Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
June 2005
Advanced Subsidiary Examination

PHYSICS (SPECIFICATION B) **PHB2**
Unit 2 Waves and Nuclear Physics

Friday 10 June 2005 Morning Session

In addition to this paper you will require:
- a calculator;
- a ruler.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A** and **Section B** in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.
- All working must be shown, otherwise you may lose marks.
- A *Formulae Sheet* is provided on page 3. Detach this perforated page at the start of the examination.

Information
- The maximum mark for this paper is 75.
- Mark allocations are shown in brackets.
- Marks are awarded for units in addition to correct numerical answers, and for the use of appropriate numbers of significant figures.
- You are expected to use a calculator where appropriate.
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate.
- The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

Advice
- You are advised to spend about 30 minutes on **Section A** and about 1 hour on **Section B**.

For Examiner's Use			
Number	Mark	Number	Mark
A			
5			
6			
7			
8			
9			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

Answer **all** questions in this section.

There are **24** marks in this section.

1 An interference pattern is produced using monochromatic light from two coherent sources. The separation of the two sources is 0.25 mm and the fringe separation is 7.8 mm. The interference pattern is observed on a screen that is 3.5 m from the sources.

(a) Calculate the wavelength of the light used to produce the interference pattern.

wavelength ....

(3 marks)

(b) **Figure 1** shows light from two coherent sources, S_1 and S_2, superimposing to create a bright fringe at point **Q**. **Q** is equidistant from S_1 and S_2. The diagram is not to scale.

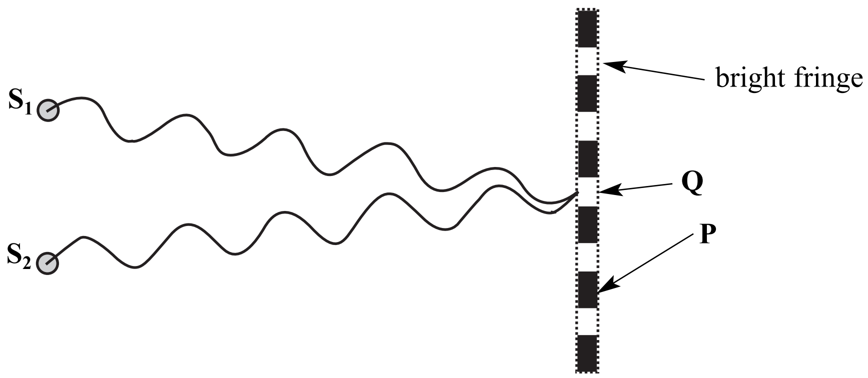

Figure 1

Explain how the dark fringe at the point **P** is caused.

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(3 marks)

Detach this perforated page at the start of the examination.

Foundation Physics Mechanics Formulae

moment of force $= Fd$

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s = \frac{1}{2}(u + v)t$

for a spring, $F = k\Delta l$

stored in a spring $= \frac{1}{2}F\Delta l = \frac{1}{2}k(\Delta l)^2$

$T = \dfrac{1}{f}$

Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

in series circuit, $R = R_1 + R_2 + R_3 + ...$

parallel circuit, $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + ...$

t voltage across $R_1 = \left(\dfrac{R_1}{R_1 + R_2}\right) \times$ input voltage

Waves and Nuclear Physics Formulae

fringe spacing $= \dfrac{\lambda D}{d}$

single slit diffraction minimum $\sin\theta = \dfrac{\lambda}{b}$

diffraction grating $n\lambda = d\sin\theta$

Doppler shift $\dfrac{\Delta f}{f} = \dfrac{v}{c}$ for $v << c$

Hubble law $v = Hd$

radioactive decay $A = \lambda N$

Properties of Quarks

Type of quark	Charge	Baryon number
up u	$+\frac{2}{3}e$	$+\frac{1}{3}$
down d	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\overline{u}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\overline{d}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

Lepton Numbers

Particle	Lepton number L		
	L_e	L_μ	L_τ
e^-	1		
e^+	–1		
ν_e	1		
$\overline{\nu}_e$	–1		
μ^-		1	
μ^+		–1	
ν_μ		1	
$\overline{\nu}_\mu$		–1	
τ^-			1
τ^+			–1
ν_τ			1
$\overline{\nu}_\tau$			–1

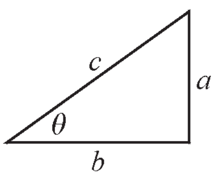
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

area of a circle $= \pi r^2$

surface area of sphere $= 4\pi r^2$

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



$\sin\theta = \dfrac{a}{c}$

$\cos\theta = \dfrac{b}{c}$

$\tan\theta = \dfrac{a}{b}$

$c^2 = a^2 + b^2$

Turn over ▶

NO QUESTIONS APPEAR ON THIS PAGE

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2 The following is an incomplete equation for the decay of a free neutron.

$$^{1}_{0}\text{n} \longrightarrow \ ^{1}_{1}\text{p} + \ ^{0}_{-1}\text{e} + \ \ldots\ldots\ldots\ldots$$

(a) Complete the equation by writing into the space, the symbol for the missing particle.

(2 marks)

(b) Use the principles of conservation of charge, baryon number and lepton number to demonstrate that the decay is possible.

Conservation of charge ....

Conservation of baryon number ....

Conservation of lepton number ....

(3 marks)

3 **Figure 2** shows the block diagram for a radio communication system.

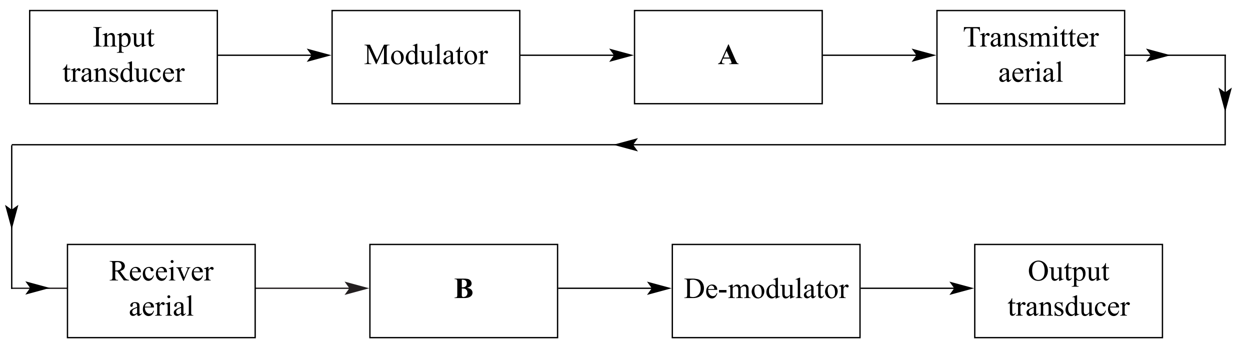

Figure 2

Identify the missing components, **A** and **B**, and describe the purposes of each stage of the transmission part of the process shown by the block diagram.

Two of the 7 marks for this question are available for the quality of your written communication.

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(7 marks)

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4 **Figure 3** illustrates one way in which radio signals can be detected beyond the line of sight around the Earth's curvature.

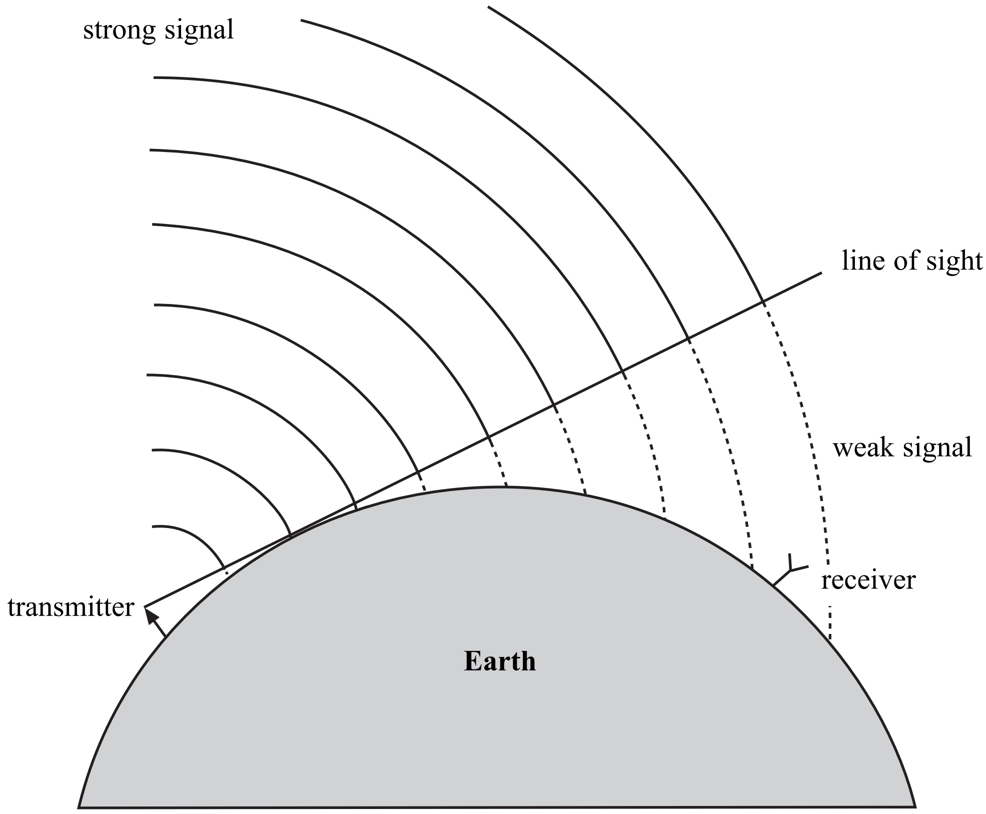

Figure 3

(a) (i) State the name of the process that allows the weak signal to spread beyond the line of sight.

....

(1 mark)

(ii) Explain why this effect is more noticeable with long wave signals than it is with short wave signals.

....

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....

(2 marks)

(b) State **three** other ways in which telecommunications signals can reach areas beyond the horizon.

First way ....

Second way ....

Third way ....

(3 marks)

24

TURN OVER FOR THE NEXT SECTION

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SECTION B

Answer **all** questions in this section.

Total for this question: ***13 marks***

5 (a) (i) Alpha and beta emissions are known as *ionising radiations*. State and explain why such radiations can be described as *ionising*.

....

....

....

(2 marks)

(ii) Explain why beta particles have a greater range in air than alpha particles.

....

....

....

(2 marks)

(b) **Figure 4** shows the variation with time of the number of Radon (^{220}Ra) atoms in a radioactive sample.

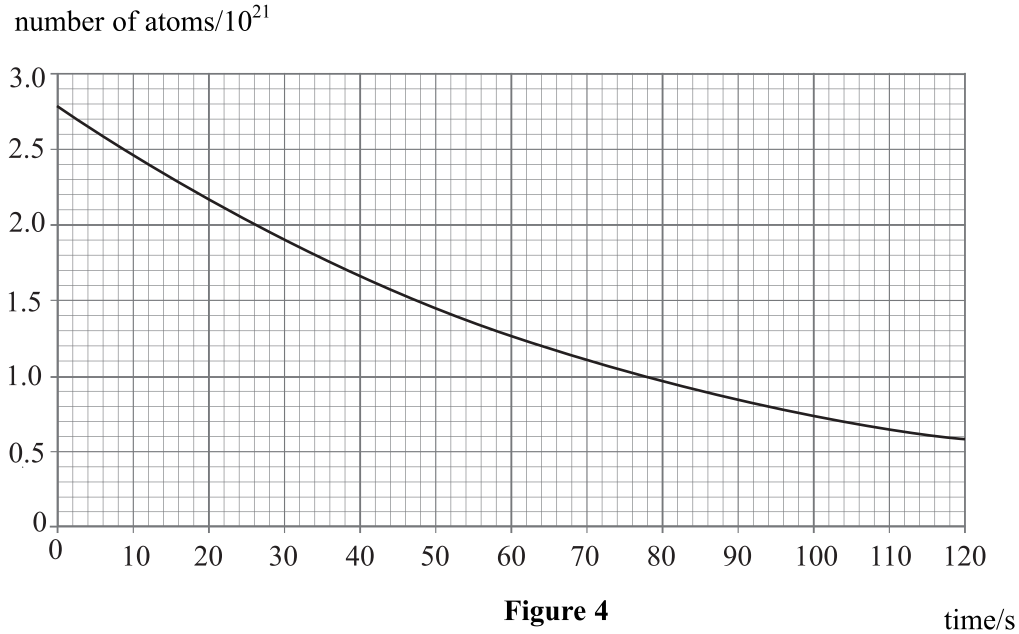

Figure 4

(i) Use the graph to show that the half-life of the decay is approximately 53 s. Show your reasoning clearly.

(3 marks)

(ii) The probability of decay (decay constant) for ^{220}Ra is $1.3 \times 10^{-2}\,s^{-1}$. Use data from the graph to find the activity of the sample at a time $t = 72\,s$.

activity ....

(3 marks)

(c) (i) State **two** origins of background radiation.

....

....

(2 marks)

(ii) Suggest why it should be unnecessary to allow for background radiation when measuring the activity of the sample described in part (b)(ii).

....

....

(1 mark)

13

TURN OVER FOR THE NEXT QUESTION

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Total for this question: ***11 marks***

6 (a) Describe a way of measuring the speed of sound in free air **in the laboratory**. Your description should include details of the following:

- the apparatus you would use
- the measurements you would make
- the way in which you would work out the speed
- how you would make your determination accurate.

You will probably find it helpful to draw a diagram of your apparatus.

Two of the 6 marks for this question are available for the quality of your written communication.

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(6 marks)

(b) **Figure 5** shows a plan view of two rooms separated by a doorway. The doorway is 0.85 m wide. The loudspeaker, **L**, emits sound with a frequency of 560 Hz.

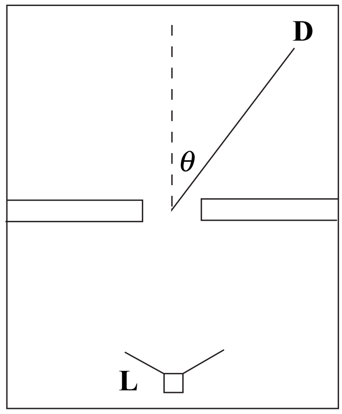

Figure 5

(i) Calculate the wavelength of the sound.
speed of sound in air = $340\,m\,s^{-1}$

wavelength ....
(2 marks)

(ii) The first-order diffraction minimum is detected at the point marked **D** in **Figure 5**. Calculate the angle, θ, between the normal to the doorway and the point **D**.

θ..
(3 marks)

11

Total for this question: ***10 marks***

7 (a) **Figure 6** shows the path taken by an alpha particle, **B**, as it is deflected by a gold nucleus, **G**, in Rutherford's alpha scattering experiment. Also marked on **Figure 6** are the starts of two further tracks, **A** and **C**, made by alpha particles travelling with the same initial speed as **B**.

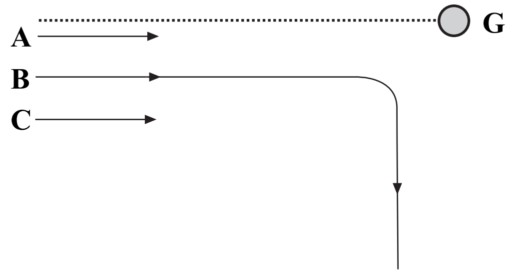

Figure 6

(i) On **Figure 6**, complete the tracks of the alpha particles marked **A** and **C**.

(2 marks)

(ii) State and explain what the results of the experiment indicated about the structure of the gold atom.

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(3 marks)

(b) **Figure 7** shows the track of a proton moving through a bubble chamber.

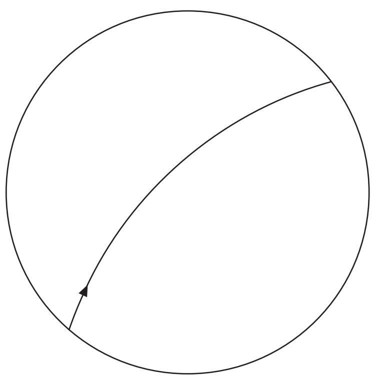

Figure 7

(i) State what is normally applied to a bubble chamber to cause the proton to move in a curved path.

....

(1 mark)

(ii) Draw on to **Figure 7** the track of another proton moving with a greater speed than the original proton but with the same initial position and direction as it enters the bubble chamber. **Label this track P**.

Draw on to **Figure 7** the track of an electron moving with the same speed as the original proton and the same initial position and direction as it enters the bubble chamber. **Label this track E**.

(2 marks)

(c) **Figure 8** shows the apparatus for an experiment in which nitrogen gas was bombarded by alpha particles. Other particles, produced by the bombardment hit the zinc sulphide screen, **Z**, causing flashes of light that were observed through the microscope.

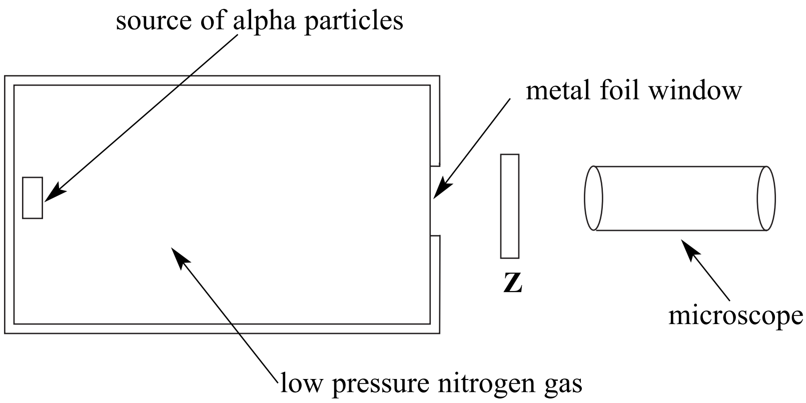

Figure 8

(i) Explain why the flashes from the zinc sulphide screen could not have been caused by the impact of alpha particles with the screen.

....

....

(1 mark)

(ii) When the alpha particle collides with a nitrogen nucleus ($^{14}_{7}N$) an isotope of oxygen ($^{17}_{8}O$) is produced. What other particle will be produced in this collision, resulting in the flashes of light seen on the screen?

....

(1 mark)

10

Turn over ▶

Total for this question: ***10 marks***

8 (a) Explain how a stationary wave is produced when a stretched string is plucked.

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(3 marks)

(b) (i) On **Figure 9**, draw the fundamental mode of vibration of a stretched string. Label any nodes with a letter **N** and any antinodes with a letter **A**.

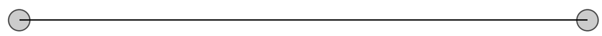

Figure 9

(2 marks)

(ii) On **Figure 10**, draw the fourth harmonic (third overtone) for the stretched string. Label any nodes with a letter **N** and any anitinodes with a letter **A**.

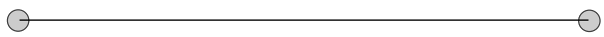

Figure 10

(2 marks)

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(c) The fundamental frequency of vibration, f, of a string is given by:

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

where T = the tension in the string
l = the length of the string
μ = the mass per unit length of the string

A string has a tension of 180 N and a length of 0.70 m.

(i) What would need to be done to the length of the string in order to double the frequency?

....

(1 mark)

(ii) What would need to be done to the tension of the string in order to double the frequency?

....

(2 marks)

—
10

TURN OVER FOR THE NEXT QUESTION

Total for this question: ***7 marks***

9 **Figure 11** shows the continuous spectrum emitted by the Sun, **S**. It also shows the spectrum emitted by another star, **A**.

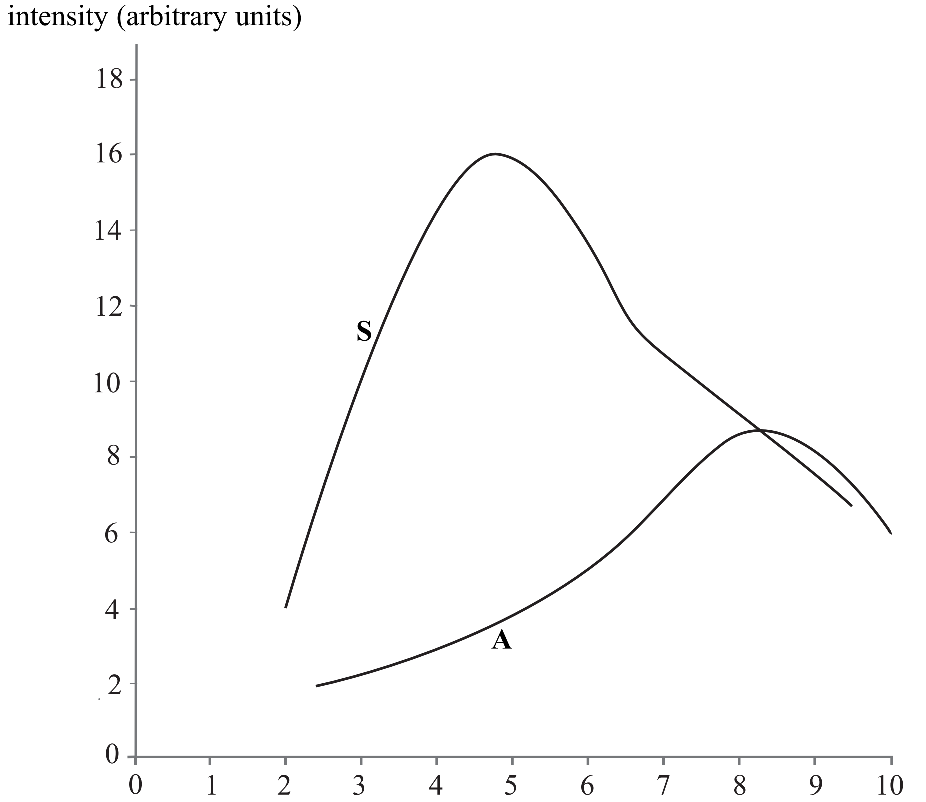

Figure 11

(a) State and explain how you would expect the appearance of star **A** to differ from that of the Sun.

....

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....

....

....

(3 marks)

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(b) The spectrum emitted by the Sun is a continuous spectrum with dark lines across it.

(i) Explain why there are dark lines in the Sun's spectrum.

....

....

....

....

(2 marks)

(ii) Explain why the dark lines are significant to astronomers who are observing the spectra of light from distant galaxies.

....

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(2 marks)

7

END OF QUESTIONS

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