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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6456
Specification B

PHB4 Further Physics

Mark Scheme

2006 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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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**	

PHB4 Further Physics

Question 1				
(a)	(i)	correct general shape (0.2 J at ±0.16 m and 0 at centre) not straight lines	**M1**	**4**
		crossing at 0.1 J (guideline: allow errors of about 1 mm)	**A1**	
	(ii)	graph showing zero at ±0.08 m rising to a peak at 0 ≤ 0.1 J	**B1**	
		maximum shown as 0.05±0.005 J	**B1**	
(b)		force/acceleration toward equilibrium position/centre/fixed point **or** force/acceleration opposite direction to displacement **or** quotes $a = -ks$ and states a is opposite direction to s	**B1**	**2**
		the force/acceleration must be proportional to the displacement from the equilibrium position centre/fixed point **or** quotes $a = -ks$ and defines terms	**B1**	
(c)	(i)	k = 0.9/0.058 (15.5 N m^{-1}) **or** $F = m\omega^2 x$ (or $\omega^2 x$ and $F=ma$) or a_{max} = 1.5 m s^{-2}	**C1**	**4**
		T = 2 × 3.14 √(0.6/ 15.5) = 1.24 s **or** ω = √0.9/(0.6 × 0.058)=5.09 rad or 1.5 = $(2\pi f)^2$ 0.058	**C1**	
		0.81(0.809) Hz (s^{-1}) c.n.a.o.	**A1**	
	(ii)	s = 0.16 sin 2π0.81t or s = 0.16 cos 2π0.81t (ecf for frequency)	**B1**	
		s = 0.16 cos 5.1t (allow 5t) s = 0.16 sin $\frac{2\pi}{1.24}t$ etc		

(d)	1 *forced oscillation* oscillations induced by application of (an external) periodic force (not regular but allow 'regular intermittent') or occurs when a body is made to oscillate by (a force/energy from) another oscillator	**B1**	**max 5**
	2 driven oscillator frequency = signal generator(driver) or vibrator frequency or as driver frequency increases the driven frequency increases	**B1**	
	3 *resonance* occurs when the forcing (driver) frequency = natural frequency condone 'at the natural frequency' (or description of)	**B1**	
	4 at resonance **amplitude** is a **maximum** (**n.b.** penalise confusion between displacement and amplitude)	**B1**	
	5 as frequency increases amplitude increases to a maximum then falls again	**B1**	
	6 the maximum (or resonance) occurs at 0.81 Hz (their frequency)	**B1**	
	max 2 for information given only on an annotated diagram and then no QWC		
	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 + **Good or 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 17

Question 2				
(a)	(i)	the aircraft is accelerating or velocity is a vector	**B1**	**5**
		the direction of motion is changing	**B1**	
	(ii)	there is a **horizontal component** of the lift force	**B1**	
	(iii)	$F = mv^2/r$ or $F = mr\omega^2$ or $L \cos \theta$ (or $L \sin \theta$) with angle clearly and correctly identified (e.g. on diagram)	**M1**	
		all terms correctly defined (force not necessary) allow m = mass v = velocity/speed but r must be radius of circular path (or description of) L defined as lift force **not** reaction	**A1**	
(b)	(i)	correct use of $a = v^2/r$ (ignore powers of 10)	**C1**	**3**
		$4.5\,(4.46)\,\text{m s}^{-2}$ or $(58000)\,57900\,\text{km h}^{-2}$ (c.n.a.o. + unit essential)	**A1**	
	(ii)	reaction with seat or friction between passenger and seat or pilot is part of the system that is accelerated by the lift force (owtte) if (a) (ii) is correct	**B1**	
				Total 8

Question 3				
(a)		area of overlap of the plates	**B1**	**2**
		separation of/distance between the plates	**B1**	
		permittivity/dielectric constant of free space/the material/dielectric between the plates (condone of the gap)		
		B1 for 1 factor clearly stated B1 for other two clearly stated		
(b)	(i)	$Q = VC$ (any form) or $0.047\,\mu\text{F} \times 12$ (ignoring powers of 10)	**C1**	**6**
		$5.6(4) \times 10^{-7}\,\text{C}$ $(0.56\,\mu\text{C})$	**A1**	
	(ii)	time constant $= 4.7 \times 10^{-5}\,\text{s}$ or $0.01 = e^{-t/RC}$	**C1**	
		$0.01 = e^{-t/(0.000047)}$ or $0.01 = e^{-t/47}$ or $\frac{t}{RC} = 4.605$	**C1**	
		$2.2\,(2.16) \times 10^{-4}\,\text{s}$ or $0.22\,\text{ms}$	**A1**	
	(iii)	their (i) × 400 (230 (226) μA or $2.3 \times 10^{-4}\,\text{A}$ if correct)	**B1**	
				Total 8

Question 4				
(a)	(i)	electrons/atoms remain in the metastable state for **longer** time or condone 'it' has a longer lifetime or it is more stable or use of typical lifetimes (e.g. 10^{-3} c.f. 10^{-8}s)	**B1**	**6**
	(ii)	$E = (3/2)\,kT$ or $8 \times 10^{-21} = (3/2) \times 1.4 \times 10^{-23}\,T$	**C1**	
		380 (381) K or 108 (110)°C	**A1**	
	(iii)	photon energy = 3.06×10^{-19} J (subtraction seen)	**B1**	
		$E = hf$ and $f = c/\lambda$ or $E = hc/\lambda$ (or correct sub^{n} with any energy)	**C1**	
		$6.47\ (6.5) \times 10^{-7}$ m or 650 nm (c.n.a.o.)	**A1**	
(b)	(i)	area of beam = 5.0×10^{-11} m^2 or $\pi \times (4 \times 10^{-6})^2$ seen in calculation **n.b.** not $4 \times \pi \times (4 \times 10^{-6})^2$	**C1**	**4**
		(photons per s per m^2) = $8.5 \times 10^{26}/4 \times 10^{-19}$ (= 2.13×10^{45}) photons per second = $\{\frac{8.5\times10^{26}\times5\times10^{11}}{4\times10^{-19}}\}$ earns both marks	**C1**	
		photons from laser = $1.1\ (1.07) \times 10^{35}$ (c.a.o.)	**A1**	
	(ii)	sensible medical or industrial use of laser e.g. cutting/drilling **of metal**; igniting gases in rockets destruction of cancer cells/tissue or kidney/gall stones specified eye operations; (not just 'cutting'; 'in medical operations'; reading CDs; surveying)	**B1**	
				Total 10

Question 5				
(a)	(i)	energy/heat input needed to change liquid into gas/vapour when at its boiling point/without change of temperature	**M1**	
		energy per unit mass/1 kg	**A1**	
	(ii)	idea that more energy has to be supplied to separate molecules than to break solid bonds or for vaporisation work is done against atmospheric pressure or Idea that there is a greater change in PE in L-G than S-L	**B1**	
(b)	(i)	$ml = Mc\Delta\theta$ or energy gain by water = 89250 (J) $m \times 2.3 \times 10^6 = 0.25 \times 4200 \times 85$	**C1**	**4**
		m = 0.0388 kg	**A1**	
		total mass = 0.289 (0.29) kg (0.25 + their m)	**B1**	
	(ii)	energy from steam is needed to raise temperature of the cup or energy/heat will be lost to the surroundings/cup/tube during the heating	**B1**	
				Total 7

Question 6				
(a)		**any two:**		**max 2**
		molecules undergo perfectly elastic collisions (KE conserved)	**B1**	
		time spent in collisions is small compared with time moving freely	**B1**	
		no forces of attraction/repulsion between molecules	**B1**	
(b)	(i)	momentum = mv or $6.8 \times 10^{-27} \times 1300$ or 8.84×10^{-24}	**C1**	**3**
		1.8 (1.77) $\times 10^{-23}$ kg m s^{-1} (c.n.a.o.)	**A1**	
	(ii)	number of collisions per m^{-2} = $\frac{1.5\times10^{5}}{1.77\times10^{-23}} = 8.47\times10^{27}$ (e.c.f. for their (b) (i))	**C1**	
		force (on 1 cm^2 of wall) = pressure x area = $p \times 10^{-4}$ or 15 N seen or implied by division by 10^4	**C1**	
		8.47 (8.5) (8.33) (8.3) $\times 10^{23}$ (collisions per second per cm^2; no unit required condone any even if incorrect) (answer = $\frac{15}{(b)(ii)}$)	**A1**	

(c)	(i)	in experiment 1 volume constant so no work is done or $p\Delta V = 0$ or $\underline{W} = 0$	**B1**	**7**
		all energy raises temperature of the gas or becomes internal energy or $\Delta U = Q$	**B1**	
		in experiment 2 work done in expanding the gas or work done by gas = $p\Delta V$ or $W = -p\Delta V$	**B1**	
		less energy to produce temperature rise or less energy becomes internal energy or internal energy change is lower or $\Delta\underline{U} = Q - p\Delta V$	**B1**	
	(ii)	experiment 1: (+)150 0 (+)150 experiment 2: (+) 93 −57 (+)150 B1 for $\Delta U = 93$ J B1 for $Q = 150$ J and $\Delta U = Q + W$	**B1** **B2**	
				Total 14

Question 7			
(a)	clear statement of the photoelectric effect: e-m (light/uv or condone) radiation/photon causes electron emission **from the** surface **n.b.** must clearly not be ionisation	**B1**	**5**
	two sets of:		
	observation	**M1**	
	explanation of how observation provides evidence for photons	**A1**	
	explanation why observation cannot be explained by wave	**A1**	
	(up to 2 marks allowed for explaining one observation)		
	throughout, the candidate may refer to a specific photoelectric experiment (e.g. electroscope with zinc) so low frequencies may be 'red light' and high frequencies 'uv' etc		
	1 there is a threshold frequency M1 e-m 'particle' energy depends on frequency photon energy, $E = hf$ A1 with waves electrons would be expected at all frequencies A1		
	2 there is a max KE of emitted electrons M1 candidate explains this using photoelectric equation A1 with waves no limit on maximum energy A1		
	3 no delay/emission starts immediately M1 provided particle has enough energy electrons emitted A1 with waves delay expected (for low intensity) or expect energy build up quicker so quicker emission for high intensity waves A1		
	allow B1 for high intensity light of low frequency – no emission or light of low intensity but high frequency causes emission		
	At least 2 marks for physics + **Good QWC**	**2**	**max 2**
	At least 2 marks for physics + **Poor QWC**	**1**	
	At least 2 marks for physics + **Very Poor QWC**	**0**	
	1 or 2 marks for physics + sufficient attempt + **Good or Poor QWC**	**1**	
	1 or 2 marks for physics + insufficient attempt or **Very Poor QWC**	**0**	
	No marks for physics or **Very Poor QWC**	**0**	

(b)	(i)	6.2×10^{-19} J	**B1**	
	(ii)	Momentum of electron = $\sqrt{2mE}$ or substitution seen or $(9.3 – 9.4) \times 10^{-25}$ (N s) or 4.8×10^{19} = ½ x $9.1 \times 10^{-31} v^2$ or $v = 1.03 \times 10^{6}$ (m s^{-1})	**C1**	**4**
		$\lambda = h/p$ or $6.6 \times 10^{-34}/9.3(5) \times 10^{-25}$ or $\lambda = 6.6 \times 10^{-34}/9.1 \times 10^{-19} \times$ their v	**C1**	
		$(7.0 - 7.1) \times 10^{-10}$ m	**A1**	
				Total 11