OCR
RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 7888**

Advanced Subsidiary GCE **AS 3888**

Mark Scheme for the Units

June 2008

3888/7888/MS/R/08

OCR (Oxford, Cambridge and RSA Examinations) is a unitary awarding body, established by the University of Cambridge Local Examinations Syndicate and the RSA Examinations Board in January 1998. OCR provides a full range of GCSE, A level, GNVQ, Key Skills and other qualifications for schools and colleges in the United Kingdom, including those previously provided by MEG and OCEAC. It is also responsible for developing new syllabuses to meet national requirements and the needs of students and teachers.

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:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 870 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

CONTENTS

Advanced GCE Physics B (Advancing Physics) (7888)

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

MARK SCHEMES FOR THE UNITS

2860 Physics in Action

General advice to Assistant Examiners on the procedures to be used

YOU WILL BE REQUIRED TO UNDERTAKE 10 PRACTICE AND 10 STANDARDISATION SCRIPTS BEFORE STARTING TO MARK LIVE SCRIPTS.

1 The schedule of dates for the marking of this paper is very important. It is vital that you meet these requirements. If you experience problems then you must contact your Team Leader (Supervisor) without delay.

2 An element of professional judgement is required in the marking of any written paper. Candidates often do not use the exact words which appear in the detailed sheets which follow. If the physics is correct and also answers the question then the mark(s) should normally be credited. If you are in doubt about the validity of any answer then consult your Team Leader (Supervisor) by phone, the messaging system within SCORIS or e-mail.

3 Correct answers to calculations always gain full credit even if no working is shown. (The 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

4 Some questions may have a 'Level of Response' mark scheme. Any details about these will be in the rationale, for this paper see 1/2/3 style.

1/2/3 style allow full credit for a well annotated diagram if included:

1 will indicate a sensible attempt has been made with a little relevant physics / comment
2 will indicate the description is satisfactory, but may contain serious errors or omissions
3 will indicate the description is essentially correct but perhaps not totally complete, but is without gross errors

5 If an answer has been crossed out and no alternative answer has been written then mark the answer crossed out.

6 In addition to the award of 0 marks, there is a NR (No Response) option on SCORIS.

<u>Award 0 marks</u>

- if there is any attempt that earns no credit (including copying out the question or some crossed out working)

<u>Award NR (No Response)</u>

- if there is nothing written at all in the answer space
  OR
- if there is any comment which does not in any way relate to the question being asked (eg 'can't do', 'don't know')
  OR
- if there is any sort of mark which is not an attempt at the question (eg a dash, a question mark)

7 Abbreviations, annotations and conventions used in the detailed Mark Scheme.

/ = alternative and acceptable answers for the same marking point
(1) = separates marking points
not = answers which are not worthy of credit
reject = answers which are not worthy of credit
ignore = statements which are irrelevant
allow = answers that can be accepted
( ) = words which are not essential to gain credit
__ = underlined words must be present in answer to score a mark
ecf = error carried forward
AW = alternative wording
ora = or reverse argument

8 Annotations: the following annotations are available on SCORIS.

✓ = correct response placed in script at point of award
× = incorrect response placed in script at point where a marking point is lost or gross error occurs
bod = benefit of the doubt
nbod = benefit of the doubt **not** given
ECF = error carried forward
^ = information omitted (can usefully be placed on the question stem to indicate missing part of response)
FT = not used on this paper
TV = trivial response below expected level
REP = repetition
RE = not used on this paper
CON = contradiction
SF = only penalise on questions indicated, on this paper we are not using SF penalty

Highlighting is also available to highlight any particular points on the script.

Once cleared for **live marking**; the following questions should be annotated with ticks (and other annotations) to show where marks have been awarded in the body of the text:
9(biii) & (c), 10(c) if not NR, 0, 3/3
& 10(d), 12(d) and 13(b all parts) if not NR or 0.
Annotate BOD / CON / ECF etc. throughout at the point in the response where appropriate.

9 The Comments box
The comments box will be used by your PE to explain their marking of the practice scripts for your information. Please refer to these comments when checking your practice scripts. You should only type in the comments box yourself when you have an additional object of the type described in Appendix B of the Handbook for Assistant Examiners and Subject Markers.
Please do not use the comments box for any other reason.
Any questions or comments you have for your Team Leader should be communicated by phone, SCORIS messaging system or e-mail.

10 Please send a brief report on the performance of the candidates to your Team Leader (Supervisor) by the end of the marking period. The Assistant Examiner's Report Form (AERF) can be found on the Cambridge Assessment Support Portal. This should contain notes on particular strengths displayed, as well as common errors or weaknesses. Constructive criticisms of the question paper/mark scheme are also appreciated.

Section A

Question			Expected Answers	Marks	Additional Guidance
1			A s **(1)** J C^{-1} **(1)** A V^{-1} **(1)**	**3**	**not** alternative equivalent units C ; V ; S **enforce** ↔ candidates double headed arrows to swap posn.
2	**a**		5 (alternatives = 2^{bits}) 2^5 = 32 (> 26)	**1** **1**	bits = 5 **not** 2^5 **not** 2^5 = 32 explained **allow** $2^{4.7}$ = 26 **allow** counting alternatives to 32 / 31 **not** just 32 alternatives **not** just 2^4 = 16
	b		characters x bits $character^{-1}$ 10 < bits < 1000	**1** **1**	clear method **allow** numerical method **not** characters > 200 ecf on bits from (a) a correct bare estimate scores 1/2
3			(18 x 10^6 x 12 x 25) = 5.4 x 10^9 (bits s^{-1})	**1**	**allow** correct evaluation only
4	**a**		images of (very) distant objects at *f* from lens / waves (or rays) from distant objects converge at F due to parallel rays (from point on object at ∞) / curvature of waves (from distant object) is zero / negligible compared to that added by lens image position is behind CCD	**1** **1**	AW **accept** broad range of rays / curvature / equations / diagrams approaches but only reward correct physics **not** just image is at f / F / CCD **accept** no discrimination between *f* (focal length) and F (principal focus) of lens if symbols are used **allow** $u \approx \infty$ so $1/u \approx 0$ **(1)** and $1/v = 1/f$ / $v = f$ for 2 marks
	b		image is at 16 mm behind lens / 8 mm behind CCD / object and image at 2 *f* / a nearly symmetrical ray diagram by eye	**1** **1**	**accept** in words / diagrams **not** image is out of focus explanation by correct calculation / quality words eg lens is unable to add enough curvature to form image on CCD **allow** calculations of *f* from given *v* and *u* as reverse argument i.e. what *f* for *u* = -0.016 m and *v* = 0.008 m giving *f* = 5.3 mm

Section A

Question			Expected Answers	Marks	Additional Guidance
5	**a**		(e.m.f.) = 1.5 ± 0.02 (V)	**1**	**allow** tolerance ± ½ graph square **not** 1.45 V gross error
			(max current) = 560 ± 5 mA	**1**	**allow** 0.56 A if milli is crossed out
	b		r = | gradient | /	**1**	method **allow** any correct method including numerical if clear
			$r = (\varepsilon - V) / I$ /		**accept** method mark only for r = 1.5 / <u>560</u>
			r = 1.5 / 0.56		**ignore** $r = V / I$
			must get to r as subject of a correct equation		**not** r = 0.75 / 0.28 i.e. from any single graph point but is incorrect method - this one happens to give the correct value
			2.7 (Ω tolerance ± 0.1 on other graph values)	**1**	evaluation **allow** ecf on both values from (a)
6			(strength) property of material (not specimen) / (breaking stress) takes x-sectional area into account / is independent of dimensions of specimen / breaking force depends on dimensions of specimen / double area doubles force to break	**2**	Any two points AW **allow** stress = force /(x-sectional) area or symbols for one weak mark **not** strength depends on x-sectional area or force! **allow** strength / breaking stress is an intensive property **allow** breaking force is an extensive property
7			bass must reduce by 1 / 2 bars	**1**	**allow** decrease on either/both of leftmost pair of bars
			treble must increase by 1 or more bars	**1**	**allow** increase on either/both of rightmost pair of bars **ignore** middle frequency bar
			Total: Section A	**20**	

Question			Expected Answers	Marks	Additional Guidance
8	**a**		3 or more metal particles separate and randomly arranged	1	must be labelled clearly as metal **not** regularly arranged **not** all on top of polymer chains **not** labelled QTC particles
			background matrix / long chain polymers (any orientation / coiling / alignment)	1	must be labelled clearly as matrix / chains / polymers **allow** shaded area labelled matrix with no chains **not** round / point polymer particles / only one chain **accept** aligned polymers / polymer grid no labels = no marks
	b	**i**	(ρ) scale is logarithmic / goes up as x 100 (per equal distance increment)	1	**allow** goes up in x 100 units / constant multiples / constant factors **allow** goes up (linearly) in powers of 10 **not** just a times / factors scale / non-linear scale / scale is in powers of ten
		ii	12	1	**not** 10^{12}
	c	**i**	value from graph $\rho = 10^{-2}$ (Ω m)	1	**allow** any evidence even in otherwise incorrect calculations **not** 10^{-2} for σ **allow** $\sigma = 10^{2}$
			$R = \rho L / A$ / $= 10^{-2} \times 10^{-3} / (3.6 \times 10^{-3})^2$	1	method **allow** correct equation for R (in any arrangement) in symbols / words / numbers
			0.77 (Ω) ecf on ρ value	1	evaluation
		ii	weighing scales / force-meter / stress / strain gauge / pressure alarm sensor	1	**allow** any application involving stress / strain / force / pressure **accept** mass balance
			Total Question 8	**8**	

Question			Expected Answers	Marks	Additional Guidance
9	a		increases / rises / goes up 2.4 ± 0.3 kΩ lowest / low / lower / small	1 1 1	**allow** any stated value or range ≤ 1 (W m^{-2}) **accept** even if units kΩ
	b	i	LDR and fixed resistor connected in series with battery	1	**accept** LDR symbol without circle but with arrows **accept** zig-zag resistor symbol **accept** ammeter in series but no other extra components **allow** any orientation or order **allow** this mark even if V meter in series **not** incomplete circuits **not** incorrect circuit symbols e.g. thermistor / general transducer / variable resistor / photodiodes / LEDs / fuse
		ii	Voltmeter in parallel with fixed resistor	1	must be correctly positioned and labelled V (meter) **allow** ecf V meter around incorrect circuit symbol if clearly R_{fixed} (don't penalise symbol again)
		iii	LDR and fixed resistor have same resistance for ½ battery voltage from divider (from graph R) = 2.3 ± 0.05 k(Ω)	1 1 1	AW complete correct reasoning for **two** marks **allow** algebraic reasoning based on any correct resistance ratio R_1 / R_2 = 1 / R_1 / R_{total} = ½ **(1)** being equal to the appropriate voltage ratio = V_1 / V_2 / = V_1 / V_{total} **accept** inverse ratio arguments if correct **accept** ratios as fractions / using : / numeric **allow** 1 mark for a correct potential divider equation for their circuit labels 2 marks for correct value substitution in pot. Divider eq. **allow** one mark for getting as far as current I = 1.3 mA evaluation tolerance ± ½ a grid square for k(Ω) missing max 2 i.e. penalise once **accept** bare correct answer for 3 marks (see advice note 3)

	c		voltage ratio now 2:1 resistance ratio also 2:1 / $R_{LDR} = R_{fixed} / 2$ / $R_{LDR} = 2.3\ k\Omega / 2$ / $= 1.15\ k\Omega$ (from graph) 2.4 ($\pm$ 0.2 W m^{-2})	1 1 1	AW complete correct reasoning for **two** marks **allow** algebraic reasoning based on any correct resistance ratio R_{fixed} / $R_{LDR} = 2$ / $R_{fixed} / R_{total} = ⅔$ being equal to appropriate voltage ratio = V_{fixed} / V_{LDR} / = V_{fixed} / V_{total} **accept** inverse arguments if correct **allow** 1 mark for a correct potential divider equation for their circuit labels 2 marks for correct values substituted **allow** ecf on ½ R_{fixed} value from (biii) **allow** ecf on graph from ½ R_{fixed} value from (biii) ecf on graph from their value for R_{LDR} **check for this on incorrect** R_{LDR} values especially 0.5 W m^{-2}
			Total Question 9:	**11**	

Question			Expected Answers	Marks	Additional Guidance
10	**a**	**i**	AB **(1)** CD **(1)**	2	one mark each **allow** BA & DC
		ii	BC	1	**not** two answers CON
	b	**i**	120 (MPa)	1	**not** 120 x 10^6 (MPa)
		ii	0.0105 to 0.0106	1	**allow** 1.05% / 1.06%
	c		$E = \sigma / \varepsilon$ from an elastic region = 120 x 10^6 / 0.0015 = 8 x 10^4 (MPa) / 8 x 10^{10} Pa	1 1 1	**allow** gradient of AB / DC i.e. clearly from *either* elastic region **not** just $E = \sigma / \varepsilon$ **allow** any other correct graph values from *either* elastic region **not** ecf from (b) **allow** ecf on incorrect values from elastic region **accept** all working in MPa if answer correct **not** 130 MPa / 0.012 = 1.1 x 10^4 (Pa) scores 0/3
	d		(arrangement of atoms) e.g. regularity / dislocations / lattice / close packed planes (elastic region) bonds stretch and return (after stress is removed) (plastic region) layers of atoms slip / slide over each other / better explanation using dislocation motion ideas	1 1 1	AW throughout **allow** correct ideas from well labelled diagrams throughout **not** just layers of atoms **not** any credit for answers only describing macroscopic level
			Total Question 10:	**11**	

Question			Expected Answers	Marks	Additional Guidance
11	**a**	**i**	current remains at zero / constant and then increases rapidly / exponentially / logarithmically (as p.d. increases) changes at p.d. of 1.5 to 1.6 V / threshold	1 1	AW **allow** increases suddenly / quickly / dramatically / **not** just increases **accept** turn on voltage / activation voltage **not** until a certain point / voltage / or other general terms
		ii	(at 50 mA) p.d. is 2.3 V ($P = I\,V$) = 120 (mW) rounded calculation	1 1	**not** 2.4 V **accept** 115 mW ecf on wrong voltage from graph (incl. 2.4 V)
		iii	(electron energy goes) into creating photons	1	**allow** light or heat / thermal **not** k.e.
	b	**i**	If one LED fails then remainder function normally	1	AW **allow** other sensible answers **allow** circuit is low voltage so very safe to operate **allow** reverse argument (assuming series circuit) **not** so resistance is low / so voltage is equal
		ii	12.(1) (W)	1	ecf correct evaluation of 105 x (aii)
		iii	hot filaments produce large amounts of infra-red other colours from the visible spectrum need filtering out	1 1	**allow** more heat **not** just less efficient **not** to raise temperature of filament (a negligible quantity)
		iv	safety aspects – less down time for repair / economic aspects – cheaper to operate / environmental aspects / less global warming / faster response / more directional	1	any sensible suggestion AW **accept** lamp is not as efficient **accept** LED has lower energy consumption **not** easier to see
			Total Question 11:	**10**	
			Total Section B:	**40**	

Question			Expected Answers	Marks	Additional Guidance
12	**a**	**i**	e.g. PET scan of brain tumour	0	**any** useful image sets context **no mark**
		ii	e.g. γ rays consistent with chosen image	1	**allow** ultrasound / electron current in SEM / STEM etc.
			f = 1.2 x 10^{20} Hz must have units	1	appropriate to any e/m / ultrasound
			λ = 2.4 x 10^{-12} m must have units	1	**allow** $\pm$ 1 order magnitude on sensible values of f and λ for that radiation bandwidth e.g. ultrasound (around MHz and mm) **allow** for SEM / STEM e.g. for 10 kV electrons λ (= h / mv) $\approx$ 10^{-11} m f (= $E_{kinetic}$ / h) $\approx$ 10^{18} Hz or wider energy values
		iii	product correctly worked out e.g. 2.9 x 10^{8}	1	expect near light speed for e/m radiation / sound speed in medium (about 1500 m s^{-1}) / electrons around 10^{7} m s^{-1} **allow** ecf on penalised poor estimates for f and λ **allow** appropriate speed for radiation if f and λ blank
			units m s^{-1}	1	**not** only Hz m
		iv	speed of the radiation / speed of e/m / sound	1	**allow** speed of light / speed of waves **not** just speed
	b		e.g. helps doctors to locate and diagnose tumours and prepare treatment programme	1	use must be explicit and specific **not** trivial **not** e.g. taking x-ray photos / identifying health problems **allow** e.g. diagnosing broken bones using x-rays / monitoring foetal development / gender

12	**c**		e.g. see some ideas from : O^{15} tracer isotope / is carried blood sugar / decays by positron emission / positron annihilates with nearby electron / emits a pair of γ photons / These are detected by scintillation crystals / which emit visible photons / amplified by photo-multiplier tubes / Time delay between detection of anti-parallel photons / allows site of γ emission to be computed / stored in computer memory / A slice by slice representation of the brain is built up by this tomographic technique.	3	1/2/3 style allow full credit for a well annotated diagram: 1 will indicate a sensible attempt has been made 2 will indicate the description is satisfactory, but contains errors 3 will indicate the description is essentially correct but perhaps not totally complete – no gross errors for ultrasound expect to see some ideas from : transmitter / receiver / piezoelectric crystal, partial reflection, time delay gives depth of reflection, intensity of reflections indicates change of density / material / voltage at crystal gives intensity / image formed from scan / multiple sources, image formed on screen from greyscale values. **not** gross errors like x-rays reflected

	d		name of image **process** / basic idea e.g. noise removal / smoothing / edge detection / contrast stretch / brightness adjustment / false colour etc. **purpose / improvement** relevant to example: e.g. clearer image by removing random noise pixels / softens boundaries spreads noise / emphasises boundaries / makes invisible details clearer / aids ease of viewing overly dark or bright images / emphasises certain pixel values / ranges pixel value **manipulation** must be correct and relevant to their process:	1 1 1	**not** increase pixel density / magnification / digital zoom / resolution e.g. tomograph images are built from a 3-dimensional array of pixel values, usually in 2-d slices. The usual processing technique is to add false colour. Pixel values within distinct ranges are ascribed a different colour e.g. active sites with pixel values in range 200 – 255 are coloured red, less active sites in range 150 – 199 are coloured yellow etc. Hence an immediately recognisable visual image scan is produced from the invisible γ photon emissions. e.g. noise removal - replace pixel value with median / mean / average of pixel and 8 neighbours edge detection – subtract NSEW pixel values from 4 x central pixel value contrast stretch – map current pixel value range onto full range of pixel values 0 to 255 **accept** x constant value brightness adjustment – add or subtract constant number from pixel values if more than one process mentioned, credit best single process as above
			Total Question 12:	**13**	

Question			Expected Answers	Marks	Additional Guidance
13	**a**		example e.g. USB connection from PC to webcam nature e.g. carrying image info	1	need **two** descriptors for one mark to set context don't worry about distinction between example / nature **allow** email / text / image / sound / voice / fax / fibre optic / radio / tv / mobile phone etc. **accept** analogue / digital information **not** just waves / electromagnetic / light / data or other vague responses
	b	**i**	analogue – sketch of signal showing a continuous variable digital – sketch of signal on 2 discrete levels added quality in words / sketch graphs: e.g. time axis **and** digital levels labelled 0/1 / on/off / high/low / p.d / V / varying mark : space ratio e.g. 00111010100 / statement of continuous variable for analogue	1 1 1	**not** analogue graphs going "backwards in time" **not** digital on more than 2 levels / sloping verticals CON **not** any credit for unidentified sketches third mark for **quality** **not** any credit for advantages of digital over analogue **not** just reference to a continuous signal
		ii	(sampling) regular / periodic measurement of signal (digitising) to nearest level added quality in words / sketch graphs e.g. ascribing binary values for each sample as 000 001 010 etc. on y-axis / digitising showing selection of nearest level / sampling clearly marked sample points /	1 1 1	**allow** words or regular intervals by eye on time axis **allow** words or discrete levels on signal axis third mark for **quality** **not** just turns signal into 0/1's **accept** clear illustration of quantisation errors

		iii	Two examples: e.g. sampling rate / frequency too low insufficient binary levels / lack of resolution / noise corruption during the reconstruction added quality e.g. sampling $f < 2 \times f_{max}$ causes high f loss sampling at low f causes aliasing quantisation errors explained / illustrated noise from voltage spike during reconstruction	1 1 1	**not** just fewer samples **not** noise / attenuation during digital transmission third mark for **quality** description / diagram illustrating the nature of the errors / how they are introduced e.g. showing loss of higher *f* / introduction of spurious low *f* / quantisation error introduced by sampling labelled **allow** full credit from well labelled diagrams
	c		e.g. (live webcam communications not possible) limiting video-conferencing **(1)** These reduce the need to travel **(1)** and so reduce carbon pollution / global warming **(1)**	3	1/2/3 style **accept** advantages / disadvantages credit answers with no physics content 1 will indicate a sensible attempt has been made 2 will indicate the description is satisfactory, but contains errors 3 will indicate the description is essentially correct **max 2** for different example than (a) or no example in (a) **not** any credit for general analogue / digital comparison
			Total Question 13:	**13**	
			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

General advice to Assistant Examiners on the procedures to be used

YOU WILL BE REQUIRED TO UNDERTAKE 10 PRACTICE AND 10 STANDARDISATION SCRIPTS BEFORE STARTING TO MARK LIVE SCRIPTS.

1 The schedule of dates for the marking of this paper is very important. It is vital that you meet these requirements. If you experience problems then you must contact your Team Leader (Supervisor) without delay.

2 An element of professional judgement is required in the marking of any written paper. Candidates often do not use the exact words which appear in the detailed sheets which follow. If the physics is correct and also answers the question then the mark(s) should normally be credited. If you are in doubt about the validity of any answer then consult your Team Leader (Supervisor) by phone, the messaging system within SCORIS or e-mail.

3 Some questions may have a 'Level of Response' mark scheme. Any details about these will be in the rationale, for this paper see 1/2/3 style.

1/2/3 style allow full credit for a well annotated diagram if included:

1 will indicate a sensible attempt has been made with a little relevant physics / comment
2 will indicate the description is satisfactory, but may contain serious errors or omissions
3 will indicate the description is essentially correct

4 If an answer has been crossed out and no alternative answer has been written then mark the crossed out answer.

5 In addition to the award of 0 marks, there is a NR (No Response) option on SCORIS.

Award 0 marks

- if there is any attempt that earns no credit (including copying out the question or some crossed out working)

Award NR (No Response)

- if there is nothing written at all in the answer space
  OR
- if there is any comment which does not in any way relate to the question being asked (eg 'can't do', 'don't know')
  OR
- if there is any sort of mark which is not an attempt at the question (eg a dash, a question mark)

6 Abbreviations, annotations and conventions used in the detailed Mark Scheme.

/ = alternative and acceptable answers for the same marking point
(1) = separates marking points
not = answers which are not worthy of credit

ignore = statements which are irrelevant
allow = answers that can be accepted
( ) = words which are not essential to gain credit
__ = underlined words must be present in answer to score a mark
ecf = error carried forward
AW = alternative wording
ora = or reverse argument

7 Annotations: the following annotations are available on SCORIS.

✓ = correct response placed in script at point of award
✗ = incorrect response placed in script at point where a marking point is lost or gross error occurs
bod = benefit of the doubt
nbod = benefit of the doubt **not** given
ECF = error carried forward
^ = information omitted (can usefully be placed on the question stem to indicate missing part of response)
SF = only penalise on questions indicated, on this paper we are using SF penalty in Q 2(b).

Highlighting is also available to highlight any particular points on the script.

On the **standardisation sample** annotate all questions fully where the mark is **not** NR, 0 or a maximum value for the part question. Once cleared for **live marking**; the following questions should be annotated with ticks (and other annotations) to show where marks have been awarded in the body of the text: 12(c)

8 The Comments box
The comments box will be used by your PE to explain their marking of the practice scripts for your information. Please refer to these comments when checking your practice scripts. You should only type in the comments box yourself when you have an additional object of the type described in Appendix B of the Handbook for Assistant Examiners and Subject Markers.
Please do not use the comments box for any other reason.
Any questions or comments you have for your Team Leader should be communicated by phone, SCORIS messaging system or e-mail.

9 Please send a brief report on the performance of the candidates to your Team Leader (Supervisor) by the end of the marking period. The Assistant Examiner's Report Form (AERF) can be found on the Cambridge Assessment Support Portal. This should contain notes on particular strengths displayed, as well as common errors or weaknesses. Constructive criticisms of the question paper/mark scheme are also appreciated.

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 owtte = or words to that effect ora = or reverse argument

Qn	Expected Answers	Marks	Additional guidance
1 (a)	D ✓	**1**	
(b)	A ✓	**1**	
(c)	D ✓	**1**	
2(a)	1/300 000 ✓$_m$ (= 3.33 x 10^{-6} m) or (10^{-3}/300)	**1**	Be wary of mistakes with units/orders of magnitude. May be done in stages. ora
(b)	using $\lambda = d \sin\theta$ → 3.3 x 10^{-6} x sin 11° ✓$_{m,s}$ acceptable answer range = 6.3 x 10^{-7} to 6.4 x 10^{-7} (m) ✓$_e$ **Sig fig penalty** – lose second mark if more than 3 sf.	**2**	No ecf allowed For the award of both marks correct working must be seen. First mark MUST show use of equation AND correct substitution of values.
3(a)	s = (1011 x 10^3) / 3600 ✓$_{m,s}$ = 280 to 281 (280.83) ✓$_e$ (ms^{-1})	**2**	
(b)	280 (or 300) / 1.4 = 200 to 214.3 (range) ($m s^{-2}$) ✓$_m$ 200 / 9.8 ✓$_m$ = 20.4 to 22 (range)	**2**	ora See possible range of acceptable answers, including use of g=10. Look to award two method marks.
4(a)	λ / v^2 or v^2/λ = **a** constant/ λ / v^2 = k ✓$_m$ 6.0 5.75 5.88 or 0.17 0.17 0.17 ✓$_e$ (inverse values)	**2**	test proposed may be implicit in the working. Test MUST be carried out on all 3 sets of data.
(b)	conclusion consistent with outcome of arithmetic test	**1**	Zero marks for a test that was only carried out on two data sets.

Qn	Expected Answers	Marks	Additional guidance
5(a)	$6.6x10^{-34}x3.0x10^{8}$ /($550x10^{-9}$) ✓$_{m,\ s}$ = **3.6** x 10^{-19} (J) ✓$_{e}$	**2**	(f = 5.45 x 10^{14} Hz) Answer can be in table or after working. In table 10^{-19} not needed.
(b)	Any two from three: ✓✓ white light is a mixture of colours most red and blue (photons) absorbed green (photons) least absorbed or most reflected	**2**	
6(a)	C (acceleration) ✓	**1**	
(b)	A (velocity) ✓	**1**	`
7(a)	period = 36 / 4.5 ✓$_{m}$ = 8 (s) ✓$_{e}$	**2**	4.5 complete waves in 36 s.
(b)	72 (s) ✓	**1**	ecf but can also be awarded independently of (a)
	Section A TOTAL	**22**	

Qn	Expected Answers	Marks	Additional guidance
8(a)			
(i)	wavelength = 0.8 m ✓	**1**	
(ii)	**(using** v = fλ) 320 x 0.8 $✓_{m,\ s}$ = 256 $✓_e$ (m s^{-1})	**2**	ecf
(iii)	**N** and **A** in appropriate positions on Fig.8.1 ✓	**1**	If more than one A, N given they must all be correct
(iv)	waves **reflect** at ends ✓ AW **superposition**/interference occurs ✓ constructive and destructive explicitly linked to A and N ✓	**3**	alternative/equivalent versions to be marked on merit
(b)(i)	Any sensible energy type (eg internal, heat, kinetic, sound etc) **or** any sensible 'destination' (eg supports, inside the wire etc) ✓	**1**	
(ii)	5 x 320 = 1600 (vibrations) $✓_m$ 1600 / 200 = 8 $✓_m$ 0.75^8 = 0.1 $✓_e$	**3**	Take care to follow logic of different approaches, credit appropriately.
	Total	**11**	
9 (a)(i)	sensible **scales** ✓ accurate **plot** ✓ best fit **line** ✓ (for the points plotted)		Must be within the printed graph area. Inaccurate plots (eg shown by deviations from a smooth curve) can still be awarded best fit line mark No numbers on scale gets 3rd mark only
(ii)	initially accelerating / speed increasing ✓ then reaches constant speed/terminal velocity ✓ reasoning based on **either** correct explanation of use of gradients **or** correct detailed description of physical situation (e.g balancing of forces) ✓	**3**	Credit 'decreasing rate of acceleration' as correct reasoning for third mark.
(b)(i)	simple description of use of **<u>distance</u>** & **<u>time</u>** measurements✓ specific statement relating to 80-120cm and/or 3.4-4.2s ✓	**2**	Second marking point is a quality mark for recognising that the measurements are centred around the x=100cm point.

Qn	Expected Answers	Marks	Additional guidance
(ii)	at 100 cm, rate of change / speed /gradient is constant✓ at 40 cm rate of change / speed /gradient is changing ✓	2	or average speed and 'speed' are same (at 100cm) and different (at 40 cm)
	Total	10	
10 (a)(i)	horizontal component = 5.0 sin30° ✓ (= 2.5) vertical component = 5.0 cos30° ✓ (= 4.33)	2	or 5 cos60° or 5 sin60° could use Pythagoras
(ii)	direction of (vertical component of) velocity reversed ✓ velocity is a vector quantity/understanding of change from +ve to –ve direction ✓	2	
(iii)	(considering horizontal component) **stating or using** F = ma ✓$_m$ F = $\frac{0.046 \times (1.8 - 2.5)}{5.0 \times 10^{-3}}$ ✓$_s$ = (-) 6.44 ✓$_e$ (N)	3	accept (u – v) ignore minus sign a= 140 ms^{-2} Accept rate of change of momentum argument
(b)	(v_H =) 3.3 sin25° = 1.39 ✓$_e$ (m s^{-1}) Δv = (-1.39 – (2.5)) = (-) 3.89 ✓$_e$ (m s^{-1}) 3.89 / 0.7 = 5.6 ✓$_e$	3	or 3.3 cos 65° or by $F = m\Delta v/\Delta t$ giving F = 35.83 (N) then (ratio =) 35.83/6.4 = 5.6 or by calculating and comparing accelerations No ecf within question
	Total	10	
11 (a)(i)	**6** phasors drawn tip to tail ✓ (approx same length & **joined** together) resultant phasor **arrow** drawn correctly ✓	2	Penalise 1 mark for completely 'in phase' Accept detached arrow if consistent with phasor direction
(ii)	**6** phasors drawn tip to tail ✓ (approx same length & **joined** together) resultant phasor **arrow** drawn correctly, must be smaller than rpa in (a) ✓	2	Penalise 1 mark for not significantly out of phase.
(iii)	rpa is large for paths close to the direct path ✓ **probability** of photons arriving α (rpa)^2✓	2	

Qn	Expected Answers	Marks	Additional guidance
(b)(i)	diffraction ✓	1	
(ii)	H **4** 0.16 32 G 0 0 0 F 1 **0.01** 2 ✓✓	2	
	Total	9	
12 (a)(i)	Appropriate experiment (eg Young's Double slit) or effect resulting from superposition (eg fringe pattern, colours on soap bubbles) ✓	1	
(ii)	appropriate wavelength ✓ correct unit ✓ No marks are being awarded for speed – ignore any answers	2	Acceptable range of values Light 10^{-6}m – 10^{-9}m Sound cm – 10m
(b)	clear labelled diagram ✓✓✓ …with some omissions or errors ✓✓ …. for some attempt made ✓	3	3 / 2 / 1
(c)	**Annotation is required on this section for all scripts.** for 3 separate relevant and correct observations ✓✓✓ for explanation in terms of superposition ✓✓✓	6	For high quality answers can award up to two marks for an explanation of one observation.
	Total	12	
13	**In order to ensure consistency between parts (a), (b) and (c) it is suggested that part (c) is scrutinised first.**		F=ma answers gain no credit for section (a), (b) & (c)
(a)	Appropriate measurements, eg distance travelled ✓ time taken ✓ (or final speed and distance travelled, or final speed and time taken)	2	Penalise a mark for each omission
(b)	eg (metre) ruler ✓ clock ✓ and precisely what will be measured with them. ✓✓	4	method of measurement must match quantities to be measured i.e. distance from A to B NOT just distance.

Qn	Expected Answers	Marks	Additional guidance
(c)	eg using $s = {}^1/_2at^2$ ✓$_m$ rearrangement $a = 2s/t^2$ ✓$_m$ or $v = u + at$ rearrangement $a = (v-u)/t$; or $v^2 = u^2 + 2as$ rearrangement $a = (v^2-0)/2s$)	**2**	Watch out for incorrect use of average velocity used as v - this can still get credit in (a) and (b) Award 2 marks for stating directly a=(v-u)/t
(d)(i)	credit two factors (reaction time/ parallax/etc as appropriate to method) ✓✓ which would introduce uncertainties into the **method**	**2**	not friction/air resistance. unless using the F=ma approach.
(ii)	sensible precautions to take to reduce uncertainty/error, or improvement in technique / instrumentation. ✓✓	**2**	Sensible suggestion for both, or quality answer for improving one method.
Qo WC	**Total** ✓✓✓✓	**12** **4**	
	Section C TOTAL	**28**	

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.

2863/01 Rise and Fall of the Clockwork Universe

Qn	Expected answers	Marks	Additional Guidance
1(a)	s ✓	**1**	
1(b)	J ✓	**1**	
1(c)	s^{-1} ✓	**1**	
2(a)	$m = p/v$ = 3.5 /45 ✓ = 0.078	**1**	accept 0.077
2(b)	v= 3.5/0.20 = 17.5 ✓m s^{-1}	**1**	17.7 m s^{-1} if 0.078 kg used
3(a)	Q = 470 x 10^{-6} x 12 ✓ = 5.6(4) mC	**1**	Check correct power of ten
3(b)	Q = 470 x 10^{-6} x 10 = 4.7 mC ✓ ΔQ = 5.6 – 4.7 ✓ mC = 0.9 mC	**1** **1**	Or $\Delta Q = C\Delta V$ or implicit✓ Correct evaluation✓
3(c)	**Rate** of flow of charge/discharge or current **falls** (with time) ✓ AW	**1**	Beware experimental error explanations Accept $I = V/R$ and V falls $I = \Delta Q/\Delta t$ not sufficient
4(a)	speed = $2\pi r/T$ = 2xπx2.2/1.7 ✓= 8.1 m s^{-1}	**1**	
4(b)	F = mv^2/r✓ = 7.3 x 64/2.2 = 210 N✓	**2**	212 N if 8.1 m s^{-1} used 219N/220N if carried forward from 4a. Equation can be implicit. No sf penalty. Ecf allowed. No marks for centripetal acceleration alone
5	Energy released = 150 x 3350 x 55✓ = 28 MJ ✓	**2**	Accept 27.6 MJ etc
6(a)	Eg. Lower viscosity (AW), higher temperature, larger hole size, hole lower in can, can of smaller diameter (same volume of liquid -> greater height of liquid) ✓	**1**	**More** dense acceptable
6(b)	Value from graph = 7.7. ✓ (range: 7.0 -> 9.0) ϕ = 0.693/7.7 = 0.09✓ s^{-1} ✓	**3**	Other values can be found from graph – final answer in range 0.077 – 0.099
7(a)	5 Hz ✓	**1**	
7(b)	Peak at lower f ✓	**1**	Ignore reference to amplitude
8(a)	• Reduced drag ✓as fewer collisions between rocket and particles in atmosphere✓ • Less fuel/energy needed ✓as less air resistance/drag✓ • Greater acc/velocity ✓as less air resistance/drag ✓	**2**	Suggestion/explanation pairs needed for two marks. Do not accept 'friction'.
8(b)	Uniform gradient ✓	**1**	'straight line' acceptable
8(c)	Using mgΔh with const. g✓: 3800 x 9.7 x 90 x 10^3 ✓= 3.3 x 10^9 OR: mΔV_g ✓ and correct calculation✓	**2**	3.32 x 10^9 for calc. 3.34 x 10^9 from graph Equation can be implicit
8(d)	Net force = 74 x 10^3 – (9.7 x 3800) = 37140 N. ✓a = 37140/3800 = 9.8 m s^{-2} ✓	**2**	Or more elegant method.

Qn	Expected answers	Marks	Additional Guidance
8(e) (i)	p.e. gain = k.e. loss. ✓ Lower k.e. -> lower speed✓ OR: force acting towards Earth/weight✓ Opposes motion✓	**2**	
(ii)	'Outside' atmosphere (2 marks max) • only force is gravity. • Passengers and craft experience same acceleration • An object inside the craft will not be accelerated towards one region of the craft. • No reaction force between craft and passengers In thicker atmosphere (2 marks max) • Collisions/air resistance with craft cause an accelerating/decelerating force • Passengers do not experience this force inside the craft • Passengers experience a different acceleration to that of the craft • Passengers will be accelerated towards one region of the craft/passengers move 'forward' as craft slows down. •	**2** **2**	High quality of explanation of reappearance of weight on re-entry can gain 4 marks.
9(a)	Acceleration towards eqm position.AW ✓	**1**	
9(b)	Finding $f = 1/2\pi \times (k/m)^{0.5}$ clearly using equations given✓ Correct substitution ✓evaluating to 0.83 Hz ✓	**3**	$a = 5.5\ ms^{-2}$ worth one mark.
9(c) (i)	Sum of energies is ~ 0.8 J✓ AW	**1**	Obvious (possibly implicit) ref to KE and PE
(ii)	Total energy = ½ kA^2 = 20.5 x 0.04✓ = 0.82 J✓ OR: Two or more pairs values from graph✓ and sum. ✓	**2**	One mark for one summed pair
(d)	Total energy is proportional to A^2 ✓the amplitude has increased by a factor of 1.4, 1.4^2 is 2 ✓so energy will double. OR: 1.4 x max amplitude gives 1.4 x max velocity ✓which gives 2 x max k.e. ✓	**2**	Can compare 0.20^2 with 0.28^2 for second mark. Arithmetic with no explanation gives one mark.
(e)	No change in total energy ✓ peak (energy) would decrease ✓ if oscillation (sufficiently) damped	**2**	No marks for amplitude. Accept pictorial explanation

Qn	Expected answers	Marks	Additional Guidance
10 (a) (i)	$PV = nRT$✓ ->$n = PV/RT$ = 1.2 x 10^5 x 1/8.3 x 300 ✓= 48.2 mol	2	Clear working or own value.
(ii)	48 x 6.0 x 10^{23} ✓= 2.88 x 10^{25}	1	48.2 gives 2.89 x 10^{25}
(b)	pV = 1/3Nm c^2 c = $(3pV/Nm)^{0.5}$ = (3 x 1.2 x10^5x 1/2.9 x 10^{25} x3.3 x 10^{-27})$^{0.5}$ ✓= 1939✓	2	$v_{rms} = (3kT/m)^{0.5}$ = (3 x 1.4 x 10^{-23} x 300/3.3 x 10^{-27})$^{0.5}$ ✓= 1950✓ Can equate kinetic energy to kT giving 1600 m s^{-1}
(c)	volume = Avt = 6.5 x 10^{-19} x 2000 x 1 = 1.3 x 10^{-15} ✓ no. in volume v = 1.3 x 10^{-15} x 2.88 x 10^{25} = 3.7 x 10^{10} ✓	2	Answer = 3.8 x 10^{10} if 2.9 x 10^{25} is used
(d)	Eg: higher temp -> higher v -> more collisions (per second) or vice versa Eg: lower pressure/density ->fewer molecules m^{-3} /greater intermolecular distance -> fewer collisions (per second) or vice versa	2 2	State (higher temp) to correct conclusion gives 1st mark, middle step gains second Need direction of change for two marks. State (lower pressure) to correct conclusion gives 1st mark, middle step gains second Don't award the same physics twice.
(e)	Many collisions give many chances to 'get lucky' ✓so give some particles sufficient energy to ionise ✓AW	2	
11 (a) (i)	Increase in wavelength of radiation ✓	1	Not shift to red
(ii)	Wavelength increases as space expands✓ light from more distant galaxies has been expanding for a longer time/distance ✓ AW	2	Can gain (ai) mark here Beware fudge
(b)	Values/s^{-1}x 10^{-18}: 2.21,2.17,2.20✓ Mean: either 2.2 x 10^{-18} or 2.1 x 10^{-18}✓ Valid explanation✓	3	2 sf fine
(c) (i)	1/ 2.2 x 10^{-18} = 4.5 x 10^{17} ✓ = 1.4 x 10^{10} ✓years	2	
(ii)	• galaxies were not formed at the beginning of the Universe✓ • variation of Hubble constant/expansion rate✓ • variation in data✓	1	

QWC on 8 (a), 8 e(i) & (ii), 10 (d), 11 (a)

2864/01 Field and particle Pictures

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.

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. Ticks should **not** be placed in the right-hand margin. 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 ($^1/_2$) 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.

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

4 The marks awarded for each part question should be indicated in the right-hand margin. The mark total for each double page should be ringed at 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, mark the first answers up to the total required. Strike through the remainder.

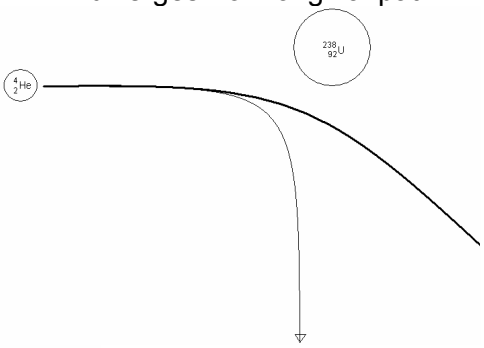
6 The mark awarded for Quality of Written Communication in the margin should equal the number of ticks under the phrase.

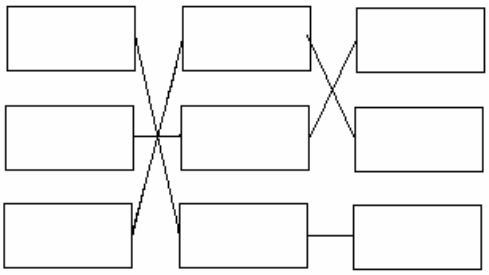
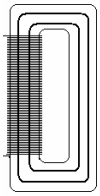
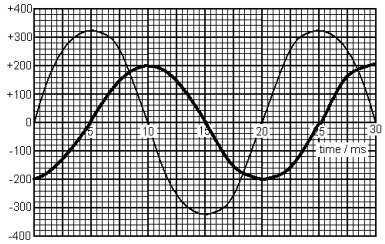
7 Correct answers to calculations should obtain full credit even if no working is shown, unless indicated otherwise in the mark scheme.

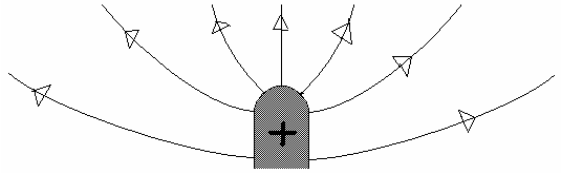
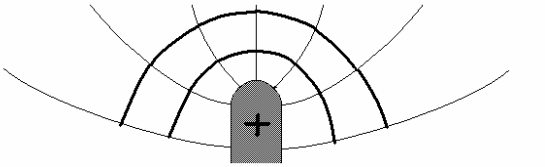
8 Strike through all blank spaces and pages to give a clear indication that the whole of the script has been considered.

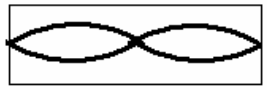
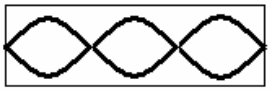
The following abbreviations and conventions are used in the mark scheme:

m = method mark
s = substitution mark
e = evaluation mark
/ = alternative correct answers
; = 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
ora = or reverse argument
eor = evidence of rule

1	**(a)**	Bq	**1**
	(b)	J kg^{-1} NOT Gy	**1**
2		any of the following, maximum [2] • stronger magnet • reduced air gap • shorter iron loop / magnetic circuit • thicker / fatter core • increase all dimensions • use higher permeability / softer magnetic material in core NOT more turns of wire / increase rotation speed / larger or smaller core / laminated core / more current in the coil ACCEPT permeance instead of permeability	**2**
3	**(a)**	all of the following for [1] • same initial path (by eye) • gets closer to the nucleus • diverges from original path	**1**
	(b)	 	**1**
4	**(a)**		**1**
	(b)	accept × as not being a tick ✓ (paper) is a poor conductor of flux / has low permeability / is not magnetic / puts a gap in (magnetic) circuit; ACCEPT air gap / low permeance so less flux / flux density / magnetic field / field lines / field strength; NOT weaker electromagnet NOT no / zero flux	**1** **1**

5		total dose equivalent = $0.05\times10^{-3} \times 120 = 6\times10^{-3}$ Sv risk = $6\times10^{-3} \times 3 = 1.8\times10^{-2}$ % (ACCEPT 1.8×10^{-4} with no percent sign) one error for ecf.: 9×10^{-3} %, 3×10^{-4} %, 18% for [1]	**1** **1**
6	**(a)**	C	**1**
	(b)	D	**1**
	(c)	A **c**an **d**avid **a**ct?	**1**
7	**(a)**	mass loss = $0.018884 \times 1.66\times10^{-27} = 3.13\times10^{-29}$ kg $E = mc^2 = 3.13\times10^{-29} \times (3.0\times10^8)^2 = \underline{2.8}\times10^{-12}$ J correct method (calculate any mass change in kg, apply $E=mc^2$) correct answer	 **1** **1**
	(b)	nuclei must get close (for reaction) / nuclear forces are short range large potential energy when nucleii are close / large amount of work done against (coulomb) repulsion NOT the nuclei repel	**1** **1**
8		left-hand links correct right-hand links correct 	**1** **1**
9	**(a)**	 inside the core, all the way round, and not touching	**1**
9 (b)	**(i)**	sinusoidal waveform, correct period, constant amplitude all the way across (by eye) lead or lag by 90° (by eye) 	**1** **1**
	(ii)	$\varepsilon = \frac{d(N\Phi)}{dt}$ area (under curve) = $\varepsilon dt = d(N\Phi)$ (owtte) flux linkage goes from peak to zero (in first 5 ms)	**0** **1** **1**

9 (b)(iii)	accept triangle approximation for area, or count squares eg area = 0.5 × 320 V × 5×10^{-3} s = 0.8 Wb evidence of measuring / calculating area from graph ACCEPT correct integration of a sine function area = 1.00 Wb ± 0.25 Wb ecf: Φ = 1.0 / 920 = 1.1×10^{-3} Wb (from 1.4×10^{-3} to 0.8×10^{-3}) ACCEPT correct answer within range by any method for [3]	 **1** **1** **1**
(c)	output = 230 × (115/920) = <u>28.8</u> V because transformer rule $V_p/V_s = n_p/n_s$ applies	**1** **1**
(d)	any of the following points, [1] each: • reduces eddy currents in the core • which waste energy / reduce flux / reduce emf • caused by emf induced in the core • by changes of flux • glue increases (electrical) resistance of the core • high permeability of iron • increases / guides flux	**4**
10 (a)(i)	pointing away from needle on all lines 	1
(ii)	curves approximately as shown (ACCEPT dotted lines) crossing all relevant field lines at right angles (by eye) 	1 1
(iii)	closest spacing of <u>field</u> lines ACCEPT closest spacing of equipotentials if clear from their diagram	1
(b) (i)	$E = V/d$ (or equivalent rule stated explicitly) $V = 5.0\times10^{6} \times 2.6\times10^{-6}$ (= 13 V)	1 1
(ii)	$E_k = QV$ (or equivalent rule stated explicitly) $E_k = 1.6\times10^{-19} \times 13 = \underline{2.08}\times10^{-18}$ J	1 1
(c)	any of the following, [1] each • electrons have negative charge • electrons are attracted towards dust • electrons can move through conductors • forming a layer of negative charge at surface of conductor • attractive force between opposite charges	4

11 (a)	 n = 2  n = 3	**1**
(b)	momentum-wavelength relationship: eg $p = \frac{h}{\lambda}$ wavelength-n relationship: $\lambda = 2d/n$ substitution (and manipulation): $E = \frac{(nh/2d)^2}{2m} = \frac{n^2h^2}{8md^2}$	**1** **1** **1**
(c)(i)	$E = n^2 \times (6.6\times10^{-34})^2 / 8 \times 9.1\times10^{-31} \times (0.30\times10^{-9})^2$ $E = n^2 \times 6.65\times10^{-19}$ J and correctly evaluated once line drawn at $4 \times 6.65\times10^{-19}$ = **27**$\times10^{-19}$ J (by eye) line drawn at $9 \times 6.65\times10^{-19}$ = **60**$\times10^{-19}$ J (by eye) ACCEPT correct lines with no calculation for [3]	**1** **1** **1**
(c)(ii)	$E = hf$, $f = c/\lambda$ $E = hc/\lambda = 6.6\times10^{-34} \times 3.0 \times10^{8} / 500 \times10^{-9} = 4(.0)\times10^{-19}$ J smaller than any <u>difference</u> of energy levels / energy <u>gap</u> photons can only be absorbed if they match the difference between energy levels	**1** **1** **1** **1**
12 (a)	$^{235}_{92}U + ^{1}_{0}n \rightarrow 4\,^{1}_{0}n + 2\,^{116}_{46}Pd$ four neutrons on rhs, one neutron on lhs, with correct symbols proton number of uranium 92 (IGNORE the rest)	1 1
12 (b)(i)	$V = kQ/r$ $Q = 46e$ (= 7.36×10^{-18} C) $V = 9.0\times10^{9} \times 46 \times 1.6\times10^{-19} / 1.5\times10^{-14}$ = <u>4.4</u>$\times10^{6}$ V	0 1 1
(ii)	$E = QV$ ecf incorrect V: $E = 46 \times 1.6\times10^{-19} \times 4.4\times10^{6} = 3.24\times10^{-11}$ J ecf incorrect E: $E = 3.24\times10^{-11} / 1.6\times10^{-19}$ J = 2.0×10^{8} eV ecf: 4 MV gives 2.94×10^{-11} J and 1.8×10^{8} eV for [3]	1 1 1
(c)	each fission must trigger one other fission (on average) EITHER neutrons may be lost before they reach another uranium nucleus OR absorbed by something else OR fail to trigger a fission when absorbed OR going too fast to be absorbed	1 1

Marking quality of written communication

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

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

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

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

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

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

2865 Advances in Physics

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 forwar*d: 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.

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.

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, (eg '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	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 owtte = or words to that effect ora = or reverse argument

Qn	Expected Answers	Marks	Additional guidance
1 (a)	(i) transverse ✓ (ii) dark bit gets light /changes✓; happens twice in the rotation/ dark-light change happens when rotated by 90° ✓	**1** **2**	
(b)	(i) compass indicates magnetic N ✓ geographic N is different ✓ (ii) Difference in direction slight in Europe further S owtte✓ Comparison of angles ✓ (iii) realising that vertical component is significant ✓; needle pointing down will stick/ not free to rotate owtte✓	**2** **2** **2**	Angles can be inferred from distances between poles and to Europe. First mark is 'components', second is 'consequence'
	Total:	**9**	
2 (a)	One similarity: eg results in force on appropriate object, can be represented by field lines, both vector quantities✓ One difference: eg *E* acts on all charges, *B* only on moving charges ✓	**2**	Answer must be about field not cause of field
(b)	loop through C ✓ ; loop through E ✓; N pole & S pole along axis AB ✓	**3**	Complete loops, roughly symmetrical left/right, not crossing axis AB – loops should follow arrows. Ignore arrows added by candidates.
(c)	Compass lies along flux line (could be drawn) ✓; Solid (iron) is better 'conductor' of flux than air ✓; Flux lines take shortest path through hole✓; (any two points)	**2**	Allow ideas of attractive force to continent.
	Total:	**7**	

Qn	Expected Answers	Marks	Additional guidance
3 (a)	Correct choice/use of $F = \frac{GMm}{R^2}$ or $g = \frac{GM}{R^2}$ ✓ $M = \frac{R^2F}{Gm} = \frac{(6.4\times10^6)^2 \times 9.8\,(\text{ecf})}{6.7\times10^{-11}\times1} = 5.99\times10^{24}$ kg $\approx 6 \times 10^{24}$ kg ✓s✓e	3	
(b)	(i) $V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi \times (3.5\times10^6)^3 = 1.8\times10^{20}\ \text{m}^3$ $\approx 2\times10^{20}\text{m}^3$✓	1	
	(ii) $M = \rho V$ = 11 000 × 1.8 × 10^{20} = 2.0 × 10^{24} kg ✓	1	In (ii), use of $2\times10^{20}\text{m}^3$ gives 2.2 × 10^{24} kg
(c)	$V_{(\text{crust + mantle})}$ = 1.0 × 10^{21} – 1.8 × 10^{20} = 8.2 × 10^{20} m^3 ✓ M = 6.0 × 10^{24} – 2.0 × 10^{24} = 4.0 × 10^{24} kg ✓ ρ = 4.0 × 10^{24} / 8.2 × 10^{20} = 4900 kg m^{-3} ✓	3	e.c.f from (b) if necessary. $2\times10^{20}\text{m}^3$ and 2.2 × 10^{24} kg give 4750 kg m^{-3}
	Total:	**8**	
4 (a)	Any reference to change in speed✓ Any stated difference between P & S waves (eg S transverse & P longitudinal, P faster than S)✓; Effect related to change in mantle properties (egstiffness or density) with depth✓	3	Mark (i) and (ii) as one block of 3 marks
(b)	(i) $v_S = \sqrt{\frac{E}{\rho}} = \sqrt{\frac{5.0\times10^{10}}{3200}} = 3950\ \text{m s}^{-1} \approx$ 4000 m s^{-1}✓	1	
	(ii) $v_S \uparrow \Rightarrow$ ratio $E/\rho \uparrow$ ✓ E must have a greater percentage increase than ρ for this to be true. ✓	2	ratio E/ρ determines v✓ reason for greater fractional change in E✓
(c)	$v_P = \sqrt{\frac{7}{3}} \times 4000 = 6110\ \text{m s}^{-1} \approx 6100\ \text{m s}^{-1}$✓m ✓e Sig Fig error applies for >3 s.f.	2	Can do arithmetically with E, ρ from (b)(i). Using 3950 m s^{-1} [from (b)] gives 6000 m s^{-1}.
(d)	(i) normal drawn along radius (judge by eye) ✓; angles indicated clearly ✓	2	
	(ii) slowing down at boundary ✓; speed change must imply a different material✓	2	'at boundary' shows abrupt change. Allow 'as it enters the core'.
	Total:	**12**	

Qn	Expected Answers	Marks	Additional guidance
5 (a)	(i) $n = 1.0 \times 10^{23}$ kg/(56×10^{-3} kg) = 1.8×10^{24} mol $\approx 2 \times 10^{24}$ mol ✓m ✓e (ii) Total energy = $1.5 \times 10^{4} \times 2 \times 10^{24}$ J = 3×10^{28} J ✓ $t = 3 \times 10^{28} / 9 \times 10^{12}$ s = 3.3×10^{15} s = $3.3 \times 10^{15} / 3.2 \times 10^{7}$ years = 1.04×10^{8} years ✓m ✓e (iii) Earth is much older than 100 million years, so this method would have resulted in much more solidifying (if energy was lost at this rate). ✓	**2** **3** **1**	Must calculate out for second mark. 1.8×10^{24} mol gives 2.7×10^{28} J and 9.3×10^{7} years
(b)	(i) first row (about 1/10, slightly less than 1/2) ✓ (ii) λ for K-40 = ln(2)/($1.3 \times 10^{9} \times 3.2 \times 10^{7}$) =$1.7 \times 10^{-17}$ s^{-1} ✓ activity = $\lambda N = 1.7 \times 10^{-17} \times 8 \times 10^{41} = 1.3 \times 10^{25}$ s^{-1} ✓ energy released $s^{-1} = 1.3 \times 10^{25} \times 7.7 \times 10^{-14}$ $= 1.0 \times 10^{12}$ W ✓ This is about 10%/a considerable fraction of the total owtte ✓	**1** **4**	last mark depends on correct method used.
	Total:	**11**	
6 (a)	Using Faraday's Law of Electromagnetic Induction, $N = 1$ and $\Phi = BA$ The flux density is constant $A = xL$ velocity is rate of change of displacement	**3**	Put × by each incorrect placement. 5 right: ✓✓✓ 3 right: ✓✓ 2 right: ✓
(b)	Reason: (i) core could be solid ✓ rotation slow ✓ Explanation: no 'moving conductor'✓ very little rate of change of flux ✓	**2**	Accept 2 reasons, or 1 reasons + explanation for either planet
	Reason: (ii) conducting metallic mantle ✓ rotation very rapid ✓ Explanation: very large currents to produce field✓ very large rate of change of flux ✓	**2**	Can treat as electromagnetic machine of smaller (V) / larger (J) scale for one mark in each case.
(c)	Complex interactions within the earth's core owtte✓ More detail, eg complications due to large volume of core, many layers, combination of Earth's rotation with convection. ✓	**2**	(First mark is a straight quote from the article.) Allow Geodynamo deep inside Earth ✓ not able to investigate experimentally ✓
	Total:	**9**	

Qn	Expected Answers	Marks	Additional guidance
7 (a)	(i) 99 above and 42 below✓ (ii) (anti)neutrino ✓	1 1	
(b)	(i) $140\times10^3 \times 1.6\times10^{-19} = 2.24 \times10^{-14} \approx 2.2 \times 10^{-14}$ ✓m ✓e (ii) $\Delta m = E/c^2 = 2.2\times10^{-14}/(3.0\times10^8)^2 = 2.4\times10^{-31}$ kg✓m ✓e (iii) Radiation not absorbed by patient and so more available for detection / less damage to patient ✓	2 2 1	(iii) reason needed.
(c)	Mass of patient= 65kg Assumption for calculation on energy absorbed: assume all photons absorbed/distributed over all 65 kg ✓ Energy absorbed = $400 \times 10^6 \times 2.2 \times 10^{-14} \times 6 \times 3600$ = 0.19 J ✓m ✓e Absorbed dose (= dose equivalent here) = 0.19 /65 = 3.0×10^{-3} Sv (< 20 mSv) ✓	4	
(d)	(i)To protect radiographer/nurse who administers the treatment frequently ✓ (ii) Dense/small half-thickness for gammas because needs to absorb gamma radiation ✓	1 1	Needs reason
	Total:	13	
8 (a)	(i) $k = F/x = (0.8 \times 9.8)/ 0.2 = 39 \approx 40$ N m^{-1} ✓m ✓e (ii) $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.8}{40}} = 0.89$ s $\approx$ 0.9 s✓m ✓e	2 2	
(b)	(i) $E_k = eV = 1.6 \times 10^{-19} \times 3000 = 4.8 \times 10^{-16}$ J $\frac{1}{2}mv^2 = E_k \Rightarrow v = \sqrt{(2 \times 4.8 \times 10^{-16}/9.1 \times 10^{-31})}$ $= 3.24 \times 10^7 \approx 3 \times 10^7$ m s^{-1} ✓m ✓e (ii) 5 parallel lines, possibly convex at edges✓ arrows upwards✓ (iii) Horizontal: Constant velocity /no force ✓ Vertical: constant force / acceleration ✓ (iv) f = 1/T = 1/0.89 s = 1.1 Hz✓	2 2 2 1	0.9 s also gives 1.1 Hz

Qn		Expected Answers	Marks	Additional guidance
(c)		(i) Any reasonable two factors, eg pressure of gas, mass/weight of car, temperature of gas, volume of vessel, area of piston. ✓ (ii) Suggestion✓ and explanation ✓ eg gas at higher pressure; greater resistance to increase in pressure/smaller vessel; pressure increases more rapidly (iii) $pV = nRT$ implies pV = constant if T does not change. ✓ 9 $\times 10^5 \times 1.0 \times 10^{-3} < 3.0 \times 10^5 \times 0.75 \times 10^{-3}$ m^3 so nRT has increased, meaning T has increased ✓m✓e	**2** **2** **2**	✓ per factor. Allow 'density of gas' on grounds of higher p increases ρ for air.
		Total:	**17**	
Quality of Written Communication: use pages 2 – 6. **Criteria are on the following page**			**4**	

QWC Marking quality of written communication

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

Grade Thresholds

Advanced GCE Physics B (Advancing Physics) (3888/7888)
June 2008 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2860	Raw	90	62	54	46	39	32	0
	UMS	100	80	70	60	50	40	0
2861	Raw	90	62	55	48	41	35	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
2863A	Raw	127	98	88	78	68	58	0
	UMS	100	80	70	60	50	40	0
2863B	Raw	127	98	88	78	68	58	0
	UMS	100	80	70	60	50	40	0
2864A	Raw	119	91	81	71	62	53	0
	UMS	110	88	77	66	55	44	0
2864B	Raw	119	91	81	71	62	53	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	61	55	49	43	37	0
	UMS	90	72	63	54	45	36	0

Specification Aggregation Results

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

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

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

	A	B	C	D	E	U	Total Number of Candidates
3888	24.3	43.9	63.3	79.6	91.0	100	6942
7888	32.3	54.0	73.5	88.2	97.3	100	5166

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.

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

OCR Customer Contact Centre

14 – 19 Qualifications (General)
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553