ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2004

GCE

Physics B

Unit PHB4

Marking Scheme

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. Use the following criteria to award marks:

2 marks: Candidates write legibly with accurate spelling, grammar and punctuation; the answer containing information that bears some relevance to the question and being organised clearly and coherently. The vocabulary should be appropriate to the topic being examined.

1 mark: Candidates write with reasonably accurate spelling, grammar and punctuation; the answer containing some information that bears some relevance to the question and being reasonably well organised. Some of the vocabulary should be appropriate to the topic being examined.

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 AE 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 CE (consequential error).

4 With regard to incorrect use of significant figures, normally two, three or four significant figures will be acceptable. Exceptions to this rule occur if the data in the question is given to, for example, five significant figures as in values of wavelength or frequency in questions dealing with the Doppler effect, or in atomic data. In these cases up to two further significant figures will be acceptable. 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 SF and, in addition, write SF 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.

PHB4

Question 1

(a)		acceleration/force is directed toward a (fixed) point/the centre/the equilibrium position **or** $a = -kx$ + '–' means that a is opposite direction to x	B1		
		acceleration/force is proportional to the distance from the point/displacement **or** $a = -kx$ where a = acceleration; x =displacement and k is constant	B1	**2**	
(b)	(i)	$3.2 = 2\pi\sqrt{l/9.8}$ (condone use of g = 10 m s^{-2} for C mark) (use of $a = -\omega^2 x$ is a PE so no marks)	C1		
		2.5(4) m	A1	**2**	
	(ii)	Correct value at 0.5 m and correct curvature	M1		
		Energy at 1 m = 160 J	A1	**2**	**6**

Question 2

(a)		below yield stress material behaves elastically **or** returns to original length when forces are removed	B1	
		above the yield stress: (condone 'at the yield stress') material behaves plastically/is permanently deformed/is ductile	B1	
		extends considerably/has large strain/extension	B1	
		for very small increases in stress/force	B1 **Max 2**	
(b)	(i)	Strain = 3.33 x 10^{-4} **or** $\frac{1.5 \times 10^{-3}}{4.5}$ seen	C1	
		E = stress/strain **and** *stress = F/A*; ***or*** $E = Fl/A\Delta l$	C1	

		$A = 2.8 \times 10^{-4}$ m^2 **or** $\frac{\pi(0.0019)^2}{4}$ or $\pi(9.5 \times 10^{-3})^2$ seen	C1		
		Stress = 7.0×10^7 Pa	C1		
		2 max for C marks			
		Force = 19.6 to 19.8 (20) kN	A1	**3**	
	(ii)	Strain energy = ½ $F\Delta l$ or ½ their (b)(i) x (1.5×10^{-3}) condone incorrect power or no 10^{-3} for C mark **or** ½ $\sigma\varepsilon$ x *volume*	C1		
		14.6 to14.9 (15) J (e.c.f.)	A1	**2**	**7**

Question 3

(a)		momentum before (a collision) = momentum after (the collision) total (resultant) momentum constant **or** momentum of system is constant allow $m_1v_1 + m_2v_2$ = etc **or** reference to isolated/closed system or that no external forces act	C1		
		resultant/total/sum of momentum of a system is constant/same before and after a collision/interaction provided no external forces act/in an isolated system	A1	**2**	
(b)	(i)	impulse = Ft ; or I =area under graph (condone ½ Ft) **or** clear attempt to multiply a force by a time e.g. multiplies 1.8 by 0.15	C1		
		0.135 (0.14) Ns **or** kg m s^{-1}	A1	**2**	
	(ii)	impulse = change in momentum or 0.135 = m x 0.6 (condone $Ft = mv$)	C1		
		0.225/0.233 (0.23) kg (ecf from (b)(i))	A1	**2**	
	(iii)	0 (no unit penalty)	B1	**1**	**7**

Question 4

(a)	(i)	Energy = ½ CV^2 **or** *½ QV and Q = VC*	C1		
		Calculation initial or final energy correctly (0.202 J or 0.0625 J) **or** energy = ½ (20 000 x 10^{-6} ($4.5^2 - 2.5^2$) **condone** no or incorrect power of 10	C1		
		0.137 to 0.140 J	A1	**3**	

	(ii)	PE = 0.015 x 9.8 x 0.35 (0.0515) (0.052 J) or arrives at 0.368 or 0.371	C1	
		36 to 38 (36.8 (37) % is correct) (ecf 0.052 x 100/their (a)(i)) (penalise use of 0.05 J)	A1	**2**
	(iii)	heating/energy loss due to resistance of wires	B1	
		work done against friction allow energy/heat loss due to friction	B1	
		work done against air resistance due to motion of the mass	B1	
		sound energy due to vibrations of the motor	B1	**Max 2**
(b)	(i)	Power = work done/time (*W/t or E/t*) **or** work done = their PE from (a)(ii)/1.3 **or** power = 0.14/1.3 (i.e. use of input energy from (a)(i))	C1	
		40 (39.6) mW	A1	**2**
	(ii)	$V = V_o e^{-t/RC}$ or $Q = Q_o e^{-t/RC}$ and $Q = VC$	C1	
		$2.5 = 4.5\ e^{-1.3/0.02R}$ (ignore incorrect power of 10 for *C* in substitution)	C1	
		111 (110) Ω Allow B1 for realising $0.69CR \approx 1.3$ leading to 94 Ω	A1	**3**

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Question 5

(a)	(i)	Suitable method clear $\frac{p_1V_1}{p_2V_2} = \frac{T_1}{T_2}$ or $\frac{p_1}{p_2} = \frac{T_1}{T_2}$ or $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ **or** calculate n = 0.053 and substitutes in $pV = nRT$	C1	
		555 to 580 K (567 K) depending on data used from graph	A1	**2**
	(ii)	Corresponding values of p and V read correctly for either graph	C1	
		Substitutes data in $pV = nRT$; ignore powers of 10	C1	
		0.053 mol (answer will have range dependent on accuracy of graph drawing)	A1	**3**
(b)	(i)	Attempt to find area enclosed	C1	
		Number of squares = 80 ± 6 small squares 3 to 3.4 large squares **or** energy per square = 0.5 J	C1	
		40 J (± 3 J)	A1	**3**
	(ii)	work done ON the gas	M1	
		more work is done on the gas when compressing than by the gas when expanding **or** work done = $p\,\Delta V$ and compression is at higher pressure	A1	**2**
	(iii)	Change in internal energy, $\Delta U = nc_v\Delta\theta$ (condone Q or W) or Statement that no work is done (on or by the gas) since ΔV = 0 or volume is constant **or** W = 0 since ΔV = 0)	C1	
		their (a)(ii) x 20 x (their temperature change) (1.06 x their ΔT) 240 to 250 J (241J to 244 J if correct)	A1	**2**

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Question 6

(a)	(i)	$F = mr\omega^2$ or mv^2/r and $v = r\omega$	C1	
		$\omega = 2\pi f$ (40.8 rad s^{-1})	C1	
		6.2 to 6.3 N	A1	**3**
	(ii)	arrow shown at tangent to circular path	B1	**1**
(b)		'−sin' shape graph drawn and 1 cycle	B1	
		period 0.15 s or 1/6.5 or 2/13 used as labels correctly	B1	**2**
(c)		a forced oscillation occurs : when a body is subject to a periodic force **or** a body/oscillator is made to oscillate/vibrate by another oscillator/frequency OWTTE	B1	
		as speed increases there is an increase in the frequency of the periodic force/the vibrations from the wheel	B1	
		as speed/frequency of the 'driver' increases the frequency of the forced oscillations increases **or** frequency of driver/vibrations from wheel = frequency of driven/mirror	B1	
		resonance occurs at natural frequency **or** resonance occurs when the forcing frequency = natural frequency	B1	
		amplitude reaches a maximum **or** amplitude increase greatly when frequency of rotation of the wheel is 6.5 rev.p s **or** frequency of the force is 6.5 Hz **or** when resonant frequency is reached	B1	
		above this frequency/speed the amplitude falls again	B1	
		last two marks may be awarded for a well drawn and clearly labelled amplitude-**frequency** graph **last mark** may be awarded for an amplitude-speed graph	**Max 5**	
		At least 2 marks for physics + use of Physics is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar	**Max 2**	
		At least 1 mark for physics + the use of Physics is accurate, but the answer lacks coherence or spelling, punctuation and grammar are poor	**Max 1**	**7**
		the use of Physics is inaccurate, the answer is disjointed, with significant errors in spelling, punctuation and grammar	0	

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Question 7

(a)	(i)	An electron moves from a higher level to a lower level	C1	
		(An electron) falls/moves/drops from–2.43 x 10^{-19} J to –3.0 x 10^{-19} J levels	A1	**2**
	(ii)	$E = hf$ and $c = f\lambda$ or $E = hc/\lambda$	C1	
		correct substitution of data (allow ecf from (i) for incorrect levels or level value) **or** f = 8.64 x 10^{13} Hz	C1	
		(3.47 to 3.49) x 10^{-6} m **or** 3.5 x 10^{-6} m (cao)	A1	**3**
(b)	(i)	an atom/electron stays in a metastable/excited state for a longer time or relatively long time **or** metastable state has a longer lifetime than other (excited) states **or** stated times (e.g. 10^{-3} s compared with 10^{-8} s)	B1	**1**
	(ii)	Vague answer e.g. More electrons in higher level than in a lower level (condone ground state) or diagram that gives reasonable view of population inversion	C1	
		there are more atoms: with electrons in a higher energy level than in a lower level in a metastable state than in a lower state in an excited state than in a lower state	A1	**2**

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Question 8

(a)	occurs when electromagnetic radiation/photons is/are incident on a surface/plate/named metal/cathode	M1	
	electrons are emitted/ejected from the surface	A1	**2**
(b)	Diagram of suitable apparatus which will work e.g. electroscope with zinc plate or photocell with electrometer Procedure and observations For electroscope experiment	B1	**1**
	e.g. Charge electroscope negatively	B1	
	illuminate with visible light(low f) – no effect	B1	
	illuminate with uv radiation (high f) - leaves collapse	B1	

increase intensity with visible light has no effect	B1
low intensity uv discharges electroscope	B1
discharge begins instantly	B1
	Max 3
For photocell	
e.g. polarity correct for approach used	B1
illuminate with visible light (low *f*) - no current	B1
illuminate with uv radiation (high *f*) - current	B1
or	
with uv a larger back off voltage is needed	B1
to reduce current to zero	B1
increase intensity with visible light –no effect	B1
low intensity uv current observed.	
current begins instantly	
	Max 2

Why this suggests particle nature

e.g. with waves energy arriving all the time whatever the wavelength
emission would be expected at all wavelengths /frequencies
or
with particles no emission unless the particle has enough energy
or there is a threshold frequency/different frequency needed to emit electrons for different metals
photon/particle energy is wavelength/frequency dependent
or
with waves would expect a delay for low intensity
expect energy build up and quicker emission for high intensity waves
or
provided particle have enough energy
emission starts as soon as a particle arrives at the surface

At least 2 marks for physics + use of Physics is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar	**Max 2**
At least 1 mark for physics + the use of Physics is accurate, but the answer lacks coherence or spelling, punctuation and grammar are poor	**Max 1**
the use of Physics is inaccurate, the answer is disjointed, with significant errors in spelling, punctuation and grammar	**0 8**
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