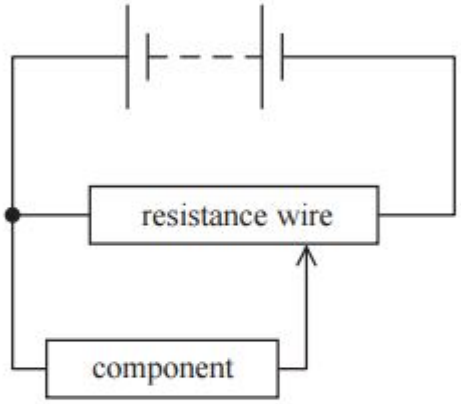
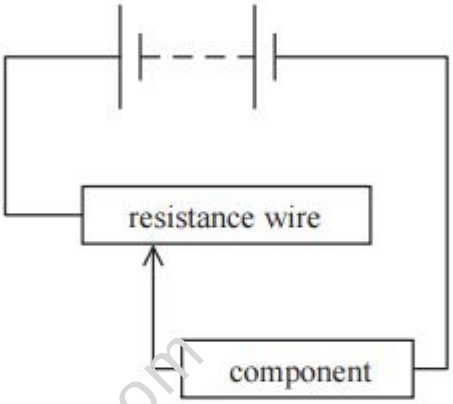
1 A student is investigating the relationship between current and potential difference (p.d.) for a component. He does not have access to a power supply which can apply a varying p.d. He decides to use a length of resistance wire to control the p.d. applied across the component.

(a) The student could use the wire to set up a potential divider or as a variable resistor in series with the component.



Potential divider circuit



Variable resistor circuit

State the advantage of using the potential divider circuit.

(1)

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(b) The student uses a wire of resistance 24 Ω.
Calculate the diameter of the wire.

resistivity of wire = 1.2×10^{-6} Ω m
length of wire = 50 cm

(3)

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Diameter = ...

(c) Another potential divider of length 40.0 cm and resistance 50.0 Ω has a p.d. of 12.0 V applied across its length.

The p.d. is measured across 7.16 cm of the wire.

Calculate this p.d.

(2)

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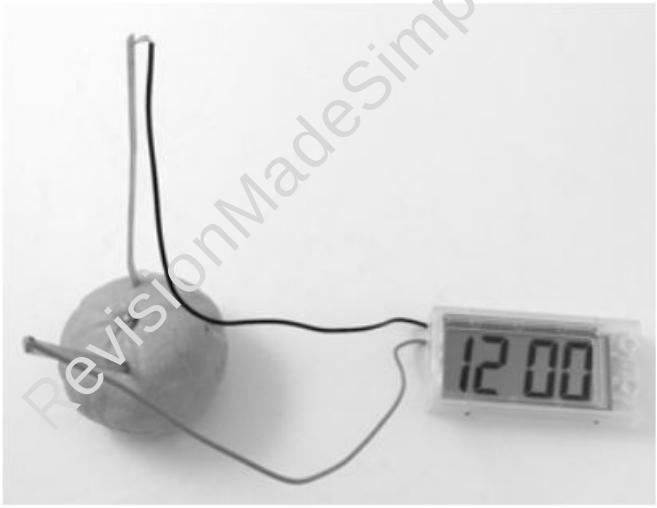
p.d. = ...

2 An orange cell is made by inserting magnesium and copper electrodes into an orange. The orange cell acts as a source of e.m.f. which can be used to power a clock as shown.



The following measurements are obtained from the circuit.

e.m.f. / V	1.79
p.d. across clock / V	1.72
current in clock / μA	4.20

(a) Show that the internal resistance of the orange cell is about 20 kΩ.

(3)

(b) Calculate the output power of the cell when it is used to power the clock.

(2)

Power = ...

(c) The e.m.f. measurement was obtained by removing the clock and connecting a voltmeter with a resistance of 1.0×10^7 Ω across the electrodes.

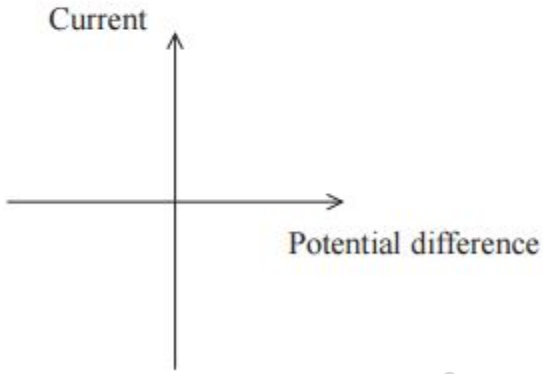
Discuss the suitability of this method.

(4)

3 Thermistors are semiconductor devices that can be used in control circuits. The resistance of a thermistor depends on its temperature.

(a) Sketch a graph on the axes below to show how current varies with applied potential difference for a negative temperature coefficient thermistor.

(2)



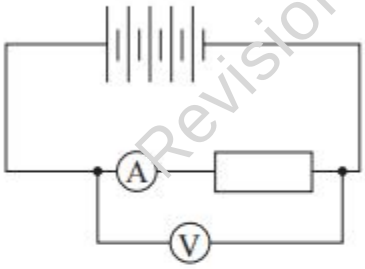
*(b) Explain why the resistance of a negative temperature coefficient thermistor changes as the potential difference is increased.

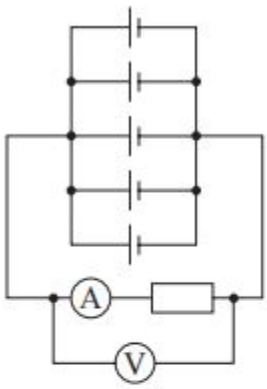
(4)

4 The photograph shows a type of fish called an electric ray. Electric rays can produce an electric discharge to stun their prey.

Parts of a ray's body act as cells in a battery. In a ray living in fresh water the cells are arranged in series, but for a ray living in salt water the cells are arranged in parallel.

(a) The cell arrangement in rays can be investigated by comparing a circuit containing five cells in series with a circuit containing five cells in parallel. Each arrangement of cells is connected across a range of load resistors and the current and terminal potential difference (p.d.) are measured, as shown in the diagram.





(i) The results for current are shown in the table.

Load resistance / Ω	Current in series arrangement / A	Current in parallel arrangement / A
0.1	2.7	7.2
1	2.0	1.3
10	0.55	0.14

It has been suggested that the cells are in series for a ray living in fresh water because fresh water is a poorer conductor of electricity than salt water.

Discuss whether the results support this suggestion.

(2)

(ii) Calculate the internal resistance of one cell using the following results for five cells in series. The e.m.f. of the five cells together is 6.9 V.

Load resistance / Ω	Terminal p.d. / V	Current / A
2.2	3.3	1.5

(3)

Internal resistance = ...

(iii) Explain why the voltmeter should only be connected directly across the load resistor if the ammeter has negligible resistance.

(2)

5 The e.m.f. of an alkaline cell marked 1.5 V is measured with a high resistance voltmeter and found to be 1.54 V.

Explain why the voltmeter used must have a high resistance.

(2)

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