OCR
RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 7888**

Advanced Subsidiary GCE **AS 3888**

Combined Mark Schemes And Report on the Units

January 2006

3888/7888/MS/R/06J

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CONTENTS

Advanced GCE Physics B (Advancing Physics) (7888)

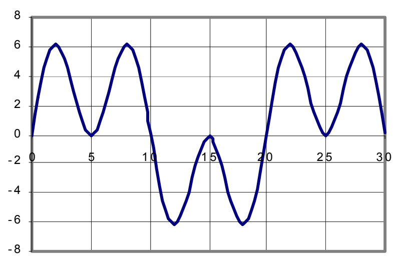
Advanced Subsidiary GCE Physics B (Advancing Physics) (3888)

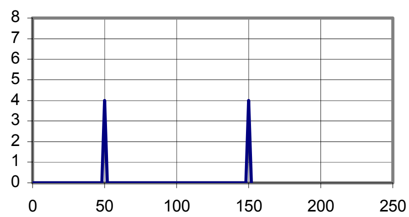
MARK SCHEMES FOR THE UNITS

REPORT ON THE UNITS

Mark Scheme 2860
January 2006

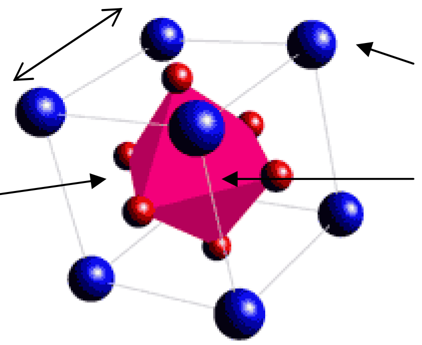
Qn	Expected Answers	Marks	Additional guidance
	Section A		
1	strong ; brittle	2	either order !
2(a) (b) (c)	Angle i = 30 $\pm$ 1° sin$C$ = (1/n) ; C = sin^{-1} (1/n) / = sin^{-1} (1/ 2.4) C = 24.6° t.i.r. ray r = i by eye	1 2 1 1	mark (a) then (c) formula ; method (algebra / numbers) evidence of evaluation ecf on correct refracted ray consistent with (a)
3(a) (b)	Area of chip / Area of cell = 5 x 10^{-5} / (8 x 10^{-15}) = 6.25 x 10^{9} (is greater than 6 Gbits) t = info / rate / = 6.0 x 10^{9} / (2 x 10^{6} x 8) = 375 s / = 400 s (1 s.f.) (accept answers based on 1G = 1.07 x 10^{9} and 1M = 1.05 x 10^{6})	 1 1 1	no method mark only evaluation method: word / number evaluation
4	correct pair of points read from graph correct method based on r = $(\varepsilon - V)/I$ OR $\lvert \Delta V/\Delta I \rvert$ evaluation r = 3.0 $\pm$ 0.2 Ω	1 1 1	use of graph method must be clear evaluation
5(a; b)	(a) greater than (b) equal to equal to less than	2 2	one mark each part one mark each part
6(a) (b)	waveform : signal amplitude = 6 $\pm$ 1 V signal = 0 V at 5 ms and 15 ms (25 ms) correct shape two 4 V peaks at 50 and 150 Hz Total Section A :	1 1 1 1 21	see below as well as 0, 10, 20 ms **see below**

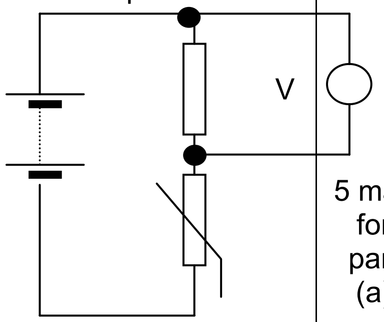




Qn	Expected Answers	Marks	Additional guidance
	Section B		
7(a)	Concave wavefronts showing correct **constant** λ	1	1.3 $\pm$ 0.3 cm
(b)	P = 1 / f / 1/(0.0125) ; = 80 (D)	2	method : words / numbers ; evaluation
(c)(i)	u = ($\pm$) ∞ / 1/u = 0	1	reasoning in algebra / words (curvatures)
	v = 0.0125 / 1/v = 1/f leading to	1	
	v = f	1	
(ii)	1/v = 1/(-2.0) + 80 ; = 79.5	2	method : words / numbers ; substitution ;
	v = 0.0126 m / = 12.6 mm S.F. penalty if not 3 S.F.	1	evaluation to 3 S.F.
(d)	(12.6 - 12.5 =) 0.1 mm is very small distance (so remains in focus for all distances greater than 2.0 m)	1 10	AW for implication of the small change in v
8(ai)	T = 1/f / = 1/(44 x 10^3) ; = 22.7 (μs) OR from graph T = 300 / 13 ; = 23 $\pm$ 1 (μs)	2	method : words / numbers ; evaluation
(ii)	2^{16} = 65536	1	accept 65500
(iii)	range / (levels – 1) / = 16 mV / (65535) allow 65536	1	method : words / numbers ecf on (i)
	(= 2.44 X 10^{-7} V) = 0.24 μV	1	evaluation
(b)	sample rate (bits s^{-1}/ bits $sample^{-1}$ = 64000/8) = 8 kHz / (Nyquist) only reproduces up to half sampling f (4 kHz) / greater quantisation error / poorer resolution / sampling rate too low / aliasing / spurious low f / sensible points about range of human hearing	3 8	one easy mark then expect better avoid crediting same point twice if not developed AW throughout
9(ai)	2(.00) ; 0.67 (penalise use of recurring symbol)	2	allow 0.667
(ii)	sensible scales (>½ axes) ; accurate points ; best fit line	3	ecf on values (i)
(iii)	(graph of G vs 1/ L) is a straight line ; through (0,0)	2	$G \propto 1/L$ gets 2 marks
(bi)	(gradient) = Δy/Δx / = 0.5 / 5.0 ; = 0.1(0) Sm	2	method ; evaluation
(ii)	σ = gradient / A = 0.1/ (2.3 x 10^{-6}) / table values ; = 4.3 x 10^4	2 11	method ; evaluation ora A = 2.5 x 10^{-6} (m^2)
10ai)	$A\,h\,\rho$; $A\,h\,\rho\,g$ ecf on (a) x g ; $A\,h\,\rho\,g\,/\,A$	3	any symbol order
(ii)	greatest / most stress at base / base supports weight of whole column	1	AW
(iii)	A cancels in (i) / A does not appear in stress formula / double area gives double weight but same stress	1	expect mention of A
(bi)	h = stress / ρg / = 2.4 x 10^8 / (2700 x 9.8) ; = 9.1 km	2	method ; evaluation ora σ = 2.38 x 10^8 (Pa)
(ii)	Everest is nearly as high as the yield stress prediction / taller mountains on Earth would crush the base rock ; Mons rock might be less dense ; Mons rock might be stronger / have greater yield stress ; g on Mars less (than Earth) ; same object weighs less ; g on Earth greater ; by x 22/9 (= 2.4) / g on Mars less by ; by x 9/22 (= 0.41)	1 1 1 10	any 3 well argued points NOT just different AW throughout only award same point once
	Section B Total :	39	

Qn	Expected Answers	Marks	Additional guidance
	Section C		
11a)	material named e.g. barium titanate $BaTiO_3$ basics of application e.g. used in capacitors more detail of application e.g. as a di-electric filling	1 1 1	 reward details about application
(bi)	e.g. $BaTiO_3$ is a ferro-electric material. When an electrical field is applied the titanium ions are drawn over to one side of the unit cell causing electrical polarisation of the crystal as a whole; this makes the capacitor more efficient at storing charge.	1 1 1	state relevant physical property ; explain property ; linked to application / structure
(ii)	e.g. $BaTiO_3$ is a good electrical insulator. This is essential between the plates of a capacitor so that discharge does not occur between the charged plates; the capacitor stores charge effectively.	1 1 1	state reason / property; explain reason / prop ; linked to application
(c)	scale of structure given e.g. unit cell ≈ 0.5 nm UP structure diagram 1/2/3 style	1 3	separate scale mark property explained for 3rd quality 1/2/3 mark
		13	



12ai)	context for sensor system e.g. monitors temperature	0	no mark
(ii)	1/2/3 style for circuit diagram 	5 max for part (a)	max 2 marks for active sensor with meter i.e. no potential divider
(iii)	1/2/3 style for explaining how circuit operates e.g. as temperature rises, resistance of thermistor falls, the p.d. across the thermistor falls / p.d. across the fixed resistor rises, giving a greater output p.d. signal.		
(bi)	**sensitivity** is the change of its output divided by the change in input / Δoutput / Δinput **response time** is the time taken for the system to respond to a change.	3	basic definition gets 1 quality definition for either gets 2
	e.g. temperature sensor has a sensitivity of 50 mV °C^{-1} **/** e.g. slow response time caused by the (high) thermal capacity / (low) conductivity of thermistor / estimate for value e.g. 20 s		accept sketch graphs max 3 part (bi)
(ii)	**both** change input e.g. alter the temperature ;	1	
	sens measure the change in physical variable input e.g. with thermometer ;	1	specify instrument
	measure change in output e.g. p.d. across R_{Fixed} **/** **resp** measure time taken for output to reach new value ; plot V(t) graph / known new value guides end of period	1	
(c)	Random error explained e.g. has to do with small unpredictable variations in quantities / for example electrical noise where the error is equally likely to be $\pm$ of the expected value.	1	NOT unexpected
	Systematic error explained e.g. biases in measurement which lead to measured values being systematically too high or too low / or zero error of the instrumentation.	1 13	accept "constant error"
	Quality of written communication	4	
	Total Section C:	30	
	Paper Total:	90	

QWC 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.

Mark Scheme 2861
January 2006

Qn	Expected Answers	Marks	Additional guidance
1 (a)	**D** ✓	1	
(b)	**B** ✓	1	
(c)	**C** ✓	1	
2	using s = vt ✓$_m$ time in s ✓$_s$ halving ✓ (3.4 m)	3	
3	…. getting destructive interference✓ (for red light) because .. waves are in antiphase / path.diff odd no. of half wavelengths (idea) ✓ other colours still there ✓	3	accept argument in terms of phase difference, resultant phasor amplitude and probability
4(a)	$\sqrt{((1.5)^2 + (2)^2)} = 2.5$ ✓$_m$ $\tan\theta = 2/1.5$ ✓$_m$ (or accurate scale drawing ✓$_m$ 2.5 and 53^o shown✓$_m$)	2	
(b)	river flow only affects sideways motion ✓ velocity (component) across river stays the same ✓ (.. greater distance compensates greater speed 1 mark)	2	x and y motions treated independently
5(a)	3 phasors drawn 'tip-to-tail' and correct resultant arrow ✓	1	
(b)	for max resultant phasor = 3 ✓ for ratio = 9 ✓	2	
6(a)	R/M^3 or M^3/R a constant ✓$_m$ carried out on **3** sets of data (0.91 0.90 0.92 or 1.103 1.116 1.091) ✓$_e$	2	proposed test could be implicit in working
(b)	conclusion consistent with test ✓	1	for conclusion consistent with wrong test on 3 sets, [2 mark]
7	**C** ✓	1	
	Section A total	20	

8(a)(i)	using $c = f\lambda$ ✓ substituted into $E = hf$ ✓	2	
(ii)	3.6×10^{-19} (J) ✓	1	
(b)(i)	λ violet is smaller OAW ✓ (then **mechanism** as to **why** θ is smaller) using $\sin \theta = \lambda/d$ or a sketch/diagram ✓	2	accept rotating phasor argument linked to paths
(ii)	$d = (5.5 \times 10^{-7}) / \sin 9.5$ ✓$_m$ = 3.33×10^{-6} m ✓$_e$	2	
(iii)	$1/(3.33 \times 10^{-6})$ ✓$_m$ (= 300086 m^{-1}) converted to mm^{-1} ✓$_e$ **ecf from (b)(ii)**	2	$1/(3.3 \times 10^{-6})$ gives 303030 m^{-1}
(iv)	sig figs in answer should correspond to least number of sig figs in data used ✓ (may justify one more in a calculation)	1	sig. fig. penalty applied at this stage
	total	10	
9(a)	$v = \sqrt{(2x9.8x30)}$ ✓$_m$ = 24.2 m s^{-1} ✓$_e$	2	may be by suvat
(b)(i)	½ x 3.0 x $(24.2)^2$ ✓$_m$ = 878 (J) (24 gives 864) (ecf from (a) ✓$_m$)	1	may use $mg\Delta h$ = 882J
(ii)	**gravitational** potential energy ✓	1	not just 'potential energy' or 'gravitational energy'
(c)(i)	starting from work done by force = Fd ✓ so F = E/d rearranged ✓	2	algebra or words
(ii)	F = 880/10 = 88 (N) ✓$_m$ F2 = 3 x 9.8 ✓$_m$ = 29.7 (N))	2	accept working out 88 / 9.8 and comparing to 3 kg
(iii)	accept ideas such as internal energy in water internal energy in gannet into water pushing water aside/doing work ✓	1	accept 'heat energy' but not just 'into the water'
(d)(i)	buoyancy / drag ✓	1	
(ii)	accept change in density/pressure with depth ✓ drag depends on speed	1	
	total	11	

10 (a)	using $\lambda = c / f$ ✓ using 2.5×10^9 ✓ 0.12 (m) ✓	3	
(b)	microwaves reflect✓superposition/interference occurs ✓	2	
(c)(i)	one wavelength correctly labelled on diagram ✓	1	
(ii)	X and Y marked at displacement antinodes ✓	1	
(d)	more uniform melting / more marshmallows melted ✓ because of passage through the antinodes ✓ OAW	2	credit reference to pattern of melting / idea that melting may take longer and other plausible observations
	total	9	
11 (a)(i)	must start with F = ma idea ✓ ($N = kg\ m\ s^{-2}$)	1	**not** from $F = K\rho Av^2$ and k dimensionless
(ii)	$[K] = \dfrac{kg\ m\ s^{-2}}{(kg\ m^{-3})(m^2)(m^2\ s^{-2})}$ ✓	1	units need not be explicitly cancelled
(iii)	forces balanced (equal) ✓ zero resultant/acceleration ✓	2	
(iv)	start from $mg = K\rho Av^2$ ✓ convincingly **rearranged** to give v ✓	2	
(b)(i)	$A = \pi r^2$ (or $A \propto r^2$) **used** to show why A becomes 4A✓	1	If wrong formula quoted no mark
(ii)	$M \propto V$✓ $V = 4/3\ \pi\ r^3$ (or $V \propto r^3$) **used** to show why V (or M) becomes 8V (or 8M)✓	2	
(c)	$V_{2r} = [(8mg) / (K\rho 4A)]^{1/2}$ ✓ $V_r = [(mg) / (K\rho A)]^{1/2}$ leading to 1.414 or $\sqrt{2}$ ✓	2	accept 'rudimentary' substitution of multiplying factors leading to $\sqrt{2}$
	total	11	
	Section B total	41	

12 (a)(i)	for stating the superposition effect ✓ and saying why it is of interest or of importance ✓	2	
(ii)	for a sensible order of magnitude for the wavelength ✓	1	
(b)	essentially correct ✓✓✓ satisfactory with some error/omission ✓✓ some attempt made ✓ labelled ✓	4	
(c)	for 3 observations that could be made with the apparatus $✓_o✓_o✓_o$ for explanations in terms of wave superposition $✓_e✓_e✓_e$	6	
	total	13	
13 (a)	for stating a quantum phenomenon	1	
(b)	for naming a relevant quantum object	1	
(c)	essentially correct ✓✓✓ satisfactory with some error/omission ✓✓ some attempt made ✓ labelled ✓	4	
(d)	for 3 observations that could be made with the apparatus $✓_o✓_o✓_o$	3	
(e)	for explanations in terms of quantum behaviour $✓_e✓_e$✓	3	
	total	12	
	Quality of Written Communication	4	
	Section C total	**29**	

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

Mark Scheme 2863/01
January 2006

Qn	Expected Answers	Marks	Additional guidance
1(a)	Distance = 3 x 10^8 x 3.2 x 10^7 ✓x 4.3 = 4.1 x 10^{16} m ✓ (1 light year = 9.6 x 10^{15} m worth on mark)	2	
2 (a)	40 000/ 6 x 10^{23} = 6.7 x 10^{-20} J ✓	1	ORA
2 (b)	BF increases with temperature ✓at an increasing rate✓. AW (accept increases exponentially but nor parabolic)	2	
2 (c)	similar origin, steeper curve ✓	1	Curve starts within on or below 0.4 and diverges up.
3 (a)	mv = 0.03 x 500 = 15 ✓	1	Do not accept 15/110.03
3 (b)	v = (+) 15/ 110 = 0.14 m s^{-1} ✓	1	Do not accept 0.13 m s^{-1} Accept 0.1 m s^{-1}
4 (a)	210 x 1.3 = 273 kg ✓ (270 ok)	1	
4 (b)(i)	energy = 273 x 1000 x 7 ✓= 1.9 ✓ MJ (ecf)	2	43 J if 0.006kg 1.1 MJ if 161 kg
4 (c)	e.g. currents taking warm air out of room or other sensible. ✓	1	Specific reason needed.
5a	ΔN = 9.0 x 10^5 x 0.14 s^{-1} ✓ = 1.26 x 10^5 9 x 10^5 - 1.26 x 10^5 ✓= 7.74 x 10^5	1 1	Accept bare values
5b(i)	clear use graph ✓	1	Alternative pairs of lines leading to 4.6 is ok.
5b(ii)	model holds decay rate constant during time interval/ in real life decay rate falls during time interval✓ Make Δt smaller. ✓	2	
6 (a)	E = 1.4 x 10^{-23} x 10^7 = 1.4 x 10^{-16} J ✓	1	As estimate 1x 10^{-16} J ok 2.1 x 10^{-6} ok
6(b)	Energy ratio ✓ = 1667 ✓ Temp ratio ✓= 1667✓ AW	2	Calculating energy of photons at 6000K (= 8.4 x 10^{-20} J) one mark

Section A total: 20

Qn	Expected Answers	Marks	Additional guidance
7a (i)	Q = 4700 x 10^{-6} x 6 = 0.028 C ✓	1	
(ii)	E = ½ x 0.028 x 6 ✓= 0.084 J ✓ ecf	2	0.085 to 2sf
(iii)	I = 6/ 12 000 ✓ = 0.5 mA ✓	2	Or 5 x 10^{-4} A (0.5 A gains one mark)
b (i)	As charge leaves, V on capacitor decreases ✓. Therefore, lower V across resistor✓ and lower I through resistor. AW	2	Can gain second mark through V = IR
(ii)	Time constant = 12000 x 4700 x 10^{-6} ✓ = 56 s	1	
c (i)	1 mA or ecf ✓	1	UNIT PENALTY once in c(i) and (ii)
(ii)	28 s ✓ UNIT PENALTY once in c(i) and (ii)	1	
(d)	Sensible feature✓ linked to correct explanation ✓ Sensible feature✓ linked to correct explanation✓ (Look for following features: sudden rise, slow fall, peak pd of 6V, 10 s period, curved discharge, minimum 4.2/**4**.25/4.4 V.) Accept exponential nature of discharge as an explanation. Look at feature and explanation together.	2 2	e.g. falling to given value of charge linked to time constant. Vertical line at 10 s intervals linked to recharging through low resistance.
8 a (i)	Energy transfer through collisions ✓	1	
a (ii)	c = (3 x 1.4 1.38 x 10^{-23} x 350 /5.85 x 10^{-25})^{½} ✓ =157 m s^{-1}✓	2	If 1.4 x 10^{-23} J K^{-1} used = 159 m s^{-1} 160 m s^{-1} acceptable
a (iii)	Rearranging equation to c = $(3kT/m)^{½}$ ✓ Following through argument to ratio ✓	2	Penalise lack of clarity
a(iv)	$(5.85/5.80)^{½}$ x 159 ✓= 160 m s^{-1} (3sf) ✓	2	157 -> 158 (3sf)
(b)	Travelling faster therefore ✓more attempts per second✓ AW	2	
(c)	Difference in speed small ✓ so almost as many of the more massive particles will diffuse through the barrier (in given time)/ improvement to concentration is small ✓	2	Accept 'some of the massive particles'.
9 (a)	V = (-) 6.7 x 10^{-11} x 6.4 x 10^{23}/6 x 10^{6}✓ = (-)7.1 x 10^{6} ✓J/kg	2	Need own value 7.15 ok, 7.2 is not acceptable
(b)	Potential energy of craft becomes more negative✓ (less) some of this is transferred to KE therefore v increases✓	2	Attractive gravitational force✓ accelerates ✓craft
(c)	Particles collide with craft ✓momentum change of particles exerts decelerating force on craft /transfer energy to particles✓AW	1 1	
(d)(i)	*g = (-) GM/R*^{2} ✓=(-) 6.7 x 10^{-11} x 6.42 x 10^{23}/3400000^{2} ✓= (-) 3.7✓ N kg^{-1}	3	
(d) (ii)	v = (2 x 4.0 x 15)^{½} ✓= 11 m s^{-1} ✓ 10.5 if 3.7 used	2	

Qn	Expected Answers	Marks	Additional guidance
10 (a)(i)	$x = F/k = 0.2 \times 9.8/24$ ✓ $= 0.082$	1	
(a)(ii)	$E = ½ \times 24 \times 0.08^2$ ✓ $= 0.08$ J ✓	2	
(a)(iii)	Change in g.p.e. = 9.8 x 0.2 x 0.08 ✓= 0.16 J ✓	2	
(a)(iv)	Some is transferred to the environment through heating AW ✓	1	Accept motion of air do not accept air resistance
b(i)	gradient of line is zero at this point (turning point)	1	
b(ii)	any point of zero displacement	1	
c (i)	peaks decrease in size ✓ in constant ratio AW ✓	2	
	Quality of Written Communication	4	QWC 7c, 8 b and c, 9 c

Section Total: 50 marks

QWC 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/C) of the paper.

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Mark Scheme 2864/01
January 2006

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.

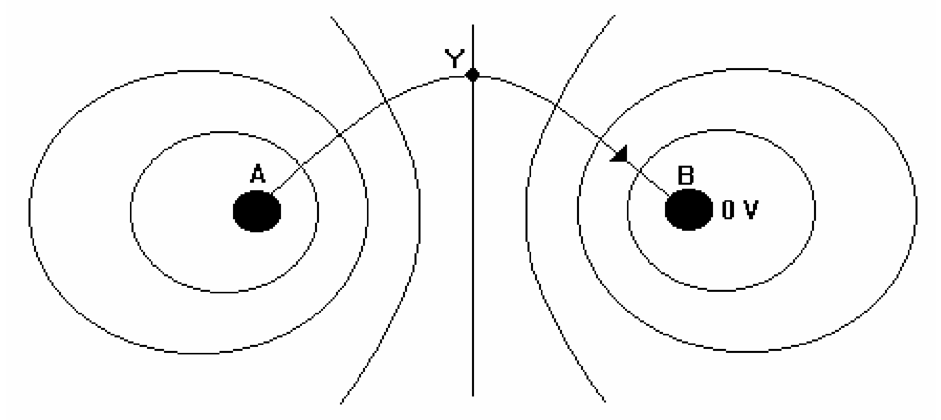
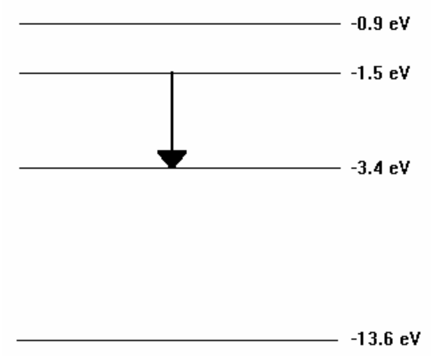
6 The mark awarded for Quality of Written Communication in the margin should equal the number of ticks under the phrase.

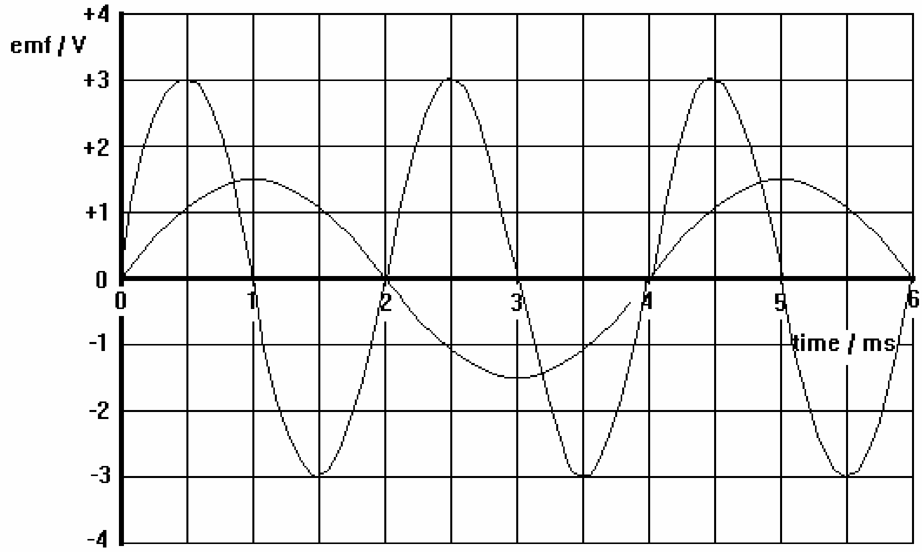
7 Correct answers to calculations should obtain full credit even if no working is shown, unless indicated otherwise in the mark scheme.

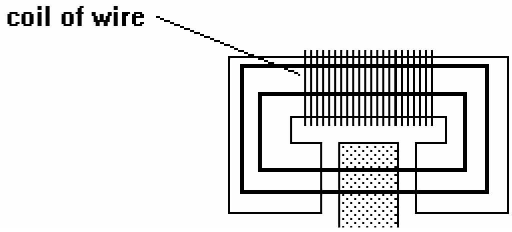
8 Strike through all blank spaces and pages to give a clear indication that the whole of the script has been considered.

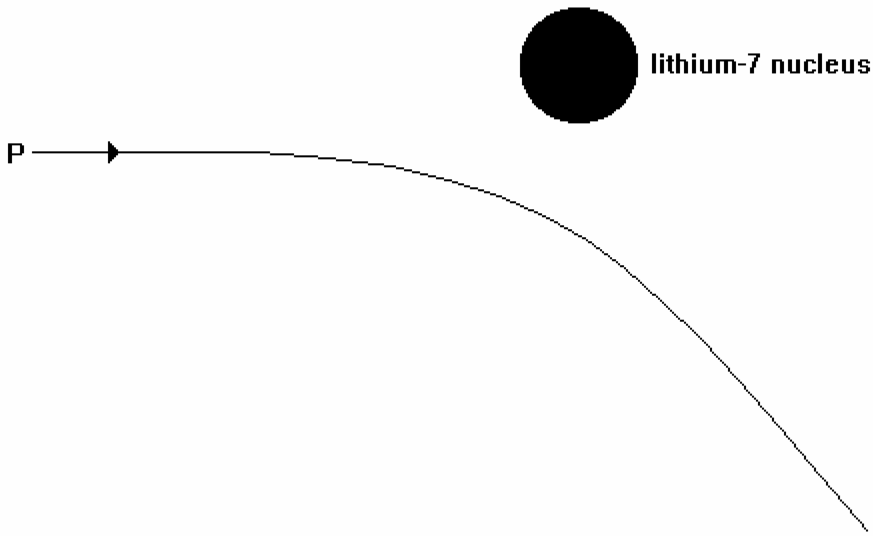
The following abbreviations and conventions are used in the mark scheme:

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

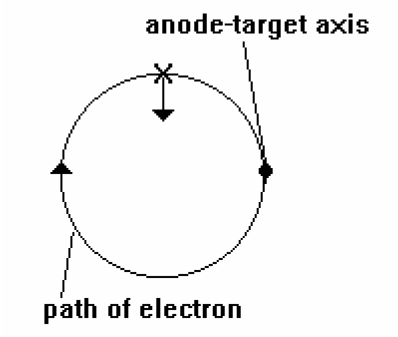
1 (a) 1 (b)	N C^{-1} Wb m^{-2}	1 1
2 (a) 2 (b)	160 kV at right angles to all equipotentials, by eye, from A to B through Y ecf incorrect curve: arrow from A to B ignore lines not through Y 	1 1 1
3 (a) 3 (b)(i) 3(b)(ii)	 must have downwards arrow atom can only sit at an energy level, not in between (wtte) (+)1.8 eV	1 1 1
4	C	1

5 (a)	flux / flux linkage / field (of the iron core / coil) changes (as magnet rotates)	1 1
5 (b)	$40\times10^{-3} \times 25 = 1$ s or equivalent calculation	1
5 (c)	sine curve with period of 20 ms sine curve with amplitude of 3 V ACCEPT any phase 	1 1
6 (a)	five lines at right angles to plates equally spaced (by eye) (doesn't have to fill the gap) ACCEPT correct edge effects arrows pointing upwards	1 1 1
6 (b)	$E = V / d$ (eor) $V = dE = 5.0\times10^{-2} \times 8.0\times10^{4} = 4.0\times10^{3}$ V	1 1
7	A	1

8 (a)(i)	any of the following, maximum [2] • change of flux • as disc enters or leaves field region • induces emf in disc • low resistance of disc allows current	2
8 (a)(ii)	currents interact with field so as to oppose change of flux ACCEPT eddy currents generate heat [1] work = force × distance [1]	1 1
8 (a)(iii)	slowing down disc decreases <u>rate of change</u> of flux decreasing emf / current	1 1
8 (b)(i)	two non-intersecting loops through the coil of wire staying inside electromagnet except when crossing the disc  	1 1
8 (b)(ii)	(soft / pure) iron results in a large magnetic field / has large permeance / magnetic domains line up easily / conducts flux (wtte)	1 1
8 (c)	any one of the following suggestions and explanations • decrease air gap in electromagnet • to increase value of field / flux / flux linkage • increase number of coils • to increase the value of field / flux / flux linkage • increase size of electromagnet • to increase the field / flux / flux linkage in the disc • add more electromagnets • to create more eddy currents • increase thickness of disc • to lower resistance / increase current • gear up shaft to spin disc faster • increasing rate of change of field / flux / flux linkage • replace disc with material of higher conductivity • to increase the size of the eddy currents	2

9 (a)	correct shape (by eye), overall deflection of 45° (by eye) 	1
9 (b)(i)	Any of the following, maximum [2] • as alpha particle approaches nucleus, potential energy increases • and kinetic energy decreases • closest approach when all KE has been transferred to PE NOT force arguments	2
9 (b(ii)	$E = kQ_1Q_2 / r$ $E = 9\times10^9 \times 3.2\times10^{-19} \times 4.8\times10^{-19} / 4.2\times10^{-15}$ $= 3.3\times10^{-13}$ J	1 1 1
9 (c)(i)	mass change = 10.0011 + 1.0087 - 7.0144- 4.0015 = -6.1×10^{-3} u ecf: mass loss = $6.1\times10^{-3} \times 1.7\times10^{-27}$ (eor) (= 1.04×10^{-29} kg)	1 1
9 (c)(ii)	$E = mc^2$ energy released = $1.0\times10^{-29} \times 9\times10^{16} = 9.0\times10^{-13}$ J ecf incorrect energy released: energy of neutron = $9.0\times10^{-13} + 3.3\times10^{-13} = 1.2\times10^{-12}$ J 1.04×10^{-29} kg gives 1.26×10^{-12} J (accept 1.3×10^{-12} J)	0 1 1

10 (a)	nucleon number He = 4 proton number Rn = 86	1 1
10 (b)(i)	no change in nucleon number, so must have nucleon number of 0 needs charge / proton number of -1 for balance	1 1
10 (b)(ii)	EITHER must be antiparticle which is a lepton to balance lepton number OR needs nucleon <u>and</u> proton numbers of 0	1
10 (c)(i)	any of the following, maximum [2] • gamma have smaller quality factors / ionise less than alphas • gamma may have much lower energy then alpha • many gamma will not be absorbed by body / very penetrating • all alphas will be absorbed by a small mass of tissue	2
10 (c)(ii)	47% of 2.5 mSv per year = 1.18 mSv per year dose rate = $1.18\times10^{-3} / 3.2\times10^{7} = 3.74\times10^{-11}$ Sv s^{-1} $1.0\times10^{-12} \times$ activity $\times 20 / 70 = 3.74\times10^{-11}$ (eor) activity = 131 s^{-1}	1 1 1 0
10 (d)(i)	$\lambda T_{1/2} = 0.69$ $T_{1/2} = 3.8 \times 24 \times 3600 = 3.28\times10^{5}$ s $\lambda = 0.693/3.28\times10^{5} = \underline{2.1}\times10^{-6}$ s^{-1}	0 1 1
10 (d)(ii)	$A = -\lambda N$ $N = 130/2.1\times10^{-6} = 6.2\times10^{7}$ 2.0×10^{-6} s^{-1} gives 6.5×10^{7}	1 1

11 (a)	$eV = 0.5mv^2$ $v^2 = 2 \times 1.6\times10^{-19} \times 350 / 9.1\times10^{-31} = 1.2\times10^{14}$ $v = 1.1\times10^7$ m s^{-1} accept reverse calculation	1 1 1
11 (b)(i)	pointing to centre of circle (by eye)  	1
11 (b)(ii)	$F = Beu$ $F = mu^2/r$ $Beu = mu^2/r$ and manipulation to final answer (accept v for u)	0 1 1
11 (b)(iii)	$u = 2\pi r/T$ substitution and manipulation to final answer	1 1
11 (b)(iv)	m and e same for all electrons formula does not contain u *Quality of Written Communication – criteria on following page*	1 1 4

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.

Mark Scheme 2865
January 2006

Qn	Expected Answers	Marks	Additional guidance
1 (a)	Resistivity level with first tick above 10^{15} Ω m ✓ Cost level with first tick to right of 10 000 £ m^{-3} ✓	2	
(b)	(i) Flexible/cheap/✓ (ii) Higher resistivity ✓	1 1	
(c)	Less steep region (A) ✓ Much steeper region (B) ✓	2	Allow A to include first steepish region
(d)	(i) F atoms hinder rotation/AW ✓ (ii) Steeper than PE graph in (flat) region A ✓	1 1	ecf from candidate's (c): must be on same graph as (c), even if redrawn
	Total:	**8**	
2 (a)	Mass of UF_6 = 238 + 6 × 19 = 352 ✓ Mass of N_2 = 2 × 14 = 28 ≈1/10 of 352 ✓	2	Second calculation + comparison for 2nd ✓
(b)	(i) M is mass <u>of the sample/AW</u> of gas ✓ ; (ii) $pV = \frac{1}{3}M\overline{c^2}$ so $p = \frac{M}{3V}\overline{c^2} = \frac{\rho}{3}\overline{c^2}$ so $\overline{c^2} = \frac{3p}{\rho}$ ✓✓ (iii) For U-235 and then U-238 $\overline{c^2} = \frac{3p}{\rho} = \frac{3 \times 1.01 \times 10^5}{15.5} = 19500$ so $\sqrt{\overline{c^2}} = 140\ \mathrm{m\ s^{-1}}$ ✓ $\overline{c^2} = \frac{3p}{\rho} = \frac{3 \times 1.01 \times 10^5}{15.7} = 19300$ so $\sqrt{\overline{c^2}} = 139\ \mathrm{m\ s^{-1}}$ ✓ (iv) Diffusion due to movement with repeated collisions so diffusion rate ∝ molecular speed ✓ Range of molecular speed means actual speeds of two species of molecules will overlap greatly ✓ Need repeating / large diffusion run to get reasonable separation ✓	1 2 2 2	✓m and then ✓e for both results / both $\overline{c^2}$ ✓ and then both $\sqrt{\overline{c^2}}$ ✓ Any two points or similar, clearly made. Second mark can be for linking argument to need for large scale apparatus.
	Total:	**9**	

3 (a)	(i)Circular motion requires central force/owtte✓ (ii) C	1 1	
(b)	(i) 1.7 <u>and</u> -1.6 ✓ (ii) anticlockwise arrow(s) ✓	1 1	
(c)	(i) 1 GeV = 1 × 10^9 × 1.6 × 10^{-19} J = 1. 6 × 10^{-10} J✓ $E_{rest} = mc^2$ = 1.7 × 10^{-27} kg × (3.0 × 10^8 m s^{-1})^2 = 1.5 × 10^{-10} J ≈1.6 × 10^{-10} J ✓m ✓e (ii) rest energy = 1 GeV « total energy E ✓ so $E^2 \approx (pc)^2 \Rightarrow E \approx pc$ ✓ (iii) From Table 1, p = 35000 × <u>10^{-20}</u> N s ✓ $E \approx pc$ = 35000 × 10^{-20} × 3.0 × 10^8 = 1.1 × 10^{-7} J (which is close to 1.6 × 10^{-7} J) ✓	3 2 2	First mark for correct value of p 10^{-20} essential. Comparison not essential. Relativistic p is essential.
	Total:	**11**	

4 (a)	Increasing current increases heat dissipated ✓ ; heat produced will damage coils ✓; core may become saturated (although not relevant here) ✓	2	Any two or similar plausible points.
(b)	Copper has resistance so $V = RI$ ✓; presence of resistance reduces current✓; all strands in parallel so have same p.d. = 0 ✓; $I = 0$ when $V = 0$✓	2	Any two points
(c)	(i) Flux change induces emf✓; rapid change (collapse) produces large emf ✓;large emf produces large current✓ (ii) Copper lower resistance than Ni-Ti so current flows in copper✓ (iii) Large current produces (I^2R) heating in resistance ✓.	2 1 1	Any two points (iii)Resistance should be stated or implied /description in terms of electron collisions in the lattice is OK.
(d)	Large force (or torque) produced by large field which may damage the body / large emf could be induced. ✓	1	Or other valid point e.g. iron distorts field and affects image.
	Total:	**9**	
5 (a)	X-rays absorbed (significantly only) by bone ✓; X-rays show cracks clearly ✓; MRI shows all tissues, so scan more complex✓; MRI scan produces sections ✓	2	Any two points
(b)	(i) each pixel coded by one byte ✓ byte has values 0 to 255 ✓; inverted by subtracting from 255 owtte ✓ (ii) enhancement ✓ detail ✓, e.g. improve contrast by increasing pixel differences/make adjacent parts more obviously different, increase brightness by raising/lower pixel values/make whole image easier to see (iii) Resolution = smallest discernable distance owtte ✓	3 2 1	255 could be any stated maximum value. In (ii), either the method or an explanation of the enhancement is OK qualitative description in terms of lots of pixels per unit area is OK.
	Total:	**8**	
6 (a)	$\Delta V_{grav} = \text{final } V_{grav} - \text{initial } V_{grav} = -GM\frac{1}{r} - (-GM\frac{1}{r_E})$ $= GM(\frac{1}{r_E} - \frac{1}{r})$ ✓ ✓	2	One mark for manipulating two V_{grav} terms, one for correct logic in signs.
(b)	(i) $\Delta V_{grav} = GM(\frac{1}{r_E} - \frac{1}{r}) = 4.0\times10^{14}\left(\frac{1}{6.4\times10^6} - \frac{1}{6.8\times10^6}\right)$ $= 3.68 \times 10^6 \approx 4 \times 10^6$ J kg^{-1}✓m ✓e (ii) $\Delta PE = m\Delta V_{grav} = 190\,000 \times 3.68 \times 10^6 = 7.0 \times 10^{11}$ J✓ (iii) $v = (2\pi r)/T = (2\pi \times 6.8 \times 10^6)/(90 \times 60) = 7900$ m s^{-1}✓ KE = $\frac{1}{2}mv^2 = 0.5\times190\,000\times(7900)^2 = 5.9 \times 10^{12}$ J ✓m ✓e (iv) Energy required to lift booster rockets, Shuttle, etc ✓; energy required to lift fuel ✓; energy for construction ✓	 2 1 3 2	 4×10^6 J kg^{-1} gives 7.6×10^{11} J Any two points
(c)	$\Delta V_{grav} = 58$ MJ kg^{-1} - 11✓ MJ kg^{-1} = 47 MJ kg^{-1} ✓ $\Delta PE = 190\,000 \times 47 \times 10^6 = 8.9 \times 10^{12}$ J	2	Each reading $\pm$ 2MJ kg^{-1} Range $(8.2 – 9.7)\times10^{12}$ J
	Total:	**12**	

7 (a)	$E = (5.44 - 2.41) \times 10^{-19}$ J = 3.03×10^{-19} J ✓ $f = E/h = 3.03 \times 10^{-19}$ J/$6.63 \times 10^{-34} = 4.57 \times 10^{14}$ Hz $\lambda = c/f = 3 \times 10^{8}/4.57 \times 10^{14} = 6.56 \times 10^{-7}$ m ✓m ✓e	3	
(b)	(i) $d = 1 \times 10^{-3}/600 = 1.666 \times 10^{-6} \approx 1.67 \times 10^{-6}$ m ✓ ; (ii) $n\lambda = d \sin\theta \Rightarrow \sin\theta = 1 \times 656 \times 10^{-9}/1.67 \times 10^{-6}$ $\sin\theta = 0.39 \Rightarrow \theta = 23.1° \approx 23°$ ✓m ✓e	1 2	
(c)	Both lines further out and symmetrical ✓e	1	ignore zero order
(d)	$\Delta\lambda/\lambda = 0.0020/100 = 2.0 \times 10^{-5}$ ✓ ; $v = c\Delta\lambda/\lambda = 2.0 \times 10^{-5} \times 3.0 \times 10^{8} = 6000$ m s^{-1} ✓s ✓e	3	Allow ecf
(e)	100 × dimmer means $\sqrt{100} = 10$ × further away distance = 30 × 10 = 300 parsecs ✓m ✓e	2	
(f)	(i) $\lambda = 122 \times 10^{-9}$ m and $\lambda + \Delta\lambda = 1.34 \times 10^{-6}$ m ✓ $1+z = 1.34 \times 10^{-6}/122 \times 10^{-9} = 11.0 \Rightarrow z = 10$ ✓ (ii) λ stretches as the Universe expands✓ $1+z$ is scaling factor (new λ)/(old λ) ✓	2 2	
	Total:	**16**	
8 (a)	(i) $f = 1/30 = 0.033$ m✓ $1/v=1/u + 1/f = (-1/0.05)+(1/0.033) = -20 + 30 = 10$ $v = 1/10 = 0.10$ m ✓m ✓e (ii) Light on LDR brighter/ beam narrower✓	3 1	Using $1/v=1/u +P$ gains the first mark here also.
(b)	(i) $R = 300 + 1500 = 4500\ \Omega$✓ $I = V/R = 12/4500 = 2.67 \times 10^{-3}$ A ≈ 3 mA (ii) $V = 12$ V × (1500 Ω/4500 Ω) = 4 V ✓m✓e (iii) $I = V/R = 11.3/1500 = 7.53$ mA✓ $R_{LDR} = V/I = (12.0 - 11.3)$ ✓/0.00753= 92.9 Ω ≈ 100 Ω ✓ (iv) value of R_{LDR} very small compared with 1M Ω so small p.d. across LDR, and almost all across fixed resistor ✓ changes in R_{LDR} very small compared with 1M Ω so small voltage changes ✓	1 1 2 3 2	 Or use Ohm's Law Or potential divider
	Total:	**13**	
	Quality of Written Communication	**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 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.

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Report on the Units
January 2006

2860: Physics in Action

Section 1 (General Comments)

It was felt that the level of difficulty was appropriate, and similar to previous sessions, but candidates seemed to struggle more with elementary concepts than is usually the case. There was no evidence that candidates had lacked time to complete the paper. Section A was answered less well than previous sessions, particularly the questions on critical angle 2(b), the circuit concepts 5, and the waveform and spectra question 6. Candidate's answers showed that the concept of sensor sensitivity in question 12 was also less well understood than in previous sessions. Almost all incorrectly described the resolution of the sensor rather than its sensitivity.

The examiners were disappointed with the care taken with the presentation of diagrams. In question 7, for example, insufficient care was taken with the shape and spacing of the wavefronts that the candidates were asked to add to the diagram. The differentiation in sections B and C was comparable to past sessions, producing a wide range of marks, but very high scores were rare. Most candidates made a reasonable attempt to describe a material and a sensor circuit of their choice in section C, although perhaps rather too many still opt for copper for wiring, rubber for tyres or glass for windows.

Section 2 (Comments on individual questions):

Section A:

1. This was about choosing appropriate mechanical properties from a list, and was a good starter for most candidates. A few contradicted themselves by putting down brittle with tough or plastic, rather than strong, but the marks were awarded independently and contradiction was not applied here.

2. This question about the critical angle in diamond was very poorly answered. Some candidates could not measure the correct angle; there were many 60° responses (instead of 30°) and some guesses (perhaps due to having no protractor?). Sadly, very few candidates could calculate the critical angle from the data given. Most candidates drew a refracted ray in the diagram, rather than a totally internally reflected ray, including those having measured the correct angle of incidence (even though this was greater than the given critical angle).

3. This question about information storage and transfer was answered well. In (a) more candidates worked out that the area needed for 6.0 Gbits was $4.8 \times 10^{-5} m^2$, rather than the amount of information stored being 6.25 Gbits, but scored the mark by reverse argument. In (b) weaker candidates forgot to convert bytes to bits or v.v. and a few used the value 6.25 Gbits and lost a mark.

4. This question on internal resistance was a good differentiator. Several weaker candidates did not know how to calculate internal resistance, but managed to get the correct answer 3Ω just by using the point (1,3) and applying $R = V / I$. This was awarded a maximum one mark if their method was no clearer than that. Better candidates argued that at a p.d. of 3.0 V the internal and external resistance are equal, used the gradient of the graph or the equation $V = E - Ir$ to gain the full three marks. A tolerance of $3.0 \pm 0.2\ \Omega$ was allowed for reading errors from the graph.

5. This straightforward question on GCSE level understanding was poorly answered.
Ideas about parallel and series circuits should be basic at this level, most candidates could not answer the questions correctly and very few scored all four marks.

6. This question on waveforms and frequency spectra was not well answered. Many candidates got the idea that the signal was zero at t = 5,10,15 ms etc. But fewer candidates got the shape or the amplitude correct. In part b) common incorrect answers were single peaks at 100Hz (average) or 200Hz (sum) frequencies, rather than the two distinct components at 50 and 150 Hz.

Section B:

7. This question centred on the lens equation was badly answered by many candidates. The diagram (a) was carelessly completed; most candidates drawing the wavefronts too close together, or not keeping their separation sensibly constant. (They also ignored the advice to draw only two more wavefronts, which was there to help them). In part (b) there were several candidates who did not convert 12.5 mm into metres before calculating the power; and some who did the conversion incorrectly, thus losing a mark. In part (c) there were many errors made. Several candidates confused u and v in both parts (i) and (ii), or their conventional signs, although these are defined on the formulae and data sheet. Some weaker candidates substituted mixed units of 2 m and 12.5 mm into the equation before calculating the image distance in part (ii); or they failed to calculate the inverse and quoted their answer for $1/v$ instead of v. Only the best candidates who could see the closeness of the image distance for a 2.0 m object (12.6 mm), to the fixed focal length of the lens (12.5 mm) and comment upon it gained the last mark.

8. This question on digital sampling was less well answered than similar ones from past papers. The most common error in part (a)(i) was to divide 300 μs by 14 samples, rather than 13 intervals. Several candidates also estimated the gap between the labelled samples, rather than do the simpler $1/f$, but gained only a method mark because their estimate was too crude, being outside (23 $\pm$ 1 μs). Most candidates got part (ii) correct; and many got the method mark in part (iii), by trying to do 16/66000 mV, but then using the incorrect powers of ten. Many answers to part (b) were too vague and really only repeated the stem of the question, they needed to give more specific answers to gain credit.

9. This question about data handling and graphing in the context of a Conductance experiment was generally well answered. Nearly all the candidates got the value 2.0 in the table, but quite a few lost the 0.67 mark on sig. figs. Or by using the recurring symbol which the examiners penalised. Most candidates could plot the points and draw the best-fit graph sufficiently accurately (to $\pm$ 0.5 graph squares). There were a few who could not plot the point (0.67,0.07) correctly, and there were even fewer who did not use sensible scales. In part (a)(iii) those candidates who mentioned the straight line often omitted to mention that it went through the origin. Weaker candidates mentioned only a positive correlation, which was not credited, as the data supports a much stronger functional relationship (the direct proportionality of $G \propto 1/L$). Most candidates correctly calculated the gradient, although some made mistakes with powers of ten, or found the inverse. Many candidates correctly calculated the conductivity, by using a pair of values from the table, rather than directly from the gradient for full credit. Full marks were also awarded by reverse argument for calculated conductance from the table or graph values. Weaker candidates got confused between G and σ, or failed to rearrange the formula correctly, but overall most candidates scored well.

10. In this question about gravity induced stress in rock columns some candidates were happy with the algebraic manipulation requested in (a)(i), others struggled, but ecf was applied to the middle box for their first answer x g. Most candidates managed to answer part (ii), but missed the point in part (iii) of the Area having cancelled so that stress at the base of column is independent of its x-sectional area. Part (b)(i) was generally answered well, some scoring fully by calculating the stress by reverse argument ($\sigma = 2.38 \times 10^8$ Nm^{-2}). A common mistake was to try and calculate stress using $\sigma = F/A$, and failing to estimate an appropriate area or weight. Part (ii) was answered reasonably well, with the majority of candidates scoring at least one mark for mentioning that g on Mars was less than on Earth. Other common points mentioned were possible lower density or greater compressive stress of Mars's rocks; (just mentioning different values would not credit the mark). Some incorrect responses included some discussion of erosion, atmospheric conditions.

Section C:

Most candidates made a reasonable attempt to describe a material and a sensor circuit of their choice in section C, although perhaps rather too many still opt for copper for wiring, rubber for tyres or glass for windows for their material choice! There was also evidence that candidates would do well to read the whole of a section C question before planning their answer. Many organised candidates underline key / trigger words in the roots of questions to aid their construction of targeted answers.

11. Material and application. Some of the candidates got confused here, about the number of applications (one) and properties (two) that needed to be mentioned. Many wrote lists of both applications and properties rather than continuous linked prose. Some candidates discussed completely new applications in part (b)(ii). There was generally a wide selection of materials mentioned from each Centre. There was the usual confusion in mechanical properties between stiffness, elasticity, toughness and strength. Many candidates lost a mark by omitting the scale for their diagram in part c, where they were describing the internal structure of their material, examiners are instructed to mark the scale estimate to $\pm$ 1 order of magnitude.

12. Electrical sensing system. Part (a) to draw the circuit diagram was reasonably well answered. Most candidates use a potential divider circuit, but the weaker ones get confused about which p.d. increases when the resistance of their sensor increases. Vague R and V “changes” answers are not credited in (iii) explaining the circuit. In part (b) most candidates were able to explain response time, but nearly all defined sensitivity as the smallest measurable change in input (resolution). In part (ii), only a few candidates got the point about measuring the change in input with another device (luxmeter, thermometer, etc). The difference between systematic and random errors was too hard for most candidates to explain.

2861: Understanding Processes

The paper was of a similar standard to those in previous sessions and provided good differentiation between candidates of different abilities. A majority of the candidates completed the paper in the 90 minutes allocated. Performances in sections A and B were essentially sound, but answers to section C questions were generally well below the standard seen in June. Candidates who had prepared themselves well for the Section C questions produced very good answers, but the quality of answers provided to questions in this section was variable across the entry. The better candidates produced excellent scripts that were a pleasure to read and mark amid other examples of work which were of a disappointingly poor standard.

Section A

In Section A, which contained the shorter questions, performances ranged widely across the mark range, but it was rare to find a candidate scoring the maximum 20 marks available. In general, clear working was shown and gained credit. In question 1, parts (a) and (b) were well done, but in (c) graph **A** proved to be a popular distracter. In question 2, where there were 3 marks available, there were three opportunities to go wrong. Candidates needed to select and use $s = vt$, the time had to be converted to seconds from milliseconds (10×10^{-3} s), and the distance across the room was half the 'trip distance' of the pulse. The question proved to be quite discriminating. In question 3, many candidates showed a complete lack of understanding of the principle at work. Consequently many of the answers which resulted were fanciful. Most candidates successfully showed how the magnitude of the resultant velocity (2.5 m s^{-1}) was found in question 4, but then stopped before showing how the angle 53^o was evaluated. Generally speaking, the attempts at question 5 were poor and in part (b) few seemed to know that intensity α (resultant phasor amplitude)^2. Many pleasing answers were seen to question 6, but there are still those who insist that values of 0.906, 0.896 and 0.917 (obtained by calculating the values of R/M^3 for the data) are 'different' and therefore mean that the relationship $R = qM^3$ is not supported by the data given. In question 7 the apparent similarity between answers **B** and **C** inexorably led many to select **B,** in preference to the correct answer which was **C**.

Section B

Question 8. This question was about using a diffraction grating to observe emission spectra.

Part (a) was designed to give a straightforward start to this question, and so it proved to be for the majority, but weaker candidates were unable to answer (a)(i) convincingly. In answering the question in (b)(i), it was not uncommon to find candidates correctly asserting $\lambda_V < \lambda_G$ (as given in the table), but then failing to go on to explain why this meant that the violet line is produced at a smaller angle θ. In (ii) a sizeable minority put $n = 3$ in $d\sin\theta = n\lambda$ to calculate the slit spacing d; reasoning that the green line was the third from the centre. Nevertheless it was impressive to see how many candidates were able to work from their value of slit spacing (in metres) to the corresponding number of lines per millimetre. In part (iv) the better candidates were able to justify the number of significant figures in terms of the accuracy of the data used in the calculation. However it was not uncommon to see confusion between 'significant figures' and 'decimal places'.

Question 9. This question was about a gannet 'plunge-diving' to catch fish.

Generally speaking, this question was very well done by a substantial number of candidates. Parts (a) and (b) were very competently answered and provided most candidates with an accessible start to the question. In (c) and (d) candidates were required to apply their knowledge of the physics to this novel situation, and good discrimination resulted. In (c)(i) a majority used the connection between work done by the force and the change in energy to show that F = E/d, but parts (c)(ii) and (iii) were much more discriminating. In (d)(i) many were able to offer one reason why there was an upward force on the gannet, but very few were able to produce convincing answers in (d)(ii) as to why the force would be changing.

Question 10. This question was about standing waves in a microwave oven.

Calculations in part (a) were competently executed by a majority of candidates. Rearrangement of the formula $v = f\lambda$ and conversion of the frequency from GHz to Hz were effortlessly accomplished by most. Part (b) proved to be more discriminating as expected. In part (c) a majority of candidates showed that they had a sound grasp of the basic physics of standing waves and many showed a good appreciation of the situation in their answers to part (d).

Question 11. This question was about raindrops falling through the air.

In part (a)(i) candidates were expected to make the connection between force and acceleration as embodied in F = ma, and then go on in (a)(ii) to show clearly that K, in $F = K\rho Av^2$, was a dimensionless constant. Assuming K to be dimensionless in (a)(i) did not attract credit. The responses to (a)(iii) were encouragingly good, but (a)(iv) exposed weaknesses in algebraic manipulation. Answers to part (b) were too often lacking in rigour and detail, leaving too much for the reader to assume. In (b)(ii) very few made the explicit link between volume and mass. Answers to part (c) were unexpectedly good.

Section C

The two questions in section C invited candidates to choose the contexts for their answers. In question 12 they were asked to describe and explain an example of wave superposition and in question 13 to describe and explain a phenomenon in which quantum behaviour is important.

Candidates' answers to question 12 were generally better than those to question 13. An interesting range of superposition effects was described successfully, but explanations were quite variable in quality. In contrast, a very limited range of quantum phenomena was in evidence this session. Phenomena described, and given a quantum explanation, included double slit interference patterns, diffraction patterns from transmission gratings, the photoelectric effect, and light emitted from an LED. As in previous sessions there were candidates who, having earned marks in the descriptive sections of the question, offered an explanation only in terms of wave superposition. Hybrid explanations with reference to phasor wheels, and some mention of photons, but without providing a coherent explanation of the observations ought to be avoided. The examiners felt that lack of preparation on the Section C topics by a significant number of these candidates who performed relatively well in other parts of the paper, resulted in lower overall marks for them.

2862: Physics in Practice

General Comments

110 candidates presented coursework portfolios in January. This was from an original entry of 182 with many centres withdrawing all their candidates. It was very helpful that most centres met the 10 January deadline – or were very close to it. A few administrative points are worth mentioning and these are raised to help in the summer session:

- As mentioned last year, it would be helpful if Centres who do withdraw all candidates still send their MS1 forms to the Moderator, with ‘A’ clearly marked by the candidates’ name, this avoids Moderators having to telephone the Centres.

- The resubmission of previous coursework raised the problem that certain Centres only sent the reworked part of the student’s portfolio and not the work that had been submitted in the summer examination period. The January module is a totally new module and therefore the whole coursework portfolio for any student entering this module must be sent to the Moderator for moderation.

- If your Centre has only a small entry (less than 10) then all the work should be sent to the moderator before the deadline date along with the completed MS1 form and other relevant paperwork

- It would be most helpful if internal assessors checked their arithmetic on totalling the different strands on the mark forms and in calculating candidates’ total marks. A considerable amount of time is taken up in sending amendment forms back to Centres because of arithmetical errors.

The work done by the students had, in the large majority of cases, been carefully marked by the internal assessors and in the main was helpfully annotated. Annotations genuinely help in the moderation process because they help moderators know how the marking points have been made. Only a small proportion of Centres have had their marks adjusted and it is clear that the majority of Centres fully understand the requirements of the module and are providing good advice to candidates on how to maximise their performance. There are, however, some points which are worth re-iterating.

Instrumentation Task:

In the Instrumentation Task there were a significant number of candidates who did not include a safety statement, causing a loss of marks in strand A(ii). In D(i) to gain high marks for the ‘accuracy’ part of this strand, candidates must, at least, repeat their readings to the same number of significant figures and note if there are any major discrepancies between the readings. Also, many candidates do not really consider the ‘fitness for purpose’ aspect in sufficient detail ie actually make measurements from their graphs etc, to score well in D(ii). To gain maximum marks in the section it is deemed necessary for candidates to make two quantitative calculations of relevant fitness of purpose quantities.

Material Research Task:

In the Material Research Task many candidates do not submit a plan of their research and presentation and this should lead to zero marks being awarded for this particular sector of strand A(i). However, candidates are getting much better at linking their sources to their presentation and many should be congratulated on the standard of their work. For maximum marks in D(ii) candidates must provide a printed copy of slides used in a power point presentation along with talk notes.

Data Task:

The Data Task is often the task that is assessed most leniently. In skill A(ii) the statement in the grid 'e.g. Use of a calculator' should not be taken as the only necessity required for maximum marks. Candidates are also expected to show other good ICT skills. Annotation on the scripts for skill A(ii) is a great help to show why the marks were allocated for skill in ICT. Graphs that lack both horizontal and vertical grid lines should be regarded as showing poor use of ICT. As with last year there were instances where the essential physics of the experiment had not been clearly discussed (B(ii)) and where the analysis was rather superficial and led to no clear conclusion (strand D). In these cases the work should not be rated highly. With this task, it is very helpful to moderators when centres provide the information about the experiment or the data that has been given to the candidates.

The topics chosen for all three tasks tended to follow work seen in previous sessions.

2863: Rise and Fall of the Clockwork Universe

General Comments

This paper produced a wide range of marks. Nearly all candidates finished the paper and only the weakest candidates failed to attempt the majority of the individual questions The mean mark on the paper was 43 out of 70. Once again, the quality of the work at the top end of the range was most impressive.

Centres are preparing candidates for 'show that' questions and it is noticeable that almost all candidates will give their own value of the answer to give evidence of calculation. In doing so they avoid losing marks needlessly.

Some weaker candidates have difficulties with standard notation and do not translate the reading on a calculator into a suitable value on the examination paper. In this way ' 3×10^{4}' is sometimes written as 3^{-04}. If this is seen in the classroom it may be worth spending a little time with the uninformed student so the problem is solved.

It is still evident that whilst many candidates are effective at performing calculations, they do not always think sufficiently deeply about the fundamental physics they are considering. This means that their explanatory answers are less convincing than answers to numerical questions.

Comments on Individual Questions

Section A Most candidates scored more than ten marks out of the twenty available for this section.

1 (a) This question was straightforward but a surprising number of candidates calculated the distance of one light year rather than 4.2 light years.

2 This Boltzmann factor question seemed very accessible.

3 This proved more difficult than expected. Whereas the majority of the candidates successfully calculated the momentum of the gas there were many arithmetical errors in the second part of the question.

4 An accessible question causing few problems.

5 This question on modelling was more discriminating than expected. Some candidates did not use the model to calculate the number of nuclei remaining after a given time period but chose to use the exponential decay equation. However, it was the last part of the question which really demonstrated the misunderstandings of the candidates. The best answers were clear and concise whilst many suggested that the situation was not a model but an experiment and could therefore be improved by taking more readings, minimising background count or other physical factors.

6 This question was well answered although there were a significant number of answers giving 10^{-15} rather than 10^{-16}.

Section B

7 This question was about capacitor discharge. It gave candidates an opportunity to demonstrate some straightforward arithmetic and explain some ideas in physics

(a) Although this was correctly answered by many it is clear that some candidates do not know what a microfarad is. This led to the expected power of ten errors.

b(i) This was not answered well. Candidates stuck to GCSE explanations instead of considering the situation presented to them.

b(ii) This very basic calculation caused problems to only the weakest candidates.

(c) This part of the question could be tackled by reasoning or further calculation. The better candidates showed understanding of the situation and simply doubled the current and halved the time constant. Weaker candidates re-calculated the values.

(d) This part, relying on stating and explaining features of a discharge/charge graph, proved surprisingly difficult. Many candidates scored disappointingly because they did not state the features sufficiently precisely. For example, writing 'it goes up', without stating that it rises to 6V or that the charging appears instantaneous.

The explanations of the features were also often disappointing and frequently amounted to a further description of the feature rather than a consideration of the physics involved. For example, few students correctly explained the speed of the charging cycle in terms of the lack of resistance in the charging circuit.

8 This question on kinetic theory required candidates to consider behaviour of gases in an unfamiliar context.

(a)i This proved as accessible as expected.

a(ii) A sizeable proportion of the candidates gave the mean square speed rather than root mean square speed as required. This left the answer as a very large value and it is noticeable that this did not cause concern to those who reached this value – suggesting that the calculator is always believed and that answers are not critically considered in the heat of the examination.

(iii) Algebraic manipulation often causes problems. In this case a common error was to remove the constants (k and T in this case) but to leave the relationship as an equality.

(iv) This proved reasonably accessible although some candidates continued to consider mean square speed.

(b) Most candidates correctly identified comparative speed as the issue and the best considered the rate of collisions with the walls of the container.

(c) The best responses considered the small difference in velocity to be the crucial factor here. Weaker responses relied upon GCSE knowledge – when used correctly this gained a mark but only those who considered the information in the question critically gained both marks.

9 This question was about energy transfers when approaching a planet.

(a) This 'show that' question caused few problems.

(b) Although the question was framed in terms of energy only the best answers demonstrated an understanding of gravitational potential energy becoming more negative as the spacecraft approached the planet. Many answers (reflecting GCSE knowledge) clearly assumed field strength to be constant over the range considered in the question.

Credit was given to answers considering force but it was disappointing to see so many candidates suggesting that acceleration requires an increasing force on the spacecraft. Such weaker responses show a desire to fit known ideas (force can give acceleration) into a new situation (increasing force).

(c) Whilst many responses to this question gained one mark there were relatively few answers that correctly considered energy transfer or the role of momentum transfer.

(d) (i) Candidates have clearly memorised the required equations but there was evidence of confusion between force and field strength.

(ii) The surprise here was that so many responses used the field strength as 9.8 N kg^{-1} out of habit rather than the value of 4 N kg^{-1} as given in the question.

10 The final question was about simple harmonic motion and the properties of a spring. There was evidence of some candidates tiring at this point

(a) (i) A simple calculation that proved to be of little difficulty.

(ii) Another simple calculation that caused few problems.

(iii) There were signs of fatigue here as some candidates used the gravitational potential energy equation from the previous question to obtain some very strange values.

(iv) This question demonstrated that the difference between force and energy is not well understood.

(b) The majority of responses showed that graphical representation of oscillation has been covered in some detail. Only the weakest candidates made errors.

(c) Many candidates seemed to think that any downwards curve is 'exponential' whilst better responses skirted around the idea of a constant ratio property or 'half-life'.

2863/02: Practical Investigation

There were approximately 2600 Candidates from 210 Centres entered for the coursework component in the January session. The requirement to send the Moderator just one copy of the Centre Authentication form and no copies of the Candidate Authentication form is now well established. A number of Centres did not send the MS1 mark sheets to the Moderators by the deadline date. This can cause real difficulties especially when further delays are involved in sending the requested moderation samples to the Moderators who have their own deadlines imposed by the exam board.

Whilst it is still the case that most Centres ensure the independence of the work done by their Candidates, the moderating teams are increasingly citing examples where this requirement of the Specifications is not being met. Perversely it is from some of the smaller entry number Centres, where there is no reason why each Candidate should not investigate a different topic, that Moderators find much commonality in the work presented. For a Centre entering six Candidates it is surprising to find that four of them are fascinated by dropping objects through fluids and at the same time be convinced that they worked independently. When the basic experimental set up and any extensions are also the same, the impression is that this has been a whole class activity with the homework being "to write up your findings" and this will "get the coursework out of the way". Such an approach adds to the folklore that coursework tolerates any easy workround and more importantly Candidates working in this way are missing out on an opportunity to do some really interesting physics. The ideal, of course, is that each Candidate should investigate a topic of interest to them and of their choosing. When this is not possible there is a rich source of ideas to be found on the Advancing Physics website, located at http://advancingphysics.iop.org/teacher/A2cswk.html . These can be regarded as starters involving quite simple apparatus from which a Candidate can obtain some useful results within a single lab class, this can then act as a springboard to the more advanced and innovative work expected at the A2 level.

The lack of appreciation of the uncertainties in any measurement can affect the validity of the conclusions made. Take for example the manual timing in a falling sphere viscometer arrangement or parachute investigation. It is not unusual to see in the table of results drop times in the region of one or two seconds. Values such as 1.16s are quite acceptable at the data reading stage since this is the value presented by the stopwatch. It is however expected that Candidates should consider the effect their reaction time, at both the "start" and "stop" stage, will have on the uncertainty in the time measurement. This uncertainty should be carried through and be reflected in the values quoted for derived results such as velocity. Many Candidates recognise there is an uncertainty but optimistically assess this as 0.01s based on the stopwatch display. Perhaps all Candidates using a stopwatch should be encouraged to visit websites such as www.fetchfido.co.uk/games/reaction/reaction_test.htm at an early stage of their investigation.

Section C(ii) on the rating sheet addresses the quality of the report and this has raised several issues recently. Like an article in a journal the report should be a self-contained document consisting of paginated sheets securely fixed together. It should not be necessary to provide additional evidence in the form of samples, rough notebooks or Centre-generated safety tick-box sheets. Moderators have noted an increasing tendency for the written style of many reports to be very much that of a teenage chat magazine or txt msg. This can make it difficult for the Moderator, who has only the written report before him, to understand what the Candidate has done. Such a report detracts from what other merit the investigation may have. Even when Candidates attempt to use the precision of scientific language phrases are often used without any consideration for their meaning e.g. "……. viscosity is indirectly proportional to concentration". There is an increasing use of bulk to conceal a lack of results. Extremely verbose reports should not receive high marks in C(ii). Verbal padding involving too much preamble and not enough physics should be discouraged along with scanned pages from text books, website downloads and physical padding such as using thin card for text and graphics. References should be embedded in the text where necessary and clearly linked to a list at the end of the report. A URL list by itself is of no value.

2864/01: Field and Particle Pictures

General Comments

The usual small entry for this paper doubled this year. This appeared to be due to an unusually large number of weak candidates taking the exam for the second time. As ever, weak candidates found Section B particularly hard, as they struggled to keep the context of the questions clear in their heads all the way through. Too often they were treating each section as a question in its own right, rather than part of a greater whole. Similarly, over-reliance on the formula sheet to provide a rule for doing a calculation proved to be the undoing of many candidates.

The comments which follow apply to the performance of candidates working at grade E and above. There is little point in discussing the performance of candidates who were clearly ill-prepared for this exam.

Comments on Section A

This section always contains a number of shorter questions which cover the material which isn't examined in the four Section B questions. Some questions are easier than others, but a significant number of candidates earned full marks this year. The majority of weak candidates earned at least half the marks, suggesting that Section A was possibly less tricky than usual.

1. The traditional start to this paper asks candidates for units of quantities. Few candidates had any difficulty in identifying N C^{-1} and Wb m^{-2} as the units of electric and magnetic field strength.

2. Although most candidates worked out that the potential of the cable is 160 kV, some drew the field line carelessly. Too many lines did not look as if they were at right angles to all the equipotentials, losing the mark.

3. A disappointing number of candidates drew an upwards arrow on the diagram, suggesting a total lack of understanding of the situation. Many candidates could not explain why the atom was unable to accept all of the kinetic energy of a colliding electron, and only a few could work out that the electron was left with 1.8 eV after the collision. Too often, candidates simply took the two numbers mentioned in the stem (12.0 eV and -13.6 eV) and added them together, earning no marks. Only a minority were able to demonstrate a real understanding of the energy level diagram and use the information provided in it to obtain the correct answer of 1.8 eV.

4. Most candidates knew that the correct response was C, showing a good understanding of flux in transformers.

5. The idea that changing flux generates an emf was obvious to many candidates. Similarly, the idea that rotating the magnet at twice the speed doubles the frequency of the alternating emf was just as obvious. However, only a minority of candidates remembered that this would also double the amplitude of the emf.

6. As expected, many candidates drew the arrow in the wrong direction, forgetting that the deflected electrons have negative charge. The formula $E = V/d$ does not appear on the formula sheet, so many candidates were tempted to divide the numbers provided instead of multiplying them.

7. Many candidates struggle with this style of question. All three statements are correct, so they have to choose which one best supports the explanation of chain reactions in nuclear piles. Knowing that these reactions lead to a release of energy, many candidates plumped for response C, without realising that it is true for **all** fission reactions.

Comments on Section B

Although most candidates answered every question in this section, there was more evidence than usual of weak candidates running out of time. This is possibly because the last question required a certain fluency with algebra rather than just plugging numbers into a formula to obtain other numbers.

8. Section B always starts with a question about an application of magnetic fields. Candidates were, on the whole, well prepared for this. Even if they couldn't explain that eddy currents flow in such a way as to oppose the change of field which created them, most candidates could sketch the flux loops required and suggest and explain a modification to improve the performance of the system. However, only the strongest candidates were able to provide a coherent explanation for the origin of the eddy currents in the spinning disc.

9. This question probed candidates' understanding of alpha particle scattering. Sketching the trajectory of the scattered particle proved to be straightforward, but many candidates were very confused about the energy transfers which take place in a head-on collision with a nucleus. Calculating the energy required to get the alpha particle close to its target nucleus was problematic for many candidates, since the formula required does not appear on the formula sheet. Too many candidates failed to recognise the two-part nature of the final question, using the mass of a neutron instead of the mass change of the nucleus to calculate the energy of the neutron.

10. Most candidates could complete the nuclear equations correctly, but also failed to explain themselves clearly enough to justify why the mystery particles could be an electron and an antineutrino. Too often, their answers failed to use both the changes in nucleon and proton number to justify their choice of particle, relying instead on arguments based on the idea that "if a neutron became a proton an electron and an antineutrino were always emitted". To earn the marks, some mention of charge and lepton number conservation was required. The risk calculation, unsurprisingly, proved to be the hardest one on the paper, with many weak candidates not knowing where to start. A question which provides six quantities to calculate a seventh can clearly only be successfully attempted if you understand the physics behind it. It was good to find so many candidates able to recover from this calculation to correctly show that 6.2×10^{7} nuclei of radon-222 were required

11. A disappointingly few candidates were able to use $\frac{1}{2}mv^2 = eV$ to calculate the velocity of the electrons from the accelerator. Too many wanted to use $E = mc^2$ ... probably because it is on the formula sheet? Getting the correct direction of the force on the electron as it circles around the magnetic field lines was equally problematic. There are still too many candidates who automatically want the force on a particle to be parallel to its velocity. The algebraic manipulation in the next two parts of the question defeated many candidates, and only a few realised that it was the independence of the orbit time from the velocity which allowed all electrons emerging from the accelerator to be arrive at the target.

2864/02: Research Report

General Comments

Although ostensibly there were about 130 candidates entered from 21 Centres only a few of these had been entered correctly. In order to retake the assessment module called 'Field & Particle Pictures' it is not a requirement that the coursework component, 'Research Report' is redone. A number of centres really meant their students to have their coursework marks carried forward and a number withdrew candidates without explanation.

Of the centres that had entered students correctly only about 6 entered more than 3 students. Some candidates who entered were probably trying to improve their grade after a summer disaster whilst the remainder came from centres that had probably chosen to tackle the course in reverse order. That is chapters 15-19 first (Electromagnetic machines, Fields, Radioactivity) followed by 10-14 (Models, Space & Cosmology, Thermodynamics). This gives these centres perhaps a more restricted range of titles than the synoptic summer entrants in the May session and a slight tendency to tackle topics more firmly rooted in the AS course than is desirable. One Centre moderated in this session chose to tighten the choice for its candidates even more by suggesting Energy in Transport as an umbrella context.

Very little of the work received from centres failed to achieve 20/40 marks for this component but similarly very few achieved high marks (greater than 35). Some coursework arrived from centres with very little evidence that they had been marked at all. It cannot be overemphasised that centres not providing supporting evidence for the marks that they submit are more likely to risk adjustment. Supporting comments particularly where the Physics reported by the candidate is dubious should be considered an imperative.

It can be difficult for centre moderators working in isolation to make judgements about the required standard at this level particularly where only a small number of candidates are being examined. To help prepare Centre assessors OCR offers Autumn Coursework training sessions usually in London and the Midlands in October and November. Where Centres feel they are in need of extra guidance it would be well worth considering attendance. Another service provided free of charge called Coursework Consultancy allows centres to submit a sample of their marked work for detailed analysis and feedback by an expert. Details of these services can be found on the OCR website.

2865: Advances in Physics

There was only a small number of candidates again this January. Most were re-sit candidates, although one particular centre entered a substantial entry, as it has each January. Most candidates were well-prepared for the questions set on the article, with few scoring very low marks, and there were relatively few examples of candidates omitting entire questions.

Details of individual questions:

Section A

Question 1 (Polymer properties) This was the highest-scoring question on the paper; the one failing shown by weaker candidates was that they often did not draw their sketch graph required in (d)(ii) on top of the existing graph for polythene in the previous part (c), so preventing the comparison required in the question.

Question 2 (UF_6) Candidates were generally successful in the algebraic derivation of $\overline{c^2} = \frac{3p}{\rho}$, but found it harder to explain the need for large-scale apparatus in terms of the speeds of UF_6 molecules.

Question 3 (Tevatron) Candidates successfully realised that objects moving in circular paths have centripetal forces; unfortunately, not many then combined this with the qvB force to choose the correct direction for the magnetic field. Calculations were mostly well done, although many used $E = pc$ with $p = mv$ rather than reading the momentum from the table in the article s instructed.

Question 4 (Superconducting electromagnets) This was the least successful question for most candidates, partly because of the inherent difficulties in electromagnetism, and partly due to the conceptual difficulty of having superconductors in parallel with ohmic conductors. The most successful candidates showed clear physical thought here.

Question 5 (Medical images) Most candidates had obviously prepared this aspect of the article well, and gave many sensible answers to aspects on imaging not met since the very beginning of the AS course..

Question 6 (Satellite orbits) The usual problem with the minus sign in the gravitational potential equation was a stumbling-block here for many, although they were able to do the arithmetic calculations well. Only the best candidates realized why the energy required to put a satellite into orbit very greatly exceeds the sum of the kinetic and gravitational energies; GCSEish answers were common. Determining gravitational potential energy by reading potentials off a graph and then multiplying the difference by the mass was done by about half the small cohort.

Section B

Question 7 (Light and astronomy) Energy level and photon energy calculations were well done here, as were calculations on the grating equation. However, being able to sketch the effect of red-shift on the first- and zeroth-order lines of a spectrum proved difficult – few knew that the zero-order was unaffected, and red-shift was met approximately as frequently as blue-shift, left-shift and right-shift; probably the commonest response here was to move on to the next part.

Question 8 (Position sensors) The lens equation was generally done well, with the expected errors in the sign of 1/u by some. The circuitry was done encouragingly well, in view of the fact that this had not been ‘flagged up’ in the article.

Advanced GCE Physics B (Advancing Physics) (3888/7888)
January 2006 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2860	Raw	90	60	53	46	39	33	0
	UMS	100	80	70	60	50	40	0
2861	Raw	90	61	53	46	39	32	0
	UMS	110	88	77	66	55	44	0
2862	Raw	120	97	85	73	62	51	0
	UMS	90	72	63	56	48	36	0
2863A	Raw	127	98	88	78	68	59	0
	UMS	100	80	70	60	50	40	0
2863B	Raw	127	98	88	78	68	59	0
	UMS	100	80	70	60	50	40	0
2864A	Raw	119	90	80	70	60	51	0
	UMS	110	88	77	66	55	44	0
2864B	Raw	119	90	80	70	60	51	0
	UMS	110	88	77	66	55	44	0
2865	Raw	90	62	56	50	45	40	0
	UMS	90	72	63	56	48	36	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

Unit	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:

Unit	A	B	C	D	E	U	Total Number of Candidates
3888	12.4	30.2	56.6	76.9	93.8	100	246
7888	13.0	47.8	69.6	89.1	97.8	100	49

For a description of how UMS marks are calculated see;

www.ocr.org.uk/OCR/WebSite/docroot/understand/ums.jsp

Statistics are correct at the time of publication.

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