OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS (B) (ADVANCING PHYSICS) 2860

Physics in Action

Thursday **12 JANUARY 2006** Morning 1 hour 30 minutes

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

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 round 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	**21**	
B	**39**	
C	**30**	
TOTAL	**90**	

This question paper consists of 19 printed pages and 1 blank page.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

Section A

1 A wine glass can support large compressive stress, but may shatter, by crack propagation, if dropped a small distance onto a hard surface.

Here is a list of some mechanical properties of materials.

brittle **elastic** **plastic** **strong** **tough**

Write down the two properties of glass from the list that best fit the statement about the wine glass.

..... and ..... [2]

2 Fig. 2.1 shows a ray of light incident on a diamond-air boundary.

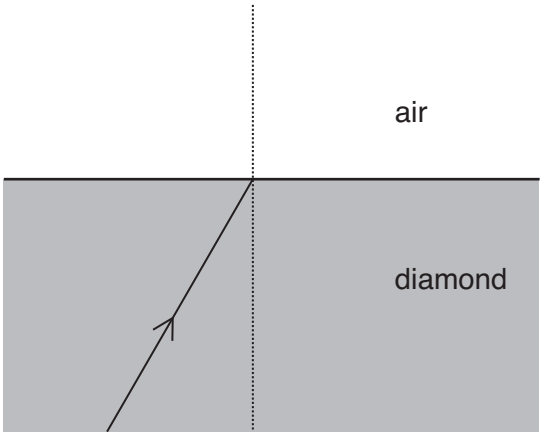


Fig. 2.1

(a) Use a protractor to measure the angle of incidence.

angle = ...° [1]

(b) The refractive index *n* of diamond is 2.4.

Show that the critical angle for diamond is about 25°.

[3]

(c) On Fig. 2.1, complete the path of the ray of light after it meets the diamond-air boundary. [1]

3 Nano-technologists can now produce memory cells each of area $8 \times 10^{-15}\,m^2$. Each cell stores **one bit** of information.

(a) Show that about 6 Gbits of information can be stored on a chip of area $5 \times 10^{-5}\,m^2$.

[1]

(b) Information can be transferred at a rate of **2 Mbyte s^{-1}** to and from the chips.

Calculate the time taken to transfer **6 Gbits** at this rate.

time = ... s [2]

[Turn over

4 A battery of emf E of 6.0 V and internal resistance $R_{internal}$ is connected across a variable load resistor R_{load} as shown in Fig. 4.1.

The graph in Fig. 4.2 shows how the p.d. V across the load varies with current drawn from the battery.

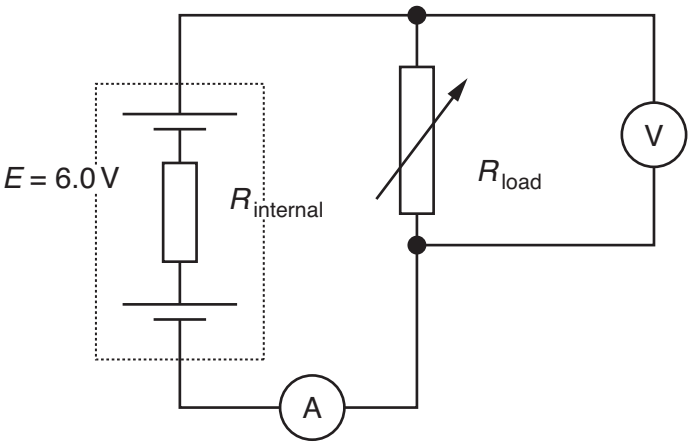


Fig. 4.1

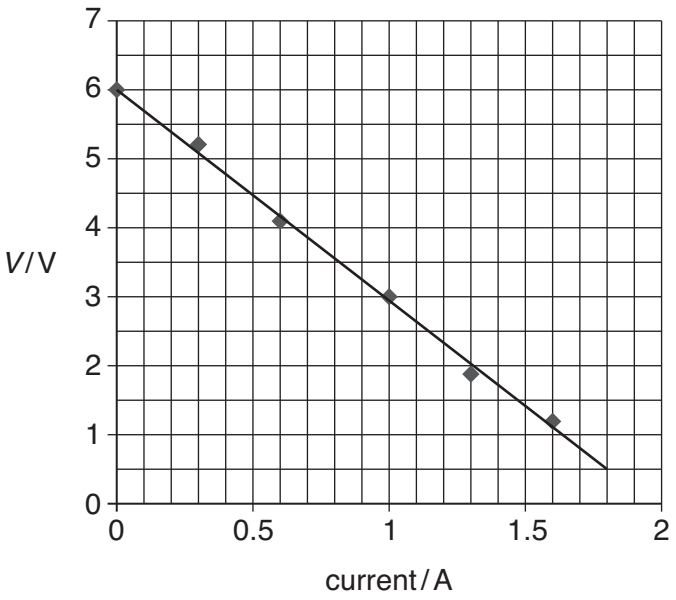


Fig. 4.2

Use data from the graph to calculate the internal resistance $R_{internal}$ of the battery. Make your method clear.

internal resistance $R_{internal}$ = ... Ω [3]

5 **(a)** To demonstrate some ideas in electricity, a teacher connects two different lamps **A** and **B** in parallel with a car battery as shown in Fig. 5.1.

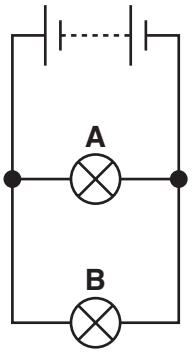


Fig. 5.1

Lamp **B** glows brighter than lamp **A**.

Complete the following sentences by adding one phrase from the list below.

greater than **equal to** **less than**

The current in lamp **B** is ..... that in lamp **A**.

The p.d. across lamp **B** is ..... that across lamp **A**. [2]

(b) The teacher then connects the lamps **A** and **B** in series with the car battery as shown in Fig. 5.2.

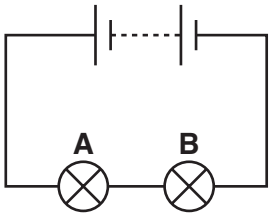


Fig. 5.2

Lamp **A** now glows brighter than lamp **B**.

Complete the following sentences by adding one phrase from the list below.

greater than **equal to** **less than**

The current in lamp **B** is ..... that in lamp **A**.

The p.d. across lamp **B** is ..... that across lamp **A**.

[2]

[Turn over

For Examiner's Use

6 This question is about the relationship between analogue waveforms and their frequency spectra.

Fig. 6.1 (a) shows the waveform of a pure sound and Fig. 6.1 (b) its frequency spectrum.

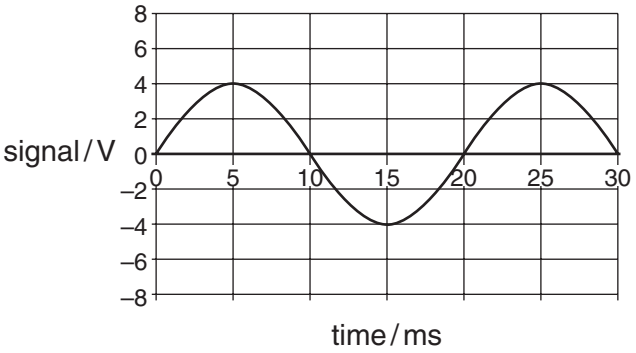


Fig. 6.1 (a) waveform

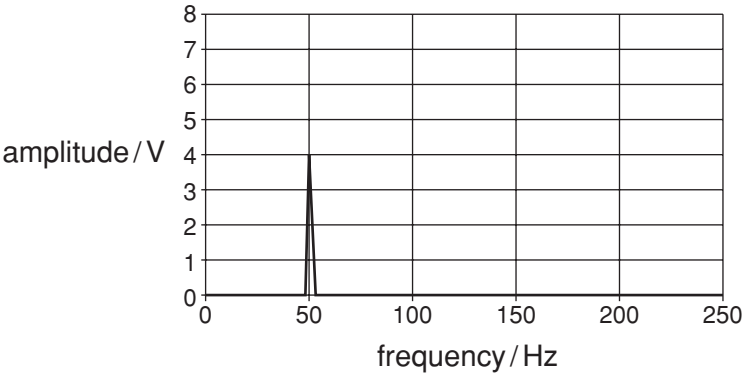


Fig. 6.1 (b) frequency spectrum

Fig. 6.2 (a) and (b) below show the waveform and frequency spectrum of a higher frequency sound.

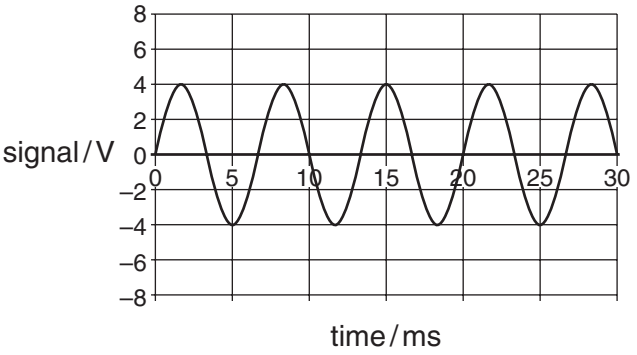


Fig. 6.2 (a) waveform

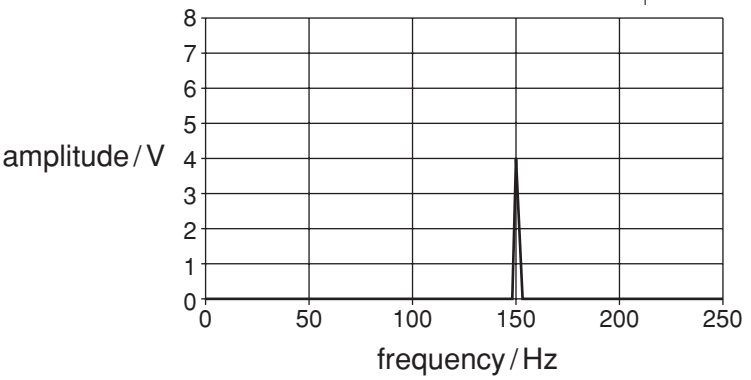


Fig. 6.2 (b) frequency spectrum

The waveforms of Fig. 6.1(a) and 6.2(a) are to be added to produce a combined waveform.

(a) On Fig. 6.3 (a), sketch this combined waveform. [3]

(b) On Fig. 6.3 (b), draw the frequency spectrum of the combined waveform. [1]

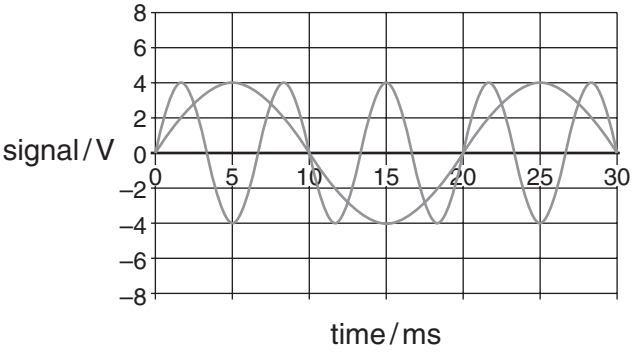


Fig. 6.3 (a) waveform

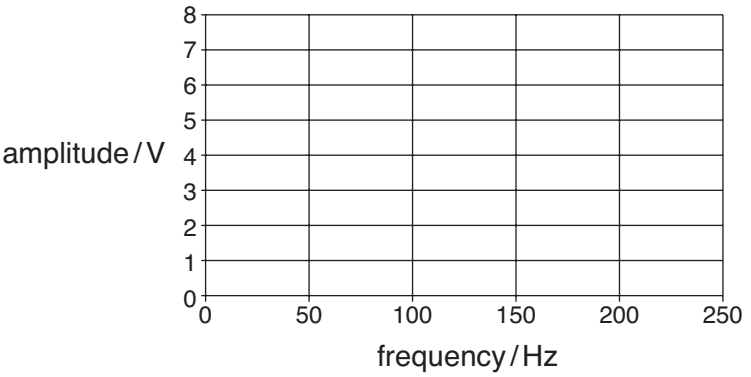


Fig. 6.3 (b) frequency spectrum

[Section A Total: 21]

BLANK PAGE

Section B

7 This question is about the fixed focus disposable camera, shown in Fig. 7.1.

An image has been removed due to third party copyright restrictions

Details: An image of a disposable camera

Fig. 7.1

(a) Fig. 7.2 shows three wavefronts of light moving towards a lens from a very distant object.

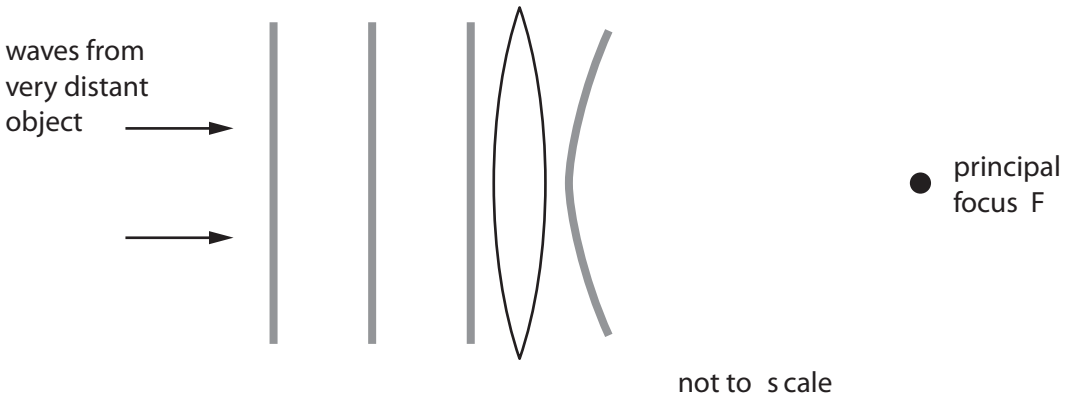


Fig. 7.2

On Fig. 7.2, draw the wavefronts of light after passing through the lens, as they move towards F the principal focus of the lens.
One wavefront has been drawn for you. [1]

(b) The focal length f of the camera lens is 12.5 mm.

Calculate the power of the lens, in dioptres.

power = ... D [2]

(c) (i) The camera is used to photograph a very distant object.

The film is 12.5 mm behind the lens.

Using the equation $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$

explain why the image is in focus on the film.

[3]

(ii) Calculate the distance of the image from the lens, when the object is 2.00 m in front of the lens.

Give your answer to an appropriate number of significant figures.

image distance = ... mm [3]

(d) An advertisement for the camera states that the depth of field is from 2.0 m to infinity(∞). The depth of field is the range of object distances which give a reasonable focus on the film.

Suggest how your answer to **(c)(ii)** supports this statement.

[1]

[Total: 10]

[Turn over

8 This question is about converting an analogue musical sound signal into a digital signal so that it may be written to a CD.

This is for high fidelity (good quality) sound reproduction.

The graph Fig. 8.1 shows part of the analogue waveform and the digital sampling points.

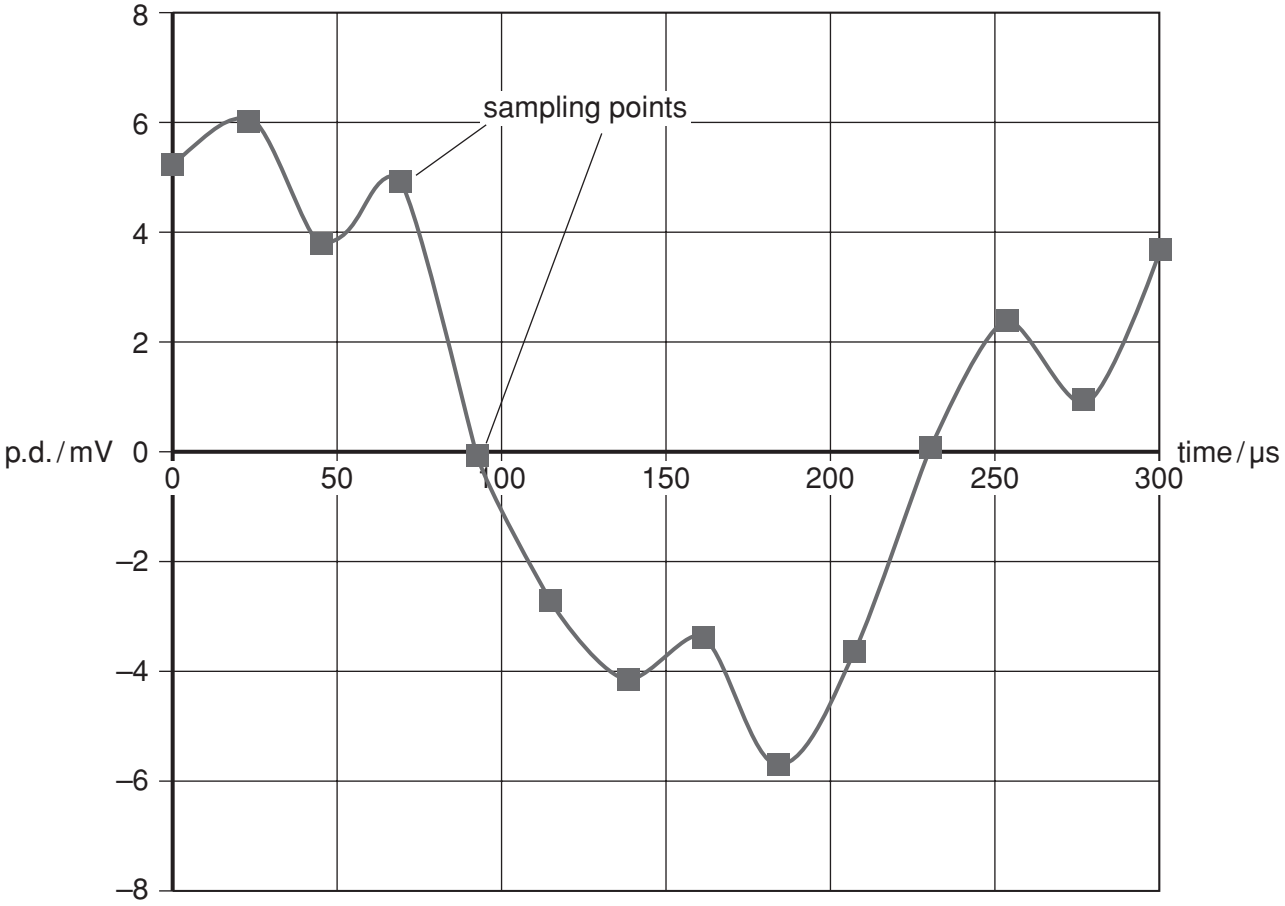


Fig. 8.1

(a) (i) The sampling rate is 44 kHz.

Show that the time between samples is between 20 µs and 25 µs.

[2]

(ii) The system uses 16 bit sampling.

Show that the number of voltage levels coded by 16 bits is about 66 000.

[1]

(iii) The signal voltage covers a range of 16 mV (between ± 8 mV).

Calculate the voltage resolution of this system.

voltage resolution = ... μV [2]

(b) A telephone line uses 8 bit sampling at an information rate of 64 kbits per second.

Explain the **disadvantages** of this sound reproduction system compared with the high quality system described in **(a)**.

[3]

[Total: 8]

9 The conductance G of a wire is related to its length L and cross-sectional area A by the relationship

$$G = \frac{\sigma A}{L}$$

where σ is the electrical conductivity of the material.

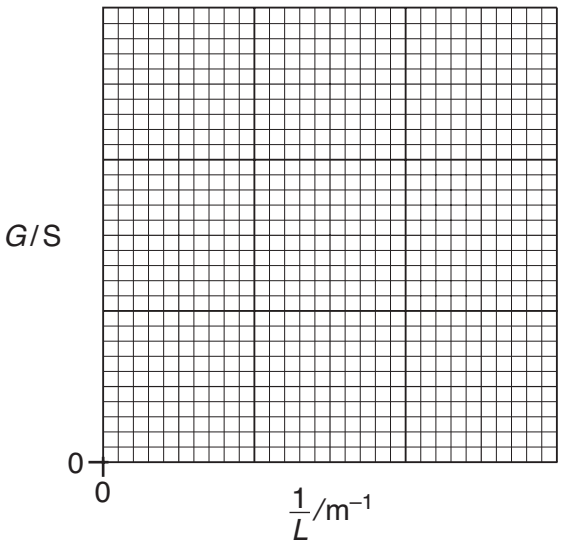
(a) In an experiment to investigate this relationship, a student gathers the following data for wires of the same material and of the same cross-sectional area.

conductance G / S	length L / m	$\frac{1}{L}$ / m^{-1}
0.50	0.20	5.00
0.20	0.50	
0.11	0.90	1.11
0.07	1.50	

(i) Complete the third column. [2]

(ii) Plot the data on a suitably scaled graph of G against $\frac{1}{L}$ below.

Draw the line of best fit.



[3]

(iii) Explain how your graph shows that G is **inversely proportional** to L.

[2]

(b) (i) Calculate the gradient of the graph, making your method clear.

gradient = ... S m [2]

(ii) Show that the conductivity of the material is about $4 \times 10^4\,\text{S m}^{-1}$.
Use your data from **(b)(i)**.

Take the cross-sectional area A as $2.3 \times 10^{-6}\,\text{m}^2$.

[2]

[Total: 11]

10 This question is about the height h of a column of solid material that can support its own weight without yielding under compression.

(a) Fig. 10.1 shows a vertical column of a solid material.

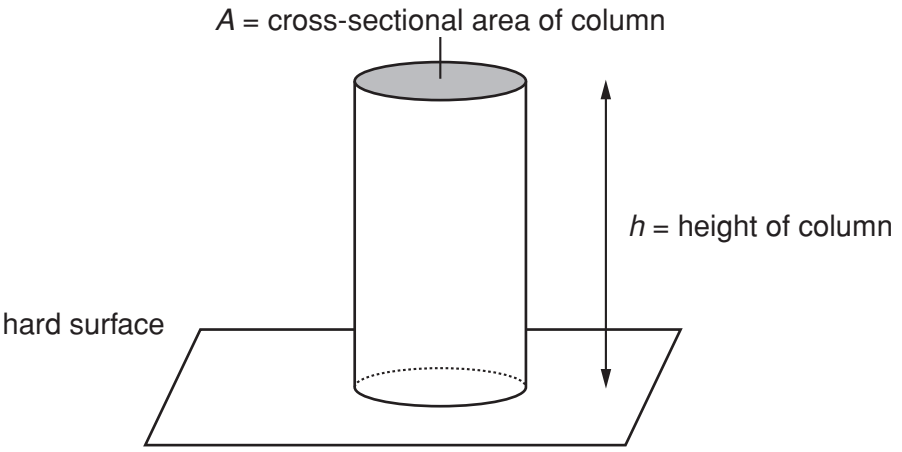


Fig. 10.1

(i) The stress at the base of the column = $h \rho g$

where ρ = density of material and g = gravitational field strength.

Derive this expression, by completing the following algebraic reasoning.
Fill the boxes, using the symbols given above.

volume of column = $A \times h$

mass of column = [ ]

weight of column = [ ]

stress at base of column = $\frac{\text{weight}}{\text{area}}$ = [ ]

= $h \rho g$ [3]

(ii) Explain why the failure of a tall column of solid material is most likely to occur at its base.

[1]

(iii) Explain why columns of the same material fail at the **same value** of h regardless of their cross-sectional area.

[1]

(b) (i) The compressive stress at which rock yields is about 2.4 $\times 10^8$ N m^{-2}.

Show that the maximum height h of a column of rock that could support its own weight on Earth is about 9 km.

density of surface rock on Earth = 2700 kg m^{-3}

gravitational field strength on Earth = 9.8 N kg^{-1}

[2]

(ii) Everest is the highest mountain on Earth. It is about 8.8 km high.
On the planet Mars the highest point is the volcano Olympus Mons, shown in Fig. 10.2, which is about 22 km high.

An image has been removed due to third party copyright restrictions

Details: An image of the volcano Olympus Mons on Mars, image from Nasa

Fig. 10.2

Suggest explanations why no mountain higher than Everest exists on Earth and why Olympus Mons can be so much higher.

[3]

[Total: 10]

[Section B Total: 39]

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.

11 Materials are chosen, or can be designed, to have properties suitable for a particular application. You are asked to illustrate these ideas using your own example.

(a) State your choice of material and give some details of an application of the material.

material .....

details of application

[3]

(b) **(i)** State and explain a physical property of the material that is important for your application.

[3]

(ii) State and explain another reason for using the material in this application.
This reason may be another physical property or from a wider context, for example from a cultural, historical or economic perspective.

[3]

(c) Materials have internal structure, possibly on several different scales.
Explain a physical property of your material, chosen in **(b)**, by describing its internal structure.

Use a labelled diagram, indicating the scale of the structure, to illustrate your explanation.

[4]

[Total: 13]

[Turn over

12 In this question, you are asked to describe the operation of an electrical sensor system.

(a) (i) State what physical variable your system is designed to monitor or measure.

.....

(ii) Draw and label a circuit diagram for your electrical sensor system.

(iii) Explain how the circuit operates.

[5]

(b) (i) Explain what is meant by **sensitivity** and **response time** of a sensor system.

sensitivity

response time

[3]

(ii) For your sensor system, describe how you would investigate **either** the sensitivity **or** the response time.

[3]

(c) A sensor system can be affected by both random and systematic errors.

Explain the difference between these two types of error.

[2]

[Total: 13]

[Quality of Written Communication: 4]

[Section C Total: 30]

END OF QUESTION PAPER