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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 5456

Specification B

PHB2 Waves and Nuclear Physics

Mark Scheme

2008 examination - June series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Dr Michael Cresswell Director General

NOTES
Letters are used to distinguish between different types of marks in the scheme.

M indicates OBLIGATORY METHOD MARK
This is usually awarded for the physical principles involved, or for a particular point in the argument or definition. It is followed by one or more accuracy marks which cannot be scored unless the M mark has already been scored.

C indicates COMPENSATION METHOD MARK
This is awarded for the correct method or physical principle. In this case the method can be seen or implied by a correct answer or other correct subsequent steps. In this way an answer might score full marks even if some working has been omitted.

A indicates ACCURACY MARK
These marks are awarded for correct calculation or further detail. They follow an M mark or a C mark.

B indicates INDEPENDENT MARK
This is a mark which is independent of M and C marks.

e.c.f is used to indicate that marks can be awarded if an error has been carried forward (e.c.f. must be written on the script). This is also referred to as a 'transferred error' or 'consequential marking'.

Where a correct answer only **(c.a.o.)** is required, this means that the answer must be as in the Marking Scheme, including significant figures and units.

c.n.a.o. is used to indicate that the answer must be numerically correct but the unit is only penalised if it is the first error or omission in the section (see below).

Only **one** unit penalty **(u.p.)** in this paper unless there is a mark allocated specifically for giving a correct unit in the marking. Note that the unit is only penalised in the final answer to the question.

Only **one** significant figure penalty **(s.f.)** in this paper.
Allow 2 or 3 s.f. unless otherwise stated. s.f. penalties include recurring figures and fractions for answers.

Marks should be awarded for **correct** alternative approaches to numerical question that are not covered by the marking scheme. A correct answer from working that contains a physics error (PE) should not be given credit. Examiners should contact the Team Leader or Principal Examiner for confirmation of the validity of the method, if in doubt.

Quality of Written Communication

Before accessing marks for the Quality of Written Communication (QWC) a candidate must first score a minimum of one mark for the physics that is being communicated – this will allow access to 1 mark for QWC. If the candidate scores more marks for physics (a minimum of two or three – depending upon the total mark for that part of the question) then this will allow access to 2 marks for QWC.

Good QWC: the answer is fluent/well argued with few errors in spelling, punctuation and grammar	**2**	
Poor QWC: the answer lacks coherence or spelling, punctuation and grammar are poor	**1**	**Max 2**
Very Poor QWC: the answer is disjointed, with significant errors in spelling, punctuation and grammar	**0**	

GCE Physics, Specification B, PHB2, Waves and Nuclear Physics

Question 1			
(a)	4.75×10^{14} 335 (3.35×10^{2}) answers to 3 s.f. expected consistent with data 1 sig fig penalty microwaves	**B1** **B1** **B1**	**3**
(b)	sound because it is longitudinal (wave)/because it is not a transverse (wave)	**B1** **B1**	**2**
		Total	**5**

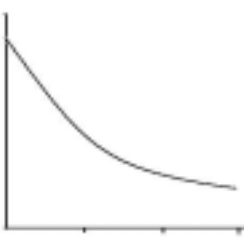
Question 2			
(i)	the distance light travels in one year condone incorrect numerical value **or** allow 9.5 (9.46) $\times 10^{15}$ m or equivalent if no word definition **not** 9.4×10^{15} m	**B1** **B1**	**5**
(ii)	speed is proportional to distance from Earth/observer (condone away) **or** speed is equal to the Hubble constant times the distance from Earth	**M1**	
(iii)	**recession** speed (or equivalent) $v = 65 \times 2.5 \times 10^{6}/(3.3 \times 10^{6})$ (condone 3.3 here) 49(.2) – (49.4) km s^{-1} (u.p.)	**A1** **C1** **A1**	
		Total	**5**

<table>
<tr><td>Question 3</td><td></td><td></td><td></td></tr>
<tr><td>(a)</td><td>two from (must state source and origin)
<table>
<tr><th>source</th><th>origin</th></tr>
<tr><td>rocks/in the earth</td><td>radioisotopes/ radioactive/minerals/ ores/material (or named isotope e.g. uranium or radon gas)</td></tr>
<tr><td>atmosphere</td><td>radon gas or C-14</td></tr>
<tr><td>living things</td><td>radioisotopes/ radioactive materials/ minerals (or named isotope e.g. C-14)</td></tr>
<tr><td>fallout from nucleus tests and/or accidents</td><td>radioactive isotopes etc (or named isotope e.g. strontium-90)</td></tr>
<tr><td>stars/Sun</td><td>fusion/nuclear reactions</td></tr>
<tr><td>cosmic rays/radiation</td><td>implied in source</td></tr>
<tr><td>X-ray machines</td><td>implied X-ray production</td></tr>
<tr><td>medicine/industry/ smoke detectors</td><td>radioisotopes/ radioactive materials etc (or named isotope e.g. radioactive iodine, technetium</td></tr>
</table></td><td>B2</td><td>max 2</td></tr>
<tr><td>(b)</td><td>the radiation (or alpha, beta or gamma named) ionises (living cells)
plus two from
the cells/genes/DNA are killed/destroyed/modified or caused to mutate
radiation causes cancer/or damage to body tissue/organs/radiation burns
radiation damage may pass on to children
a large dose would affect many/more cells or produce more ionisation or increased probability of damage/ radiation sickness</td><td>B1
B1
B1
B1
B1</td><td>max 3</td></tr>
<tr><td></td><td></td><td>Total</td><td>5</td></tr>
</table>

Question 4			
(i)	$\sin\theta = \lambda/b$	B1	5
	$4.0 \times 10^{-7}/5.0 \times 10^{-3}$	B1	
	$\theta = 4.6\ (4.58) \times 10^{-3}$ (°)	B1	
(ii)	red light has a longer wavelength	B1	
	the object would **not** be resolved/resolution worse	M0	
	the diffraction maxima would overlap more/the minimum angle for resolution would be greater	A1	
	or correct calculation of angle for longer wavelength using their estimate for wavelength of red light		
		Total	**5**

Question 5			
(a)	apparent/observed/measured/detected change in frequency/wavelength (condone 'pitch')	B1	2
	wave **source** and observer are moving relative to each other	B1	
(b)	**must relate to Doppler effect in recognised technique using ultrasound (condone sound for the M0)**	M0	3
	ultrasound waves sound	A1	
	waves reflected by the moving blood (cells)	A1	
	(**change in frequency**/**wavelength** enables) **the speed** (**of blood flow**)/**rate of flow** (**of blood**) to be found	B1	
	or speed of blood flow can be calculated from $\Delta f/f = v/c$ if the cross-sectional area of the vein is known, (volume) flow rate is found	B1	
		Total	**5**

Question 6				
(a)		row spots/bands/fringes/dots/lines equally spaced	**M1** **A1**	**2**
(b)		$\lambda = xd/D$ or $x = \lambda D/d$ substitutes in either formula including powers of 10 $\lambda = 5.00 \times 10^{-3} \times 0.22 \times 10^{-3}/2.4$ or in terms of x 4.58×10^{-7} (m)	**B1** **B1** **B1**	**3**
(c)	(i)	$2.1(2) \times 10^{-6}$ m or $2.1(2) \times 10^{-3}$ mm (u.p.)	**B1**	**6**
	(ii)	$\sin\theta = n\lambda/d$ **or** $n\lambda = d\sin\theta$ $3 \times 4.58 \times 10^{-7}/(2.12 \times 10^{-6}) = 0.648$ (condone incorrect powers of 10) e.c.f. for their d from part (i)	**C1** **C1**	
	(iii)	θ = 10-41.1° answer must be in range but ignore unit (i.e. no e.c.f. in answer) reduced 1/9 of its original intensity	**A1** **C1** **A1**	
			Total	**11**

Question 7			
(a)	**allow 1 mark for stating that the half-life is (very) long but no further credit** correct $T_{1/2}$ about 29 years or time elapsed converted to seconds compares half life with time elapsed: e.g. provides date when activity would be half (2014/2015)/or states how long ago Chernobyl disaster occurred (22 years ago) over half of the **strontium-90/activity/radioactivity/ radioactive nuclei** of the contamination is still left **or** less than half has decayed	**B1** **M1** **A1** **A1**	**3**
(b)	 activity = 800 after 9×10^8 s or approximately after 28.6/29/30 y; ≈ 10000 d/250000 h **including unit** (correct scale minimum 3 half lives necessary) activity 200 after three half lives – 86 years (3 × their time to reach 800) reasonable shape starting at (0, 1600) and constant half life	**B1** **B1** **B1**	**3**
(c)	$_{39}Y + {}^{0}_{-1}X$ beta; beta minus; beta particle or electron **not** beta plus	**B1** **B1**	**2**

(d)	**four from** a the graph shows that the beta particles exhibit a wide range of (kinetic) energies/do not have the same (kinetic) energy b constant amount of energy available for the decay c conservation of energy mentioned d if only beta emitted KE should be one energy only e appreciation that some energy goes to recoil nucleus (Y) f another particle/neutrino/antineutrino carries energy difference/some of the energy/missing energy g when beta has high energy neutrino has low energy (and vice versa)	 **B1** **B1** **B1** **B1** **B1** **B1** **B1**	**max 4**
	At least 2 marks for physics + **Good QWC** At least 2 marks for physics + **Poor QWC** At least 2 marks for physics + **Very Poor QWC** 1 mark for physics + sufficient attempt + **Good or Poor QWC** 1 mark for physics + insufficient attempt or **Very Poor QWC** No marks for physics or **Very Poor QWC**	**2** **1** **0** **1** **0** **0**	**max 2**
		Total	**14**

Question 8			
(a)	no electric charge	**B1**	**max 2**
	not affected by **electric/magnetic fields/charged particles/alpha particles**	**B1**	
	leaves **no track** in a cloud chamber/produces **little/no ionisation**	**B1**	
(b)	(approximately) same mass/similar masses	**B1**	**max 2**
	similar radius/diameter	**B1**	
	both found in the nucleus/both are nucleons	**B1**	
	both baryons (or have same baryon number (1))	**B1**	
	both affected by the strong nuclear force	**B1**	
(c) (i)	udd	**C1**	**6**
	down-down-up (must be in words) c.a.o.	**A1**	
(ii)	uud e.c.f. (for wrong way round i.e. allow ddu if neutron = uud)	**C1**	
	up-up-down (must be in words) (c.a.o.)	**A1**	
(iii)	sensible attempt given their answer to (c) (ii) as e.c.f.	**C1**	
	$2 \times (+\frac{2}{3}) + (-\frac{1}{3}) = 1$	**A1**	
		Total	**10**

Question 9			
	higher: u.v. **or** X-rays **or** gamma rays	**B1**	**max 6**
	lower: radio **or** microwaves **or** infrared	**B1**	
	plus two *similarities*		
	both can travel through a vacuum or same speed	**M1**	
	both travel at the same speed in a vacuum (must link)	**A1**	
	both are transverse/can be polarised	**B1**	
	not affected by electric or magnetic fields	**B1**	
	plus two *differences*		
	higher frequency: higher energy photons/shorter wavelength	**B1**	
	higher frequency: more penetrating/dangerous/ harmful	**B1**	
	difference in degree of diffraction/refraction/reflection properties	**B1**	
	or comparison of way their types are produced **e.g. (depending on chosen pair)**		
	infrared emitted by vibrating particles or outer electron transitions	**B1**	
	gamma rays ejected from the nucleus	**B1**	
	radio and microwaves produced by oscillating currents	**B1**	
	u.v. and X-rays emitted by inner electron transitions	**B1**	
	At least 2 marks for physics + **Good QWC** At least 2 marks for physics + **Poor QWC** At least 2 marks for physics + **Very Poor QWC** 1 mark for physics + sufficient attempt + **Good or Poor QWC** 1 mark for physics + insufficient attempt or **Very Poor QWC** No marks for physics or **Very Poor QWC**	**2** **1** **0** **1** **0** **0**	**max 2**
		Total	**8**

Question 10			
(a)	analogue: **continuously varying** signal/wave/voltage signal can take any value (of voltage) digital: pulsed signal/binary/two-state/bits/discrete/ square waves/0s and 1s/(condone on and off) allow 1 mark for clear diagrams showing A and D	**B1** **B1**	**2**
(b)	better quality/clearer images and sound more channels less interference/less affected by noise (condone no noise/interference)	**B1** **B1** **B1**	**max 2**
(c)	idea of sampling the signal as **regular** time intervals/certain rate/even time intervals need evidence of regularity of sampling e.g. not just sampling rate **displacement/voltage/value** of the analogue signal converted to a binary code or a series of 0s and 1s sampling rate = 2 × highest frequency	**M1** **A1** **M1** **A1** **B1**	**max 3**
		Total	**7**