RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Combined Mark Schemes And Report on the Units

January 2006

3883/7883/MS/R/06J

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GCE Physics A (7883)

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MARK SCHEMES ON THE UNITS

REPORTS ON THE UNITS

Mark Scheme 2821
January 2006

FINAL MARK SCHEME 2821 FORCES AND MOTION

JANUARY 2006

Mark Scheme Page 1 of 6	Unit Code 2821	Session JANUARY	Year 2006	Version FINAL

Question 1	Expected Answers	Marks
1 (a)(i)	speed = d / t	C1
	= 24 / 55	
	= 0.436 (m s^{-1}) allow 0.44 do not allow one sf	A1
(ii)	kinetic energy = ½ m v^2	C1
	= 0.5 x 20 x $(0.436)^2$	
	= 1.9 (J) note ecf from (a)(i)	A1
(iii)	potential energy = mg h	C1
	= 20 x 9.8 x 4	
	= 784 (J)	A1
	penalise the use of g = 10	
(b)(i)	power = energy / time or work done / time	C1
	= (15 x 784) / 55 note ecf from (a)(iii)	
	= 214 (W)	A1
(ii)	needs to supply children with kinetic energy air resistance friction in the bearings of the rollers / belt total mass of children gives an average mass of greater than 20 kg	B1 B1 B1 B1 Max B2
		Total: 10

Question 2	Expected Answers	Marks
2 (a)(i)	velocity = displacement / time or rate of change of displacement	B1
(ii)	acceleration = change in velocity / time or rate of change of velocity	B1
(b)(i) 1.	distance / displacement	B1
2.	acceleration	B1
(ii)	use of area of squares under the line	C1
	value for the distance in the range 0.45 to 0.55 (cm) (use of a triangle area scores 1/2 [0.40 cm]) (do not allow 1sf)	A1
(iii)	acceleration is a maximum at A / decreases from A to 0.2 s	B1
	acceleration goes to zero at 0.2 s	B1
	acceleration is maximum at B / opposite direction at B / decelerates from 0.2 s to B / acceleration increases from 0.2 to B	B1 MAX 2
(v)	acceleration = [(-)3.8 – (+ 3.6)] / 0.3	C1
	= 24.7 (cm s^{-2})	A1
	allow 24 to 25 for 2 marks and 23 to 26 for one mark	Total: 10

Question 3	Expected Answers	Marks
3 (a)(i)	pressure = force / area	B1
(ii)	moment = force multiplied by the perpendicular distance (from the line of action of the force) to the pivot	B1
(b)(i)	force drawn vertically upwards at plunger	B1
	force drawn vertically at H	B1
(ii)	20 x 500 / force on Plunger x 120 (one correct moment stated)	B1
	Plunger force x 120 = (20 x 500)	B1
	Plunger force = 83(.3) (N)	A0
(c)(i)	pressure = force / area	
	$= 83 / 4 \times 10^{-3}$	C1
	= 20800 (Pa)	A1
(ii)	decrease area of plunger / decrease distance H to plunger / increase F / increase length of arm	B2 MAX 2
		Total: 10

Question 4	Expected Answers	Marks
4 (a) (i) 1	mass = 360 / 9.8 36.7 (kg) (allow 2sf)	B1
2	density = mass / volume	C1
	= $36.7 / 4.7 \times 10^{-3}$	
	= 7.8×10^{3} unit kg m^{-3}	A1 B1
(a)(ii)	right angled triangle with an additional correct angle marked	M1
	set of correct force labels and correct arrows	A1
	algebra shown or scale given	C1
	tension = 270 (N) or value in the range 255 to 285 (N)	A1
(b)(i)	tension is a vector / has magnitude and direction	B1
	direction involved in addition / the tensions or ropes act in different directions	B1
(ii)	sum =270 sin37 + 360 sin53	B1
	=162.5 + 287.5 (or one mark each for values of 162.5 and 287.5 seen)	B1
	= 450 (N)	A0 Total: 12

Question 5	Expected Answers	Marks
5 **(a)(i)**	Stress = force / area	C1
	force = stress x area	
	= $180 \times 10^{6} \times 1.5 \times 10^{-4}$	
	= 27000 (N)	A1
(ii)	Y M = stress / strain	C1
	= $180 \times 10^{6} / 1.2 \times 10^{-3}$ or using the gradient	C1
	= 1.5×10^{11} N m^{-2}	A1
(b)	brittle elastic/ graph shown up to elastic limit obeys Hooke's law / force α extension / stress α strain no plastic region	B3 max 3
		Total: 8

Question 6	Expected Answers	Marks
6 (a)	road surface / conditions brake system tyre surface / tread speed of car mass gradient of road	MAX B2
	Explanation to include the affect on the acceleration / force (and hence the braking distance)	MAX B2
(b)	crumple zone seat belts airbag protective cell / side impact protection	MAX B2
	explanation to include increase in time / distance of stop decreases force for crumple zone or airbag / absorbing energy (safely) for crumple zone seat belt restrains /prevents collision with steering wheel / windscreen	MAX B2
QWC	SPAG (less than four errors) use of technical language	B1 B1
		Total: 10

Mark Scheme 2822
January 2006

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

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

1		
(a)	Voltmeter connected in parallel with **X**	B1
(b)	Same reading / no effect / no change	B1
(c)(i)	LDR / light-dependent resistor	B1
(c)(ii)	The resistance decreases (as the intensity of light increases)	B1
(c)(iii)	3.5 – 4.0 × 10^{-7} (m) (to) 6.5 – 7.5 × 10^{-7} (m)	B1
(d)(i)	$R = \frac{V}{I}$ / $R = \frac{1.8}{4.8(\times 10^{-3})}$	C1
	resistance = 375 ≈ 380 (Ω)	A1
(d)(ii)1	*Q* = *It* (Allow with or without the Δ notation)	C1
	Q = 4.8 × 10^{-3} × 30	C1
	charge = 0.144 ≈ 0.14 (C)	A1
(d)(ii)2	*W* = *VQ* / *W* = *VIt*	C1
	W = 1.8 × 0.144 / *W* = 1.8 × 4.8 × 10^{-3} × 30	
	energy = 0.259 ≈ 0.26 (Possible ecf)	A1
	unit: joule / J / VC /VAs	B1
	(Allow 1/3 if power is 0.0086 (W))	
		[Total: 13]
2		
(a)	Kirchhoff's <u>second</u>	B1
(b)	Ohm's	B1
(c)	Resistance	B1
(d)	Electronvolt (Allow eV)	B1
		[Total: 4]
3		
(a)(i)	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ / $R = \frac{R_1 R_2}{R_1 + R_2}$	C1
	$\frac{1}{R} = \frac{1}{20} + \frac{1}{30}$ / $R = \frac{20 \times 30}{20 + 30}$	
	resistance = 12 (Ω)	A1
(a)(ii)	*R* = 10 + 12	
	resistance = 22 (Ω) (Possible ecf)	B1
(b)	*R* = 10 (Ω) / Resistance between B and C = 0	M1
	$I = \frac{5.0}{10}$	
	reading = 0.5 (A)	A1
		[Total: 5]

4		
(a)	Any <u>two</u> from: 1. Concentric circle(s). (Judge by eye) 2. Separation between successive circles increases with distance from wire 3. Correct direction of field (clockwise).	B1 × 2
(b)(i)	Three correct: 2/2 Two correct: 1/2 One correct 0/2 first finger: (magnetic) field second finger: (conventional) current thumb: force / motion	B2
(b)(ii)	The field is parallel to the current / wire	B1
(b)(iii)	Out of (plane of) paper. (Do not allow 'up')	B1
(b)(iv)	**AB** and **CD** experience forces in opposite directions (Allow reference to either torque or couple)	B1
(b)(v)	*F* = *BIL* (Allow any subject)	C1
	$B = \dfrac{3.8\times10^{-2}}{5.2\times0.023}$	C1
	magnetic flux density = 0.318 ≈ 0.32 (T)	A1
		[Total: 10]
5		
	Any <u>four</u> from: 1 (As temperature increases) the resistance of the thermistor / **T** decreases 2 The <u>total</u> resistance decreases (Possible ecf) 3 The current increases (in the circuit) (Possible ecf) 4 The (voltmeter) reading increases / voltage across **R** increases (Possible ecf) 5 The voltage across the thermistor / **T** decreases (Possible ecf) 6 Correct use of the potential divider equation / comment on the 'sharing' of voltage / correct use of $V = IR$	B1 × 4
		[Total: 4]
6		
(a)	$R = \dfrac{\rho L}{A}$ (Allow any subject)	B1
(b)	The resistance decreases	M1
	by a factor of four (because resistance is inversely proportional to radius^2)	A1
(c)(i)	$2200 = \dfrac{3.5\times10^{-5}\times1.3\times10^{-2}}{A}$ / $A = \dfrac{\rho L}{R}$	C1
	$(A =)\dfrac{3.5\times10^{-5}\times1.3\times10^{-2}}{2200}$	C1
	(*A* =) 2.07×10^{-10} (m^2) ≈ 2×10^{-10} (m^2)	A0
(c)(ii)	$P = I^2R$ / $P = VI$ <u>and</u> $V = IR$	C1
	$0.50 = I^2 \times 2200$	C1
	current = 0.015 (A)	A1
	(2.23×10^{-4} scores 2/3 – answer not square rooted)	
		[Total: 8]

7

(a) *Electromagnetic waves* **-** *Any <u>two</u> from:* *B1 × 2*

1. EM wave / light behave like 'particle'/ photon / quantum of energy
2. $E = hf$ / $E = hc/\lambda$
3. E is the energy of <u>photon</u> and f is the frequency (of EM waves) / λ is the wavelength

Moving electrons - Any <u>four</u> from: *B1 × 4*

4. Moving / travelling particle / electron behaves like a wave
5. Mention of the <u>de</u> <u>Broglie</u> (equation)
6. $\lambda = \dfrac{h}{mv}$
7. λ is the wavelength of <u>particle</u>/<u>electron</u>, m is the mass (of particle) and v is speed
8. Electrons can be diffracted (Can score on diagram)
9. Electrons travelling through matter /graphite (show diffraction effects) (Can score on diagram if not scored in 8 above)
10. Electrons diffract because their wavelength is comparable to the size of atoms /gap between atoms (Do not allow 'particles in place of atoms)

	QWC	Spelling, punctuation and grammar	B1
		Organisation	B1
(b)(i)		The <u>minimum</u> frequency needed to free an electron (from the surface of a metal)	B1
(b)(ii)1		Line extended intersects (the f axis at) this value / At this frequency, $E_k = 0$	B1
(b)(ii)2		(ϕ =) $h \times 5.0 \times 10^{14}$ / (ϕ =) $6.63 \times 10^{-34} \times 5.0 \times 10^{14}$	C1
		work function energy = 3.3×10^{-19} J	A1
(b)(iii)1		The gradient / slope of the line is the same	B1
		The gradient is equal to h / independent of the metal	B1
(b)(iii)2		The line is shifted to the right	B1
		The threshold frequency is greater (AW)	B1

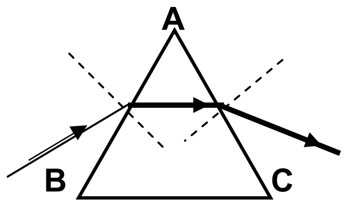
[Total: 16]

Mark Scheme 2823/01
January 2006

MARKSCHEME: 2823 Wave Properties January 2006 – FINAL VERSION

1. (a) ratio of sini/sinr is constant (WTTE) (accept sini/sinr = n or RI) -------- B1
(do not accept ratio of speeds)
incident ray, refracted ray (and normal) all lie in the same plane------ B1 [2]
(allow 'angles of …..')

(b) (i) *correct path through the prism showing:*
refraction towards normal on entry -------------------------------------- B1
refraction away from normal on exit ------------------------------------- B1 [2]



(ii) ray of light slows down (allow changes speed) as it enters glass.----- B1 [1]

(iii) Recall of n =sini/sinr --- C1
correct substitution ⇒ 1.47 = sin 50/sinr ------------------------------- C1
sinr = sin50/1.47 ⇒ r = 31^{O} (31.4) (allow 31.6 or 32) ----------------- A1 [3]

(iv) angle of incidence must be greater than (or = to) critical angle ------ B1 [1]
{ignore any reference to density of media}

(v) correct substitution into n=1/sinC ⇒ e.g. sinC = 1/1.47 ---------------- C1
⇒sinC = 0.680 ⇒C = 43^{O} (42.9) -- A1 [2]

[Total = 11]

---

2. (a) (i) Recall of n= c_i /c_r {or in words} --- C1
⇒ c_r = (3 x 10^8)/1.52 = 1.97 x 10^8 ms^{-1} (allow 2x10^8) ---------- A1 [2]

(ii) Use of speed = distance/time -- C1
t = 3000/1.97x10^8 = 1.52 x 10^{-5} s --------------------- A1 [2]

{allow ecf from (i)}

(b) *meaning of multipath dispersion: e.g.:*
rays (or pulses) take different paths (WTTE) --------------------------- B1
and arrive at different times (WTTE) -------------------------------------- B1
smeared/blurred/spread/elongated/distorted/data corruption -------- B1 [3]
(allow diagrams) (do not allow reduced intensity)

allow any valid method of reducing multipath dispersion, but expect:
use monomode fibre (WTTE) -- B1
so that most rays follow the same path ---------------------------------- B1 [2]

{also allow core/cladding interface has very large critical angle (WTTE) ---- B1
reducing amount of TIR -- B1}

[Total = 9]

3. (a) (i) wave sources that have a constant phase difference (WTTE) ------ B2
{max of 1 mark for sources have same frequency/wavelength/in phase C1}

(ii) sum of <u>displacements</u> (= resultant displacement) (WTTE) ------ B1 [1]
(no marks for reference to amplitude)

(b) (i) constructive interference/waves in phase for maxima
OR destructive interference/waves 'out of phase' -------------------- C1
maxima produced when path difference is 0 OR $n\lambda$ (WTTE) ---- A1
minima produced when path difference is $(n+1/2)\lambda$ (WTTE) ------ A1 [3]
(NB answers that do not account for SERIES of both maxima and minima can score maximum of 2 marks only)

(ii) recall of $x = \lambda D/a$ --- C1
{expressed in any form; allow unusual symbols if correctly identified}
correct substitution: $x = (3.0 \times 50)/6$ ------------------------------------- A1

$x = 25$ cm -- A1 [3]

(iii) microwaves <u>vibrate/oscillate/displaced</u> in <u>one plane</u> (WTTE) --------- B1.
{do not allow travel/propagate in one plane)
signal decreases to zero (WTTE) -- B1 [2]

[Total = 11]

4. (a) waves (travel out from centre and) are reflected (WTTE) ----------- B1
interference/superpositioning occurs (WTTE) ----------------------------- B1 [2]

(b) correct shape drawn -- M1
N labelled at <u>both</u> ends and A in the middle -------------------------- A1 [2]

(c) wavelength = 0.5 x 2 = 1.0m {allow ecf from (b)} ---------------------- B1 [1]

[Total = 5]

5 (a) the spreading out (WTTE) of waves -------------------------------------- B1
(reject bending/change in direction)
when they pass through a gap OR pass a barrier edge --------------- B1 [2]

(b) (i) semicircular wavefronts leaving the gap --------------------------------- B1
no change in wavelength stated OR
clearly shown (at least 3 waves needed) – judged by eye --------- B1 [2]

(ii)	LESS diffraction would occur – shown or stated ----------------------	B1	
	wavefronts mainly plane (by eye) (allow curved at edges) ---------	B1	[2]
(iii)	MORE diffraction for SOUND --	B1	
	Wavelength of sound > wavelength of light (WTTE) -----------------	B1	
	Valid comparison of wavelength of light or sound with doorway e.g. doorway of similar size to wavelength of sound OR wavelength of light is very small compared to door (WTTE) -------	B1	[3]

[Total = 9]

Mark Scheme 2823/03
January 2006

Planning Exercise - Skill P

A1	Diagram of arrangement of apparatus including loaded beam and measurement of tension in wire	**1**
A2	Correct practical procedure (i.e. determine force and angle; change angle and measure new force, – allow graph or table).	**1**
A3	Angle changed by varying vertical height	**1**
B1	Method for measuring angle Use a protractor or correct trigonometry	**1**
B2	stress = force/(cross sectional) area	**1**
B3	Use of micrometer screw gauge to measure thickness of wire	**1**
C1/2	Maximum two separate safety precautions, explicit statements required Danger of heavy loads: sand below load; keep feet away from load; place load near ground; boots with steel toe-caps. Danger of whiplash: use safety screens; eye protection etc.	**2/1/0**
R1/2	Evidence of the sources of the researched material Two or more (vague) references or one detailed reference score one mark. Two or more detailed references scores two marks. Detailed references should have page or chapter numbers or be internet pages.	**2/1/0**
D1/2/3/4	Any further relevant detail. Examples of creditworthy points might be; Value of breaking stress for steel or elastic limit for steel wire used Determination of max force/ diameter of wire, angles Load kept constant Length kept constant Method of ensuring beam is horizontal Further detail on measuring thickness of wire Further detail on measuring angle e.g., white paper backing, use of thin wire, plumb line Evidence of relevant preliminary investigation in the laboratory	max **4**
QWC	Quality of written communication This is for the organisation and sentence construction. Accounts that are rambling, or where the material is not presented in a logical order will not score these marks. Do not award both of these marks if the word count exceeds the recommended length by more than 50%.	**2/1/0**

16 marks total.

Question 1

(a) Determination of angle θ **2/1/0**
$\tan\theta = l/h$ scores one mark
θ scores one mark

(c) Measurements **2/1/0**
Write the number of readings as a ringed total next to the table of results.
Six sets of values for *T* and *d* scores 2 marks. 5 sets scores 1 mark
Minor help from Supervisor then –1.
Major help (equipment set up for the candidate) then -2.
No trend (i.e. random scatter of plots) then -2.

(c) Column headings in the table **2/1/0**
One mark for *d* heading(s) correct.
One mark for *T* heading(s) correct.
Ignore units in the body of the table.

(c) Consistency of raw readings 2/**1**/**0**
One mark for *T* which must be be to the same no of d.p.
One mark for *d* which must be to the nearest mm

(d) Axes **2/1/0**
Sensible scales must be used. Awkward scales (e.g. 3:10, 6:10, 7:10) are not allowed.
The scales must be labelled with the quantities plotted. Ignore units.
Do not allow more than three large squares without a scale label.
Plotted points must occupy at least half the graph grid in both *x* and *y* directions (i.e. 4 x 6 large squares). If false origin, indicate with "FO"
One mark for each correct axis.

(d) Plotting of points **2/1/0**
Count the number of plots and write as a ringed number on the graph grid.
All observations must be plotted. Check a suspect plot. Tick if correct otherwise indicate the correct position.
If the plot is accurate $\leq$ half a small square, then two marks awarded.
One mark if the plot is out by > half a small square and < than one small square.

(d) Line of best fit **2/1/0**
Judge by scatter of points about the line.
There must be a fair scatter of points either side of the line of best fit.
Allow line through five trend plots for full credit (if done well).
Do not allow a line through a curved trend.

(d) Quality of results **2/1/0**
Judge by scatter of points about the Examiner's line of best fit.
Five or more good trend plots on the graph grid needed for two marks to be scored.
Five or more plots with a little scatter then only one mark.

(e) Gradient **2/1/0**
The hypotenuse of the Δ must be ≥ half the length of the drawn line. 1 mark.
Read-offs must be accurate to half a small square and ratio correct. 1 mark.

(f) *y*-intercept **1/0**
Expect the value to be seen and read from the *y*-axis to the nearest half small square.
Or correct substitution from point on line into $y = mx + c$.

(g) (i) Gradient equated with $W/l\cos\theta$ (can be implied from working)
Method of calculating W using candidate's gradient value
Value within 10% of SV [usually 2.7 -3.3]
Sig Figs of W: allow 2 or 3 only
Unit of W **5/4/3/2/1/0**
If substitution is used, max 2 marks

(g) (ii) *y*-intercept equated with $R/2\cos\theta$
Method of calculating *R*
Sig Figs of *R*: allow 2 or 3 only
Unit of *R* **4/3/2/1/0**

28 marks available. Write the mark as a ringed total at the bottom of page 6.

Question 2

(a) (ii)	Calculates *A* correctly	**1**
(b)	Percentage uncertainty in *A*	
	Δd = 1 - 3 mm	**1**
	ratio idea correct ($\Delta d/d$x100%)	**1**
	answer 2 x %uncertainty for d ideas	**1**
	Method must be seen.	
(d) (iv)	Δh correct	**1**
(e)	mass calculated correctly	**1**
	POT loses this mark	
(f)	Evaluation of procedure	**8**

Relevant points must be underlined and ticked with the appropriate marking letter.

	Problem	**Solution**
A	Difficulty in measuring *h*	Scale on tube Clamp rule so distances can be found more easily Use a thinner tube
B	Parallax /meniscus problems Meniscus changes during experiment (by displacement)	Eye to be level Scale close to tube
C	Difficulty with measuring the diameter of the tube	Use vernier callipers/micrometer
D	Tube at an angle	Measure *h* from opposite sides and find average/ use a thinner tube
E	Large uncertainty in *h*	Use a larger value of *N* Use a thinner tube
F	One set of readings is not enough	Take many readings for a range of *N* and plot a graph (i.e. Δh v *N*)
G	Tube not steady/moves around	Use more sand/guide

One mark for each box to a maximum of 8.

No credit for simple 'repeats' or 'using a computer'or digital meters or vague human error.

Quality of written communication (i.e. spelling, punctuation and grammar). **2/1/0**
Capital letters at the beginning of sentences, full stops at the end scores one mark
Correct spelling scores one mark. Allow max two errors.

16 marks available. Write the mark as a ringed total at the bottom of page 11.

Results

Question 1

$L = 0.800$ m
$h = 0.500$ m

$Tan\theta = 0.8/0.5 = 1.6$
$\theta = 58.0\,°$

d / cm	T / N
20.0	2.3
30.0	2.9
40.0	3.6
50.0	4.4
60.0	5.1
70.0	5.7

Plotting a graph of *T* against *d* produces:
Gradient = 6.97
y-intercept = 0.863

gradient = W/lcos θ
W = 0.800 x cos58.0 x 6.97 = 2.95 N

y-intercept = R/2cos θ
R = 2cos58.0x 0.863 = 0.91 N

Results:

(a) d = 2.3 cm
$A = 4.15 \times 10^{-4}\ m^2$

(c) $h_0 = 3.9$ cm

(d) $N = 8$
$h_1 = 3.1$ cm
$\Delta h = 0.8$ cm

(e) $m = 4.15 \times 10^{-4}$ kg or 0.42 g

Summary of shorthand notation which may be used in annotating scripts:

SFP	Significant figure penalty
ECF	Error carried forward
AE	Arithmetical error
POT	Power of ten error
NV	Not valid
NR	Not relevant
GAP	Insufficient scale markings on an axis
NBL	Not best line
FO	False origin
NGE	Not good enough
BOD	Benefit of the doubt
R	Point repeated (no further credit)
NA	Not allowed
SV	Supervisor's value
SR	Supervisor’s report
OOR	Candidate's value is out of range
CON	contradictory physics not to be credited
✓Δ	Used to show that the size of a triangle is appropriate (gradient calculation)
✓A1	Used to show the type of mark awarded for a particular piece of work
✓C	Used to show that the raw readings are consistent
✓d	Used to show that the raw readings have correct spacing
✓SF	Used to show calculated quantities have been given to an appropriate number of significant figures
^	Piece of work missing (one mark penalty)
^^	Several pieces of work missing (more than one mark penalty)
↔	Scale can be doubled in the x-direction
↕	Scale can be doubled in the y-direction

Mark Scheme 2824
January 2006

Mark Scheme	Unit Code 2824	Session January	Year 2006	Final version

Page 1 of 3

Abbreviations, annotations and conventions used in the Mark Scheme	/	= alternative and acceptable answers for the same marking point
	;	= separates marking points
	()	= words which are not essential to gain credit
	ecf	= error carried forward
	AW	= alternative wording

Question			Expected Answers	Marks	
1	**a**	**i**	3.8 ± 0.3 (N s)	**1**	
		ii	momentum (of the ball) *accept impulse*	**1**	
		iii	mv = 3.8 or v = 3.8/0.16; = 23 (m s^{-1}) *ecf a*	**2**	
		iv	use F = ma giving 24 = 0.16a; a = 150 (m s^{-2})	**2**	**6**
	b	**i**	exponential	**1**	
		ii	e.g. $h_1/h_2 = e^k$ = 2.1(5) ; giving k = 0.74 to 0.76 **or** substitution from a line of table; gives 0.748, 0.757 or 0.746	**2**	
		iii	1.5 (m)	**1**	
		iv	Δk.e. = mgΔh; = 0.16 x 9.8 x 0.38 (= 0.60 J)	**2**	**6**
			Total		**12**
2	**a**	**i**	Fig. 2.1 : x and a in opposite directions/acceleration towards equilibrium point/AW; Fig. 2.2 : proportional graph between x and a/AW *Figures not identified max. of 1 mark*	**1** **1**	
		ii	$a = 4\pi^2f^2x$; $50 = 4\pi^2f^2.50 \times 10^{-3}$; giving $f^2 = 25$ and f = 5.0 Hz	**3**	
		iii	cosine wave with initial amplitude 25 mm; decreasing amplitude; correct period of 0.2 s (for minimum of 2.5 periods);	**2** **1**	**8**
	b	**i**	the acceleration towards A/centripetal acceleration or force; is constant	**2**	
		ii	$a = v^2/r$; so $50 = v^2/10$; $v^2 = 500$ giving v = 22.4 m s^{-1}	**3**	**5**
			Total		**13**
3	**a**		appropriate shape; lines perpendicular to and touching plate and sphere; arrows towards negative sphere	**2** **1**	**3**
	b	**i**	By moments, e.g F cos 20 = W sin 20 / by triangle of forces / by resolution of forces / other suitable method; *i.e. justification needed*	**1**	
			$F = 1.0 \times 10^{-5}$ tan 20 ; $= 1.0 \times 10^{-5} \times 0.364$; (= 3.64×10^{-6} N) triangle of forces gives W/F = tan 70, etc	**2**	
		ii	E = F/Q ; = $3.64 \times 10^{-6} / 1.2 \times 10^{-9} = 3.0 \times 10^3$;N C^{-1} / V m^{-1}	**3**	**6**
	c		$E = (1/4\pi\varepsilon_o)Q/r^2$; $3.0 \times 10^3 = 9 \times 10^9 \times 1.2 \times 10^{-9}/r^2$; or use $F = (1/4\pi\varepsilon_o)Q^2/r^2$;	**2**	
			$r^2 = 3.6 \times 10^{-3}$ giving $r = 6 \times 10^{-2}$ (m)	**1**	**3**
	d		field line sketch *minimum of 5 lines symmetrical about line joining centres with arrows* ; Fig 3.1 sketch matches RHS of Fig 3.2/plate analogous to mirror/AW relating to symmetry	**1** **1**	**2**
			Total		**14**

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Question			Expected Answers	Marks	
4	**a**		29; 34		**2**
	b		λ = 0.693/T = 0.693/(120 x 3.2 x 10^7) = (1.8 x 10^{-10} s^{-1}) *accept ln 2*		**1**
	c	**i**	Q = CV = 1.2 x 10^{-12} x 90 ; evidence of calculation (= 1.1 x 10^{-10} C)	**2**	
		ii	n = Q/e = 1.1 x 10^{-10}/1.6 x 10^{-19} ; = 6.9 x 10^8 *allow sig. fig. variations*	**2**	
		iii	A = λN ; N =6.9 x 10^8/1.8 x 10^{-10} ; = 3.8 x 10^{18} *using 7.0 gives 3.9*	**3**	
		iv	1 y is less than 1% of 120 y so expect to be within 1%/ using $e^{-\lambda t}$ gives exactly 1% fall/ problem of random emission or other relevant statement	**1**	**8**
			Total		**11**
5	**a**	**i**	F is towards 'open' end of tube; using Fleming's L.H.rule	**2**	
		ii	F = BIw	**1**	
		iii	F = 0.15 x 800 x 0.0025; = 3.0 (N)	**2**	**5**
	b	**i**	A voltage is induced across moving metal as it cuts lines of flux/AW;	**1**	
			voltage is proportional to flux change per second/AW;	**1**	
			the flux change per second is Bwv / is proportional to the area of metal moving through the field per second / is proportional to v	**1**	
			or Faraday's law fully stated; with reasonable attempt to;	**2**	
			relate flux linkage per second proportionally to speed	**1**	
		ii	flux (linkage) doubles; so using Faraday's law V doubles/AW	**2**	**5**
			Total		**10**
6	**a**		Internal energy is the sum of the <u>random</u> kinetic and potential energies of the <u>particles/molecules/atoms</u> in the system/body	**2**	
			only 1 mark if random omitted		
			s.h.c. is the change in (internal) energy per unit mass/energy required to heat unit mass/kg per unit rise in temperature/^{o}C/K	**1**	**3**
	b		Electrical heating of body for given time/ energy input = VIt;	**1**	
			measurement of mass of body and temperature rise;	**1**	
			hence VIt = mcθ with c found;	**1**	
			comment on heat loss and how avoided/compensated for;	**1**	
			suitable description of apparatus,etc. *max 4 marks*	**1**	**4**
			method of mixtures is an acceptable alternative		
	c	**i**	Q = 2.0 x 920 x 293 ; evidence of calculation (= 540 kJ)	**2**	
		ii	2 kg contains 2/0.027 = 74 moles;	**1**	
			no. of atoms in 2 kg = 74 x 6.02 x 10^{23} = 4.46 x 10^{25};	**1**	
			energy per atom = 5.4 x 10^5/4.46 x 10^{25} (= 1.2 x 10^{-20} J)	**1**	
		iii	e.g 2 x 920/74;= 24.9 J mol^{-1} K^{-1} **or** alternative methods		
			1 mark for suitable method; 1 mark for correct solution	**2**	**7**
			Total		**14**

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Question		Expected Answers	Marks	
7	a	nature and features:		
		α-particle is 2p + 2n/ mass 4 u	1	
		charge of +2e	1	
		very short range/heavily ionizing/absorbed by paper	1	
		spontaneous; and random nature of radioactive decay	2	
		energetically more favourable to eject four particles together than a single one/other comment about energy minimisation/mainly occurs from higher A nuclei/AW	1	
		small mass decrease/loss provides kinetic energy of α-particle	1	
		particle energy of a few MeV; particular decay is monoenergetic	2	
		α-particle scattering:		
		suitable diagram **and**/**or** description to illustrate experiment *up to 2 marks*	2	
		most particles have little if any deflection	1	
		large deflection of very few shows nucleus is small; and very massive	2	
		(Coulomb's law enables closest approach to) estimate nuclear size (in case of α-particle back scattering with conservation of energy argument)	1	
		max 7		7
	b	description:		
		(4) hydrogen or light nuclei/protons are fused together to form a helium/heavier/larger nucleus;	1	
		two positrons must also be released; to conserve charge;	2	
		the process is more complicated than the summary equation suggests/AW;		
		mass reduction provides energy release/ $\Delta m = \Delta E/c^2$	1	
		the process requires very high temperatures (to bring the protons together);	1	
		normally achieved inside a star; only by man in a bomb so far;	1	
		comparison:	2	
		Energy release in fusion is much greater than in radioactive decay;		
		because mass reduction/change in fusion is much greater than in radioactive	1	
		decay/AW;	1	
		as the helium nucleus is so strongly bound;	1	
		also energy release from annihilation of positrons; *max 5*	1	5
		Quality of Written Communication		4
		Total		16

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1	(a)(i)	**Any two from:** Sun in centre Circular planetary orbits Planets move at constant speed Moons orbiting Jupiter Fewer epicycles (accept no epicycles)			2
	(a)(ii)	**Any one from:** Motion of planet would cause wind to blow Motion of planet would prevent objects falling vertically Stellar parallax expected but not observed		1	
	(b)	$(5.2 \times 1.5 \times 10^{11}) = 7.80 \times 10^{11}$m			1
				Total 4	
2.	(a)	**Any two from:**			
		Surface Area/ Volume	1		
		Mass		1	
		Temperature		1	2
	(b)(i)	(Atair) 0.98			1
		(Castor) - 1.03			1
	(b)(ii)	Plot points correctly		1	
	(b)(iii)	Best straight line			1
	(b)(iv)	b = 4.8 from intercept on M axis			1
		correct calculation of gradient			1
		a = - 2.5			1
	(b)(v)	log(star luminosity/Sun luminosity) = 1			1
		absolute magnitude of Sun = 4.8			1
	(b)(vi)	**Any 3 from**:			
		<u>Surface</u> area increases		1	
		Temperature decreases		1	
		Absolute magnitude increases negatively	1		
		Larger surface area raises luminosity/ lower temperature decreases luminosity	1	3	
				Total 14	

3.		Hydrogen atoms/particles		1
		Collapse under gravity/ decrease of gpe		1
		Increase in kinetic energy/ temperature		1
		Fusion of protons		1
		Energy released/ ref. to $E = \Delta mc^2$		1
			Total	5
4.	(a)(i)	**any 2 from**		
		dark lines from absorption of wavelengths 1		
		by atoms/particles in Sun's atmosphere	1	
		re-radiation in all directions	1	2
	(a)(ii)	dark lines correspond to known spectra		1
	(b)(i)	wavelength has undergone Doppler/red shift	1	
		star is receding		1
	(b)(ii)	$v/c = \Delta\lambda / \lambda$		1
		$\Delta\lambda = 1.4\text{nm}$		1
		$v = 1.4 \times 10^{-9} \times 3 \times 10^{8} / 119.5 \times 10^{-9}$	1	
		$v = 3.51 \times 10^{6}\ \text{ms}^{-1}$		1
			Total	9
5.	(a)	A gamma (accept X ray)		1
		B ultra violet		1
		C visible		1
		D radio	1	
	(b)(i)	uniform intensity in all directions		1
		when Universe became transparent/ big bang		1
	(b)(ii)	**any 1 from:**		
		intensity of microwaves on Earth's surface is small 1		
		ripple in intensity is very small/too small for accurate measurement on Earth's surface 1 1		
			Total	7

6.	(a)	$v \alpha r$ / $v = H_o \times r$			1
		labels (including one reference to Earth/Sun/Galaxy)			1
	(b)	infinite Universe			1
		all lines of sight end on star		1	
		so night sky should be bright/ not dark			1
		either			
		expanding Universe/light undergoes red shift		1	
		more distant galaxies have greater red shift	1		
		or			
		age of Universe is finite		1	
		light from distant stars not yet reached Earth	1	2	
				Total	7
7.	(a)(i)	**accept description of plan view or side view.**			
		side: central bulge		1	
		galactic disc <u>each side</u>		1	
		plan: accumulation of stars in centre.		1	
		spiral arms (minimum of 2 arms)		1	2
	(a)(ii)	correct position of Sun (accept 28000ly from centre)			1
	(b)(i)	hydrogen / helium gas			1
		formed after big bang/ remnants of supernovas			1
		critical density is condition for flat Universe.		1	
		dark matter increases density of Universe.		1	
		density greater than critical density.		1	
		Universe will contract/ big crunch.			1
				Total	9

8.	(a)	where Newton's first law is followed (all valid equivalent descriptions accepted.)	1	
	(b)	**any 5 from** a valid thought experiment described eg train, tunnel, lamps.	1	
		observer A at rest (at mid-point of tunnel)	1	
		observer B in moving frame (at constant velocity)	1	
		A measures train equal in length to tunnel from lamps flashing simultaneously	1	
		B measures train to be longer than tunnel from lamps flashing at different times	1	
		symmetry, detail of experimental arrangement.	1	5
	(c)	$l = l_o (1 - v^2/c^2)^{½}$		1
		$v^2/c^2 = (1 - l^2/l_o^2)$		1
		$v = 4.46 \times 10^7$ ms^{-1}		1
			Total	9
9.	(a)(i)	acceleration		1
	(a)(ii)	speed of light constant		1
		frequency is decreased		1
	(b)(i0	gravitational fields and acceleration are indistinguishable	1	
	(b)(ii)	wavelength remains increased		1
		downward gravitational field has same effect as acceleration		1
			Total	6

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1 (a)(i) 10^{-12} (Wm^{-2}) (1)

(ii) …is the <u>minimum</u> intensity / that can be detected by the ear, (1)
at the frequency at which the ear is most sensitive / 1-3 kHz (1)

(b)(i) <u>subjective</u> response of an individual (1)
to <u>sound intensity</u> / <u>intensity level</u> (1)

(ii) any two from
ear is most sensitive at 1 - 3 kHz (1)
as frequency decreases and increases either side of 2 kHz, intensity level must increase in order for the sound to be heard at the <u>same</u> <u>loudness</u> (1)
any comment about points on the graph of <u>equal</u> loudness (1)

(c)(i) I.L. = 10 lg I/I_o (0)
= 10 lg (4.0×10^{-12} / 1×10^{-12}) (1) ecf (a)(i)
= 6.02 dB (0)

(ii) 48 dB (1)

(iii) 48 = 10 lg I / 10^{-12} (1) ecf (ii)
$10^{4.8} \times 10^{-12}$ = I (0)
I = 6.3×10^{-8} W m^{-2} (1)

(iv) any sensible answer e.g.
ear has a logarithmic response to sound (1)
intensity range is very large / easily represented by dB scale / manageable numbers (1)
intensity level is proportional to perceived loudness (1)
it makes the threshold value zero (1)

2 (a) clockwise moments = anti-clockwise (at equilibrium) (1)
24 x 0.6 + 50 x 0.3 = F x 0.03 (1)
F = 980 N (1)

(b) MA = load / effort (1)
= 24 / 1000 (0)
= 0.024 (1)

(c) any sensible answer to a **max. of 4** e.g.
work done for both systems is the product of F and s / W = F x s (1)
small force means large s / effort moves further than load from pivot (1)
energy change is the same for both systems (1)
MA >1 means <u>small</u> F (1)
and hence <u>large</u> s
muscles would have to move further (1)
bones would have to be larger (1)
bones would have to move further (1)
pivot further from muscles / closer to load(1)
plus a reason why this would be disadvantageous to a **max.1** e.g.
awkward / non-compact shape of body (1)
to a total of 5

3 **Formation of image to a max 3** e.g.

X-rays are detected by a film / scintillation counter etc., (1)
High 'Z' means high attenuation / low transmission
[Allow atomic mass / nucleon number] (1)
shadow on the film / reference to exposure after attenuation (1)
Reference to photoelectric effect / energy range around 1-100keV /
absorption $\propto Z^3$ (1)

Explanation of the use of a contrast medium to a max.4 e.g.

X-rays do not differentiate / show up soft tissues well …(1)
… as similar absorption / 'Z' is similar / 'Z' is low for these tissues. (1)
Contrast medium has high 'Z' / absorbs X-rays strongly.(1)
It is usually taken orally / as an enema / can be injected.(1)

Example of type of structure that can be imaged to a max.1 ***e.g.***

digestive tract / throat / stomach.(1)

to a max. 8

4 (a)(i) depth of field (1)

(ii) before / in front of the retina (1)

(iii) the image on the retina is not in focus (0)
but it is considered to be acceptably clear (1)

(b) change the shape of the lens (1)
so that the power of the lens may be altered / reference to focusing on different objects (1)

(c)(i) convex shape (1)

(ii) long sight / hypermetropia / presbyopia (1) ecf (i)

(iii) $1/f = 1/u + 1/v$ (1)
$1/f = 1/2 + 1/1$ (1)
$f = 67$ cm (1)

(iv) $p = 1/f$ (1)
$p = 1/ 0.67$ (0) ecf (iii)
$p = 1.5$ D (1)

(d) **cornea-retina distance:**
$1/f = 1/u + 1/v$
$59 = 1/\infty + 1/v$ (1)
$v = 1.7$ cm (0.01695) (1)

power of eye and lens:
$P_e + 1.5 = 1/0.25 + 1/0.017$ (1)
$P_e = 61.5$ D (1)

near point :
61.5 = 1/u + 59 (1)
u = 40 cm (1)

5(a) 6 points plotted correctly (1)
remaining point plotted correctly (1)
sensible continuous smooth graph drawn (1)

(b)(i) 0.95 +/- 0.10 mm (1)

(ii) $I / I_o = e^{-\mu x}$ (1)
$0.50 = e^{-\mu\ 0.0009}$ (1)
μ = 730 (1)
m^{-1} (1)

6(a) H = Q x D (0) terms identified (1)

(b) **either :**
alpha particles are attenuated in 2-3 cm of air (1)
so all of the ionisation occurs in this small volume (1)
:**or**
beta-particles are attenuated in a much greater distance (1)
so energy is dissipated over a larger volume (1)
to a max. 2

(c) (i) $20 \times 5 \times 50 \times 1.0 \times 10^{-6} = 5.0 \times 10^{-3}$ Sv (1)
$+ 6 \times 10^{-3}$ Sv $= 11 \times 10^{-3}$ Sv (1)

(ii) comment with respect to MPL (and background radiation) (1)

7 **Medical uses of an endoscope [2 marks]:-**

Any **TWO** e.g.
To view inside the body./ named area e.g. stomach (1)
To view a second named area etc., (1)
To carry out minor surgical operations / keyhole surgery / incisions (e.g ulcers, cancers) (1)
To get tissue samples (1)
To remove obstacles from the stomach, etc.(1)

How light rays pass through optic fibres to a max. 2 e.g.

reference to total internal reflection(1)
explanation: 'i' is greater than 'c' / cladding is less (optically) dense than fibre (1)

Explanation of the use of coherent / non-coherent bundles *to a max. 3* e.g.

the meaning of coherent in this context (1)
non-coherent fibres are used to take light to the area (1)
coherent fibres are used to convey / construct the image (1)

Question	Expected Answers		Marks	
8				
(a)	*either* (If in parallel) when one bulb fails, other bulbs stay on *or* (If in parallel) can identify which bulb has failed;		1	[1]
(b)(i)	$P = VI$		1	
	$0.5 = 240\,I$			
	$I = 2.1 \times 10^{-3}$ A 1 s.f. in answer (-1) once only		1	[2]
(ii)	$R = V/I$		1	
	$= 240/(2.1 \times 10^{-3})$			
	$= 1.14 \times 10^{5}\,\Omega$ or $1.15 \times 10^{5}\,\Omega$	ans		
	accept $(1.1 \text{ to } 1.2) \times 10^{5}\,\Omega$	.	1	[2]
(iii)	$A = \rho l / R$		1	
	$= 1.1 \times 10^{-6} \times 6.0 \times 10^{-3} / (1.14 \times 10^{5})$ (= 5.79×10^{-14} m^2)			
	$A = \pi r^2$		1	
	$5.79 \times 10^{-14} = \pi r^2$ so $r = 1.4 \times 10^{-7}$ m		1	[3]
(iv)	filament too thin / fragile to be manufactured / used without damage; allow ecf from **(iii)**.		1	[1]
(c)	**P**: 0 V **Q**: 0 V;		1	
	R: 240 V **S**: 240 V		1	
	current is zero (1) p.d. across (any intact) bulb becomes zero (1) so all 240 V across Y (1)	any 2	2	[4]

d(i)	*either* set B bulb(s) have less resistance (than set A bulbs) *or* adding (each) set B bulb lowers circuit resistance;	1	
	either so current increases (when set B bulb inserted) *or* p.d. across (each) bulb increases *or* any valid argument using V^2 / R ;	1	
	so power dissipation (in any bulb) increases;	1	[3]
(ii)	set A bulbs fail first;	1	
	Then *either* Failure current for set A bulb $I_f = \sqrt{P/R} = \sqrt{0.75/200} = 0.0612$ A;	1	
	When failure occurs <u>total</u> resistance of set = 240 / 0.0612 (= 3920);	1	
	Let X be number of 50 Ω bulbs substituted 3920 = 50X + 200(24 - X) ; so X = 5.87 bulbs , so 5 or 6 bulbs;	1	
	or Total initial resistance = 24 x 200 = 4800 Ω After substituting X set B bulbs, resistance = 4800 - 150 X (1) Current = 240/(4800 - 150 X) (1) So power in a set A bulb, $P = I^2 R = [240/(4800 - 150\,X)]^2 \times 200 = 0.75$ for failure (1) This gives X = 5.87 i.e. 5 or 6 bulbs		[4]

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1. (a) (i) 6 (1)
(ii) 12 (1) [2]

(b) (i) 1 mole contains 6.0×10^{23} atoms / mass of 6.0×10^{23} gold atoms is 0.197 kg (1)
mass of a gold atom = $0.197/ 6.0 \times 10^{23}$ (= 3.3×10^{-25} kg) (1) [2]
[Allow $1.93 \times 10^4 / 5.9 \times 10^{28}$ (= 3.3×10^{-25} kg)]

(ii) Number of moles of gold in 1 m^3 = $1.93 \times 10^4 / 0.197$ = 9.80×10^4
Number of gold atoms in 1 m^3 = $9.80 \times 10^4 \times 6.0 \times 10^{23}$ (= 5.9×10^{28}) (1)
OR
Number of gold atoms in 1 m^3 = density / mass of gold atom
= $1.93 \times 10^4 / 3.3 \times 10^{-25}$ (= 5.9×10^{28}) (1) [1]

(c) (i) Volume of 5.9×10^{28} gold atoms = 0.74 m^3 (1)
Volume of a gold atom = $0.74 / 5.9 \times 10^{28}$ = 1.25×10^{-29} m^3 (1) [2]

(ii) Volume of sphere, $V = 4\pi/3 \times (\text{radius})^3$ (1)
radius = $[(3 \times 1.25 \times 10^{-29}) / 4\pi]^{1/3}$ = 1.44×10^{-10} m (Allow e.c.f.) (1) [2]

[Total: 9]

2. (a) Grains in which atoms are arranged in a repeating pattern; (1)
Separated by grain boundaries; (1)
from other grains with patterns in different orientations. (1) [3]

(b) (i) Atoms are farther apart in graphite (than in diamond). [1]

(ii) (Compared with diamond) atoms in graphite are farther apart so bonds between them are weaker. / Less thermal energy is required to break bonds between atoms in graphite (than in diamond). [1]

(iii) Graphite consists of parallel layers of carbon atoms; (1)
which easily slide over each other / readily undergo plastic deformation. (1) [2]

(iv) Very strong bonds between diamond atoms; (1)
make diamond harder than other materials (and so able to scratch them). (1) [2]

[Total: 9]

3. (a) Area of cross-section = $\pi \times (5.9 \times 10^{-5})^2 = 1.09 \times 10^{-8}$ (m^2) (1)
Conductivity = 1/resistivity (1)
= $L/RA = 0.61/[71 \times \pi \times (5.9 \times 10^{-5})^2]$ = 7.86×10^5 (1)
$\Omega^{-1}m^{-1}$ (1)
Allow 1 mark for resistivity = 1.27×10^{-6} (Ωm) [4]

	(b)	v = I/nAe;	(1)
		n: number of free electrons per m^3 / charge carriers per m^3 ;	
		I: current A: cross-section of filament (e: electron charge).	(1) [2]
	(c)	(i) Fuse-wire has a smaller cross-section than the copper wire;	(1)
		Fuse wire has lower n / free electron / charge carrier concentration than copper / has fewer electrons in the conduction band.	(1) [2]
		(ii) In a metal, conducting electrons collide with metal atoms;	(1)
		increasing their (vibrational) kinetic energy of atoms causing higher temperature;	(1)
		Energy transfer to atoms is greater in the fuse (than in the copper wire);	(1)
		because greater speed / k.e.of conducting electrons in the fuse;	(1)
		outweighs the effect of a larger number of conducting electrons in copper.	(1) max
			[Total: 12]
4.	(a)	Graph of correct shape <u>passing through origin;</u>	(1)
		showing zero gradient at maximum B.	(1) [2]
	(b)	Mention of domains;	(1)
		Mention of dipoles;	(1)
		When B is zero / I is zero / at origin, domains are randomly orientated;	(1)
		Reference to domains orientated in the (general) direction of the magnetising field;	(1)
		Walls of these domains move / these domains grow (others shrink);	(1)
		Dipoles (within domains) rotate to be in line with magnetising field;	(1)
		This occurs where gradient of graph is less steep / This process takes place less readily / requires more energy;	(1)
		Where graph is horizontal / gradient zero;	(1)
		B has reached maximum (saturation) value when all dipoles are aligned;	(1) max
			[Total: 9]
5.	(a)	Labelled diagram showing: valence band below energy gap;	(1)
		energy gap labelled 1.1 eV.	(1)
		conduction band above energy gap.	(1) [3]
	(b)	In the dark few electrons in the conduction band;	(1)
		In daylight light <u>photons</u> provide energy;	(1)
		to promote (many) more electrons from valence band to conduction band;	(1)
		High / low resistance related to few / many conduction band electrons.	(1) [4]
	(c)	(i) Circuit with battery connected to LDR;	(1)
		Ammeter and voltmeter correctly connected.	(1) [2]
		(ii) Control and measurement of light intensity:	
		Arrangement to shield LDR from light from unwanted sources / Carry out experiment in darkened room;	(1)
		Use constant light source placed at variable distance from LDR / Use light source of variable power at fixed distance from LDR;	(1)
		with light meter to record light intensity at position of LDR.	(1) [3]

Ranges of meters:
Voltmeter with range applicable to battery voltage / say 0 - 10 V scale; (1)
For maximum light conditions use milliammeter; (1)
and for minimum light conditions use microammeter. (1)
OR
Reference to multimeter to read current (1) with appropriate change of scale. [3]

Readings and calculations:
For each position of light source / power value of light source, measure (and record) readings from light meter; (1)
Read (and record) readings from voltmeter and ammeter and calculate resistance using R = V/I. (1) [2]

[Total: 17]

6. (a) (i) Speed v = c/n (1)
$= 3.0 \times 10^8 / 1.47 = 2.04(1) \times 10^8$ m s^{-1} (1) [2]

(ii) Time for the mean wavelength = s/v (1)
$= 1000 / 2.04 \times 10^8 = 4.9(00) \times 10^{-6}$ s (e.c.f.) (1) [2]

(b) Speed of the maximum wavelength $= 2.041 \times 10^8 \times 1.001$ (e.c.f.)
$= 2.042(9) \times 10^8$ m s^{-1} (1)

Time for the maximum wavelength $= 1000 / 2.043 \times 10^8 = 4.8951 \times 10^{-6}$ s (e.c.f.) (1)
Time difference $= 4.9 \times 10^{-6} - 4.8951 \times 10^{-6} = 5.0 \times 10^{-9}$ s (1) [3]

(c) (i) [Do not accept multipath dispersion without explanation]
A pulse of radiation spreads out as it travels through the fibre; (1)
Causing a signal to be distorted; (1)
Imposing a limit to the number of pulses able to be transmitted per second. (1) max

(ii) Use infra-red from a laser; (1)
The band of wavelength / frequency from a laser is narrower, so less variation in speed / smaller time difference. (1) [2]

(d) Between 1.35 μm and 1.45 μm photons are absorbed by (hydoxyl ion) impurities in the glass; (1)
At λ = 1.5 μm the amount of Rayleigh scattering is low, and absorption by other processes is minimal; (1)
Above 1.5 μm photons are (increasingly) absorbed by vibrating bonds in the glass structure. (1) [3]

[Total: 14]

Question	Expected Answers		Marks	
7				
(a)	*either* (If in parallel) when one bulb fails, other bulbs stay on *or* (If in parallel) can identify which bulb has failed;		1	[1]
(b)(i)	$P = VI$		1	
	$0.5 = 240\,I$			
	$I = 2.1 \times 10^{-3}$ A 1 s.f. in answer (-1) once only		1	[2]
(ii)	$R = V/I$		1	
	$= 240/(2.1 \times 10^{-3})$			
	$= 1.14 \times 10^{5}\,\Omega$ or $1.15 \times 10^{5}\,\Omega$	ans		
	accept $(1.1$ to $1.2) \times 10^{5}\,\Omega$	.	1	[2]
(iii)	$A = \rho l / R$		1	
	$= 1.1 \times 10^{-6} \times 6.0 \times 10^{-3} / (1.14 \times 10^{5})$ (= $5.79 \times 10^{-14}\,m^2$)			
	$A = \pi r^2$		1	
	$5.79 \times 10^{-14} = \pi r^2$ so $r = 1.4 \times 10^{-7}$ m		1	[3]
(iv)	filament too thin / fragile to be manufactured / used without damage; allow ecf from **(iii)**.		1	[1]
(c)	**P**: 0 V **Q**: 0 V;		1	
	R: 240 V **S**: 240 V		1	
	current is zero (1) p.d. across (any intact) bulb becomes zero (1) so all 240 V across Y (1)	any 2	2	[4]

d(i) *either* set B bulb(s) have less resistance (than set A bulbs)
or adding (each) set B bulb lowers circuit resistance; 1

either so current increases (when set B bulb inserted)
or p.d. across (each) bulb increases
or any valid argument using V^2 / R ; 1

so power dissipation (in any bulb) increases; 1 [3]

(ii) set A bulbs fail first; 1

Then
either Failure current for set A bulb $I_f = \sqrt{P/R} = \sqrt{0.75/200} = 0.0612$ A; 1
When failure occurs <u>total</u> resistance of set = 240 / 0.0612 (= 3920); 1
Let X be number of 50 Ω bulbs substituted
3920 = 50X + 200(24 - X) ; 1
so X = 5.87 bulbs , so 5 or 6 bulbs;

or Total initial resistance = 24 x 200 = 4800 Ω
After substituting X set B bulbs, resistance = 4800 - 150 X (1)
Current = 240/(4800 - 150 X) (1)
So power in a set A bulb,
$P = I^2 R = [240/(4800 - 150\,X)]^2 \times 200 = 0.75$ for failure (1)
This gives X = 5.87 i.e. 5 or 6 bulbs [4]

Mark Scheme 2825/04
January 2006

Question	Expected Answers	Marks
1 (a)	forces F_S and F_G acting inwards, force F_E acting outwards - all through centre of proton; 3 forces 2/2, 2 forces 1/2, marked and labelled	2 [2]
(b)	$F_E = F_S + F_G$; accept $F_E + F_S + F_G = 0$ allow ecf from **(a)**	1 [1]
(c)(i)	$F_E = Q^2/(4\pi\varepsilon_0 r^2)$ $= (1.6 \times 10^{-19})^2 / [4\pi \times 8.85 \times 10^{-12} (2.8 \times 10^{-15})^2] = 29\,\text{N}$ use of $r = 1.4 \times 10^{-15}$ m (-1) once only	1 1
(ii)	$F_G = m^2 G / r^2$ $= (1.67 \times 10^{-27})^2 \times 6.67 \times 10^{-11} / (2.8 \times 10^{-15})^2 = 2.4 \times 10^{-35}\,\text{N}$	1 1
(iii)	F_S = 29 N / same as F_E allow ecf	1 [5]
(d)	$F_E >> F_G$ so F_G negligible / insignificant / can be ignored or AW	1 [1]
(e)(i)	$F_E = 0$ (1)	
(ii)	$F_G = 2.4 \times 10^{-35}$ N (approx.) allow ecf (1)	
(iii)	$F_S = 2.4 \times 10^{-35}$ N (approx.) (1) comment: F_S now repulsive (not attractive) or AW *or* indicated by minus sign with F_S ; (1) any 3	3 [3] **12**
2(a)(i)	${}^{238}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{239}_{92}\text{U}$	1
(ii)	${}^{239}_{92}\text{U} \rightarrow {}^{239}_{93}\text{X} + {}^{0}_{-1}\text{e} + {}^{(0)}_{(0)}\nu(\text{–bar})$	2
(iii)	${}^{239}_{93}\text{X} \rightarrow {}^{239}_{94}\text{Pu} + {}^{0}_{-1}\text{e} + {}^{(0)}_{(0)}\nu(\text{–bar})$ omits any neutrino (-1) once only electron incorrectly represented (-1) once only	1 [4]

(b)(i)	24 000 year / >24 000 year	1	[1]
(ii)	λ = ln 2 / $T_{½}$ = ln 2 / (24000 x 365 x 24 x 3600) subs. = 9.16 x 10^{-13} s^{-1} *or* < 9.16 x 10^{-13} s^{-1} ans. failure to convert years to s, giving 2.89 x 10^{-5}, gets 1/2	1 1	 [2]
(c)(i)	239 g of Pu contain 6.02 x10^{23} atoms *or* alternative correct use of N_A N = (0.05 x 4.4 / 0.239) x 6.02 x 10^{23} ie applies % and units correctly (= 5.54 x 10^{23} (atoms))	1 1	 [2]
(ii)	activity = λN = 9.16 x 10^{-13} x 5.54 x 10^{23} allow ecf = 5.08 x 10^{11} Bq / s^{-1} ans. + unit	1 2	 [3] **12**
3(a)	p.e. increases k.e. decreases *or* k.e. is converted to p.e. gets 2/2 eventually <u>all</u> k.e. is changed to p.e.	1 1 1	 [3]
(b)	E_P = (1.6 x 10^{-19})^2 / (4 π x 8.85 x 10^{-12} x 2.1 x 10^{-15}) (= 1.1 x 10^{-13} J) so k.e. of <u>each</u> proton = ½ x 1.1 x 10^{-13} = 5.5 x 10^{-14} J	1 1	 [2]
(c)	5.5 x 10^{-14} = 2.07 x 10^{-23} T so T = 2.7 x 10^9 K ans. accept 2.6 x 10^9 K	1	[1]
(d)	*either:* E_K is the *mean* k.e. of protons (1) protons (in plasma) have a range of k.e.s (1) any 1 so (at any instant) some protons have much greater k.e. than average *or:* protons can fuse for separations > 2.1 fm (1) because of (quantum) tunnelling (effects) (1)	 1 1	 [2]

(e)(i) (ii)	$2 \times (2.3 \times 10^{-13}) + 2 \times (8.8 \times 10^{-13}) + (20.6 \times 10^{-13}) = 42.8 \times 10^{-13}$ J adds energies, without x 2 gives 31.7×10^{-13} J for 1/2 (2) neutrinos escape from the Sun (and carry away energy)	2 1	[2] [1]
(f)	*either* T ($\propto E_K$) $\propto Q_1 Q_2$ and $Q_1 Q_2$ is greater for reactions in carbon cycle (eg 1 x 12 > 1 x 1); *or* verbally: repulsion is greater between nuclei in carbon cycle; greater repulsion / Coulomb barrier means more energy needed (so higher temp.)	 1 1	 [2] **13**
4(a)	fixed target: accelerate one beam of particles / use high velocity / high energy particles; collide with stationary particles / nuclei; colliding beam: accelerate two beams of particles / use high velocity / high energy particles; collide them head-on / from opposite directions; 'fired at' / 'aimed at' / 'directed at' instead of accelerated etc, (-1) once Advantages: fixed target: no steering problems; (1) high probability of collision / many collisions; (1) because high density of particles in fixed target; (1) no problems of recoil in target; (1) any 1 colliding beam: (total) initial mtm. (can be) zero so final (overall) mtm. (can be) zero; *either* so <u>all</u> k.e. can contribute to making new particles *or* two beams means twice as much energy available; allow any other relevant point up to appropriate max.	1 1 1 1 1 1 1	 [7]

(b)(i)	$m_e c \approx m_Z c$ so $m_e \approx m_Z$	1 1	 [2]
(ii)	ratio = $(1.6 \times 10^{-25})/(9.11 \times 10^{-31}) = 1.8 \times 10^5$	1	[1]
(iii)	mass increases with speed positron and $^{(0)}_{(0)}Z$ have different speeds (so masses have changed by different amounts)	1 1	 [2]
(c)	much / most of input energy goes into k.e. of $^{(0)}_{(0)}Z$ particle (so less energy available to create $^{(0)}_{(0)}Z$)	1	[1] **13**
5(a)	β^+ : $^{192}_{79}Au \rightarrow {}^{0}_{1}e + {}^{192}_{78}Pt + {}^{0}_{0}\nu$ β^- : $^{192}_{79}Au \rightarrow {}^{0}_{-1}e + {}^{192}_{80}Hg + {}^{0}_{0}\nu$ (-bar) omits both neutrinos gets 1/2 max.	1 1	 [2]
(b)	β^+ decay: reactant mass = 191.921 47 u product mass = 191.918 24 + 0.000 55 = 191.918 79 u products mass < reactant mass so reaction <u>can</u> occur β^- decay: (reactant mass = 191.921 47 u) product mass = 191.921 41 + 0.000 55 = 191.921 96 u products mass > reactant mass so reaction <u>cannot</u> occur	1 1 1 1 1	 [5]

(c)	β^+ mass defect / mass loss = 191.921 47 - 191.918 79 (= 0.002 68 u) then *either*: mass loss in kg = 0.002 68 x 1.66 x 10^{-27} (= 4.45 x 10^{-30} kg) so energy loss = $\Delta m\, c^2$ 4.45 x 10^{-30} x (3.0 x 10^8)^2 = 4.00 x 10^{-13} J *or* : 0.002 68u = 0.002 68 x 932 MeV (2) = (2.50 MeV) = 2.50 x 10^6 x 1.6 x 10^{-19} (1) = 4.00 x 10^{-13} J (1) accept 930 - 934 MeV u^{-1} giving 3.99 - 4.00(5) x 10^{-13} J	1 1 1 1	 [4] **11**
6(a)	all free hadrons (thought to be) (somewhat) unstable; (1) protons and neutrons are (both) hadrons; (1) + (1) protons and neutrons inside a nucleus are stable; (1) free neutrons have half life of 10 - 15 minutes; (1) free protons are stable / have half life of about 10^{32} year; (1) any 5 allow equivalent marks for other hadrons and / or other relevant points	5	[5]
(b)(i) **(ii)** **(iii)**	weak (force / interaction); ${}^{3}_{1}H$ -> ${}^{3}_{2}He$ + ${}^{0}_{-1}e$ + $\bar{\nu}$; d -> u + e + $\bar{\nu}$; d -> u gets 1/2 u d -> u + e / β + $\bar{\nu}$ is not in simplest form, so gets 1/2 d baryon reaction ${}^{1}_{0}n$ -> ${}^{1}_{1}p$ + ${}^{0}_{-1}e$ + $\bar{\nu}$ gets 1/2	1 1 2	[1] [1] [2] **9**

Mark Scheme 2825/05
January 2006

Question 1	Expected Answers	Marks

(a)

(i) Frequency of signal generator

One cycle of waveform lasts 30 ms 1

frequency = 1 / period

= 1 / 0.030 = 33 Hz 1

(ii) Frequency of sampling

Each sample lasts for a time of 2.5 ms 1

frequency = 1 / 0.0025 = 400 Hz 1

(iii) Number of wires

Number of voltage levels = 12 1

Number of bits converted = 2 1

Number of bits converted = 4 1

(Allow answer of 5 if zero volt common line is included)

(b)

(i) Increasing ADC sampling:The trace would look almost identical to Fig.1.2 1

because there are only 16 possible levels, no matter how fast the sampling 1

(ii) Increasing the number of bits: Trace would still look almost identical to Fig.1.2

because no matter how many possible levels, they only occur every 2.5 ms 1

(c)

(i) Long distance multicore cable would be expensive

Cross-talk would occur between parallel lines

Long distance transmission of parallel word results in skew (bits don't arrive at same time) (any two) 1 1

(do not award any comment on multipath dispersion as this applies to parallel and serial)

(ii) The n-bit parallel word from the ADC is input to a Parallel-to-Serial shift register circuit 1

which outputs each bit into the single line one after the other 1

At the other end of the line a Serial-to-Parallel shift register circuit reassembles the output. 1

Question 2	Expected Answers	Marks

(a)

(i) Difference amplifier The output at C depends on the difference between B and A 1

V_C = (V_B - V_A) x open-loop gain 1

(ii) -ve saturation (allow from -13V to -15V) 1 0 V 1
+ 2V (ignore sign) 1

(b) Voltage at A = 15 x 12 / (18 + 12) 1

= 6 V 1

(c) (i) Thermistor correctly circled 1

(ii) As the temperature of the thermistor increases / decreases

the resistance of the thermistor decreases / increases

①

(iii) If B = 6V , the current in 5 kW resistor = 6 / 5 = 1.2 mA 1

Resistance of thermistor = V / I = (15 - 6) /1.2 1

= 7.5 kW 1

(d) The motor current is only P / V = 150 / 15 = 10 mA

The op-amp is not capable of delivering a large current to a powerful motor

The op-amp output is limited by saturation

The op-amp has too large an output resistance (any two points) 1 1

(e) Without the diode the motor would run all the time

(ie function of diode or wtte) 1

Because both +ve and -ve saturations will drive motor 1
(ie effect of function of diode)

(f) When it is cold, the resistance of the thermistor is greater than 7.5 kW

so the voltage at point B is less than 6V and op-amp is in -ve saturation - motor off

When it is hot, the resistance of the thermistor is less than 7.5 kW

So the voltage at B is greater than 6V and op-amp is in +ve saturation - fan turns.

(any three points) 1 1 1

Question 3	Expected Answers	Marks

(a) AM AM = Amplitude Modulation 1

The amplitude of a high frequency carrier wave

is controlled by the (instantaneous) value of information signal 1

FM FM = Frequency Modulation 1

The frequency of a high frequency carrier wave

is controlled by the (instantaneous) value of information signal 1

(b) FM is constant amplitude signal so no information is contained in amplitude

Noise accumulates on FM amplitude and so can be removed

However, in AM the amplitude variation is the information

Thus noise is integral part of AM signal (or wtte)

(up to 2 marks for comments on *noise*)1 1

FM broadcasts an audio bandwidth up to 15 kHz

AM broadcasts are limited to a maximum audio bandwidth of about 4 kHz.

Broadcast FM has a greater dynamic range than FM

(up to 2 marks for *other reasons*) 1 1

(c) Nationwide coverage of AM on LF would require only one transmitter 1

located in middle of country / population

because LF propagates by surface wave over 1000 km. 1

Nationwide coverage of FM on VHF would require many transmitters 1

located all over country with different carrier frequencies

because VHF propagates by space wave only to a range of about 40 km. 1

(d) Diagram of Dipole aerial 1 Typical VHF carrier f = 100 MHz 1

(between 30MHz and 300MHz)

Wavelength $\lambda = c / f$

$= 3 \times 10^8 / 100 \times 10^6$

$= 3$ m 1

Dipole length = $\lambda / 2 = 1.5$ m 1

Question 4	Expected Answers	Marks

(a) Noise — Any unwanted energy / power added to signal — 1

(b) Signal power decreases along transmission path ie attenuation occurs — 1

Noise power remains more or less constant - hence ratio decreases — ①

(c)

(i) Signal-to-noise = 34 = $10 \lg P_{sig} / 0.28 \times 10^{-6}$ — 1

Thus $P_{sig} = 10^{3.4} \times 0.28 \times 10^{-6}$ — 1

= 0.70 mW

(ii) Attenuation along fibre = $10 \lg 0.70 \times 10^{-3} / 22 \times 10^{-3}$ — 1

= 15 dB — 1

(iii)	Separation of exchanges	=	5 (sections) x 15 / 0.30			1
		=	250 km			1
(d)	Speed of light in core	=	3×10^8 / 1.5	=	2×10^8	1
	Minimum time in fibre	=	250×10^3 / 2×10^8			1
		=	1.25 ms			1

Question 5	Expected Answers	Marks

Mobile Telephone Network

System uses carrier frequencies in the UHF region / GHz region

This means using small wavelengths in the order of cms

This means small and inconspicuous aerials can be used to transmit and receive

Waves in the UHF region travel by line-of-sight so have limited terrestrial range

Low power transmitters mean the same frequencies can be used as carriers over and over again

Up to 3 points

Country is divided into cells

Each cell is normally in the order of a few km radius

At the centre of each cell is a base station

Several base stations from a cluster of cells are connected to a cellular exchange

The cellular exchange is connected to the Public Switched Telephone Network (PSTN)

Up to 3 points

When mobile phone is activated it transmits an identifying digital signal

This signal is picked up by a number of base stations under the control of cellular exchange

Cellular exchange selects appropriate base station through which to link mobile to PSTN

Up to 2 points

Mark Scheme 2825
Common Question
January 2006

Question	Expected Answers	Marks
(a)	*either* (If in parallel) when one bulb fails, other bulbs stay on *or* (If in parallel) can identify which bulb has failed;	1 [1]
(b)(i)	$P = VI$ $0.5 = 240\,I$ $I = 2.1 \times 10^{-3}$ A 1 s.f. in answer (-1) once only	1 1 [2]
(ii)	$R = V/I$ $= 240/(2.1 \times 10^{-3})$ $= 1.14 \times 10^{5}\,\Omega$ or $1.15 \times 10^{5}\,\Omega$ ans accept $(1.1$ to $1.2) \times 10^{5}\,\Omega$.	1 1 [2]
(iii)	$A = \rho l / R$ $= 1.1 \times 10^{-6} \times 6.0 \times 10^{-3} / (1.14 \times 10^{5})$ $(= 5.79 \times 10^{-14}\,m^2)$ $A = \pi r^2$ $5.79 \times 10^{-14} = \pi r^2$ so $r = 1.4 \times 10^{-7}$ m	1 1 1 [3]
(iv)	filament too thin / fragile to be manufactured / used without damage; allow ecf from **(iii)**.	1 [1]
(c)	**P**: 0 V **Q**: 0 V; **R**: 240 V **S**: 240 V current is zero (1) p.d. across (any intact) bulb becomes zero (1) so all 240 V across Y (1) any 2	1 1 2 [4]
d(i)	*either* set B bulb(s) have less resistance (than set A bulbs) *or* adding (each) set B bulb lowers circuit resistance; *either* so current increases (when set B bulb inserted) *or* p.d. across (each) bulb increases *or* any valid argument using V^2 / R ; so power dissipation (in any bulb) increases;	 1 1 1 [3]
(ii)	set A bulbs fail first; Then *either* Failure current for set A bulb $I_f = \sqrt{P/R} = \sqrt{0.75/200} = 0.0612$ A; When failure occurs <u>total</u> resistance of set = 240 / 0.0612 (= 3920); Let X be number of 50 Ω bulbs substituted 3920 = 50X + 200(24 - X) ; so X = 5.87 bulbs , so 5 or 6 bulbs; *or* Total initial resistance = 24 x 200 = 4800 Ω After substituting X set B bulbs, resistance = 4800 - 150 X (1) Current = 240/(4800 - 150 X) (1) So power in a set A bulb, $P = I^2 R = [240/(4800 - 150\,X)]^2 \times 200 = 0.75$ for failure (1) This gives X = 5.87 i.e. 5 or 6 bulb	1 1 1 1 [4]

Mark Scheme 2826/01
January 2006

1 **(a)** speed as distance per unit time and velocity as displacement per unit time {1}

velocity requires a direction to be given as well as a magnitude {1} [2]

OR definition of speed or velocity followed by

speed as a scalar quantity and velocity as a vector quantity

(b) elastic materials return to their original shape when a distorting force is removed {1}

plastic materials are have their shape permanently changed by a distorting force {1} [2]

Allow in terms of elastic/plastic collisions

(c) Heat is a form of energy which flows as a result of a temperature gradient {1}

Temperature is the property of a body which determines the direction of heat flow {1}

Allow Temperature (of an ideal gas) is proportional to the (mean) kinetic energy of the molecules

[2]

(d) fission is when splitting (into two parts releasing energy) takes place and

fusion is when joining together takes place {1}

nuclei as the active particles {1}

[2]

(e) kinetic energy is the energy a body possesses by virtue of its speed {1}

as an energy it is a measure of force x distance {1}

the rate of change of momentum defines force {1}

momentum is therefore a measure of force x time {1} [4]

Other possible answers will score a <u>maximum of 3</u> unless the force x distance relationship is given for kinetic energy and the force x time relationship is given for momentum

momentum is <u>always</u> conserved in a collision (in the absence of external forces) {1}

but kinetic energy may be lost – with qualification of what happens {1}

kinetic energy is proportional to v^2 but momentum is proportional to v {1}

kinetic energy is a scalar; momentum is a vector {1}

[Total : 12]

2. (a) (i)

capacitor	capacitance / μF	charge / μC	p.d. / V	energy / μJ
X	5	30	= Q/C = 6 (V) {1}	=½ CV^2 {1} = ½ x 5 x 6^2 = 90 {1}
Y	25	= CV = 25 x 6 = 150 (μC) {1}	= 6 (V) {1}	= 450 {1}
Z	10	30 + 150 = 180 (μC) {1}	= Q/C = 180/10 = 18 (V) {1}	= 1620 {1}

Each box correctly calculated scores [1] + [1] for ½ CV^2 [9]

(ii) **1** 18 V + 6 V = 24 (V) {1}

2 180 (μC) {1}

3 180 / 24 = 7.5 {1}

4 90 + 450 + 1620 = 2160 (μJ) {1} [4]

(b)(i) Kirchhoff's second law OR conservation of energy {1}

(ii) Kirchhoff's first law OR conservation of charge {1} [2]

(c)(i) time constant = CR {1}

= 7.5 x 10^{-6} x 200 000 = 1.5 (s) {1} [2]

(ii) $Q = Q_o e^{-\frac{4CR}{CR}}$ {1}

$Q/Q_o = e^{-4} = 0.0183$ {1} [2]

[Total : 19]

3.	**(a)**	work got out / work put in OR in terms of power OR as a percentage OR percentage of useful output	{1}	[1]
	(b)	e.g insulation improved by increasing thickness of insulating material	{1}	
		efficiency dependent so less heat is lost through the insulation	{1}	
		so less fuel needs to be burnt to heat the house	{1}	
		so less carbon dioxide is produced	{1}	[3]
		MAXIMUM 3 points required only but must be in a sensible sequence		
	(c)(i)	efficiency = 42 MW x t / 120 MW x t	{1}	
		= 0.35 (= 35%)	{1}	[2]
	(ii)	maximum theoretical efficiency = (750 – 290)/ 750	{1}	
		= 460/750 = 0.613 (= 61.3%)	{1}	[2]
	(iii)	T_H needs to be ……..raised: T_C needs to be ………lowered	{1}	[1]
	(iv)	**1** e.g. raising T_H would increase the pressure in the turbine (so it might explode) OR the materials in it might melt	{1}	
		2 e.g. lowering T_C would be very difficult as it is the temperature of the cooling water (impossible to wait until winter)	{1}	
		if done by refrigeration this would need power, (which would reduce overall efficiency) AND/ OR the cooling water might freeze	{1}	[3]
	(v)	0 (zero) K	{1}	[1]
				[Total : 13]

4	(a)		zero (do not allow 'small')	{1}	[1]
	(b)		300 W for 1 watt therefore 300 W x 20 for 20 W 6000 W	{1}	[1]
	(c)		e.g. if run at 92 K there is a danger that superconductivity will cease as a result of a slight temperature rise	{1}	
			a 15 K difference provides a safety region	{1}	
			77 K is the boiling point of liquid nitrogen	{1}	
			other sensible suggestion	{1}	
			MAXIMUM [2]		[2]
	(d)	(i)	area of cross-section of wire = 10^{-6} m^2	{1}	
			current = 10^{-6} m^2 x 2.0 x 10^8 A m^{-2}	{1}	
			= 200 A	{0}	[2]
		(ii)	$B = \dfrac{1.26\times10^{-6}\times200\times3200}{2\times0.30}$	{1}	
			= 1.34 T	{1}	[2]
	(e)	(i)	$F = BQv$	{1}	[1]
		(ii)	$BQv = m \times \dfrac{v^2}{r}$	{1}	
			$r = mv/BQ$	{1}	
			m = 235 x 1.66 x 10^{-27} kg	{1}	
			$r = \dfrac{235\times1.66\times10^{-27}\times8.3\times10^5}{1.34\times1.6\times10^{-19}} = 1.51$ m	{1}	[4]
		(iii)			
			circular paths for both ions	{1}	
			U-235 ion with slightly smaller radius	{1}	
			paths curving upwards	{1}	[3]

[Total : 16]

Mark Scheme 2826/03
January 2006

A1 *Method of achieving low temperature (e.g. solid CO_2 or spray)* **P1**
Do not allow liquid nitrogen. Do not allow unqualified freezer.

A2 *Diagram showing method of heating capacitor (e.g. beaker containing oil, oven)* **P1**
Do not allow water in contact with the capacitor. This mark could be given on the diagram.

A3 Method of measurement of temperature **P1**
Specified thermometer must be able to measure temperatures in the range specified.
Accept thermocouple/thermistor/platinum resistance/digital/probe etc.

B1 Correct circuit diagram **P2/1/0**
One mark for correctly placed voltmeter to measure p.d. across plates.
One mark for correct circuit to determine Q.

B2 Procedure **P2/1/0**
For particular θ, measure values of charge Q and V, change V and measure new Q (1 mark)
Change θ and repeat (1 mark)

B3 Detail relating to charge measurement **P1**
Divide discharge current by reed switch frequency to find charge
Allow equivalent Coulombmeter ideas or datalogging methods, or correct use of $Q=It$.
Do not allow use of $Q = CV$ to find Q.

B4 Method of determination of capacitance of capacitor (e.g. using $C = Q/V$). **P1**

C Any valid safety precaution (e.g. safety screens, or gloves for low temperature work) **P1**
Do not allow 'safety goggles'. Accept polarity consideration of capacitor in circuit

D Any further relevant detail, e.g. **P2/1/0**
Explanation of use of reed switch
Let temperature stabilise before taking readings
Use CRO to check that capacitor has discharged sufficiently
Sensible CR consideration to find R
Suitable value given for resistance of discharge resistor
Series protective resistors to prevent sparking at reed contacts
Suitable suggestion for frequency applied to reed coil
Good reason for selection of suitable thermometer
Valid preliminary work

R Evidence of research of material **P2/1/0**
i.e. at least two detailed references have been given (i.e. chapter and/or page numbers must be given). Allow Internet pages to be sourced.
Two or more vague references (i.e. no chapter or page reference) scores one mark.
One detailed reference scores one mark. One vague reference scores zero.

Underline and tick each relevant point in the body of the text. The ticks must have a subscript showing which marking point is being rewarded (e.g. $\checkmark_{D1}$).

Q **2 marks** are reserved for quality of written communication (organisation) **P2**
Rambling and poorly presented material cannot score both marks.
16 marks in total.

Question 1

(a) (i) Circuit set up correctly with no help **I2/1/0**
Ignore any help given with polarity of capacitor.
If minor help is given (e.g. voltmeter incorrect), then -1.
If excessive help is given (i.e. circuit wired for candidate) then -2.
Please indicate when help has been given to a candidate by writing **SR** at the top of the front page of the candidate's script. Also, please indicate the type of help that has been given by writing a brief comment by the table of results.

(a) (iii) Sensible value for $t_{½}$ **I1**

(b) (i) Percentage uncertainty in value of $t_{1/2}$ **E2/1/0**
Sensible Δt (0.1 s to 0.4 s), one mark
Correct ratio idea and 'x 100', one mark

(b) (ii) Parallax error **E1**

(c) Readings **I3/2/1/0**
Write the number of readings as a ringed total by the results table.
6 sets of values for *C* and $t_{1/2}$ scores three marks.
5 sets of values for *C* and $t_{1/2}$ scores two marks.
4 sets of values for *C* and $t_{1/2}$ scores one mark.
Check the *C* values: should be 333/500/666/1000/1500/2000/3000. Any 6.
Calculation error in *C*, minus one mark

(c) Quality of results **I1**
Judge by scatter of points about the line of best fit.

(c) Repeated readings **I1**
An average value must be calculated.

(c) Column headings **I1**
The columns for *C* and $t_{1/2}$ must be headed with a quantity and a unit.
There must be some distinguishing mark between the quantity and its unit.
Please ✓ each correct column heading to show that it has been seen.

(c) Consistency of raw readings in the table of results **I2/1/0**
Expect all the values of $t_{½}$ to be given to the nearest 0.1 s or 0.01 s. One mark.
Values of *C* to nearest μF or 10μF,. One mark

(d) (i) Axes **A2/1/0**
Each axis must be labelled with a quantity.
Scales must be such that the plotted points occupy at least half the graph grid in both the *x* and *y* directions.
Do not allow more than 3 large squares between scale markings.
Do not allow awkward scales (e.g. 3:10, 6:10, 7:10, 8:10 etc.).
One mark for each correct axis.

(d) (i)	Plotting of points Count the number of plots on the grid and write this value by the line and ring it. Do not allow plots in the margin area. Do not award this mark if the number of plots is less than the number of observations. Check one suspect plot. Circle this plot. Tick if correct. If incorrect then mark the correct position with a small cross and use an arrow to indicate where the plot should have been. Allow errors up to and including half a small square.	**A1**
(d) (ii)	Line of best fit There must be a reasonable balance of points about the line.	**A1**
(d) (iii)	Measurement of gradient of line The hypotenuse of the triangle must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square and the ratio must be correct. Please indicate the vertices of the triangle used by labelling with Δ. If the triangle is of an appropriate size then ✓Δ. One mark for appropriate size of triangle. One mark for read-offs and ratio correct.	**A2/1/0**
(e) (i)	Awareness that $V/V_0 = ½$. One mark. Correct working to give $t_{1/2} = CR \ln 2$ from $V = V_o e^{-t/CR}$. One mark.	**A2/1/0**
(e) (ii)	Gradient equated with $R \ln 2$ (one mark) Value for R from gradient, sensible value, with unit (one mark)	**A2/1/0**
(e) (iii)	Resistance of voltmeter Correct formula, one mark. Correct value for resistance (units not necessary). One mark. Allow ecf	**A2/1/0**
(e) (iii)	Significant figures in R_v Accept 2 or 3 sf only.	**E1**
(f)	Use a datalogger to take the voltage readings, or Measure the capacitance of all the capacitors before starting the experiment, or Use of digital voltmeter. Do not accept "more repeated readings".	**E1**

28 marks in total.

Question 2

(a)	Pointer Q readings to the nearest half millimetre or millimetre Extension correct and to nearest millimetre	**I1**
(b)	Calculation of spring constant *k* = 0.98/*x* answer must be given in N m^{-1}. Ignore any negative signs. Do not allow fractions.	**A1**
(c) (i)	Sensible diameter of one mass to nearest millimetre	**I1**
(c) (ii)	Correct substitution into $A = \pi r^2$. ECF from **(c) (i)**.	**A1**
(e)	Value in range 400 – 1600 kg m^{-3} (or 0.40 to 1.60 g cm^{-3}) Method of working must be correct.	**A1**
	Unit correct (kg m^{-3} or g cm^{-3} consistent with substitution)	**A1**
(f)	Evaluation	**E8**

Pointers, masses, springs wobble around/ draughts
Take sensible corrective measures (e.g. wait, close doors and windows, hold spring steady, or other sensible suggestions).
One set of readings to find *k* not enough
Plot *F* v. *x* graph, measure gradient.
One set of readings of *d* and *l* not enough
Take several sets of readings, plot suitable graph

Hard to see the water surface/surface tension problems
Refraction effects/ water causes distortion
Parallax error when measuring *d* or *l*
Use calibrated beakers /paper behind/mirror behind/travelling microscope/scale in water

Slot in mass gives incorrect *A*
Use vernier callipers or micrometer for diameter of mass
Bottom of hanger is different diameter to other masses
Masses used are not accurate
Use top pan balance to find mass
Top and bottom of masses are not flat giving incorrect *d* value
Stem of mass holder is also immersed and has not been taken into account

Allow other valid points.
NOT elastic limit ideas or human error

2 marks are reserved for quality of written communication (SPAG) **E2**

16 marks maximum to be awarded.

Sample results for capacitor experiment

t_1/s	t_2/s	t_{av}/s	C/μF
8.3	8.2	8.3	333
12.0	12.1	12.1	500
16.6	16.8	16.7	666
22.9	22.7	22.8	1000
37.6	37.5	37.6	1500
47.1	47.4	47.3	2000
73.1	73.0	73.1	3000

R_v = 49 kΩ (measured with ohmmeter).

R = 100 kΩ

Gradient of graph = 2.42 x 10^{-2} = R ln 2, Hence R = 34600 Ω .

If the resistor R has a resistance of 100 kΩ then R_v = 52 kΩ compared with the measured value of 49 kΩ).

Scatter of points on the graph is probably due to the variability of the capacitance of the capacitors.

Sample results and theory for density of water experiment

Consider the forces acting on the mass when submerged. Let T be the upward force on the mass from the spring, U be the upthrust from the water and W be the weight of the mass.

The mass is in equilibrium:

$$T + U = W$$

$$kx + m_w g = mg$$

$$\therefore k(l - l_o) + \rho_w V_w g = mg$$

where l_o is the distance from A to B with no load and ρ_ω is the density of water.

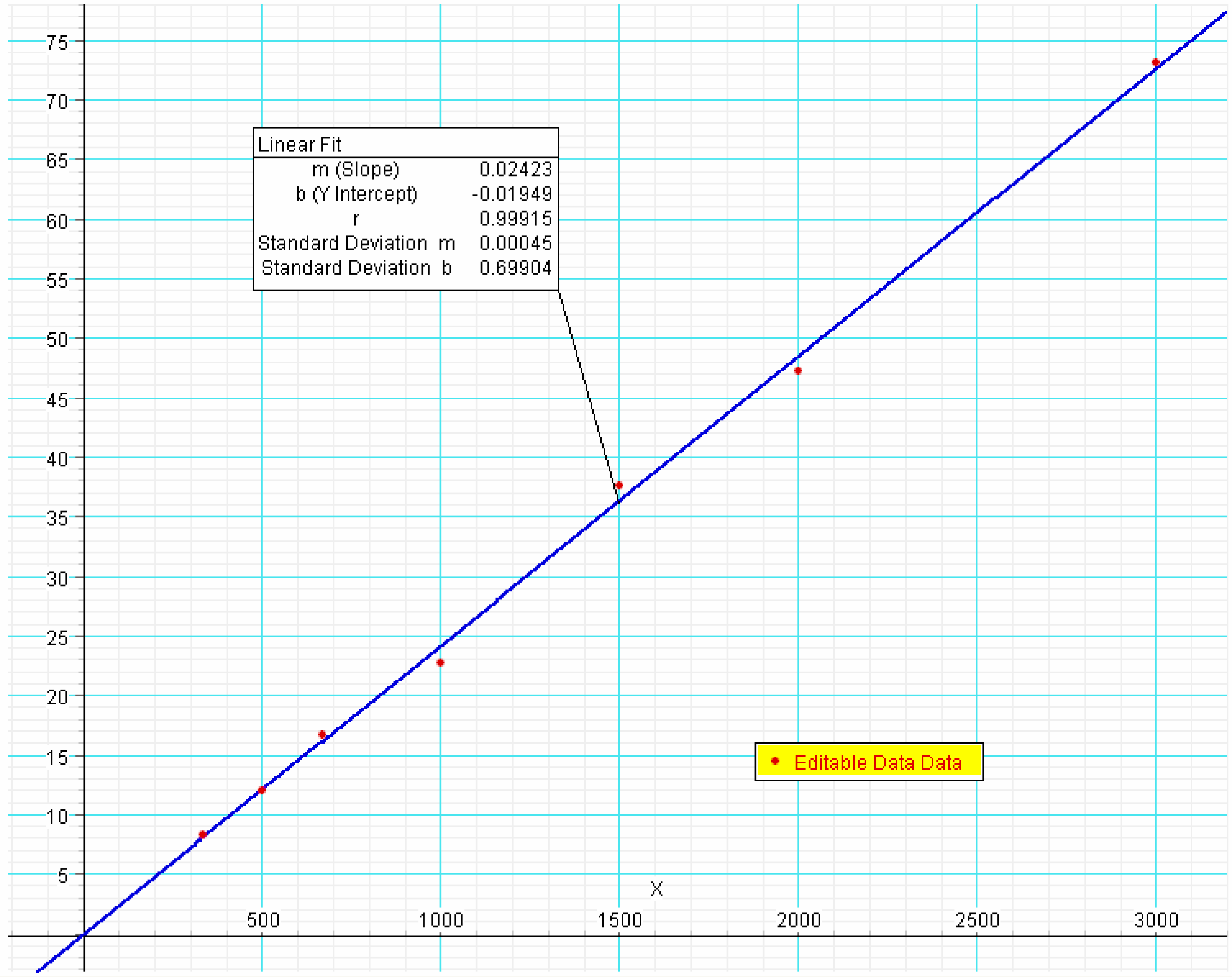
$$kl - kl_o = -\rho_w dAg + mg$$

h_A/cm	h_B/cm	d/cm	l/cm
13.8	32.0	2.9	18.2

k = 1/(70 –32) x 10^{-3} = 26 N m^{-1}

Diameter of mass = 3.3 cm giving A = 8.6 x 10^{-4} m^2, and hence ρ_ω = 960 kg m^{-3}.

Graph of sample results for question 1



Summary of shorthand notation which may be used in annotating scripts:

SFP	Significant figure penalty
ECF	Error carried forward
TE	Transferred error
AE	Arithmetical error
POT	Power of ten error
NV	Not valid
NR	Not relevant
GAP	Insufficient scale markings on an axis
NBL	Not best line
FO	False origin
NE	Not enough
NGE	Not good enough
BOD	Benefit of the doubt
R	Point repeated (no further credit)
NA	Not allowed
SV	Supervisor's value
SR	Supervisor's report
OOR	Candidate's value is out of range
wtte	Words to that effect
eeoo	Each error or omission
CON	Contradictory physics not to be credited
✓Δ	Used to show that the size of a triangle is appropriate (gradient calculation)
✓A3	Used to show the type of mark awarded for a particular piece of work (Qu. 2)
✓C	Used to show that the raw readings are consistent
✓SF	Used to show calculated quantities have been given to an appropriate number of significant figures
^	Piece of work missing (one mark penalty)
^^	Several pieces of work missing (more than one mark penalty)
↔	Scale can be doubled in the x-direction
↕	Scale can be doubled in the y-direction

Report on the Units
January 2006

AS LEVEL PHYSICS A

JANUARY 2006

MODULE 2821 FORCES AND MOTION

General comments

The general impression of the Examiners who marked the paper for this module was that the level of difficulty of the questions was appropriate for the candidates for whom it was intended. The paper consisted of a wide range of questions and candidates produced a very wide range of responses so good differentiation was achieved. There was an almost complete range of marks but very few scored less than 10 or more than 55. This suggests that the paper contained sufficient material to test the most able candidate. There were a significant number of candidates with less than 20 but the number of candidates scoring more than 50 was more than in previous years. Those candidates with less than 20 were often unable to give acceptable definitions, were careless in their calculations and gave vague explanations. The mean mark for candidates in this session was 35.8, which was 4.0 marks higher than the mean mark obtained in the January session in 2005.

All the questions provided the opportunity for the weaker candidates to score some marks, and each question had at least one part in which the more able candidates were able to show their understanding of the subject. The responses differed widely depending on the Centre. There were many centres whose candidates had clearly been very well prepared but equally there were a number of centres where the candidates had only a very sketchy understanding of the concepts involved. The lack of precision, poor use of English, basic errors in calculations and the failure to read the question carefully reduced the marks of many candidates of the full range of abilities. However, the majority of candidates were able to give good answers to some parts of every question.

Candidates from the whole ability range were able to gain marks for definitions but the weaker ones tended to write more simplistic and hence unacceptable versions. Questions one allowed a good proportion of the candidates to get off to a good start with the paper. Questions two and four then proved more of a test, with a wide range of performance becoming evident. In general, the most able candidates scored highly in all the questions coping well with the required definitions and with the recall of formulae and their application in numerical problems. They also completed calculations correctly and gave precise and accurate explanations. Those with average ability tended to be less precise in their recall of definitions but generally knew the required formulae and succeeded with most calculations.

The length of the paper was considered to be about correct with the vast majority of the candidates finishing the paper in the required time. The standard of written communication was generally adequate with a significant number of candidates scoring at least one of the marks available for written communication. Marks were lost by a significant number of candidates who failed to write their answers in sentences but the majority gained a mark for use the required technical language.

Comments on Individual Questions

Question one

In part (a) the calculations caused little difficulty, with frequent award of six marks. A number of candidates did lose marks for incorrect rounding down or too few significant figures. In (a) (i) the accepted answer of 0.436 or 0.44 was given as 0.43, 0.45 or 0.4. The correct kinetic energy formula was given in (ii) but a few candidates then forgot to square the velocity in their calculation. In (b)(i) the correct formula was given but there were more elements to bring together and therefore more frequent mistakes were made. Common errors were to ignore g and to use Fv with the value of v equal to 24/55 instead of 4/55. In (b)(ii) very few candidates scored both marks. Many candidates had not read the question carefully and referred to the inefficiency of the motor. Reference to the provision of kinetic energy was almost entirely missed. Very few identified a source of friction. A common answer suggested a misunderstanding of the term ‘average’ as they stated that some of the children would have a mass greater than 20 kg. This kind of comment did not score the mark.

Question two

The definitions in part (a) were generally well known. A number of statements, which were **not** accepted, gave velocity as speed in a specified direction and acceleration as rate of change of speed or change in velocity with respect to time. Inclusion of units in the definitions or formulae with symbols undefined was also penalised. In part (b) many scored both marks in part (i). However, few were able to calculate the area under the graph with enough precision in part (ii). The vast majority calculated the area assuming the graph was a triangle. Very few tried to estimate the area using the area of the squares. Parts (iii) and (iv) proved to give good differentiation. The descriptions in (iii) were often very vague and did not relate the changes in gradient to the variations in the acceleration. There were insufficient references to the various changes in the acceleration of the mass and the values given on the graph. The decrease in the magnitude of the acceleration between 0 and 0.2 s was often incorrectly described as a deceleration. This was despite giving the correct answer to (i) 2. In part (iv) there were many inaccurate readings from the graph or a misunderstanding of the term ‘average’. However, there were many correct answers given even by candidates who had scored very marks in parts (ii) and (iii). There were comparatively fewer cases of mistakes involving the signs of the two velocities.

Question three

The pressure definition was well known. However, some candidates failed to give an acceptable statement for pressure in (a) (i) but they were able to calculate the correct pressure in part(c) (i). A poor definition of the moment of a force cost a number of candidates a mark due the missing of ‘perpendicular distance’ of the lack of a reference to a ‘pivot or point’. Part (b) proved difficult for a great number of candidates. The identification of two further forces proved difficult even for the most able candidates. Very few candidates used a ruler or were concerned about the direction of the line that they had drawn. Candidates seldom showed the force at the hinge. Poor presentation of the moment calculation cost many candidates at least one mark. The question was a ‘show that’ and required the full working, correctly presented for both marks to be scored. The majority of candidates scored three or four marks in part (c). The weaker candidates did not use the force given in part (b) to calculate the pressure and seemed not to have read the information given below the figure or in the parts (b) (i) and (ii). Their answers to part (c) (ii) were very vague and did not explain how the force on the plunger could be increased or which area should be decreased.

Question four

There were many all-correct answers to part (a) (i). The common error was in stating the unit of density. There were some errors made in the density calculation due to the incorrect use of the powers of ten given in the volume. In part (a) (ii) the triangles were deficient in labels, arrows or angles. Candidates were able to continue to obtain the correct value for the force X. This part was only completed well by the above average candidate as expected. The concept of vector addition did not occur to the vast majority of candidates in part (b) (i). There were some answers that referred to the tensions acting at angles to each other but very few took the hint from part (a) (ii) that the addition carried out was for vectors. The good candidates generally completed the numerical work in part (b) (ii) correctly. There were some candidates who lost a mark for not showing the complete working. The question was a ‘show that’ and this needs all parts of the calculation to be given.

Question five

The question overall was generally well done with maximum marks not uncommon. The most frequent errors arose from missing the 10^6 and 10^{-3} on the axes of the graph or using them as 10^{-6} and 10^3 in their calculations. Part (b) was quite well done even though questions that require extended writing usually show the inability of the majority of candidates to write fluently, accurately and precisely about the particular points in the stem.

Question six

A significant number of candidates lost marks in part (a) by discussing factors that affect thinking time. The candidates who referred to tyre tread often failed to differentiate between the requirements for wet and dry road surfaces and lost a mark. Generally candidates were able to identify friction in the context of road surfaces and brake performance. The weaker candidates referred to 'grip' and did not state that there was a frictional force between the tyre surface and the road (in the backward direction). The candidates who chose speed or mass of the vehicle had more difficulty in giving an explanation and were more likely to be penalised. In part (b) the vast majority of candidates scored two marks for identifying two safety features. However, many candidates were unable to describe their use in terms of physics rather than everyday terms and phrases. There were many candidates that scored at least 8 for this question and this had been expected for this type of question at this level. The weaker candidates referred to forces being absorbed and their direction was rarely given. They also described the use of a wide seat belt to reduce the force rather than the pressure on the body. There were also descriptions given of an increase in energy, speed acceleration of the driver or of the driver being thrown forwards by the impact. The airbag being used to 'cushion the impact', the crumple zone was used to absorb the force and seat belts that were 'stretchy' were all common phrases that were used but that lacked the required technical language.

Electrons and Photons (2822) ~ Jan 2006

General comments

The candidates were better prepared to tackle this paper and demonstrated a good comprehension of the material. Some Centres have done extremely well in preparing their students for this paper. In general, candidates did better at recalling definitions and equations. In previous sessions, a disturbing number of candidates struggled with basic arithmetic, algebra, units and recalling definitions that are clearly signposted in the specification. There has been a significant improvement in the calibre of the candidates taking this paper. There was a definite move away from sloppy work when presenting analytical solutions.

The Quality of Written Communication (QWC) was assessed in **Q7**. The majority of the candidates secured two marks for spelling & grammar and organisation of their answers. As in the previous papers, there has been an increased trend to use 'text-messaging' words and the legibility of some candidates remains a real problem. Most candidates finished the paper in the scheduled one hour.

Comments on Individual Questions

Question One

This opening question was accessible to most candidates. A large number of candidates secured more than nine marks.

For **(a),** almost all candidates correctly drew a voltmeter connected across the LDR. A disturbing number of candidates were a bit perplexed with **(b)** and thought that the current shown by the ammeter would decrease when transferred to point **P**. A frighteningly large number of candidates still think that a component '*uses up current'*.

Most candidates correctly named the unknown component to be a light-dependent resistor in **(c)(i)**. Inevitably, a few candidates guessed the name of the component. The most popular wrong answer was the LED, which is not even in the specification. A significant number of candidates could not correctly recall the variation of the resistance of the LDR in **(c)(ii)**. Across the entire ability spectrum, **(c)(iii)** presented the greatest obstacle. Candidates over the years have found it extremely difficult to recall the wavelengths of the principal waves of the electromagnetic spectrum. Many candidates unsuccessfully tried to quote the wavelengths in nanometres. Wavelengths in the range 10^{-12} m to 10^{12} m were not unusual.

The answers to both **(d)(i)** and **(d)(ii)1** were well structured and presented no major problems for the candidates. Only a few candidates had calculator problems or incorrectly recalled the main equations. **(d)(ii)2** was generally well answered with candidates either using $W = VQ$ or $P = VIt$ route. Some candidates simply found the electrical power but still gave the unit as joules.

Question two

In previous examination papers, candidates have always been imprecise with their definitions for important quantities. The format in this question was more palatable to the candidates. The modal mark for this question was two. There was some inevitable confusion. In **(a)**, candidates had some interesting variations for Kirchhoff's name and failed to identify that it was the second law. The examiners were very lenient with the spelling of Kirchhoff on this occasion. Some candidates guessed the name with attempts like Faraday, Hooke, Snell, Lenz etc. The marks for both **(b)** and **(c)** were well accessed by the candidates. A good number of candidates identified the electronvolt as the answer to **(d)**.

Question three

Most candidates presented excellent answers for both **(a)(i)** and **(a)(ii)**. Many candidates used $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ to determine the resistance between B and C. Only a small percentage of candidates wrote 0.083 Ω having forgotten to invert this answer.

Most candidates struggled with **(b)**. The majority of the candidates took the resistance between B and C to be 30 Ω rather than 0 Ω. Hence, the vast number of scripts had the answer 0.125 A rather than 0.50 A.

Question four

The majority of candidates successfully negotiated this question. Most candidates picked up two marks for their sketch of the magnetic field pattern for the current-carrying wire in **(a)**.

Candidates were quite familiar with the Fleming's left-hand rule in **(b)(i)** but many lost a valuable mark by being vague with their comments for **(b)(ii)**. In order to gain the mark, candidates had to appreciate that the wire was parallel to the magnetic field and therefore experiences no force. Answers like '*the wire does not cut the field*' or '*the wire is not right angles to the field'* could not be awarded any marks. Most candidates correctly identified that the wire would move out of the plane of the paper in **(b)(iii)**. There were fewer answers like '*upwards'* or '*northerly*. The answers for **(b)(iv)** were quite comprehensive with most candidates securing one mark. Most candidates successfully calculated the magnetic flux density in **(b)(v)**. A very small cohort of candidates either used an incorrectly recalled equation or incorrectly manipulated the equation $F = BIL$.

Question five

In previous papers, candidates have struggled with potential divider circuits. Sadly, this was confirmed again in this paper. The success rate in this question was very much Centre dependent. Most candidates realised that the resistance of the thermistor decreased as the temperature in the greenhouse increased. Many candidates decided not to make any reference to the fate of the current in the circuit. A good number of candidates appreciated that the potential difference across the thermistor would decrease and either using Kirchhoff's second law or the potential divider equation, argued the case for the voltmeter reading increasing. A disappointing number of candidates lost valuable marks because it was not clear from their answers whether it was the resistance of the total circuit or the thermistor that was changing. Sometimes it was difficult to decipher what potential difference was being discussed with statement such as '*the current makes the voltage increase'.*

Question six

Only a small number of candidates failed to quote the correct equation in **(a)**. Most candidates realised that the resistance of the wire would decrease in **(b)**. Sadly, the majority of candidates argued that the resistance decreased by a factor of two because the '*cross-sectional area will double when the diameter of the wire is doubled'*.

Many candidates managed to score maximum marks for **(c)(i)** because the answer was given in the question. A lot of candidates had several tries before securing the answer of 2.0×10^{-10} m^2. Candidates were much more comfortable using $P = I^2R$ to determine the maximum current in the resistor in **(c)(ii)**. A few candidates forgot to square root their current^2 values but they still managed to gain two marks for their attempts.

Question seven

Many candidates made excellent use of the space provided for the answer to **(a)**. Their answers were often wide ranging and contained diagrams to support their answers. Many candidates did not carefully scrutinise the question because their answers were either entirely based on the photon and the photoelectric effect or on the wave behaviour of electrons. This question, once again, surfaced the common misconceptions of candidates. Some candidates truly thought that the electron diffraction experiment was demonstrating the '*diffraction of light on the fluorescent screen'*. Quite often the electron was synonymous to the photon. The role of the graphite in this experiment also perplexed many candidates. Some candidates thought that there '*were tiny gaps within the graphite*' that gave rise to the familiar diffraction rings on the screen. Many candidates eventually did manage to gain marks by referring to the important $E = hf$ and $\lambda = \frac{h}{mv}$ equations.

The definition for the threshold frequency in **(b)(i)** was generally quite good. Some candidates made reference to '*minimum energy'* and therefore were really defining the work function energy of the metal. In **(b)(ii)**, candidates struggled to explain why the threshold frequency was 5.0×10^{14} Hz but they used this value successfully to determine the work function energy. A pleasing number of candidates used the information from the graph and Einstein's photoelectric equation to determine the work function energy. Most candidates struggled with **(b)(iii)**. A pleasing number of high-scoring candidates managed to state the change to the line shown in Fig.7.1 but sadly, they struggled to provide adequate explanations.

2823/01 Wave Properties January 2006

General Comments

The general standard of work was similar to last year and the paper provided ample opportunity for candidates to demonstrate their knowledge and understanding of the module content. There was no evidence of candidates being short of time and there were very few weak scripts. The vast majority of candidates scored over 18 marks (i.e. 40%).

Comments on Individual Questions

Q1. Surprisingly, this question caused problems for a significant number of candidates. Many could not state the two laws of refraction and very few were able to successfully draw the path of the ray through the prism. Most did better in the final parts of the question by being able to calculate the angle of refraction and the critical angle for the glass/air interface.

Q2. Part (a) caused few problems but many of the explanations offered for the phenomenon of multipath dispersion lacked the full detail required to score all of the marks. Many for example did not fully explain how multipath dispersion could be reduced.

Q3. This followed a similar pattern with candidates often scoring full marks in part (a) by correctly stating the meaning of *coherent sources* and the *principle of superposition,* but many lost marks in part (b). Explanations of the cause of the maxima and minima produced by the coherent microwave sources often failed to refer to the path difference between the waves even though this had written in bold in the question. Most correctly calculated the distance between neighbouring maxima but only a minority of candidates scored full marks for the explanation of plane polarisation and the consequences of rotating the receiver through 90^{o}.

Q4. Most scored full marks in this straightforward question but some candidates were not familiar with the notion of the fundamental mode of vibration.

Q5. Most candidates showed a very good knowledge of diffraction and scored marks readily in this final question. The final part provided good differentiation with only the most able candidates scoring the full 3 marks for the explanation of why sound waves are diffracted at the open door much more than light.

PRINCIPAL MODERATOR'S REPORT FOR 2823/02 AND 2826/02

General Comments

Candidates continue to show the benefits of a great deal of hard work. The marking and annotation exhibited by most Centres allowed the moderation process to proceed with ease.

The entry for this module is always small and Centres are asked to be particularly careful about using the correct entry codes, about one third of the entries for coursework were changed after the original forms had been received.

Some of the Centres trying this module for the first time failed to follow the mark scheme with respect to the fact that both descriptors have to be agreed before the mark can be awarded, e.g. if 5a and 5b are justified then the mark is 5. Intermediate marks are available for partial agreement with one of the higher descriptors, e.g. with 5a, 5b and 7a agreed then the mark is 6. This marking error has caused some Centres to suffer a downward adjustment.

The level of work seen at AS remains satisfactory but it should be borne in mind that the marks for analysing can all be gained by the discussion of one graph, there is, therefore, little to be gained in producing a much larger amount of material.

The key to A2 is giving the candidate the opportunity to show their worth by suggesting a broad simple investigation rather than a detailed worksheet with little room for individuality. The extension of the work into other areas of the specification or indeed beyond the areas of detailed study is absolutely vital. Some work at this level is particularly pleasing.
Some of the salient features of the mark scheme are given below.

Planning

Attention should be paid to the progressive increase in scientific knowledge and understanding as the basis of the mark descriptors. There should be a variety of external sources referred to in the text. A detailed discussion on the choice of equipment to be used (in terms of precision and reliability) is essential.

Implementing

All results should be recorded to the degree of precision available from the apparatus e.g. to 1mm with a metre rule, and they should be consistent. All observations should be repeated and tabulated properly with units. Care should be taken that we are only looking at direct observations in this section and any inconsistencies in derived figures should be assessed at A7a.
Analysing

It is difficult to progress in this section with anything other than the analysis of a straight-line relationship. Very few candidates take the statistical route though these descriptors and the measurement of a gradient or intercept is more usual. The use of small triangles when taking a gradient is to be discouraged due to the large uncertainty that this would introduce. Only one gradient is needed to assess the mark.

Where ICT is used, strict attention should be paid to the significant figure problems that may be introduced. Again, the use of good scientific knowledge and understanding is at the root of these descriptors.

Evaluating

The numerical evaluation of uncertainties is required and then the combination of these uncertainties into the final values to give, where possible, an “x +/- y” result.
Comparison with a recognised value is of use to assess reliability but is not what this section is about. The level of work involved needs only to be similar to that found in the appendix of “ Physics 1”
Once the uncertainties of observations or procedures have been looked at, improvements should be suggested to increase the reliability of the investigation. This should really be attempted in some detail rather than the simple addition of a computer without the description of how it might be used and to what level the improvement might be.

2823/03: Practical Examination 1

General Comments

The general standard of the work done by candidates was very similar to last year. Presentation of results and graphical work continues to be done reasonably well. Candidates are still experiencing difficulties with both the analysis section in question one and the evaluation section in question two.

The majority of Centres obtained the necessary apparatus and few difficulties were reported with the experiments. Supervisors should be aware that the experiment set as part of question 2 is designed so as to enable candidates to write an evaluation.

Candidates appeared to complete the paper within the necessary time allocation. Candidates should be encouraged to show all the steps clearly when carrying out calculations. In addition candidates should be encouraged to include greater detail in their answers to descriptive type questions, giving explanations where necessary.

Both the Supervisors' report and a specimen set of results should be completed and sent with the scripts to the Examiner. There are occasions when marks are awarded for comparing candidates' answers with the Supervisor's value. Where candidates do not submit a plan, it would be very helpful if this could be indicated on the Supervisor's report. Centres are reminded that the cover sheet of the plan needs to be signed by both the candidate on page 2 and the Supervisor on the front page. It is also extremely helpful if Supervisors could arrange the candidates' scripts so that the Test is attached to the Plan with the Test on top.

During the practical examination Supervisors must be particularly vigilant to ensure that candidates have set up their particular experiments correctly. Supervisors may give assistance with the physical set up of an experiment so as to enable a candidate to gain results. The extent of the help given to any candidate must be detailed in the Supervisor's report. Supervisor's are reminded that help with the presentation and analysis of results is **not** permitted.

Comments on Individual Questions

Plan

Candidates were required to plan a laboratory experiment to investigate how the stress in a steel wire supporting a loaded bridge-like structure is affected by the angle that the wire is to the vertical. Again it was pleasing to note that the plans were about an appropriate length with few candidates reproducing downloaded pages from the internet. The plans were usually well organised and logically ordered.

It is expected that the candidates will plan a practical experiment. Theoretical calculations should be included in the plan where they support the choice of apparatus, e.g. the value of any load applied to the bridge-like structure.

Parts **(a)** to **(g)** on the planning sheet are designed to focus candidates' attention to relevant areas where marks will be awarded. Candidates should be encouraged to give a response to each section with reasoning.

In part **(a)** candidates should have described the procedure to be followed and included the range of readings that should have been taken. Large labelled diagrams are very helpful. Many candidates did not indicate a method of measuring force in the laboratory.

Most candidates just stated that the angle would be measured using a protractor. Better candidates suggested the use of a larger protractor or correct trigonometry methods. Few candidates detailed the use of a plumb line to enable the angle to be measured accurately to a vertical reference point.

Candidates were expected to explain how the stress should be determined. Although the majority correctly quoted the equation for stress correctly, many did not indicate how the area would be determined. A significant number of candidates stated that a micrometer would measure the area rather than explaining the measurement of thickness and the appropriate calculation.

There are always marks awarded for further detail such as:
the value of the breaking stress or elastic limit for steel,
the determination of the max force/diameter or wire/angles used,
the method for ensuring the bridge-like structure is horizontal,
keeping other quantities constant.

Safety precautions should be relevant to the experiment being designed and not general laboratory rules. In this case precautions relating to the danger of heavy loads and the danger of whiplash gained credit.

In the notes for guidance for the plan it is stated that candidates should list clearly the sources that have been used. Two marks were available for evidence of the sources of the researched material. Detailed references should have page or chapter numbers or be internet pages. Two or more detailed references score two marks. Two or more vague references scored one mark.

Most of the more able candidates were able to score two marks for the quality of written communication which were awarded for the organisation and sentence construction of the Plan.

1) In this experiment candidates were required to investigate how the tension in the string supporting a metre rule depends on the position of a weight along the metre rule.

(a) The majority of candidates correctly determined the angle the string was to the vertical. A number of candidates did not show their working which was penalised if the angle was not calculated correctly.

(c) The majority of candidates took the necessary readings with very little help from Supervisors. Large numbers of candidates also repeated the experiment.

Results tables were generally well presented with the majority of candidates labelled the columns with both a quantity and the appropriate unit. It is expected that all raw data should be included in a table of results – thus candidates' values' from part (b) should have been included. Many candidates did not measure the distance to the nearest millimetre.

(d) The plotting of graphs varied by Centre. Weaker candidates often used either less than half of the graph grid or awkward scales particularly in the *y*-direction. There were also a larger than usual number of candidates who did not label the axes. Several candidates were careless when plotting points – points should be plotted accurately to the nearest half square. The majority of candidates drew their line of best fit with a fair balance of points.

(e) It is expected that the gradient should be calculated from points on their best fit line which are at least half the length of their line apart. Weaker candidates often lost marks either by using triangles that were too small or by working out $\Delta x/\Delta y$. Good candidates clearly indicate the points that they have used and show their calculation. Again some candidates lost marks by not taking care in reading off the points from their graph.

(f) The majority of candidates found the *y*-intercept from the *y*-axis. It is expected that the line should be extended so as to touch the *y*-axis and the reading should be to the nearest half square. Where there is a false origin it is expected that candidates should substitute a point from their line into the equation $y = \mathrm{m}x + \mathrm{c}$. The more able candidates carried out this technique correctly.

(g) The analysis section still causes the most difficulty on question 1. Too many candidates did not follow the instruction to use their answers for the gradient and *y*-intercept to determine the values for *W* and *R*. Candidates who substitute values from their table of results into the given equation did not gain credit. It is expected that candidates should also give their final answer to an appropriate number of significant figures and include an appropriate unit (N). There was also a mark available for gaining an answer within range of the Supervisor's stated value.

2) In this question candidates were required to determine the mass of a steel ball.

(a) Most candidates measured the outer diameter and correctly determined the cross sectional area of the tube.

(b) Few candidates calculated the percentage uncertainty of *A* correctly. Most candidates knew the ratio but large numbers of candidates did not calculate the percentage uncertainty in *d* and even fewer gave an explicit method for the effect of squaring *d*.

(d) & (e) The majority of candidates answered these parts correctly.

(f) Many weak candidates still describe the procedure they followed. It is important that candidates evaluate the experiment they have attempted rather than suggest different experiments. Good candidates scored well by describing relevant problems and suggesting specific ways to overcome them. Vague suggestions without explanation did not gain credit.

Some credit worthy points are:
Parallax /meniscus problems
Meniscus changes during experiment (by displacement)
Eye to be level
Difficulty with measuring the diameter of the tube
Use vernier callipers/micrometer
Tube at an angle
Measure h from opposite sides and find average
Large uncertainty in h
Tube not steady/moves around
Scale on tube
Clamp rule so distances can be found more easily
One set of readings is not enough
Take many readings for a range of N <u>and</u> plot a graph (i.e. Δh v N)

Two marks were available for spelling, punctuation and grammar in this part. Candidates should be encouraged to ensure that sentences have capital letters at the beginning and full stops at the end.

2824: Forces, Fields and Energy (Written Examination)

General Comments

Candidates appeared to be very familiar with the layout and style of the question paper which has remained unchanged. Candidates appeared to have adequate time to complete all questions. In fact the majority wrote two full sides on Q7. Very few left parts of questions unanswered unless they did not know where to start. There was a good range of responses to most questions enabling differentiation to be achieved. Many middle of the range candidates scored widely different marks on different questions, showing significant knowledge of some topics and little of others. To gain an A grade it is necessary to have a knowledge of the full specification. It is a deliberate policy to set each paper in such a way that it covers as wide a range of topics from the specification as possible. The most successfully answered questions by all candidates were Q1(b) and Q5(a). Candidates should be reminded that it is important that they must not only show their working but also explain or justify it in order to gain full marks. This is especially true in the 'show that' questions, namely Q2(a)(ii), Q3(b)(i), Q4(c)(i) & (ii) and Q6(c) in this paper. The answer given on the examination paper is usually only approximate and is there to help any candidate attempt further parts of the question. Candidates should therefore be reminded to write down the answer to their calculation rather than equate an arrangement of multiplied and divided numbers directly to the answer given on the examination paper. It was also worthwhile allowing adequate time to draw graphs and/or diagrams carefully to gain full marks, e.g. Q2(a)(iii), Q3(a) & (d).

Comments on Individual Questions

Q1 (a) This first part on impulsive forces was either answered well or hardly at all. The estimate of area usually gave answers in the expected range but the physical quantity represented, namely momentum, was rarely given correctly although credit was given to impulse as an answer. A common error was to state 'kinetic energy'. Correct response to (ii) was usually followed by a correct response to part (iii). However, many, who had failed in (ii) and (iii), managed to calculate the maximum horizontal speed in (iv).

(b) The exponential decay was usually identified correctly and over half of the candidates were able to find the value of k. The initial height was also given correctly showing that candidates can interpret an equation. Many correctly calculated the change in potential energy through the loss of height at the second bounce but then failed to inform the examiner that this was the loss of kinetic energy. However in this and several other questions later, candidates were often poor at showing how a given value was obtained.

Q2 (a) In part (i) many answers were just statements of the definition of simple harmonic motion rather than being diagram specific as requested. Part (ii) was done well by those who remembered the appropriate equation. The common error was to fail to realise that the displacement was measured in millimetres. In part (iii) the mark awarded for the period was given if the curve was drawn correctly for at least 2.5 cycles. Many candidates made a mistake either in the first or the last 0.05 second.

(b) The change from SHM to circular motion was not always appreciated by the weaker candidates with fewer than expected giving the correct answer of *a constant centripetal acceleration*. Less than half were able to quote the formula for the centripetal force and then some were unable to access the correct values for *a* and *r* from the given data.

Q3 (a) The drawing of field lines was rarely performed very neatly or with attention to accuracy. Candidates gained one mark for the general shape and one mark for the attention to detail. The third was given for the direction of the field.

(b) Showing that the force was the given value proved quite difficult for many. A common wrong answer was to give the weight multiplied by sin 20. Full credit was not given unless the candidate could justify clearly that the function was tan 20. It was apparent that a common approach was to experiment with numbers on the calculator and to change sine into tangent on the script to achieve the correct solution. The definition of electric field strength was known better than this time last year. All three marks were usually gained for (ii).

(c) The calculation of the separation of the spheres was however often incorrect because candidates were unable either to manipulate the initial equation into a form with *r* as the subject or to substitute correctly for $4\pi\varepsilon_o$.

(d) In many cases the field pattern was drawn adequately here even if it had been incorrect in (a) but few recognised the situation as that of a mirror image.

Q4 (a) The decay question was asked in a less familiar form to make candidates read and apply their knowledge to the situation rather than just recite what they should have learnt. As a result the proton and neutron numbers were rarely both given correctly. The most popular incorrect answers were 28 and 35.

(b) Very few did not calculate the decay constant correctly.

(c) Parts (i) and (ii) were usually answered well. As both of these parts were *show that* questions it was necessary to include working, *i.e.* in (ii) to show that the number was 6.9×10^8, and not just quote 7×10^8, to gain full marks. In the more testing part (iii) few gave the activity relation $A = \lambda N$. In the final part any justified sensible reason gained the mark. Answers scoring zero were often too vague and did not refer to the data given or the idea of randomness of decay.

Q5 (a) This was the best answered section of the paper. The drawing and description of direction of the force were usually correct. The formula and calculation too was often correct. Blw^2 was the only wrong answer in (ii) and missing the fact that *w* was measured in millimetres the only error in (iii).

(b) About half of the candidates were able to state Faraday's law fully but only a minority managed to relate the width times speed to the area linking the field per second. In part (ii) more candidates actually stated that the flux linked per second was BA/t and hence with *B* doubled the voltage doubled.

Q6 (a) The descriptions of internal energy usually included the words kinetic and potential energies but it was necessary to indicate that the kinetic energy is the random energy of thermal motion. More importantly it was necessary to indicate that the energies were those of the constituent molecules or particles of the body. The definition of specific heat capacity was well known.

(b) The outline descriptions of the experimental determination of the s.h.c. of aluminium were very poor lacking the essential details necessary to achieve a result.

(c) In (i) most candidates were able to convert 20°C to 293 K and verify the figure given for the internal energy of the block. Many candidates satisfied themselves that they had arrived at the mean energy per atom in part (ii) but few were able to explain clearly their derivation or the steps involved. The same comment was true for (iii).

Q7 (a) The descriptions of the nature of alpha particles and of Rutherford's scattering experiment were not well answered by many pupils. Clearly some students had studied it well and were able to link observation with interpretation. Others were rather too vague and did not compose clear descriptive answers. There were many marking points available but few managed to gain the full marks. The descriptions were inclined to emphasise the repulsion of like charges rather than to realise that the reason for the bouncing back of the alpha particles is the mass of the nucleus and also that the reason that these events are so few is the size of the nucleus. Many candidates stated that the particles were diffracted by the nucleus, rather than being scattered or reflected.

(b) The fusion equation given was new to most candidates and few were able to interpret it correctly. Basic charge conservation was not considered so most candidates jumped to the conclusion that 'e' stood for electron. Most candidates appear to have learnt that the resultant nucleus in a fusion reaction is more stable than the fusing nuclei. Unfortunately this idea was written in the form that the less stable protons fused into the more stable helium. Weaker candidates wrote of hydrogen atoms fusing into the more stable helium atom. Many realised that the Coulomb force had to be overcome to fuse the protons and gave good answers as to how this is achieved. The mass defect or more often the binding energy was given as the source of the released energy. Better candidates scored good marks on this part, which differentiated well.

QWC The presentation and layout of the answers to this question have improved. However too many candidates do not stop to think and plan a short succinct answer to the question; but ramble on writing many sentences which do not gain them any marks and possibly contradict valid points already made, that would otherwise have been credited.

2825/01: Cosmology January 2006

General Comments

The entry was similar in number and ability to previous years. Candidates showed a range of attainment and pleasingly, there were very few scripts showing inadequate preparation, which helped to raise the average mark slightly compared to January 2005. Graphs were generally drawn accurately but errors were apparent in calculating the gradient. The standard of writing for the extended answer questions was good but weaker candidates tended to make the same point several times, thereby restricting the credit that could be given. Candidates should exercise caution in the use of non-standard abbreviations. For example, *BBT* will be accepted as *black body temperature* when a reference to 2.7 *K* makes the meaning clear. Without a strong association such as this, an obscure abbreviation may well be disregarded.
Marks were generally highest for Qu. 1, 2, 3 and 6 whilst Qu. 8(c), Qu. 9 and parts (c) and (d.ii) of Qu. 10 proved most demanding.
Where appropriate, candidates benefited by showing their working clearly and including all relevant equations in their answer.

Comments on Individual Questions

1. **(ai)** This topic has been asked several times in the past and the Copernican heliocentric model was understood by most candidates. A small minority stated the planets moved in elliptical orbits, otherwise most answers correctly referred to circular orbits at constant speed or another aspect of the model.

(aii) The new model was not easily absorbed into the generally accepted rules of motion that prevailed in the era of Copernicus. A majority of candidates were able to refer to the fact that a moving or rotating Earth might result in a wind, give rise to stellar parallax or prevent objects from falling vertically. in the latter example answers which simply stated that 'objects should not fall' were not given credit.

(b) The value of the Astronomical Unit was, pleasingly, known by many but some candidates made very simple arithmetical errors or neglected to multiply by the factor of 5.2.

2. **(a)** The factors which contribute towards the luminosity of stars were well known.

(bi) Most candidates calculated the logarithm of the ratio correctly, but some omitted the minus sign for Castor. As is usual, any error in this part was not penalised again when it came to plotting the points and drawing the line.

(bii) Most points were plotted well, but the different scales caused some confusion. The most common error was to plot the point -1.03 as -0.03. This would be easy to pick up and candidates should be encouraged to make a very quick check, particularly where a point does not seem to follow the trend.

(biii) The lines were generally drawn accurately. Where plotting errors had been made, the best straight line through the points was expected. Lines were accepted which ignored a single point that was obviously off-trend. In these cases it would help a candidate to ring the relevant point and make a simple comment.

(biv) The majority of candidates knew the relation between the constants *a*, *b* and the graph, but errors in the calculation were not uncommon. The negative aspect of the gradient caused problems; a number of candidates used dx/dy for the gradient and a surprising number of candidates chose points for their triangle which, although close, did not actually lie on the line. The latter error could produce a significantly different result, particularly where the size of the triangle was small.
Most candidates correctly read the value of *b* from the graph. Some calculated *b* from their value of *a*, but credit was given only if it corresponded to the value shown by the *y*-intercept.

(bv) Many candidates correctly deduced the logarithm of the ratio of intensities and either calculated a correct value for *b* or quoted their previous answer. Arithmetic errors were rare.

(bvi) The fact that the absolute magnitude becomes smaller or more negative when the luminosity increases puts the onus on candidates to make their meaning clear. The increase in surface area was appreciated by many but statements such as '*so the absolute magnitude increases'* were insufficient unless backed up with a reference to the change in luminosity or brightness. Credit could not be awarded where ambiguity remained. It was not infrequent for a discussion about temperature change and luminosity to conclude that the either the temperature must increase or the overall luminosity decrease.

3. The accumulation of hydrogen and helium, gravitational collapse followed by a rise in kinetic energy and temperature were well known. Many candidates gave details of the proton-proton fusion reactions but references to mass-energy conversion or $E = mc^2$ were rare. A good number of candidates alluded to the requirement for an equilibrium between gravitational forces and radiation pressure. Quality of written communication is not assessed in this paper but *fussion* – meaning 'fusion' - is unfortunately close to *fission* and candidates would be well advised to make the distinction clear in their answers.

4. **(ai)** Many candidates knew the diagram represented an absorption spectrum but fewer than half of the answers correctly stated where the absorption occurred or discussed re-radiation. A number of candidates believed the absorption took place within the star or on its surface.
(aii) The uniqueness of spectra was well known and answers were accepted which referred to a single line or a combination of lines.
(bi) The Doppler effect or wavelength red-shift was correctly identified by most candidates and the majority of these inferred that the star was receding from Earth. A small number of answers attempted to explain the graphs from the rotational motion of the Sun and got into difficulties.
(bii) Many candidates gained full marks on this part. The common errors occurred whilst reading values from the graph; converting nanometres to metres (although unnecessary); using 120.9 nm in the denominator or making an arithmetic error.

5. **(a)** The graph showing transmission of radiation through the atmosphere has come up in the past and it was pleasing to see that most candidates could apply their knowledge when the information was presented in a slightly different format. Full or near-full marks were not uncommon. B was sometimes confused with infra-red radiation and some candidates thought C corresponded to UV.

(bi) Uniform intensity of the background microwave radiation was quoted by many candidates and its evidence for the Big Bang Theory was well known. Answers such as '*the microwave radiation is the same everywhere'* are a little too vague, containing no reference to direction or the intensity of the radiation.

(bii) Most candidates appreciated the relevance of the graph to this part of the question and gave sensible answers, although some stated that the intensity of the radiation at the Earth's surface was zero.

6. **(a)** Hubble's law was known in algebraic form by all but a few candidates. The question asked for all symbols to be explained: in this respect '*speed'* and '*distance'* by themselves were not enough and one reference somewhere to a galaxy (or star) was required for the second mark.

(b) Descriptions of Olbers' paradox were usually full and detailed, based upon the twin aspects of a static and infinite Universe. Many answers gave very good explanations as to why the night sky might be expected to be bright and this part of the course has clearly been well understood.
Candidates should be aware that answers such as '*there would be no night sky'* do not necessarily convey enough information in the context of this type of question.
The resolution of the paradox through an expanding Universe was given by many but fewer were able to relate a red-shift, gravitational or otherwise, to a decrease in intensity.

7. **(ai)** The spiral shape of the Universe was described well and the concentration of mass in the centre was well known. Some diagrams were not quite symmetric and contained arms of different lengths, but a good deal of leeway was allowed in this instance.

(aii) Nearly all candidates could correctly mark the position of the Sun or state that it is approximately 2/3 out from the galactic centre.

(bi) Many candidates could correctly state that the gas consisted mostly of Hydrogen and Helium and knew that its origin would most likely be from the Big Bang and hence, possibly, the remnants of supernovas.

(bii) Many candidates explained how the fate of the universe could be considered in terms of its density and the critical density (the symbol ρ_0 is defined at the start of the paper). Answers which used the *mass* of the Universe only, could gain little credit. A total of 3 marks were available for a general discussion but to gain full credit candidates needed to relate an increase in mass to a corresponding rise in density.

8. **(a)** An inertial frame of reference was explained by a large majority of candidates and all correct forms were allowed. Where answers required constant *velocity* as a criterion, constant *speed* was rejected.

(b) Candidates had clearly learnt the thought experiment thoroughly and it was not unusual for answers to this part to gain nearly full marks. The train-tunnel scenario was used almost without exception. The most common difficulties arose from the placement of the observers and over the decision of where to fix the lights. Some answers described the observations correctly but failed to give the conclusions, or just gave one conclusion and so made no comparison. Surprisingly few candidates stated that the speed of light was independent of the frame of reference and it was very rare to have any discussion concerning the symmetry of the observations.

(c) A good number of candidates attempted this part successfully. The most common errors were made in the algebraic manipulation of the equation. Candidates who showed all their working were in a position to gain credit despite failing to achieve the correct final answer.

9. This proved to be a difficult question overall. It was set up to reflect the thought experiment concerning time and the principle of equivalence.

(ai) The majority of candidates realised that the rocket must be accelerating, the remainder suggesting the velocity was constant.

(aii) About 1/3 of candidates realised the frequency must reduce but fewer gave the correct reason. Many thought that the frequency must remain constant while others guessed that it, too would increase.

(bi) The principle of equivalence was correctly quoted by many candidates but, as in previous years, credit was lost when answers stated that gravity and acceleration were *equal* or were *the same thing.*

(bii) Few candidates appreciated that the gravitational field would have the same effect as accelerated motion, thereby reducing the wavelength.

2825/02: Health Physics January 2006
General Comments

This paper produced a good range of marks with few candidates scoring below 30 marks. It was noticeable that many candidates 'tailed off' in the last question. Where the question was unstructured, answers required were frequently found in jumbled, unexplained workings.

Comments on Individual Questions

1. (a)(i) Most candidates were able to give the correct response to this question.
(ii) Many candidates were able to describe the 'threshold' idea but failed to go on to say that the value of I_0 occurs at the frequency at which the ear is most sensitive.

(b) (i) Many candidates found describing the term 'loudness' to be difficult. It was expected that a reference be made to the subjective nature of this term.
(ii) It was clear that most candidates did not interpret the graph correctly, mistaking it for the more commonly seen graph of the variation of threshold intensity with frequency.
(c) (i) Most candidates were able to state the intensity level equation and substitute the required values into it.
(ii) The intensity level pattern in Fig.1.2 was well spotted and most candidates were successful in gaining credit here.
(iii) The first mark for substituting into the equation was gained by most candidates. The calculation of the intensity was less successfully carried out.
(iv) Most candidates were able to score one of the available marks here for saying that the intensity level scale is more manageable or easier to use. Many candidates failed to relate the scale to the behaviour of the ear in response to the wide variation in intensity.
(a)(i) 10^{-12} W m^{-2} (c)(ii) 48 dB (c)(iii) 6.3×10^{-8} W m^{-2}

2 (a) Less than one half of the responses commenced with a word equation to explain the reasoning taken. Most candidates launched in with numerical work. It is essential that candidates show clearly all steps in a 'show that' response.

(b) This was answered well. The most common error was to add the weight of the arm to that of the load.

(c) It was expected that the answer would contain reasoning along the lines of explaining the structure of something that had a mechanical advantage of >1. Many candidates guessed that 'muscles wouldn't be able to cope' or that 'the bones wouldn't withstand the stress'. It was common to see the phrase ' more work would be done' if the mechanical advantage was greater than 1.

3 This question was generally well answered. A small number of candidates offered a description of the production of X-rays prior to their use in the imaging process.

4 (a)(i) Most candidates gained credit here with the most popular incorrect answer being 'depth of focus'.
(a)(ii) It was hoped that candidates would suggest that the image might be found in front of the retina. This was the most popular response with a smaller number suggesting that it might be found behind the retina.

(iii) This was poorly answered. The previous sub-sections of the question were leading pupils to an explanation for the depth of field. It was hoped that pupils might have described the uncertain / subjective nature of the term 'in focus'. In other words describe the image as being 'not in focus but acceptably clear'.

(b) This was well answered. Some responses described only the function with no reference to the effect of the described change to the shape of the lens on the optical system of the eye.

(c) (i)(ii) Most responses were correct to these questions. Where a candidate chose the wrong lens in (i) credit was given for the subsequent ecf.

(iii) This was well answered. The most common error was to offer the answer in m.

(iv) This was again well answered. The most common error was the failure to convert the focal length from cm to m.

(d) The unstructured nature of this part of the question meant that candidates needed to explain their workings. Few candidates showed the steps leading to their final answer. Many used the power of the eye when focusing on an object at infinity and added it to the power of the spectacle lens to give the power of the eye when focusing on an object at the near point.

(c)(iii) 67 cm (c)(iv) 1.5 D (d) 40 cm

5 (a) The plotting of the points on the graph was generally good. One mark was reserved for the drawing of a smooth line of best fit. This was generally poor with a significant minority of candidates joining the points with a series of straight lines.

(b) (i) Only a minority of candidates arrived at a value for the half-thickness of the absorber: most simply took a value from a single reading off the graph.

(ii) Once the ecf had been taken into consideration, most candidates were able to arrive at a correct value for μ. A small number of candidates used 1.0×10^{-12} for I_o.

(b)(i) 0.95 +/- 0.10 mm (ii) 730 m^{-1} +/- 80 m^{-1} (allow equivalent ans. in mm^{-1})

6 (a) Most candidates gained credit for their response here. A number gave a letter equation without explaining the symbols.

(b) Very few candidates seemed to realise that the quality factor is linked to the density of ionisation produced.

(c)(i) Many candidates omitted the background radiation in their calculation.

(ii) This was well answered.

7 There were plenty of good answers to this question. The term *coherent* when applied to a fibre was occasionally mixed up with *phase*. Otherwise the only problem was the inability of some candidates to describe clearly in their own words what they understood.

8 (a) Most candidates got the idea that if one bulb failed, the others remained lit.

(b)(i)(ii) These questions generally did not cause candidates too much difficulty.

(iii) The first two marks for the words equations $R = \rho l / A$ and $A = \pi r^2$ were mostly gained, however the subsequent calculation proved difficult for many candidates.

(iv) Many responses described that the filament would probably ‘blow’. A few described the practical problems associated with such a small diameter.

(c) This part of the question was poorly answered. Only one quarter of candidates were able to give a correct reading for the voltmeter when placed across P,Q,R and S. It was common to see terminology such as 'the voltage flows through P…'. Very few candidates stated the obvious with regard to 'zero current' when bulb Y fails.

(d)(i) Many candidates described the reduction in resistance and most went on to discuss the consequential increase in current in the circuit. The most commonly missed point was regarding the power dissipated in each bulb. It was common to see a sentence to the effect that *the bulbs will 'blow'.*

(ii) Very few candidates calculated the current at which bulb failure occurs. Even fewer reasoned the number. It was common to see the question completely left as a blank space.

2825/04: Nuclear and Particles Physics

General Comments

Many candidates were at least adequately prepared for this examination and acquitted themselves well. Indeed a small number of candidates scored very highly. However it was disappointing to note again that a large minority appeared not to have prepared satisfactorily for this A2 paper and consequently scored marks which did them no credit. Parts of the paper, as would be expected, were demanding and would be expected to be answered only by candidates of the highest ability. However, again following normal practice, other parts were routine and either asked directly for the relevant piece of Specification work, or repeated a question which has occurred on earlier papers. Clearly such questions ought to have been well answered by most candidates, but sadly they were not. Of particular relevance were the nuclear equations. These occur on every Nuclear and Particles paper and should have led to full marks in most cases. Instead many candidates lost marks repeatedly by omitting standard elements such as charge or mass numbers, neutrinos or nuclide symbols. Once again, the setting-out of numerical answers was less than satisfactory, making the examiner's task more difficult and increasing the likelihood of work deserving of credit failing to be recognised. One specific difficulty was the spelling of 'annihilation'!

Comments on Individual Questions

1(a) Candidates were asked to show the forces acting on one of two adjacent protons. They were expected to show the electrostatic, gravitational and strong forces acting from the centre of proton B and mark them along the line of centres. Most candidates were able to do this satisfactorily. Marks were lost however through showing the forces too far from the line of centres or not making it clear which proton they acted on. A few candidates also lost credit for showing the gravity force in a (supposed) downward direction rather than towards the other proton.

(b) The equation relating the three forces should have stated the electrostatic force to be equal to the sum of the other two forces, but an (effectively) vector equation stating that the sum of the three forces is equal to zero was accepted. A minority of candidates lost this mark by attempting to form an equation involving a *ratio* between two or more of the forces.

(c)(i) Most candidates were able correctly to state the expression for the electrostatic repulsion between two charged particles. However many lost the credit for calculating the repulsive force by substituting a value for the radius of the proton, rather than the separation of the two protons.

(ii) Candidates fared similarly in this part. While most were able to state the correct expression for the gravity force, they went on to substitute a value for *r* which was only half the correct value. They were not, however, penalised again for this error.

(iii) Here candidates were expected to find the difference, either on paper or mentally, between the electrostatic and gravity forces in order to deduce the strong force. Since the gravity force was minute, this amounted to writing down again the electrostatic force. Most succeeded in doing this.

(d) Candidates were expected to note that not only is the gravity force much smaller than the electrostatic force; it is so small as to be negligible. Many stated that it is smaller without going on to state that it is negligible.

(e) This part asked candidates, in effect, to repeat part *(c)* for two neutrons, but without further calculation. Most correctly stated the electrostatic force to be zero and the gravity force to be the same as in *(c)*. However, in the last part most failed to realise that the strong force between two neutrons has only to balance the gravity force and thus has the same magnitude as their answer to part *(e)(ii)*. Many candidates wrote down the value of the strong force deduced in part *(c)*.

2(a) Candidates were expected to write full nuclear equations for the absorption by a uranium-238 nucleus of a neutron and the subsequent beta decays. As mentioned above, a seemingly straightforward question, of a kind which is asked every year, did not prompt the full and correct equations which should have been routine. Where marks were lost the cause was usually either omission of the neutrino in the beta decays, failure to represent the emerging beta-particle correctly, omission of mass number or proton number or simply failure to represent correctly a nuclide symbol. A particularly unsatisfactory feature of some candidates' answers was to show the beta particle emerging sideways from the reaction arrow rather than as one of the product particles.

(b)(i) Most, but not all candidates were able to remember the half-life of plutonium-239.
(ii) Many candidates were able to calculate the decay constant for plutonium-239 from its half-life and the natural logarithm of 2. The commonest omission was the conversion of the half-life into seconds.

(c)(i) This part was generally well done. Most candidates were able to calculate 5% of 4.4 kg. They were then able to find the molar mass of plutonium-239 and so find how many moles were present in the fuel rod. Multiplication by the Avogadro constant yielded the number of atoms present. Some candidates adopted the equally valid approach of finding the mass of a plutonium-239 atom and dividing this into the mass of plutonium-239 in the fuel rod. One small point; a number of candidates used the mass of the proton rather than the (similar) unified atomic mass unit for finding the mass of the plutonium-239 atom.
(ii) This synoptic part required candidates to calculate the activity of the fuel rod as the product of the decay constant and the number of atoms. Most were able to achieve this. Those who had an incorrect value for the decay constant could still achieve full credit here by the 'error carried forward' concession. Some lost credit because they attempted to use $A = A_0 e^{-\lambda t}$. A correct statement of Bq or s^{-1} as the appropriate unit of activity could still be rewarded however.

3(a) The energy changes of the two protons approaching each other with equal initial speeds, along the same straight line consist of the loss of kinetic energy and gain of potential energy, with all the energy in the form of potential when the particles are at rest. This was a question which has been asked in various forms before and many candidates were able to give a full answer. A few lost credit by confining their answer to the forces between the protons, or their changes of speed, without addressing the question of energy changes.

(b) There were two parts to this answer. First, candidates needed to calculate the total potential energy when the two protons are at their position of closest approach. This could be achieved by merely substituting into the equation given. It was then necessary to realise that this also represented the combined kinetic energy of the two protons initially and to divide the figure by 2 in order to find the kinetic energy of a single proton. The commonest error was to omit the division by 2. A small number of candidates lost credit by *doubling* the proton charge in the expression for potential energy rather than *squaring* it. A few others substituted 1.0 as the charge on the proton, failing to realise that the charge needed to be in coulomb.

(c) Calculating the temperature at which the protons in the plasma would have the required kinetic energy was a simple matter of substituting in the given expression. Most candidates succeeded in doing this albeit in some cases benefiting from the error carried forward provision.

(d) Candidates were asked how it is possible for fusion between protons to take place inside the Sun at temperatures very much lower than the value calculated in *(c)*. They were expected to realise that the calculated value of the kinetic energy is only a *mean* value and that protons (like the molecules in a gas) have a range of energies. Therefore, at any given moment there will always be a small proportion of the protons which have much more energy than the mean value, and so will be able to undergo fusion. It was surprising that so few candidates seemed aware of this, especially as this area has been touched upon in previous A2 questions. Candidates unaware

of this had to resort to explanations involving the role of high pressure or gravity forces inside the Sun, or making statements such as 'the strong force overcomes repulsion between the protons'.

(e)(i) In this question, candidates were given the three reactions which form the hydrogen cycle, together with the energy liberated in each reaction. Candidates were expected to realise that to arrive at the combined reaction, which was also given, it was necessary to apply multiplying factors of 2 to the first two equations, before summing them. This meant that the same multiplying factor would need to be applied to the energies in order to calculate the overall energy output. This was a slightly different question from ones which have been asked in this area before and it was pleasing to note how many candidates were able to answer it correctly. Others simply added the three energies (without any multiplying factor) and scored partial credit.

(ii) Candidates were asked why the heat generated inside the Sun is less than would be expected and they were expected to be aware that the neutrinos which are emitted in the hydrogen cycle will escape, most of them failing to interact at all and that this represents a net loss of energy from the Sun. The question was very poorly answered, most candidates seeming to be totally unaware that neutrinos carry energy. Of those who attempted any answer, the commonest statements were that the energy is carried off as light, or that it is (somehow) used in making other particles.

(f) This part was better answered. Most candidates seemed to realise that carbon and nitrogen have bigger charges and therefore exert bigger repulsive forces on a proton. The proton therefore needs greater energy for fusion to occur and this implies higher temperatures. Some lost credit however for attributing the difference to the greater *size* or *mass* of the carbon and nitrogen nuclei. Others tried to explain it in terms of the greater stability or greater binding energy of these larger nuclei.

4(a) Candidates were asked to explain what is meant by fixed target and colliding beam experiments. It was expected that they would state that in a fixed target experiment a beam of particles is accelerated and made to collide with a target consisting of other particles. The colliding beam experiment should have been identified as one in which two beams of particles are accelerated and made to collide head-on. Candidates had a general idea of the two kinds of process but often failed to score fully by omitting important features such as the fact that the moving particles all have to be accelerated or that the target has to consist of appropriately chosen particles. The statement that particles are made to hit the target was not enough to score. Equally, it was essential to state that the collisions between moving particles is head-on; it was not enough to refer to beams of particles 'crossing' or simply 'colliding' since this did little more than repeat what was stated in the question.

The advantage of the fixed target experiment is that far more collisions can be guaranteed. Most candidates were able to state this though some thought that the main advantage was that a collision with a fixed target could easily be located by experimenters. The advantages of colliding beam methods were less obvious to candidates. Many scored a mark for stating that, as two sets of particles have kinetic energy the total energy of the collision is twice as great. However, full credit could be gained only by using an argument involving momentum, to the effect that in a colliding beam experiment the total initial, and therefore total final momentum must be zero and that therefore *all* the input energy can be used to create new particles. Some candidates also lost credit by confusing kinetic energy and momentum.

(b)(i) In this part candidates were told how a high-energy positron, colliding with a stationary electron could create a Z particle and, given that both the incoming positron and the outgoing Z particle are moving at speeds close to the speed of light, asked to use the principle of conservation of momentum to compare the masses of the positron and the Z particle. Many were able to state that since the product of mass and velocity (i.e. the momentum) of the two particles are the same and since their speeds are also approximately equal, their masses must also be equal.

(ii) Candidates were then asked to calculate the ratio of the two rest masses, yielding an answer very much greater than unity. This was a very easy mark to win but a surprisingly large proportion of candidates calculated the inverse of the ratio asked for.
(iii) This time candidates were asked to explain why the two apparently contradictory values were not in fact in conflict. Only a minority of candidates realised that since the particles were moving at speeds close to the speed of light, the actual masses will be much greater than their rest masses, because of relativity. Even fewer realised that although both were moving at *approximately* the speed of light, their speeds must have been slightly different because the positron's mass had increased by a much larger fraction than that of the Z particle and that therefore it must have been travelling closer to the speed of light i.e. slightly faster.

(c) Asking candidates why creating a Z particle by means of the fixed target method was not very productive was really firming up the answer to *4(a)* by spelling it out in a specific case. However, few candidates were able to state that the reason is that the Z particle will carry kinetic energy and this energy was not available to contribute to the rest mass of the Z. Many candidates thought the answer had something to do with the fact that the electron and positron were annihilating each other.

5(a) Candidates were asked to write nuclear equations for two proposed decay reactions of a gold nuclide. Most were able to achieve this successfully but a disappointingly large number lost one or both of these marks, usually by omitting the neutrinos. A few lost credit because they failed to represent the beta particle fully; a nuclear equation requires the charge and mass number of every particle to be shown.

(b) Candidates were required to determine which of the suggested decays was possible. It was expected that they would compare the masses of the reactant (the gold nucleus) with that of the products (the product nucleus plus the electron/positron mass). Many candidates were able to deduce that only the positron decay resulted in a loss of rest mass; the electron decay would have needed a gain in rest mass and this reaction was not therefore possible (without an external input of energy). A significant minority of candidates, however, tried to answer by considering the balance of charge, baryon number and strangeness. Since they had no given information about these and since they would in any case be expected to balance in both cases, this approach proved fruitless.

(c) This question asked candidates to calculate the maximum possible kinetic energy of any emitted beta particle. Candidates needed to calculate the energy E using the equation $E = mc^2$ where m represents mass loss in the positron decay and c the speed of light. Many were able to achieve this. The commonest error among those who did arrive at a numerical answer was to use the usual equation for kinetic energy, namely
$E = \frac{1}{2} m v^2$. This was inappropriate here because, at any likely speed of the emitted particle, the mass would be significantly greater than the rest mass m.

6(a) Candidates' discussion of the stability or otherwise of hadrons needed to make clear that all hadrons are unstable to some degree and then to refer to the proton and neutron, stating their half-lives when free. It was necessary also to state that, when in a stable nucleus, both are stable. This was well done by many candidates, a significant minority of whom scored full marks. Marks were lost in some cases however by failing to distinguish between stability when inside a nucleus and stability of the free hadron. Some candidates referred to baryons and mesons but did not have enough detailed information to substantiate their argument. One or two candidates quoted the half-life of the proton to be 1032 years, presumably as a result of misreading 10^{32} from poorly transcribed notes!

(b)(i) Most candidates were able to state that the weak force is responsible for beta decay.

(ii) Although many candidates successfully wrote the nuclear equation for the decay of tritium, many others lost the mark by omitting the neutrino or failing fully to represent one or other of the particles in the reaction.

(iii) This part required candidates to analyse the reaction of *(ii)* in terms of quarks and reduce it to its simplest form. This was not well done; many candidates failed to cancel quarks which appeared on both sides of the equation, or (again) omitted the neutrino. Some candidates merely stated, in words or symbols, that a down quark changes to an up quark. This scored partial credit only.

7(a) Most candidates were able to state that the advantage of connecting Christmas tree lights in parallel rather than in series is that failure of one bulb does not prevent the other bulbs from lighting up.

(b)(i) Straightforward application of the equation relating power to current and voltage enabled most candidates to arrive at a correct value for the current through a bulb in the parallel circuit. A small number of candidates lost credit for giving only 1 significant figure in their answer.

(ii) It was then possible for nearly all candidates to use this current value to find the resistance of a bulb.

(iii) The usual resistivity equation then enabled about half the candidates to calculate the radius of the bulb filament. Probably the commonest omission was to give the cross sectional area as the answer, without going on to calculate the corresponding radius. A few misquoted the resistivity equation.

(iv) Many candidates realised that the extraordinarily thin filament which they had calculated would be too fragile to make or use. Some thought that this would be a problem because the thin filament would burn out too easily, forgetting that in a parallel circuit the power dissipation is *inversely* proportional to the resistance.

(c) Sadly, the simple situation of a failed Christmas tree bulb in a series circuit proved one of the worst answered questions on the paper. It rapidly became clear that the great majority of candidates had no clear understanding of potential difference and its relation to current. Thus we had potential difference flowing and/or current flowing through one part of the circuit but not another. All that was required was to realise that if one bulb fails, the current in *all* parts of the circuit becomes zero and this means that the potential difference across every bulb (except the failed one) becomes zero. So all of the 240 V occurs across the failed bulb.

(d)(i) This question described the common situation of replacing failed bulbs in one set of Christmas tree lights with bulbs from another set. Candidates were expected to realise that replacing a set A bulb with a set B bulb would reduce the resistance of the circuit and so increase the current, leading to an increased power dissipation in the remaining set A bulbs which would therefore, after repeated replacements, reach their 0.75 W power limit and fail. Most candidates were able to score in this part and a significant minority achieved full credit.

(ii) This proved a challenging calculation which few fully solved. The most productive approach would have been to realise that each substitution resulted in a reduction of 150 Ω in the circuit resistance. Thus, by assuming (say) a maximum of *X* substitutions it was possible to form an equation relating *X* to the maximum power dissipation and thus solve for *X*. Some candidates used an alternative approach which, though flawed, had some merit. These candidates deduced that the total resistance of the full circuit of set A bulbs was 4800 Ω. The normal working current was found to be 0.050 A and the failure current in a set A lamp was 0.075 A. By assuming (incorrectly) that all bulbs are identical during the substitution process these candidates arrived at a value of 3200 Ω for the resistance of the circuit of A and B bulbs at the point of failure. By dividing this figure by 150 Ω these candidates deduced that 10 or 11 bulbs would have been substituted and they scored partial credit for an approach which showed some understanding of the problem.

Physics 2826/01

General Comments

One topic which occurs with every examiner and teacher is the problem of careless mistakes. It was pleasing this year to note that there has been a considerable drop in the number of such mistakes. Perhaps the message is getting through to candidates that continuous checking must be done if careless mistakes are to be consistently avoided. Checking at the end of an examination is not soon enough. By being alert and checking virtually at the end of every line mistakes can be picked up and corrected before they lead to a mass of lost marks. The paper this January, marked out of 60, resulted in a mean mark of 37.7. This was 4.2 marks higher than last year. The standard deviation was 10.1. No candidate scored less than 14 and the highest mark was 58. No one taking this paper was short of time but there were some Centres where many candidates seemed ill prepared for an A-Level paper at this time of the year.

The question of significant figures often worries teachers and candidates. It is not easy to be completely precise about the requirements here but in most cases three significant figures will not result in any penalty as answers seldom require anything but two, three or four figures and normally one figure either way is not penalised. Candidates who are used to using the number of significant figures quoted in the question can run into difficulty in a multi-part question as they do sometimes round up time and time again. This should be avoided. It is better to keep too many, rather than too few figures in the calculator. When problems do arise it is usually when the number starts with a 1. A two significant figure number like 1.2 has an 8% uncertainty, whereas 9.8 has only a 1% uncertainty.

Comments on Individual Questions

1. This question was not answered very well. Too many important features of the answers were missing. For example, in (a), where all candidates should have achieved 2 marks, many only scored 1 because they omitted to state that speed is distance per unit time. These candidates gave as their full answer something along the lines of 'speed is how fast you are going and velocity is speed in a given direction'. (b) was answered well. Candidates were able to deal with the question either in terms of the material itself or in terms of collisions. (c) was seldom answered well. A variety of approaches were allowed, for example in those Centres where the idea of heat is treated as a verb. The main problem though was that clearly, in many cases candidates treat the two words as synonyms. If heat was treated as internal energy then it clearly is a form of energy, which temperature is not. For example, if you take two beakers of water at the same temperature and add the first to that in the second beaker, then the second beaker contains twice as much internal energy but the temperature has not changed. Temperature itself is actually defined by the zeroth law of thermodynamics. This is not in the specification as such but temperature is and candidates should know that it is temperature which controls the direction in which heat flows between two bodies. Candidates could say that temperature is proportional to the mean kinetic energy of the molecules in a system – but not that it <u>is</u> the energy of the molecules. In (d) many candidates lost a mark by not referring to a <u>nuclear</u> fission or fusion. Answers to (e) were often too brief. There are many differences between the two properties but the key difference is that change in momentum is force x time whereas change in kinetic energy is force x distance. The statement 'kinetic energy of a body is the work it is able to do by virtue of its speed', is a useful one which candidates generally are not familiar with.

2. This question was very discriminating. Candidates who understood the topic were able to gain all 19 marks. For those candidates who had limited understanding, the main stumbling block related to the conservation of charge. They generally could not find the charge on Z to be 180μC and they tended to add up all the charge for (a)(ii)2, rather than giving 180 μC again. A small point here, but please note, e^{-4} was not regarded as a complete answer to (c)(ii). 0.0183 is required.

3. This was another question which good candidates could score highly on but on which poor candidates made many unnecessary mistakes. Some of the weaker candidates got into a muddle with efficiency as power out/power in, and with getting 65% for (c)(i). Too many candidates thought that global warming was due to all the heat escaping from houses. Part (c) was quite discriminating. Having first stated that the efficiency is higher if the temperature of the steam is raised many candidates then gave extra cost in raising the temperature as a disadvantage. It must be worthwhile to pay extra for the higher temperature. Cooling the cooling water would require increased costs which would negate the advantage gained – even if the water did not freeze. In (v), too many candidates did not add K to their zero. (Some gave 0 °C; some even −273 K).

4. This was another discriminating question. The passage and the idea of superconducting caused no appreciable difficulty and most realised that if the equipment operates at 92 K then a small rise in temperature will cause loss of superconductance. Some even knew that 77 K is used because it is the temperature at which liquid nitrogen boils. Most could establish from its unit that current density is current per unit area and that the area is 10^{-6} m^2. With questions asking for an answer to be shown, it is important that this is done clearly. In this question too many candidates wrote $I = 2.0 \times 10^8 / 1.0 \times 10^{-6} = 200$. In part (e) two difficulties were common among the weaker candidates. The first was getting the mass − 235 kg was a common mistake; the second was the urge to include Force = $Q_1 Q_2/kr^2$. There was a good opportunity here for checking that answers were sensible. Two successive papers had answers 4.3×10^{35} m and 2.7×10^{-26} m. There were also some extraordinary paths drawn on the papers. One particularly common mistake was for nothing to happen to the particles until they were well into the field, at which point they suddenly started to go round in a circle. Even some of the good candidates lost a mark because they did not draw two paths with the 238 nucleus having the smaller deflection. A mark was not deducted if the difference between the two paths was unreasonably large.

Report for Centres on Physics A2 Practical Exam 2826/03 for January 2006

As for last year the examination was taken by only a few candidates, but the standard was generally good, with only a few really weak scripts.

The plan this time proved to be a reasonable discriminator between candidates. There were no reported difficulties with circuits in question one, or with apparatus in questions one and two. Question one proved to be rather more straightforward and easier than in previous years. No candidate appeared to be short of time.

Comments on Individual Questions

Planning Exercise

In this exercise candidates were required to design experiments to investigate the charge-voltage relationship for a capacitor at different temperatures, ranging from –40°C to 130°C.

There were two problems to be solved. One was to decide how the range of temperatures would be obtained in the laboratory, and the other was to decide how to measure the charge stored in the capacitor at different voltages.

Many candidates did a lot of commendable research on laboratory freezers and ovens, but often lost a mark through lack of a diagram, asked for in the question. Use of liquid nitrogen lost credit, as did the immersion of the unprotected capacitor in water. The best answers used dry ice for the cooling, and hot oil or an oven for the higher temperatures.

Circuit diagrams were generally good, except that some charge/discharge circuits lacked the necessary resistors. Very few used the traditional reed-switch method for measuring charge. Some used a coulombmeter, but most measured the area under the charge-time graph, whether for charging or discharging the capacitor. Others used charge sharing with a known capacitor. However, only about half the candidates realised that the charge needed to be measured for a range of different voltages at the same temperature. Those who used the formula $Q = CV$ to find the charge of the capacitor under test were not credited, since this proportionality was what they were trying to verify.

Most candidates used gloves for the temperature extremes and so earned the safety mark. “Detail marks” were usually earned by the use of good research about the correct choice of thermometer, or for allowing time for the temperature to stabilise. Only a very few discussed time constants, and hence were able to decide on the best value of the resistance to use in the circuit.

Too many candidates are still not giving two full references, which should include page numbers, from books or the internet. It was pleasing to see that most earned the two “quality of written communication” marks, providing well-written accounts of about 500 words. A considerable leeway is allowed, but the few overlong accounts (one of over 1000 words) lost marks here. Some hand-written scripts failed to leave a margin on the right hand side, as requested in the rubric.

Question 1

In this question candidates were required to set up a circuit to charge a capacitor, and then discharge the capacitor through a known resistor with a voltmeter across it. They then had to measure the time for the voltage to drop to half the initial value.

The setting up of the circuit and the carrying out of the experiment proved to be very straightforward. Candidates had to obtain six different values of capacitance from different combinations of three given 1000μF capacitors (formulae were given), and only a very few had problems with these calculations.

Most obtained a good straight-line graph with little or no scatter. Axes were sensibly chosen and gradients nearly always correctly calculated from large triangles. Tables of results were generally good but some lost the "consistency of raw readings" mark for quoting capacitances for example as 333⅓ μF or 1000.0 μF. They were required to give values to the nearest 1μF or 10 μF. Most candidates obtained credit for repeating readings, but there are still too many failing to do this. There was no evidence that candidates were short of time so it should have been possible.

Nearly all candidates correctly estimated the percentage error in the measured time, although many still think that they can measure to an accuracy of ±0.01 s for a stopwatch reading.

The analysis section of the question proved to be more difficult. Only a few correctly derived $t_{½} = CR\ln 2$ from the exponential expression given, but most realised that the gradient was $R\ln 2$. The calculation of resistance then required that powers of ten be sorted out, and units given, and these were often omitted.

For candidates who had got this far, the resistance of the voltmeter was obtained from a simple calculation involving resistances in parallel, but there were some who used the resistance in series formula.

Question 2

In this question, candidates were asked to find the density of water by measuring the apparent loss of weight when known masses were immersed in water.

Detailed instructions were given, together with a suitable formula, but only a handful of candidates finally arrived at a sensible value for the density of water. Power of ten errors, and incorrect manipulation of the equation, were the usual mistakes. The experiment does however need to be done very carefully to obtain good results.

As usual the evaluation turned out to be a challenge for a number of candidates. The experiment gave rise to plenty of inaccuracies and hence discussion points. To obtain good marks candidates needed to discuss several of these points, stating the difficulty and then suggesting possible solutions, without being too vague.

Most candidates raised the problem of the pointers, spring or masses moving while measurements were being taken, and suggested sensible solutions, such as waiting for the movement to settle or holding the spring steady. Most stated that it was difficult to see the masses through the side of the beaker, and credit was given for saying why it was difficult. A lot of workable solutions were suggested (scales inside beaker etc.). The other common problem was the measurement of the mass diameter with a ruler, and vernier calipers or a micrometer were generally suggested as the solution.

The best candidates also gained credit for suggesting that several sets of readings be taken. But to earn this credit, details needed to be given of exactly what extra readings should be taken, and how the results should be shown graphically. A vague statement that more readings should be taken and the results averaged was not good enough.

Nearly all candidates covered some of the above, but too many rambled on about one particular problem for too long, and failed to cover a sufficient number of points.

Advanced GCE Physics A (3883/7883)

January 2006 Assessment Session

Unit		Maximum Mark	a	b	c	d	e	u
2821	Raw	60	46	41	36	31	27	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	49	44	40	36	32	0
	UMS	120	96	84	72	60	48	0
2823A	Raw	120	97	86	75	65	55	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	97	86	75	65	55	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	93	84	75	66	58	0
	UMS	120	96	84	72	60	48	0
2824	Raw	90	61	54	47	40	34	0
	UMS	120	96	84	72	60	48	0
2825A	Raw	90	65	59	53	47	41	0
	UMS	120	96	84	72	60	48	0
2825B	Raw	90	61	55	49	43	38	0
	UMS	120	96	84	72	60	48	0
2825C	Raw	90	65	58	51	44	38	0
	UMS	120	96	84	72	60	48	0
2825D	Raw	90	64	56	48	41	34	0
	UMS	120	96	84	72	60	48	0
2825E	Raw	90	64	56	48	41	34	0
	UMS	120	96	84	72	60	48	0
2826A	Raw	120	94	84	74	64	54	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	94	84	74	64	54	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	94	85	77	69	61	0
	UMS	120	96	84	72	60	48	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
3883	300	240	210	180	150	120	0
7883	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
3883	17.3	36.7	56.5	75.8	96.0	100	251
7883	5.0	52.5	75.0	92.5	97.5	100	52

For a description of how UMS marks are calculated see;
www.ocr.org.uk/OCR/WebSite/docroot/understand/ums.jsp

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