OCR
RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 7888**

Advanced Subsidiary GCE **AS 3888**

Mark Scheme for the Units

January 2009

3888/7888/MS/R/09J

Oxford Cambridge and RSA Examinations

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by Examiners. It does not indicate the details of the discussions which took place at an Examiners' meeting before marking commenced.

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.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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MARK SCHEMES FOR THE UNITS

Physics B (Advancing Physics) mark schemes - an introduction

Just as the philosophy of the *Advancing Physics* course develops the student's understanding of Physics, so the philosophy of the examination rewards the candidate for showing that understanding. These mark schemes must be viewed in that light, for in practice the examiners' standardisation meeting is of at least equal importance.

The following points need to be borne in mind when reading the published mark schemes:

- Alternative approaches to a question are rewarded equally with that given in the scheme, provided that the physics is sound. As an example, when a candidate is required to "Show that..." followed by a numerical value, it is always possible to work back from the required value to the data.
- Final and intermediate calculated values in the schemes are given to assist the examiners in spotting whether candidates are proceeding correctly. Mark schemes frequently give calculated values to degrees of precision greater than those warranted by the data, to show values that one might expect to see in candidates' working.
- Where a calculation is worth two marks, one mark is generally given for the method, and the other for the evaluation of the quantity to be calculated.
- If part of a question uses a value calculated earlier, any error in the former result is not penalised further, being counted as *error carried forward*: the candidate's own previous result is taken as correct for the subsequent calculation.
- Inappropriate numbers of significant figures in a final answer are penalised by the loss of a mark, generally once per examination paper. The maximum number of significant figures deemed to be permissible is one more than that given in the data; two more significant figures would be excessive. This does not apply in questions where candidates are required to show that a given value is correct.
- Where units are not provided in the question or answer line the candidate is expected to give the units used in the answer.
- Quality of written communication will be assessed where there are opportunities to write extended prose.

For some of the longer descriptive questions three marks will be used (in scheme called the 1/2/3 style).

1 will indicate an attempt has been made
2 will indicate the description is satisfactory, but contains errors
3 will indicate the description is essentially correct

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme.
   You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

   x = incorrect response (errors may also be underlined)
   ^ = omission mark
   bod = benefit of the doubt (where professional judgement has been used)
   ecf = error carried forward (in consequential marking)
   con = contradiction (in cases where candidates contradict themselves in the same response)
   sf = error in the number of significant figures

4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each double page should be ringed at the end of the question, on the bottom right hand side. These totals should be added up to give the final total on the front of the paper.

5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

7. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

2860 Physics in Action

Section A

Question			Expected Answers	Marks	Additional guidance
1			kg m^{-3} ; N m^{-2} ; J m^{-2}	3	
2	(a)		**B**	1	
	(b)		**C**	1	
3	(a)		14.5 cycles / 10 ms ; 1450 Hz (± 150)	2	method must identify a time period for the **highest frequency** (i.e. time period less than 1ms) and substitute into 1 / T ; evaluation (**no** ecf)
	(b)		shorter line / amplitude less than ⅔ of lowest freq component;	1	
			at 1450 Hz	1	**allow** ecf on frequency from (a)
4	(a)		wavefronts converge to shorter focal length ; fewer waves of similar wavelength to original lens, by eye	2	**accept** 3/4/5 wavefronts no credit for focal length from ray diagrams
	(b)		more powerful since more refraction / convergence at each surface / more curvature added to wave fronts	1	use of P=1/f must be clarified by f is smaller **not just** because focal length is smaller answer to (b) must be consistent with (a)
5	(a)		*t* = *E* / *P* / 14000 / (0.8 x 60 x 60) ; 4.9 hrs	2	method ; evaluation **allow** 4 hrs 52 mins / 4.86 hrs **SF penalty** : 5 hrs / 4.861 etc. **reject** answers in minutes or seconds for evaluation mark
	(b)		cell / LED lasts longer / (wastes) less power (as heat) / less cost to the environment /	1	**allow** any physics, green aware or good economic answer – e.g. lower running costs **allow** more efficient **allow** still functions if one fails

Question			Expected Answers	Marks	Additional guidance
6	(a)		Better resolution / more resolution / more detail	1	**allow** lower resolution / less pixellated **not** clearer, sharper or AW **not** higher or increased resolution
	(b)		greater pixel density	1	**accept** more pixels (as they have the same area) **not** bigger array / larger CCD / lens or distance arguments **ignore** refs to higher resolution
7	(a)		Polystyrene stiffer / higher Young modulus / higher (yield) strength / more brittle / less plastic OR Polythene less stiff /lower Young modulus / lower yield strength / tougher / less brittle / more plastic	1	must be comparison of a mechanical property **accept** stronger **not** references to flexibility / elasticity must be comparison of a mechanical property **accept** lower strength **not** weaker **not** references to flexibility / elasticity
	(b)		(lower freedom of bond rotation) means that same force gives smaller change in length / side rings interlock giving greater force between molecules OR (In tension) side chains interlock, preventing molecules sliding past one another	1	must go **beyond** detail in root of question (i.e. bond rotation) expect a quality answer - accept any convincing suggestion consistent with (a)
			Total section A :	**19**	

Section B

Question			Expected Answers	Marks	Additional Guidance
8	**(a)**		**D ; A ; P**	3	
	(b)		gradient of linear region / ≈ 180 MPa / 0.0008 (2.25 ± 0.25) x 10^{11} Pa	1 1	method for estimate must be clear from words / numbers evaluation, no ecf using values beyond elastic region scores zero
	(c)	**(i)**	Straight line from C to strain value of 0.05%, by eye	1	
		(ii)	0.0005 / 0.05%	1	**allow** ecf on the x intercept judgement of value by eye
	(d)		stronger / stiffer / less plastic impurities lock motion of dislocations / planes of atoms	1 1	**ignore** non-mechanical properties; penalise CON any reference to tougher scores zero must be comparative **not** composite properties sensible AW
			Total Question 8	**9**	

Section B

Question			Expected Answers	Marks	Additional Guidance
9	(a)		800 x 600 x 24 x 15 = 173 M (bit s^{-1})	1	
	(b)		172.8 x 10^6 x 40 = 6.9 x 10^9 Hz / 6.9 GHz	1	**accept** 7 GHz **allow** ecf from (a) on values >= 150Mbit s^{-1}
	(c)	(i)	20 x 10^3 x 12 = 0.24 Mbit s^{-1} 0.24 Mbit s^{-1} << 173 Mbit s^{-1}	1 1	comparison with 173 Mbit s^{-1} must be clear; needs idea of "*much* smaller than" **not** just 0.24 Mbit s^{-1} is negligible **do not allow** ecf
		(ii)	10 kHz ; at least one sample is needed on each wave peak and one on each wave trough or variation is missed	2	**not** just ½ sampling *f* AW, **allow** clear annotated diagrams
	(d)	(i)	(1 / -0.25) = (-) 4.0 (D)	1	
		(ii)	1/ *v* = (-4.0 + 250) = 246 D *v* = 1 / 246 = 4.07 x 10^{-3} m (principal F at 1/250 = 4.0 x 10^{-3} m) ∴0.07mm	1 1 1	method mark awarded for 246D evaluation, **allow** ecf from 254D (gives 3.94 x 10^{-3} m) evaluation, **allow** ecf from *v* for sensible values of distance given context.
			Total Question 9:	**10**	

Section B

Question			Expected Answers	Marks	Additional Guidance
10	(a)		ray passes straight through the drop	1	**accept** with a back reflected ray must be continuous and reach back of drop
	(b)	(i)	sin r = sin i / n / sin 45° / 1.33 = 0.53(2) r = $\sin^{-1}(0.532)$ = 32.(1)°	1 1 1	method part evaluation full evaluation **allow** 3 marks for correct answer
		(ii)	ray on diagram at 32 ± 2°	1	**allow** ecf from b(i) for 0 < angles < 45°
		(iii)	radii make isosceles triangle / two equal sides and two equal angles	1	requires geometrical argument
	(c)	(i)	sin C = 1 / n / C = $\sin^{-1}(1 / n)$ = 49°	1 1	recall formula in any form evaluation **accept** 48.8°
		(ii)	(Some) light refracts at 45° AW some reflects internally AW	1 1	**accept** good quality diagram **not** idea of total internal reflection
		(iii)	water's index n varies with colour / f / λ	1	**accept** idea that different λ travel at different speeds in water so refracted at different angles
			Total Question 10:	**11**	

Section B

Question			Expected Answers	Marks	Additional Guidance
11	(a)	(i)	($R = V / I = 12 / 2$) = 6.0 (Ω)	1	evaluation
		(ii)	(6 Ω / 300 Ω m^{-1}) = 0.02 m	1	evaluation **allow** ecf on value of *R* from (i) appropriate unit must be recorded for the mark **accept** 2 cm
		(iii)	(slightly) shorter larger diameter / radius / x-sectional area	1 1	**not** less resistance **not** larger surface area
	(b)	(i)	resistance rises (as current increases) (at greater currents the) temperature of filament rises / gradient of chord through origin increases / *V / I* ratio increases	1 1	statement explanation **not** gradient increases
		(ii)	(each lamp runs at 6.0 V) current is 1.5 A (total power = 1.5 x 6.0 x 2) = 18 (W)	1 1	reasoning / value quoted from graph evaluation **allow** ecf from incorrect current in range 1.45 to 1.55 Amps
		(iii)	slightly below / to right of graph line for **A** **and** passing through (2.1,12)	1	**accept** if sketch graph does not reach origin but aims at it
		(iv)	**A** has a greater resistance at a given current therefore **A** has greater p.d. across it because *V* ratio = *R* ratio AW	1 1	**no credit** for bare answer **A** has greater p.d. ecf from b(iii) if line for C drawn above A **accept** both lamps have same current ; (the graph shows that) for a given current **A** has higher pd
			Total Question 11:	**11**	
			Total Section B:	**41**	

Section C

Question			Expected Answers	Marks	Additional Guidance
12	(a)	(i)	e.g. strain	1	**accept** any physical variable **not** light – needs intensity etc
		(ii)	circuit diagram mark 1/2/3 style e.g. strain gauge in series with fixed resistor of about equal value connected with cell across both as a potential divider with voltmeter across one of the resistors	3	penalise each incorrect symbol and circuit fault or omission **accept** use of bridge circuit with amplifier circuits with gross errors (i.e. non-functioning) score zero circuits measuring R or I maximum 2 marks
		(iii)	circuit explanation mark 1/2/3 style e.g. when strain gauge stretches its resistance increases, slightly longer and thinner wires. It therefore takes an increasing proportion of the p.d. of the potential divider	3	**do not** award 3rd mark if the sense of the change in sensor resistance with respect to change in the physical variable is incorrect
	(b)	(i)	calibration explanation e.g. change and measure physical variable – strain measure electrical output p.d. plot graph *V* vs strain good graphical illustration of calibration graph	 1 1 1 1	 **accept** create a look up table must have axes labelled correctly, with line of best fit identified from plotted points
		(ii)	uncertainty explanation e.g. repeat readings to estimate spread in *V* values use sensitivity / gradient of calibration graph v to find corresponding change in physical variable – strain	 1 1 1	 give some credit for discussions of resolution of instruments **accept** evidence from a clear sketch graph **accept** evidence from a clear sketch graph
			Total Question 12:	**14**	

Section C

Question			Expected Answers	Marks	Additional Guidance
13	**(a)**	**(i)**	e.g. steel for suspension bridge cables	1	requires material and clear application for the mark
		(ii)	properties must be appropriate to example e.g. (yield) strength ; large stress or F / A to break ; Pa / Nm^{-2} stiff ; high stress / strain ; Pa / Nm^{-2} tough ; large energy to break create new surface ; J m^{-2}	 3 3	one mark each for property named ; defined ; units must be intrinsic material property **accept** low strain ; extension / length ; no units (ratio of lengths)
		(iii)	e.g. if not strong enough cables could break / the structure fail ; and vehicles and occupants on the bridge put in danger	1 1	one mark max if property considered is not clear must be appropriate to example for any credit look for outcome (first mark) and consequence (second mark)
	(b)		mark 1/2/3 style for the structural diagram and annotation / explanation taken together e.g. iron atoms held by strong non-directional metallic bonds ; supplied by free electrons ; the carbon impurity atoms in steel lock up dislocation motion making slip less likely and material stronger	3	**accept** discussions of polycrystallinity and locking of dislocation motion at grain boundaries for full credit Property does not need to be named, but must be implicit and consistent with a(ii) otherwise MAX 2 3rd mark for good quality somewhere MAX 2 marks for structure and MAX 2 marks for explanation (**TOTAL** 3)
			Total Question 13:	**12**	
			Quality of Written Communication	**4**	See notes on final page
			Total Section C:	**30**	

QoWC Marking quality of written communication assess section C only

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

4 max 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.

OR the candidate has written nothing in section C of the paper.

2861 Understanding Processes

Question	Expected Answers	Marks	Additional guidance
1 (a)	300 ✓	1	
(b)	3 ✓	1	
(c)	0.0003 ✓	1	
2	$v = \sqrt{}(2x9.8x28)$ ✓m,s = 23.4 (23) ✓e (m s^{-1}) **SF penalty** max 3 assumptions … neglecting (air) resistance / u=0 vertically / centre of mass falls 28 m /constant acceleration or other sensible suggestions ✓	3	Use of a correct equation + substitution of correct values for first mark
3	For drawing or otherwise **showing *correct*** resultant vector ✓ eg arrow $v = \sqrt{}[(3)^2 + (5)^2]$ ✓ (= 5.83) (m s^{-1}) $\theta = \tan^{-1}(5/3)$ ✓ (= 59°)	3	may get numerical answers by scale drawing and protractor
4(a)	For correctly recognising and using $E = hc/\lambda$ or from $E = hf$ / ✓m	1	
(b)	for correct use of multiplier 10^{-9} in substitution ✓ for working out the value 3.42×10^{-22} (J) ✓	2	Ignore minus sign
5(a)	11 million (N) ✓	1	
(b)	Correct use of F=ma and m=W/g ✓m 6.7 ✓ (m s^{-2})	2	Accept 6.88 from rounding
6(a)	B	1	
(b)	speed of light different ✓ (in water and air) attempt to explain **longer path** in air and **shorter path** in water (gives shorter trip time) ✓	2	
7(a)	180° or π (radians) ✓	1	
(b)	Sine wave in phase with A ✓ amplitude as B ✓	2	
	Section A TOTAL	**21**	

Question	Expected Answers	Marks	Additional guidance
8(a)	(12 / 65) = 0.18 ✓$_e$ (kg m^{-1})	1	calc value 0.1846 (kg m^{-1})
(b)	(30 x 9.8) = 294 ✓ (N)	1	calc value 294 (N) Only accept 30x10 if use of g=10 justified
(c)	Idea of progressive wave/ at the correct **frequency**/ wave reflects/ superposition or interference occurs/ correct explanation of nodes or antinodes	3	any three marking points
(d)(i)	Single N and A correctly shown ✓	1	
(ii)	λ increasing ✓ v=f x λ and f constant/ speed α λ✓	2	
(iii)	tension greater at top ✓ and μ less at the top ✓ or (tension greater at top ✓ and v α $\sqrt{T}$ ✓) or (T greater at top *because* supporting weight of rocks **and** weight of rope) **total**	2 10	could be separate points or one point developed
9(a)	Accept three from four marking points waves are 'in antiphase/ so destructive interference or cancelling/ waves in phase/ so constructive interference or bigger resultant	3	accept ''out of phase' accept arguments re path difference
(b)(i)	0.00132 (1.32 x 10^{-3})(m) ✓$_e$	1	
(ii)	λ = xd/L ✓m = 0.00132 x 0.0004 / 0.9 ✓s = 5.86 x 10^{-7} ✓$_e$ (m) (……. which is 590 nm)	3	or θ = tan^{-1} 0.00132/0.9 then using d sinθ = λ for correct evaluation
(c)	fringes vanish / light spreads out over similar region/ description of single slit pattern ✓ no interference from two slits / diffraction spreads light/ correct explanation of single slit pattern ✓ **total**	2 9	

Question	Expected Answers	Marks	Additional guidance
10 (a)(i)	'air (resistance)' / molecules of air 'bouncing off' the cyclist ✓	1	Do not accept any reference to the 'road'
(ii)	(9.5 x 750) = 7125✓ (W)	1	
(iii)	F is greater than D ✓ the motorcycle decelerates ✓	2	
(b)	W/t = Fs/t W/t = P and s/t = v ✓ OAW	1	
(c)(i)	D=F (stated or implied) ✓ Correct argument, clearly stated ✓	2	ora
(ii)	**8** times ✓	1	
(iii)	comparing product 'kA' ✓ **justifying** less power/drag (requires less fuel) ✓ **total**	2 **10**	Values of kA = 0.392 and = 0.33
11 (a)(i)	E = $6.6 \times 10^{-34} \times 3.0 \times 10^{8} / 5.0 \times 10^{-7}$ ✓m = 3.96×10^{-19} (J) ✓e	2	f = 6.0×10^{14}
(ii)	0.1 / 3.96×10^{-19} ✓m = 2.525×10^{17} ✓e (photons s^{-1})	2	4.0×10^{-19} gives 2.5 exactly
(iii)	(electrons s^{-1}=) $(1.2 \times 10^{-3}) / (1.6 \times 10^{-19})$ = 7.5×10^{15} ✓m fraction = 7.5×10^{15} / 2.5×10^{17} ✓m = 0.03 ✓e (= 3%)	3	Using current ratio gives 1.2/40mA
(iv)	1 mark for plausible suggested reason ✓m explained ✓m	2	e.g. photons reflect off surface, so few reach electrons; electrons released deep inside metal, don't reach surface etc
(b)	photon energy too small only single photons can be absorbed more power only means more photons per second ……. ✓✓ for 2 sensible relevant points **total**	2 **11**	Allow correct arguments using frequency

Question	Expected Answers	Marks	Additional guidance
12 (a)	clear statement of measurement ✓	1	
(b)	Sensible reason for wanting to make this measurement	1	penalise trivial reason
(c)	diagram labelled - could be set up ✓✓✓ some errors or omissions ✓✓ some plausible attempt made ✓	3	good labelling required for 3 marks
(d)	pulse sent out ✓ reflected and received ✓ time delay measured/recorded ✓	3	what would need to be done in this case depends on example selected
(e)	s = vt ✓ stating specifically what v represents here ✓ time delay halved ✓	3	
(f)	for 2 relevant sources of error ✓✓	2	or 1 factor and the consequence
	total	**13**	
13 (a)	for a complete set of measurements required, not inconsistent with (b)(ii). ✓✓	2	F = ma approach scores zero in sections a) and b)
(b)(i)	apparatus to measure quantity 1✓ apparatus to measure quantity 2✓ one of the measurements must relate to relevant region✓	3	
(ii)	use of correct equation✓ rearranged with 'a' as subject✓ correct identification of conditions (eg v = 0) ✓	3	
(c)(i)	Credit two factors (reaction time/ parallax/etc as appropriate to method) which would affect the accuracy of the **method**	2	not friction air resistance etc, unless using F = ma or mgh = KE
(ii)	Sensible precautions to be taken to reduce uncertainty or error, or improvement in technique or instrumentation✓ explained ✓	2	
	total	**12**	
	✓✓✓✓	4	
QoWC	**Section C total**	**29**	

QoWC Marking quality of written communication assess section C only

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

4 max 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.

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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.

OR the candidate has written nothing in section C of the paper

2863/01 Rise and Fall of the Clockwork Universe

Question	Expected Answers	Marks	Additional guidance
1 (a) **(b)**	A ✓ C ✓	1 1	
2 (a) **(b)**	Point of crossing time axis✓ Any point of maximum displacement✓	1 1	
3 (a) **(b)** **(c)**	12 s ✓ I = 4.5/5600 ✓= 0.8 mA 0.8 x 0.37 ✓.= 0.3 mA✓.	1 1 2	 Substitution or own value Accept 0.29 mA Valid method ✓
4 (a) **(b)**	Goes up by factor of four/quadruples ✓ Collisions✓ leading to interchange of energy✓	1 2	 Accept momentum change Maxwell-Boltzmann distribution stated worth one mark
5 (a)	$F = (-)GMm/r^2$ ✓ $= 6.7 \times 10^{-11} \times 6.0 \times 10^{24}$ kg x600 / $(4.2 \times 10^7)^2$ ✓ = 140 N ✓	3	Subject of equation must be correct (e.g. not g)
6	0.024(-8 - 25) ✓ = -0.79 kg m s^{-1}✓	2	One mark maximum if minus sign missing.
7 (a) **(b)**	53.0 x 0.5 x 3 x 10^8 = 8 x 10^9 m s^{-1} ✓ e.g. change in c through atmosphere, movement of asteroid, timing systems, weak signals	1 1	 Accept any reasonable responses
8	$T = pV/nR$ or $T = 1.5 \times 10^3 \times 2.4 \times 10^{-2}/4.5 \times 8.3$ ✓ = 170 K✓	2	Do not accept N for number of moles

Section A total:20

Question	Expected Answers	Marks	Additional guidance
9 (a)	$g.\ r^2$ = -constant✓ (Can be implicit) on two pairs of points✓	2	Allow 'g quarters if r doubles' owtte as suggested test
(b) (i)	$g = (-)\ GM/R^2$ leading to equation given ✓	1	Beware fudge
(ii)	density = (-) 3 $g/(4\ G\ \pi\ R)$ ✓ = 3 x 0.6/(4 x6.7 x 10^{-11}x π x1.2 x 10^6) ✓ = 1.8 x 10^3 kg m^{-3} ✓ OR: M = gr^2/G; correct substitution✓ evaluation✓	3 2	Second method will give answers in range 1.2 10^{22} to 1.3 x 10^{22} Allow ecf
(iii)	mass = 4/3 xπ x (1.2 x 10^6)^3 x 1.8 x 10^3 ✓ = 1.3 x 10^{22} ✓kg		
(c) (i)	V_g = - 6.7 x 10^{-11} x 2 x 10^{30} /7.4 x 10^{12} ✓= -1.8(1) x 10^7 Jkg^{-1}	1	Minus sign mandatory
(ii)	Two marks from : Total energy constant ✓ Calculate k.e. at aphelion✓ k.e. increases as p.e. decreases/becomes more negative. ✓ equate Δ k.e. with Δ p.e. ✓ Second two marks: Calculate k.e. at perihelion = k.e. at aphelion + Δ k.e./ (-)Δ p.e ✓ Calculate speed as (2(k.e. /mass of Pluto))$^{1/2}$✓	4	Look for other points of detail Don't expect peri-ap- helion.

Question	Expected Answers	Marks	Additional guidance
10 (a)	$\lambda = 0.16/4 \times 10^{10}$ ✓ $= 4 \times 10^{-12}\ s^{-1}$ ✓ or reverse argument	2	2 sf OK .
(i)		2	ecf look for own value
(ii)	Half life = $0.693/(4 \times 10^{-12} \times 3.2 \times 10^{7})$ ✓ = 5400 years✓		
b(i)	Correct y intercept ✓ correct curve through two points✓	2	Eg 5500,20 x 10^{10} and 11, 10 x 10^{10}
		2	Ecf on line
(ii)	Value read from 2.2 x 10^{10} to nearest half square ✓	1	Allow calculation
	uncertainty 250 to 500 years ✓	1	5400 years give 9.3. Ecf from aii.
(c)(i)	50,000/5,500 = 9 half lives ✓		
(ii)	$0.16/2^{9} = 3.1 \times 10^{-4}$ ✓	1	9.1 half lives gives 2.9 x 10^{-4}
(iii)	low level of decay ✓ /too difficult to measure/discriminate against background/too little carbon-14		9.3 gives 2.5 x 10^{-4} Alternative methods acceptable. Ecf from ci.
(d)	modern organic matter has greater proportion of carbon-14/higher activity ✓	3	
	this will decrease the measured age✓		
	older samples will be more affected (as a contemporary sample will not be affected at all !) ✓		
11(a)	Force = weight = mg = 5300 x 9.8 ✓= 52 x 10^{3} N	1 1	(own answer: 5190 N)
(b)	Force = rate of change of momentum ✓	1 1	Equation acceptable
(c)(i)	Vol of air per sec = $\pi r^2 v$, mass = vol x density ✓	2 1	
	Force = $\Delta mv/\Delta t = \pi r^2 v\ \rho.v$✓ = $\pi r^2 v^2\ \rho$	2	
	$v^2 = (52 \times 10^3/\pi \times 9.9^2 \times 1.2)$ ✓ -> v = 11.9 m s^{-1} ✓	2	Or by direct calculation, M✓ E✓
(ii)	$v = (F/\pi r^2\ \rho)^{1/2}$ r constant ✓		
(iii)			
d(i)	$v^2 = 11.9^2 \times 1.2/0.9 = 189\ m^2 s^{-2}$ ✓ v = 13.7 m s^{-1}✓		
(ii)			
(iii)	As height increases density decreases/ Lower density requires greater blade speed✓		
	Low density leads inefficient engine/Speed of blades has an upper limit. ✓		

Question	Expected Answers	Marks	Additional guidance
12 (a)(i)	E ~ kT = 1.4 x 10^{-23} x 295 ✓ = 4.1 x 10^{-21} J	1	3/2kT gives 6.15 x 10^{-21} J
(ii)	$e^{-(2 \times 10^{-19}/4 \times 10^{-21})}$ ✓ =1.9 x 10^{-22}	1	Many different values acceptable
		1	
(b)	1 x 10^{-7}/1.6 x 10^{-19} ✓= 6.3 x 10^{11}	2	
(c)	electrons s^{-1}	3	
(d)	Two ratios✓ consistent, justified conclusion ✓ probability (chance) of escape /the proportion with sufficient energy doubles✓ therefore doubling the rate of escape ✓link between charge/electrons and current. ✓		

QWC on 9 c(ii), 10 (d) 12 (d)

QoWC Marking quality of written communication

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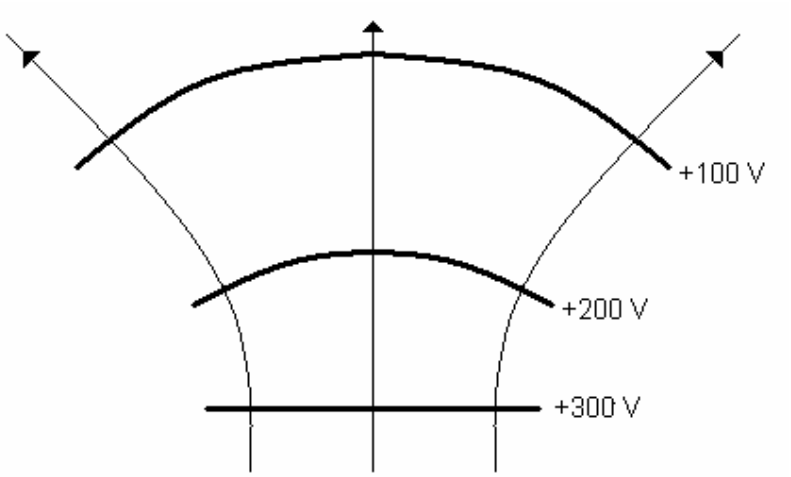
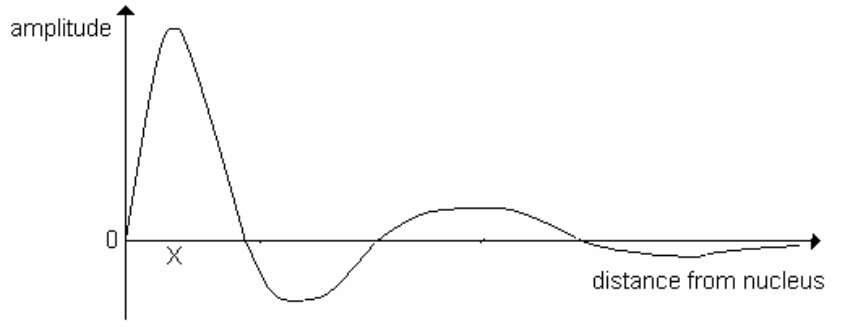
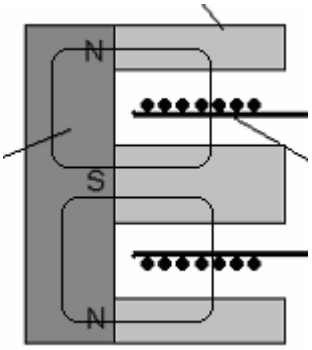
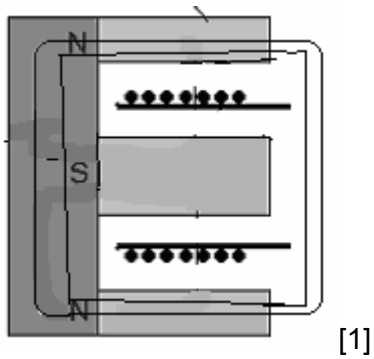
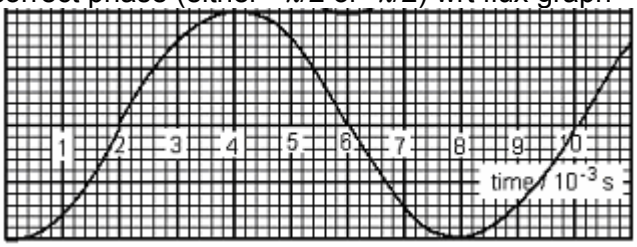
2864/01 Field and particle Pictures

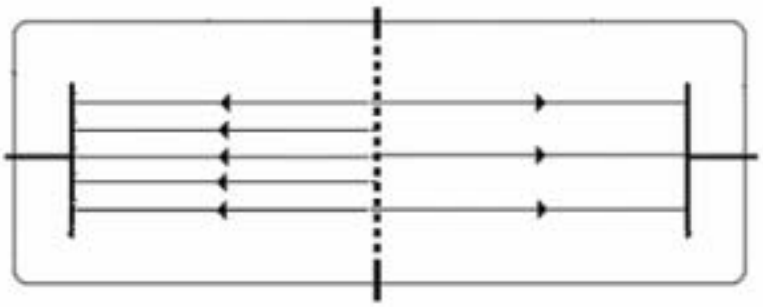
Question	Expected Answer	Marks
1 (a)	Wb m^{-2}	1
1 (b)	J C^{-1}	1
2	$q = 2e$, $Q = 84e$ $E_p = kqQ/r$ $E_p = 9.0\times10^9 \times 2 \times 84\ (1.6\times10^{-19})^2 / 7.3\times10^{-15} = 5.3\times10^{-12}$ J ecf: $q = 4e$, $Q = 210e$ gives 2.65×10^{-11} J for [2] ecf: $q = Q = e$ gives 3.16×10^{-14} J for [2]	1 1 1
3 (a)	correct shape, at right angles to field lines (by eye)	1
3 (b)	correct sequence of voltage spacing increases as field lines diverge e.g.  	1 1
4 (a)	$\lambda T_{1/2} = 0.69$ $\lambda = 0.69 / 1200 = 5.8\times10^{-4}$ s^{-1}	0 1
4 (b)	B	1

Question	Expected Answer	Marks
5 (a)	to conserve charge / baryon number ACCEPT conserve nucleon / hadron number	1
5 (b)	correct conversion to or from eV: e.g. 26 GeV = 4.2×10^{-9} J correct use of $E = mc^2$ e.g. $m = 4.2\times10^{-9} / 9\times10^{16} = 4.7\times10^{-26}$ kg or $E_{proton} = 1.53\times10^{-10}$ J pairs = $4.7\times10^{-26} / 2 \times 1.7\times10^{-27} = 13.7$ 13 pairs (NOT 14 or 13.7) all marks independent, so 8.50×10^{19} pairs for [2]	1 0 1 1
6	(F) D E B A C daft examiners benefit any claim ACCEPT one mistake for [1]	2
7	density linkage	1 1
8 (a)	at peak e.g.  ACCEPT X on the peak itself.	1 1
8 (b)	wavelength increases as you go away from centre (wtte)	

Question	Expected Answer	Marks
9 (a) (i)	two non-intersecting loops through N and S one loop in each edge pole-piece IGNORE arrows  [2]  [1]	1 1
9 (a) (ii)	iron high permeability / high permeance / good conductor of field or flux (not magnetism) / easily magnetised / low reluctance	1 1
9 (b)	any of the following, maximum [3] • stronger magnet • smaller gap between pole pieces • increased diameter / lower resistance of wire in coil (owtte) • longer wire of coil • higher permeance of pole pieces (owtte) • more turns of wire on coil • increase all dimensions (i.e. bigger magnet and coil) NOT fatter / thicker / bigger magnets	3
9 (c) (i)	attempt to measure gradient correct gradient leading to emf = $6.5\times10^{-3} \pm 1.0\times10^{-3}$ V or Wb (turns) s^{-1} ACCEPT mV, μV etc. if correct. correct answer earns all marks	1 1 1
9 (c) (ii)	correct shape and period, any constant amplitude correct phase (either $+\pi/2$ or $-\pi/2$) wrt flux graph  	1 1

Question	Expected Answer	Marks
10 (a) (i)	any of the following for [1] each, maximum [4] hazardous: • not spread over whole body, raising dose equivalent to liver • alphas are very ionising / high quality factor • short half-life means high activity difficult to detect: • alphas won't be detectable outside body • polonium can't be detected by secondary gammas • product is stable so no gammas or betas for detection NOT lead is poisonous	4
10 a ii	alpha particle correct ecf incorrect alpha particle: equation correct $^{210}_{84}Po \rightarrow {}^{4}_{2}He + {}^{206}_{82}Pb$	1 1
10 (b) (i)	use of quality factor: absorbed dose = 10 / 20 = 0. 5 Gy dose rate = 0.5 / 6.0×10^{5} = $\underline{8.3}\times10^{-7}$ Gy s^{-1}	1 1
10 (b) (ii)	dose rate = activity × energy / mass (eor) activity = $8.3\times10^{-7} \times 2.3 / 8.5\times10^{-13} = \underline{2.2}\times10^{6}$ Bq (accept 2.3×10^{6}) show that, so correct answer on its own for [0]	1 1
10 (b) (iii)	$A = \lambda N$ $N = 2.2\times10^{6} / 5.8\times10^{-8} = 3.8\times10^{13}$ mass = $3.8\times10^{13} \times 210 \times 1.7\times10^{-27} = 1.4\times10^{-11}$ kg 2×10^{6} Bq gives 3.4×10^{13} particles and 1.2×10^{-11} kg for [2] ecf missed 210: 6.5×10^{-14} kg for [1]	0 1 1
10 (c)	$^{209}_{83}Bi + {}^{1}_{0}n \rightarrow {}^{210}_{83}Bi$ (NOT N for n) ecf: $^{210}_{83}Bi \rightarrow {}^{210}_{84}Po + {}^{0}_{-1}e + {}^{0}_{0}\bar{\nu}$ (allow β for e) must have antineutrino for second mark	1 1

Question	Expected Answer	Marks
11 (a) (i)	$Bev = mv^2 / R$ $B = mv / eR$	1 1
11 (a) (ii)	use of $E = pc$: $p = 1.6\times10^{-19} \times 7.0\times10^{12} / 3.0\times10^{8} = 3.73\times10^{-15}$ N s ecf incorrect p: $B = 3.73\times10^{-15} / 1.6\times10^{-19} \times 4.3\times10^{3}$ $B = 5.4$ T Assuming 8.3 T gives $r = 2.8\times10^{3}$ m for [3]	1 1 1
11 (a) (iii)	Q is 82*e* for lead $E = BQRc$ from (i) and (ii) $E = 82 \times 7 = 574$ TeV	1 1 1
11 (b) (i)	EITHER centripetal force must increase with energy / momentum / mass (not speed) to keep same path OR $B = E / eRc$ so increasing E means increasing B B ends up at $(7.0\times10^{12} / 450\times10^{9}) \times 0.5 = 7.8$ T (reverse calculation gives 0.53 T)	1 1
11 (b) (ii)	time taken for one transit of the ring = $2\pi R/c = 9.0\times10^{-5}$ s $Q = ne = It$ ecf incorrect t: $n = It/e = 0.56 \times 9.0\times10^{-5} / 1.6\times10^{-19} = 3.2\times10^{14}$ (t not just 1 s)	1 1

Question	Expected Answer	Marks
12 (a) (i)	three parallel evenly spaced lines (by eye) arrows to right 	1 1
12 (a) (ii)	ecf: half the spacing of lines on rhs (at least two lines) ecf: arrows in opposite direction	1 1
12 (b) (i)	any of the following, maximum [4] The electrons: • gain KE as they move from cathode to grid. • lose KE as they move from grid to collector. • need > 3 eV at the grid to reach the collector • collide elastically (owtte) with atoms for < 5 eV • lose all energy in a collision if at 5 eV • retains some energy after collision if > 5 eV The atoms: • cannot gain energy from electrons below 5 eV • move up an energy level when hit by 5 eV electrons The current: • shows the rate at which electrons reach the anode • drops sharply when electrons lose energy to atoms	4

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2865 Advances in Physics

Question	Expected Answers	Marks	Additional guidance
1 (a)	Atom is nearly all empty ✓ Contains something massive ✓ Massive thing is (electrically) charged ✓	2	Any two points
(b)	proton is 1/1 ✓ A and Z both add correctly✓	2	
(c)	Au nucleus has (substantially) greater charge then N✓ More repulsion/greater potential hill in Au than N✓	2	Allow other reasonable suggestion, e.g. greater stability of gold nucleus
	Total:	**6**	
2 (a)	(i) 200 000 / 200 k(eV) ✓ (ii) 200 000 x 1.6 × 10^{-19} = 3.2 × 10^{-14} J ✓	1 1	
(b)	Δm = 8.003 108 – 2 × 4.001 508 = 9.2 × 10^{-5} u = 9.2 × 10^{-5} × 1.7 × 10^{-27} kg = 1.6 × 10^{-31} kg ✓m✓e $E = mc^2$ = 1.6 × 10^{-31} × 9 × 10^{16} = 1.4 × 10^{-14} J ✓	3	Allow calculation of rest energy of Be (1.22448 × 10^{-9} J) ✓ and of 2 × He (1.22446 × 10^{-9} J) ✓ and subtraction✓. Last mark requires that previous data is not rounded to <6 s.f.)
	Total:	**5**	
3 (a)	(i) (field) lines closer together owtte ✓ (ii) -1000 ✓ V ✓ (iii) perpendicular to field lines (by eye)✓ symmetrical ✓	1 2 2	Allow J C^{-1}
(b)	(i) tangent to field line, arrow heading NE ✓ (ii) horizontal beam in centre has no vertical force ✓ vertical component accelerates towards the centre as particles enter the gap ✓ (and away from the centre after the midpoint of the gap) horizontal component greatest for particles near centre✓	1 2	Any two points

Question	Expected Answers	Marks	Additional guidance
(c)	Suggestion ✓+ explanation ✓e.g. need voltages of GV size; cannot produce such voltages in single stages/ apparatus not able to withstand such high voltages; cannot insulate components adequately/would get dischage between electrodes; due to residual gases in linac	2	
	Total:	**10**	

Question	Expected Answers	Marks	Additional guidance
4 (a)	(i) Protons are positive so it must be (more) negative (than source) to attract them owtte ✓ (ii) If p.d. did not reverse, ring 2 would repel instead of attract / field in wrong direction owtte ✓	2	
(b)	Number of stages = $1.6 \times 10^6 / 40 \times 10^3 = 40$✓ Assumes initial particle energy (significantly) less than 40 kV/ negligible / no energy losses / not relativistic✓	2	Allow 41 electrodes to give 40 gaps
(c)	(i) P on line where gradient is greatest (by eye)✓ (ii) $T = 1/10 \times 10^6 = 0.1$ μs so x-scale unit = 0.05 μs ✓ y-axis scale unit = 40 ✓	1 2	
(d)	Velocity increase at start as accelerated to first electrode✓ velocity graph flat when protons in electron/polarity changing✓ Recognising that energy = kinetic energy E_k will be constant when velocity is constant ✓ $E_k \propto v^2$ ✓ $v\uparrow$ 2 × $\Rightarrow$ $E_k \uparrow$ 4 × with reference to values on graph ✓	3	Any 3 points. Reference to graph values should compare values at t = 0 with one of the horizontal sections.
	Total:	**10**	
5 (a)	Four lines vertical on Fig. 5.1b ✓	1	Direction (upwards) not needed; no arrowheads needed
(b)	Equating mv^2/R with evB ✓ Simplifying and eliminating a v ✓ Substituting $p = mv$ and rearranging if necessary ✓	3	

Question	Expected Answers	Marks	Additional guidance
(c)	(i) I. $B=p/eR$ = $1.7 \times 10^{-27} \times 3 \times 10^{7}$ / $1.6 \times 10^{-19} \times 100$ = 3.2×10^{-3} T ✓s✓e II. $B=p/eR$ = $220 \times 1.7 \times 10^{-27} \times 3 \times 10^{8}$ / $1.6 \times 10^{-19} \times 100$ = 7.0 T ✓ (ii) total energy = γ × rest energy = 220 × 940 MeV = 210 GeV ✓ (iii) When $\gamma \approx 1$, total energy is negligible compared with rest mass, so total energy ≈ 940 MeV ✓ Ratio or other comparison between 207 GeV and 940 MeV (= γ = 220) ✓ large amount of energy is available to create other particles✓ ref. to typical rest energies ✓ (iv) identify ✓and explain✓ difficulty, e.g. expense etc. of obtaining Ni-Ti wires, need to cool large volumes of material to very low temperatures, possible damage to workers etc. by intense fields.	2 1 1 2 2	Accept 207 GeV or 207 000 MeV if unit replaced Any two points in (iv)
	Total:	**12**	

Question	Expected Answers	Marks	Additional guidance
6 (a)	(i) Both ionising <u>electromagnetic radiation</u> (with overlapping ranges) ✓ (ii) Advantage: reduces damage to adjacent tissues ✓ Disadvantage: less damage to tumour itself. ✓	1 2	Assumes tumour is more sensitive than surrounding tissues.
(b)	(i) Are electrically charged ✓ Greater ionising effect / damage to cells etc. ✓ (ii) $Q = It = 0.1 \times 10^{-6} \times 3 = 3 \times 10^{-7}$ C ✓ No of protons = $3 \times 10^{-7}/1.6 \times 10^{-19} = 1.9 \times 10^{-12}$ protons✓ (iii) energy absorbed = $2 \times 10^{12} \times 3.2 \times 10^{-13} = 0.64$ J dose = 0.64 J/ 0.1 = 6.4 Gy ✓ dose equivalent = 6.4 × 10 = 64 Sv ✓	2 2 2	Allow reasoned argument on KE Allow use of 1.9×10^{-12}
	Total:	**9**	
7 (a)	Use of Polaroid / polarising filter ✓ Rotate in beam and observe dim-bright (every 90°)✓	2	
(b)	(i) $d = 1 \times 10^{-3}/1000 = 1 \times 10^{-6}$ m✓ $\lambda = d \sin \theta = 1 \times 10^{-6} \times \sin(35°) = 570$ nm (yellow) ✓ (ii) will be a maximum at this angle for $n\lambda$ where $n = 2$ (3, etc.) also giving λ= 290 nm (UV) ✓absorb UV with filter transparent to visible light✓	2 2	Calc of λ is enough
	Total:	**6**	
8 (a)	(i) Width between 1 & 3 cm; height between 2 & 4 cm✓ area with correct conversion to give m^2 ✓ (ii) No. = area / $(2.5 \times 10^{-5})^2 = 6 \times 10^{-4}/(2.5 \times 10^{-5})^2$ $= 9.6 \times 10^5 \approx 10^6$ ✓m✓e (iii) each pixel of print consists only of 'line' or 'groove'✓, so one bit will encode it✓	2 2 2	Can divide w & h by resolution and multiply. Must have area factor. Realising print has no grey areas ✓black and white = 2 options ✓

Question	Expected Answers	Marks	Additional guidance
(b)	(i) rays bend in at lens ✓ symmetrically✓ A to Y and B to X✓ (ii) Where rays cross ✓ (iii) 1/*v* = 1/0.03 = 33.3 D ✓ 1/*u* = 1/-0.3 = -3.3 D ✓ *P* = curvature added = 33.3 – (-3.3) = 37 D ✓ (iv) magnification = v/u = 3/30 = 0.1 so image is 1.0 mm across	3 1 3 1	Allow refract at each surface or lens centre. Can use lens equati0on and go via *f.* Allow rounding to give 36 D
	Total:	**14**	

Question	Expected Answers	Marks	Additional guidance
9 (a)	visible✓	1	
(b)	(i) $F = GMm/R^2$ ✓ $= 6.7\text{x}10^{-11}\times 2.0\text{x}10^{30}\times 950/(1.5\text{ x }10^{11})^2 = 5.7\text{N} \approx 6\text{N}$✓s✓e (ii) $F = 6.7\text{x}10^{-11}\times 6.0\text{x}10^{24}\times 950/(7\text{x}10^{10})^2 = 8\times 10^{-5}\text{N}$✓s✓e Comparison with (i) ✓	3 3	
(c)	(i) Grav. potential energy is zero at infinity ✓ work must be done to reach infinity from anywhere near a mass so all gravitational potential energies are negative✓ (ii) Makes even more negative✓ as more energy needed to escape from earth as well as from Sun✓	2 2	Can say Spitzer is bound and so must have negative overall energy✓, therefore substantial negative PE to add to positive KE✓ Allow force from Earth is much smaller ✓so work done in removal is much less ✓
(d)	(i) Helium molecules which evaporate (get lucky) are the more energetic ones ✓ remaining helium molecules have less energy on average ✓ lower energy content per molecule means lower energy/use of $E=kT$✓ (ii) Liquid helium will escape / boil off in use/ when He is all gone, telescope will warm up and not function properly. ✓	2 1	Any two points in (i)
	Total:	**14**	
Quality of Written Communication: use Q 9 if enough writTen, otherwise look over whole script. Criteria are on the following page		**4**	

QWC Marking quality of written communication

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Grade Thresholds

Advanced GCE Physics B (Advancing Physics) (3888/7888)
January 2009 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2860	Raw	90	53	47	41	36	31	0
	UMS	100	80	70	60	50	40	0
2861	Raw	90	64	58	52	46	40	0
	UMS	110	88	77	66	55	44	0
2862	Raw	120	97	85	73	62	51	0
	UMS	90	72	63	54	45	35	0
2863A	Raw	127	96	86	76	66	57	0
	UMS	100	80	70	60	50	40	0
2863B	Raw	127	96	86	76	66	57	0
	UMS	100	80	70	60	50	40	0
2864A	Raw	119	88	78	68	59	50	0
	UMS	110	88	77	66	55	44	0
2864B	Raw	119	88	78	68	59	50	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	60	54	48	43	38	0
	UMS	90	72	63	54	45	35	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	11.2	35.0	59.3	84.7	98.4	100	589
7888	11.1	37.0	69.1	91.4	100	100	83

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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