Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
January 2008
Advanced Subsidiary Examination

AQA
ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Friday 11 January 2008 1.30 pm to 3.00 pm

For this paper you must have:
- a calculator
- a ruler.

Time allowed: 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in **Section A** and **Section B** in the spaces provided.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- A *Formulae Sheet* is provided as a loose insert to this question paper.

Information
- The maximum mark for this paper is 75.
  Four of these marks will be awarded for using good English, organising information clearly and using specialist vocabulary where appropriate.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- Questions 6(a) and 10 should be answered in continuous prose. In these questions you may be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

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

For Examiner's Use			
Question	Mark	Question	Mark
A		6	
		7	
		8	
		9	
		10	
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

There are no questions printed on this page

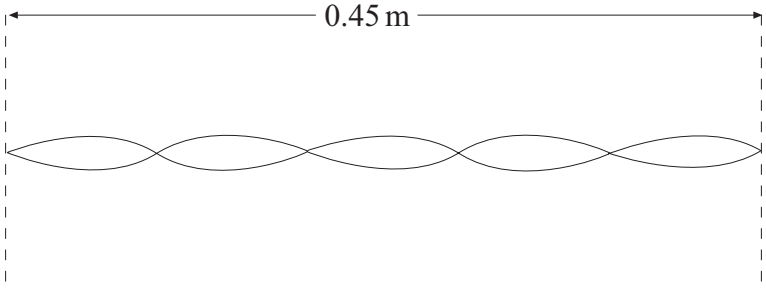
SECTION A

Answer **all** questions in this section.

There are 26 marks in this section.

1 **Figure 1** shows the mode of vibration for a stretched string of length 0.45 m when it is emitting a note of frequency 900 Hz.

Figure 1



(a) (i) How many nodes are there in the waveform?

number of nodes .....

(ii) State the wavelength of the waves shown in **Figure 1**.

wavelength .....

(2 marks)

(b) (i) Calculate the speed of waves along the string.

speed of waves .....

(ii) The maximum frequency of vibration of this string that can be heard by an observer is 3600 Hz. How many 'loops' would occur when the string is emitting this frequency?

number of loops .....

(3 marks)

2 A particle **X** is a hadron that consists of one up quark (u) and one antidown ($\bar{d}$) quark.

(a) (i) State the hadron sub-class to which the particle **X** belongs.

.....

(ii) Determine the charge carried by **X**.
electron charge = -1.6×10^{-19} C

charge.....

(iii) State the quark structure of the antiparticle of **X**.

.....

(3 marks)

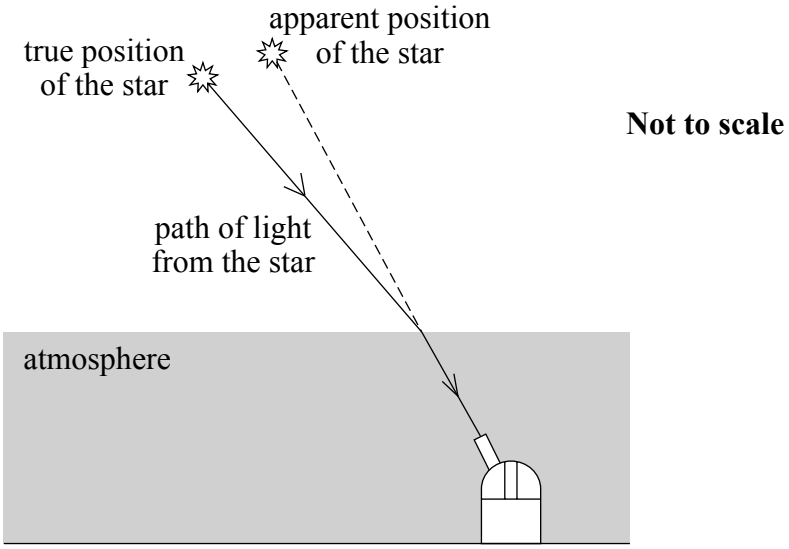
(b) Quarks are thought to be fundamental particles. Tick the boxes to indicate which **three** of the following are classified as fundamental.

proton	**tau**	**anti-neutrino**	**alpha particle**	**electron**

(2 marks)

3 **Figure 2** shows that when an astronomer makes observations of a star in an observatory on Earth, the star is not seen in its true position due to the effects of the atmosphere.

Figure 2



(a) (i) State the name of the effect shown in **Figure 2**.

.....

(ii) Explain what causes the effect to occur.

.....

.....

(3 marks)

(b) Give **two** reasons why the presence of the atmosphere reduces the brightness of the image of the star seen by the astronomer.

reason 1 .....

reason 2 .....

(2 marks)

4 The table shows how light intensity, I, varies with distance, d, from the filament of a lamp.

d/m	I/Wm^{-2}
0.080	55
0.100	35
0.120	25

(a) Show that these data obey an inverse square law.

(3 marks)

(b) Calculate the power emitted by the light source.

power emitted.....

(2 marks)

(c) Give **one** reason why the variation of the intensity of sound with distance, directly in front of a loudspeaker, would **not** be expected to follow an inverse square law.

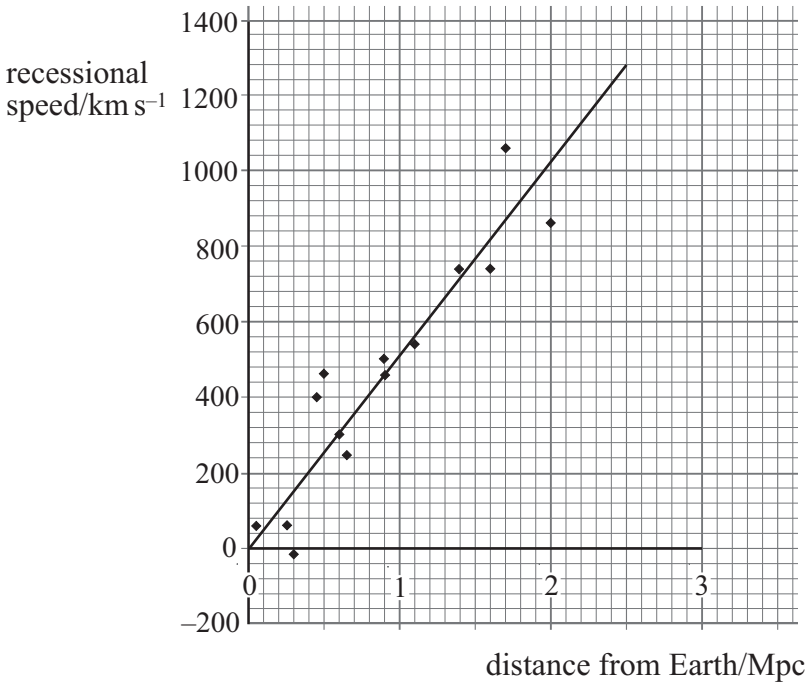
.....

.....

(1 mark)

5 **Figure 3** shows a plot of some data relating the recessional speeds of astronomical objects to their distances from the Earth used by Hubble in 1929. Hubble's line of best fit for all his data is shown.

Figure 3



(a) (i) What is meant by the term *recessional speed*?

.....

(ii) The value of the Hubble constant calculated by Hubble was quite different from the accepted value today. Calculate the value for the Hubble constant suggested by the data in **Figure 3**.

(3 marks)

(b) Explain how the Hubble law can be used to determine the maximum distance from Earth at which an astronomical object could possibly be observed.

.....

.....

.....

(2 marks)

26

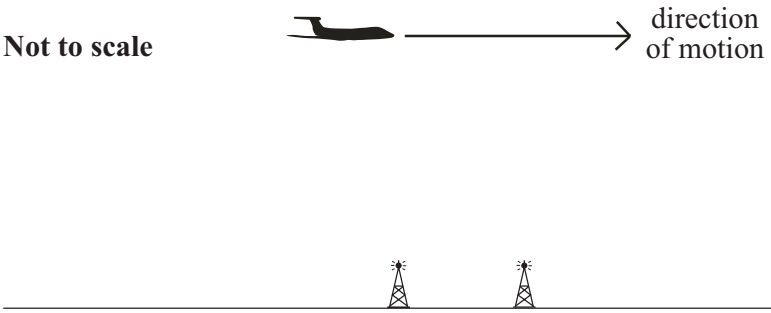
Turn over ▶

SECTION B

Answer **all** questions in this section.

6 The aircraft shown in **Figure 4** is flying horizontally at 125 m s^{-1}. The flight path is directly over two radio transmitters that are known to be 550 m apart. The transmitters emit *coherent waves* of wavelength 32 m. The pilot notices that the signal strength varies and is a minimum every 3.2 s.

Figure 4



(a) Explain what is meant by coherent waves and why the strength of the signal received varies.

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(7 marks)

(b) (i) Calculate the distance travelled by the aircraft between one position of minimum signal strength and the next.

distance travelled.....

(ii) Calculate the height at which the aircraft is flying.

height.....

(4 marks)

11

Turn over for the next question

7 **Figure 5** shows a star system which consists of two identical stars that move in the same circular path around their centre of mass. At the instant shown, star **X** is moving directly towards an observer on Earth and star **Y** is moving directly away.

Figure 5

not to scale

The frequency of one spectral line is 6.2×10^{14} Hz when measured using light from a discharge tube in a laboratory.
The frequency of the same line in the spectrum of light emitted by **X** is observed to have changed by 1.2×10^{11} Hz.

speed of electromagnetic radiation in a vacuum, $c = 3.0 \times 10^{8}\,\text{m s}^{-1}$

(a) (i) On **Figure 5** indicate a point on the path of the stars when the measured frequency of the light from the star will be the same as that from the laboratory source. Label this **S**.

(ii) Calculate the speed of the stars in their circular path.

speed of stars.....

(iii) Calculate the difference between the observed frequencies of the light emitted from **X** and **Y** at the instant shown in **Figure 5**.

difference in frequencies.....

(iv) State whether the observed frequency of the light from **X** at the instant shown in **Figure 5** is higher or lower than that measured in a laboratory on Earth.

.....

(5 marks)

(b) The wavelength of the light from the laboratory source is 483 nm.
Calculate the number of lines per mm on a diffraction grating that will produce a second order maximum at an angle of 50° for this wavelength.

lines per mm.....

(4 marks)

(c) State **two** pieces of information, other than the relative motion of a star, that can be discovered from observations of the spectrum of the radiation from the star.

First .....

Second .....

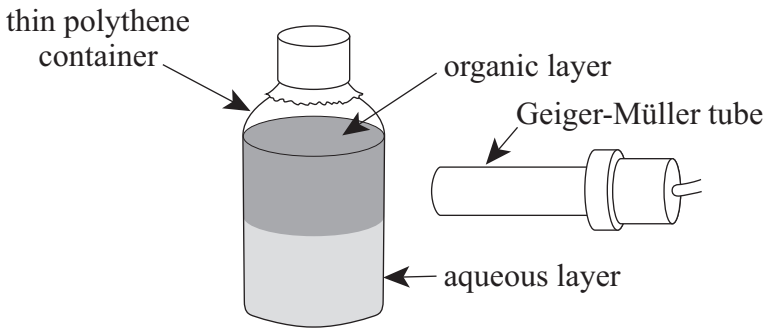
(2 marks)

11

Turn over for the next question

8 **Figure 6** shows part of the apparatus used to measure the half-life of protactinium-234.

Figure 6



The protactinium is formed in the aqueous layer by the decay of uranium-238 ($^{238}_{92}U$) which decays to protactinium-234 ($^{234}_{91}Pa$) in a series of decays.

The protactinium is extracted from the aqueous layer by the organic layer when the container is shaken. The protactinium-234 in the organic layer then decays to uranium-234 by the emission of negative beta (β^-) particles which are detected by the Geiger-Müller tube.

(a) (i) State the number of alpha and beta particles that are emitted when a uranium-238 nucleus decays into a protactinium-234 nucleus.

Number of alpha particles .....

Number of beta particles .....

(ii) Name another particle emitted when a protactinium-234 nucleus decays into a uranium-234 nucleus.

.....

(iii) Explain why the container is made of thin polythene.

.....

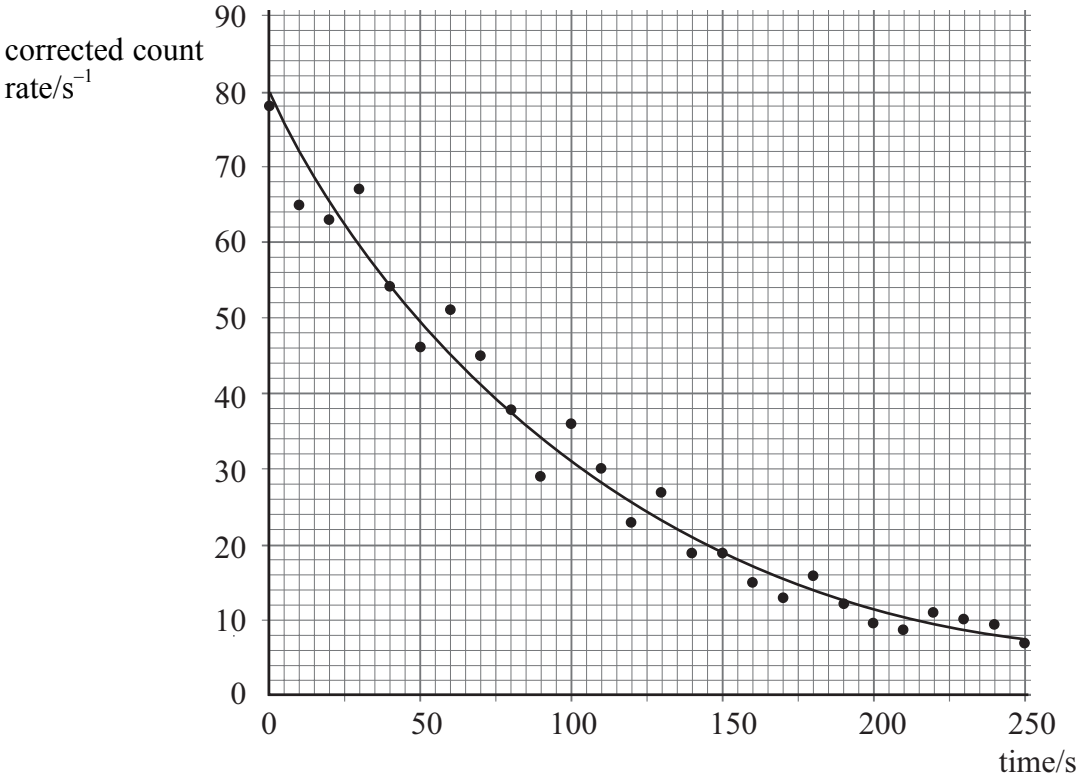
.....

.....

.....

(5 marks)

(b) The graph shows data for one set of results and the line of best fit for the data.



(i) Explain why there is a wide scatter of the data points around the line of best fit.

.....

.....

.....

(ii) Explain why the count rate has to be 'corrected' and how the correction is applied.

.....

.....

.....

(iii) Calculate the half-life of the protactinium-234.

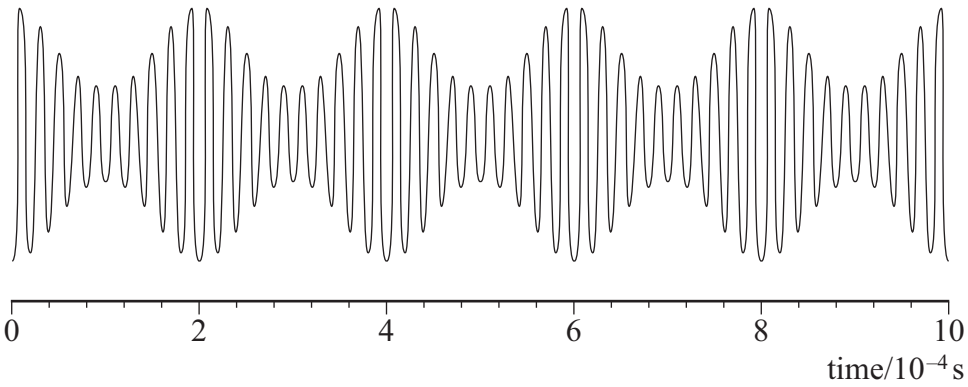
half-life.....

(7 marks)

12

9 **Figure 7** shows the waveform of a carrier wave when transmitting information.

Figure 7



(a) Explain why carrier waves are used in the transmission of information.

.....

.....

.....

(2 marks)

(b) (i) State the property of the carrier wave that is being modified in **Figure 7**.

.....

(ii) State another property that can be changed to transmit information using a carrier wave.

.....

(2 marks)

(c) Determine the minimum bandwidth needed to transmit the information carried by the wave shown in **Figure 7**.

minimum bandwidth .....

(3 marks)

7

10 Images formed using X-rays or ultrasound techniques are used by doctors to examine organs in the body.

Describe **two** ways in which the waves used in these techniques differ. Go on to explain **two** advantages and **two** disadvantages of using ultrasound when compared with X-rays for clinical diagnosis.

Two of the 8 marks are available for the quality of your written communication.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(8 marks)

8

END OF QUESTIONS

There are no questions printed on this page

General Certificate of Education
January 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Formulae Sheet

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, $F = k\Delta l$

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

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

Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

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

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

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

Waves and Nuclear Physics Formulae

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

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

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

Doppler shift $\frac{\Delta f}{f} = \frac{v}{c}$ 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	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\overline{\text{u}}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\overline{\text{d}}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

Lepton Numbers

Particle	Lepton number L		
	L_e	L_μ	L_τ
e^-	1		
e^+	−1		
υ_e	1		
$\overline{\upsilon}_e$	−1		
μ^-		1	
μ^+		−1	
υ_μ		1	
$\overline{\upsilon}_\mu$		−1	
τ^-			1
τ^+			−1
υ_τ			1
$\overline{\upsilon}_\tau$			−1

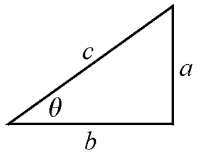
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

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

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

This insert page should **not** be sent to the examiner