OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE UNIT **2860**

PHYSICS B (ADVANCING PHYSICS)

Physics in Action

FRIDAY 12 JANUARY 2007 Afternoon

Time: 1 hour 30 minutes

Additional materials:
Data, Formulae and Relationships Booklet
Electronic calculator
Ruler

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.
- Show clearly the working in all calculations, and round answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 90.
- You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
- There are four marks for the quality of written communication in Section C.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.

For Examiner's Use		
Qu.	**Max.**	**Mark**
A	**20**	
B	**40**	
C	**30**	
Total	**90**	

This document consists of **20** printed pages.

Answer **all** the questions.

Section A

1 Here is a list of electrical units.

As **J s^{-1}** **S m^{-1}** **Ω m** **Ω**

Choose a correct unit for

(a) power ....

(b) charge ....

(c) resistivity. ....

[3]

2 A clarinet plays a musical note. The note is recorded, as shown in Fig. 2.1.
It shows the waveform over a time interval of about 40 ms.

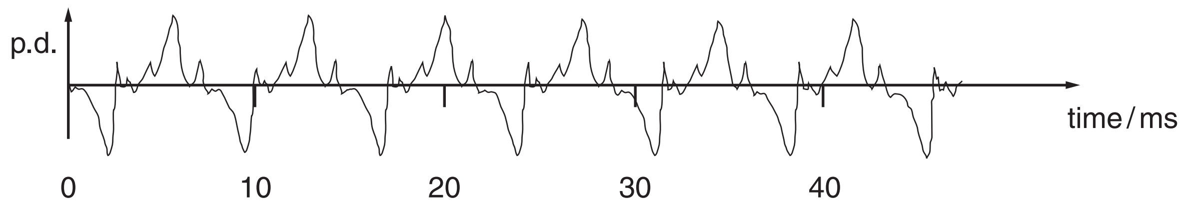

Fig. 2.1

(a) Draw on the waveform of Fig. 2.1 a box enclosing exactly **one** complete oscillation of the lowest frequency component of the note. [1]

(b) Use Fig. 2.1 to estimate the time period of this lowest frequency component of the note.

time period = ... ms [1]

(c) Calculate the frequency of the lowest frequency component of the note using your value for the time period from **(b)**.

frequency = ... Hz [1]

3 An ultrasound scanner produces waves of frequency 2.5 MHz.

(a) Calculate the wavelength of the waves in soft tissue.

speed of ultrasound in soft tissue = 1500 m s^{-1}

wavelength = ... m [2]

(b) Fig. 3.1 shows the wavefronts of the ultrasound at a boundary between soft tissue and bone.
The waves are travelling at right angles to the boundary.
In the bone, the ultrasound waves travel **faster**.

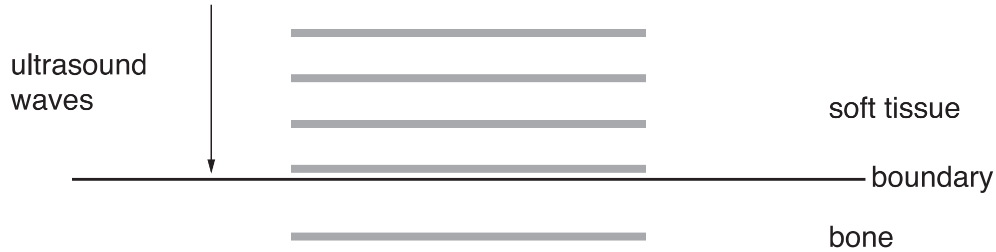

Fig. 3.1

Complete Fig. 3.1 to show the wavefronts being transmitted through the bone.
The first wavefront in the bone has been drawn for you.
Add **three** more wavefronts. [1]

(c) Some of the wave energy is **not** transmitted through the bone.
State what happens to this wave energy.

[1]

4 This question is about some properties of materials.

Fig. 4.1 shows, on a plot of the compressive strength against toughness, ranges of values for different classes of material.

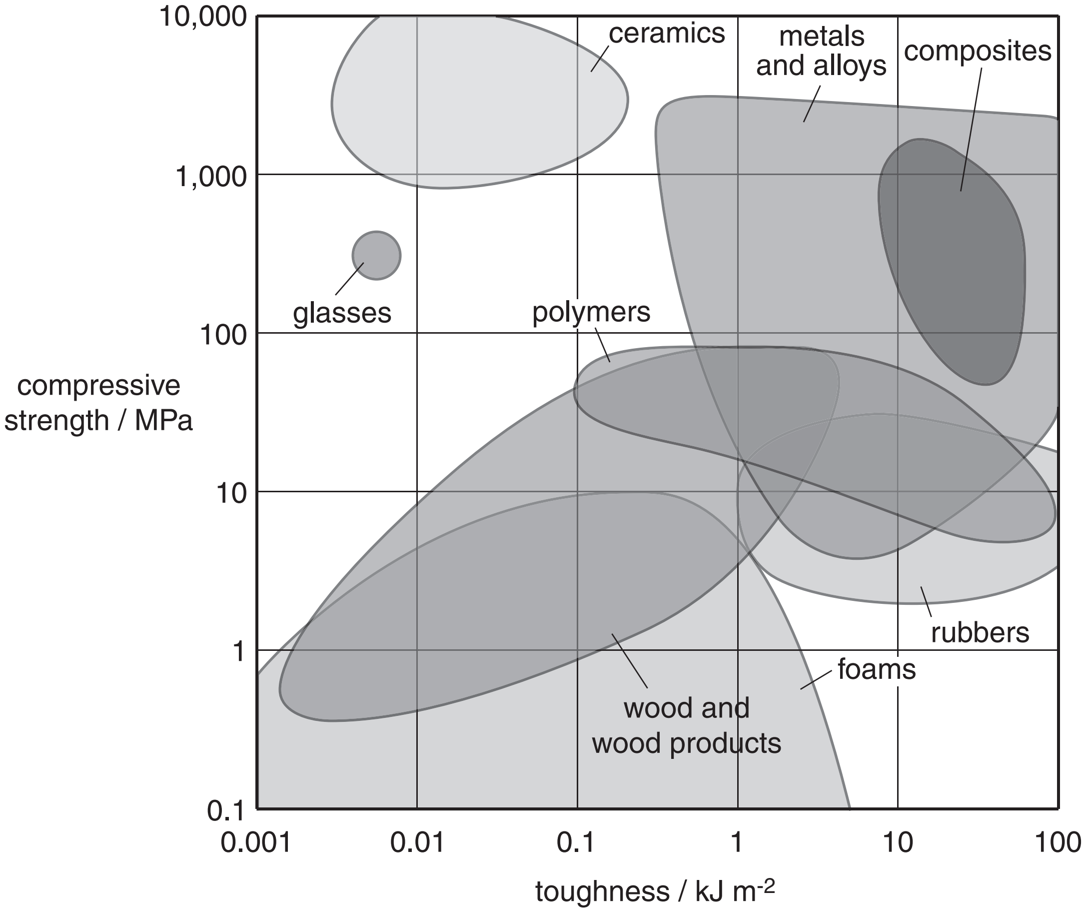

Fig. 4.1

(a) State the class of materials shown in Fig. 4.1 that has the greatest average strength in compression.

[1]

(b) State what is meant by the compressive strength of a material.

[1]

(c) The head of a hammer needs to be strong.

Explain whether the class of material you named in **(a)** might be suitable for constructing the head of a hammer.

[1]

5 Fig. 5.1 shows two conductors connected in parallel.
The conductors have conductances of 1.0 mS and 3.0 mS as shown.

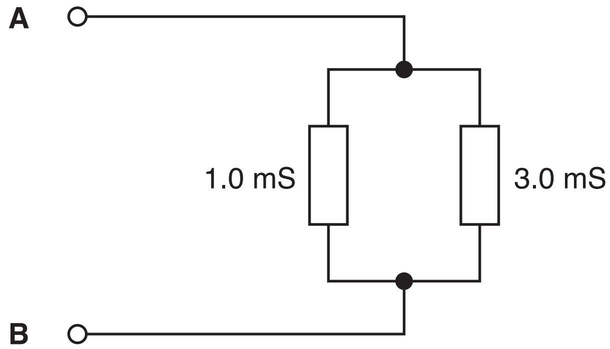

Fig. 5.1

(a) State the total conductance of the parallel conductors.

total conductance = ... mS [1]

(b) A battery of emf 6.0 V and negligible internal resistance is connected between **A** and **B**.

Calculate the current drawn from the battery.

current = ... A [2]

6 A metal surface is divided into a square grid of side 1.0 nm.
A single xenon atom can be placed on any square.
Fig. 6.1 shows an array of xenon atoms written onto the surface.
The presence of a xenon atom represents binary 1 and the absence of a xenon atom represents binary 0.

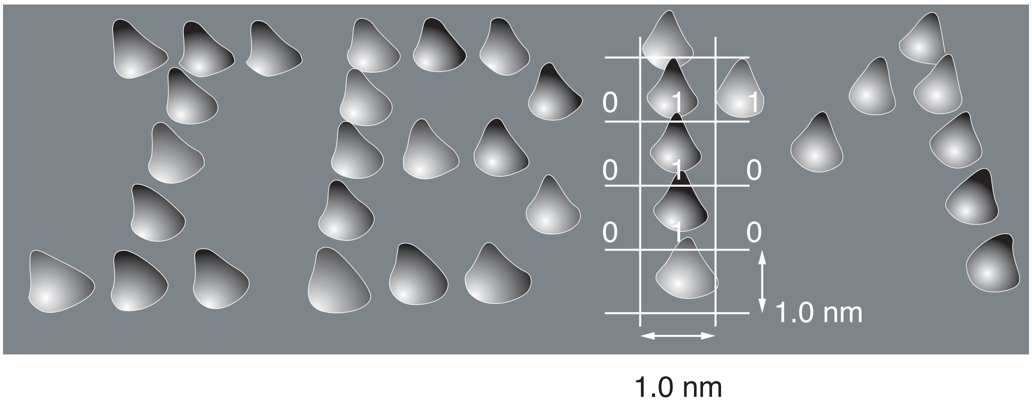

Fig. 6.1

This technique has been suggested as a way of writing the smallest possible encyclopaedia.

Show that the amount of information that could be stored per cm^2 of surface is greater than 10 Tbytes.

1 Tbyte = 10^{12} bytes

[2]

7 Fig. 7.1 shows an analogue signal from which digital samples are taken for transmission. The reconstructed analogue signal at the receiver is also shown.

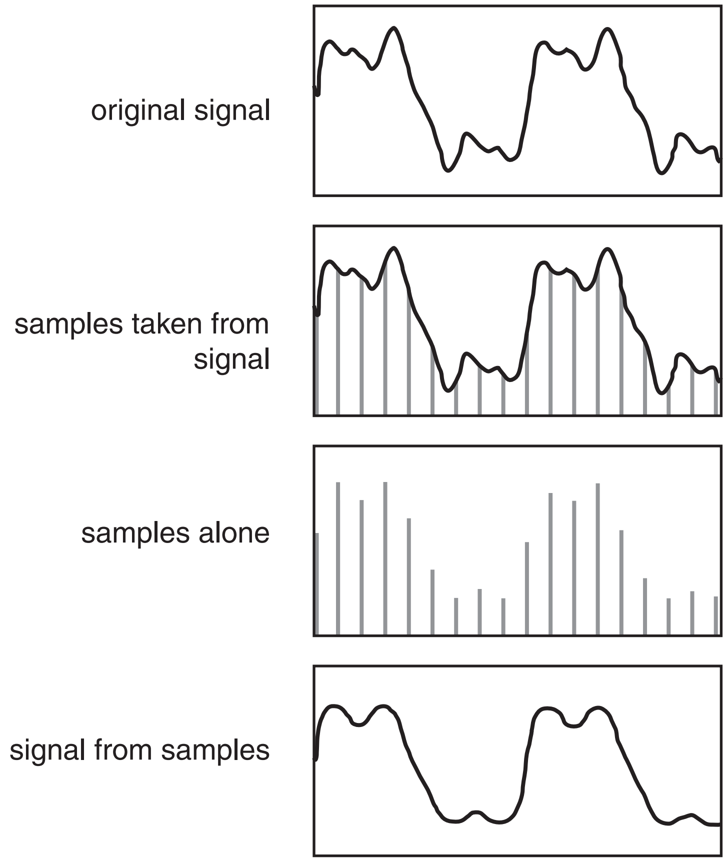

Fig. 7.1

(a) The diagrams show that the reconstructed signal is not exactly the same as the original signal.

State a difference between the signals.

[1]

(b) Suggest how to improve the quality of the reconstructed signal.

[1]

[Section A Total: 20]

[Turn over

Section B

8 This question is about steel wires in tension.

A sample of steel wire is tested in the laboratory. Fig. 8.1 shows the force-extension graph obtained when the wire is stretched elastically.

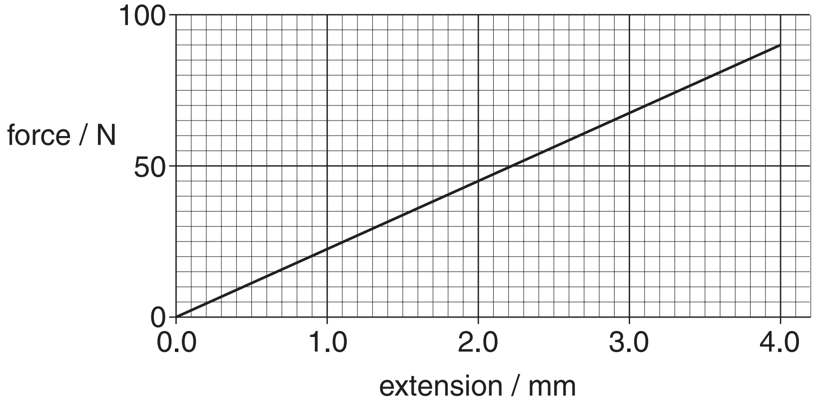

Fig. 8.1

(a) (i) Describe how the extension varies as the force is increased.

[1]

(ii) The test is repeated using another sample of the same wire, but of only **half** the original length.

Draw on the axes of Fig. 8.1 the force-extension graph for this wire, as the force is increased to 90 N. [1]

(iii) Explain why both wires have the **same** value for the Young modulus.

[1]

(b) **(i)** The original steel wire has an unstretched length of 2.0 m and a cross-sectional area of 2.5×10^{-7} m^2.

Use these facts and information from the graph to calculate the stress and strain in the wire at a force of 90 N.

stress = ... Pa [2]

strain = ...[2]

(ii) Calculate the Young modulus of the steel.
State the unit.

Young modulus = ... unit ....[2]

[Total: 9]

9 This question is about the resistances of ammeters and voltmeters.

(a) (i) A battery of emf 12.0 V and negligible internal resistance is connected to a resistor of resistance 2.5 Ω, as shown in Fig. 9.1.

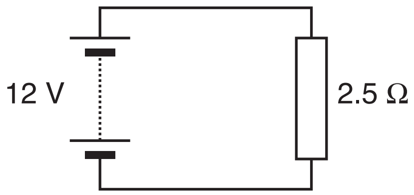

Fig. 9.1

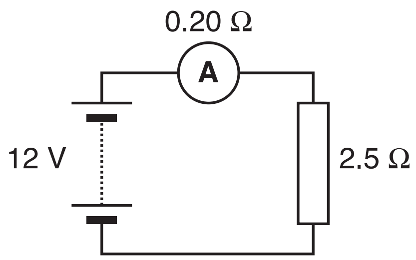

Fig. 9.2

Calculate the current in the circuit of Fig. 9.1.

current = ... A [1]

(ii) An ammeter of resistance 0.20 Ω is connected in series in the circuit as shown in Fig. 9.2 to measure this current.

1 Calculate the current in the circuit of Fig. 9.2 after the ammeter is added.

current = ... A [2]

2 Explain why the current is **lower** in Fig. 9.2.

[1]

(iii) A good quality ammeter alters the current it is measuring by as little as possible.

Suggest the best value of the resistance of an ammeter to make it perfect.

[1]

(b) A battery of emf 12.0V and negligible internal resistance is connected across two resistors in series as shown in Fig. 9.3.

Each resistor has a resistance of 25kΩ.

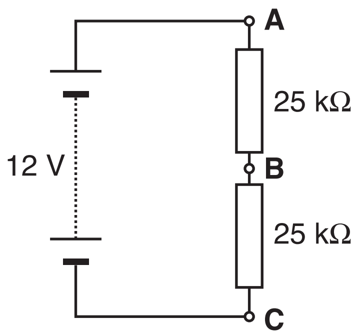

Fig. 9.3

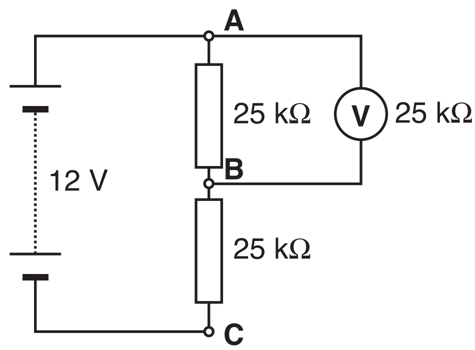

Fig. 9.4

(i) Explain why the potential difference V_{AB} between points **A** and **B** in Fig. 9.3 is 6.0V.

[1]

(ii) A voltmeter of resistance 25kΩ is now connected across **AB** as shown in Fig. 9.4, to measure V_{AB}.

1 Explain why two identical resistors connected in parallel have a combined resistance of **half** the value of one resistor on its own.

[1]

2 Calculate V_{AB} in the circuit of Fig. 9.4.

V_{AB} = ... V [2]

3 Explain why V_{AB} is **lower** in the circuit in Fig. 9.4.

[1]

(iii) A good quality voltmeter alters the p.d. it is measuring by as little as possible.

Suggest the best value for the resistance of a voltmeter that makes it perfect.

[1]

[Total: 11]

10 The surface of Saturn's moon Titan was first explored in 2005.
Fig. 10.1 shows a close-up image taken from the surface.

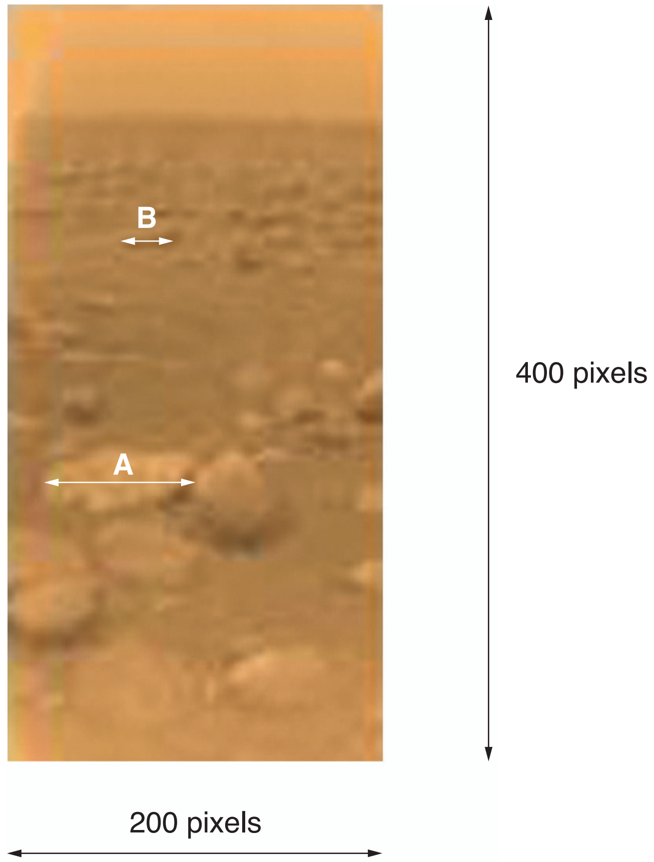

Fig. 10.1

(a) The image is 400 pixels tall × 200 pixels wide.

The image is recorded on a greyscale using 5 bits per pixel.

(i) Calculate the amount of information in the image in **bytes**.

information = ... bytes [2]

(ii) Suggest how this image could be stored in a smaller amount of computer memory than you calculated in **(i)**.

[1]

(iii) Calculate the number of alternative levels on this greyscale using 5 bits per pixel.

number = ...[1]

(b) The resolution of the image at the feature marked **A** on Fig. 10.1 is 2.0 mm per pixel.

(i) Calculate the width of the feature marked **A**.

width = ...m [2]

(ii) Feature **B** appears to be a **one third** the size of **A** in the image.
In fact, features **B** and **A** are the same size.

Explain how this can be the case.
(You may wish to use diagrams in your answer.)

[2]

(c) The part of the image that is most clearly focused is for an object at a distance of 0.85 m from the camera lens.

The power *P* of the camera lens is 60 D.

Calculate the image distance *v* from the lens to the CCD of the digital camera, for this image.

image distance *v* = ...m [3]

[Total: 11]

11 A student constructs a circuit to demonstrate the effect of loading a battery by adding resistors in parallel across it. The ammeter of negligible resistance measures the total current drawn from the battery.

Resistors are added into the circuit by closing switches in the order **A**, **B**, **C**, **D**, **E** as shown in Fig. 11.1.

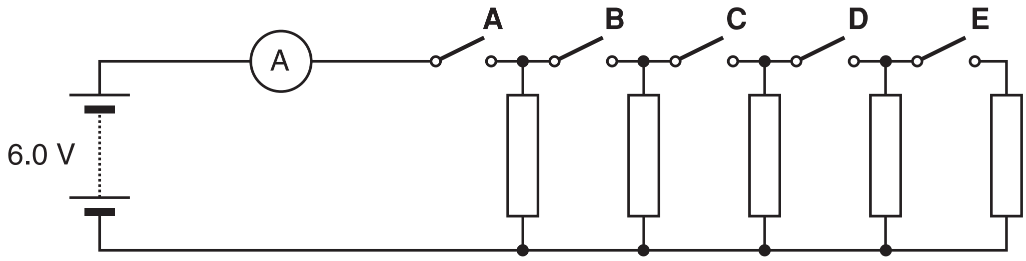

Fig. 11.1

(a) The battery has an emf of 6.0 volts and each of the resistors has a labelled value of 10 Ω.

The student assumes that the internal resistance of the battery is negligible.

(i) Calculate the current when only switch **A** is closed, using this assumption.

current = ... A [1]

(ii) Due to the way the resistors are made, there is a **random** variation of ± 5% in their value.

Calculate the possible variation in the value of the current.
Give your answer to 1 significant figure.

variation in current = ±.. A [2]

(b) Fig. 11.2 shows the student's predicted and actual results.

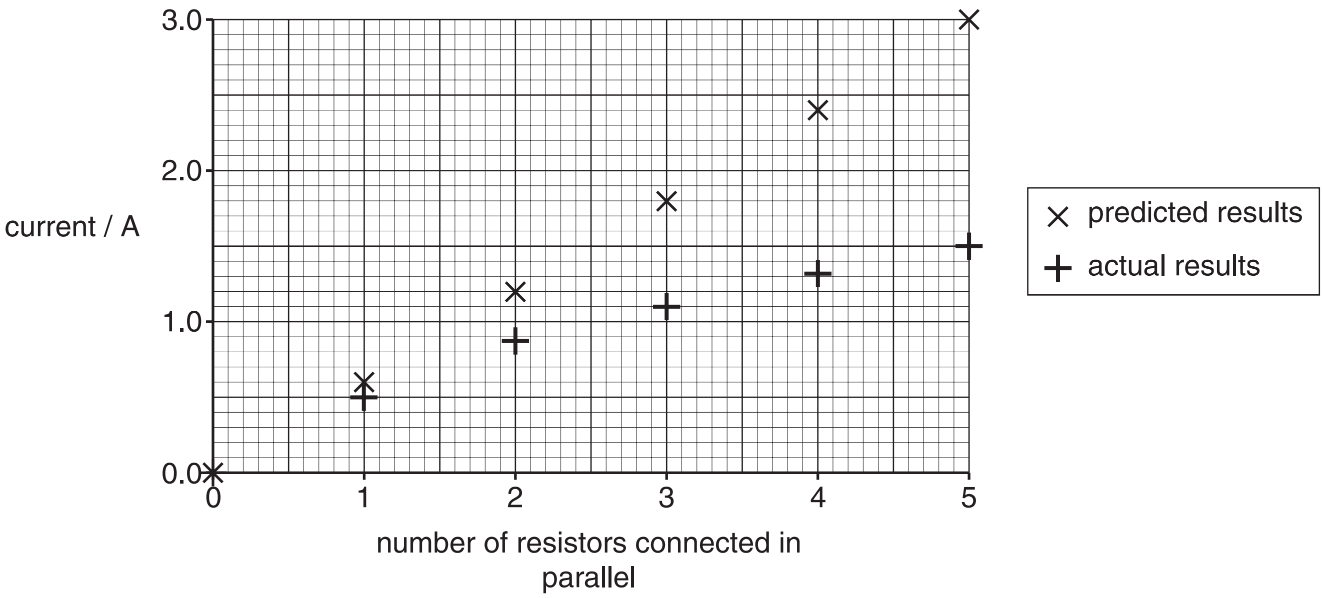

Fig. 11.2

(i) The student **incorrectly** suggests that the difference between the two sets of results can be explained by the value of the resistors varying **randomly** (± 5%) from their labelled values.
Explain how the data in Fig. 11.2 show that this is **incorrect**.

[2]

(ii) Another student **correctly** suggests that a constant internal resistance of the 6.0V battery can explain why the actual results are **systematically lower** than the predicted results in Fig. 11.2.
Explain how the presence of internal resistance leads to **systematically lower** currents.

[2]

(iii) Five 10Ω resistors connected in parallel have a measured resistance of 2.0Ω.
Use this fact and data from Fig. 11.2 to calculate the internal resistance of the battery.
Make your method clear.

internal resistance = ... Ω [2]

[Total: 9]

[Section B Total: 40]

[Turn over

Section C

In this section, you will choose the context in which you give your answers.

Use diagrams to help your explanations and take particular care with your written English. In this section, four marks are available for the quality of written communication.

12 In this question, you are asked to choose and discuss an application of signal transmission.

(a) State your example of signal transmission and what carries the information.

example of signal transmission ....

information carrier.. [2]

(b) Draw a labelled diagram showing how the signal transmission system operates.

You should indicate clearly how the information is gathered or encoded, transmitted and stored or displayed.

[4]

(c) **(i)** Give an estimate of the speed of the signal in your system.

signal speed = ... m s^{-1} [1]

(ii) Calculate the distance the information could be carried in 1.0 μs.

distance = ... m [1]

(d) **(i)** Give an estimate of the bit rate at which information is carried in your system.

bit rate = ... bit s^{-1} [1]

(ii) Calculate the time it would take your system to transmit 1 Mbyte of information.

time = ... s [2]

(iii) Suppose that this information rate is far too slow for a certain application.

Suggest how the information rate could be increased in your system.

[2]

[Total: 13]

13 Materials are chosen or can be designed with properties suitable for a particular application. You are asked to illustrate this with your own example.

(a) **(i)** State your choice of material and the application.

material ....

application ....[1]

(ii) State **two** properties of the material that are important in your application.

Explain why the properties are important in your application.

first property ....

second property ....

[5]

(b) Materials have internal structure, possibly on several different scales.

(i) Describe the internal structure of your material on a scale that helps you explain **one** of the properties chosen in **(a)(ii)**.

Use a labelled diagram, indicating the structure and its scale in metres.

[4]

(ii) Explain this property in terms of the structure described in **(b)(i)**.

[3]

[Total: 13]

[Quality of Written Communication: 4]

[Section C Total: 30]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE