| Surname | | Other Names | |
|---|---|---|---|
| Centre Number | | | Candidate Number | | | | |
| Candidate Signature | | | | | | | | | |

For Examiner's Use

General Certificate of Education
June 2008
Advanced Subsidiary Examination

AQA
ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Thursday 22 May 2008 1.30 pm to 3.00 pm

**For this paper you must have:**
- a calculator
- a ruler
- a formulae sheet insert.

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.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**
- The maximum mark for this paper is 75. This includes up to 4 marks for the Quality of Written Communication.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- A *Formulae Sheet* is provided as a loose insert to this question paper.
- Questions 7(d) and 9 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 | |
| | | | |
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| Total (Column 1) → | | | |
| Total (Column 2) → | | | |
| TOTAL | | | |
| Examiner's Initials | | | |

## SECTION A

Answer **all** questions in this section.

There are **25** marks in this section.

**1** (a) Complete the table in **Figure 1**.

**Figure 1**

| wave type | wavelength/m | frequency/Hz | speed in air/m $s^{-1}$ |
|---|---|---|---|
| red light | $6.31 \times 10^{-7}$ | | $3.00 \times 10^{8}$ |
| sound | 0.654 | 512 | |
| | $4.10 \times 10^{-2}$ | $7.32 \times 10^{9}$ | $3.00 \times 10^{8}$ |

*(3 marks)*

**1** (b) State and explain which **one** of the waves shown in **Figure 1** cannot be polarised.

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*(2 marks)*

**2** (i) What is a light-year?

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**2** (ii) State the Hubble law in words.

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**2** (iii) The Andromeda galaxy is $2.5 \times 10^6$ light-years from Earth.
Calculate its speed relative to the Earth.

Hubble constant = $65\,\text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1}$
1pc = 3.3 light-year

relative speed.....

*(5 marks)*

**Turn over for the next question**

**3** Radioactivity in our environment is called background radiation.

**3** (a) State **two** sources of background radiation.

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*(2 marks)*

**3** (b) Explain why high doses of radiation from radioactive sources are a health hazard.

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*(3 marks)*

**4** When light enters an eye it is diffracted by the pupil causing a diffraction pattern on the retina. Two small objects which are close together can just be resolved by the eye into two separate images if the diffraction maximum of one coincides with the first minimum of the other.

**4** (i) Show that for a human eye to just resolve two small objects in blue light the angle subtended at the eye by the objects must be about $5 \times 10^{-3}$ degrees.

diameter of pupil = 5.0 mm
wavelength of blue light = $4.0 \times 10^{-7}$ m

**4** (ii) Two objects which can just be resolved in blue light are viewed in red light. State and explain whether or not they can be seen as separate objects.

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*(5 marks)*

**5** (a) What is the Doppler effect?

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*(2 marks)*

**5** (b) Briefly explain how the Doppler effect can be used to investigate blood flow in a patient.

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*(3 marks)*

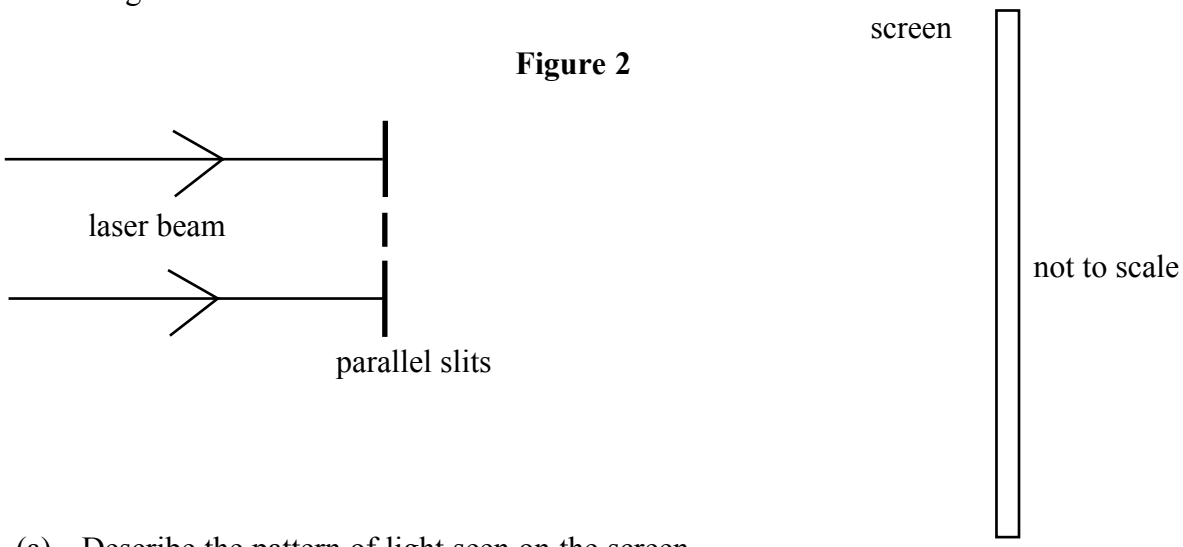
**25**

## SECTION B

Answer **all** questions in this section.

**6** **Figure 2** is an arrangement used to measure the wavelength of light from a laser. The laser beam is directed normally onto two parallel slits and the light emerging from the slits is incident on a screen some distance away. The plane of the screen is parallel to the plane containing the slits.

**Figure 2**




**6** (a) Describe the pattern of light seen on the screen.

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*(2 marks)*

**6** (b) The distance between one position of maximum intensity and the next is 5.00 mm. The centres of the slits are 0.220 mm apart and the distance from the slits to the screen is 2.40 m. Show that the wavelength of the light is about $4.6 \times 10^{-7}$ m.

*(3 marks)*

**6** (c) The parallel slits are replaced by a diffraction grating that has 472 lines per mm.

**6** (c) (i) Calculate the distance between adjacent lines on the grating.

distance between lines.....

**6** (c) (ii) At what angle to the normal is the third order spectral line formed?

angle.....

**6** (c) (iii) The amplitude of the laser beam is reduced to one third of its original value. How is the intensity of the spectral lines affected?

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*(6 marks)*

**11**

**7** The Chernobyl nuclear accident in 1986 resulted in radioactive contamination over a very wide geographical area, including parts of the UK. One of the contaminants was the nuclide strontium-90. This nuclide can find its way into cows' milk if the animals have been grazing on contaminated grassland.

**7** (a) The half-life of strontium-90 is about $9 \times 10^8$ s. Explain why strontium-90 contamination from Chernobyl is still a problem for some dairy farmers today.

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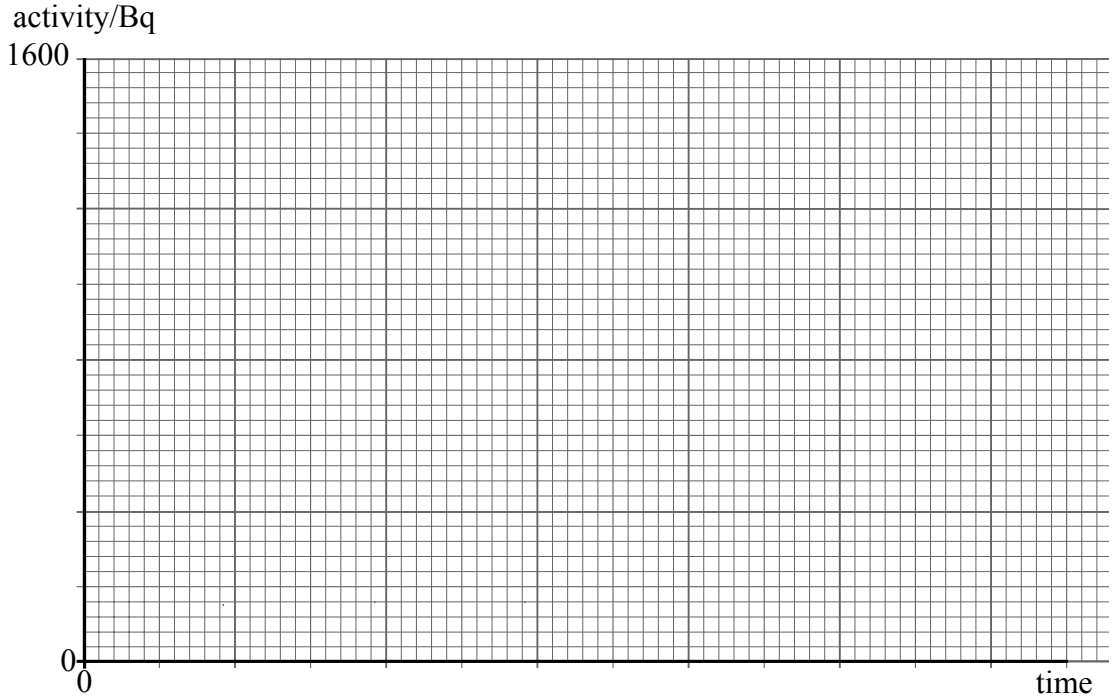
*(3 marks)*

**7** (b) The initial activity of a sample of strontium-90 is 1600 Bq. On the axes in **Figure 3**, sketch a graph of the activity against time for this sample over three half-lives. Mark a scale on the time axis.

**Figure 3**




*(3 marks)*

**7** (c) The following is an incomplete equation that describes the decay of strontium-90 into yttrium-90 by the emission of an antineutrino and a particle represented by X.

$$^{90}_{38}\text{Sr} \rightarrow {}^{90}_{\ldots\ldots}\text{Y} + {}^{\ldots\ldots}_{\ldots\ldots}\text{X} + \bar{\nu}_e$$

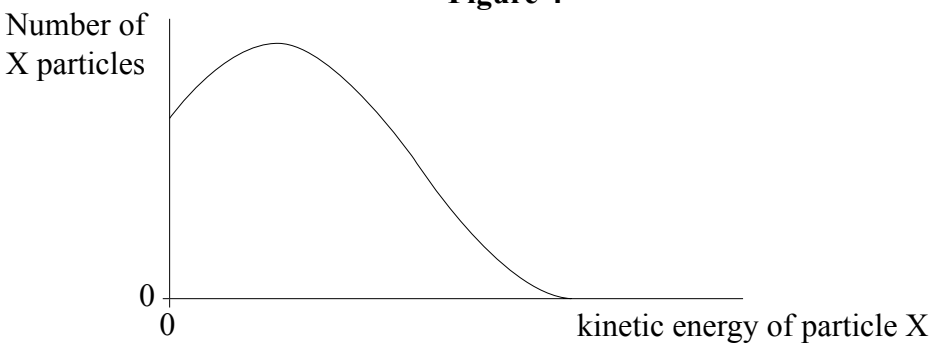
Complete the equation to include the missing numbers and state the name of particle X.

particle X.....

*(2 marks)*

**7** (d) When a sample of strontium-90 decays, the particles represented by X produce the energy spectrum shown in **Figure 4**.

**Figure 4**




Describe and explain how this graph provides evidence for the existence of the anti-neutrino.

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

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*(6 marks)*

14

**Turn over ▶**

**8** In 1932 Chadwick discovered the neutron by bombarding beryllium with alpha particles.

**8** (a) Explain why the neutron is difficult to detect.

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*(2 marks)*

**8** (b) Chadwick directed neutrons into a block of paraffin wax and was able to demonstrate their existence because they knocked protons out of the wax.

Neutrons and protons have a number of characteristics in common. State **two** ways in which neutrons and protons are similar, other than their quark sub-structure.

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*(2 marks)*

**8** (c) (i) Describe the quark sub-structure of a neutron.

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**8** (c) (ii) Describe the quark sub-structure of a proton.

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**8** (c) (iii) Show how the quark sub-structure of a proton leads to its charge.

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*(6 marks)*

**10**

**9** Visible light is part of a wide spectrum of electromagnetic radiation. Name **one** type of radiation that has a higher frequency than visible light and **one** type that has a lower frequency than visible light.
State clearly which is which and write an account describing similarities and differences between the types of radiation you have named.

Two of the 8 marks in this question are the for the quality of your written communication.

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*(8 marks)*

8

**Turn over for the next question**

**10** *Analogue* terrestrial television broadcasts in the UK are being phased out so only viewers with *digital* receivers will be able to watch the programmes.

**10** (a) Explain the terms analogue and digital in this context.

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*(2 marks)*

**10** (b) State **two** advantages to the viewer of receiving television programmes via a digital transmission system.

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*(2 marks)*

**10** (c) Briefly describe the principles involved in converting an analogue signal into a digital signal.

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*(3 marks)*

7

**END OF QUESTIONS**

General Certificate of Education
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**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 $L$ | | |
|---|---|---|---|
| | $L_e$ | $L_\mu$ | $L_\tau$ |
| $e^-$ | 1 | | |
| $e^+$ | −1 | | |
| $\upsilon_e$ | 1 | | |
| $\overline{\upsilon}_e$ | −1 | | |
| $\mu^-$ | | 1 | |
| $\mu^+$ | | −1 | |
| $\upsilon_\mu$ | | 1 | |
| $\overline{\upsilon}_\mu$ | | −1 | |
| $\tau^-$ | | | 1 |
| $\tau^+$ | | | −1 |
| $\upsilon_\tau$ | | | 1 |
| $\overline{\upsilon}_\tau$ | | | −1 |

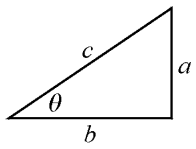
### Geometrical and Trigonometrical Relationships

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