Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
January 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Friday 12 January 2007 1.30 pm to 3.00 pm

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

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

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.
- 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 on page 3. Detach this perforated page at the start of the examination.

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 7(c) and 8(b) 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**.

SECTION A

Answer **all** questions in this section.

There are 26 marks in this section.

1 An ultrasonic signal from a ship travels vertically downwards through the water. The wavelength of the waves is 5.3×10^{-2} m and the frequency of the waves is 29 kHz.

(a) Calculate the speed of the sound through the water.

speed .....
(3 marks)

(b) The sound is reflected from the sea bed and is received back at the ship 0.23 s after it is transmitted. Calculate the depth of the water.

depth .....
(2 marks)

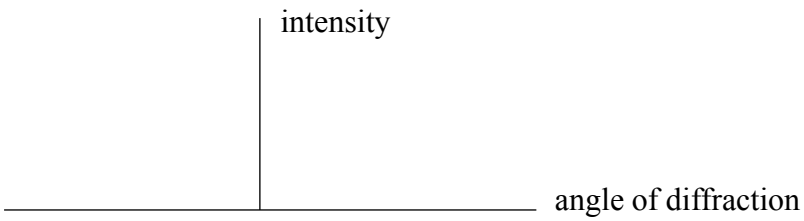
2 Radio waves of wavelength 2.7×10^{-2} m are incident on a slit of width 6.3×10^{-2} m.

(a) Calculate the angle at which the first order diffraction minimum occurs.

angle .....
(3 marks)

(b) Sketch on **Figure 1** the variation of intensity with angle of diffraction.

Figure 1



(2 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, $F = k\Delta l$

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

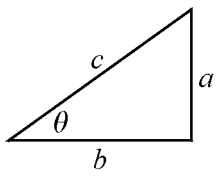
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

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

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

There are no questions printed on this page

3 (a) Sound of frequency 420 Hz is produced by a car engine. The car moves towards an observer. Because of the Doppler effect, the observer hears the sound at a frequency of 450 Hz.

(i) Calculate the speed of the approaching car.
speed of sound = 330 m s^{-1}

speed .....

(ii) Calculate the frequency of the sound heard by the observer as the car moves away from him.

frequency .....
(4 marks)

(b) State an industrial or medical use of the Doppler effect.

.....
(1 mark)

Turn over for the next question

4 (a) **Figures 2** and **3** illustrate cloud chamber tracks of particles produced by radioactive sources.

Figure 2

Figure 3

(i) Identify the particles producing the tracks.

Figure 2 .....

Figure 3 .....

(ii) Explain, in terms of the properties of the particle causing the track, the characteristics of the tracks in **Figure 3**.

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(4 marks)

(b) When a magnetic field is applied to a bubble chamber, the particles move in circular paths. State **two** deductions that can be made from the curvature of the tracks.

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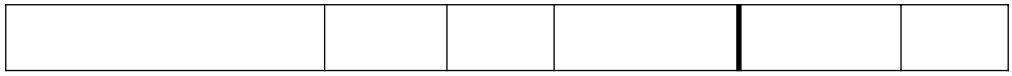
(2 marks)

5 **Figure 4** shows part of the helium spectrum with the range of the wavelengths marked.

Figure 4



250 nm wavelength 750 nm

Figure 5

250 nm wavelength 750 nm

(a) On **Figure 5**, sketch a typical helium spectrum that would be observed on Earth if the light had been transmitted from a distant galaxy that was moving away from the Earth.

(2 marks)

(b) Explain how the difference between the spectra in **Figure 4** and **Figure 5** give information to astronomers about the nature and origin of the universe.

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(3 marks)

26

SECTION B

Answer **all** questions in this section.

6 Carbon-14 ($^{14}_{6}C$) decays by beta emission. Other isotopes with proton numbers near to that of carbon are $_{2}He$, $_{3}Li$, $_{4}Be$, $_{5}B$, $_{7}N$, $_{8}O$, $_{9}F$, $_{10}Ne$.

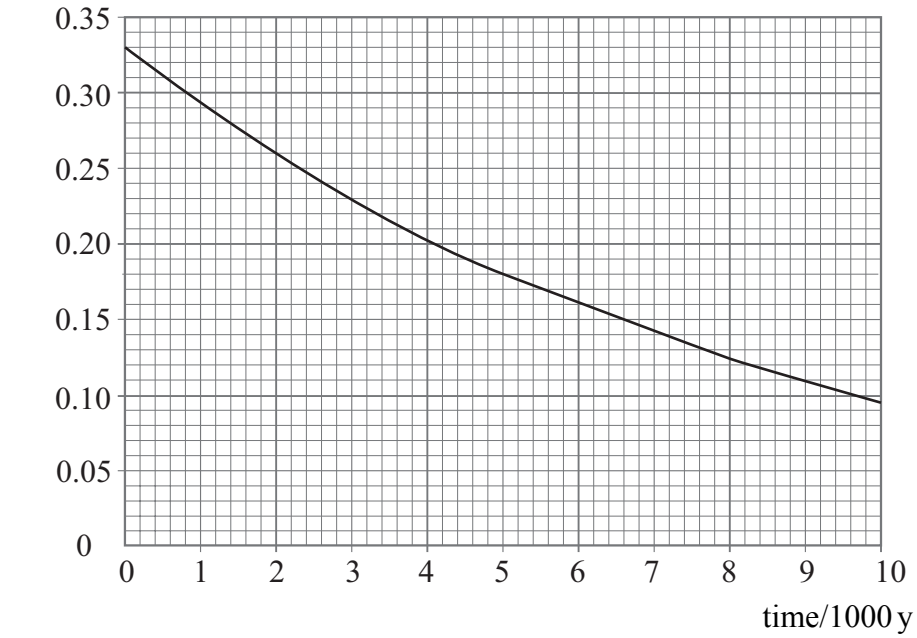
(a) Complete the decay equation for carbon-14, giving the proton and nucleon numbers for all of the decay products.

$$^{14}_{6}C \rightarrow$$

(3 marks)

(b) When trees are growing, the wood absorbs carbon-14 so that each gram of wood has an activity of 0.33 Bq. When a tree is cut down, the carbon-14 is not renewed and the activity begins to decay in the normal way. **Figure 6** shows the change of activity of a 1.0 g sample of wood over time.

Figure 6



(i) Use data from **Figure 6** to show that the half-life of carbon-14 is approximately 5700 year.

(ii) Calculate the number of carbon-14 atoms in a 1.0 g sample of wood when its activity is 0.33 Bq.

number of atoms .....

(5 marks)

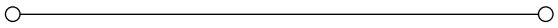
(c) A 5.0 g sample of wood from a door post found on an archaeological site has an activity of 1.2 Bq. Use data from **Figure 6** to find the age of the wood.

age .....

(2 marks)

10

7 The line below represents a string stretched between two fixed points.



(a) Draw on the diagram the fundamental mode of vibration of the string. Label any antinodes with a letter **A** and any nodes with a letter **N**. *(2 marks)*

(b) (i) The length of a stretched string affects its fundamental frequency of vibration. State **one** other factor that would affect the fundamental frequency of vibration.

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(ii) State the way in which the factor you have named affects the fundamental frequency.

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(2 marks)

(c) Describe how you would perform an experiment to investigate the variation of the fundamental frequency of vibration with the length of a stretched string.

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

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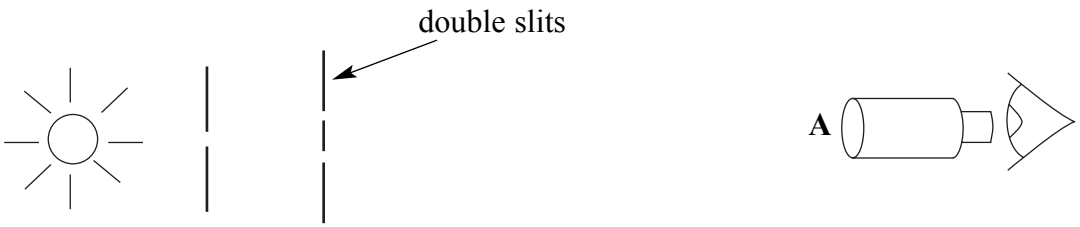
(7 marks)

11

Turn over for the next question

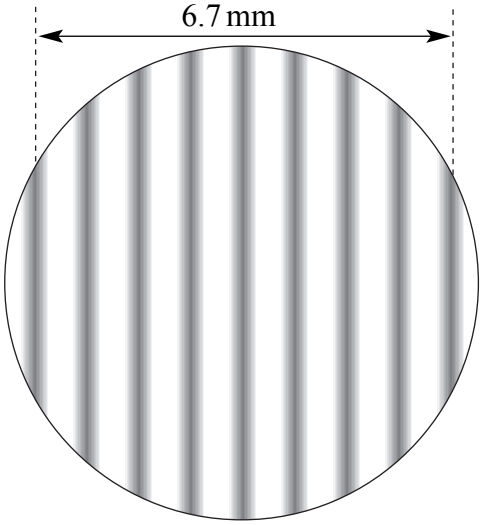
8 (a) Red light of wavelength 6.2×10^{-7} m is incident on the double slits in **Figure 7**.

Figure 7



Interference fringes are observed through a microscope at **A**. Eight fringes are seen to cover a distance of 6.7 mm, as can be seen in **Figure 8**. The distance between **A** and the slits is 0.80 m.

Figure 8



(i) Calculate the slit separation.

slit separation .....

(ii) The red light is replaced with a monochromatic blue light. State and explain any differences (apart from the colour) between the appearance of the blue and red fringes.

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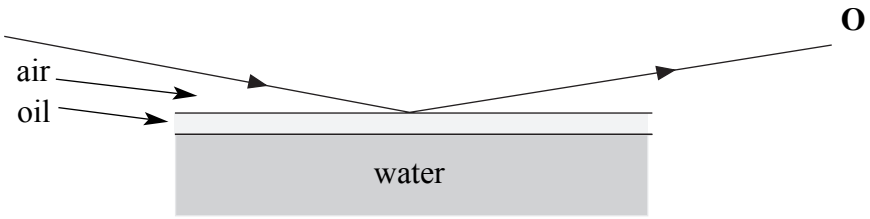
(5 marks)

(b) **Figure 9** shows a ray of light from a monochromatic source incident on a thin layer of oil floating on water. Some of the light is reflected from the top surface of the oil. Explain why interference fringes may be observed by an observer at **O**.

Figure 9



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

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(6 marks)

11

Turn over for the next question

9 (a) Leptons include muons, electrons, tau particles, their antiparticles and associated neutrinos and antineutrinos.
Compare the characteristics of electrons, muons and neutrinos.

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(4 marks)

(b) Use the principles of conservation of charge, baryon number and lepton number to decide whether or not the following decay is possible. Show your reasoning.

$$\tau^+ \rightarrow \mu^+ + \nu_\tau$$

conservation of charge: .....

conservation of baryon number: .....

conservation of lepton number: .....

.....

(3 marks)

7

10 The waveband for "medium wave" transmissions is 500 kHz to 1600 kHz. Speech, or music of a reasonable quality, contains frequencies of between 50 Hz and 4500 Hz.

(a) Calculate the number of radio stations that can be clearly transmitted on the medium waveband.

number of stations .....

(3 marks)

(b) Explain why the acceptable base bandwidths vary from about 3 kHz for telephone conversation, to 15 kHz for high quality music.

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(2 marks)

Question 10 continues on the next page

(c) (i) Explain how analogue signals are sometimes digitised for transmission.

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(ii) Explain how digitisation may improve the quality of sound heard by a radio listener.

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(5 marks)

10

END OF QUESTIONS