeter reading increases because the current through the cell decreases.

D The voltmeter reading increases because the current through the cell increases.

112. 9702/12/M/J/21 Q37

A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected to a circuit.

The circuit has currents I_1, I_2 and I_3, and potential differences V_1, V_2 and V_3, as shown.

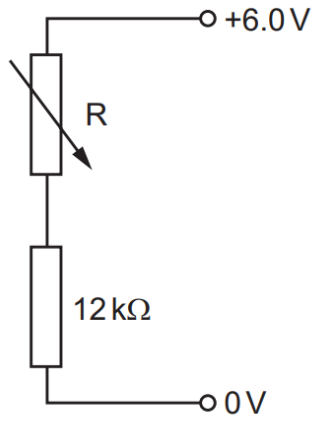


Which equation represents a statement of Kirchhoff's first law?

A $I_1 = I_2 + I_3$ **B** $I_1 = I_2 = I_3$ **C** $E = V_1 + V_2$ **D** $V_1 = V_2 = V_3$

113. 9702/12/M/J/21 Q38

Two resistors are connected in series with a 6.0 V power supply, as shown.

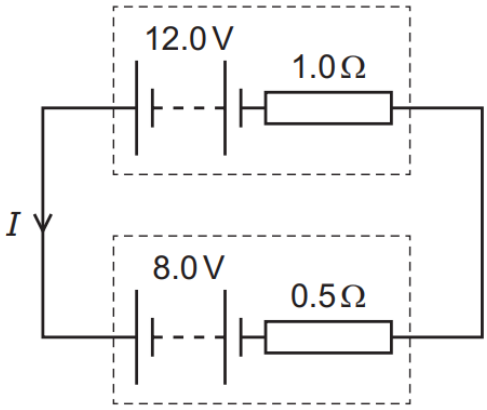


What is the resistance of the variable resistor R to give a potential difference of 1.0 V across the 12 kΩ resistor?

A 2.0 kΩ **B** 10 kΩ **C** 60 kΩ **D** 72 kΩ

114. 9702/13/M/J/21 Q35

The diagram shows a circuit containing two batteries connected together.

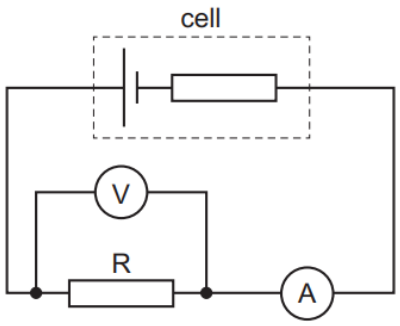


What is the current I?

A 2.7 A **B** 4.0 A **C** 8.0 A **D** 13 A

115. 9702/13/M/J/21 Q36

The circuit shown includes a cell of constant internal resistance and an external resistor R.



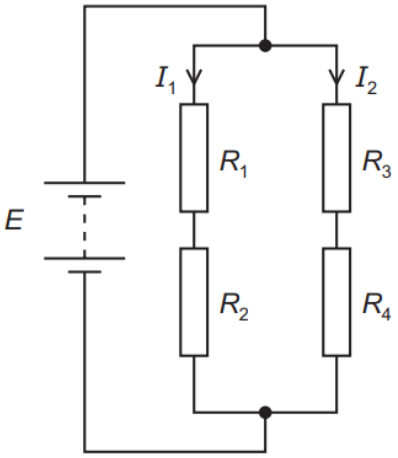
A student records the ammeter and voltmeter readings. She then connects a second identical external resistor in parallel with the first external resistor.

What happens to the ammeter reading and to the voltmeter reading?

	ammeter reading	voltmeter reading
A	decreases	decreases
B	decreases	stays the same
C	increases	decreases
D	increases	stays the same

116. 9702/13/M/J/21 Q37

A battery of electromotive force (e.m.f.) E and negligible internal resistance is connected to four resistors of resistances R_1, R_2, R_3 and R_4.



The currents I_1 and I_2 in the resistors are as shown.

Which equation is correct?

A $0 = I_1(R_1 + R_2) + I_2(R_3 + R_4)$

B $0 = I_1(R_1 + R_2) - I_2(R_3 + R_4)$

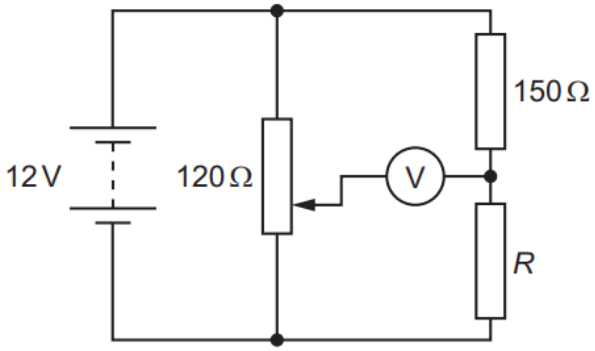
C $E = I_1(R_1 + R_2) + I_2(R_3 + R_4)$

D $E = I_1(R_1 + R_2) - I_2(R_3 + R_4)$

117. 9702/13/M/J/21 Q38

In the circuit shown, a potentiometer of total resistance 120 Ω is connected in parallel with a resistor of resistance 150 Ω and a resistor of resistance *R*.

The battery has electromotive force (e.m.f.) 12 V and negligible internal resistance.



The voltmeter reads 0 V when the slider of the potentiometer is $\frac{1}{4}$ of the way from its lower end, as shown.

What is resistance *R*?

A 30 Ω **B** 38 Ω **C** 50 Ω **D** 450 Ω

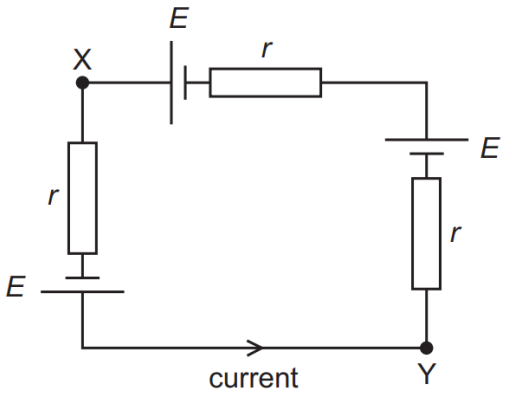
118. 9702/11/O/N/21 Q36

What is the circuit symbol for an oscilloscope?

A **B** **C** **D**

119. 9702/11/O/N/21 Q37

Three identical cells, each of electromotive force (e.m.f.) *E* and internal resistance *r*, are connected as shown.

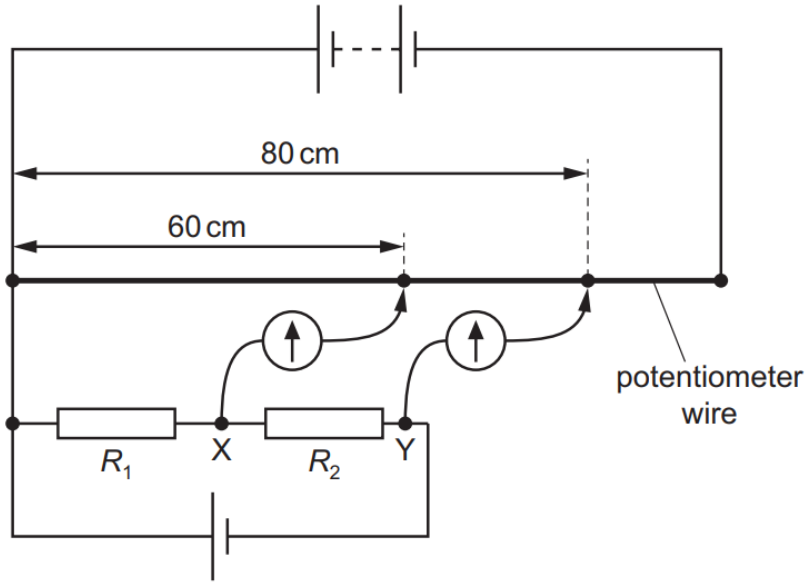


What is the potential difference between points X and Y?

A 0 **B** *E* **C** 2*E* **D** 3*E*

120. 9702/11/O/N/21 Q38

Potential differences across two resistors of resistances R_1 and R_2 are compared using a potentiometer wire (uniform resistance wire) in the electrical circuit shown.



One terminal of a galvanometer is connected to point X. The galvanometer reads zero when its other terminal is connected to a point that is a distance of 60 cm from one end of the potentiometer wire.

One terminal of a second galvanometer is connected to point Y. This galvanometer reads zero when its other terminal is connected to a point that is a distance of 80 cm from the same end of the potentiometer wire.

What is the ratio $\frac{R_2}{R_1}$?

A $\frac{1}{3}$ **B** $\frac{3}{4}$ **C** $\frac{3}{1}$ **D** $\frac{4}{3}$

121. 9702/12/O/N/21 Q36

The electromotive force (e.m.f.) of a cell is 6.0 V. It has negligible internal resistance and is connected across a resistor. The potential difference (p.d.) across the resistor is also 6.0 V.

The e.m.f. and the p.d. have the same numerical value but represent different processes.

Which statement about the different processes is correct?

A The e.m.f. is the energy transferred from chemical energy to electrical energy in the cell and the p.d. is the energy transferred from electrical energy to thermal energy in the resistor.

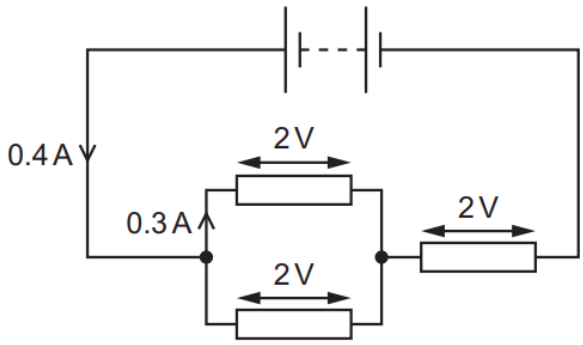
B The p.d. is the energy transferred from chemical energy to electrical energy in the cell and the e.m.f. is the energy transferred from electrical energy to thermal energy in the resistor.

C The e.m.f. is the energy transferred per unit charge from chemical energy to electrical energy in the cell and the p.d. is the energy transferred per unit charge from electrical energy to thermal energy in the resistor.

D The p.d. is the energy transferred per unit charge from chemical energy to electrical energy in the cell and the e.m.f. is the energy transferred per unit charge from electrical energy to thermal energy in the resistor.

122. 9702/12/O/N/21 Q37

A battery of negligible internal resistance is connected to three resistors, as shown.



The potential difference across each resistor is 2 V.

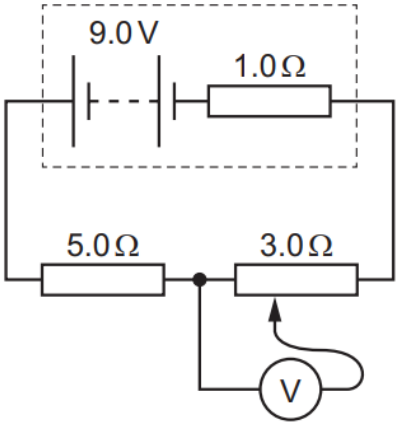
The current from the battery is 0.4 A and the current through one of the resistors connected in parallel is 0.3 A.

What is the current through the other resistor connected in parallel and what is the electromotive force (e.m.f.) of the battery?

	current / A	e.m.f. / V
A	0.1	4
B	0.3	4
C	0.1	6
D	0.3	6

123. 9702/12/O/N/21 Q38

A battery of electromotive force (e.m.f.) 9.0 V and internal resistance 1.0 Ω is connected to a fixed resistor of resistance 5.0 Ω and a potentiometer of maximum resistance 3.0 Ω, as shown.



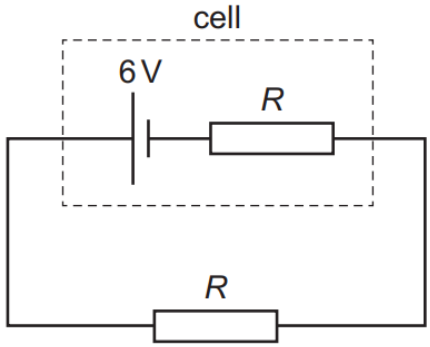
The sliding contact of the potentiometer is moved over its full range of movement.

What is the maximum value of the potential difference that is measured by the voltmeter?

A 3.0 V **B** 3.4 V **C** 4.5 V **D** 5.4 V

124. 9702/13/O/N/21 Q34

A cell has an electromotive force (e.m.f.) of 6 V and internal resistance *R*. An external resistor, also of resistance *R*, is connected across this cell, as shown.



Power *P* is dissipated by the external resistor.

The cell is replaced by a different cell that has an e.m.f. of 6 V and negligible internal resistance.

What is the new power that is dissipated in the external resistor?

A 0.5*P* **B** *P* **C** 2*P* **D** 4*P*

125. 9702/13/O/N/21 Q35

A wire of uniform cross-section has resistance R.

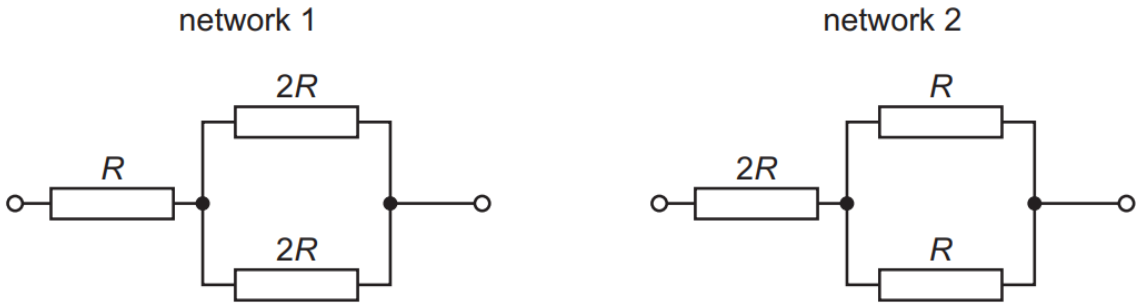
A second wire is made of the same material but is twice as long and has twice the diameter of the first wire.

What is the resistance of the second wire?

A $\frac{R}{8}$ **B** $\frac{R}{2}$ **C** R **D** $8R$

126. 9702/13/O/N/21 Q36

The diagram shows two resistor networks.

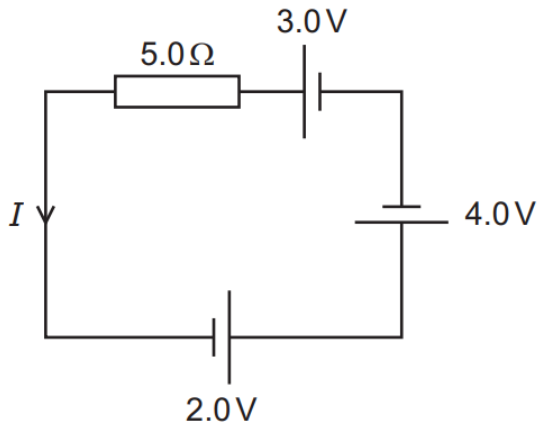


What is the ratio $\frac{\text{total resistance of network 1}}{\text{total resistance of network 2}}$?

A $\frac{4}{5}$ **B** $\frac{5}{4}$ **C** $\frac{1}{2}$ **D** $\frac{2}{1}$

127. 9702/13/O/N/21 Q37

The circuit shown contains three cells of electromotive forces 3.0 V, 2.0 V and 4.0 V, in series with a resistor of resistance 5.0 Ω. The cells have negligible internal resistance.

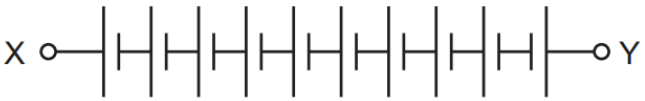


What is the current I in the circuit?

A 0.20 A **B** 0.60 A **C** 1.0 A **D** 1.8 A

128. 9702/12/F/M/22 Q33

Ten cells, each of electromotive force (e.m.f.) 1.5 V, are connected together, as shown.



What is the combined e.m.f. between terminals X and Y?

A 8 V **B** 9 V **C** 12 V **D** 15 V

129. 9702/12/F/M/22 Q35

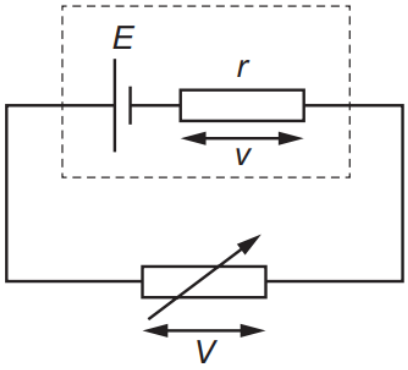
Each of Kirchhoff's two laws presumes that some quantity is conserved.

Which row states Kirchhoff's **first** law and names the quantity that is conserved?

	statement	quantity
A	the algebraic sum of currents into a junction is zero	charge
B	the algebraic sum of currents into a junction is zero	energy
C	the e.m.f. in a loop is equal to the algebraic sum of the product of current and resistance round the loop	charge
D	the e.m.f. in a loop is equal to the algebraic sum of the product of current and resistance round the loop	energy

130. 9702/12/F/M/22 Q34

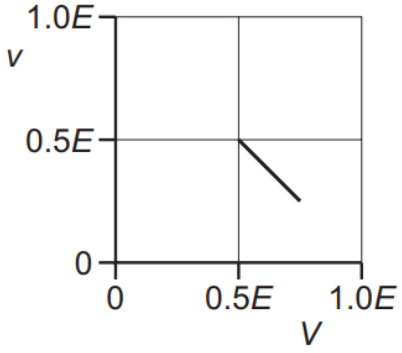
A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor, as shown.



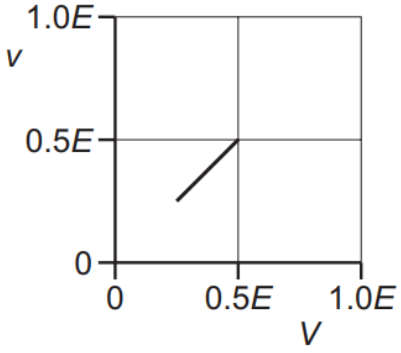
The resistance of the variable resistor is gradually increased from r to $3r$.

Which graph shows the variation of the potential difference (p.d.) v across the internal resistance with the p.d. V across the variable resistor?

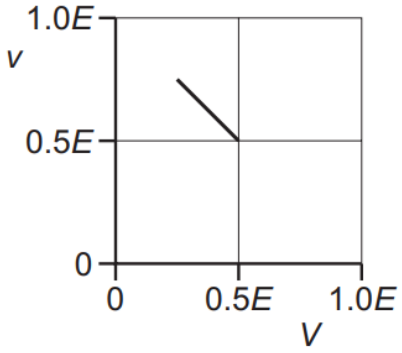
A



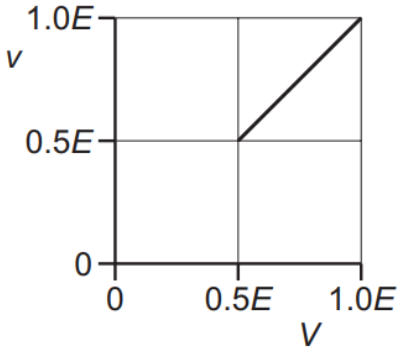
B



C

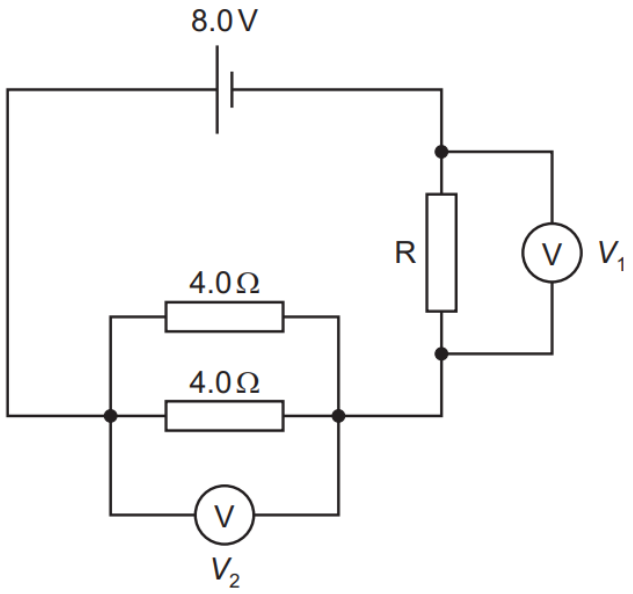


D



131. 9702/12/F/M/22 Q36

A cell has an electromotive force (e.m.f.) of 8.0 V and negligible internal resistance. The cell forms part of a circuit, as shown.



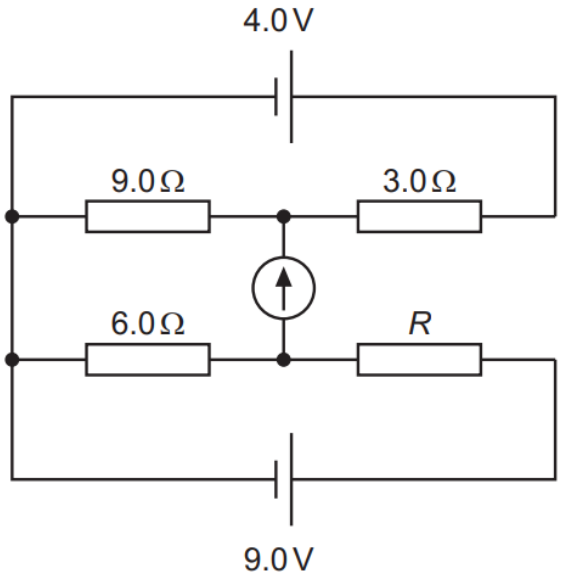
The reading V_1 is 4.0 V and the reading V_2 is also 4.0 V.

What is the resistance of resistor R?

A 0.50 Ω **B** 2.0 Ω **C** 4.0 Ω **D** 8.0 Ω

132. 9702/12/F/M/22 Q37

In the circuit shown, the cells have negligible internal resistance and the reading on the galvanometer is zero.

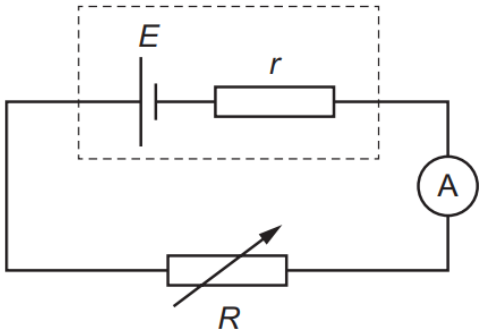


What is the value of resistor *R*?

A 2.0 Ω **B** 6.0 Ω **C** 12 Ω **D** 18 Ω

133. 9702/11/M/J/22 Q35

A cell has internal resistance *r* and electromotive force (e.m.f.) *E*. The cell is connected in series with an ammeter and a variable resistor of resistance *R*.



When *R* is 10 Ω the ammeter reads 0.3 A.

When *R* is 5 Ω the ammeter reads 0.4 A.

What is the value of *E*?

A 0.5 V **B** 2 V **C** 3 V **D** 6 V

134. 9702/11/M/J/22 Q36

The sum of the currents entering a junction in an electrical circuit is always equal to the sum of the currents leaving the junction.

Why is this?

A It is a consequence of the conservation of charge.

B It is a consequence of the conservation of electromotive force.

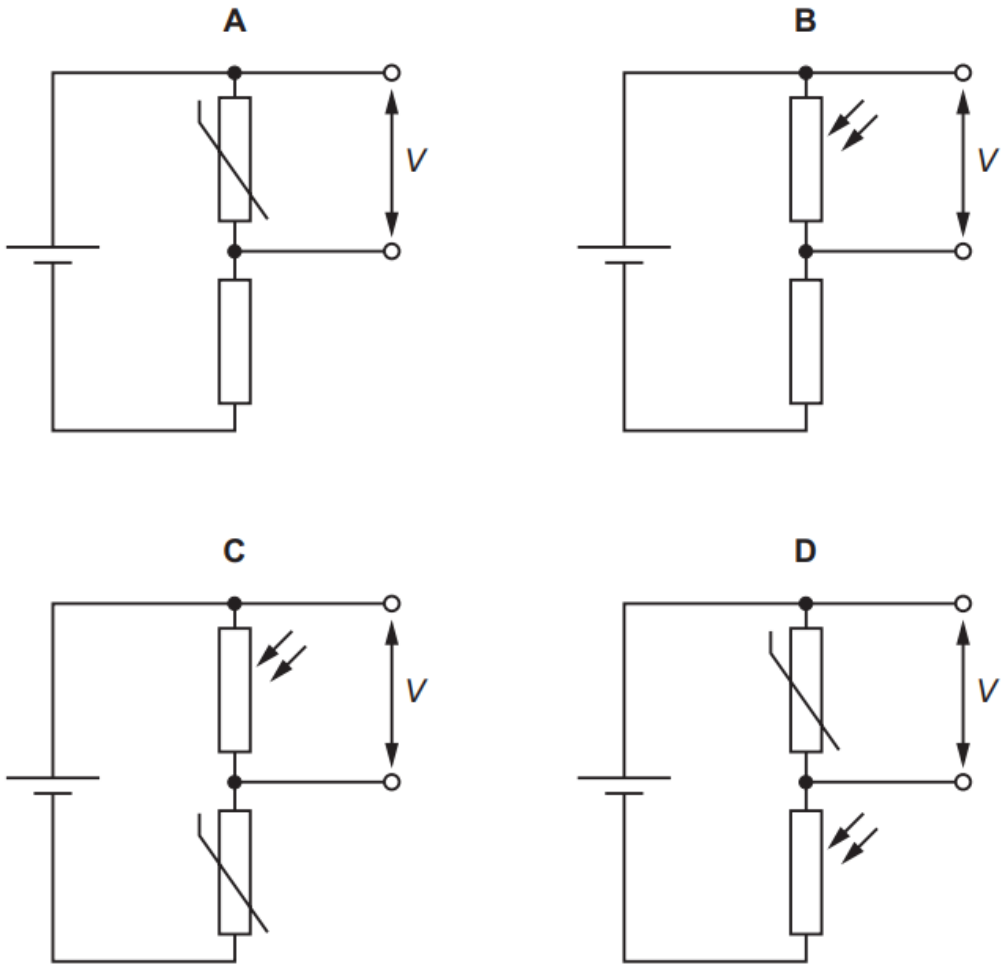
C It is a consequence of the conservation of energy.

D It is a consequence of the conservation of potential difference.

135. 9702/11/M/J/22 Q37

In the circuits shown, the temperature remains constant.

In which circuit does the potential difference (p.d.) *V* increase with increasing light intensity?



136. 9702/12/M/J/22 Q35

A cell with constant electromotive force (e.m.f.) is connected across a fixed resistor. Over time, the internal resistance of the cell increases.

Which change occurs as the internal resistance of the cell increases?

A a decrease in the charge of each charge carrier

B a decrease in the potential difference measured across the cell

C an increase in the energy dissipated per unit time in the fixed resistor

D an increase in the number of charge carriers leaving the cell per unit time

137. 9702/12/M/J/22 Q36

Kirchhoff's first and second laws are consequences of the conservation of different quantities.

What are those quantities?

	Kirchhoff's first law	Kirchhoff's second law
A	charge	energy
B	energy	current
C	current	charge
D	energy	charge

138. 9702/12/M/J/22 Q37

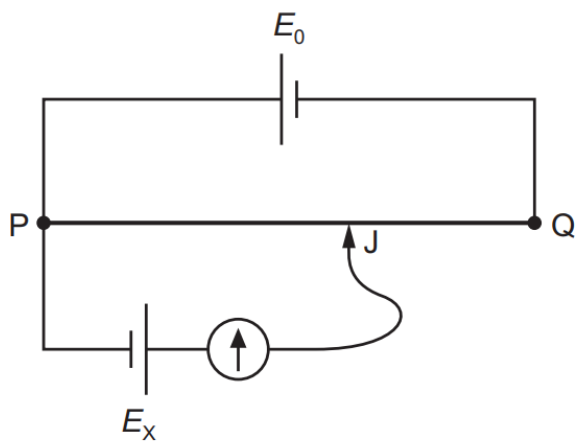
A potentiometer circuit is used to determine the electromotive force (e.m.f.) E_X of a cell. The circuit includes a second cell of known e.m.f. E_0 and negligible internal resistance, and a uniform resistance wire PQ of known length.

E_X is less than E_0.

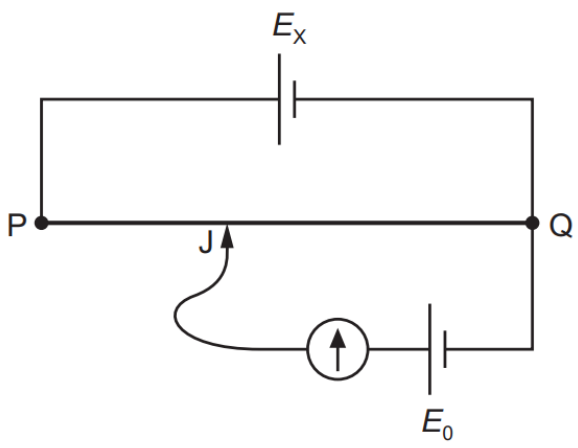
The movable connection J can be positioned anywhere along the length of the resistance wire.

Which circuit is suitable for determining E_X?

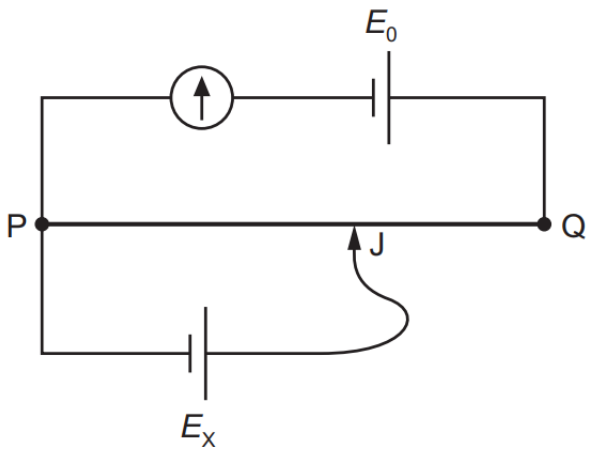
A



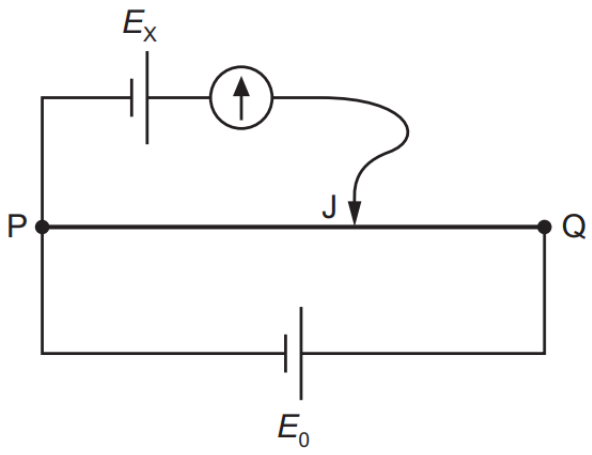
B



C



D



139. 9702/13/M/J/22 Q36

The diagram shows the symbol for a component that may be used in an electrical circuit.

Which component is represented by this circuit symbol?

A buzzer

B electric bell

C loudspeaker

D microphone

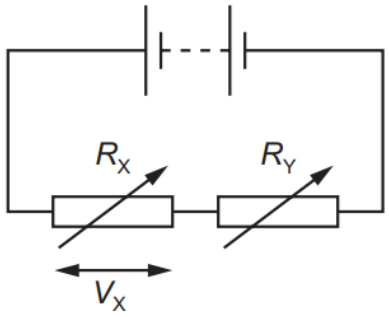
140. 9702/13/M/J/22 Q37

Which row correctly describes Kirchhoff's laws?

	Kirchhoff's first law	physics principle applied for first law	Kirchhoff's second law	physics principle applied for second law
A	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy
B	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge
C	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge
D	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy

141. 9702/13/M/J/22 Q38

A potential divider circuit is formed by connecting a battery of negligible internal resistance in series with two variable resistors, as shown.



The variable resistors have resistances R_X and R_Y.

V_X is the potential difference (p.d.) across the variable resistor with resistance R_X.

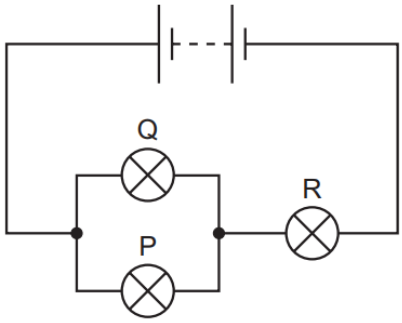
R_X and R_Y are both changed at the same time.

Which combination of changes **must** cause V_X to increase?

	R_X	R_Y
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

142. 9702/11/O/N/22 Q34

Three identical filament lamps, P, Q and R, are connected to a battery of negligible internal resistance, as shown.



The filament wire in lamp Q breaks so that it no longer conducts.

What are the changes in the brightness of lamps P and R?

	lamp P	lamp R
A	brighter	brighter
B	brighter	dimmer
C	dimmer	brighter
D	dimmer	dimmer

143. 9702/11/O/N/22 Q35

Which ratio has the same units as electromotive force (e.m.f.)?

A charge per unit energy transferred

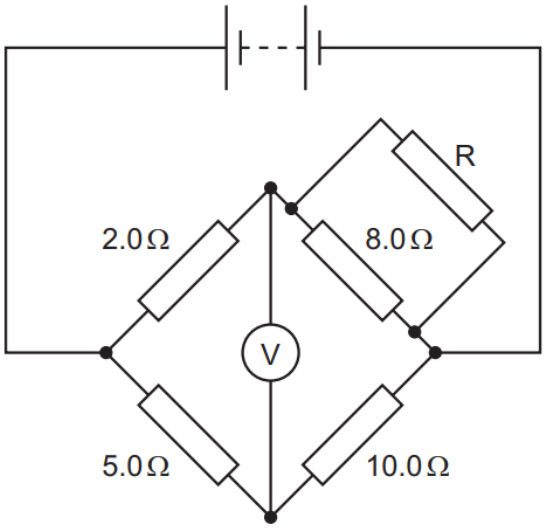
B charge per unit time

C energy transferred per unit charge

D energy transferred per unit time

144. 9702/11/O/N/22 Q36

A circuit consists of a battery, a voltmeter and five fixed resistors, as shown.



The voltmeter reading is zero.

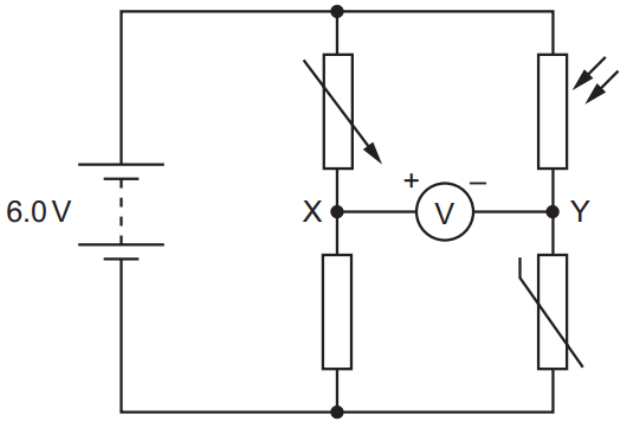
What is the resistance of resistor R?

A 1.1Ω **B** 2.1Ω **C** 4.0Ω **D** 8.0Ω

145. 9702/11/O/N/22 Q37

A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to a voltmeter and four other components, as shown.

The voltmeter is connected between points X and Y. The positive terminal of the voltmeter is connected to X and the negative terminal of the voltmeter is connected to Y.



Initially, the resistance of each of the four components is 1.0 kΩ.

Which change, on its own, will cause the voltmeter to show a positive reading?

A Decrease the temperature of the thermistor.

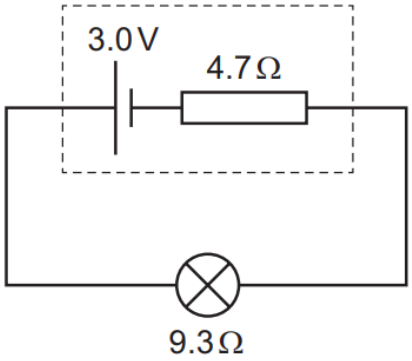
B Increase the resistance of the variable resistor.

C Reduce the intensity of light incident on the light-dependent resistor (LDR).

D Replace the fixed resistor with a 500 Ω resistor.

146. 9702/12/O/N/22 Q35

The diagram shows a cell of electromotive force (e.m.f.) 3.0 V and internal resistance 4.7 Ω connected across a lamp. The lamp has a resistance of 9.3 Ω.

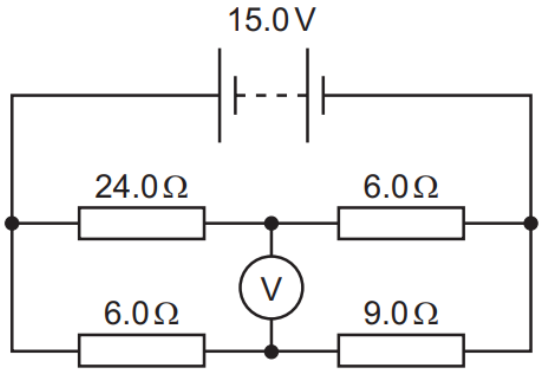


What is the power dissipated by the internal resistance of the cell?

A 0.22 W **B** 0.43 W **C** 0.64 W **D** 1.0 W

147. 9702/12/O/N/22 Q36

A circuit consists of a battery, a high-resistance voltmeter and four fixed resistors, as shown. The battery has an electromotive force (e.m.f.) of 15.0 V and negligible internal resistance.

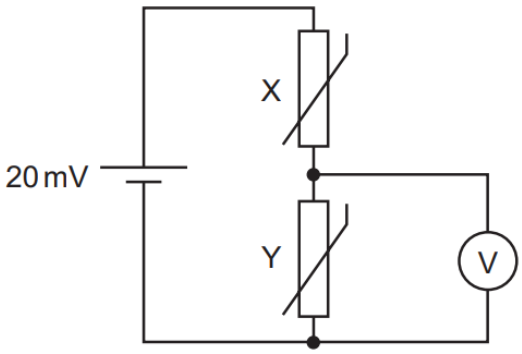


What is the reading on the voltmeter?

A 3.0 V **B** 6.0 V **C** 9.0 V **D** 12.0 V

148. 9702/12/O/N/22 Q37

A potential divider circuit is designed to detect the difference in temperature between two different places.



The cell has electromotive force (e.m.f.) 20 mV and negligible internal resistance.

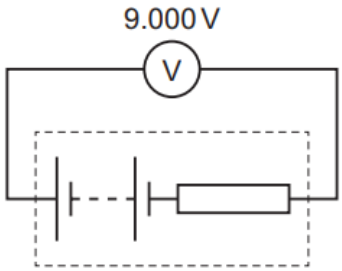
Initially, thermistors X and Y are at the same temperature and have the same resistance. The voltmeter reads 10 mV. X is then placed in a cold environment and its resistance doubles. Y is placed in a warm environment and its resistance halves.

What is the new reading on the voltmeter?

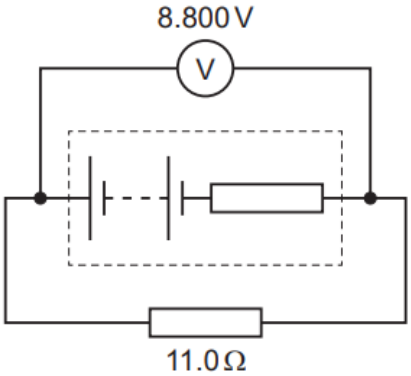
A 4 mV **B** 5 mV **C** 15 mV **D** 16 mV

149. 9702/13/O/N/22 Q34

A voltmeter reads 9.000 V when it is connected across the terminals of a battery.



When a resistor of resistance 11.0 Ω is connected in parallel with the battery, the voltmeter reading changes to 8.800 V.



What is the internal resistance of the battery?

A 0.244 Ω **B** 0.250 Ω **C** 10.8 Ω **D** 11.3 Ω

150. 9702/13/O/N/22 Q35

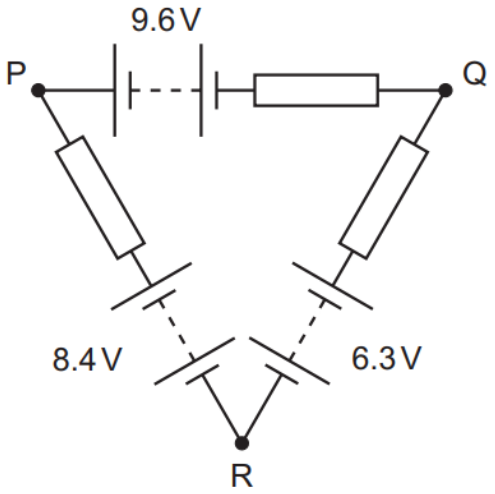
Each of Kirchhoff's laws is linked to the conservation of a physical quantity.

Which conserved physical quantities are used in the derivation of Kirchhoff's first law and of Kirchhoff's second law?

	Kirchhoff's first law	Kirchhoff's second law
A	energy	charge
B	energy	momentum
C	charge	energy
D	momentum	energy

151. 9702/13/O/N/22 Q36

Three batteries and three identical resistors are connected in a circuit PQR, as shown.



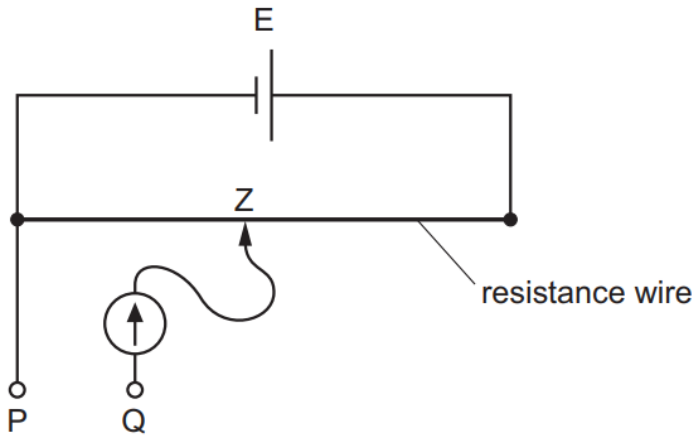
The batteries have negligible internal resistance.

What is the potential difference between points P and Q?

A 1.5 V **B** 2.1 V **C** 7.1 V **D** 12.1 V

152. 9702/13/O/N/22 Q37

A cell E, of electromotive force (e.m.f.) 2 V and negligible internal resistance, is connected to a uniform resistance wire of resistance 10 Ω and length 1.0 m.



Z is a connection that may be made at any position along the resistance wire. A galvanometer is connected between Z and a point Q.

A new source of e.m.f. of approximately 8 mV is connected between points P and Q. The e.m.f. of the new source is determined by changing the position of Z until the reading on the galvanometer is zero.

Which change to the circuit allows a much more precise value for the e.m.f. of the new source to be obtained?

A Add a resistor of resistance 0.1 Ω in series with cell E.

B Add a resistor of resistance 1000 Ω in series with cell E.

C Add a resistor of resistance 10 Ω in series with the new source.

D Add a resistor of resistance 800 Ω in series with the new source.