



General Certificate of Education

Physics 5456 *Specification B*

PHB2 Waves and Nuclear Physics

Mark Scheme

2006 examination – January 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.

Notes for Examiners

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 Mark 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 questions that are not covered by the mark 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**

PHB2 Waves and Nuclear Physics

Question 1			
	meson has 2 quarks; baryon has 3 quarks/3 antiquarks good extra detail	B1 B1	2
		Total	2

Question 2			
(a)	3 kHz or 0 - 3 kHz	B1	1
(b)	poorer than original/low quality <i>not</i> 'less clear' frequencies omitted from original	C1 A1	2
		Total	3

Question 3			
(a)	4 mm	B1	1
(b)	3:1; 3/1 9 or 9:1	C1 A1	2
		Total	3

Question 4			
(a)	fringe spacing = $(\lambda D/d) = 0.025 \times 3.0 / 0.080$ 0.94 m	C1 A1	2
(b)	wave is polarised/oscillations confined to one plane radio waves are transverse	B1 B1	2
		Total	4

Question 5			
(a)	single loop/half of sine wave shown between fixed points	B1	1
(b) (i)	3 loops shown	B1	2
(ii)	node	B1	
(c)	greater mass per unit length of string/thicker string	B1	2
	less tension/loosen string/slacken string	B1	
		Total	5

Question 6			
(a)	1.06×10^{-6} m	B1	1
(b)	use of $n\lambda = d\sin\theta$ with $n = 2$ and $d =$ ans to (a)	C1	3
	$\lambda = 1.06 \times 10^{-6} \times \sin 55^\circ/2$	C1	
	4.34×10^{-7} m	A1	
		Total	4

Question 7			
	626 on left-hand side	B1	3
	37 in bottom right	B1	
	71 in middle right	B1	
		Total	3

Question 8			
(a)	microwave/radio/[radar]	B1	1
(b)	higher not 'blue shift' waves arrive at observer more often OWTTE	B1 B1	2
(c)	converts correctly to 18 m/s correct subst into equation 1.26 kHz <i>allow 1260Hz</i>	C1 C1 A1	3
(d)	reflection/absorption and re-emission	B1	1
		Total	7

Question 9			
	some alphas not deflected <i>or</i> some alphas deflected small number deflected through large angles most of atom is empty space atom consists of small/dense nucleus nucleus is positive mention of other valid scattering experiment	B1 B1 B1 B1 B1 B1	Max 4 1
	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 or 2 marks for physics + sufficient attempt + Poor QWC 1 or 2 marks 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	7

Question 10			
(a)	$^{14}_7\text{N}$ on rhs $^0_{-1}\text{e}^0_{-1}\beta$ on rhs antineutrino shown	B1 B1 B1	3
(b) (i)	Becquerel/Bq	B1	3
(ii)	$6.3 \times 10^{19} \times 3.8 \times 10^{-12}$ $= 2.4 \times 10^8$ [no unit required]	C1 A1	
(c)	<p>route A</p> <p>activity is proportional to the number of atoms</p> <p>activity is the change in the number of atoms per second</p> <p>max 2 from:</p> <p>graph shows: N decreases as activity decreases</p> <p>exponential</p> <p>constant half life</p> <p>gradient decreases as N decreases</p> <p>or</p> <p>route B</p> <p>defines half life in words or by example</p> <p>$t_{1/2}$ related to λ</p> <p>same λ implies constant $t_{1/2}$</p> <p>graph shows constant half-life behaviour</p>	B1 B1 B1 B1 B1 B1 B1 B1	Max 4 Max 4
		Total	10

Question 11			
(a)	(i)	wavelength read-off = 1.2 mm	B1
	(ii)	3200/1.2 × 10 ⁻³ e.c.f. from (a) (i) 2.7 MHz	C1 A1
(b)		read-off correct 1.3 μs	C1
		factor of two correct	C1
		= 2.1 × 10 ⁻³ m [2.08] c.a.o.	A1
		Total	6

Question 12			
(a)		refraction angle smaller than incident	B1
		reduced wavelength clear	B1
		partial reflection shown and reflected angle sensible by eye	B1
		wavelength of reflection unchanged	B1
(b)	(i)	$\theta [= \sin^{-1}(\lambda/d)] = \sin^{-1}(0.045/0.62)$ = 4.16° or 4.2° or 0.0726 rad c.a.o.	C1 A1
	(ii)	$r = 500 \times \tan \theta$ [e.c.f.] 36.4 m	C1 A1
(c)		smaller wavelength/increased frequency	B1
		larger aperture/larger receiving aperture	B1
(d)		modulator somewhere	C1
		amplifier somewhere	C1
		aerial in last box	A1

(e)	<p>three of communication paths:</p> <p>series of line-of-sight antennae/aerials</p> <p>fibre optic</p> <p>(under-sea) cable</p> <p>diffraction around Earth's surface</p> <p>sky waves/ reflected/refracted by ionosphere</p> <p>satellite/space waves</p>	<p>three corresponding λ range:</p> <p>any radio wavelength</p> <p>visible light to infra-red</p> <p>d.c. to audio/electrical</p> <p>long wave radio</p> <p>long wave radio</p> <p>microwaves/vhf radio or greater</p>	<p>B1 + B1</p>	<p>6</p>
	<p>At least 2 marks for physics + Good QWC</p> <p>At least 2 marks for physics + Poor QWC</p> <p>At least 2 marks for physics + Very Poor QWC</p> <p>1 or 2 marks for physics + sufficient attempt + Poor QWC</p> <p>1 or 2 marks for physics + insufficient attempt or Very Poor QWC</p> <p>No marks for physics or Very Poor QWC</p>	<p>2</p> <p>1</p> <p>0</p> <p>1</p> <p>0</p> <p>0</p>	<p>Max 2</p>	
		<p>Total</p>	<p>21</p>	