ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2003

GCE

Physics B

Unit PHB2

Unit 2: Waves and Nuclear Physics

Notes for guidance

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.

Note: 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.

Where an error carried forward (e.c.f.) is allowed by the marking scheme for an incorrect answer, e.c.f. must be written on the script if an error has been carried forward.

Instructions to examiners

1 Give due credit to alternative treatments which are correct. Give marks for what is correct; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the script to the Awards meeting if poor presentation forbids a proper assessment. In each paper candidates may be awarded up to two marks for the Quality of Written Communication in cases of required explanation or description. However, no candidate may be awarded more than the total mark for the paper. Use the following criteria to award marks:

2 marks:	Candidates write with almost faultless accuracy (including grammar, spelling and appropriate punctuation); specialist terms are used confidently, accurately and with precision.
1 mark:	Candidates write with reasonable and generally accurate expression (including grammar, spelling and appropriate punctuation); specialist terms are used with reasonable accuracy.
0 marks:	Candidates who fail to reach the threshold for the award of one mark.

3 An arithmetical error in an answer should be marked A.E. thus causing the candidate to lose one mark. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks (indicated by ticks). These subsequent ticks should be marked C.E. (consequential error).

4 With regard to incorrect use of significant figures, normally a penalty is imposed if the number of significant figures used by the candidate is one less, or two more, than the number of significant figures used in the data given in the question. The maximum penalty for an error in significant figures is **one mark per paper**. When the penalty is imposed, indicate the error in the script by S.F. and, in addition, write S.F. opposite the mark for that question on the front cover of the paper to obviate imposing the penalty more than once per paper.

5 No penalties should be imposed for incorrect or omitted units at intermediate stages in a calculation or which are contained in brackets in the marking scheme. Penalties for unit errors (incorrect or omitted units) are imposed only at the stage when the final answer to a calculation is considered. The maximum penalty is **one mark per question**.

6 All other procedures, including the entering of marks, transferring marks to the front cover and referrals of scripts (other than those mentioned above) will be clarified at the standardising meeting of examiners.

Section A

Question 1

(a)	A repelled,	B1
	B bends away from nucleus	M1
	B & C would cross beyond nucleus	A1
(b)	one piece of information	B1
	second piece	B1
	[*e.g. substructure of atom/size of nucleus/charge on nucleus/density of nuclear material, atoms mostly empty space/massive nucleus/evidence for nucleus/alpha particle*]	**5**

Question 2

(a)	all correct	
	(–1 for each mis-classification or omission; total not to go below zero)	
	hadrons: proton/neutron/pion	
	leptons: electron/muon/neutrino	B4
(b)	proton	B1
	neutron	B1
	(–1 for each mis-classification; total not to go below zero)	**6**

Question 3

	reflection wavefront direction sensible	B1
	refraction wavefront direction sensible	B1
	one pair of wavefronts correctly spaced	B1
		3

Question 4

(a)(i)	fringe spacing = 0.11 m	B1
(ii)	λ = (*fringe spacing from a(i)*) * *d/D* [ecf] = $0.11 \times 0.2/2.5$	M1
	$= 8.8 \times 10^{-3}$ m	A1
(b)	**three maximum from**	
	mention of single-slit difraction *after*	
	good diagram of diffraction intensity	
	mention of interference fringes/two-slit *before* interference/superposition/Young's slits or alternative *before*	
	good physics description of superposition	
	e.g. interference between overlapping waves from each slit	
	good physics description of diffraction	
	equally separated fringes *before*	
	central maximum is twice width of others *after*	
	decrease in intensity for each successive maxima *after*	
	change in spacing *after*	
	fainter from middle outwards *after*	B3
		6

Question 5

(a)(i)	90	B1
(ii)	[228-90 =] 138	B1
(b)(i)	*second* $^{-1}$	B1
(ii)	$\lambda = 3.0 \times 10^{13} / 2.6 \times 10^{21}$	M1
	$= 1.2 \times 10^{-8}$ [s^{-1}]	A1
		5

Section B

Question 6

(a)	Reflection implied /2 waves in opposite directions/fixed end (not ends)	B1
	Similar amplitude/little energy loss at wall	B1
	frequency constant **or** same frequency/wavelength **or** correct wavelength condition specified	B1
(b)	displacement perpendicular to rest/average/mean position of string **or** string displacement perpendicular to energy propagation direction OWTTE	B1
(c)	A larger than B	
	A **180°** /**π** out of phase with B OWTTE	B1
		B1
(d)	$\lambda = 1.2$	
	$c = f\lambda$; *allow e.c.f. from wrong* λ	B1
	$f = 6.2/1.2 = 5.2$ Hz	M1
		A1
(e)(i)	diagram correct (6 loops)	
(ii)	Q **and** R correctly in phase with P; must be a position where mvt occurs	B1
		B1
		11

Question 7

(a)	recognises GHz as 10^9	B1
	$\lambda = 3 \times 10^8 / 2.3 \times 10^9 = 0.13[0]$ m	B1
(b)	microwaves [e.c.f from (a)]	B1
(c)	use of $\sin\theta = \lambda/b$	M1
	$= 0.13/0.6 = 0.217$ [e.c.f. from (a)]	C1
	$\theta = 12.5°$	A1
(d)	mention of/evidence of use of inverse-square law	B1
	64 nW	A1
(e)	$\Delta f = fv/c = 2.3 \times 10^9 \times 2.5/3 \times 10^8$	M1
	$= 19.2$ Hz	A1
(f)	higher	B1
		11

Question 8

(a)	separation = $1/5.2 \times 10^{5}$ m = 1.9×10^{-6} m	B1
(b)	[$n\lambda = b \sin\theta$] $n = 2$ $\sin\theta = 1 \times 5.9 \times 10^{-7} \times 5.2 \times 10^{5}$ $\theta = 37.9°$ [37.85°] **or** $\sin\theta = 0.614$	B1 C1 A1
(c)	$\sin\theta = 3 \times 5.9 \times 10^{-7} \times 5.2 \times 10^{5}$ $\theta = 67°$	C1 A1
(d)	$\tan\theta = x/1.5$; $\times = 1.5 \times \tan\theta$ = 3.5[3] m [rounding to 69° yields 3.9 m]	M1 A1
	maximum four good points orders close in/fringe spacing decreases more orders visible central maximum unchanged explains [λ drops so $\sin\theta$ drops, **must** state n, d const, **or** re-work formula] calculates a new order position **or** shows 4^{th} order visible/invisible explicit comparison of one new and old order angle	B4 **Max 4**
	the use of physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **and** scores **3+**	B2
	the use of physics terms is accurate, but the answer lacks coherence or the spelling, punctuation and grammar are poor **and** scores **1+**	B1
	the use of physics terms is inaccurate, the answer is disjointed with significant errors in spelling, punctuation and grammar	B0
		14

Question 9

Maximum five points from:
mention of suitable *named* source (e.g. Co-60)
mention of detector (GM tube + scaler/counter/computer/data logger/ratemeter)
recognition of need for background correction
describes data treatment correction for background
method of source–counter distance measurement stated
graphical treatment **or** arithmetic approach; suitable plot leading to straight line
e.g. I vs $1/d^2$; $\sqrt{I}$ vs $1/d$; $1/\sqrt{I}$ vs d; $\log I$ vs $\log d$ *etc*
good averaging point
good exptal point — B5

the use of physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar
and scores **4+** — B2

the use of physics terms is accurate, but the answer lacks coherence or the spelling, punctuation and grammar are poor
and scores **2+** — B1

the use of physics terms is inaccurate, the answer is disjointed with significant errors in spelling, punctuation and grammar — B0

7

Question 10

(a)(i)	microphone/telephone mouthpiece	B1
(ii)	modulator [*or* analogue– digital converter *if digital answer*]	B1
(iii)	amplifier/booster [*or* modulator *if digital answer*]	B1
(b)	mention of carrier (*as wave/frequency or bald*)	B1
	mention of frequency or amplitude modulation	B1
	by signal to be transmitted	B1
	modulation enables more information to be transmitted *or good physics alternative – may include diagram e.g. of modulated signal*	B1
		7

Total 75