GCE 2004
June Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Physics B
Unit PHB5

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.

Further copies of this Mark Scheme are available from:

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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.

PHB5 Fields and their Applications

Question 1

(a)	(i)	equates eV and $\frac{1}{2} mv^2$	C1
		$[v = \sqrt{(2Ve/m)}] = 6.5 \times 10^7$ m s^{-1}	A1
	(ii)	***25mC/1.6 x 10^{-19}***	C1
		= 1.56 x 10^{17} s^{-1}	A1
(b)	(i)	Changes in flux linkage mentioned OWTTE	B1
		produces an induced e.m.f.; *allow induced current*	B1
	(ii)	leads to heating effects, damage, additional magnetic fields etc	B1
	(iii)	$\Delta B = 7 \times 10^{-4}$ T	C1
		$\Delta(NBA) = 7 \times 10^{-4} \times 250 \times 0.004$	C1
		$E = \Delta(NBA)/\Delta t = 7 \times 10^{-4} \times 250 \times 0.004/50 \times 10^{-6} = 14$ V	A1
	(iv)	Any valid suggestion for flux reduction	C1
		Coil and field perpendicular (for max value)	A1
			Total 12

Question 2

(a)	(i)	shows arrows from + to –	B1
	(ii)	surface of constant potential/no work done in moving charge on surface OWTTE	B1
	(iii)	3 correct lines between plates, straight, labelled, +12.5 kV on left	B1
		outwards curvature at edge of plates	B1
(b)	(i)	**F = Vq/d** *or* ***50000 × 5.5 × 10^{-9}/4***	B1
		= 0.0690 [mN] [0.0688]	B1
	(ii)	$a = F/m = 0.069 \times 10^{-3}/0.12 \times 10^{-3} = 0.575/0.573$ m s^{-2}	C1
		use of appropriate kinematic equation	C1
		$t = \sqrt{2} \times 2/0.575 = (2.63)$ s	C1
		so length must be $0.8 \times 2.63 = 2.11$ m [gets mark ecf from third mark if number quoted]	B1
		allow alternative energy approach	
			Total 10

Question 3

(a)	(i)	Endpoint 1700	B1
		Endpoint 5700	B1
	(ii)	counts squares [100 ± 10]	B1
		evaluates energy/kg of one square [20 000 J/kg]	B1
		computes total energy for 1 kg	C1
		multiplies by 450 accept range 7×10^8 J $\rightarrow$ 10×10^8 J	A1
		or	
		Combines correct equations	B1
		Read off from graph correct for *g* or quotes correct value	B1
		Calculation correct	C1
		Multiplies by 450 [ans: 9.2×10^8 J]	A1
(b)	Compares correctly **up to 3** of Gravitational potential (energy) Grav field (strength)/*g*/force of gravity/gravitational attraction Escape velocity Kinetic energy *not energy bald* Distance to neutral point OWTTE Fuel weight at launch/launch vehicle size (large first stage at Earth)		B3
	Plus States earth mass > moon mass Quotes both values of g_{earth} (9.8 N/kg) and g_{moon} (1.7 N/kg) to 2sf or 6:1 ratio expressed unambiguously		B2 **Max 4**
	Use of Physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **And gains at least 2 marks for Physics**		B2
	Use of Physics terms is accurate but the answer lacks coherence or the spelling, punctuation and grammar are poor **and gains at least 1 mark for Physics**		B1
	Use of Physics terms is inaccurate, the answer is disjointed with significant errors in spelling, punctuation and grammar		B0
			Total 12

Question 4

(a)	236/92/U		B1
	4/2/α [4/2/He]		B1
(b)	(i)	Equation correct **or** Evaluates mass difference (1.349×10^{-29} kg)	B1
		Uses $E = mc^2$	B1
		to yield energy (1.21 pJ)	B1

(ii) uses $t_{½} = [\log_e 2/\lambda] = 0.69/2.1 \times 10^{11}$ M1
to yield $\lambda = 3.29 \times 10^{-12}$ s^{-1} A1

(iii) uses $A = \lambda N$ [$= 1.05 \times 10^{10}$] **or** $N_1 = N_0 e^{-\lambda t}$ C1
uses $A \times 1.21 \times 10^{-12}$ **or** $(N_0 - N_1) \times 1.21 \times 10^{-12}$ C1
= 12.7 mJ A1

(iv) $A = A_0 e^{-\lambda t}$ C1
$0.95 = e^{-3.29 \times 10\text{-}12\, t}$ [or log expression] C1
$t = 1.56 \times 10^{10}$ s = 495 years C1
correct deduction from candidate answer B1

or
100 y = 3.19×10^9 s C1
$A = A_0 e^{-\lambda t} = 1.056 \times 10^{10}\ e^{-0.0104}$ [ecf from first mark] C1
$A = 1.046 \times 10^{10}$ [ecf from first mark] C1
Change is 1 part in 105 OWTTE so no significant change B1
or
Half life calc/fractional change/2^n/99% left so no sig change
or
further alternative

Total 14

Question 5

(a) e^- likely where amplitude is max [or at $r = 1.5 \times 10^{-10}$ m] B1
or impossible where amplitude is zero/probability of finding electron
amplitude of stationary wave is related to probability C1
probability is proportional to amplitude squared A1

(b) (i) shows ½ mv^2 = ½ $(mv)^2/m$ *and* states $p = mv$ B1

(ii) States $mv = h/\lambda$ B1
½ mv^2 = ½ $(mv)2/m$ (i.e. re-writes k.e. in momentum terms) B1
[k.e. = ½ $h^2/\lambda^2/m$]

(c) (i) $\lambda = 6 \times 10^{-10}$ B1
k.e. = ½ $\times (6.6 \times 10^{-34})^2 / (6 \times 10^{-10})^2 \times 9.1 \times 10^{-31}$ [ecf] C1
= 6.65 x 10^{-19} J A1

(ii) Uses kQ/r or variant C1
p.e. = $kQ_1Q_2/r_1 = 8.98 \times 10^9 \times (1.6 \times 10^{-19})^2/1.5 \times 10^{-10}$ C1
= (-)15.3 $\times 10^{-19}$ J A1
makes it explicit that this is a negative quantity relative to k.e. A1
allow use of symbol/stated value for electron/proton charge

(iii) adds ((c) (i)) and ((c) (ii)) calcs correctly without regard to sign C1
quotes answer as –ve, addition is correct A1
(cao range -8 →-9 -8.57 x 10^{-19} J)

(iv) this is **stable** [ecf, must be consistent with (c) (iii)] B1
negative total energy so energy must be supplied to break up B1

Total 17

Question 6

(a)	(i)	length = $250 \times 2 \times \pi \times 15 \times 10^{-3}$ m	M1	
		= 23.6 m	A1	
	(ii)	$R = \rho\, l/A$	C1	
		Use of $A = \rho l/R = 1.7 \times 10^{-8} \times 23.6/8$ (can use 24)	C1	
		leading to $r = 1.26 \times 10^{-4}$ m	A1	
		dia = 0.252 mm [ecf from candidate radius]	B1	
	(iii)	$0.7 \times 0.050 \times 23.6$ [use of $F = Bil$]	M1	
		= 0.826 N no unit required [range 0.82 →0.84]	A1	
	(iv)	$F = kx$ or $F = k\Delta x$	C1	
		$0.826 = 1.2 \times 10^4 \times x$	C1	
		$x = 6.88 \times 10^{-5}$ m = 6.88×10^{-2} mm [cao 6.6 – 7.0]	A1	
(b)	(i)	[Use of $T = 2\pi\sqrt{(m/k)}$]= $2\pi\sqrt{(50 \times 10^{-3}/1.2 \times 10^4)}$	C1	
		$f = 1/T$	C1	
		= 78 or 78.0 Hz	A1	
	(ii)	general shape correct	C1	
		marks peak of curve as 78 Hz/natural frequency/resonant frequency/f_0 explained	A1	
	(iii)	mention of resonance	B1	
		when driver frequency = natural frequency	B1	
		max amplitude (peak) at this resonance	B1	
		off resonance, driver adds energy at wrong time/forces coil to wrong frequency	B1	
			Max 3	
			Total 19	

Question 7

(a)	(i)	into paper; away from candidate	B1	
	(ii)	mention of FLH/discussion of angle between current and magnetic field	B1	
		force arises when current in field	B1	
		force moves/ accelerates/speeds up the cone	B1	**3**
(b)		mass of air/number of atoms/amount of air unchanged (not '*air can't move out/escape'*)	B1	
		density or volume changes lead to pressure changes/convincing	B1	
		conservation of momentum or kinetic theory treatment to explain pressure increase/$pV = nRT$ arguments	B1	
		pressure change leads to force change		
		extra force required on cone (to move same distance)/spring stiffer/extra force opposes motion OWTTE	B1	
		extra energy required to compress air/move cone/more energy required for same displacement OWTTE	B1	
			Max 4	

	Use of Physics terms is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar **And gains at least 2 marks for Physics**	B2	
	Use of Physics terms is accurate but the answer lacks coherence or the spelling, punctuation and grammar are poor **and gains at least 1 mark for Physics**	B1	
	Use of Physics terms is inaccurate, the answer is disjointed with significant errors in spelling, punctuation and grammar	B0	
			Total 10

Question 8

(a)	Explains meaning 'in phase'/peak together/path difference λ	B1	
	description of addition/constructive interference stated	B1	
	gives greater amplitude/louder sound/sum of amplitudes	B1	
(b)	Use of $c = f\lambda$	C1	
	So wavelength = 340/60 = 5.66 m	C1	
	Labyrinth must be λ/2 long so 2.83 m	A1	
	or		
	Time required to delay is 1/120 s	B1	
	Speed = distance/time	C1	
	Length = 340/120 = 2.83 m	A1	**6**