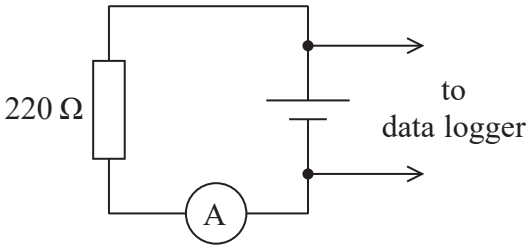
2 A student is investigating how the internal resistance of a dry cell varies over time. She sets up the circuit shown to draw current from the cell.



The student proposes to use a data logger to monitor the terminal potential difference (p.d.) of the cell over a period of time.

(a) State why a data logger would be suitable to collect data in this investigation.

(1)

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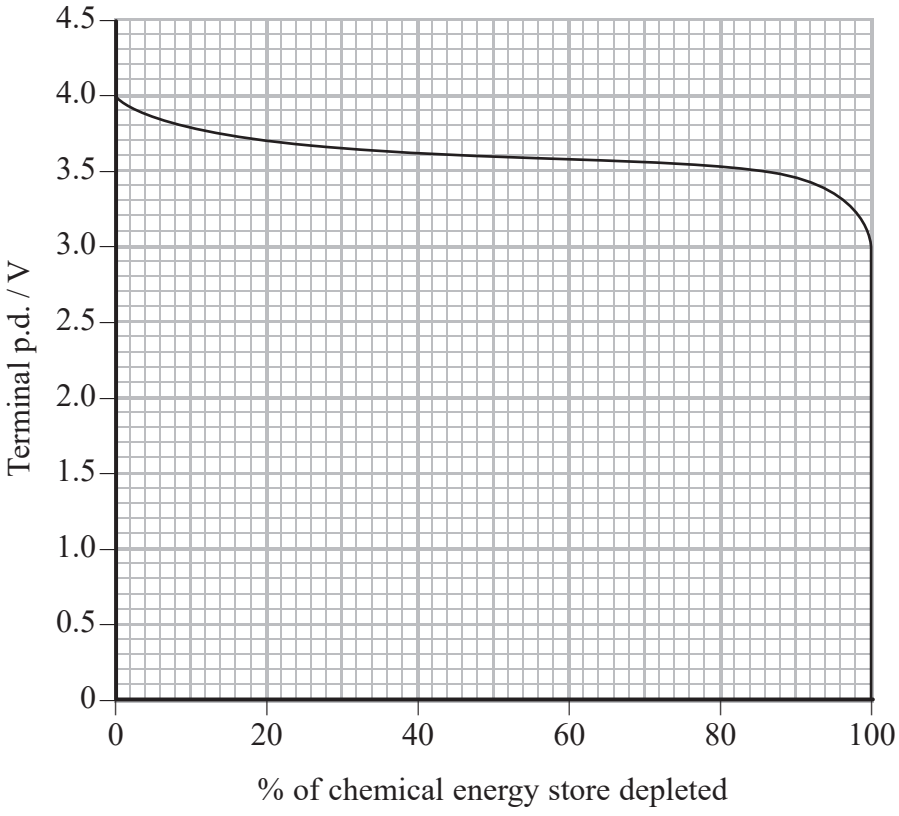
.....

(b) The graph shows how the terminal p.d. varies as the chemical energy store in the cell is depleted.



(i) Explain, using the graph, why the current drawn from the cell decreases as the chemical energy store in the cell is depleted.

(2)

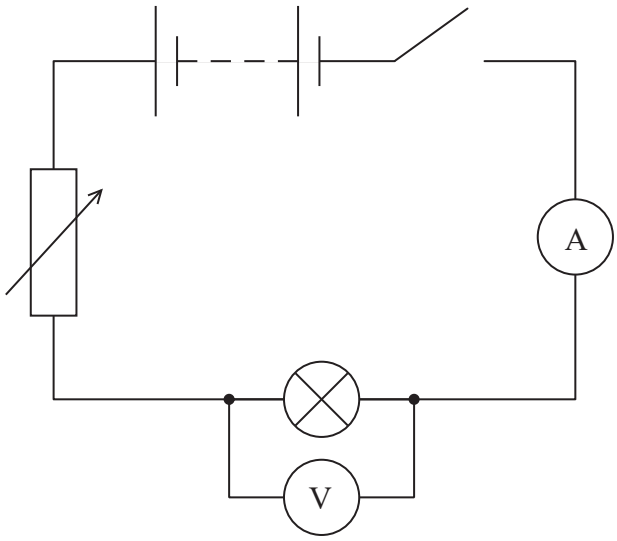
(ii) Determine the internal resistance of the cell when its chemical energy store is 80% depleted. Assume that the e.m.f. of the cell remains constant at 4.0 V.

(3)

Internal resistance = ...

(Total for Question 2 = 6 marks)

4 A student set up the circuit shown and measured the current I through the filament lamp for a range of values of potential difference (p.d.) V.



The student's data is shown in the table.

V / V	I / A
3.0	0.6
4.0	0.75
6.0	1.00
8.0	1.20
10.0	1.35
12.0	1.5

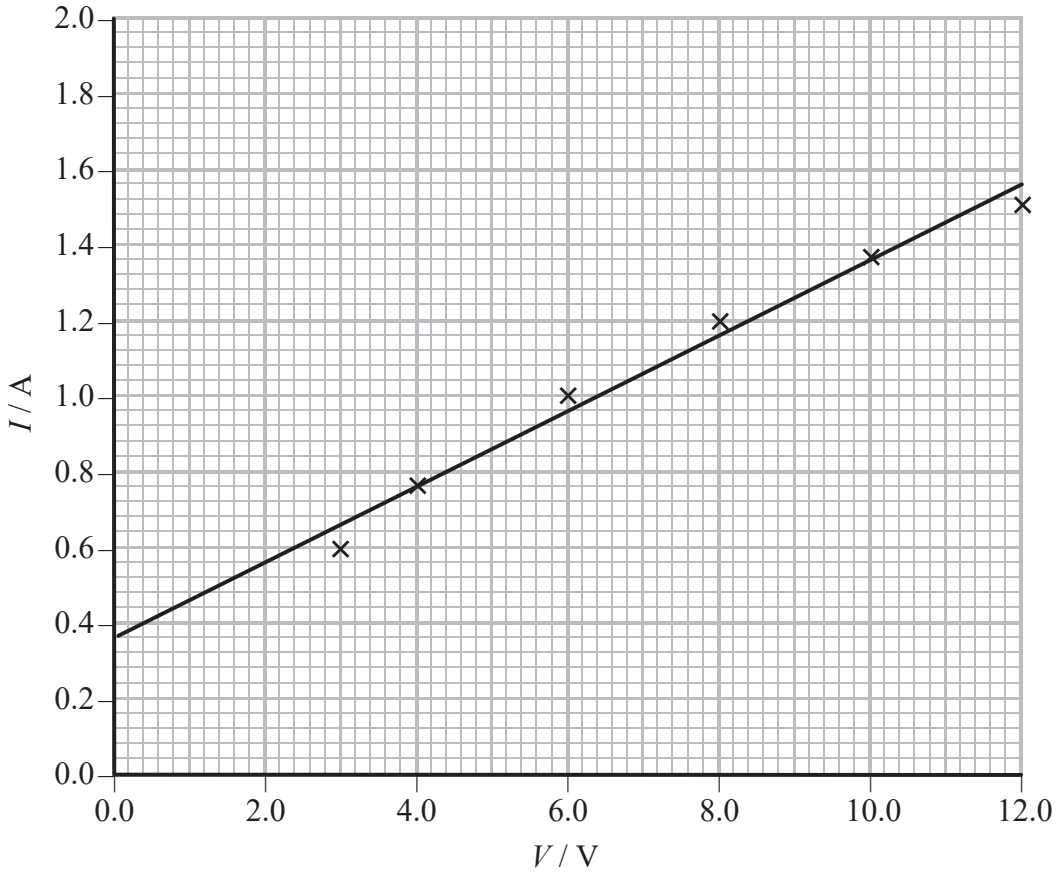
(a) Criticise the student's recording of the data.

(1)

.....

.....

(b) The student drew a graph of how current varies with p.d. She drew a straight line on the graph and claimed that the data demonstrates that the filament lamp obeys Ohm's law because the graph is linear.



Assess the validity of the student's statement.

(4)

(c) Using the circuit shown the student was unable to obtain data for p.d.s less than 2.5 V.

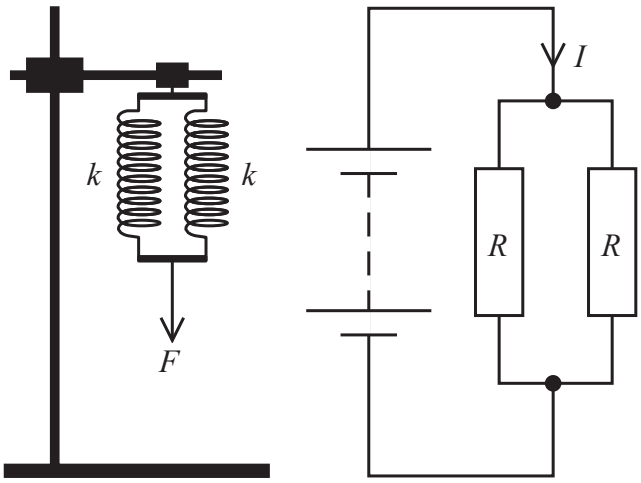
Draw a diagram of a circuit the student could have used to enable a full range of p.d.s from 0 to 12 V to be investigated.

(2)

(Total for Question 4 = 7 marks)

6 A student is experimenting with different combinations of springs and recalls that in physics it is often possible to model different physical situations in similar ways.

The student suggests that a parallel combination of springs could be a model for a parallel combination of resistors in a circuit.



(a) Derive an expression for the effective resistance R_{eff} of two resistors R_1 and R_2 connected in parallel in a circuit.

(3)

(b) Assess the validity of the student's suggestion by considering the effective stiffness of two identical springs in parallel.

(6)

(Total for Question 6 = 9 marks)

5 The photograph shows a statue of Buddha in Sri Lanka, which is protected by a lightning conductor.

(a) During a storm, a potential difference of 2.7 MV was generated between a cloud and the top of the lightning conductor on the statue. A flash of lightning passed between the cloud and the lightning conductor, producing a current of 25 kA for a time of 7.5 ms.

Calculate the energy transferred by the lightning strike.

(3)

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.....

Energy transferred = ...

(b) The lightning conductor is a length of copper wire with a diameter of 1.2×10^{-2} m and a resistance of 4.3×10^{-3} Ω. It runs along the back of the statue from the base to a height of 1.5 m above the top of the statue.

A guidebook claims that the statue is over 30 m high.

Assess the validity of this claim.

resistivity of copper = 1.7×10^{-8} Ω m

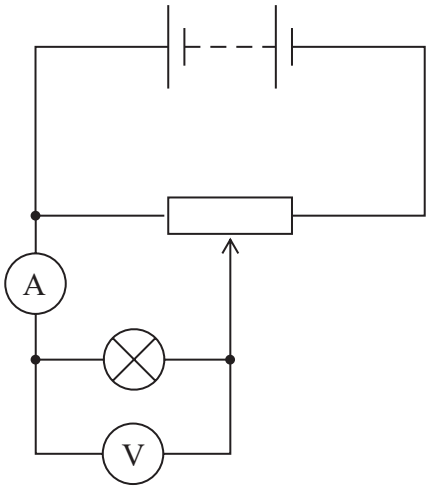
(4)

(c) Give a reason why the lightning conductor should be taller than the statue.

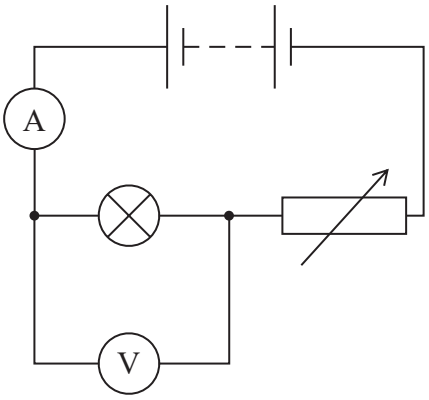
(1)

(Total for Question 5 = 8 marks)

9 A student is planning to collect data to produce a current-potential difference graph for a filament lamp. Her teacher suggests two circuits that she could use.



Circuit 1



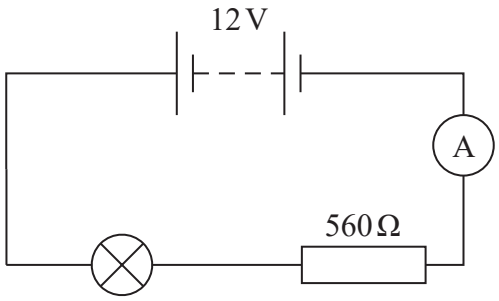
Circuit 2

Circuit 1 uses a potential divider and circuit 2 uses a variable resistor to vary the potential difference across the filament lamp.

*(a) Discuss the suitability of each circuit to collect the data.

(6)

(b) The student sets up the following circuit with the filament lamp. The battery has negligible internal resistance.



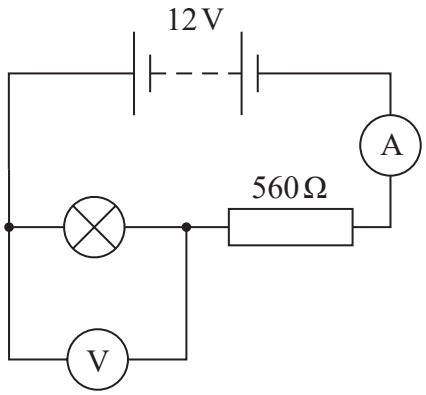
(i) The reading on the ammeter is 17.5 mA.

Calculate the value of the potential difference (p.d.) across the filament lamp.

(2)

p.d. across filament lamp = ...

(ii) When a voltmeter with a resistance of 1.5 kΩ is connected as shown, the p.d. across the filament lamp decreases.

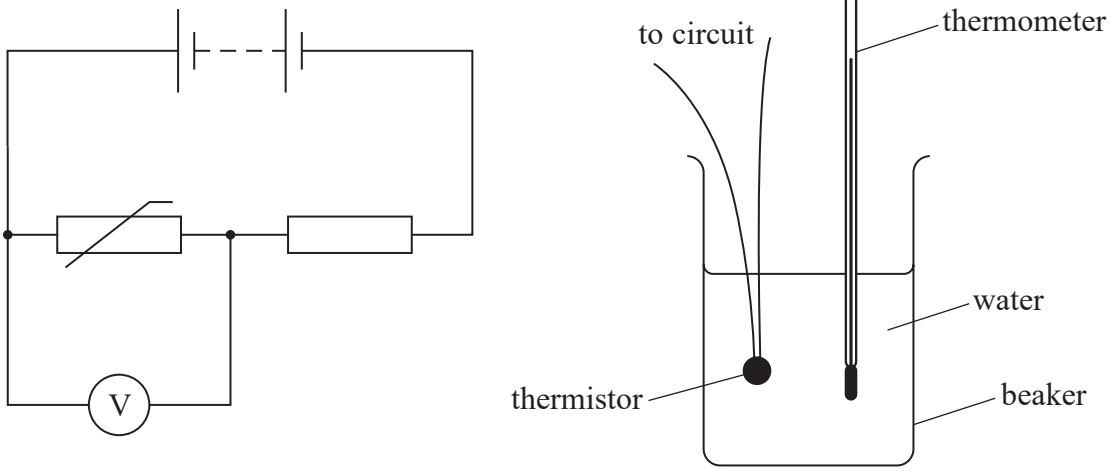


Explain why the p.d. across the filament lamp decreases.

(3)

(Total for Question 9 = 11 marks)

11 A student carried out an experiment to calibrate a thermistor. She connected the thermistor in series with a resistor and a power supply as shown. Then she placed the thermistor in a beaker of hot water and used a thermometer to record the temperature θ of the water.



The student recorded θ and corresponding values of the reading V on the voltmeter as the water cooled.

(a) Explain, making reference to charge carriers, why V increased as the water cooled.

(3)

(b) Over a limited temperature range V varies with θ according to the expression

$$V = V_0 e^{-b\theta}$$

where b and V_0 are constants.

(i) Explain why a graph of $\ln V$ against θ would give a straight line.

(2)

(ii) The student's data is shown in the table below.

θ/°C	V/V	
89.0	1.9	
74.0	2.9	
53.5	4.9	
32.5	9.1	
18.5	12.6	
3.5	18.7	

Plot a graph of $\ln V$ against θ on the grid opposite. Use the column provided to show any processed data.

(5)

(iii) Determine values for b and V_0.

(4)

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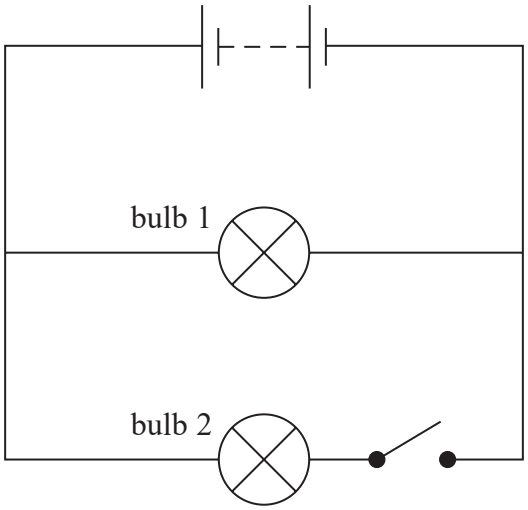
$b =$ .....

$V_0 =$ .....

(Total for Question 11 = 14 marks)

2 A battery has an e.m.f. of 12 V and an internal resistance of 0.50 Ω. The battery is connected into a circuit, as shown.



Each bulb has a normal working power of 40 W when a potential difference (p.d.) of 12 V is applied.

(a) Initially the switch is open.

Calculate the terminal p.d. of the battery when bulb 1 is lit. Assume that the resistance of the bulb has its normal working value.

(4)

Terminal p.d. of battery = ...

(b) Explain how the brightness of bulb 1 changes when the switch is closed. No further calculations are necessary.

(3)

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(Total for Question 2 = 7 marks)