# Compiled by Leong Yee Pak

# DC Circuit

## 20.1 Practical circuits
## 20.2 Conservation of charge and energy

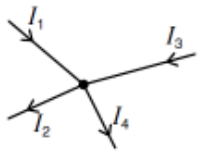
***1 June 2002 P1 Q33**

**33** The diagrams show connected wires which carry currents $I_1$, $I_2$, $I_3$ and $I_4$.

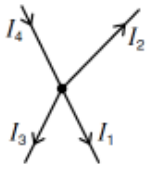
The currents are related by the equation $I_1 + I_2 = I_3 + I_4$.

To which diagram does this equation apply?

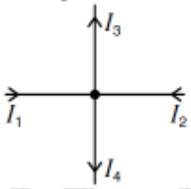
**A**



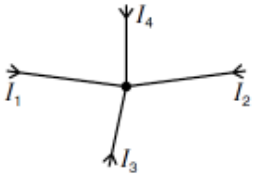

**B**




**C**




**D**




*****2 June 2002 P1 Q34**

**34** When four identical lamps P, Q, R and S are connected as shown in diagram 1, they have normal brightness.

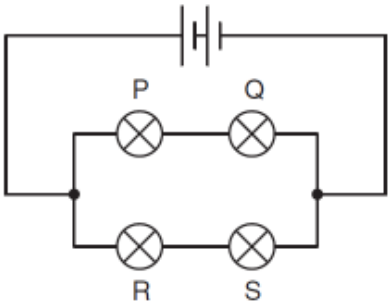



diagram 1

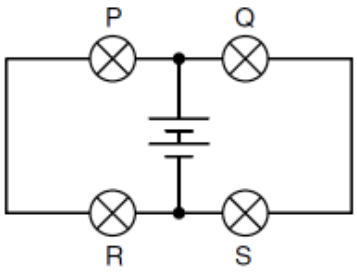



diagram 2

When the four lamps are connected as shown in diagram 2, which statement is correct?

**A** The lamps do not light.

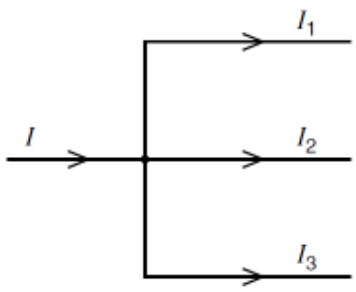
**B** The lamps are less bright than normal.

**C** The lamps have normal brightness.

**D** The lamps are brighter than normal.

***3 Nov 02 P1 Q33**

**33** At a circuit junction, a current $I$ divides into currents $I_1$, $I_2$ and $I_3$.




These currents are related by the equation

$$I = I_1 + I_2 + I_3.$$

Which law does this statement illustrate and on what principle is the law based?

**A** Kirchhoff's first law based on conservation of charge

**B** Kirchhoff's first law based on conservation of energy

**C** Kirchhoff's second law based on conservation of charge

**D** Kirchhoff's second law based on conservation of energy

****4 Nov 02 P1 Q34**

**34** The combined resistance $R_T$ of two resistors of resistances $R_1$ and $R_2$ connected in parallel is given by the formula

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

Which statement is used in the derivation of this formula?

**A** The currents through the two resistors are equal.

**B** The potential difference across each resistor is the same.

**C** The supply current is split between the two resistors in the same ratio as the ratio of their resistances.

**D** The total power dissipated is the sum of the powers dissipated in the two resistors separately.

***5 June 03 P1 Q31**

**31** 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 of the following is correct?

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

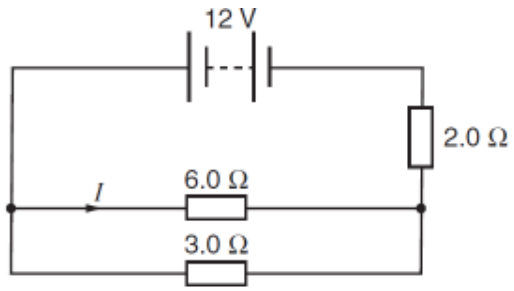
**B** This is Kirchhoff's first law, which results from the conservation of energy.

**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.

****6 Nov 03 P1 Q31**

**31** The diagram shows a circuit in which the battery has negligible internal resistance.

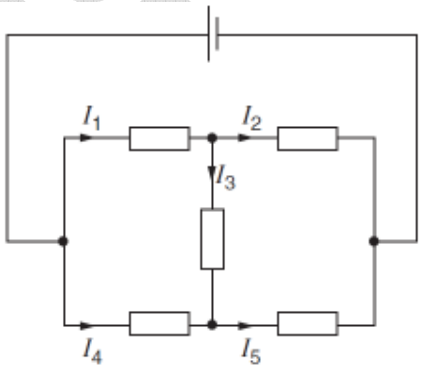



What is the value of the current $I$?

**A** 1.0 A **B** 1.6 A **C** 2.0 A **D** 3.0 A

***7 Nov 03 P1 Q32**

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




Which one of the following is correct?

**A** $I_1 = I_2 + I_3$

**B** $I_2 = I_1 + I_3$

**C** $I_3 = I_4 + I_5$

**D** $I_4 = I_5 + I_3$

***8 June 04 P1 Q36**

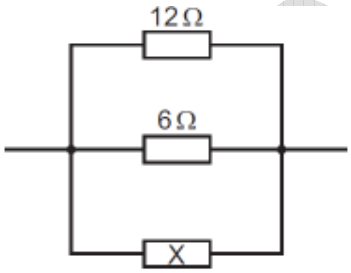
**36** Kirchhoff's two laws for electric circuits can be derived by using conservation laws.

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 |

****9 June 04 P1 Q37**

**37** The diagram shows a parallel combination of three resistors. The total resistance of the combination is 3Ω.

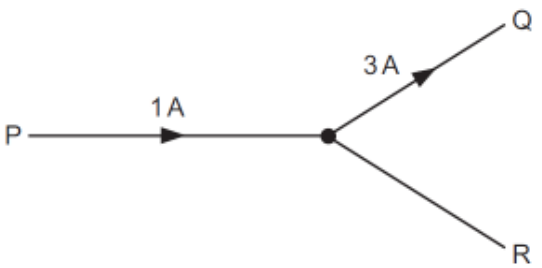



What is the resistance of resistor X?

**A** 2Ω **B** 3Ω **C** 6Ω **D** 12Ω

***10 Nov 04 P1 Q35**

**35** The diagram shows a junction in a circuit where three wires P, Q and R meet. The currents in P and Q are 1 A and 3 A respectively, in the directions shown.

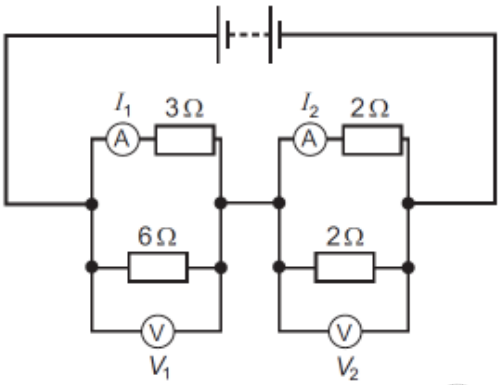



How many coulombs of charge pass a given point in wire R in 5 seconds?

**A** 0.4 **B** 0.8 **C** 2 **D** 10

*****11 Nov 04 P1 Q37**

**37** In the circuit shown, the ammeters have negligible resistance and the voltmeters have infinite resistance.




The readings on the meters are $I_1$, $I_2$, $V_1$ and $V_2$, as labelled on the diagram.

Which is correct?

**A** $I_1 > I_2$ and $V_1 > V_2$

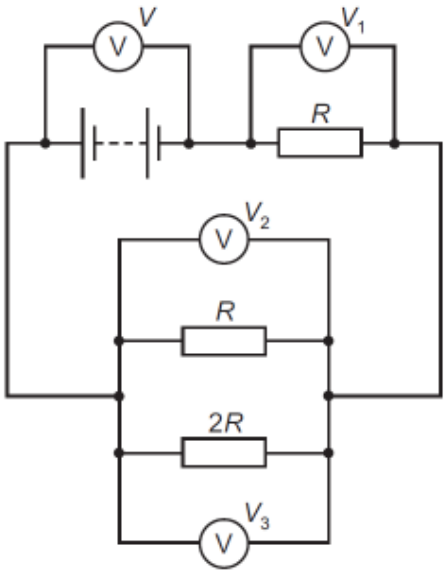
**B** $I_1 > I_2$ and $V_1 < V_2$

**C** $I_1 < I_2$ and $V_1 > V_2$

**D** $I_1 < I_2$ and $V_1 < V_2$

*****12 June 05 P1 Q36**

**36** The diagram shows a circuit with four voltmeter readings $V$, $V_1$, $V_2$ and $V_3$.



Which equation relating the voltmeter readings must be true?

**A** $V = V_1 + V_2 + V_3$

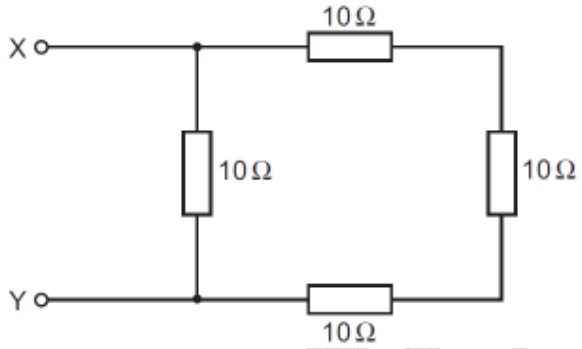
**B** $V + V_1 = V_2 + V_3$

**C** $V_3 = 2(V_2)$

**D** $V - V_1 = V_3$

****13 June 06 P1 Q34**

**35** The diagram shows an arrangement of resistors.




What is the total electrical resistance between X and Y?

**A** less than 1 Ω

**B** between 1 Ω and 10 Ω

**C** between 10 Ω and 30 Ω

**D** 40 Ω

*****14 June 06 P1 Q35**

**36** When four identical lamps P, Q, R and S are connected as shown in diagram 1, they have normal brightness.

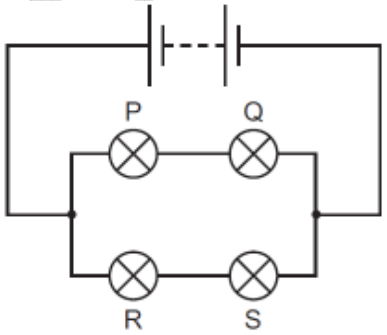



diagram 1

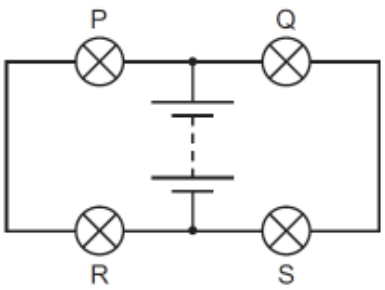



diagram 2

The four lamps and the battery are then connected as shown in diagram 2.

Which statement is correct?

**A** The lamps do not light.

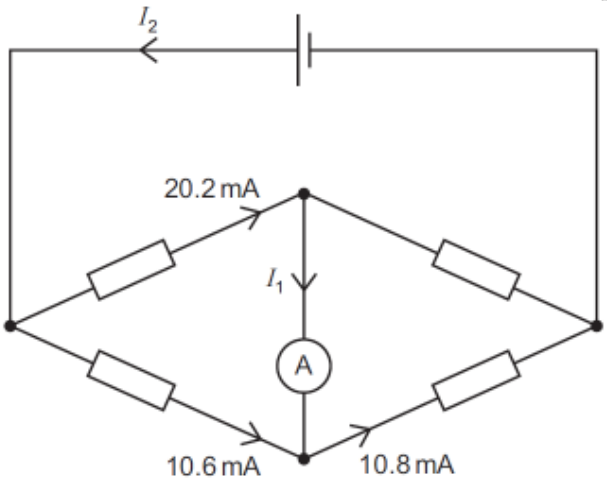
**B** The lamps are less bright than normal.

**C** The lamps have normal brightness.

**D** The lamps are brighter than normal.

****15 Nov 06 P1 Q36**

**36** The diagram represents a circuit.



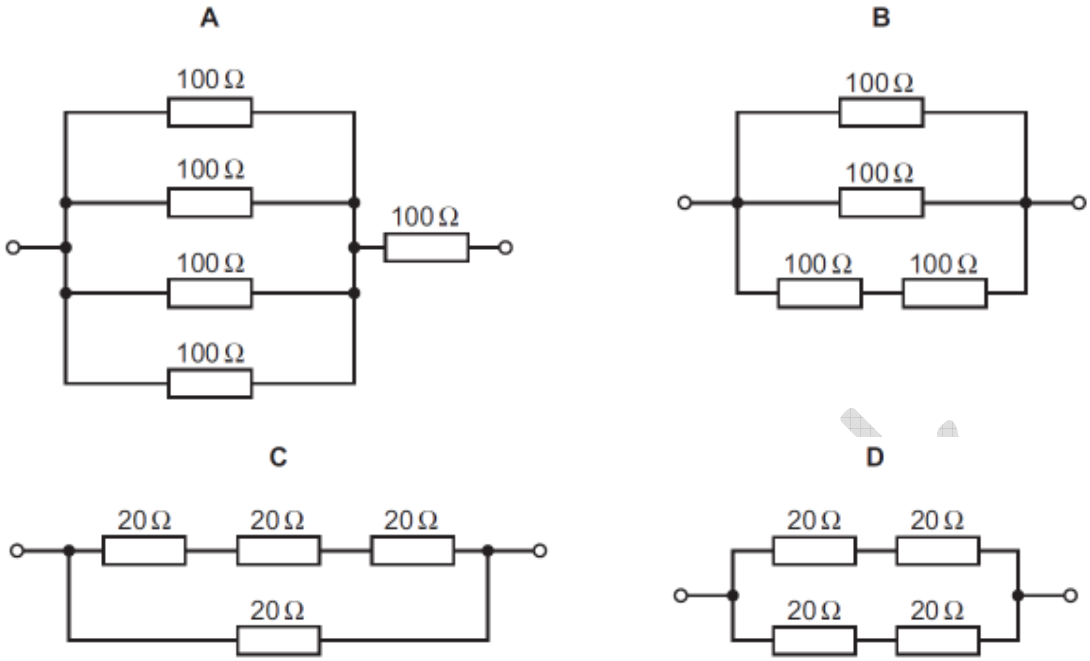

Some currents have been shown on the diagram.

What are the currents $I_1$ and $I_2$?

| | $I_1$ | $I_2$ |
|---|---|---|
| **A** | 0.2 mA | 10.8 mA |
| **B** | 0.2 mA | 30.8 mA |
| **C** | –0.2 mA | 20.0 mA |
| **D** | –0.2 mA | 30.8 mA |

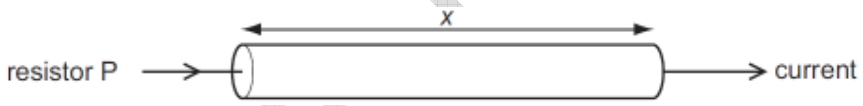
****16 Nov 06 P1 Q37**

**37** Which circuit has a resistance of 40 Ω between the terminals?

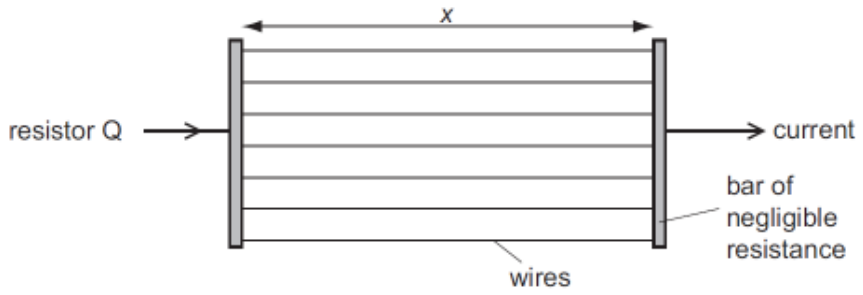



*****17 June 07 P1 Q37**

**37** A researcher has two pieces of copper of the same volume. All of the first piece is made into a cylindrical resistor P of length *x*.




All of the second piece is made into uniform wires each of the same length *x* which he connects between two bars of negligible resistance to form a resistor Q.




How do the electrical resistances of P and Q compare?

**A** P has a larger resistance than Q.

**B** Q has a larger resistance than P.

**C** P and Q have equal resistance.

**D** Q may have a larger or smaller resistance than P, depending on the number of wires made.

*****18 Nov 07 P1 Q35**

**35** When four identical resistors are connected as shown in diagram 1, the ammeter reads 1.0 A and the voltmeter reads zero.

diagram 1

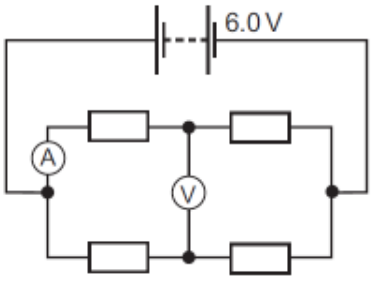
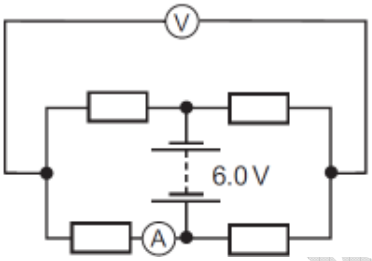



diagram 2



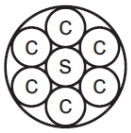

The resistors and meters are reconnected to the supply as shown in diagram 2.

What are the meter readings in diagram 2?

| | voltmeter reading / V | ammeter reading / A |
|---|---|---|
| **A** | 0 | 1.0 |
| **B** | 3.0 | 0.5 |
| **C** | 3.0 | 1.0 |
| **D** | 6.0 | 0 |

****19 Nov 08 P1 Q32**

**32** An electric power cable consists of six copper wires c surrounding a steel core s.




1.0 km of one of the copper wires has a resistance of 10 Ω and 1.0 km of the steel core has a resistance of 100 Ω.

What is the approximate resistance of a 1.0 km length of the power cable?

**A** 0.61 Ω **B** 1.6 Ω **C** 160 Ω **D** 610 Ω

# Section B

**1 June 06 P2 Q7**

**7** A circuit contains three similar lamps A, B and C. The circuit also contains three switches, $S_1$, $S_2$ and $S_3$, as shown in Fig. 7.1.

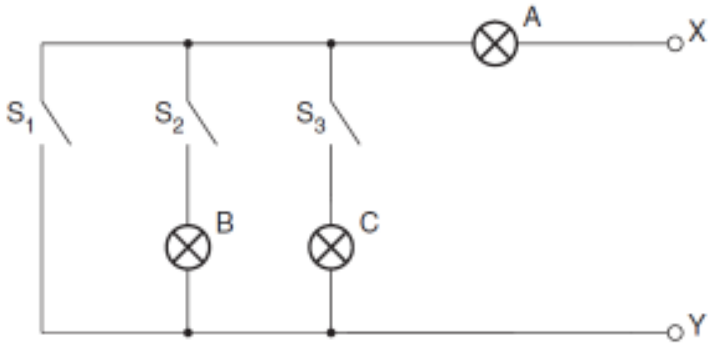



**Fig. 7.1**

One of the lamps is faulty. In order to detect the fault, an ohm-meter (a meter that measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 7.2 shows the readings of the ohm-meter for different switch positions.

| switch | | | meter reading |
|---|---|---|---|
| $S_1$ | $S_2$ | $S_3$ | / Ω |
| open | open | open | ∞ |
| closed | open | open | 15 Ω |
| open | closed | open | 30 Ω |
| open | closed | closed | 15 Ω |

**Fig. 7.2**

**(a)** Identify the faulty lamp, and the nature of the fault.

faulty lamp: .....

nature of fault: ..... [2]

**(b)** Suggest why it is advisable to test the circuit using an ohm-meter that causes negligible current rather than with a power supply.

.....

..... [1]

**(c)** Determine the resistance of one of the non-faulty lamps, as measured using the ohm-meter.

resistance = ..... Ω [1]

**(d)** Each lamp is marked 6.0 V, 0.20 A.

Calculate, for one of the lamps operating at normal brightness,

**(i)** its resistance,

resistance = ..... Ω [2]

**(ii)** its power dissipation.

power = ..... W [2]

**(e)** Comment on your answers to **(c)** and **(d)(i)**.

.....

.....

.....[2]

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**2 Nov 06 P2 Q7**

**7** **(a)** Distinguish between the electromotive force (e.m.f.) of a cell and the potential difference (p.d.) across a resistor.

.....

.....

.....

..... [3]

**(b)** Fig. 7.1. is an electrical circuit containing two cells of e.m.f. $E_1$ and $E_2$.

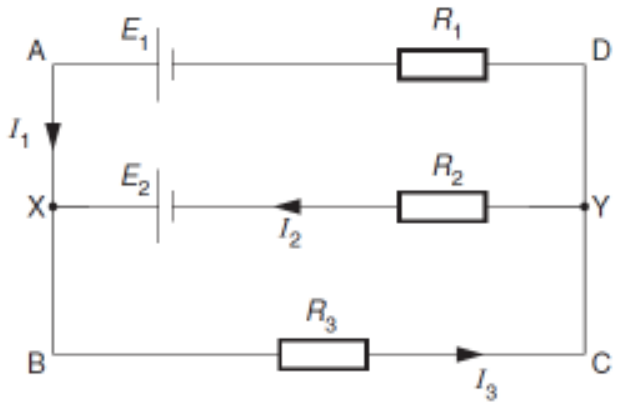


**Fig. 7.1**

The cells are connected to resistors of resistance $R_1$, $R_2$ and $R_3$ and the currents in the branches of the circuit are $I_1$, $I_2$ and $I_3$, as shown.

**(i)** Use Kirchhoff's first law to write down an expression relating $I_1$, $I_2$ and $I_3$.

..... [1]

**(ii)** Use Kirchhoff's second law to write down an expression relating

**1.** $E_2$, $R_2$, $R_3$, $I_2$ and $I_3$ in the loop XBCYX,

..... [1]

**2.** $E_1$, $E_2$, $R_1$, $R_2$, $I_1$ and $I_2$ in the loop AXYDA.

..... [1]

**3 June 07 P2 Q6**

6 A car battery has an internal resistance of 0.060Ω. It is re-charged using a battery charger having an e.m.f. of 14V and an internal resistance of 0.10Ω, as shown in Fig. 6.1.

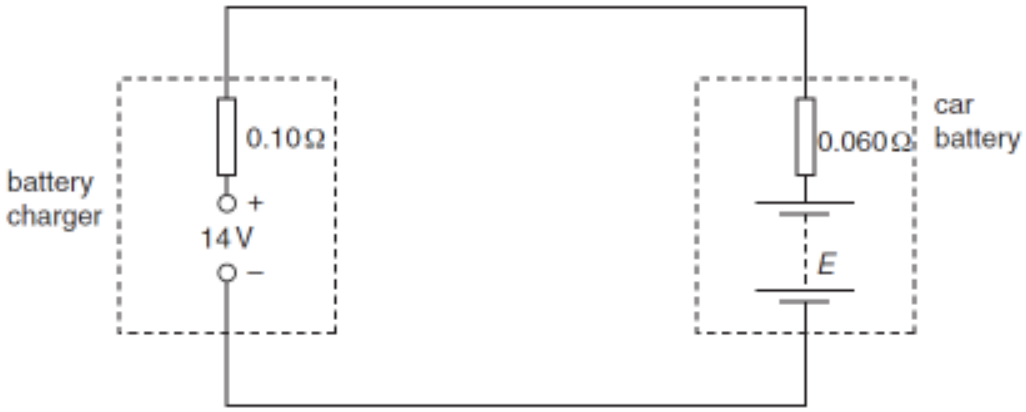


**Fig. 6.1**

**(a)** At the beginning of the re-charging process, the current in the circuit is 42A and the e.m.f. of the battery is *E* (measured in volts).

**(i)** For the circuit of Fig. 6.1, state

**1.** the magnitude of the total resistance,

resistance = ..... Ω

**2.** the total e.m.f. in the circuit. Give your answer in terms of *E*.

e.m.f. = ..... V

[2]

**(ii)** Use your answers to **(i)** and data from the question to determine the e.m.f. of the car battery at the beginning of the re-charging process.

e.m.f. = ..... V [2]

**(b)** For the majority of the charging time of the car battery, the e.m.f. of the car battery is 12V and the charging current is 12.5A. The battery is charged at this current for 4.0 hours. Calculate, for this charging time,

**(i)** the charge that passes through the battery,

charge = ..... C [2]

**(ii)** the energy supplied from the battery charger,

energy = ..... J [2]

**(iii)** the total energy dissipated in the internal resistance of the battery charger and the car battery.

energy = ..... J [2]

**(c)** Use your answers in **(b)** to calculate the percentage efficiency of transfer of energy from the battery charger to stored energy in the car battery.

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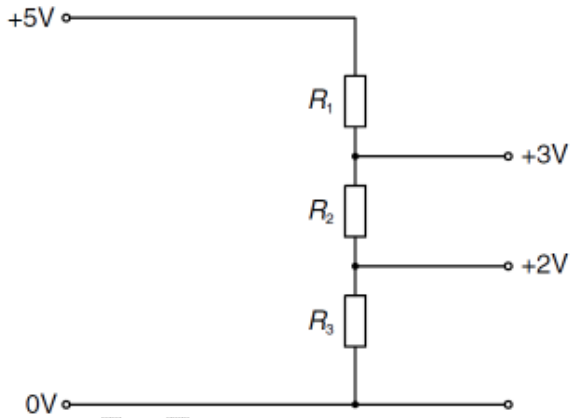
efficiency = ..... % [2]

# 20.3 Balanced potentials

**1 June 2002 P1 Q35

35 A potential divider is used to give outputs of 2 V and 3 V from a 5 V source, as shown.



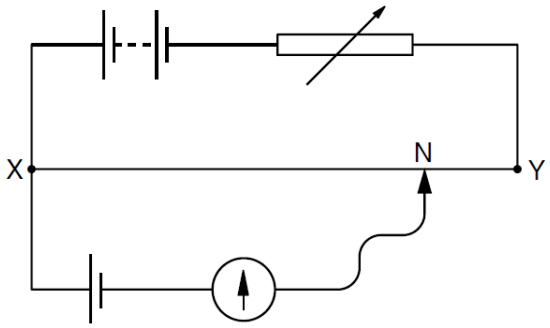

What are possible values for the resistances $R_1$, $R_2$ and $R_3$?

| | $R_1$/kΩ | $R_2$/kΩ | $R_3$/kΩ |
|---|---|---|---|
| **A** | 2 | 1 | 5 |
| **B** | 3 | 2 | 2 |
| **C** | 4 | 2 | 4 |
| **D** | 4 | 6 | 10 |

**1 June 2002 P1 Q35 C Apply potential divider principle, ratio of $R_2$ to ($R_1$ + $R_3$) = 1 to 4

***2 Nov 02 P1 Q35

35 In the potentiometer circuit below, the moveable contact is placed at N on the bare wire XY, such that the galvanometer shows zero deflection.



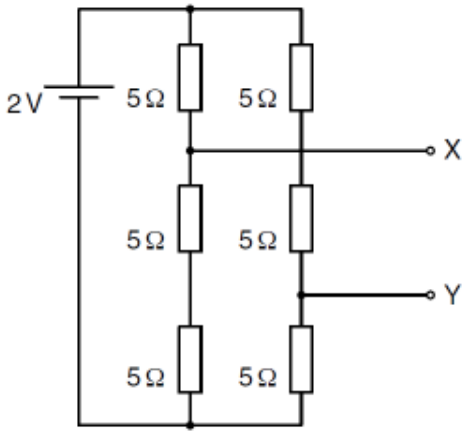

The resistance of the variable resistor is now increased.

What is the effect of this increase on the potential difference across the wire XY and on the position of the moveable contact for zero deflection?

| | potential difference across XY | position of moveable contact |
|---|---|---|
| **A** | increases | nearer to X |
| **B** | increases | nearer to Y |
| **C** | decreases | nearer to X |
| **D** | decreases | nearer to Y |

*****3 Nov 02 P1 Q36**

**36** Six resistors, each of resistance 5 Ω, are connected to a 2 V cell of negligible internal resistance.

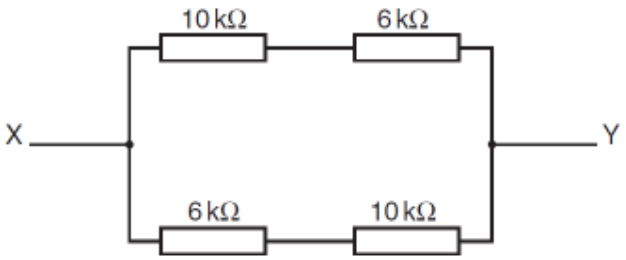



What is the potential difference between terminals X and Y?

**A** $\frac{2}{3}$ V **B** $\frac{8}{9}$ V **C** $\frac{4}{3}$ V **D** 2 V

***4 June 03 P1 Q33**

**33** The diagram shows an arrangement of four resistors.

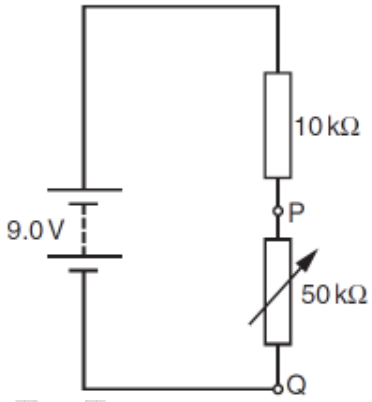



What is the resistance between X and Y?

**A** 4 kΩ **B** 8 kΩ **C** 16 kΩ **D** 32 kΩ

****5 June 03 P1 Q34**

**34** The diagram shows a potential divider connected to a 9.0 V supply of negligible internal resistance.




What range of voltages can be obtained between P and Q?

**A** zero to 1.5 V

**B** zero to 7.5 V

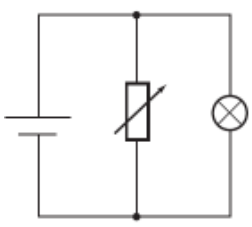
**C** 1.5 V to 7.5 V

**D** 1.5 V to 9.0 V

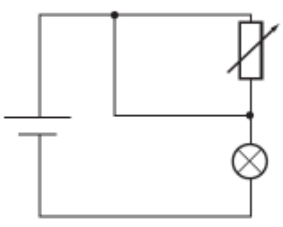
*****6 Nov 03 P1 Q33**

**33** Which diagram shows a potential divider circuit that can vary the voltage across the lamp?

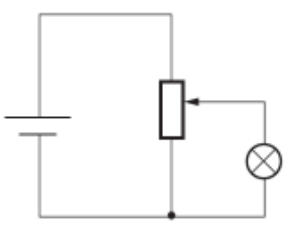
**A**



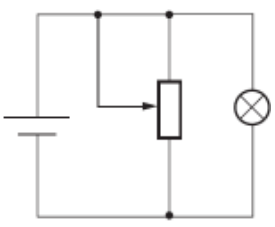
**B**



**C**

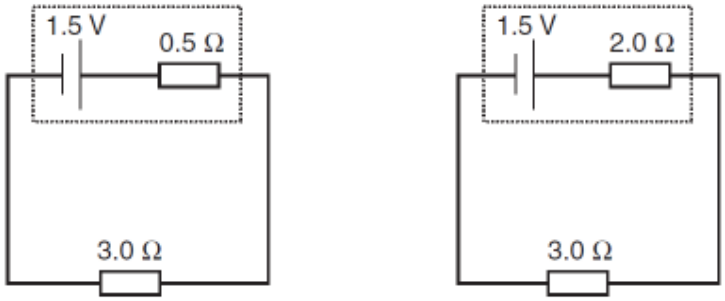


**D**



**7 Nov 03 P1 Q34

**34** The diagram shows two circuits. In these circuits, only the internal resistances differ.

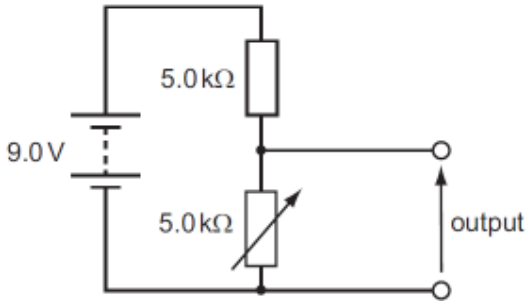



Which line in the table is correct?

| | potential difference across 3.0 Ω resistor | power dissipated in 3.0 Ω resistor |
|---|---|---|
| **A** | greater in X than in Y | less in X than in Y |
| **B** | greater in X than in Y | greater in X than in Y |
| **C** | less in X than in Y | less in X than in Y |
| **D** | less in X than in Y | greater in X than in Y |

**8 Nov 04 P1 Q36

**36** The diagram shows a potential divider circuit designed to provide a variable output p.d.

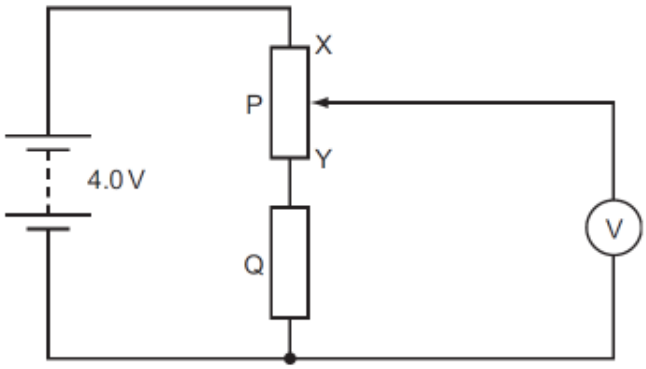



Which gives the available range of output p.d?

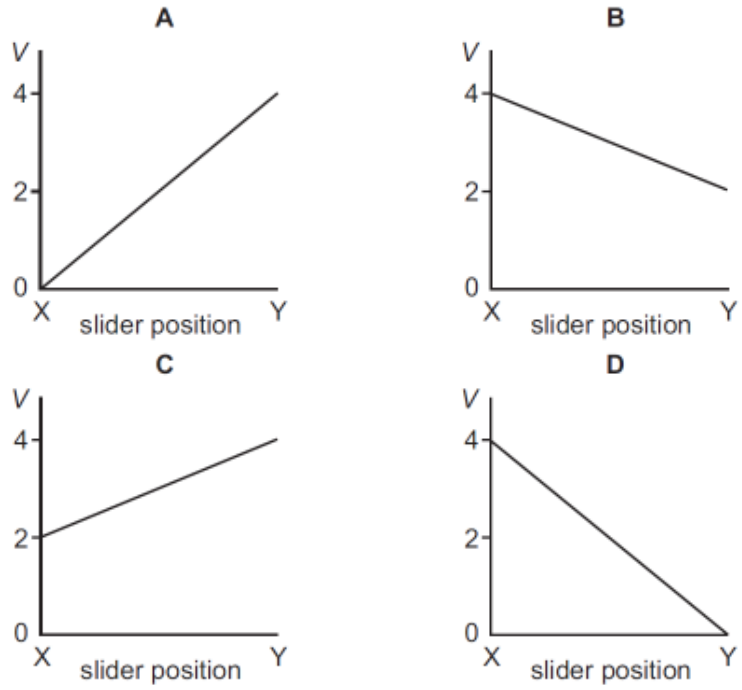
| | maximum output | minimum output |
|---|---|---|
| **A** | 3.0 V | 0 |
| **B** | 4.5 V | 0 |
| **C** | 9.0 V | 0 |
| **D** | 9.0 V | 4.5 V |

*****9 June 05 P1 Q37**

**37** 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.

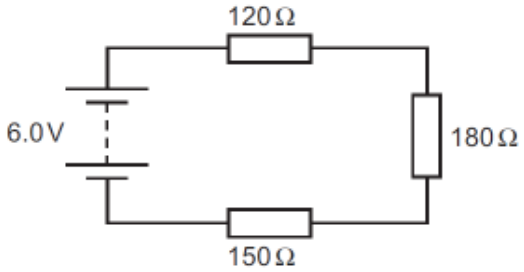



Which graph is obtained?




****10 Nov 05 P1 Q36**

**36** Three resistors are connected in series with a battery as shown in the diagram. The battery has negligible internal resistance.

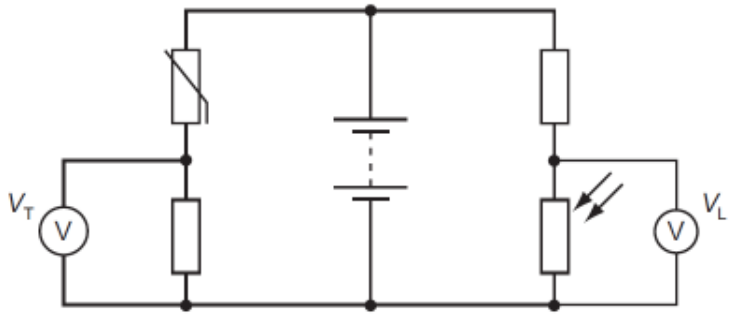



What is the potential difference across the 180 Ω resistor?

**A** 1.6 V **B** 2.4 V **C** 3.6 V **D** 6.0 V

*****11 Nov 05 P1 Q37**

**37** In the circuit below, the reading $V_T$ on the voltmeter changes from high to low as the temperature of the thermistor changes. The reading $V_L$ on the voltmeter changes from high to low as the level of light on the light-dependent resistor (LDR) changes.



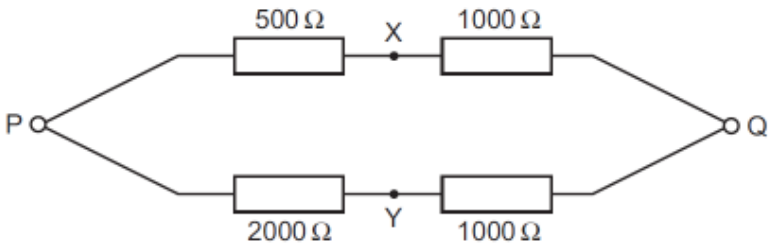

The readings on $V_T$ and $V_L$ are both high.

What are the conditions of temperature and light level?

| | temperature | light level |
|---|---|---|
| **A** | low | low |
| **B** | low | high |
| **C** | high | low |
| **D** | high | high |

*****12 June 06 P1 Q33**

**33** A p.d. of 12 V is connected between P and Q.

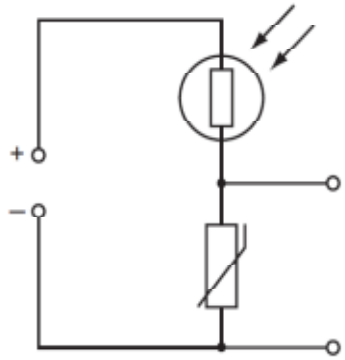


What is the p.d. between X and Y?

**A** 0 V **B** 4 V **C** 6 V **D** 8 V

****13 June 06 P1 Q37**

**37** The diagram shows a light-dependent resistor (LDR) and a thermistor forming a potential divider.

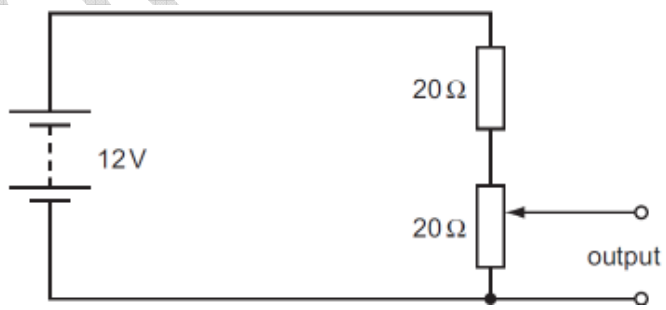



Under which set of conditions will the potential difference across the thermistor have the greatest value?

| | illumination | temperature |
|---|---|---|
| **A** | low | low |
| **B** | high | low |
| **C** | low | high |
| **D** | high | high |

****14 Nov 06 P1 Q34**

**34** 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

***15 Nov 06 P1 Q35**

**35** The resistance of a device is designed to change with temperature.

What is the device?

**A** a light-dependent resistor

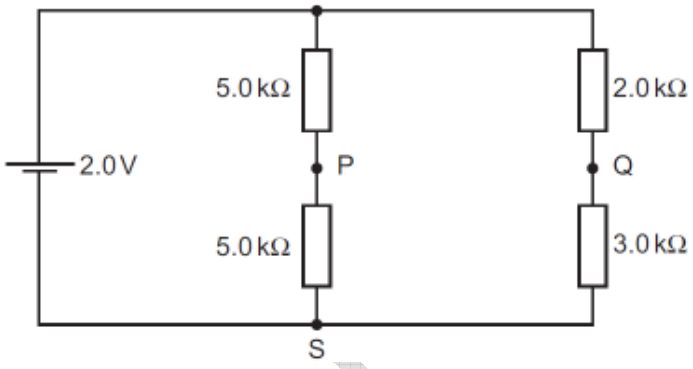
**B** a potential divider

**C** a semiconductor diode

**D** a thermistor

****16 June 07 P1 Q33**

**33** A cell of e.m.f. 2.0 V and negligible internal resistance is connected to the network of resistors shown.



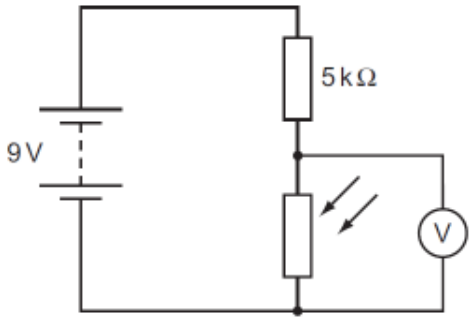

$V_1$ is the potential difference between S and P. $V_2$ is the potential difference between S and Q.

What is the value of $V_1 - V_2$?

**A** +0.50 V **B** +0.20 V **C** –0.20 V **D** –0.50 V

****17 June 07 P1 Q34**

**34** A circuit is set up with an LDR and a fixed resistor as shown.




The voltmeter reads 4 V.

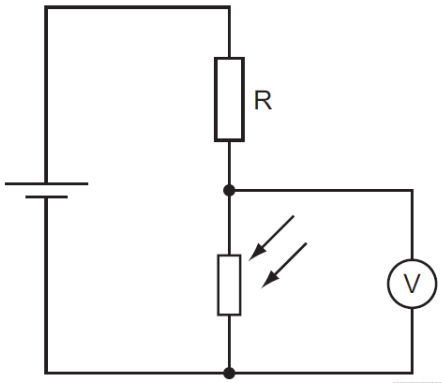
The light intensity is increased.

What is a possible voltmeter reading?

**A** 3 V **B** 4 V **C** 6 V **D** 8 V

**18 Nov 07 P1 Q32

32 A potential divider consists of a fixed resistor R and a light-dependent resistor (LDR).




What happens to the voltmeter reading, and why does it happen, when the intensity of light on the LDR increases?

**A** The voltmeter reading decreases because the LDR resistance decreases.

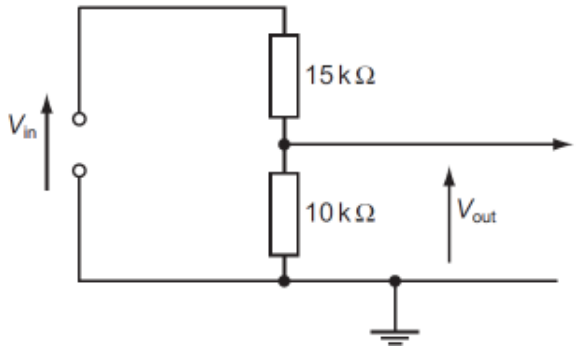
**B** The voltmeter reading decreases because the LDR resistance increases.

**C** The voltmeter reading increases because the LDR resistance decreases.

**D** The voltmeter reading increases because the LDR resistance increases.

**19 Nov 07 P1 Q33

33 The circuit is designed to trigger an alarm system when the input voltage exceeds some preset value. It does this by comparing $V_{out}$ with a fixed reference voltage, which is set at 4.8V.



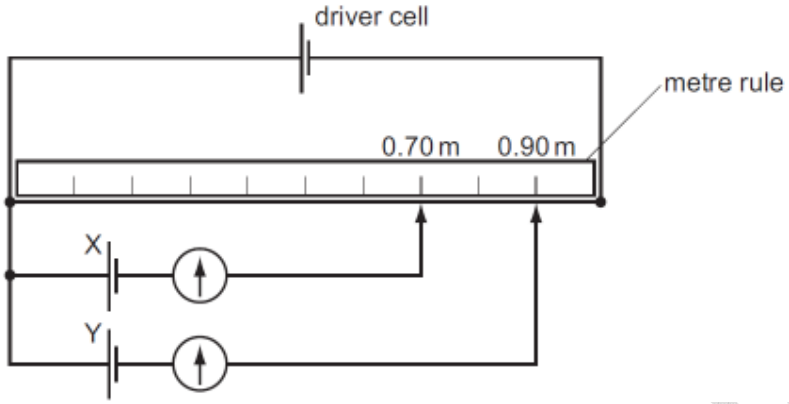

$V_{out}$ is equal to 4.8V.

What is the input voltage $V_{in}$?

**A** 4.8V **B** 7.2V **C** 9.6V **D** 12V

**20 Nov 07 P1 Q34

34 A potentiometer is used as shown to compare the e.m.f.s of two cells.




The balance points for cells X and Y are 0.70 m and 0.90 m respectively.

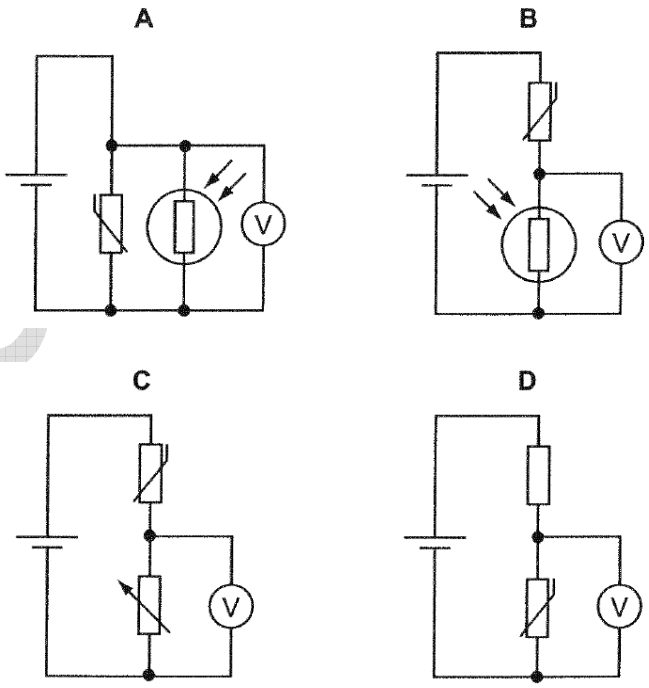
If the e.m.f. of cell X is 1.1 V, what is the e.m.f. of cell Y?

**A** 0.69 V **B** 0.86 V **C** 0.99 V **D** 1.4 V

*****21 June 08 P1 Q36**

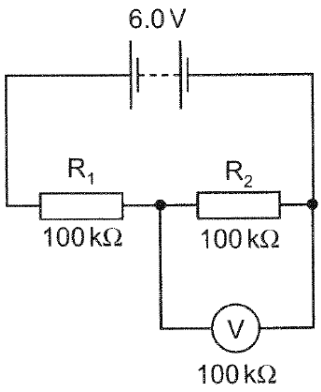
**36** A thermistor and another component are connected to a constant voltage supply. A voltmeter is connected across one of the components. The temperature of the thermistor is then reduced but no other changes are made.

In which circuit will the voltmeter reading increase?




****22 June 08 P1 Q37**

**37** In the circuit shown, the 6.0 V battery has negligible internal resistance. Resistors $R_1$ and $R_2$ and the voltmeter have resistance 100 kΩ.




What is the current in the resistor $R_2$?

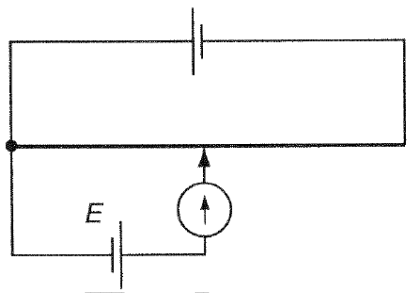
**A** 20 μA **B** 30 μA **C** 40 μA **D** 60 μA

***23 June 08 P1 Q38**

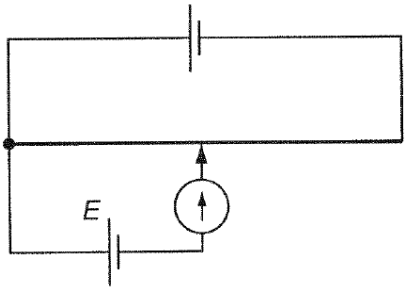
**38** The unknown e.m.f. *E* of a cell is to be determined using a potentiometer circuit. The balance length is to be measured when the galvanometer records a null reading.

What is the correct circuit to use?

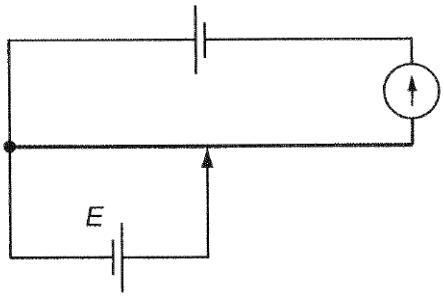
**A**



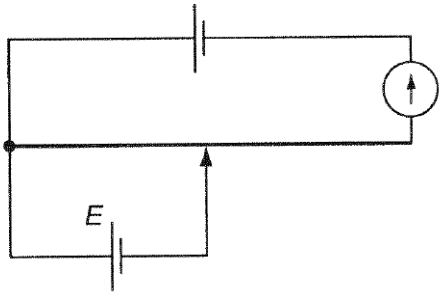

**B**




**C**

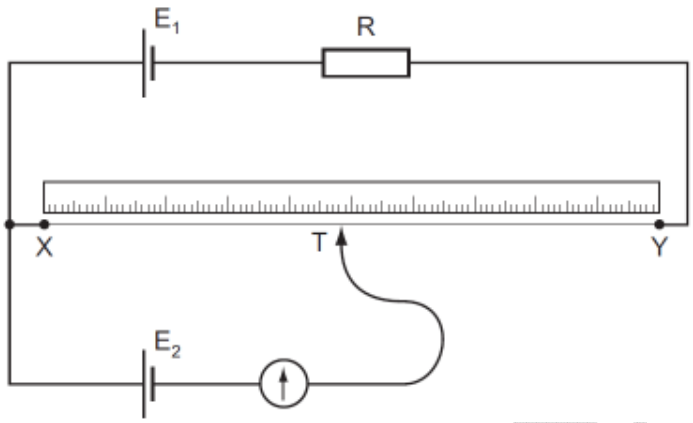



**D**



**24 Nov 08 P1 Q37

37 The diagram shows a potentiometer circuit.




The contact T is placed on the wire and moved along the wire until the galvanometer reading is zero. The length XT is then noted.

In order to calculate the potential difference per unit length on the wire XY, which value must also be known?

**A** the e.m.f. of the cell $E_1$

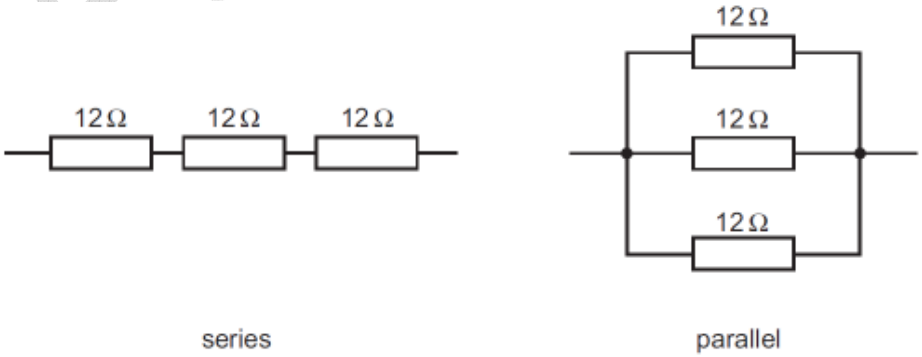
**B** the e.m.f. of the cell $E_2$

**C** the resistance of resistor R

**D** the resistance of the wire XY

**25 June 09 P1 Q34

34 Six identical 12 Ω resistors are arranged in two groups, one with three in series and the other with three in parallel.



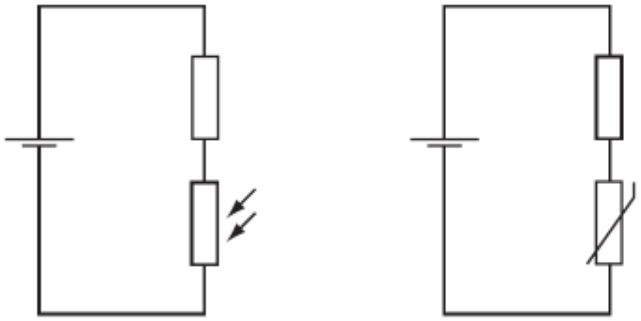

series parallel

What are the combined resistances of each of these two arrangements?

| | series | parallel |
|---|---|---|
| **A** | 4.0 Ω | 0.25 Ω |
| **B** | 4.0 Ω | 36 Ω |
| **C** | 36 Ω | 0.25 Ω |
| **D** | 36 Ω | 4.0 Ω |

****26 June 09 P1 Q35**

**35** The diagrams show a light-dependent resistor in circuit P, and a thermistor in circuit Q.



circuit P circuit Q

How does the potential difference across the fixed resistor in each circuit change when both the brightness of the light on the light-dependent resistor and the temperature of the thermistor are increased?

| | circuit P | circuit Q |
|---|---|---|
| **A** | decrease | decrease |
| **B** | decrease | increase |
| **C** | increase | decrease |
| **D** | increase | increase |

# Section B

**1 June 04 P2 Q8**

**8** A thermistor has resistance 3900 Ω at 0 °C and resistance 1250 Ω at 30 °C. The thermistor is connected into the circuit of Fig. 8.1 in order to monitor temperature changes.

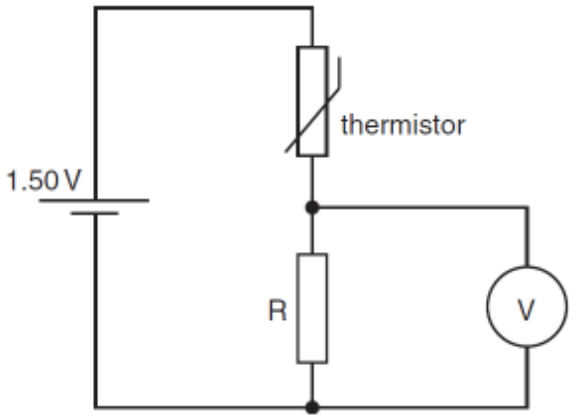



**Fig. 8.1**

The battery of e.m.f. 1.50 V has negligible internal resistance and the voltmeter has infinite resistance.

**(a)** The voltmeter is to read 1.00 V at 0 °C. Show that the resistance of resistor R is 7800 Ω.

[2]

**(b)** The temperature of the thermistor is increased to 30 °C. Determine the reading on the voltmeter.

reading = ..... V [2]

**(c)** The voltmeter in Fig. 8.1 is replaced with one having a resistance of 7800 Ω.
Calculate the reading on this voltmeter for the thermistor at a temperature of 0 °C.

Leong Yee Pak

reading = ..... V [2]

**2 Nov 2005 P2 Q7**

7 A battery of e.m.f. 4.50 V and negligible internal resistance is connected in series with a fixed resistor of resistance 1200 Ω and a thermistor, as shown in Fig. 7.1.

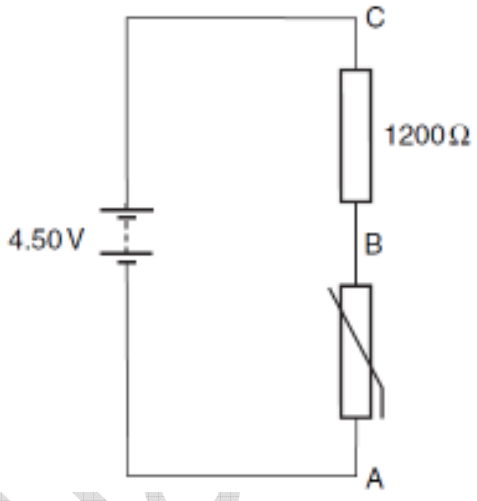



**Fig. 7.1**

**(a)** At room temperature, the thermistor has a resistance of 1800 Ω. Deduce that the potential difference across the thermistor (across AB) is 2.70 V.

[2]

**(b)** A uniform resistance wire PQ of length 1.00 m is now connected in parallel with the resistor and the thermistor, as shown in Fig. 7.2.

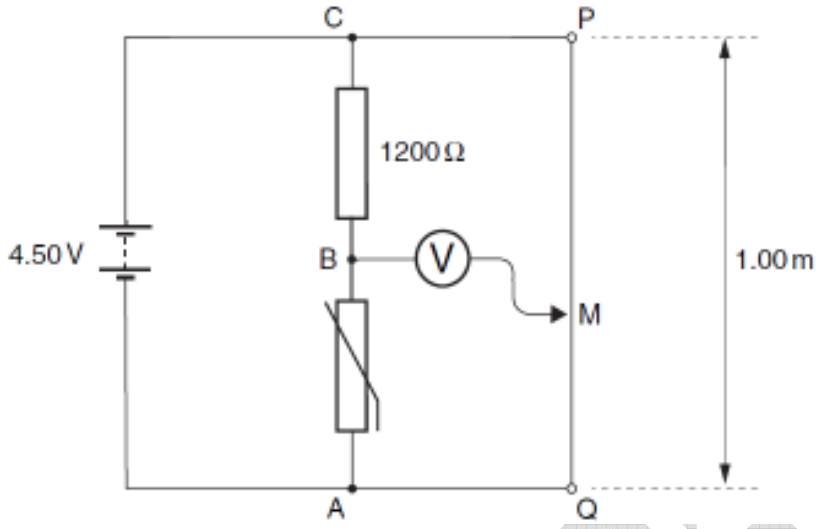



**Fig. 7.2**

A sensitive voltmeter is connected between point B and a moveable contact M on the wire.

**(i)** Explain why, for constant current in the wire, the potential difference between any two points on the wire is proportional to the distance between the points.

.....

.....

.....[2]

**(ii)** The contact M is moved along PQ until the voltmeter shows zero reading.

**1.** State the potential difference between the contact at M and the point Q.

potential difference = ..... V [1]

**2.** Calculate the length of wire between M and Q.

length = ..... cm [2]

**(iii)** The thermistor is warmed slightly. State and explain the effect on the length of wire between M and Q for the voltmeter to remain at zero deflection.

.....

.....

.....[2]

**3 Nov08 P2 Q7**

**7** A potential divider circuit consists of two resistors of resistances $P$ and $Q$, as shown in Fig. 7.1.

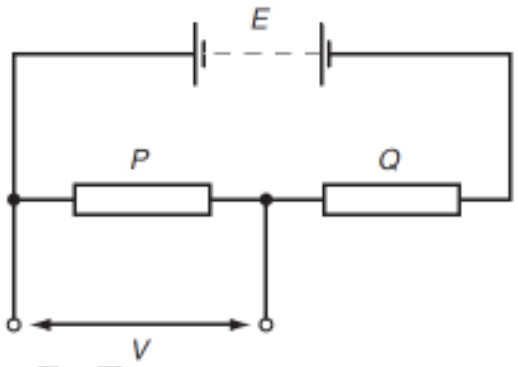



**Fig. 7.1**

The battery has e.m.f. $E$ and negligible internal resistance.

**(a)** Deduce that the potential difference $V$ across the resistor of resistance $P$ is given by the expression

$$V = \frac{P}{P+Q} E.$$

[2]

**(b)** The resistances *P* and *Q* are 2000 Ω and 5000 Ω respectively.
A voltmeter is connected in parallel with the 2000 Ω resistor and a thermistor is connected in parallel with the 5000 Ω resistor, as shown in Fig. 7.2.

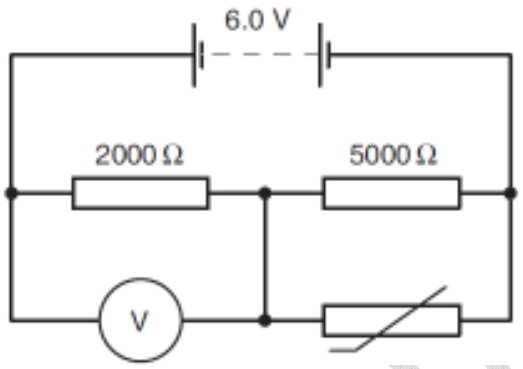



**Fig. 7.2**

The battery has e.m.f. 6.0V. The voltmeter has infinite resistance.

**(i)** State and explain qualitatively the change in the reading of the voltmeter as the temperature of the thermistor is raised.

.....

.....

.....

..... [3]

**(ii)** The voltmeter reads 3.6V when the temperature of the thermistor is 19 °C.
Calculate the resistance of the thermistor at 19 °C.

resistance = ..... Ω [4]

**4 June 09 P2 Q7**

**7 (a)** A network of resistors, each of resistance $R$, is shown in Fig. 7.1.

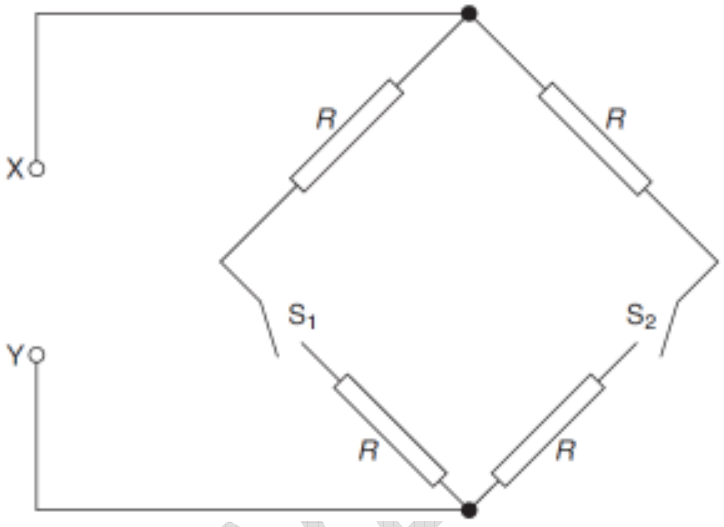



**Fig. 7.1**

Switches $S_1$ and $S_2$ may be 'open' or 'closed'.

Complete Fig. 7.2 by calculating the resistance, in terms of $R$, between points X and Y for the switches in the positions shown.

| switch $S_1$ | switch $S_2$ | resistance between points X and Y |
|---|---|---|
| open | open | ..... |
| open | closed | ..... |
| closed | closed | ..... |

**Fig. 7.2**

[3]

**(b)** Two cells of e.m.f. $E_1$ and $E_2$ and negligible internal resistance are connected into a network of resistors, as shown in Fig. 7.3.

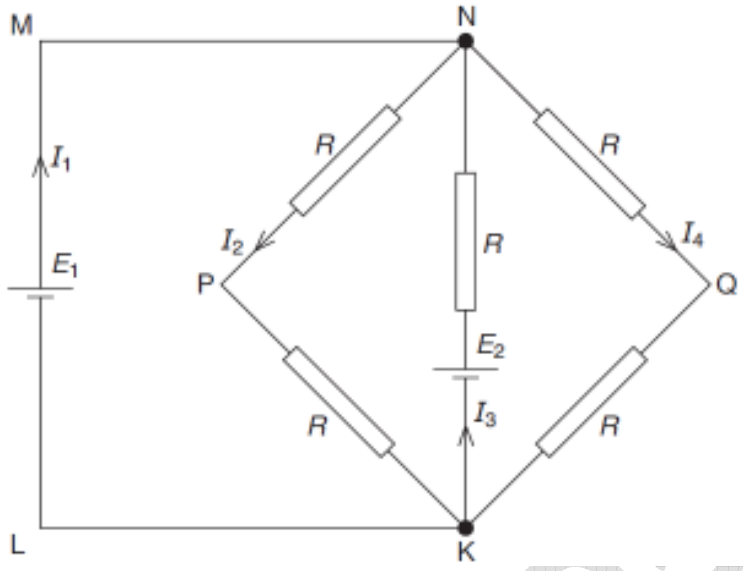



**Fig. 7.3**

The currents in the network are as indicated in Fig. 7.3.

Use Kirchhoff's laws to state the relation

**(i)** between currents $I_1$, $I_2$, $I_3$ and $I_4$,

.....[1]

**(ii)** between $E_1$, $E_2$, $R$, and $I_3$ in loop NKLMN,

.....[1]

**(iii)** between $E_2$, $R$, $I_3$ and $I_4$ in loop NKQN.

.....[1]