OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS (B) (ADVANCING PHYSICS) 2860

Physics in Action

Friday **6 JUNE 2003** Afternoon 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data, Formulae and Relationships Booklet
Electronic calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Show clearly the working in all calculations and give answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.

- The number of marks is given in brackets [ ] at the end of each question or part question.
- 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		
Section	Max.	Mark
A	20	
B	40	
C	30	
TOTAL	90	

This question paper consists of 21 printed pages and 3 blank pages.

Registered Charity Number: 1066969

Answer **all** the questions.

Section A

1 Here is a list of materials.

aluminium concrete glass rubber silicon

Choose the material which best fits each description below of its microscopic structure.

(a) It consists of a lattice of positive ions immersed in a sea of many free electrons. These electrons give it a high conductivity and reflectivity.

material is .....[1]

(b) It is non-crystalline and amorphous in structure, breaking by brittle fracture and crack propagation. It is highly transparent due to its homogeneity and lack of free electrons.

material is .....[1]

(c) It is a very extensible material made from long chain polymers. Cross-linking of the chains by sulphur bonding makes the material stiffer.

material is .....[1]

2 Fig. 2.1 shows two vertical mirrors, placed at right angles to each other on a piece of squared paper, viewed from above.
A narrow horizontal beam of light is shown travelling across the paper to the point where it strikes the first mirror.

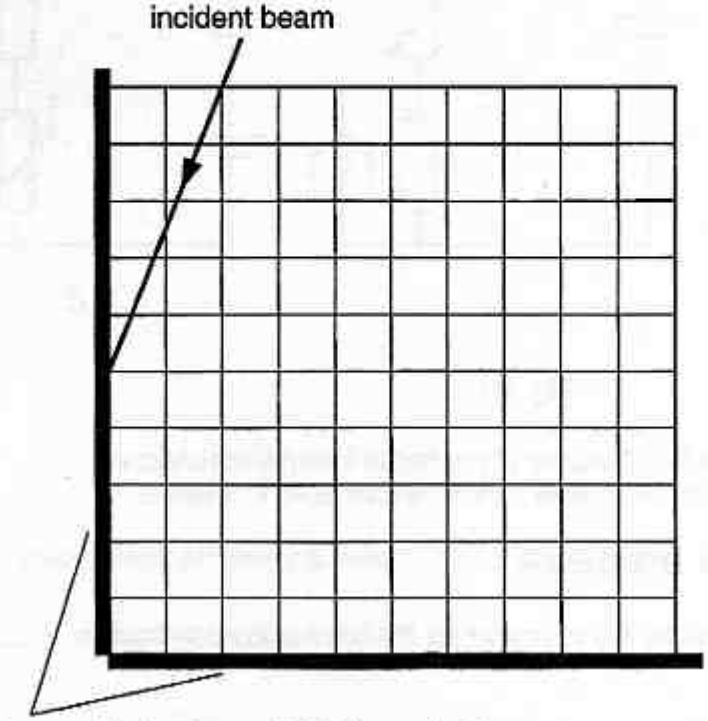


Fig. 2.1

(a) **Complete** the diagram to show two successive reflections of the incident beam.
Use the grid squares to help orient the reflected beams carefully. [2]

(b) Both motor vehicles and bicycles have rear facing reflectors. These are arrays of right-angled pairs of tiny mirrors.
Suggest and explain the purpose of this arrangement.

[2]

For Examiner's Use

3 A thermistor, fixed resistor and voltmeter are connected in three different potential divider circuits **A, B, C** as shown in Fig. 3.1.

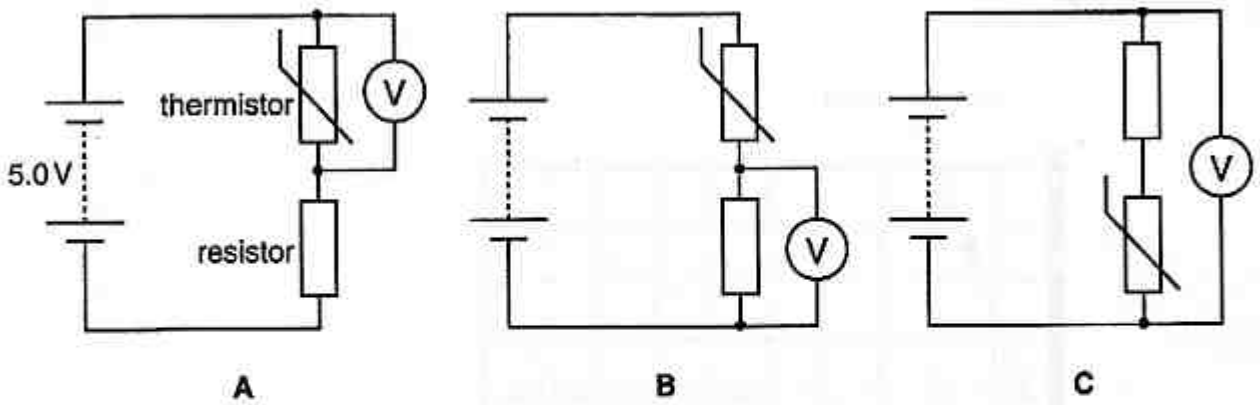


Fig. 3.1

Each divider is connected to a 5.0 V supply of negligible internal resistance.
The resistance of the thermistor decreases as the temperature increases.

State in which of the circuits **A, B, C** there is

(a) no change in p.d. recorded by the voltmeter as the temperature increases .....

(b) an increasing reading on the voltmeter as the temperature increases. .....

[2]

4 Read the paragraph below about a telephone signalling system before answering the questions about it.

The frequency range of sound transmitted by a telephone system ranges from 300 Hz to about 3400 Hz. When the signal is digitised, digital samples are taken 8000 times per second. Each sample of the signal is transmitted using 16 bits of information.

(a) State the meaning of the term **frequency**.

[1]

(b) Explain what is meant by **digital samples**.

[2]

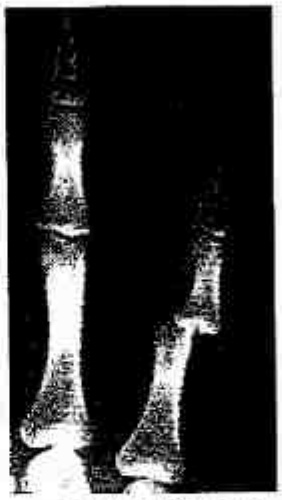
(c) State the meaning of the term **bit of information**.

[1]

5 Here are two X-ray images of a dislocated finger. Fig. 5.1 is the **original** and Fig. 5.2 shows the scanned X-ray which has been image **processed**.

original image

Fig. 5.1



processed image

Fig. 5.2

(a) State **one** difference in the appearance of the processed image as compared to the original.

[1]

(b) On the greyscale used, the pixel values vary from 0 to 255.
0 represents white and 255 represents black.

Describe how the pixel values could have been changed to produce the difference stated in **(a)**.

[1]

6 The graphs in Fig. 6.1 show how the potential difference across each of three cells **A, B** and **C** varies with current drawn from the cell.

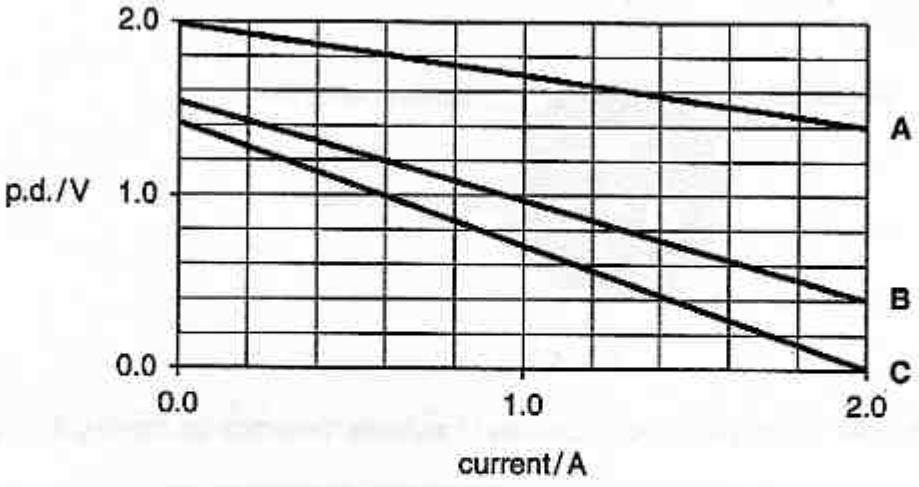


Fig. 6.1

State the cell **A, B** or **C** which

(a) has the greatest e.m.f. .....

(b) has the greatest internal resistance .....

(c) supplies a current of 2.0 A when the cell is short-circuited. ..... [3]

7 This question is about a beam of light emitted by an LED.
Light waves are emitted from a diode junction encapsulated in a curved plastic lens as shown in Fig. 7.1.

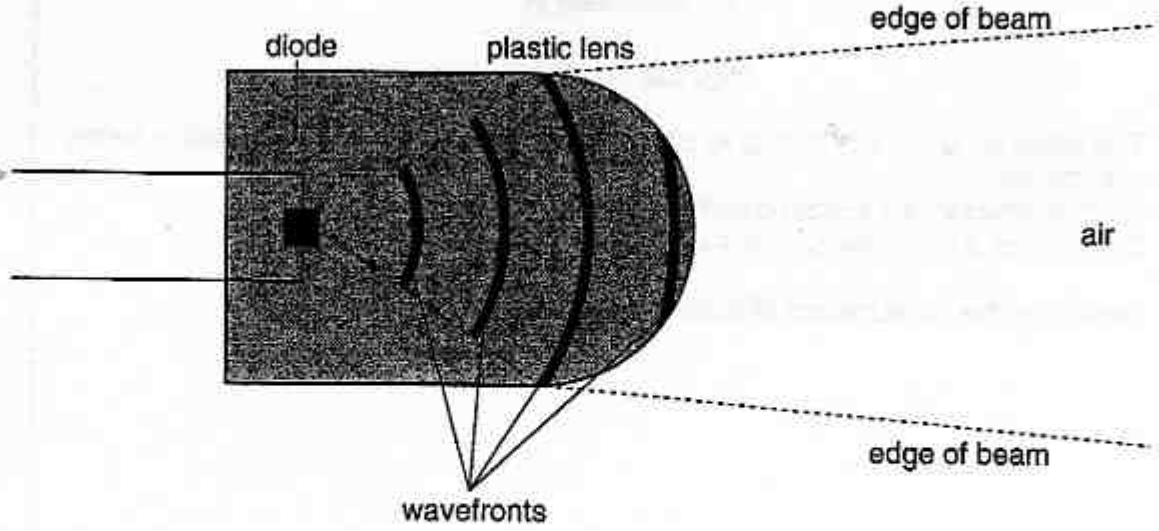


Fig. 7.1

Complete Fig. 7.1 to show **three** successive wavefronts in the beam after they have completely emerged from the plastic lens into air. [2]

[Section A Total: 20]

For Examiner's Use

Section B

8 This question is about aspects of a portable, flexible electrical extension cable, shown in cross-section in Fig. 8.1.

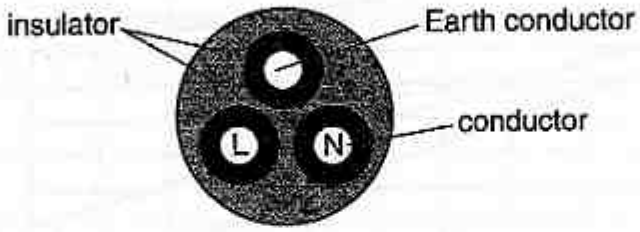


Fig. 8.1

(a) Complete the table for the required properties of suitable materials for making the cable.

	conductor	**insulator**
electrical conductivity		very low
suitable material	copper	

[2]

(b) The live **L** and neutral **N** conductors are connected in series with the load and the supply as shown in Fig. 8.2.

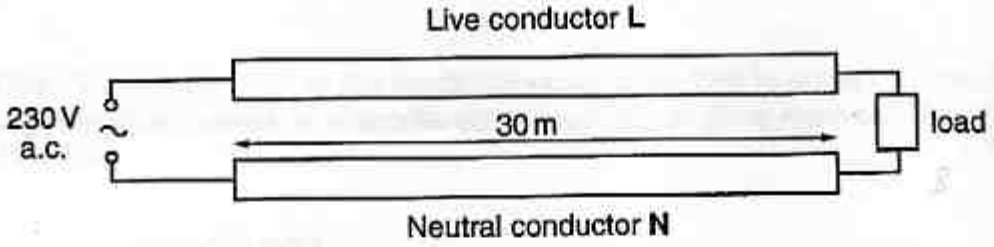


Fig. 8.2

(i) The cable is 30 m long, so that in total 60 m of conductor in the cable are in series with the load.
Each conductor has a cross-sectional area of $1.8 \times 10^{-6}\,m^2$.
Copper has a conductivity of $5.9 \times 10^{7}\,S\,m^{-1}$.

Show that the conductance of the cable is about 1.8 S.

[2]

(ii) The cable has a maximum current rating of 13 A.

Calculate the voltage dropped across the total resistance of the 60 m of conductor when there is a current of 13 A.

voltage dropped = ... V [2]

(iii) Show that the power dissipated in the cable under these conditions is of the order of 100 W.

[1]

(iv) The cable is stored by being tightly wound on a reel. The makers recommend that if the cable is used coiled on its reel, the current in it should be significantly less than 13 A.

Use the data from **(b)(iii)** to suggest and explain a reason for this recommendation.

[2]

[Total: 9]

9 This question is about the mechanical problems involved in winding a cable on a reel as shown in Fig. 9.1(a).
Fig. 9.1(b) shows part of a loop of the cable that is being bent elastically.

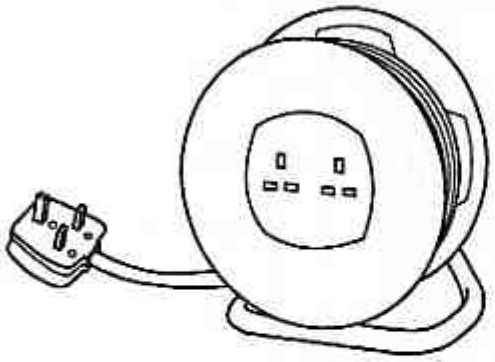


Fig. 9.1(a)

Fig. 9.1(b)

(a) Write the letter **T** at a point on Fig. 9.1(b) where the cable is in tension, and the letter **C** at a point where the cable is in compression. [2]

(b) A wire of copper conductor inside the cable is bent into a circular loop as shown in Fig. 9.2.
The wire has radius r and the circular loop has mean radius R.

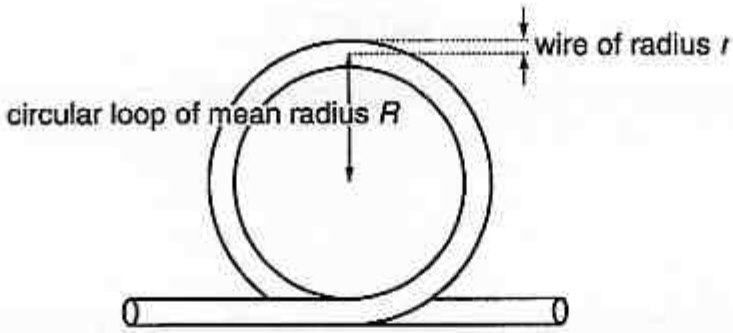


Fig. 9.2

Write appropriate symbols in the boxes below, to complete the analysis to show that the

maximum tensile strain in the wire $= \frac{r}{R}$

mean circumference for circular loop of wire $= 2\pi R$

outer circumference of circular loop of wire $= 2\pi (R + \square)$

therefore extension of the outer circular surface $= 2\pi (R + \square) - 2\pi R$

$= \square$

$$\text{strain at outer surface of wire} = \frac{\text{extension}}{\text{original circumference}} = \frac{\square}{\square} = \frac{r}{R}$$

[3]

(c) Because of the tension and compression in the cable, it may yield.
State the meaning of **yield**.

[1]

(d) (i) The conductors in the cable are usually made from several thin strands of copper rather than a solid conductor, as shown in Fig. 9.3.

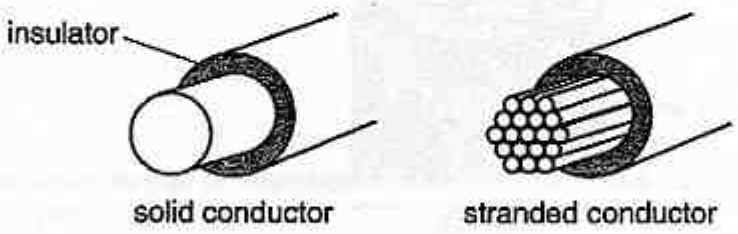


Fig. 9.3

The radius of the single solid copper conductor is 0.75 mm.
The strain at which the copper yields is 0.0020.

Use the relationship strain = $\frac{r}{R}$ to calculate the mean radius R of the smallest circular loop into which a solid copper conductor can be formed without yielding.

R = ... unit ..... [2]

(ii) A typical multi-stranded wire is illustrated in Fig. 9.3.
It contains 19 strands of wire, each of radius $r = 0.17$ mm

Calculate the mean radius R of the smallest circular loop into which the multi-stranded conductor can be formed without yielding.

R = ... unit ..... [2]

(iii) Explain the benefit of having a multi-stranded conductor rather than a solid conductor for the cable.

[1]

[Total: 11]

10 This question is about two methods of estimating the size of a molecule.

(a) This is the first method.
The field of view of an STM (scanning tunnelling microscope) is 20 nm wide. It is possible to resolve 14 molecules across it, as shown in Fig. 10.1.

Fig. 10.1

Estimate the size of a molecule using this information.

molecular size = ... m [2]

(b) Another method is to allow one drop of oil to spread out on a water surface.

(i) The oil drop has a diameter of 0.50 mm.
Show that the volume of oil in the drop is about 0.07 mm^3.

volume of sphere = $\frac{4}{3} \pi r^3$

[2]

(ii) When the oil spreads out on the water surface, it forms a circular patch.
This is assumed to be one molecule thick. Therefore the thickness of the patch gives an estimate of the size of the molecule.
The diameter of the patch can be measured because the oil has moved aside powder scattered on the water surface as illustrated in Fig. 10.2.

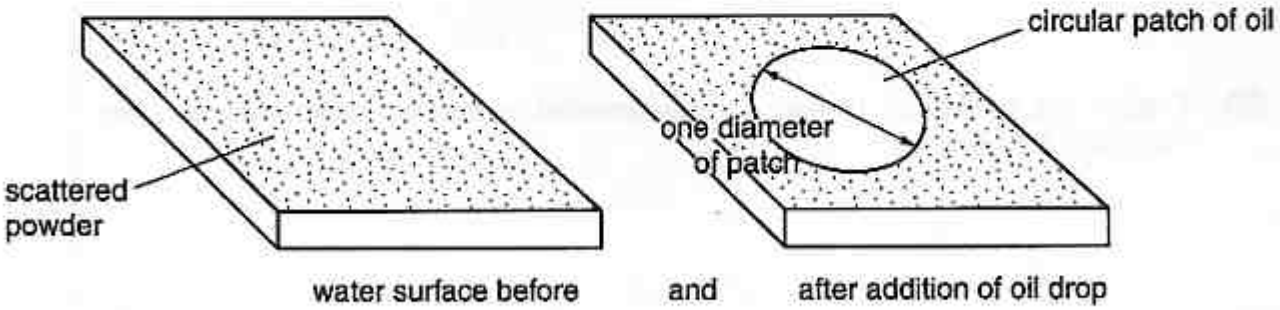


Fig. 10.2

The diameter of the patch is measured in four different directions.
The results are given below.

diameter / mm	300	280	280	260

Calculate the mean diameter of the patch from these measurements.

mean diameter = ... mm [1]

(iii) Use the mean radius of the circular patch to show that its surface area is about 6.2×10^4 mm^2.

area of circle $A = \pi R^2$

[2]

(iv) The method assumes that the oil drop and the circular patch have the same **volume.**
For a patch of area A and thickness h the volume = $A\,h$

Calculate the thickness of the patch using the data from parts **(b)(i)** and **(b)(iii).**

This is your estimate of molecular size.

estimate of molecular size = ... unit ..... [3]

[Total: 10]

11 Mary has her hearing tested. The results are shown in Fig. 11.1.

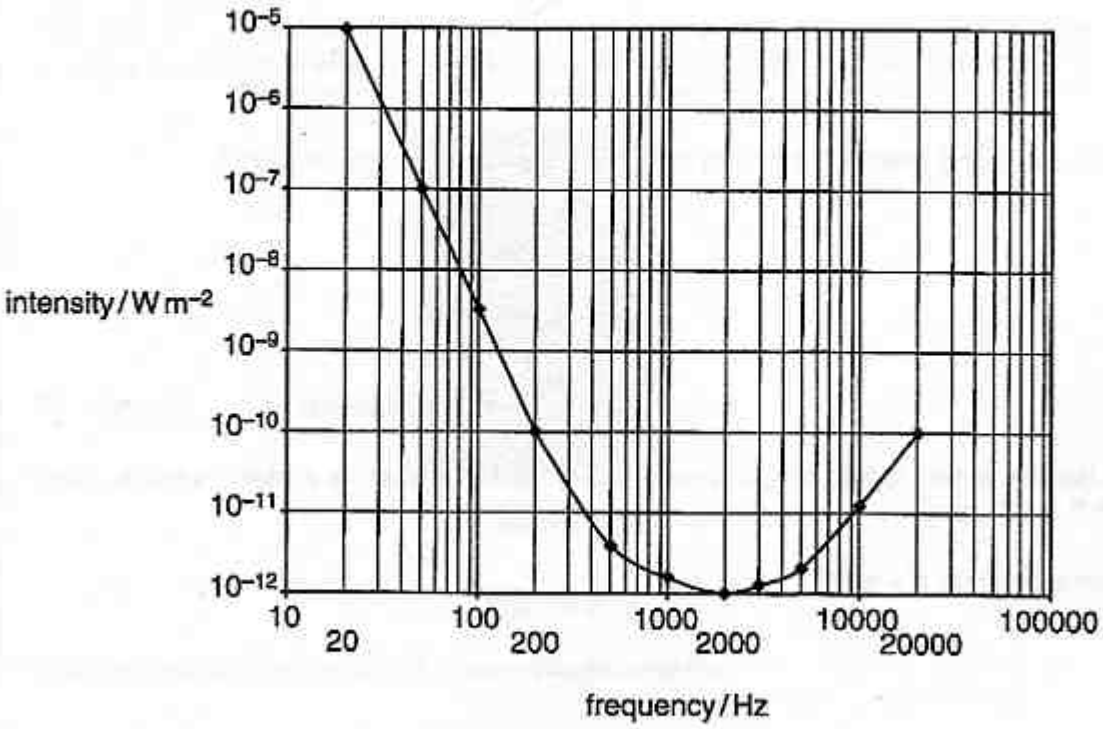


Fig. 11.1

The results show the **lowest** intensity of sound that she can hear at each frequency tested.

(a) Use the graph to find the frequency of the quietest sound Mary can hear.

frequency of quietest sound = ... Hz [1]

(b) The intensity and frequency have been plotted on logarithmic scales.

(i) State how you can tell that a logarithmic scale has been used for the intensity.

[1]

(ii) Suggest why a logarithmic scale has been used for the intensity.

[1]

(c) In Fig. 11.2, the intensity scale remains logarithmic, but the frequency scale is now linear.

(i) Sketch the results of Mary's hearing test on this new scale. [2]

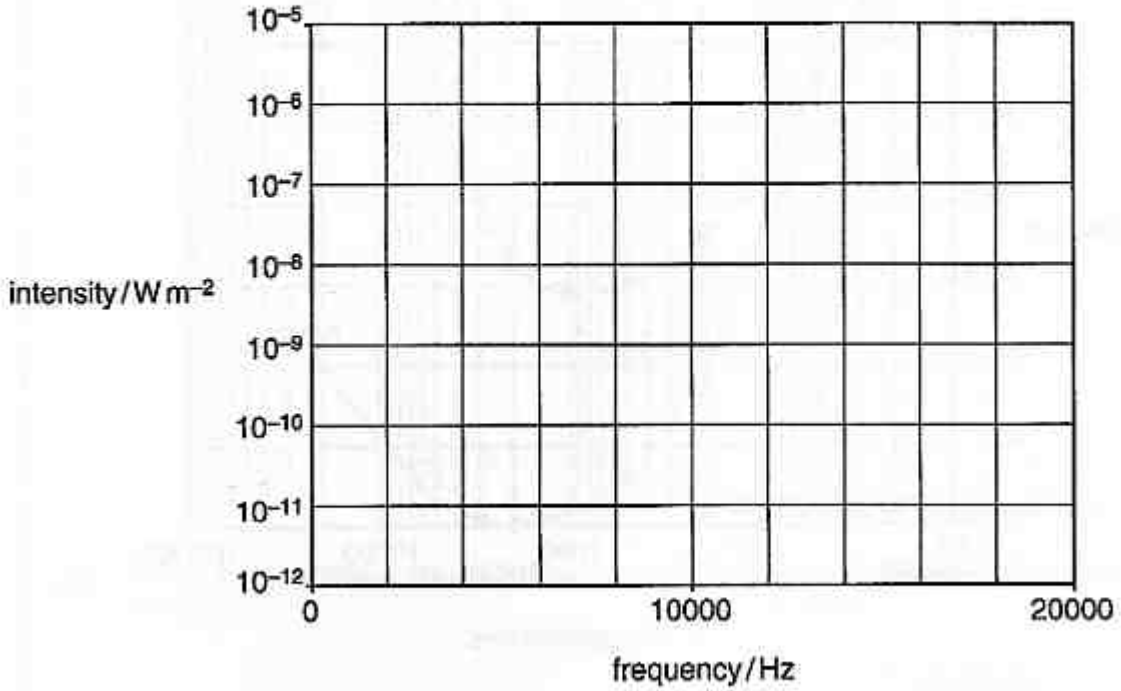


Fig. 11.2

(ii) Comment on the effect on the graph of this change of scale.

[1]

[Turn over

(d) Mary now attends a very noisy air display. After this she has her hearing re-tested. The results are compared with her original test data, as shown in Fig. 11.3.

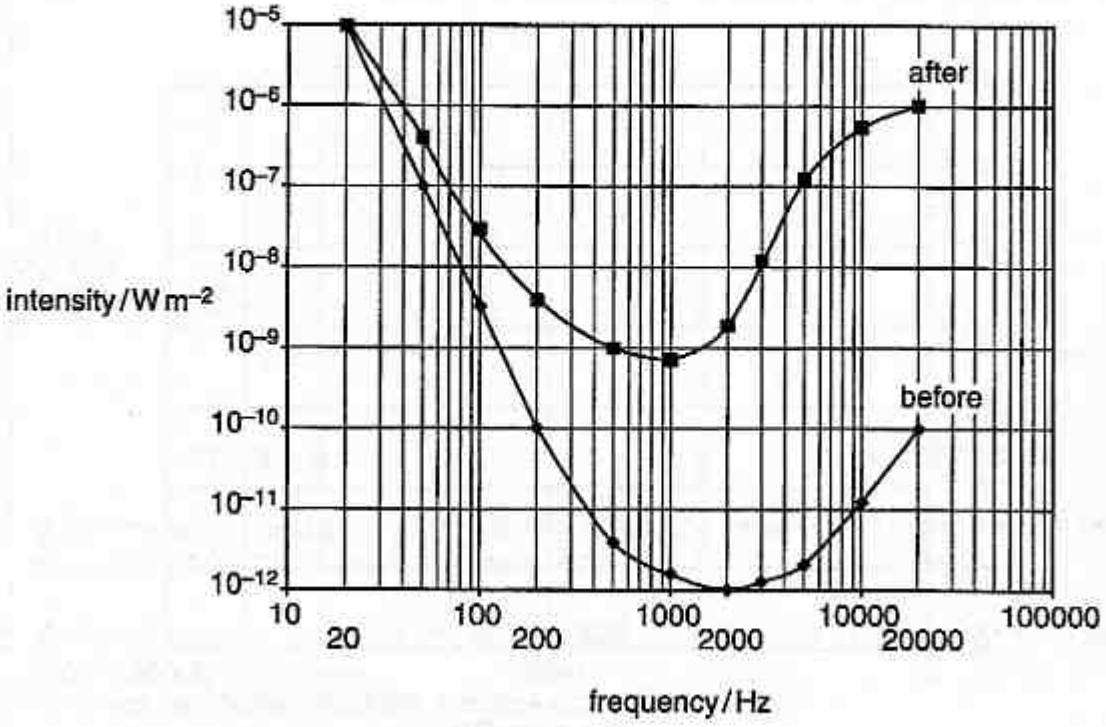


Fig. 11.3

(i) State how the graph shows that her hearing has been damaged.

[1]

(ii) From the graph, estimate by how many orders of magnitude her sensitivity has decreased at the frequency 10 kHz.

orders of magnitude = ... [1]

(iii) State and explain **one** step that Mary could have taken to protect her hearing at the air display.

[2]

[Total: 10]

[Section B Total: 40]

For Examiner's Use

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 This question is about any image that can be digitised, stored and displayed on a computer.

(a) State your own example of such an image.

Describe **two** useful pieces of information that could be obtained from the image.

[2]

(b) Describe how the data for the image are obtained.
You may find it useful to use a labelled diagram to help explain the physical principles involved.

[4]

(c) (i) For the image you have chosen, make estimates of the

number of pixels in the image = ...

number of bits per pixel. = ... [2]

(ii) Calculate the amount of information in the image using these estimates.

[1]

(iii) Calculate how long it would take to transmit your image on a system expected to transfer data at 56 kbit s^{-1}.

time = ... s [2]

(iv) In practice, the time taken could be substantially different from your estimate.

Suggest a reason for such a difference, and state whether the time taken would be more or less.

[2]

[Total: 13]

For Examiner's Use

13 In this question, you are to discuss an electrical sensor system of your own choice.

(a) State the physical variable that your chosen sensor system is intended to monitor, and a suitable choice of component(s) to make the sensor.

physical variable

component(s)

[2]

(b) **(i)** Draw a circuit diagram for the sensor.
Show how a suitable electrical output signal can be obtained from the circuit.

(ii) Describe how your circuit works.

[5]

(c) (i) Describe how you would test your sensor circuit to see whether the output is **linearly** related to the input.
It may be helpful to use sketch graphs to illustrate your answer.

[3]

(ii) State **one** benefit of having a sensor with a linear output.

[1]

(d) When making experimental tests, readings are often repeated.

Explain the purpose of this.

[2]

[Total: 13]

Quality of Written Communication [4]

[Section C Total: 30]