Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

ADVANCED GCE
ADVANCED SUBSIDIARY GCE

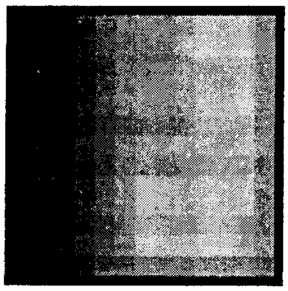
A2 7888
AS 3888

PHYSICS B (ADVANCING PHYSICS)

MARK SCHEME FOR THE UNITS

JANUARY 2004

AS/A2



3888/7888/MS/04J

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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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Advanced GCE Physics B (3888 – 7888)
January 2004 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2860	Raw	90	68	62	56	50	45	0
	UMS	100	80	70	60	50	40	0
2861	Raw	90	62	55	49	43	37	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	100	89	79	69	59	0
	UMS	100	80	70	60	50	40	0
2863 Option B	Raw	127	100	90	80	71	62	0
	UMS	100	80	70	60	50	40	0
2864 Option A	Raw	119	91	81	72	63	54	0
	UMS	110	88	77	66	55	44	0
2864 Option B	Raw	119	91	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	17.6	41.9	64.8	84.0	96.5	100	382
7888	9.4	41.5	60.4	79.2	94.3	100	54

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.
- Quality of written communication will be assessed where there are 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

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.

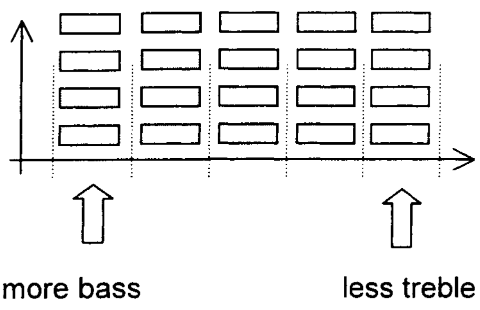
5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the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

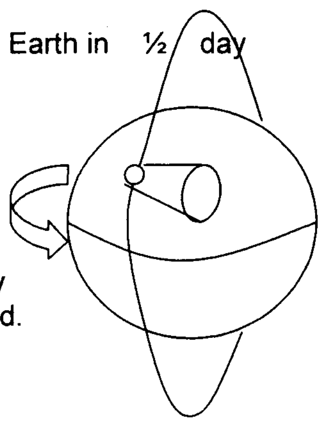
7. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

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.

Abbreviations, annotations and conventions used in the Mark Scheme		
	/	= alternative and acceptable answers for the same marking point
	;	= separates marking points
	NOT	= answers which are not worthy of credit
	( )	= words which are not essential to gain credit
	____	= (underlining) key words which **must** be used to gain credit
	ecf	= error carried forward
	AW	= alternative wording
	ora	= or reverse argument

Qn	Expected Answers	Marks	Additional guidance
	Section A		
1a;b	V ; C s^{-1}	2	
2a;	32 ;	1	
bi;	(samples/sec x bytes/sample x time) / $44.1 \times 10^3 \times 4 \times 150$ method ; = 26.4(6) Mbytes ; eval.	2	allow 25.2(3) Mbytes pc correct eval. scores 2
ii	(data) compression / fewer samples/sec / fewer bytes/sample / reduce quality / AW	1	other sensible comments NOT filtering
3 a;b;c	metal ; rubber ; glass	3	
4a;b	0.13(0) m ; 8.33 / 8.3 ;	2	
c	$\pm$ 0.3 / 0.4 D ecf on (b)	1	accept 0.33 or 0.31 or 0.32 or 0.34
5ai;ii	3 ; 8 / 2^3	2	NOT 7
		1	
bi ;	50 mV	1	accept 100 mV
ii	more (than 3) bits (per sample) / more levels / better voltage resolution AW		NOT greater sampling rate
6ai;ii	x ¼ ; x 2	2	
7		1 1	zero marks for no attempt In col. 1 accept 2/3/4 bass bars In col.5 expect 0 treble bars / OR (accept 0/1 bars in col. 4)
	Section A total	**20**	

Qn	Expected Answers	Marks	Additional guidance
	Section B		
8a	decreases / falls / drops ; 100 ($\pm$ 10) ; low(er) / 22 °C	3	"30 to 40°C" / (value in range) 20 - 30 °C
bi	connections in parallel with fixed resistor	1	
ii	$R_{Thermistor}$ = 100 to 105 (Ω) ;	1	evidence from graph
	R_{Total} = 200 + $R_{Thermistor}$ (Ω) ;	1	total resistance
	$I = (V / R_{Total}) = 6 / R_{Total}$ (= 0.02 A)	1	substitution ora
iii	($V = I R$ = 0.02 x 200) = 4.0 V	1	ecf R from b(ii) accept 4 V
ci ;	**X** ;	1	
ii	advantage (near) constant sensitivity / linear (output)	1	NOT "just" straight line allow AW or other
	disadvantage less sensitive (over most of range) / range of voltages is small / battery lasts for less time	1	sensible quality physics
9a	$\lambda = v / f$; = 1500 / 8000 ; = 0.19 m ora v = 1600 m s^{-1} is about 1500 m s^{-1} full marks	3	allow $v = f\lambda$ recall 1st mark
b	$t = s / v$ / = 5000 / 1500 ; = 3.3 s	2	2 marks correct answer
c	t = info / rate / = (1500 x 8) / 2400 ; = 5.0 s	2	words / numbers ; allow 1 mark for 0.63s
d	1/2/3 style look for: time delay, live video needs larger info rate, large amount of information, still pictures can be slowly built up, stored at receiving computer	3	AW if good physics NOT "it" is too slow expect quality reasons for the 3rd mark
10a	**brittle:** shatters (on impact) / cracks (propagate) / no plastic region ;	1	AW for all these or other correct physics
	hard: difficult to scratch / dent ;	1	
	strong: large breaking stress ;	1	NOT large yield stress
	tough: difficult to crack / large energy to break / create new surface	1	accept not brittle IF brittle correct OR v.v.
bi	x 4 / much tougher ;	1	NOT just tougher
ii	(toughness is) energy ; per (new surface) area ;	2	
ci ; ii	**B** ; tougher than **A** / less tough than **C** / stronger than **A** / less strong than **C** / about ¾ of the strength of **C**	2	one correct reason or any combination / other correct physics
11a	to reflect light back / up ; to increase illumination	2	AW
b	$P = 1/f$ OR $= 1/v - 1/u$; = 1/ 0.4 - 1/ (-0.1) ; = 2.5 + 10 = 12.5 ; D	2 2	3 marks correct value 1 mark for unit D
c	transparency ; to allow light to transmit / high refractive index ; to allow thinner lens / high melting point ; to withstand temperature / low density ; to reduce weight of lens / strong / tough / hard / stiff etc ; correct reasoning	2 2	AW allow all sensible physics answers with correct explanation NOT economics
	Total B	**40**	

Qn	Expected Answers	Marks	Additional guidance
	Section C		
12ai	student choice sets appropriate context – no marks	0	
ii	any shape of constant cross section ;	1	
iii	(good conductor) : long / thin for measurable *R / G* / (low *E*) : short / "fat" for measurable extension / constant cross-sectional area	1	
iv	Two sensible lab estimates: length ; diameter / width / thickness / area	2	
v	Micrometer / Vernier caliper / (travelling) microscope ; justification - need greater precision (accept accuracy)	1 1	allow rulers down to 10mm
bi	A practical difficulty identified e.g. very small extension in stiff material / small resistance in a good conductor	1	accept other sensible suggestions and solutions
ii	solution to difficulty – long specimen ; more relevant detail – repeat readings / averaging	1 1	
ci	For Y expect force ; extension / for σ expect p.d. ; current / Resistance	2	accept standard symbols $R = V/I$
ii	Correct words / symbols ; combined correctly e.g. $Y = Fl / Ae$ / $\sigma = Il / VA$	2	accept a complete set of equations
13a	imaging system example: e.g. satellite imaging system ; 3 obs: e.g. cloud cover ; sea temperature ; land use	1 3	expect descriptions
bi	waves / radiation : infra-red ;	1	
ii	how data obtained: e.g. low polar orbit covers whole Earth in ½ day satellite scans Earth building up infra-red images infra-red energy detected by photodiode which gives a p.d. in proportion to pixel value on image 	3	1/2/3 style full marks for well annotated diagram
ci	resolution is length represented on object / pixel ; NOT the number of pixels	1	AW e.g. smallest resolvable detail
ii	5 km on Earth / pixel ; UP	1	allow ± 1 order of mag.
d	false colour could be added to image, infra-red has no colour, but pixel value ranges can be given colour to represent intensity. This makes images easier to interpret.	3	1/2/3 style give credit for connecting physics
Q of WC		4	
	Total C	**30**	

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.

Qn	Expected Answers	Marks	Additional guidance
1 (a)	600 ✓	1	
(b)	60 ✓	1	
(c)	0.6 ✓	1	
2(a)	g.p.e. to k.e. ✓	1	
(b)(i)	$v^2 = 2 \times 9.8 \times 2.8$ ✓ v = 7.4 (m s^{-1}) ✓ (g = 10 gives 7.48)	2	By energy change or by suvat
(ii)	neglecting/negligible/no air resistance ✓ (**all** gpe goes to ke) (constant 'a' **if** suvat approach)	1	**not** wind resistance
3(a)	representation of 3 fringes minimum ✓ equispaced peaks ✓ (4 needed)	2	intensity variation is fine
(b)	fringes further apart ✓	1	
4 (a)	$f = (3 \times 10^8) / 1500$ ✓$_m$ $= 2.0 \times 10^5$ (Hz) ✓$_e$	2	
(b)	method mark $(2.4 \times 10^{17}) / (2.0 \times 10^5)$ ✓$_m$ $= 1.2 \times 10^{12}$ ✓$_e$ ecf from (a)	2	not 1.2E12 /1.2^{12}
5(a)	horizontal = 300 cos 50° = 192.8 ✓$_m$	1	
(b)	P = (horizontal component from (a)) x 0.6 ✓$_m$ So P = 116 (120) (W) ✓$_e$ (120 W from F = 200 N)	2	penalise using wrong F
6(a)	phasor arrow pointing to S.E. ✓	1	
(b)	same amplitude and wavelength ✓ 180° phase diff ✓	2	**minimum** of 1 cycle
	total	**20**	

7(a)(i)	destructively interfering ✓	1	phasors antiphase / waves out of phase
(ii)	mention path difference ✓ $\lambda/2$ idea ✓	2	phasors cancel resultant phasor = 0 so probability=0 or AW
(iii)	* (LOOK AT (a)(i) and (ii) together) idea that 2 amplitudes different ✓ cause (absorption) or effect .. not complete cancelling ✓ (others possible)	2	not quite out of phase = 0
(b)	white = many **colours** ✓ green not reflected ✓ other wavelengths give the purple colour✓	3	not purple light reflected
(c)	brighter/ greater contrast/ more focused /greener ✓ ...... explained ✓	2	
	total	**10**	
8 (a)(i)	One loop ✓ nodes and antinodes labelled ✓	2	
(ii)	0.8 (m) ✓ ecf from (a)(i)	1	
(iii)	= 440 x 0.8 ✓ = 352 (m s^{-1}) ✓ ecf from (a)(ii)	2	
(b)	N = kg m s^{-2} ✓ for coherent development✓	2	
(c)(i)	different mass per unit length (thickness/density) ✓ thicker string .... lowest note ✓	2	
(ii)	equal force on neck/ won't distort instrument/ easier to bow ✓ or other **mechanical** reason	1	
	total	**10**	
9 (a)(i)	constant speed ✓ equal distance in equal times ✓	2	or no forces acting horizontally
(ii)	accelerating ✓ increasing distances in equal times ✓	2	or gravity is acting vertically
(b)(i)	$t = x/v$ ✓ so $t^2 = x^2/v^2$ ✓	2	$t^2 = x^2/v^2$ 2 marks
(ii)	$y = {}^1/_2 gt^2$ rearranged ✓ ...... to give $t^2 = 2y/g$	1	
(iii)	$x^2/v^2 = 2y/g$ rearranged ✓ ..... to give $v^2 = x^2g/2y$	1	
(c)	$v^2 = ((4.0)^2 \times 9.8)/(2 \times 1.5)$ ✓ = 52 (52.27) $v = 7.2$ ✓ (m s^{-1}) **3 s.f. max**	2	
	total	**10**	

10 (a)(i)	arrow backwards ✓ labelled 'drag' / air or wind resistance (not just 'friction') ✓	2	through common point, drawn **on** the aircraft
(ii)	thrust = drag ✓ lift = weight ✓ forces must be 'balanced' idea/ no acceleration ✓	3	
(b)(i)	appropriate **velocity** vector arrows to scale ✓ to match Fig. 10.1	1	must have arrows
(ii) 1	method mark ✓ 11 m s^{-1} (10.8) ✓ (10.5 to 11.5 by diag)	2	by Pythagoras or measurement
(ii) 2	method mark ✓ 21.8° ✓ (20° to 25° by diag)	2	by trig or measurement
	total	**10**	
11 (a)(i)	clear statement of measurement ✓	1	
(ii)	sensible estimate **with unit** ✓ (check for appropriateness)	1	**UP**
(b)(i)	diagram labelled - could be set up ✓✓✓ some errors or omissions ✓✓ some plausible attempt made ✓	3/2/1	
(ii)	radiation sent out ✓ pulse ✓ reflected and received ✓ time delay measured/recorded ✓	4	what would need to be done in this case.. addressed (prose)
(c)(i)	s = vt ✓ stating specifically what v represents here ✓ time delay halved ✓	3	depends on example selected (analysis)
(ii)	for 2 relevant sources of error ✓✓	2	or 1 factor and the consequence
	total	**14**	
12 (a)	For a **situation** where a quantum phenomenon is observed✓	1	if not a quantum phenomenon ... zero marks total
(b)	clear labelled diagram ✓✓✓ ...with some minor omissions or errors ✓✓ .... for some attempt made ✓	3/2/1	
(c)	for four separate relevant and correct items of description ✓✓✓✓	4	
(d)	read as a whole ... upto 4 marks for relevant **quantum** ideas ✓✓✓✓	4	
	total	**12**	
Qo WC	✓✓✓✓	4	Judged solely on written communication in questions 11 and 12

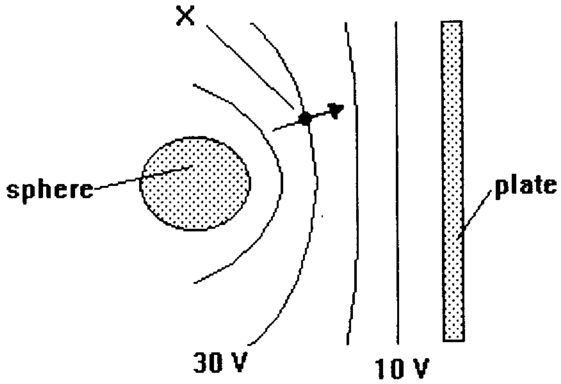
Abbreviations, annotations and conventions used in the Mark Scheme		
	/	= alternative and acceptable answers for the same marking point
	;	= separates marking points
	NOT	= answers which are not worthy of credit
	( )	= words which are not essential to gain credit
	___	= (underlining) key words which **must** be used to gain credit
	ecf	= error carried forward
	AW	= alternative wording
	ora	= or reverse argument

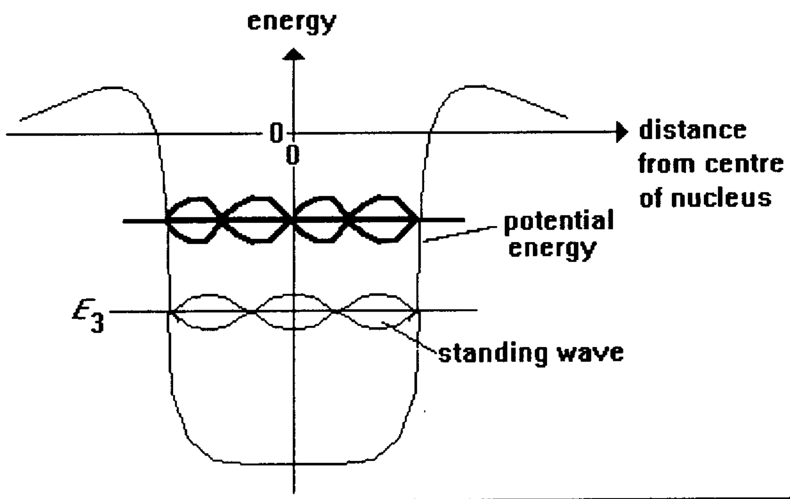
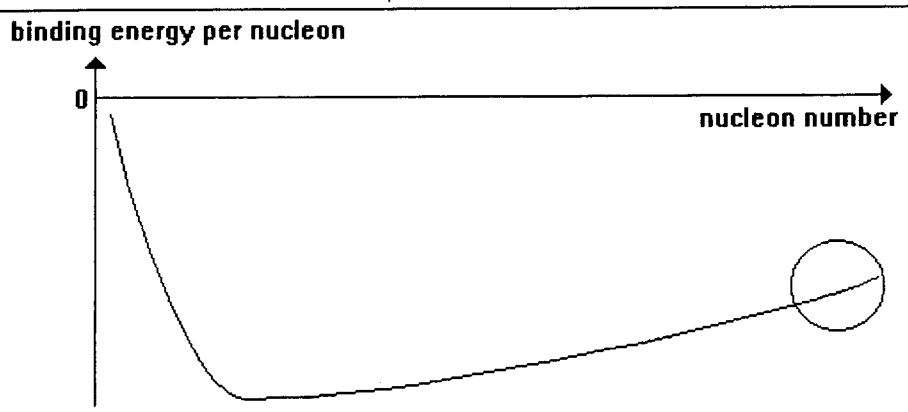
Question	Expected Answers	Marks
1 (a)	J ✓	1
(b)	N ✓	1
2	$\Delta\theta = Q/mc$ = 3.5x 10^4 / 0.21 x 4200 ✓ = 40 °c (39.7 °c) ✓ Final temperature = 40 + 20 = 60 °c ✓ (59.7 °c) marking points 'stand alone'	3
3 (a)	Q = CV ✓ -> E = ½ CV * V ✓ = ½ CV^2	2
(b)	Graph starting at 0,0 ✓ and curving upwards ✓	2
4 (a)	e.g. galaxies *receding*/ (cosmological) redshift, Hubble's Law ✓	1
(b)	Link to early Universe, e.g.: microwave radiation remnant of era of recombination (accept remnant of 'big bang') ✓ present distribution reflects earlier distribution✓ (therefore, any large scale anisotropy in early universe would be reflected in variation in background AW)	2
5 (a)	$pV = nRT$ ✓ -> $V = nRT/p$ = 1 x 8.31 x 300/ 1.0 x 10^5 ✓=0.0249 m^3 (can work backwards or use pV = NkT)	2
(b)	1.0 x 10^5 x 0.025 = p_2 x 0.020 ✓ p_2 = 1.3 x 10^5 Pa ✓ (accept 1.25 x 10^5) candidates can use their answer to 5 (a) (ecf) (e.g. 1.2 x 10^5 if 0.0249 used).	2
6 (a)	$I = V/R$ = 6/ 5.6 x 10^3 ✓= 1.1 x 10^{-3} A = (about) 1 mA ✓	2
(b)	I = 1.1 x 10^{-3} x e^{-1} = 1.1 x 10^{-3} x 0.37 ✓= 0.4 mA ✓ (accept rule of thumb third, answers using 1 mA & answers using decay equation)	2
	Section A total	**20**

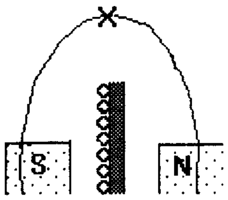
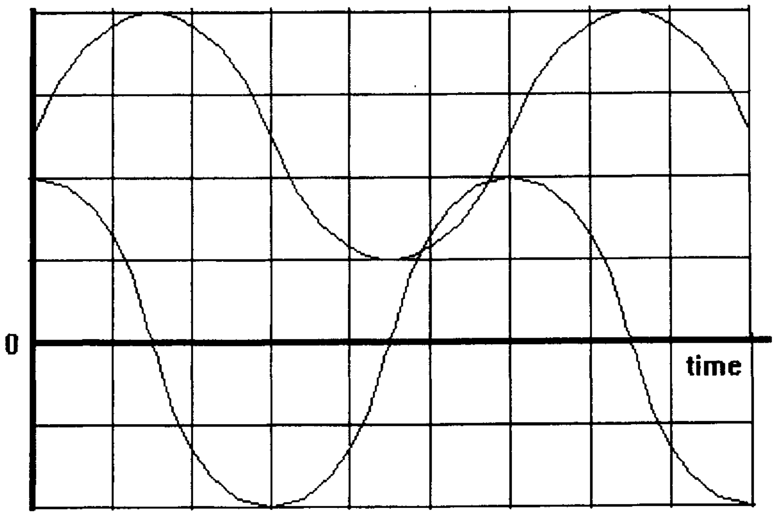
7 (a) (i)	Max depth = 15m ✓	1
(a) (ii)	Amplitude = 5 m ✓	1
(a) (iii)	Gradient at t = 6 hours ✓ correct reading from graph✓ answer worked to 3.0 m hr^{-1} ✓ (answers in range 2.5 m hr^{-1} to 3.5 m hr^{-1})	3
(b)	time period from graph = 12.5 hrs ✓ $f = 1/T = 1/12.5$ ✓= 0.080 hr^{-1} ✓	3
(c)	shading or lines drawn on graph ✓answer in range of 15.5 hrs to 16.5 hrs ✓	2
(d)	d = 10 + 5 sin (2πsin 0.080 * 9.5) ✓ = 5.0 m ✓ (allow ecf from a(ii) and b) or sin varies between +1 and –1 ✓so lowest value is 10 – A (this allows incorrect value for A to ecf) ✓	2
8 (a)(i)	Δp = 280 x 55 – 280 x 0✓ = 15 400✓ kg ms^{-1} ✓	3
(a) (ii)	f = ma = 280 x (55/0.25) ✓ = 61600 N ✓ (or use $F = \frac{mv - mu}{t}$)	2
a(iii)	argue from Newton 3 or conservation of momentum leading to a force on the plane ✓ this makes the plane move down✓ (as plane is much more massive so acceleration/movement much less than that of the pilot) . (Accept plane won't move because its on the ground for second mark)	2
(b)	$\frac{1}{2} mv^2 = mg\Delta h$ ✓ $\Delta h = v^2 / 2g = 55^2 / 19.6$ ✓ = 154 m ✓ S.F. penalty. Or suitable equation of motion chosen ✓ values substituted ✓ evaluation✓	3
(c)	Collisions between pilot and particles ✓ momentum/ direction/ velocity change of particles during collision ✓ change of momentum of particles exerts force on pilot. ✓	3
9 (a)	250 x 50 = 12500 J ✓	1
(b)	number of molecules = 5 x 6.02 x 10^{23} /18 ✓ = 1.67 x 10^{23} ✓	2
(c)	E = 12500/1.7 x 10^{23} ✓= 7.35 x 10^{-20} ✓ J (or 7.48 x 10^{-20} if 1.67 x 10^{23} used)	2
(d)	kT = 1.4 x 10^{-23} x 373 = 5.2 x 10^{-21} J✓	1
(e) (i)	5.2 x 10^{-21}/7.5 x10^{-20} = 0.07 ✓. (ecf)	1
(ii)	Argument from average energy✓ explanation of why there is a range of energies e.g. molecular collisions or 'getting lucky' ✓ (or Boltzmann arguments)	2

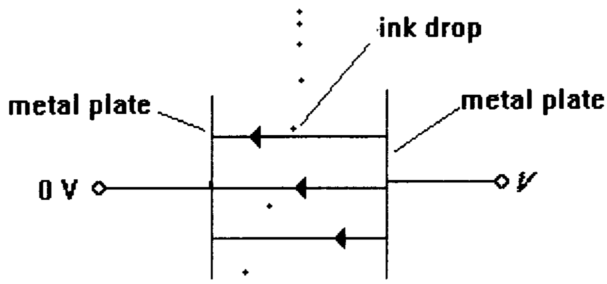
10 (a) (i)	V_{grav} = - 6.67 x 10^{-11} x 5.98 x 10^{24} / 6.38 x 10^{6} ✓ = -6.252x 10^{7} ✓J kg^{-1} Own value needed.	2
(a) (ii)	Calculating V_{grav} = - 6.27 x 10^{7} ✓J kg^{-1} using this to give ratio 6.27/6.25 =1.003(2) ✓ Own value needed. OR: explanation leading to 6.38/6.36✓ = 1.0031✓	2
a(iii)	Gravity is always attractive (AW) ✓ hence it always takes energy/work to separate gravitationally bound masses. At infinity the energy 'stored' is zero therefore an object in a field will be in a potential well. ✓ (AW)	2
(b)	g= (-)GM/r^2 ✓	1
(c) (i)	g = -6.67 x 10^{-11} x 5.98 x 10^{24} /(6.36 x 10^{6})^2 ✓= 9.86✓ N kg^{-1} ✓	3
(ii)	Value for potential depends on r whereas field strength depends on r^2. ✓ Hence field strength more sensitive to changes in r ✓ or evaluate ratio ✓ (OWTTE)	2
	QWC marks on questions 8 a(iii), 8 (c) , 9 e (ii) ✓✓✓✓	4

Section B total: 50 marks

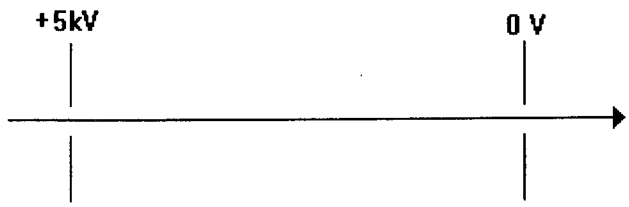
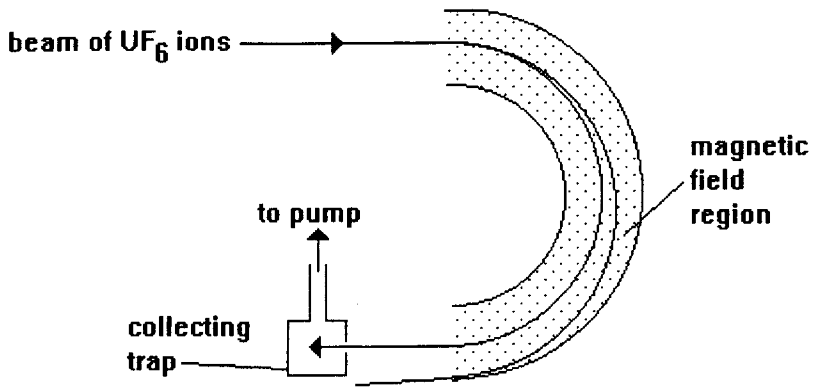
1	s^{-1}	1
2	A	1
3	10^3	1
4 (a)	A	1
4 (b)	*E* is electric field (strength) / force on unit charge	1
5 (a)	at right angles to equipotential through the point (by eye) pointing away from sphere ACCEPT curved field lines which have the correct direction at X 	1 1
5 (b)	0 V	1
6	A C	1 1

7(a)	B	1
7(b)	C	1
8	higher energy level standing wave to fit potential well more than two antinodes  	1 1 1
9 (a)	 as shown, by eye	1
9 (b)	total binding energy = $56 \times 8.8\times10^6 = 4.93\times10^8$ eV ecf incorrect eV: energy = $4.93\times10^8 \times 1.6\times10^{-19} = 7.9\times10^{-11}$ J (steps clearly shown to earn marks)	1 1
9 (c)	$E = mc^2$ ecf incorrect E: $m = E/c^2 = 7.9\times10^{-11}/9\times10^{16}$ $m = 8.8\times10^{-28}$ kg (1×10^{-10} J gives 1×10^{-27} kg)	1 1

10 (a) (i)		1
10 (a)(ii)	Any complete loop which • does not cross the other loops • joins N to S	1
10 (b)	substitution: $1.2\times10^{-3}/0.25$ answer: 4.8×10^{-3} V	1 1
10 (c)(i)	correct period and sinusoidal shape, any amplitude average value of zero correct phase (accept 90° ahead or behind) 	1 1 1
10 (c)(ii)	Description: any two of the following, 1 mark each • wind more turns on the coil • use a stronger magnet • increase the area of the turns • decrease the air gap between the poles • wind coil on an iron former • mechanical arrangement (e.g. lever) to increase displacement Explanation: each modification increases flux linkage (change) of the coil	2 1

11 (a)	$Q = ne$ (eor) $n = 8\times10^{-10} / 1.6\times10^{-19} = 5.0\times10^{9}$	1 1
11 (b)(i)	positive EITHER so that right-hand plate becomes positively charged repelling positive charge on drop OR left-hand plate becomes negatively charged to attract positive charge on the drop OR potential decreases as drop moves to the left resulting in drop gaining KE as it moves that way	0 1
11 (b)(ii)	horizontal lines equally spaced (accept correct edge-effects) arrow to the left 	1 1 1
11 (c)(i)	statement of formula: $E = V/d$ elimination of E to obtain required expression accept formula $E = V/d$ derived from expression for [2] accept $F = QV/d$ for [1]	1 1
11 (c)(ii)	correct substitution of powers of 10 ecf incorrect powers of ten: $V = \frac{Fd}{Q} = \frac{3.6\times10^{-6}\times15\times10^{-2}}{0.8\times10^{-9}} = 675\ \text{V}$ (accept 680 V)	1 1

12 (a)(i)		number of X-rays = 120 ecf: total dose equivalent = 120 × 16×10^{-6} = 1.9×10^{-3} Sv ecf :risk = 1.9×10^{-3} × 3 = 0.0058 %	1 1 1
12 (a)(ii)		cancers = 0.0058 × 55×10^{6} / 100 = 3200 (0.006% gives 3300)	1
12 (a)(iiii)		[1] + [1] per valid statement backed by correct calculation, up to [4] No ecf: e.g. • annual dose equivalent from X-rays is 32 μSv • 32/2000 = 0.016 of dose equivalent from background (ora) • risk of background is unavoidable (owtte) • and will lead to 2×10^{-3} × 60 × 0.03 × 55×10^{6} = 200 000 cancers • lifetime X-ray dose similar to annual background dose • so any cancer is much less likely to come from X-ray (ora)	4
12 (b)(i)		proposal: d.e. × distance^2 = constant shown clearly calculations: -1 per error, maximum -2 2.6×10^{-6} × 0.25^2 = 0.163 (×10^{-6}) 0.95×10^{-6} × 0.41^2 = 0.160 (×10^{-6}) 0.27×10^{-6} × 0.77^2 = 0.160 (×10^{-6})	1 2
12 (b)(ii)		any of the following, maximum [2] • X-ray emitter acts as a point source (owtte) • photons spread out evenly in all directions/in a cone • X-ray photons not absorbed by air • dose equivalent depends on photons per square metre (owtte) • doubling distance quadruples area for photons to pass through (owtte)	2
12 (b)(iii)		dose equivalent per X-ray = 0.2×10^{-3}/4000 = 5×10^{-8} Sv X-ray dose equivalent = 0.16×10^{-6}/x^2 x = (0.16×10^{-6}/5×10^{-8})$^{0.5}$ = 1.8 m	1 1

13 (a)(i)	$+4.8\times10^{-19}$ C	1
13 (a)(ii)	$m = (235 + 6 \times 19) = 349u$ ecf incorrect m: mass = $349 \times 1.7\times10^{-27} = 5.9\times10^{-25}$ kg (NOT 6×10^{-25}) ($235u$ gives 4.0×10^{-25} kg)	1 1
13 (b)(i)	EITHER (accelerating) force = charge × electric field (owtte) OR (potential) energy = charge × potential (owtte) OR charged particles repelled / attracted by charges on electrodes	1
13 (b)(ii)	pair of electrodes / colinear tubes 5 kV apart ions move from high potential to low potential 	1 1 1
13 (c)(i)		1
13 (c)(ii)	vacuum means no collisions with air molecules (owtte) to alter velocity / charge of ions which would result in a different path in magnetic field	1 1 1
	Quality of Written Communication	4

Abbreviations, annotations and conventions used in the Mark Scheme	
	m = method mark
	s = substitution mark
	e = evaluation mark
	/ = alternative and acceptable answers for the same marking point
	; = separates marking points
	NOT = answers which are not worthy of credit
	( ) = words which are not essential to gain credit
	___ = (underlining) key words which **must** be used to gain credit
	ecf = error carried forward
	AW = alternative wording
	ora = or reverse argument

Qn	Expected Answers	Marks	Additional guidance
1 (a)	Any long random linear molecular structure ✓	1	Chemical type chains OK, or just zigzags
(b)	(i) Not brittle/doesn't crack/deforms before breaking/ absorbs energy on breaking/ AW✓ (ii) Molecules tightly wound ✓ ; Strongly bonded / difficult to separate helical 'strands'✓ (iii) Molecules separate ✓ ; Less strongly bonded ✓	1 2 2	Force or energy argument acceptable for (b)(ii) and (iii)
(c)	(i) Virtually all water ✓ (ii) Very few bonds between protein strands to break ✓	1 1	
	Total:	8	
2 (a)	70 kJ mol^{-1} = 70 × 10^3/6.0 × 10^{23} J per molecule ✓m = 1.17 × 10^{-19} J / molecule ≈1.2 × 10^{-19} J / molecule✓e ora	2	Must have 1.17×10^{-19} J for second mark
(b)	(i) kT is an energy, in J ✓ ; so E/kT is dimensionless AW ✓ (ii) At 500 K, E =15kT while at 255 K, E =30kT ✓ ; Only processes with 15<E/kT<30 happen at an appreciable rate AW✓	2 2	'Argument of e must be dimensionless' gets ✓ only E/kT not big enough at 255 K would gain ✓ only
(c)	(i) Ratio of f_B = 7.51 × 10^{-11}/3.95 × 10^{-11}=1.90 ✓m ; ≈ 2 so rate is roughly doubled ✓ (ii) reaction rate depends on number of molecules having enough energy to react ✓ ; Boltzmann factor gives fraction of molecules with enough energy ✓	2 2	Ora e.g. 'should be doubled =7.9× 10^{-11} at 373 K which is close'
	Total:	10	
3 (a)	Alcohol would boil/ could not read thermometer in food✓	1	Anything plausible
(b)	12 mV is much too small to read on 2.5 V scale ✓	1	
(c)	Gradient not constant ✓ ; Show/ calculate that emf < 1.25 V ✓	2	'May' allows correction e.g. with lookup table
(d)	Appreciating that resolution is related to slope of graph✓; Resolution greatest near 0°C <u>because</u> same ΔT produces bigger $\Delta\varepsilon$ /gradient greatest near 0°C ✓	2	
	Total:	6	

Qn	Expected Answers	Marks	Additional guidance
4 (a)	(i) decreases because field lines further apart ✓ (ii) $E_{k\,max} = 4000 \times 1.6 \times 10^{-19}$ J $= 6.4 \times 10^{-16}$ J $\approx 6 \times 10^{-16}$ J ✓m✓e (iii) $650/6 \times 10^{-16}$ J $= 1.1 \times 10^{18}$ s^{-1} ✓m✓e (iv) Energy not all converted to useful output ✓	1 2 2 1	Can use 6.4×10^{-16} J to get 1.0×10^{18} s^{-1} in (iii) (iv) must refer to energy.
(b)	Arrow perpendicular to electron path✓ ; Arrow to right✓	2	Inward arrow which is not perpendicular gets one ✓
(c)	(i) Force ✓ ; On charge *q* moving at velocity *v* in field B✓ (ii) Centripetal force/ force needed ✓ ; for particle to move along arc (of radius *r*)✓ (iii) Electron starts slow and accelerates/electron gains kinetic energy, so *v* increases✓ ; $v \propto r$ (equation 2), so as *v* increases, *r* increases ✓	2 2 2	(ii) second mark needs equation to be related to this situation (iii) increased momentum not enough for second mark
	Total:	14	
5 (a)	High resistance means low conductance/vice versa ✓ ; high conductance base corresponds to low resistance in electrical circuit✓	2	First mark can be stated or implied
(b)	p.d. = ΔT shared between two different resistances and bigger resistance = egg takes bigger share ✓ ; so *T* at base of egg (Y) is close to *T* of pan (X) ✓	2	Can use constant current and Ohm's Law
(c)	Temperature at Y close to that at X ✓ ; At high temperatures, carbonisation takes place/molecules split up completely/AW ✓	2	
	Total:	6	
6 (a)	$E = hf = 6.63 \times 10^{-34} \times 2.45 \times 10^{9}$ J $= 1.62 \times 10^{-24}$ J $\approx 2 \times 10^{-24}$ ✓m✓e	2	Must calculate *E* to at least 2 sf to show this
(b)	(i) Constant ratio of adjacent/equally spaced values ✓ (ii) Test applied to $\geq$ 2 pairs ✓ conclusion (yes) ✓ (iii) Use of repeated ratio appropriately to get 1.5 – 1.7✓	1 2 1	19/24=0.79,15/19=0.79 12/15=0.80,10/12=0.83 15/24=0.63,10/15=0.67
(c)	Microwaves absorbed more as they penetrate✓; intensity lower as you go further in ✓	2	
	Total:	8	

Qn	Expected Answers	Marks	Additional guidance
7 (a)	$c=f\lambda$ ✓ ; $\lambda = c/f = 3.00\times10^8/2.45\times10^9$ m = 0.122 m ≈ 12 cm ✓s✓e	3	
(b)	Reflect✓	1	
(c)	Whole number of node-node loops✓ ; 6 loops✓	2	Must be 'loopy' and not just a travelling wave
	Total:	6	
8 (a)	(i) $\rho_{Ceres} = 8.7\times10^{20}/4.3\times10^{17} = 2000$ kg m^{-3}✓ ; $\rho_{Vesta} = 3.0\times10^{20}/7.8\times10^{17} = 3800$ kg m^{-3}✓ (ii) Densities differ (significantly) so different materials✓	2 1	Sfe penalty here for >3 sig figs.
(b)	(i) Using $T=2\pi r/v$✓ ; $\frac{2\pi r}{v} = \frac{2\pi r}{\sqrt{GM/r}} = \sqrt{4\pi^2 r^2}\sqrt{\frac{r}{GM}} = \sqrt{\frac{4\pi^2 r^3}{GM}}$ ✓m✓e (ii) $T\uparrow \Rightarrow r\uparrow \Rightarrow v\downarrow$ so Vesta is faster as T is smaller ✓m✓e	3 2	Must relate T to v for second mark in (ii)
(c)	$T = \sqrt{\frac{4\pi^2 r^3}{GM}} = \sqrt{\frac{4\pi^2 (35000)^3}{6.67\times10^{-11}\times6.69\times10^{15}}}$ s ✓s = 61600 s = 17.1 hours ≈ nearly a day ✓e	2	
(d)	(i) $t = d/c = 3\times10^{11}/3.0\times10^8 = 1000$ s✓ (ii) control from Earth not possible ✓ ; because of large (2000 s) round-trip time for signals ✓	3	
(e)	(i) 398×303= 120 594 ✓ » 10 576 ; so compressed✓ (ii) 10 576 bytes = 10 576 × 8 bits = 84 608 bits ✓ ; time = 84 608 bits /10 bits s^{-1} = 8461 s ≈ 8500 s✓	1 3	Using 120 594 instead of 10 576 is OK in (ii), ⇒964752 bits, 96000 s Ignore sfe in (ii)
	Total:	17	
9 (a)	$k=F/x$=4.0 N/0.10 m = 40 N m^{-1} ✓	1	
(b)	(i) $F \propto x$ as above ✓; $a \propto F$ by Newton II ✓ (ii) a in opposite direction to x ✓ ; reference to vector nature ✓	2 2	
(c)	0.7 s ≤ T ≤ 1.0 s✓	1	Graph gives 0.92 s
(d)	(i) $T = 2\pi\sqrt{1.0\,\text{kg}/40\,\text{N m}^{-1}} = 2\pi\times0.158$ s = 0.99 s ✓s✓e (ii) Rapid changes in x/v/a not modelled ✓ (iii) Use a much smaller time interval✓ ; example of suitable Δt (e.g. 0.01 s or smaller) ✓	2 1 2	Second mark in (iii) could be for explaining why smaller Δt is better.
	Total:	11	
	Quality of Written Communication	4	

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