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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6456

Specification B

PHB4 Further Physics

Mark Scheme

2008 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.

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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**	

PHB4 Further Physics

Question 1			
(a) (i)	acceleration (directly) proportional to displacement (from origin/equilibrium position)	**B1**	**5**
	always directed to origin/equilibrium position/centre *not fixed point* *not force; allow formula if terms defined clearly*	**B1**	
(ii)	$f = 2\pi\sqrt{k/m}$ clearly seen	**B1**	
	evaluates $1/2\pi$ successfully to 3 + s.f. (0.159)	**B1**	
(iii)	calculates f = 5.2(8) Hz	**B1**	
(b) (i)	$(2\pi \times 5.3)^2$ seen	**C1**	**5**
	A = ($2\pi \times$ *their frequency*)^2 condone power of ten	**C1**	
	= 13.1 m s^{-2}	**A1**	
(ii)	acceleration is greater than g	**B1**	
	object loses contact with surface/object in freefall	**B1**	
(c)	graph an acceptable shape *broad peak with labelled axis*	**B1**	**max 4**
	explains resonance as matching of frequencies + large amplitude	**B1**	
	indicates amplitude reduced at high engine speeds (on graph or in words)	**B1**	
	to minimise effect: (increase) damping to system with specified method/increase mirror mass/decrease k	**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	**16**

Question 2				
(a)	(i)	RC = 2400 × 6.3 × 10^{-4} *condone power of ten error in this mark*	**B1**	**4**
		1.51 s	**B1**	
	(ii)	15 = 120 e $^{-t/RC}$	**C1**	
		t = 3.14 s *not -3.14 s or solution that would yield –ve answer*	**A1**	
		[**alternative**: 'half life' = (0.69 RC =) 1.04 s	**C1**	
		120 → 15 is 3 half lives so 3.14 s]	**A1**	
(b)	(i)	use of ½ CV^2	**C1**	**4**
		4.5 J (4.54 J)	**A1**	
	(ii)	use of power = energy/time (*do not credit constant current solutions*)	**C1**	
		0.11 s (0.113) e.c.f. from (b) (i)	**A1**	
(c)		**maximum 3 from**		**max 3**
		voltage limits 120 V and 15 V for charge and discharge	**B1**	
		total time clearly computed (*3.14 + 0.11; e.c.f.*)	**B1**	
		correct charging curve	**B1**	
		relative time ok by eye, condone poor shape	**B1**	
			Total	**11**

Question 3				
(a)	(i)	Ft: impulse	**B1**	**2**
	(ii)	$\Delta(mv)$: **change in** momentum	**B1**	
(b)	(i)	836.4 [kg]	**B1**	**5**
	(ii)	uses mass × speed change	**C1**	
		83.6 (kg m s^{-2} **or** kg m s^{-1} N **or** N s)	**A1**	
	(iii)	same answer as (b) (ii) in correct units	**B1**	
		opposite direction to motion of bar *stated or drawn **on diagram***	**B1**	
(c)		use of Q = mc$\Delta\theta$ (800[836] × 440 × 1190) *do not allow 273 added to temperature change*	**C1**	**3**
		power supplied = 4.2 × 10^8/(3 × 3600)	**C1**	
		39 kW (38.8)	**A1**	
			Total	**10**

Question 4			
(a) (i)	pV evaluated correctly for **two** readings taken correctly from graph [pV = 170 J; unit not required]	**M1**	**5**
	pV evaluated correctly for **three** readings taken correctly from graph [170 J]	**A1**	
	states same so isothermal/**some slight variation** so not	**A1**	
	alternative: calculates constant and hence derives data points then compares to graph; mark as scheme		
(ii)	carry out [infinitely] slowly/container good conductor	**B1**	
	allowing heat to escape/flow in	**B1**	
(b)	uses p/T = constant	**C1**	**3**
	T = 193 (K)	**A1**	
	correct conversion of any temperature	**B1**	
(c)	**maximum 3 from**		**max 3**
	quotes $\Delta U = Q + W$ **and** defines ΔU Q and W	**B1**	
	ΔU **change in** heat energy	**B1**	
	Q at least 'heat'	**B1**	
	W at least 'work'	**B1**	
	constant volume so W = 0	**B1**	
	cools so *U* falls/ΔU *-ve*	**B1**	
	hence Q negative **and** heat needs to be removed from gas	**B1**	
	expect equation to be in sentence and grammatically correct, else 1 QWC error; allow ΔQ and ΔW		
	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**
(d)	attempts to evaluate area under line	**C1**	**3**
	area under line = 81.6 [c.a.o.] J	**A1**	
	internal energy change = [420 - 80] 340 J	**B1**	
		Total	**16**

Question 5				
(a)	(i)	$2\pi \times 260/60$	**B1**	**5**
		$= 27.2\,\text{rad}\,\text{s}^{-1}$	**B1**	
	(ii)	uses $a = r\omega^2$	**C1**	
		do not allow solutions from shm theory		
		$2200\,\text{m}\,\text{s}^{-2}$ [2220] [2700 if 30 used]	**A1**	
	(iii)	$F = ma$; 310000 N [ecf] / 378000 N	**A1**	
(b)	(i)	$\Delta l = Fl/AE = 331000 \times 2.8/0.21/1.6 \times 10^{11}$	**C1**	**4**
		$2.59 \times 10^{-5}\,\text{m}$	**A1**	
	(ii)	$\frac{1}{2} F\Delta l = 0.5 \times 331000 \times 2.59 \times 10^{-5}$	**C1**	
		4.0 J [4.04] [½ × (a) (iii) × (b) (i)]	**A1**	
(c)		without counterbalance there will be an unbalanced torque *accept force/moment*	**B1**	**3**
		counterbalance produces opposing torque/net force in shaft vertical	**B1**	
		avoiding disintegration of machine/excessive wear/vibration	**B1**	
			Total	**12**

Question 6				
(a)		readoff from graph correct [$f = 4.6 \times 10^{14}$ Hz]	**B1**	**2**
		use of $E = hf$ to give $3.0(4) \times 10^{-19}$ J	**B1**	
(b)		line **with arrow** from n = 2 to n = 3	**B1**	**1**
(c)	(i)	two loop drawn	**B1**	**3**
		not sine wave		
	(ii)	(measure of) probability	**C1**	
		probability **of finding electron** ∝ amplitude^2	**A1**	
(d)	(i)	re-arrangement to $\lambda = h/\sqrt{(2mE)}$ or equivalent	**C1**	**4**
		correct substitution	**C1**	
		3.3×10^{-10} m	**A1**	
	(ii)	0.5 × answer to (d) (i)	**B1**	
			Total	**10**