RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 7888**

Advanced Subsidiary GCE **AS 3888**

Mark Schemes for the Units

January 2010

3888/7888/MS/10J

Oxford Cambridge and RSA Examinations

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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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CONTENTS

Advanced GCE Physics B (Advancing Physics) (7888)

Advanced Subsidiary GCE Physics B (Advancing Physics) (3888)

MARK SCHEMES FOR THE UNITS

Marking quality of written communication

The appropriate mark (0-4) should be awarded based on the candidate's quality of written communication in Section B of the paper.

4 The candidate will express complex ideas extremely clearly and fluently. Answers are structured logically and concisely, so that the candidate communicates effectively. Information is presented in the most appropriate form (which may include graphs, diagrams or charts where their use would enhance communication). The candidate spells, punctuates and uses the rules of grammar with almost faultless accuracy, deploying a wide range of grammatical constructions and specialist terms.

3 The candidate will express moderately complex ideas clearly and reasonably fluently. Answers are structured logically and concisely, so that the candidate generally communicates effectively. Information is not always presented in the most appropriate form. The candidate spells, punctuates and uses the rules of grammar with reasonable accuracy; a range of specialist terms are used appropriately.

2 The candidate will express moderately complex ideas fairly clearly but not always fluently. Answers may not be structured clearly. The candidate spells, punctuates and uses the rules of grammar with some errors; a limited range of specialist terms are used appropriately.

1 The candidate will express simple ideas clearly, but may be imprecise and awkward in dealing with complex or subtle concepts. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weakness in these areas.

0 The candidate is unable to express simple ideas clearly; there are severe shortcomings in the organisation and presentation of the answer, leading to a failure to communicate knowledge and ideas. There are significant errors in the use of language which makes the candidate's meaning uncertain.

2863/01 Rise and Fall of the Clockwork Universe

Qn	Expected Answers	Marks	Additional guidance
1a b	D ✓ A ✓	1 1	
2a b	$pV = nRT$ ✓n = 2.1 x 10^5 x 2.3 x 10^{-3}/8.3 x 285 = 0.20(4) ✓ p = 300 x 2.1 x 10^5 /285 ✓= 2.2 x 10^5 ✓ Pa	2 2	Must quote equation. Must have own answer or clear working Can use $pV = nRT$ No ecf
3	A✓	1	
4a b	$F = e^{-(6.4 \text{ x } 10\text{^-}20/298 \text{ x } 1.4 \text{ x } 10\text{^-}23)}$ ✓ = 2.2. x 10^{-7} ✓ J ✓	2 1	1.7 x 10^{-7} if 1.38 used
5a b	$\Delta\theta$ = 2.9 x 10^4/0.19 x 4200 ✓ = 36 K✓ New temp = 22 + 36 = 58 ^{0}C✓	2 1	
6	Distance = 4.1 x 10^{16}/3.0 x 10^8 x3.2 x10^7 ✓= 4.3 light years✓	2	Accept 4.27
7	max at –A,+A & zero at 0.0, ✓ good curve✓	2	P.E. + K.E. = total energy (by eye)
8	Energy stored in <u>extending</u> spring (up to limit of shaded area) ✓	1	Not just energy in spring/stored in spring
9	E = ½ x 4700 x 10^{-6} x 9.0^2 ✓= 0.19 J✓	2	1.9 x 10^5 one mark 1.9 x 10^2 one mark

Section A Total: 20

Qn	Expected Answers	Marks	Additional guidance
10 (a)i ii iii	$2.3 \times 10^{-6} \times 6 \times 10^{23}/40$✓ = 3.45×10^{16}✓ $\lambda = 0.57/3.45 \times 10^{16}$ ✓= $1.7 \times 10^{-17}\ s^{-1}$✓ $T_{1/2} = 0.693/1.7 \times 10^{-17} = 4.1 \times 10^{16}$✓ $= 4.1 \times 10^{16}/3.2 \times 10^{7} = 1.3 \times 10^{9}$ years✓	2 2 2	 Ecf only one mark if λ is negative 4.2×10^{16} OK, ecf
(b)	Approx. two half lives have passed✓ age of rock = 2.6×10^{9} years✓	2	Ecf from a(iii)
(c)	ratio would appear to have greater proportion of potassium✓ therefore calculation will show lower age ✓because the original amount of potassium has been underestimated/more argon daughter produced than measured✓	3	
11(a) i	Arrow pointing towards asteroid ✓line perp. to eqp. lines ✓	2	Must go through X
ii	Separation of (equal) potential lines increases (with distance from planet) ✓	1	
(b) (i)	$g = - 6.7 \times 10^{-11} \times 8.1 \times 10^{19}/ (1.6 \times 10^{5})^{2}$ ✓=(-) 0.21 N kg^{-1}✓	2	Must have own value
(ii)	F = (-) 0.2(1) x 3.5×10^{2} = (-)0.7 x 10^{2} N ✓ (70 N)	1	Can use alternative method. Look for 73.5 N, 74.2 N
(c) (i)	speed = $2 \pi \times 1.6 \times 10^{5}/(5.6 \times 60 \times 60)$ ✓ = 49.9 m s^{-1}	1	Working or own value
(ii)	F = (-) mv^2/r ✓= $3.5 \times 10^{2} \times 50^{2}/1.6 \times 10^{5}$ ✓= (-) 5.5 ✓N	2	Look for 5.4 N
(iii)	force of weight (more than) provides centripetal force ✓	1	Must have link with centripetal force.
(iv)	centripetal acceleration of surface = 16 x that of original asteroid✓ = (-)88N ✓this is greater than weight so satellite would not remain on surface. ✓	3	Two marks for value. Third mark for comparison with weight.
12 a i	Δp = 0.065(-14 – 18) ✓ = 0.065 x -32= -2.08 ✓kg m s^{-1}	2	Must have own value. One mark for correct calculation of momenta.
(ii)	average force = 2.1/0.13✓ =16 N ✓	2	
(iii)	equal magnitude✓ opposite direction✓	2	Correct numerical answer acceptable
(b)	Any three from: *increasing T increases energy of particles * hence velocity and momentum. * Greater momentum change on collision		

Qn	Expected Answers	Marks	Additional guidance
	*increased frequency of collisions with walls *leads to greater force, *greater force gives greater *F*/*A*	3	
(c)	number = 0.5 x 1 x 10^5 /6 x 10^{-23} ✓= 8.3 x 10^{26}✓	2	
(d)	halving the speed halves the force per collision✓, but (and) there are fewer collisions per second. ✓	2	AW argument from $pV = 1/3\ Nmc^2$
13a i	maximum value of cos is +/- 1 ✓	1	
ii	v = 2 π x11 x 42 x 10^{-3} ✓= 2.9 ✓ m s^{-1}	2	
iii	zero/0/nought ✓	1	
iv	max a = $-(2\pi f)^2A$ =$(2\ \pi\ x11)^2$x 42 x 10^{-3} ✓= 200 ✓m s^{-2}	2	
b	Resonance occurs when natural frequency matches driving frequency. ✓ This can be reduced by shifting frequency of the aerial + example damping aerial + example ✓✓	1 2	One mark for explanation of resonance one mark for principle of suggested action, one mark for specific action.

QWC: 13 b, 12 b, 11 c (iv), 10 b (ii),

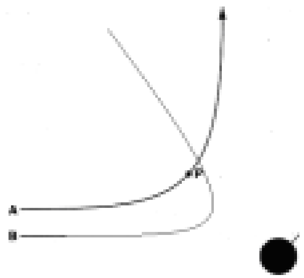
2864/01 Field and particle Pictures

Question		Expected Answers	Marks	Additional Guidance
1	**(a)**	$\mathrm{J\,C^{-1}}$	1	
	(b)	T	1	
2		total dose equivalent = 4.0×10^{-3} Sv risk = 1.2×10^{-2} percent or 1.2×10^{-4} no units	1 1	 ecf incorrect tde, $1.2\times10^{??}$ worth [1]
3		13	1	
4	**(a)**	A	1	
	(b)	1.2 V minus	1 1	
5	**(a)**	DF	1	
	(b)	length = 25×10^{-2} m, $B = 340\times10^{-3}$ T, current = 680×10^{-6} A $F = 5.8\times10^{-5}$ N	1 1	 ecf incorrect units conversion
6	**(a)**	Either $0.69 / 8.8\times10^{8} = 7.8\times10^{-10}$ or $\ln 2 / 8.8\times10^{8} = 7.9\times10^{-10}\ \mathrm{s^{-1}}$	1	
	(b)	for 7.8×10^{-10} $N = 7.2\times10^{12}$ for 7.9×10^{-10} $N = 7.1\times10^{12}$ ecf incorrect N: $m = 1.1\times10^{-12}$ kg	1 1	$1\times10^{-9}\ \mathrm{s^{-1}}$ gives 5.6×10^{12} and 8.6×10^{-13} kg
7	**(a)**	${}^{0}_{0}\gamma \rightarrow {}^{1}_{1}\mathrm{p} + {}^{1}_{-1}\bar{\mathrm{p}}$	1	
	(b)	$m = 3.4\times10^{-27}$ kg $E = 3.1\times10^{-10}$ J $E = 1.9$ GeV	1 1 1	 1.5×10^{-10} for [1] unless use of $0.5mv^2$ ecf: correct use of conversion rule for [1]
8	**(b)**	between at halfway and threequarters up on central field line at right angles to all five field lines (by eye)	1 1	accept dotted lines

Question			Expected Answers	Marks	Additional Guidance
9	(a)		any three of the following: • current (in primary coil) creates flux in core • flux in core / primary coil changes / alternates • flux in primary coil goes through secondary coil • emf across secondary coil is caused by its change of flux (linkage) • emf is rate of change of flux (linkage)	3	in words, not as a formula
	(b)		same shape as current, either in or out of phase, any constant amplitude over whole timespan	1	
	(c)		same shape as flux, either 90° ahead or behind flux, any constant amplitude over whole timespan	1	allow ecf from incorrect flux curve
	(d)	(i)	$\Delta t = 4.2\times10^{-3}$ s for a quarter cycle $\Delta N\Phi / \Delta t \approx 300$ $\Delta N\Phi = 1.3$ Wb ecf: $\Delta t = 1/60$ s gives $\Delta N\Phi = 5$ Wb for [2]	1 1 1	accept $\varepsilon = 2\pi f N\Phi_0$ to give 0.80 Wb for [3] rule [1], substitution [1], evaluation [1] accept $N\Phi_0 = \frac{1}{2}\varepsilon\Delta t$ to give 0.63 Wb for [3] Δt [1], rule [1], evaluation [1]
		(ii)	for $N\Phi = 1$ Wb, $\Phi = 2.5\times10^{-3}$ Wb $A = 2.1\times10^{-3}$ m^2 for $N\Phi = 1.3$ Wb, $\Phi = 3.3\times10^{-3}$ Wb $A = 2.7\times10^{-3}$ m^2 for $N\Phi = 0.80$ Wb, $\Phi = 2.0\times10^{-3}$ Wb $A = 1.7\times10^{-3}$ m^2 for $N\Phi = 0.63$ Wb, $\Phi = 1.6\times10^{-3}$ Wb $A = 1.3\times10^{-3}$ m^2	1 1	ecf incorrect $N\Phi$ from (i) ecf incorrect Φ from $N\Phi$ accept 2.6×10^{-3} m^2

Question			Expected Answers	Marks	Additional Guidance
10	**(a)**		Five equally spaced vertical lines between plates arrows pointing down	1 1	allow correct edge effects
	(b)	**(i)**	negative to be attracted to the top plate / repelled from bottom plate against downwards force of gravity owtte	1 1 1	 not overcome gravity
		(ii)	2.0×10^{5}	1	
		(iii1)	$mg = qE$ or equivalent statement $mg = 6.1\times10^{-8}$ N $E = 1.9\times10^{6}$ V m^{-1}	1 1 1	rule stated explicitly, more than just a sum
		(iii2)	ecf from (iii1): $d = 14\times10^{-3}$ m $V = 2.7\times10^{4}$ V	1 1	2×10^{6} V m^{-1} gives 2.8×10^{4} V for [2] 2.7×10^{7} V for [1]
		(iv)	radiation ionises air (atoms) charged ions hit the sphere (and transfer charge to it)	1 1	accept absorbed betas add -ve charge [1]

Question			Expected Answers	Marks	Additional Guidance
11	**(a)**	**(i)**	$E = mv^2 / 2$	1	use of rule for [1] but not use of $\frac{1}{2}m(v-u)^2$
			$E = 4.8\times10^{-15}$ J	1	
		(ii)	ecf from (i): $E = qV$	1	
			$V = 3.0\times10^4$ V	1	5×10^{-15} J gives 3.1×10^4 V for [2]
	(b)	**(i)**	magnetic force on ion	1	
			force at right angles to its velocity	1	
		(ii)	$F = mv^2/r$	1	rule for [1]
			$F = 5.3\times10^{-14}$ N	1	
		(iii)	ecf from (ii): $F = Bqv$	0	
			$5.3\times10^{-14} = B \times 1.6\times10^{-19} \times 4.0\times10^5$	1	substitution for [1]
			$B = 0.83$ (T) ignore missing units	1	5.0×10^{-14} N gives 0.78 T for [2]
	(c)		EITHER		
			greater mass (and same velocity)	1	
			so greater / different path in magnetic field owtte	1	
			OR		
			greater mass and smaller velocity		
			so different (greater or smaller) path in magnetic field		

Question			Expected Answers	Marks	Additional Guidance
12	**(a)**	**(i)**	$q = 3.2\times10^{-19}$ C, $Q = 1.5\times10^{-17}$ C ecf: $F = 9.0\times10^{9} \times 3.2\times10^{-19} \times 1.5\times10^{-17} / (4.2\times10^{-14})^{2}$ 24 N	1 1 1	 substitution for [1] accept 0.13 N for [2]
		(ii)	from centre of nucleus to P	1	doesn't have to pass through P
	(b)	**(i)**		3	increased angular deflection [1] closer to nucleus [1] constant aiming error [1]
		(ii)	greater force on alpha particle B because passes closer to nucleus than particle A	1 1	
	(c)		particles moving slower so more time for force to act so more scattered through 90° / increased deflection / increased transverse impulse (for the same aiming error)	1 1	

2865 Advances in Physics

Qn	Expected Answers	Marks	Additional guidance
1 (a)	Many tiny crystals owtte ✓	1	
(b)	Few/no free electrons ✓	1	
(c)	Extra electrons in structure✓ More available free electrons ⇒ increased conductivity✓	1 1	
	Total:	**4**	
2 (a)	Two loops from bottom to top of crucible (invisible bit can be assumed) ✓ which do not cross ✓	2	
(b)	flux $\phi = BA =$ 0.02 × 0.2 = 0.004 Wb ✓ flux linked with the **coil** = $N\,\phi$ = 7 × 0.004 = 0.028 Wb turns ≈ 3 x 10^{-2} Wb turns ✓	2	
(c)	Sinusoid of same period as original ✓ 90° phase difference between curves (either way) ✓	2	
(d)	Induced voltage depends upon rate of change of flux linkage or current ✓(flux linkage is in phase with the current)	1	
	Total:	**7**	
3 (a)	$A = \pi \times (0.10\text{ m})^2 = 0.031\text{ m}^2$ $V = LA = 1 \times 0.031 = 0.031\text{ m}^3$ ✓m✓e	2	
(b)	$M = V\rho$ = 0.031 × 2300 = 72 kg ≈ 70 kg✓m✓e	2	Allow ecf from (a)
(c)	Room temperature estimated.0 °C, < 30 °C ✓ ; $E = mc\Delta T$ = 70 × 690 × (1700-293)= 6.8 × 10^7 J✓m✓e	3	Allow ΔT = 1700 K if justified
(d)	Appreciable heat losses <u>from such a hot object</u> owtte✓	1	
	Total:	**8**	

Qn	Expected Answers	Marks	Additional guidance
4 (a)	Drop to 0.89 of value after 1 year, so after 40 years becomes $(0.89)^{40} = 9.5 \times 10^{-3}$ of original. $9.5 \times 10^{-3} \times 20 \times 10^{-6}$ m = 1.9×10^{-7} m ≈ 0.2 μm ✓m✓e	2	Can do arithmetically
(b)	Extrapolating line to about 10^9 in 2010/ reading 4×10^7 in 2000 and doubling 5 times → 1.3×10^9 in the CPU✓m✓e	2	Allow 5×10^8 to 5×10^9
(c)	(i) Realising that the aperture is slightly bigger than one wavelength ✓; Diffraction will spread beam of light ✓ (ii) Attempt to use $p = mv$ <u>and</u> energy = eV✓ $eV = ½mv^2$ ✓ $\sqrt{(2Vem)} = \sqrt{(2[½mv^2]m} = \sqrt{(m^2v^2)} = mv = p$✓ (iii) $p = \sqrt{(2Vem)} = \sqrt{(2\times5000\times1.6\times10^{-19}\times9.1\times10^{-31})}$ = 3.8×10^{-23} N s✓ $\lambda = h/p = 6.6\times10^{-34}/3.8\times10^{-23}=1.7\times10^{-11}<2\times10^{-11}$m ✓m✓e (iv) λ very much (29 000×) smaller than that of light ✓ Will get comparable diffraction only at very much smaller apertures than Fig. 4.1/2, so can inscribe details that much (29 000×) smaller. ✓	2 3 3 2	 ecf wrong p value
	Total:	**14**	
5 (a)	(i) $R = \rho L/A$ ✓ Getting $L_{new} = ½L_{old}$ and $A_{new} = ¼A_{old}$✓ Combining to show $R_{new} = 2R_{old}$✓ (ii) mass is proportional to volume ✓ $V_{new} = ¼A \times ½L = AL/8 = V_{old}/8$ ✓ (iii) All the areas are quartered as in (a), so it is quartered ✓	3 2 1	 Can calculate all faces. Credit bald ¼.
(b)	Greater R so V^2/R decreases ✓ ; Much smaller surface area for heat to escape, so heats up rapidly ✓	2	
	Total:	**8**	

Qn	Expected Answers	Marks	Additional guidance
6 (a)	(i) $\tau = RC = 1.3\times10^{3} \times 2.0\times10^{-13} = 2.6\times10^{-10}$ s ($\approx 3 \times 10^{-10}$s) ✓ (ii) Time (for *V*/*I*/*Q*) to drop to 37% / about 1/3 of original value. ✓	1 1	Allow bald 2.6×10^{-10} s
(b)	(i) Continues from existing curve ✓ Exponential decay curve ✓ Passes between 1 and 2 V at 0.8 ns ✓ (ii) Amplitude of output voltage would decrease ✓ Period short compared with time constant✓	3 2	
(c)	C will drop by factor of 10 explained or calculated✓; time constant is the same ✓	2	
	Total:	**9**	
7 (a)	$2 \times 10^{6} \times 16/8 = 4 \times 10^{6}$ bytes ✓ = 4000 kilobytes > 100 × 30 kilobytes✓	2	
(b)	$30 \times 10^{3} \times 25$ ✓= 750 000 < 10^{6}✓	2	
(c)	750 000 bytes s^{-1} = 750 000 × 8 bits s^{-1} = 6 Mbit s^{-1} (so 8 M bit s^{-1} is adequate)✓	1	ecf from bytes/bits conversion
(d)	Programme could freeze/bits of screen ‘drop out’/ loss of audio✓ because information not being refreshed fast enough. ✓	2	One mark for possible effect, one for relating it to refresh rate.
	Total:	**7**	

Qn	Expected Answers	Marks	Additional guidance
8 (a)	(i) $v = f\lambda$ (any form) ✓ (ii) radio anywhere below microwave ✓ UV between 3×10^{-7} m and 3×10^{-10} m ✓	3	
(b)	(i)One ✓ for each type of radiation <u>with information to be gathered</u>, e.g. IR:- crop use/cloud positions; visible:- cloud positions/troop movements; microwave/radio, radar information about topography/g variations (ii) low altitude: closer so better resolution/ stronger signal ✓ high altitude: greater coverage/less rapid movement of satellite so less blurred image ✓.	4	Any reasonable suggestions for either part of (b) Any reasonable advantages acceptable (allow a new use)
(c)	(i) No atmospheric distortion/light pollution/obscuring clouds ✓ (ii) Light is red-shifted ✓ by greater amounts for more distant galaxies ✓ caused by expansion of Universe stretching light in transit ✓ light from further galaxies longer in transit so stretched more ✓ (any 3 points) (iii) Inverse square (stated or implied)✓ 7 × further $\Rightarrow 7^2 \times$ less intense = 49 × less intense $\approx$ 50 fainter as stated ✓m✓e Condition: similar luminosities/no intervening dust etc. ✓	1 3 4	Any distinct relevant point is worth a mark
(d)	Microwave NOT radio	1	
	Total:	**16**	

Qn	Expected Answers	Marks	Additional guidance
9 (a)	Light intensity very low that far from the Sun ✓	1	
(b)	5.6 MeV = 5.6×10^{6} J × 1.6×10^{-19} J eV^{-1} = 8.96×10^{-13} J ≈ 9×10^{-13} J ✓m✓e	2	
(c)	(i) Number of decays = 630 W/ 9.0×10^{-13} J = 7×10^{14} s^{-1} ✓ (8.96×10^{-13}J gives 7.03×10^{14} s^{-1}) (ii) Mission is about $T_{½}$ /8 ✓ Assume linear change in this time for estimate ✓ Extrapolating from 7/8 = 7×10^{14} s^{-1} to 8/8 ≈ 8×10^{14} s^{-1} ✓ / can use: $T_{½} \Rightarrow \lambda$✓ and then use $\frac{dN}{dt} = \left[\frac{dN}{dt}\right]_0 e^{-\lambda t}$ (gives 7.6×10^{14} s^{-1}) ✓m✓e	1 3	Ora from 7×10^{14} s^{-1} or can use 7×10^{14} s^{-1}= $C_0\times(½)^{1/8}$
(d)	Energy = 3 × 630 W × 3.2×10^{7} s = 6.0×10^{10} J ✓ Energy absorbed by astronaut = 6.0×10^{10} J /10^{11} = 0.6J✓ Dose = 0.6 J/70 kg = 0.0086 Gy ✓	3	 ecf energy
(e)	(Very many) electrons liberated in hotter region✓ Rate of release of electrons governed by Boltzmann factor ✓ Boltzmann factor increases exponentially/expression for factor quoted with temperature✓	3	 Any relevant reference to k will do here. Either comparison between kT and E or reference to $e^{-\frac{E}{kT}}$
	Total:	**13**	

Grade Thresholds

Advanced GCE Physics B (Advancing Physics) (3888/7888)
January 2010 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2863A	Raw	127	104	93	82	71	61	0
	UMS	100	80	70	60	50	40	0
2863B	Raw	127	104	93	82	71	61	0
	UMS	100	80	70	60	50	40	0
2864A	Raw	119	93	83	73	63	54	0
	UMS	110	88	77	66	55	44	0
2864B	Raw	119	93	83	73	63	54	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	59	54	49	44	39	0
	UMS	90	72	63	54	45	36	0

Specification Aggregation Results

Overall threshold marks in UMS (ie after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3888	300	240	210	180	150	120	0
7888	600	480	420	360	300	240	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
3888	23.5	52.9	58.8	88.2	100.0	100.0	19
7888	4.7	34.5	64.9	85.1	97.3	100.0	152

For a description of how UMS marks are calculated see:
http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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