ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2003

GCE

Physics B

Unit PHB4

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales 3644723 and a registered charity number 1073334
Registered address: Addleshaw Booth & Co., Sovereign House, PO Box 8, Sovereign Street, Leeds LS1 1HQ
Kathleen Tattersall: *Director General*

Unit 4: Further 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.

Question 1

(a)	1 coulomb of charge is stored for a p.d. of 1 V between the plates (or equivalent statement) Condone 1 coulomb per volt	B1 **1**
(b)(i)	Correct substitution in $C = \frac{\varepsilon_o \varepsilon_r A}{d}$ (ignore powers of 10)	C1
	Plate area = 4.65×10^{-3} m^2 or $C = \frac{\varepsilon_o \varepsilon_r \pi r^2}{d}$ with correct data	A1
	Radius = (their area /3.14)$^{1/2;}$ 0.038(4 or 5) m if correct	B1 **3**
(ii)	E = ½ CV^2 or correct numerical substitution or E = ½ QV & Q = VC	C1
	$4.1(4) \times 10^{-10}$ J	A1 **2**
(c)	Time constant = *RC* or Time to halve = 0.69 *RC* or $V = V_o e^{-t/RC}$	C1
	Time to fall to 1/e (0.19 ms) or time to halve (0.13 ms)	C1
	or V_o = 6 V and correct coordinates of point on line (0.6 ms max)	A1
	8.1 – 8.6 MΩ	**3**
		Total 9

Question 2

(a)	stress = *force/area* and E = *stress / strain*	
	May be in one formula $E = FL/A\Delta l$	C1
	Stress = $1.9 \times 10^5/5.3 \times 10^{-3}$ or correct substitution of data in $E = Fl/A\Delta l$	C1
	1.8×10^{-4}	A1 **3**
(b)	Temperature rise = (a)/1.5×10^{-5} (12 K)	C1
	17 °C (290 K)	A1 **2**
(c)	Energy stored = ½ $F\,\Delta l$ {condone $E = \frac{1}{2}\frac{\lambda}{l}(\Delta l)^2$ }or ½ σ ε V	C1
	Extension = 50 × (a) = (8.95) 9 × 10^{-3} m	
	or correct substitution using their data	C1
	850 - 860 J (cao)	A1 **3**
		Total 8

Question 3

(a)	force is needed toward the centre or there is acceleration toward the centre	B1
	movement to the left/toward A/away from the centre (or indicated on diagram)	M1
	right hand spring (attached to **B**) has to stretch to provide force	A1
		3
(b)(i)	acceleration = v^2/r or speed = 12.5 m s^{-1}	
	or $a = r\omega^2$ and $v = r\omega$ or ω = 0.52 rad s^{-1} or $45^2/0.024$	C1
	6.5 m s^{-2} 8.4 × 10^4 km h^{-2} unit essential	A1
		2
(ii)	Force on mass = 0.35 × (i) (2.28 N if correct)	
	or use of $F = mr\omega^2$ ($0.35 \times 24 \times 0.52^2$)	C1
	0.82mm or 0.83 mm if (i) is correct; Movement = 12.6 × (i) mm	A1
		2
(c)(i)	$T = 2\pi\sqrt{M/k}$ or $a = (2\pi f)^2 A$ or f = 1.4 Hz or ω = 8.9 rad s^{-1}	C1
	k = 27.8 N m^{-1} use of $T = 1/f$ or $2\pi/\omega$	C1
	0.71 s (allow 0.70 s to 0.72 s)	A1
		3
(ii)	sketch showing amplitude reducing with time starting at max	
	ignore changing period	B1
	labelled consistently with answers to (b)(ii) and (c)(i).	
	(0.71 s and initial displacement 82 mm)	
	condone only one period shown correctly	B1
		2
		Total 12

Question 4

(a)	shc is energy supplied to raise the temperature of 1 kg by 1 K	B1
	solids expand very little or have constant volume	B1
	all energy supplied raises temperature ($Q_V = \Delta U$)	B1
	for a constant pressure change a gas has to expand	B1
	work is done or energy has to be supplied to expand gas	
	$Q_P = \Delta U + W$	B1
	more energy needed at constant pressure to raise temperature by 1 K or by a given amount ($c_p > c_v$)	B1
		Max 4
	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	Q2
	At least 1 mark for physics + the use of Physics is accurate, but the answer lacks coherence or spelling, punctuation and grammar are poor	Q1
	The use of Physics is inaccurate, the answer is disjointed, with significant errors in spelling, punctuation and grammar	Q0
		Max 2
(b)(i)	$mc\Delta\theta$ = energy OR mass flow rate × $c\Delta\theta$ = power	C1
	$\Delta\theta$ = 18.2 K (or correct substitution, 750 = 1.3 × 0.032 × 990 (45 - θ)	C1
	maximum room temperature = 27°C (300 K)	A1
		3
(ii)	increase the mass/volume flow rate	B1
	the temperature difference between the air entering and leaving the heater will decrease or less time to heat up the air passing though the heater	B1
		2
		Total 11

Question 5

(a)(i) the molecules of an ideal gas are assumed not to attract one another
or negligible attractive force — B1
molecules of an ideal gas have no internal potential energy — B1
no work is done in separating molecules at constant pressure — B1
KE increases as the molecules move faster increasing the KE — B1
Max 3

(ii) $3/2\ kT$ seen in a calculation $(3/2 \times 1.38 \times 10^{-23} \times 290)$
or energy of 1 molecule = 6.0×10^{-21}J
or $6 \times 10^{23} \times 0.025$ seen in calculation
or number of molecules = 1.5×10^{22} — C1
90 J — A1
2

(b)(i) calculation of radius using circumference = $2\pi r$ (110 mm)
$r = 0.690/2\pi$ seen in calculation — B1
calculation of volume using $4/3\ \pi r^3$ (must see evidence: either substitution of radius in equation or a calculated value to 3 sf) — B1
2

(ii) use of $T = 290$ K or pressure = 1.62×10^5 Pa in $pV = nRT$ — C1
number of moles = $pV/RT = 0.37$- 0.38 mol (0.23 mol common) — A1
mass = $0.37 \times 28 = 10.4 – 10.5$ g
(ecf common incorrect answer is 6.5) — B1
3

$pV = \frac{m}{28}8.3T$ with correct p or T gets 2

(iii) 1.53×10^5 Pa (ecf common answer with ecf is 0.95×10^5 Pa) — B1
1
Total 11

Question 6

(a)	**total** momentum before a collision = **total** momentum after a collision or total momentum of a system is constant or $\Sigma mv = 0$, where mv is the momentum no external forces acting on the system/ isolated system	B1 B1 **2**
(b)(i)	work done = Fs 63 000 J	C1 A1 **2**
(ii)	KE = ½ mv^2 or $F = ma$ and $v^2 = u^2 + 2as$ combined speed v = 4.6 (4.58) m s^{-1}	C1 A1 **2**
(iii)	reasonable attempt at a momentum conservation equation (2 terms before and one term after any signs) (+ or –) 3600 v + (2400 × 12.5) = – (6000 × 4.58) (e.c.f.) (–)16 m s^{-1} (cao ignoring sign)	 C1 C1 A1 **3**
(iv)	driver A is likely to experience the greater force force = rate of change of momentum ($\Delta mv/t$) or $F = ma$ time for deceleration on impact is (approximately) the same change in velocity of driver B = 11.4 m s^{-1} (ecf from (ii) and (iii)) and change in velocity of driver A = 17.1 m s^{-1} (ecf from (ii) and (iii)) or Δmv or Δv of A > Δmv or Δv of B	B1 B1 B1 B1 **4**
		Total 13

Question 7

(a)	Arrow showing correct transition in correct direction (must be only one arrow)	B1
		1
(b)	$v = f\lambda$ and $E = hf$ or $E = hc/\lambda$	C1
	Correct frequency calculated (4.7×10^{14} Hz) or correct substitution	C1
	639 nm	A1
		3
(c)	metastable energy level: An excited state in which an electron/atom can stay for a longer time than usual/for a long time	B1
	population inversion: more atoms/electrons in the excited /metastable state than in the lower energy state	B1
	Any 3 from	
	atoms/electrons are excited raised to a higher level (to the metastable state)	B1
	one atom/electron relaxes/de-excites/falls to lower level spontaneously	B1
	photon is stimulus for laser action	B1
	(this causes) all the other atoms/electrons to relax at the same time/simultaneously/together	B1
	the photons are all emitted in phase or coherent beam if light produced	B1
		Max5
	at least 3 marks for physics + use of Physics is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar	Q2
	at least 2 marks for physics + the use of Physics is accurate, but the answer lacks coherence or spelling, punctuation and grammar are poor	Q1
	the use of Physics is inaccurate, the answer is disjointed, with significant errors in spelling, punctuation and grammar	Q0
		Max 2
		7
		Total 11
		Total 75