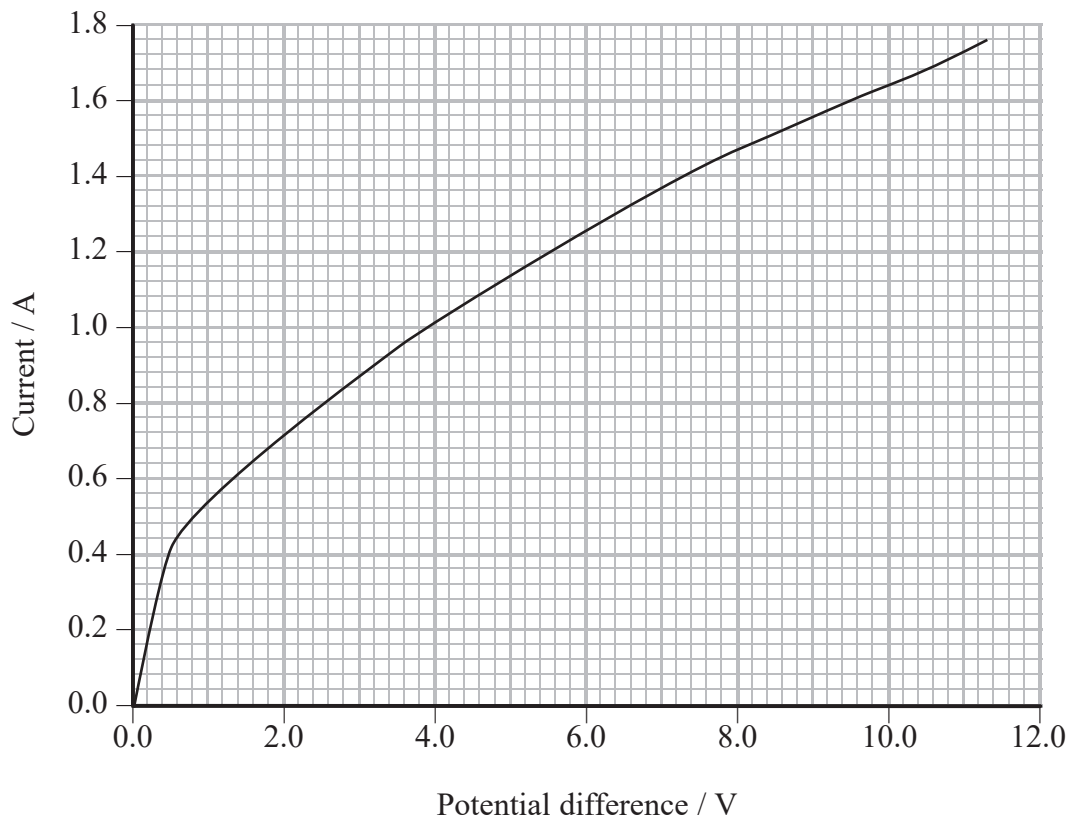**1** A student investigates how the current through a filament light bulb varies with the potential difference across it.

(a) Draw a diagram of a circuit the student could use to obtain suitable measurements for a range of potential difference from 0 V to 12 V.

(3)

(b) The student's results are shown on the graph.

The student decides to draw a tangent to the curve at a potential difference of 6 V and use the gradient of the tangent to determine the resistance of the bulb.

(i) Explain why this is **not** a correct method to determine the resistance.

(2)

(ii) Calculate the resistance of the bulb when the potential difference across it is 6 V.

(2)

Resistance =

*(c) Describe and explain the change in the resistance of the bulb as the potential difference across it is increased.

(4)

(Total for Question = 11 marks)

2 The viscosity of paint determines how smoothly and easily the paint can be applied. If the viscosity is too high, the finish will appear bumpy and if the viscosity is too low, the paint will run.
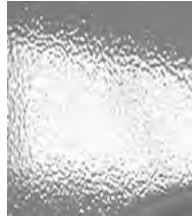
Paint viscosity too high   Paint viscosity too low

(a) State what is meant by viscosity.

(1)

(b) Before paint is applied, its viscosity can be checked using a viscosity cup. A viscosity cup has a small hole at the bottom for the paint to drain through.

viscosity cup
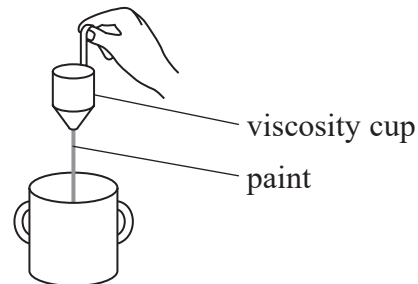
paint

The cup is filled with the paint to a fixed level and the time for the paint to drain from the bottom of the cup is measured. The time to drain the cup can then be converted to a viscosity using a table supplied by the paint manufacturer.

(i) Explain why this method can be used to determine the viscosity of the paint.

(2)

(ii) The time taken for the paint to drain from the cup was 17 s. The following day the same paint took 24 s to drain from the cup.

Suggest why the times were different.

(1)

(c) The viscosity cup is a basic way of measuring viscosity.

Suggest **two** possible sources of error with this method and state how each error would affect the time being measured.

(4)

Error 1

Error 2

(Total for Question = 8 marks)

3 (a) Explain the difference between resistance and resistivity.

(2)

(b) The resistivity of copper is 1.7×10^{-8} Ω m. A copper wire is 0.50 m long and has a cross sectional area of 1.0×10^{-6} m^2. Calculate its resistance.

(2)

Resistance =

(Total for Question = 4 marks)

4 The circuit diagram shows a battery of negligible internal resistance connected to three resistors.
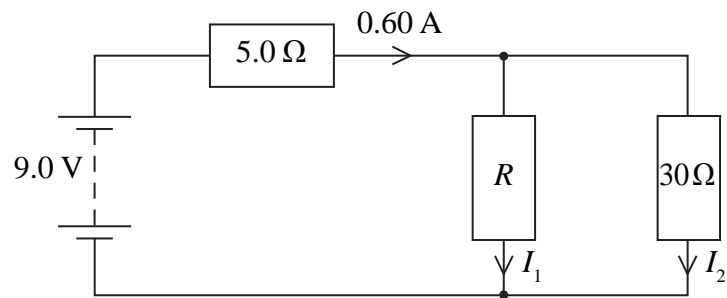
(a) Calculate the potential difference across the 5 Ω resistor.

(2)

Potential difference =

(b) Calculate the current I_2.

(2)

$I_2 =$

(c) Calculate the resistance *R*.

(2)

$R =$

(Total for Question = 6 marks)

5 If certain crystals are subjected to a mechanical stress, a potential difference is generated across them. This is called the piezoelectric effect. These crystals can be produced as very thin films.

Below is a photograph of a T-shirt with a built-in phone charger, which is being tested at a music festival. The white rectangle is a piezoelectric film.

(a) By considering how a sound wave travels through the air, explain how sound can cause a piezoelectric film to generate a potential difference.

(4)

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(b) Explain why the crystals used in the T-shirt need to be in the form of a large, thin film.

(3)

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(c) When the T-shirt is used at a music festival the sound levels are sufficient to generate about 20 kJ over ten hours. This is enough to charge one phone.

Calculate the electrical power output.

(3)

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Power output   ....

(d) Give **one** advantage and **one** disadvantage of this charger compared with a conventional charger.

(2)

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(Total for Question   12 marks)