Oxford Cambridge and RSA Examinations

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ADVANCED GCE — A2 7888
ADVANCED SUBSIDIARY GCE — AS 3888

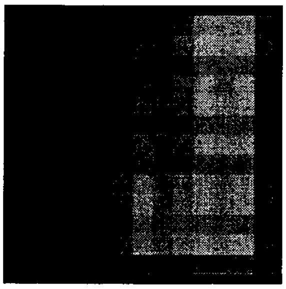
PHYSICS B (ADVANCING PHYSICS)

Second Edition (post-Tomlinson Enquiry statistics)

Published October 2002

MARK SCHEME FOR THE UNITS
JUNE 2002

AS/A2



3888/7888/MS/02

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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.

Any enquiries about publications should be addressed to:

Publications
OCR
Mill Wharf
Mill Street
BIRMINGHAM
B6 4BU

Advanced Subsidiary GCE/Advanced GCE Physics B (Advancing Physics) 3888/7888
June 2002 Assessment Session

This specification was re-graded following the Tomlinson enquiry into A Level standards. Therefore, these thresholds and statistics were revisited in October 2002. Thresholds and statistics which have changed are marked in bold.

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2860	Raw	90	69	63	57	51	46	0
	UMS	100	80	70	60	50	40	0
2861	Raw	90	64	57	50	43	36	0
	UMS	110	88	77	66	55	44	0
2862	Raw	120	97	**85**	**73**	**62**	**51**	0
	UMS	90	72	63	54	45	36	0
2863 Option A	Raw	127	97	**87**	**77**	**67**	**58**	0
	UMS	100	80	70	60	50	40	0
2863 Option B	Raw	127	97	**85**	**74**	**63**	**52**	0
	UMS	100	80	70	60	50	40	0
2864 Option A	Raw	119	90	81	**72**	**63**	**54**	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	66	**59**	**52**	**46**	**40**	0
	UMS	90	72	63	54	45	36	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. 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	**24.7**	**44.5**	**63.2**	**78.8**	**90.1**	**100.0**	**7407**
7888	**30.0**	**51.3**	**70.0**	**85.7**	**95.9**	**100.0**	**5892**

These percentages are correct at the time of going to press (October 2002).

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.
- Open questions, such as the questions in section C permit a very wide variety of approaches, and the candidate's own approach must be rewarded according to the degree to which it has been successful. Real examples of differing approaches are discussed in standardisation meetings, and specimen answers produced by candidates are used as 'case law' for examiners when marking scripts.
- 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. Missing or incorrect units in a final answer are penalised by the loss of a mark, generally once per examination paper.
- Quality of written communication will be assessed in Section C where there are more opportunities to write extended prose.

SECTION C

The outline mark schemes given here will be given more clarity by the papers seen when the examination is taken. Some of these scripts will be used as case law to establish the quality of answer required to gain the marks available.
It is not possible to write a mark scheme that anticipates every example which students have studied.

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

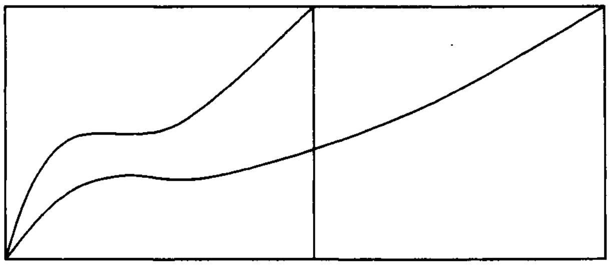
1 will indicate an attempt has been made
2 will indicate the description is satisfactory, but contains errors
3 will indicate the description is essentially correct

The following annotations may be used when marking:

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

Abbreviations, annotations and conventions used in the Mark Scheme:

/	=	alternative and acceptable answers for the same marking point
;	=	separates marking points
NOT	=	answers not worthy of credit
( )	=	words which are not essential to gain credit
___ (underlining)	=	key words which <u>must</u> be used
ecf	=	allow error carried forward in consequential marking
AW	=	alternative wording
ora	=	or reverse argument

Question	Expected Answers	Marks
	Section A	
1. a	idea of constant error (in all readings) / error on same side of true value / off by 0.5 / 0.6 A (+/- sign) AW ✓ NOT any description of random error ;	1
b	7 / 7.0 / 7.1 A ✓ NOT 5.9 / 6.0 A	1
2. a	stiff / hard / tough / low density / low friction / non porous / other relevant **mechanical** property ✓ ;	1
	NOT (durability / strength / plasticity / brittleness) correct meaning of any relevant property explained ✓ NOT cost ;	1
b	importance to hip joint explained: e.g. stiffness matched to bone OR to avoid bending of replacement / to avoid frictional wear at socket / will not break under impulsive loads AW ✓ ecf on incorrect meaning from (a)	1
3.	greater initial gradient ✓; gradient decreases then increases ✓; breaks at 30 MPa stress and 0.3 strain ✓ 	3
4. a;b	D ✓; Sm^{-1} ✓	2
5. a	M =1.2 / 0.2 = 6 ✓ ;	1
b	$M=v/u$ / $u = v/M$ / = 2.4 / 6 ✓; = 0.4(0) (m) ✓ ecf wrong M in (a)	2
6.	$v = f\lambda$ / $\lambda = c/f$ / = 300 Mm s^{-1} / 99.8 MHz ✓ ; = 3 (.01) m ✓	2
7. a;b	C ✓; A ✓	2
8.	n = sin50 ° / sin35 ° ✓ ; = 1.3(4) ✓ ; SF mark - accept 2 or 3 ✓ (rads mode yields 0.61(3)) n.b. incorrect values can still score the SF mark	3
	Total	20

	Section B	
9. a	alternatives (= 2^4) = 16 ✓ ; 16 (or ecf) > 10 so 4 bits sufficient /	1
	appropriate binary coding e.g. (0 to) 9 ✓	1
b	bits = 100 x 12 x 4 = 4800 ✓ ; bytes = bits / 8 = 600 ✓ ecf wrong bits	2
c	correct comment on number of letters e.g more letters than digits / 26 letters ✓ ;	
	better quality answer e.g. 26 letters need 5 bits /	1
	52 letters need 6 bits / 4 bits codes only 16 letters AW ✓	1
d i	5 kHz / 5000 Hz ✓	1
ii	(any two reasons beware repetition) music may contain wider frequency spectrum than speech / lower quality reproduction of speech is acceptable to human perception / music has more complex waveform / poor speaker quality / stereo needed for music / sampling rate / quantisation errors / music suffers more from: high frequency cut-off / aliasing / spurious frequencies / AW ✓✓	2
		total 9
10. a	correct symbols ✓ ; R in series with Ammeter ✓ ;	2
	Voltmeter in parallel with R / solar cell ✓ (-1 for superfluous components)	1
b i	p.d. drops (as current increases)✓ ;	1
	gradually at first then at a greater rate ✓ ; AW	1
ii	solar cell has (internal) resistance / mention of internal r / photon flux limits the output AW ✓	1
c i	correct values ✓; $P (= I\ V) = 0.05 \times 0.5$ ✓ ecf ; = 0.025 W ✓ ecf ;	3
ii	At B I is a lot less AW ✓ ; at C V is a lot less ✓ /	
	calculations of powers at B ≈ 6 (mW) , at C ≈ 6 (mW) ecf on mA AW	2
		total 11
11. a	extension ∝ force / linear through origin / F doubles as e doubles AW ✓	1
b i	½ x 90 x (4.0 x 10^{-3}) ✓ ; = 0.18 (0.36 or 180 score 1 ecf) ✓ ; J / Nm ✓	3
ii	stress = 90 / (2.5 x 10^{-7}) ✓ = 3.6 x 10^{8} (N m^{-2}) ecf ✓	2
	strain = (4.0 x 10^{-3}) / 2.0 ✓ = 2.0 x 10^{-3} ecf ✓	2
	E = (3.6 x 10^{8}) / (2.0 x 10^{-3}) = 1.8 x 10^{11} N m^{-2} ecf ✓	1
c i	straight line graph of double gradient i.e. passing (2.0, 90) ✓	1
ii	E is the same ✓ ; because E is constant for a material NOT wire /	1
	½ length means ½ extension and same strain at given stress AW ✓	1
		total 12
12. a i	equal increments along the amplitude / frequency axis represent equal multiples in value (x10) AW ✓	1
ii	logs used to accommodate the large range of values / logs represent data more clearly AW ✓	1
b i	200 Hz ✓	1
ii	reference to spreading / scattering / absorbtion / energy transfer to surroundings AW ✓	1
iii	0.1 or $^{1}/_{10}$ ✓ ; 0.01 or $^{1}/_{100}$ ✓ (if both correct raw ratios score 1)	2
iv	20 000 (Hz)✓ ; any plausible comparison e.g. - shorter waves are scattered more (by rough surfaces with variations of order of wavelength) / accept lower frequencies are more penetrating ora / molecular vibrations can absorb translational kinetic energy AW ✓	1
		1
		total 8
	section B total	40

	Section C: see also guidelines	
13. a i	type of information identified (image, sound, data, alphabetic etc.) ✓ ;	1
	relevant signal system identified (satellite, radio wave, modem, telegraph)✓	1
ii	block or schematic diagram of production ; transmission ; reception of signal 1/2/3 style ✓✓✓	3
b i	statement of how noise recognised in information – glitches in data AW ✓;	1
	more relevant detail - snow on images / crackle on sound etc. ✓	1
ii	mention of screening / blocking / filtering etc. ✓ ;	1
	more details: coax screened cable / image processing / frequency filtering✓	1
c i	two factors identified – speed of carrier / signal frequency / bandwidth / compression / internet usage loading / modem speed ✓✓ NOT resolution or sampling rate	2
ii	a sensible unit e.g. kbit per s / GHz / A4 Fax sheets per hour✓	2
	a sensible value for the estimate ✓	total 13
14. a	Imaging system selected e.g. satellite image of N. Europe ✓ ;	1
	3 pieces of information – cloud cover ; temperature ; land use etc. 1/2/3 style ✓✓✓	3
b i	Nature of waves / radiation made clear – infra-red / microwave ✓ ;	1
ii	labelled diagram and description of how image is obtained 1/2/3 style ✓✓✓ satellite scans Earth ; infra-red sensor detects energy per pixel ; A to D converts to binary data value or other sensible details	3
c i	resolution is size represented by length of pixel ✓ ;	1
	reasonable resolution estimate e.g. 100 m per pixel side ✓	1
ii	**two** factors limiting resolution e.g. wavelength of radiation / diameter of detector dish / pixel density (number) on detector / distance at which object is being imaged / bits per pixel ✓✓	2
	some detail on either factor e.g. numerical or descriptive detail ✓	1
	Quality of written communication	4
		total 17
	total section C	30

13ai	speech information analogue telephone system	text message mobile phone system	binary computer data data bus from hard disk to memory
ii	speech to electrical signal by mic. in handset ↓ signal along wire conductors electrical signal to sound by loudspeaker in the receiver	text entered on mobile keypad converted to digital code ↓ signal through air by microwave transmission signal received, decoded and displayed as text at receiver	binary data read from hard disk by read head ↓ data switched through databus to processor / memory data displayed on screen of pc
bi	crackles on speech whistling tones	incorrect characters unexpected graphics	data or graphic glitches on screen programme crashes
ii	use fibre optic link rather than copper wire optics do not pick up external electrical noise like lightning	Ensuring that no other nearby signal is using the same transmitting frequency avoids cross-talk between channels	cleaning the surface of hard disk and read head prevents dust from corrupting data as it is read from disk
ci	carrier signal speed electric signal on wires at near light speed frequency / bandwidth	carrier wave speed microwaves at light speed number of other local users loading the system	carrier signal speed electric pulses travel on databus at near light speed frequency rating of the databus / number of parallel wire in the bus
ii	10's of kbits / s OR a few words / s	100's of kbits / s OR a message / few ms	100's of Mbits / s OR 10's of pc screens / s

14a	Satellite imaging system cloud cover land use farmers sea surface temperature	Ultrasound medical scanner size / orientation of foetus heart rate of foetus in womb sex of foetus determined	Radio telescope system presence of pulsars mapping galactic radio sources SETI research
bi	infra-red / microwaves	ultrasonic waves	radio waves
ii	satellite mounted camera scans the Earth's surface by pixels radiation is reflected onto sensor that develops a voltage in proportion to the infra-red signal received A to D converter then codes signal into binary which can be relayed to Earth by radio waves	piezoelectric crystal is pulsed by high frequency oscillations ultrasound penetrates the abdomen and is reflected from layers of tissue of different densities strengths and time delays of the reflected waves returning to the piezo crystal develop voltage signals which can be displayed as a scanned image on a c.r.t.	large aperture steerable parabolic dish reflects radio waves incoming from one direction in the sky waves are focused onto a receiving circuit generating a small voltage this voltage can be amplified and recorded and turned into a false colour image of radio intensity as various angles are scanned
ci	size of smallest detectable detail in the original object represented by the length along the edge of one pixel of the image a small field is resolved / about 100m (per pixel)	size of smallest detectable detail in the original object represented by the length along the edge of one pixel of the image blood vessels resolved / about a mm (per pixel)	size of smallest detectable detail in the original object represented by the length along the edge of one pixel of the image hydrogen gas clouds in our galaxy / several light minutes (per pixel)
ii	wavelength of microwaves number / density pixels in the detector	wavelength of ultrasound response time in the crystal detector circuit	radio wavelength selected diameter of detecting dish / distance to source studied

QoWC **Marking quality of written communication**

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.

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AW	=	alternative wording
ora	=	or reverse argument
e	=	evaluation mark
m	=	method mark
s	=	substitution mark

Section A

1.	(a)	**using** $\lambda = v/f$ or 340/170 ✓ m = 2 m ✓ e	2
	(b)	(l = 2.0/4) = 0.5 m ✓ e	1
2.		appropriate drawing or Pythagoras ✓resultant = 1750 to 1850 N ✓	2
3.	(a)	**using** E = hf or $6.6 \times 10^{-34} \times 6.0 \times 10^{14}$ ✓m	
		$= 3.96 \times 10^{-19}$ J ✓e (accept 4.0 or 4 … $\times 10^{-19}$)	2
	(b)	$(1.1 \times 10^{-18})/(3.96 \times 10^{-19})$ ✓m (= 2.78) = **3** photons ✓e	2
4.		$t = x/v$ or $t^2 = x^2/v^2$ idea ✓ **used in** $y = {}^1/_2 gt^2$ ✓	2
		(or working backwards from ${}^1/_2 gx^2/v^2$ to $y = {}^1/_2 gt^2$ **using** $x = vt$)	
5.	(a)	0.15 (m) (accept $\lambda/2$ or 'half a wavelength') ✓e	
		(no marks for **phase** difference = 180°)	1
	(b)	spacing INCREASES ✓ e	
		$\sin\theta = \lambda / d$ (or $FS = \lambda D/a$) idea ✓ m	
		(or ' increased distance to travel to arrive IN/OUT of phase' ✓ m)	2
6.	(a)	$s = {}^1/_2 \times 9.8 \times (4.0)^2$ ✓ m = 78.4 m ✓e	2
	(b)	resistive/frictional forces✓ so acceleration less / time too long ✓	2
		(or takes time for sound to come back✓, so time actually less ✓ than 4s)	
7.		for relating probability to **(amplitude)^2** ✓ m ratio = 16 ✓e	2

Section A total **20**

Section B

8. (a) W = 75 x 9.8 ✓ = 735 N ✓
(accept (75 x 10) = 750 or (75 x 9.81) = 735.75) 2

(b)(i) mention air resistance/drag force ✓
air resistance/drag … increases with speed ✓
resultant/accelerating force decreases ✓ 3

(ii) the idea of balanced forces/resultant force zero ✓
(allow 'forces equal') 1

(c)(i) air resistance/drag increases ✓.......
.. idea of increased area / unbalanced force upwards✓ 2

(ii) for the idea that
'the speed at which air resistance = weight is less/different' ✓✓
(<u>or</u> 'he has slowed down to a speed when drag = weight'
<u>or</u> ' once parachute opens the forces again 'level out' reaching equilibrium but at a different speed') 2
(for just 'forces become balanced again' 1 mark)

total <u>10 marks</u>

9. (a) **A**: idea that acceleration is high initially ✓
… then decreases ✓ ('acceleration decreases' = 2 marks)
(<u>or</u> speed increases rapidly then more slowly ✓✓) 2

B: idea that acceleration goes from low – high – low ✓✓✓
(<u>or</u> speed increases slowly, then more rapidly, then more slowly = 3 marks)
(<u>or</u> acceleration increases and then decreases = 3 marks)
*** ['speed decreases' is wrong] 3

(b)(i) area under graph represents distance travelled ✓
ramps same length ✓ (accept distance travelled the same) 2
*** (do **not accept** vertical height distance or gpe the same)

(ii) 2 points to look for from:

- B has a smaller initial acceleration/ (rate of) **accn. on B is less**
- B has smaller average acceleration
- acceleration on B is less than on A (<u>accept</u> omission of 'average')
- B has lower average speed
- at all times, speed is smaller on B than on A
- B reaches higher speeds later than on A
- B travels at higher speeds for less distance
- gradient of v-t graph is 'a', and generally gradient of B graph is less than on A
- gradient of ramp B is generally less than ramp A 2

total <u>9 marks</u>

10.	(a)	in phase ✓	1
	(b)(i)	out of phase / destructive interference ✓since extra $\lambda/2$ ✓	2
	(ii)	amplitudes may not be same ✓(**no** mark for not quite out of phase) idea that may not get total cancelling/total destructive interference ✓ (or because of extra distance travelled ✓)	2
	(c)(i)	T = 1/(2000) ✓ m = 0.0005 ✓ (5×10^{-4}) s ✓e *** (no credit for attempt via $v = f\lambda$)	3
	(ii)	for **using** a $v = s/t$ idea ✓ = (**2** x 7.5 x 10^{-3})/**0.0005** ✓ (ecf from **(c)(i))** *** (no credit for attempt via $v = f\lambda$)	2

total <u>10 marks</u>

11.	(a)(i)	$4.2 \times 10^{-2} / 2.8 \times 10^{-10}$ ✓ m = 1.5×10^{8} m ✓e	2
	(ii)	$(1.5 \times 10^{8})^2$ ✓m = **2.25** x 10^{16} ✓e	2
	(b)(i)	$9.0 \times 10^{-7} / 2.25 \times 10^{16}$ ✓ m = 4×10^{-23} J ✓e (or $9.0 \times 10^{-7} / 2.3 \times 10^{16}$ ✓ = 3.9×10^{-23} ✓)	2
	(ii)	$3.2 \times 10^{-18} / 4.0 \times 10^{-23}$ ✓ m = 8.0×10^{4} s (80,000) ✓e	2
	(c)	E = $6.63 \times 10^{-34} \times 6.0 \times 10^{15}$ ✓m = 3.96×10^{-18} J ✓e	2
		for stating $3.96 \times 10^{-18} > 3.2 \times 10^{-18}$ / or comment ✓	1

total <u>11 marks</u>

Section B total **40**

Section C

12.	(a)(i)	for an example of wave **superposition** ✓	1
	(ii)	relevant historical/aesthetic/practical/physical comment ✓	1
	(b)	some indication of dimensions ✓ wavelength ✓	2
		diagram essentially correct, detailed and labelled ✓✓✓	3/2/1
		diagram essentially correct, but some omissions or errors ✓✓	
		some attempt made ✓	
	(c)	3 relevant observations ✓✓✓	3
	(d)	4 relevant comments showing understanding of physics	4

total 14 marks

13.	(a)(i)	(s and t) or (u, v and t) or (u,v and s) or (F and m) ✓✓	
		(as appropriate to method)	2
	(ii)	$s = ut + 1/2at^2$ ✓ $a = 2s/t^2$ ✓	
		or $v = u + at$ $a = (v - u)/t$	
		or $v^2 = u^2 + 2as$ $a = (v^2 - u^2)/2s$	
		or $F = ma$ $a = F/m$	2
	(b)	for clearly specifying measurements needed to be made ✓✓	
		for stating the instrument(s) to be used✓✓	4
	(c)(i)	for two different factors affecting accuracy ✓✓	
		** (**not** friction at pulley/wheels/surface)	2
	(ii)	for 2 appropriate suggestions ✓✓ (could be an improved **method**)	
		** (**not** ways of reducing friction)	2

total 12 marks

Quality of written communication 4

Section C total **30**

The following annotations may be used when marking:

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Section A

1. D ✓ (N m^{-2}) [1]

2. C ✓ (4500) [1]

3. $F = (-) GMm/r^2$ ✓ = (-) 6.67 x 10^{-11} x 2.5^2/ 1.5^2 ✓ = (-) 1.85 x 10^{-10} N (two marks if the equation or evaluation implicit. If numerical answer alone, one mark only) [2]

4. (a) $E = ½ k x^2$ = ½ x 220 x 0.03^2 ✓ = 0.099 J ✓
(can go from energy to compression) [2]

(b) reasonable assumption ✓ 0.099 = 0.08 x 9.8 x h ✓ h = 0.13 m ✓ (ecf)
Can use ½ m v^2 = 0.099 and $v^2 = u^2 + 2as$. [3]

5. (a) Q = 110 x 4200 x 30 ✓ = 1.4 x 10^7 J ✓ [2]

(b) 1.4 x 10^7 x (5/110)/ 60 ✓= 10.6 kW (10.5 kW) ✓ [2]

6. (a) amplitude (or max. gradient. NB velocity not acceptable) decreases ✓
(with time)
(b) gradient of line ✓ crossing x axis ✓ AW ('max gradient' scores 2) [3]

7 The force on 1 kg✓due to gravitational field/attraction of Earth (or another mass) AW✓ [2]

8. correct intercepts with x-axis and total energy line ✓ correct curve (lines cross in the middle square) ✓ [2]

Total [20]

Section B

9. (a) $Q = CV$ = 4700x 10^{-6} x 100 ✓ = 0.47 C ✓ [2]

(b) 0.7 = 4700 x 10^{-6} R ✓ R = 150 Ω ✓ [2]

(c) (i) E = ½ x 4700 x 10^{-6} x 72^2 ✓= 12.18 J ✓
(ii) t = 12/150 ✓ = 0.08 s✓ [4]
(iii) charging time longer than discharge time ✓ sensible reason (e.g. resistance comparision) ✓ (look for clarity) [2]

10. (a) (i) E = 1.6 x 10^{-19} x 250 ✓ = 4 x 10^{-17} J
(ii) ½ mv^2 = 4 x 10^{-17} ✓ v^2 =2 x 4 x 10^{-17}/2.2 x 10^{-25} ✓ v = 1.91 x 10^4 ✓m s^{-1} [4]

(b) (i) 2.9 x 10^{-6} x 1.9 x 10^4 ✓= 0.058 ✓ (0.055 if 1.91 used)
(ii) force = $\Delta p/\Delta t$ ✓ (or clear statement of Newton III✓)
(iii) a = 0.057/490 ✓= 1.2 x 10^{-4} m s^{-2} ✓ look for other acceptable values [5]

(c) Microscopic effect e.g.
krypton ions leave faster✓ because same energy gain for lower mass ✓
or less thrust per ion ✓as (smaller mass so) less momentum per ion✓
or other sensible.
(Macroscopic effect with sensible conclusion ✓consistent with suggested effect✓) [2]

11. (a) $V \times 2 \times 10^5 = V/3 \times$ new pressure ✓ pressure = 6.0×10^5 Pa✓ [2]

(b) PV = nRT (or NkT) = 1/3 N m c^2 ✓ r.m.s = $(3 \times 8.31 \times 300 / 4 \times 10^{-3})^{1/2}$
= 1370 m s^{-1} ✓
(or ½ mv^2 = 3/2 kT ✓ leading to 1370 m s^{-1} ✓) [2]

(c) r.m.s. = $(3\ RT/m_m)^{1/2}$
new/old = $(3\ R\ 400/m_m)^{1/2} / (3\ R\ 300/m_m)^{1/2}$✓= $(400/300)^{1/2}$✓ = $(4/3)^{1/2}$
(or by calculation or $c^2 \alpha$ T ✓ leading to correct evaluation✓) [2]

12. (a) $3 \times 10^8 \times 3.2 \times 10^7$ ✓ = 10^{16}m [1]

(b) (i) light takes 10 000 million years to reach Earth so the information received is 10 000 million years old. ✓
(ii) distance = speed x time = 10, 000 x $10^6 \times 10^{16}$ ✓ = 10^{26} m [2]

(c) (i) lengthening of wavelength
or shift (of spectral lines) to red end of spectrum ✓ AW [1]
(ii) as radiation travels through space the wavelength stretches✓ with expanding space ✓ AW quality
(Mark parts one and two together) [2]
(iii) light has been travelling for longer✓ so more time for stretching of waves/Universe has changed more ✓(one mark for Hubble-type argument) [2]

13. (a) $kT = 1.38 \times 10^{-23} \times 300$ ✓= 4.1×10^{-21} J (3/2 kT gives 6×10^{-21}) [1]

(b) $4.6 \times 10^{-26} \times 3000 \times 9.8$ ✓ = 1.35×10^{-21} J [1]

(c) E/kT = 1.35/4.1) ✓ = $e^{-0.35}$ ✓ (or implicit)= 0.72 [2]

(d) (i) Any two from:
Boltztmann factor measure of ratio of numbers of particles in states differing by E ✓
less dense because fewer particles ✓
particles have less chance of having sufficient energy to attain greater height. ✓AW
(ii) test ✓carried out ✓ conclusion ✓ (understanding of test implicit in arithmetic OK, implied conclusion OK) [5]

OR: practical test developed ✓leading to equal ratio or log discussion ✓max 2

(e) T or kT is smaller as height increases (or implicit) so E/KT is bigger ✓ so $-E/kT$ becomes more negative OR $e^{-E/kT}$ gets smaller✓ [2]

Quality of Communication **[4]**

Section B total **[50]**

Paper total **[70]**

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:

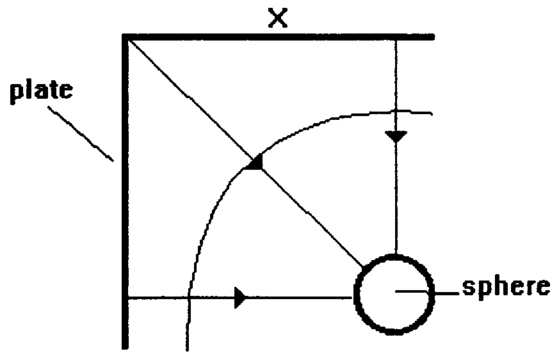
- Alternative approaches to a question are rewarded equally with that given in the scheme, provided that the physics is sound. As an example, when a candidate is required to "Show that..." followed by a numerical value, it is always possible to work back from the required value to the data.
- Open questions permit a very wide variety of approaches, and the candidate's own approach must be rewarded according to the degree to which it has been successful. Real examples of differing approaches are discussed in standardisation meetings, and specimen answers produced by candidates are used as 'case law' for examiners when marking scripts.
- Final and intermediate calculated values in the scheme 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 candidate's 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.

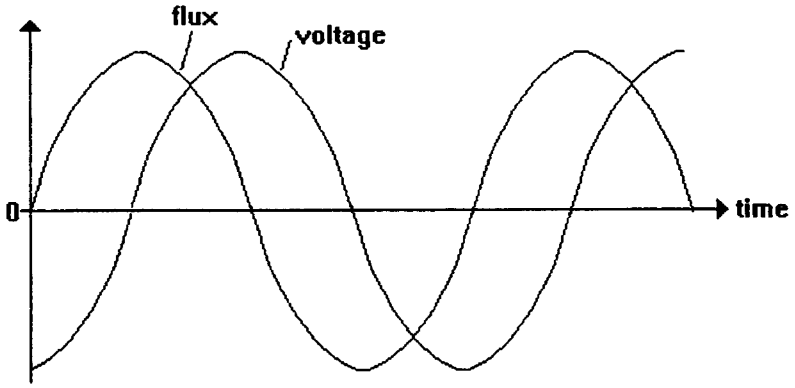
The following annotations may be used when marking:

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
up	=	omission of units with answer

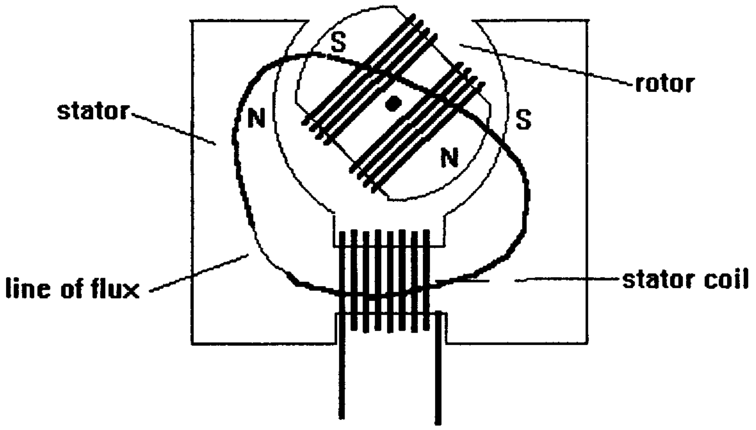
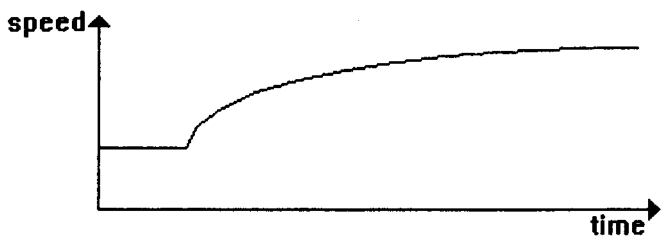
Abbreviations, annotations and conventions used in the Mark Scheme:

/	=	alternative and acceptable answers for the same marking point
;	=	separates marking points
NOT	=	answers not worthy of credit
( )	=	words which are not essential to gain credit
___ (underlining)	=	key words which <u>must</u> be used
ecf	=	allow error carried forward in consequential marking
AW	=	alternative wording
ora	=	or reverse argument
m	=	method mark
s	=	substitution mark
e	=	evaluation mark
eor	=	evidence of rule

1	 curve between sphere and plate with correct curvature line at right angles to field lines (by eye) accept dotted curves	1 1
2	A	1
3 (a) (b)	20 B	1 1
4 (a) (b)	$4.0 \times 10^{-4} / 400 = 1.0 \times 10^{-6}$ Wb (accept 10^{-6}) $\Phi = BA$ (eor) ecf (a): $B = \Phi/A = 1.0 \times 10^{-6} / 1.25 \times 10^{-5} = 8.0 \times 10^{-2}$ T ecf: $4 \times 10^{-4}/1.25 \times 10^{-5} = 32$ worth [1]	1 1 1
5	energy = mass × dose (eor) energy = 0.12 × 4.0 = 0.48 J	1 1

6	 sinusoidal shape, any amplitude, correct period (by eye) 90 degrees out of phase wrt flux (lead or lag) (by eye) minimum one complete cycle	1 1
7	decreases / hits the nucleus (wtte) argument involving conversion of kinetic energy to potential (energy) at point of closest approach accept work done against force as potential energy	1 1
8	any of following, maximum [2] • strongly ionising / high quality factor / short range • large charge / large mass • giving large (absorbed) dose / damage to local cells (wtte) accept reverse arguments for beta or gamma must be different from beta or gamma to earn mark	2
9	B	1
10	$E = kQ/r^2$ (eor) $E = 8.98\times10^{9} \times 1.92\times10^{-18} / (5.0\times10^{-11})^2 = 6.9\times10^{12}$ accept 7×10^{12}, ignore sign N C^{-1} or equivalent unit	1 1 1 **20**

11 (a)(i)	rest mass loss = 2.0141 + 2.0141 - 3.0160 - 1.0087 = (0.0035) ignore sign of final answer	1
(ii)	$m = 0.0035 \times 1.66\times10^{-27} = 5.81\times10^{-30}$ kg (eor) $E = mc^2$ ecf incorrect m: $E = 5.81\times10^{-30} \times (3.0\times10^8)^2$ $= 5.2(3)\times10^{-13}$ J 3.15×10^{14} J worth [2]	1 0 1 1
(b)(i)	${}^{1}_{1}p = {}^{1}_{0}n + {}^{0}_{1}e + {}^{0}_{0}\nu$ correct reactants and products (accept H for p and $\beta^{(+)}$ or e^+ or $\bar{e}$ for e) mass numbers correct for particles and balance charge numbers correct for particles and balance accept omission means zero	 1 1 1
(ii)	$m = 1.0073 - 1.0087 - 0.0006 = -0.00195$ ignore sign, accept 0.002	1
(iii)	Any one of the following (owtte) • mass of products greater than that of reactants • decay requires (external) input of energy	1
		9

12 (a)		
	complete loop	1
	threading both electric circuits, staying inside iron	1
	ignore direction of flux	
(b)(i)	S on left, N on right tips of rotor	1
(ii)	EITHER	
	• current in rotor coils	1
	• (interacts) with field / flux from stator	1
	OR	
	• north and south poles are attracted	
	• one pole on stator attracts opposite pole on rotor (wtte)	
	OR	
	• flux lines can be shortened	
	• by the anticlockwise rotation of rotor (wtte)	
	• to provide moment / couple / turning forces / torque	1
(c) (i)	rises exponentially as shown below	1
		
	to new steady higher speed	1
(ii)	any of the following, maximum [2]	2
	• increased flux / field (in the rotor)	
	• increases (back) emf induced in rotor	
	• reduces current in the rotor, (reducing torque on the rotor)	
	arguments based on eddy currents worth no marks	
		10

13 (a)	$I = Ne/t$ or Q/t (eor, wtte) $20\times10^{-6} / 1.6\times10^{-19} = 1.25\times10^{14}$ accept 1.3×10^{14}	1 1
(b)(i)	$E_k = mv^2/2$ (eor) change of $E_k = 3.32\times10^{-26}/2 \times (9\times10^{10} - 10000)$ $= 1.5\times10^{-15}$ J (accept 1.49×10^{-15})	1 1
(ii)	ecf incorrect E_k: $eV = 1.49\times10^{-15}$ J $V = 1.49\times10^{-15} / 1.6\times10^{-19} = 9.4\times10^3$ V accept reverse calculation	1 1
(c)(i)	Force at right angles to velocity / motion / current (wtte)	1
(ii)	$F = mv^2/r$ (eor) $F = 3.32\times10^{-26} \times (3.0\times10^5)^2 / 125\times10^{-3}$ ($= 2.39\times10^{-14}$ N)	1 1
(iii)	$F = Bqv$ (eor) $Bqv = 2.4\times10^{-14}$ $B = 2.4\times10^{-14} / (1.6\times10^{-19} \times 3.0\times10^5) = 0.50$T (accept 0.5)	1 1 1
(d)	any of the following, maximum [2] • larger mass • slower speed • magnetic force smaller • requires different radius (or curvature of path) (wtte)	2 **14**

14 (a)(i)	Any of the following, maximum [1] • The nucleons are touching each other / close packed • Accept reference to liquid drop model • Each nucleon occupies constant volume • Same distance apart from each other	1
(ii)	linking volume of sphere formula to nucleon number	1
	processing to link cube of radius to nucleon number	1
	processing to link radius to cube root of nucleon number	1
	for example: $\frac{4}{3}\pi r^3 \propto A$ $r^3 \propto A$ $r \propto A^{1/3}$ accept reverse argument for full marks	
(iii)	A = 20 (eor) diameter = 2 × radius (eor) diameter = $2 \times 1.2\times10^{-15} \times 20^{1/3}$ = (6.5×10^{-15} m)	1 1 1
(b)	any of the following, maximum [2] • electrons have a (well defined) wavelength / frequency • can take more than one path to detector • phasors can arrive at different angles (wtte) • allowing (destructive) interference / superposition of electrons / cancellation of phasors	2
(c)(i)	θ = 5 degrees $\lambda = 1.2b\sin\theta = 1.2 \times 6.5\times10^{-15} \times \sin 5 = \underline{6.8}\times10^{-16}$ m	1
(ii)	ecf incorrect λ: $p = h/\lambda = 6.63\times10^{-34} / 6.80\times10^{-16}$ m $= 9.8\times10^{-19}$ Ns accept $9(.5)\times10^{-19}$ Ns if used 7×10^{-16} m	1
(d)	nucleus presents a larger target / greater charge for the electrons to scatter off , so greater number of scattered electrons (owtte)	1
	larger diameter of target gives smaller diffraction of electrons, so minimum occurs at a smaller angle (owtte)	1 **13**
	Quality of Written Communication	4

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AW	=	alternative wording
ora	=	or reverse argument

Qn	Expected Answers	Marks	Additional guidance
1 (a)	Energy = 1.33×10^{6} eV × 1.6×10^{-19} J eV^{-1} = 2.13×10^{-13} J ≈ 2×10^{-13} J ✓✓	2	MeV to eV ✓ eV to J ✓
(b)	$E = hf \Rightarrow f = E/h$ ✓ = 2.13×10^{-13} J/6.63×10^{-34} J s = 3.2×10^{20} Hz ✓	2	ecf from (a); ue possible E=2×10^{-13} J ⇒ f=3.02×10^{20} Hz
(c)	Plausible energy level diagram ✓ Correct transitions (2 arrows downwards) ✓	2	Transitions may be to ground state or between excited states
(d)	Nuclear energy level (transitions) larger than electronic ones ✓ Higher energy photons have higher frequency. ✓	2	
(e)	Photon explores both paths from A to B ✓ Phasor sum gives probability of detection ✓	2	
2 (a)	Particle and anti-particle ✓ opposite charge ✓ same mass ✓ both leptons ✓ annihilate each other ✓ can be produced simultaneously from a gamma photon ✓ in a nucleus, neutron excess produces electron (β^-) emission while proton excess produces positron (β^+) emission ✓	2	Any two points. (but maximum one ✓if confusion with electron and proton)
(b)	Stable nucleus absorbing proton will have too many protons ✓ excess of protons associated with positron emission ✓	2	
(c)	Nucleon number 4 ✓and proton number 2 ✓ (Identified as α gets both marks; He gets proton number mark)	2	Multiple products allowed if sums correct
(d)	A day is 12 half lives ✓ 2^{12} = 4096 so activity after a day = 2000/4096 (= 0.488) ✓ comment of small value ✓ [Or $\lambda = \ln 2/T_{½}$ = 0.35 hour^{-1} (= 9.6×10^{-5}s^{-1}) ✓$C = C_0e^{-\lambda t}$ so C = 2000 exp{ −(0.35 hour^{-1} × 24 hour)} = 0.45 m✓ e✓]	3	Repeated division by 2 is OK; $8T_{½}$ will suffice. Unsuccessful attempt to use $C = C_0e^{-\lambda t}$ gets one ✓ for correct λ.
3 (a)	Pixel size is about separation of one channel/photomultiplier unit so resolution = 0.5 m / 8 = 0.0625 m ≈ 6 cm ✓	1	Allow 0.5 m/9 = 5.5 cm ≈ 6 cm
(b)	2 cm/ 'This' < 6 cm so cannot identify damaged disc. ✓	1	
(c)	Noise doesn't affect signal ✓ coincidence detectors give better precision ✓ rotating detectors increases positional accuracy ✓	2	Any two distinct relevant points; just stating 2 mm < 6 cm gets one mark
(d)	Identifying volume element as cube of side 2 mm ✓ Calculating volume = 2 × 2 × 2 = 8 mm^3 ✓ Correct conversion of mm^3 or cm^3 to common units ✓ Checking that brain volume/pixel volume = 75 000 ✓	3	Any three points; ecf allowed throughout Reverse working OK.
(e)	256 = 2^8 so 8 bits per pixel ✓8 (ecf) × 75000 = 600 000 bits ✓	2	
(f)	Differences in intensity more obvious and so more readily identified by false-colour ✓	1	

Qn	Expected Answers	Marks	Additional guidance
4 (a)	Eliminate stray photons ✓ shields (collimate), i.e. limit response to photons produced just beneath cathode ✓	2	
(b)	(i) $E = dV/dx$ / E is the gradient of the V-x graph✓ Straight line graph has constant gradient so E constant ✓	2	'Is straight' gets one ✓ Gradient mark may be in (ii)
	(ii) $E = V/d$ = 80 V/5 × 10 $^{-3}$ m Reading pair of values off graph ✓ = 16 000 V m^{-1}. ✓	2	Any 2 correct values ✓ mm to m ✓
	(iii) $F = EQ$ ✓ = 16 000 N C^{-1} × 1.6 × 10 $^{-19}$ C = 2.56 × 10 $^{-15}$ N ≈ 2.6 × 10 $^{-15}$ N✓	2	Allow ecf if wrong result in (ii) and used here.
	(iv) Calc of $a = F/m$✓{= 2.56 × 10 $^{-15}$ N/ 9.11× 10 $^{-31}$ kg = 2.8 × 10 ^{15} m s $^{-2}$} Comment✓(>> 9.81 m s $^{-2}$)	2	Including g = 9.81 m s $^{-2}$ implies comparison; can compare F with weight of electron instead e.g. m_e tiny ≈10 $^{-30}$ kg✓ So weight (10^{-29} N) <<2.6 × 10 $^{-16}$ N ✓.
5 (a)	Checking with all 3 pairs of values ✓ qualified conclusion ✓	2	Candidate needs to show awareness of different value for Pb
(b)	Any reasonable property (e.g. tough, strong, not damaged by radiation;)✓ justification in terms of road transport ✓	2	Mass or thickness not acceptable for first ✓ (half-thickness is OK)
(c)	Numbers half after each sheet ✓	1	Two emerging at end not needed
(d)	Extra thickness absorbs more photons/each sheet absorbs more photons ✓ same fraction absorbed✓ by equal thickness ✓	3	$N = N_0e^{-kx}$ gets 3 marks if variables clearly defined
(e)	120 mm = 10 half-thicknesses ✓ 1/2^{10} =1/1024 = 0.00098 < 0.1% (Or can divide 100% by 2^{10} or by 2 ten times to get 0.098%) m✓ e✓	3	Can use $N = N_0e^{-kx}$
6 (a)	Advantage ✓for each dosimeter e.g. Film Badge: distinguish different types/energies of radiation, cheap; Pen Dosimeter: instant readout, rechargeable	2	Not 'accurate' or 'sensitive'
(b)	Any reference to alphas being readily absorbed ✓	1	Full credit for (correct) rebuttal 'Paper around film absorbs alphas'
(c)	(i) Can and central rod/fibre labelled P1 and P2 respectively ✓ (ii) The air in the dosimeter ✓	2	
(d)	3^2 = 9 so dose = 160 μSv/9 = 18 μSv m✓ e✓	2	Inverse square law stated or implied gets m✓ ue possible here

Qn	Expected Answers	Marks	Additional guidance
7 (a)	(i) $E \approx kT \Rightarrow T = 8.7 \times 10^{-18}$ J/1.38 × 10^{-23} J K^{-1} = 630 000K m✓ e✓ (ii) kT at 4 K = 1.38 × 10^{-23} J K^{-1}× 4 K = 5.52× 10^{-23} J ✓ For one atom/molecule, E = 83.6 /6.02 ×10^{23} J = 1.38 × 10^{-22} J ✓ which is about 2.4 kT /<15 kT) so process happens readily ✓	5	Here or in (ii) can calculate T and compare with given value. Allow 1½kT, 15 kT, 30 kT for energy estimate. Can approach via Bolzmann factor = 0.08 >> 0
(b)	$3kT/m$ = 3 ×1.38 × 10^{-23} J K^{-1} ×310K/6.64 × 10^{-27} kg =1.93 ×10^{6} m^2 s^{-2} so $\sqrt{\overline{c^2}}$ = 1390 m s^{-1} ≈ 1400 m s^{-1} m✓ e✓	2	ora from 1400 m s^{-1} to 314 K
(c)	(i) $v^2 = 5kT/(3m)$ so $kT/m = 0.6v^2$ ✓ Equating with $kT/m = \overline{c^2}/3$ ✓ $v^2 = \overline{c^2}/(3 \times 0.6) \Rightarrow v = 0.745\sqrt{\overline{c^2}}$ ✓ Arithmetic approach acceptable: calc. of v (as (ii)) ✓ comparison with 1390 or1400 m s^{-1} ✓ ratio of ¾ ✓ (ii) 0.75 × 1390 m s^{-1} = 1040 m s^{-1} ≈ 1000 m s^{-1}✓	4	m✓ for equating kT/m or equivalent, m✓ for combining to get speeds relationship, e✓ Can credit 1040 m s^{-1} in part (i)
(d)	(i) Node-antinode distance = $\lambda/4$ so λ = 60 cm ✓ (ii) $f = v/\lambda$ ✓ = 1040 m s^{-1}/0.60 m (ecf) = 1730 Hz ✓ (iii) Sound is slower in air than helium ✓ so same wavelength produces lower frequency ✓ ora	5	Can use v = 1 km s^{-1} in (ii) sf error possible here if > 3sf 1730 Hz is high pitch gets ✓ only unless frequency justified.
8 (a)	(i) 80 × 60 × 60 = 288 000 C m✓ e✓ (ii) (10 × 80)/200 = 4 h m✓ e✓ (iii) $P = IV$ = 200 A × 24 V = 4800 W m✓ e✓ (iv) Energy dissipated by electrical heating ✓ and resistive friction✓	8	One mark only if series (48 kW) Give 2nd ✓ for good explanation of one of these mechanisms
(b)	(i) Turning coil cuts through flux lines/flux linked changes ✓ Changing flux induces emf ✓ (ii) D ✓	3	
(c)	Very massive ✓ Heavy batteries/less concentrated energy source than e.g. petrol/lots of iron in electric motor ✓low power (about 1/6 of typical 30kW saloon) ✓	2	Any reasonable point ✓ explanation ✓
	Quality of Written Communication	4	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

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