

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Mark Schemes for the Units

January 2010

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Advanced Subsidiary GCE Physics (3883)

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2824 Forces, Fields and Energy

Question			Expected Answers	Marks		Additional Guidance
1	(a)	(i)	Two vertical arrows of equal length (by eye) and opposite direction in the same vertical line passing through the ball; weight/gravity/mg/0.49 N and (normal)reaction/string tension/0.49 N	1 1	2	
		(ii)	(resultant force) = ma; = 0.05 x 2 = 0.1 (N)	2	2	
	(b)	(i)	$v^2 = u^2 + 2gh$ / $\frac{1}{2}mv^2 = mgh$ to give $v^2 = 2gh$; $v^2 = 2 \times 9.8 \times 0.8$ to give $v = 4.0$ (m s ⁻¹) accept 3.96	1 1	2	
		(ii)	$mv = 0.20$ (kg m s ⁻¹) accept 0.198	1	1	
		(iii)	$2mv = 0.40$ (kg m s ⁻¹) accept 0.396	1	1	
	(iv)	$2mv/t = 8.0$ (N) accept 7.92)	1	1	ecf b(iii)	
	(c)	gravity; acts on ball and Earth /AW contact/reaction forces; between ball and strings/racket	2 2	4		
			Total		13	
2	(a)	(i)	Force per unit mass (placed at that point)	1		
		(ii)	$g = GM/R^2$	1		
		(iii)	Choosing a correct pair of values from the graph, eg 6.4×10^6 & 9.8, 10×10^6 & 4.0; substitute, $9.8 = 6.67 \times 10^{-11} \times M / (6.4 \times 10^6)^2$ to show $M = 6.0 \times 10^{24}$ kg	1 1		
		(iv)	linear graph through origin/from 0 to R	1		
		(v)	64 km; 1/100 of R as linear graph under Earth/AW 64000 km; $g \propto 1/r^2$ so for 1/100 g $r = 10R$	2 2	9	
	(b)		$GM_e/R_1^2 = GM_m/R_2^2$; $M_e = 81 M_m$; $M_m = 6.0 \times 10^{24}/81 = 7.4 \times 10^{22}$ (kg)	2 1		ecf a(iii) accept any alternative correct method; correct figures; processed to correct answer
					Total	

Question			Expected Answers	Marks		Additional Guidance
3	(a)		$Q_0 = CV = 1.2 \times 10^{-11} \times 5.0 \times 10^3$; $= 6.0 \times 10^{-8}$; C	3	3	
	(b)	(i)	$RC = 1.2 \times 10^{15} \times 1.2 \times 10^{-11}$ or $= 1.44 \times 10^4$ (s)	1		
		(ii)	$I = V/R = 5000/1.2 \times 10^{15}$ or $= 4.17 \times 10^{-12}$ (A)	1		
		(iii)	$t = Q_0/I = 6 \times 10^{-8} / 4.17 \times 10^{-12} = 1.44 \times 10^4$ (s)	2		
		(iv)	$Q = Q_0 e^{-1}$; $Q = 0.37Q_0$ so Q lost = $0.63Q_0$	2	6	
	(c)	(i)	capacitors in parallel come to same voltage so Q stored \propto C of capacitor capacitors in ratio 10^3 so only $10^{-3} Q_0$ left on plates	1 1 1		
		(ii)	$V = Q/C = 6.0 \times 10^{-8} / 1.2 \times 10^{-8}$ or $6.0 \times 10^{-11} / 1.2 \times 10^{-11}$ or only $10^{-3} Q$ left so $10^{-3} V$ left; $= 5.0$ (V)	2	5	
			Total		14	
4	(a)	(i)	acceleration \propto displacement; indication of restoring force by negative sign/acc. in opp. direction to displacement/acc. towards origin/AW	1 1		
		(ii)	linear graph through origin; negative gradient	2	4	
	(b)	(i)	0.05 (m)	1		
		(ii)	$4\pi^2 f^2 = a/A = 12.5/0.05 = 250$; $f = 2.5(1)$ Hz; $T = 1/f (= 0.4 \text{ s})$	3	4	
	(c)	(i)	cosine wave; correct period of 0.4 s; correct amplitude of 0.05 m	3	3	ecf b(i)(ii)
		(ii)	0; 0.1/0.3/0.5/0.7/0.9 (s)	2	2	
			Total		13	
5	(a)	(i)	F is away from 'open' end of tube; using Fleming's L.H.rule	2		
		(ii)	$F = BIlw$	1		
		(iii)	$F = 0.15 \times 800 \times 0.0025$; $= 3.0$ (N)	2	5	
	(b)	(i)	A voltage is induced across moving metal as it cuts lines of flux/AW; voltage is proportional to flux change per second/AW; the flux change per second is Bwv / is proportional to the area of metal moving through the field per second or Faraday's law fully stated; with reasonable attempt to; relate flux linkage per second proportionally to speed	1 1 1 2 1		
		(ii)	flux (linkage) doubles; so using Faraday's law V doubles/AW	2	5	
			Total		10	

Question			Expected Answers	Marks		Additional Guidance
6	(a)	(i)	An element can exist in more than one form, having a different number of neutrons/can have different mass but same proton number/AW		1	
		(ii)	${}^4_2\text{He} / {}^4_2\alpha$; $(-) {}^0_{-1}\text{e} / {}^0_{-1}\beta$		2	
		(iii)	${}^{238}_{92}\text{U} \rightarrow {}^{234}_{92}\text{U} + {}^4_2\alpha + {}^0_{-1}\beta + {}^0_{-1}\beta$ or ${}^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{X} + {}^4_2\alpha$ ${}^{234}_{90}\text{X} \rightarrow {}^{234}_{91}\text{Y} + {}^0_{-1}\beta$ ${}^{234}_{91}\text{Y} \rightarrow {}^{234}_{92}\text{U} + {}^0_{-1}\beta$ or α followed by two β decays; nucleon number = $238 - 4 - 0 - 0 = 234$; proton number = $92 - 2 + 1 + 1 = 92$	3 1 1 1 1 1	3	accept answer in terms of A,p or n,p diagram
	(b)	(i)	N : the number of undecayed nuclei/nuclei of the original element (remaining) N_0 : the initial/original number of nuclei present λ : the (decay) constant relating the activity to the number of undecayed nuclei/AW/the probability of a given nucleus decaying in the next second	1 1 1	3	
		(ii)	$f = N/N_0 = e^{-\lambda t}$; $= \exp(-0.693 \times 4.6 \times 10^9 / 7.1 \times 10^8)$; $= \exp(-4.49) = 0.011$ or time = 6.48 half lives; so $f = 1/2^{6.48}$; $= 0.011$	2 1 3	3	
Total					12	

Question			Expected Answers	Marks		Additional Guidance
7	(a)		Internal energy is the sum of the random kinetic and potential energies of the <u>molecules/atoms</u> in the system/gas An ideal gas has no attraction between molecules/atoms; so its internal energy is only kinetic / internal energy of ideal gas tends to zero at 0 K; but real gas does not	2 2	4	any situation referring to forces or the result of forces between molecules, eg change of phase, to score 1 mark; max 2 marks
	(b)		Gas changes to liquid; and then solid As temperature falls internal energy decreases Absolute zero is the temperature for minimum internal energy At a change in phase there is no temperature change Arrangement/packing of particles: in liquid free to move within body of liquid in solid fixed in position but free to vibrate statement about increase in order of particle arrangement across one change of phase At phase change: large change of p.e.; little/no change in k.e. Between phases: major change in k.e; little/ no change in p.e. Quality of Written Communication	2 1 1 1 1 1 1 2 2	8 4	Other possible marking points include statements about k.e. of particles not enough to overcome attraction of intermolecular forces; how vibration energy is shared between k.e. and p.e. etc. max 8 marks
			Total		16	

2825/01 Cosmology

1.	a.	planets move in ellipses	1	
		with Sun at one focus	1	
		equal areas swept out in equal times	1	
		T^2 proportional to r^3	1	
	b.	Any 2 from		
		Sun in centre (vs. Sun at focus of ellipse)	1	
		planets move in circles (vs. planets move in ellipses)	1	
		planets move with constant speed	1	2
	c.i	backward movement of planet	1	
		with reference to position of fixed stars	1	
	c.ii	Mars moves slower than Earth (ora)	1	
		Earth overtakes Mars		1
			total	10
2.	a.i.	parallax angle subtended is 1 arcsecond	1	
		when arc length is 1 AU (owtte)	1	
	a.ii.	3.1×10^{16} (accept 1 sig. fig.)	1	
	b.	combine equations eg. $10.96 = -2.5(\lg I_B - \lg I_S)$	1	
		combine I_B and I_S eg $I_S / I_B = 10^{4.384}$	1	
		$I_S / I_B = 2.4 \times 10^4$	1	
	c.i.	$m - M = 5\lg(d/10)$	1	
	c.ii.	$-1.46 - 1.4 = 5 \lg (d/10)$	1	
		$d = 2.7\text{pc}$	1	
			total	9

3.	a.i.	Absolute magnitude/ luminosity	1	
		Temperature with correct direction of increasing temperature	1	
	a.ii.	Main Sequence	1	
	a.iii.	on main sequence line	1	
		below the half-way point	1	
	b.i.	red giants	1	
		suitable position above line, low temperature	1	
		white dwarfs	1	
		below line, high temperature	1	
	b.ii.	line up to red giants	1	
		line continues down to white dwarfs	1	
	c.	reference to temperature decreases significantly	1	
		reference to ceasing to emit light/brown dwarf/black dwarf	1	
			total	13
4.	a.	Change in wavelength/frequency	1	
		due to motion of source/observer/both	1	
	b.i.	$\Delta\lambda = \lambda \times (v/c)$	1	
		galaxy E is moving faster and so light undergoes greater change in wavelength.	1	
	b.ii.	points plotted correctly	1	
		best straight line drawn	1	
	b.iii.	equate H with gradient	1	
		calculate $H = 50$ (ecf from graph)	1	
		unit = $\text{km s}^{-1} \text{Mpc}^{-1}$	1	
	c.	Any two from		
		gravity causes galaxies to decelerate (owtte)	1	
		ratio of v/r is becoming smaller	1	
		recent evidence shows distant galaxies accelerating away	1	2
	d.	Cosmic Background Microwave Radiation	1	
		Uniform intensity	1	
		temperature approximately 3K	1	
		or		
Unexpectedly high abundance of helium		1		
Could not have come from stellar helium burning alone		1		
Helium created in the earliest moments of big bang		1	3	
		total	14	

5.	a.	gamma	no	yes	1		
		X rays	no	yes	1		
		microwaves	no	yes	1		
		radio	yes	yes	1		
	b.	advantage:	accessibility/ cost/ maintenance/ flexibility of use/ available to many users			1	
		disadvantage:	limited observation times/ lower radiation intensity/ atmospheric distortion			1	
			total			6	
	6.	a.	speed of light constant in <u>all inertial frames</u>				1
			all inertial frames are equivalent				1
b.		Any 5 from					
		diagram showing relative motion				1	
		event occupying time interval specified				1	
		path observed from stationary reference frame				1	
		path observed from moving reference frame				1	
		'moving' clock slower.....				1	
.....because longer path				1			
c.i.		t_0 time measured by observer at rest				1	
		t same time for 'external' observer				1	
c.ii.		1. time = $2750 / 3.0 \times 10^8$				1	
		= 9.17 us				1	
		2. approximately 6 half-lives				1	
		so 2^6 fewer				1	
		hence $6210 / 64 = 97$ in 5 minutes				1	
		3. half-life extended (owtte)				1	
d.		large mass in line between observer and stellar object (accept diagram)				1	
	attraction of light by large body				1		
	explanation of 2 images formed / reference to GTR				1		
		total			18		

2825/02 Health Physics

Question	Expected Answers	Marks
1(a)(i)	$3.0 \text{ div} \times 2.5 \mu\text{s div}^{-1}$ $= 0.0075 \text{ ms}$ or $7.5 \mu\text{s}$	1 1
(ii)	$2s = vt$ $4000 \times 7.5 \times 10^{-6}$ $= 1.5 \text{ cm}$	1 1
(iii)	$2d = 1500 \times 2 \times 2.5 \times 10^{-6} = 7.5 \times 10^{-3}$ $d = 0.38 \text{ cm}$	1,1 1
(b)	If gel is not used, (most reflection occurs at air / skin boundary)so <u>large first peak</u> or <u>small subsequent peaks</u>	1
	Reason: e.g. there is a very large difference in the acoustic impedance either side of this boundary or large reflection at air / skin boundary	1
		Total: 9

Question	Expected Answers	Marks
2(a)(i)	near point = 25cm +/-5cm	1
	far point = ∞	1
(b)(i)	long sight	1
	short sight	1
	allow presbyopia for one mark	
(ii)	$p = 1/v + 1/u$	1
	$p = 1/0.32 + 1/0.017$	1
	$p = 61.95 \text{ D}$	1
(iii)	$p = 1/0.25 + 1/0.017$	1
	$p = 62.8 \text{ D}$	1
	$62.82 - 61.95 = +0.87 \text{ D}$ allow ecf from (ii)	1
	allow alternative routes	
(iv)	$1/f = 1/0.017 = p = 58.8 \text{ D}$	1
	$p = 1/0.017 + 1/0.96 = 59.86 \text{ D}$	1
	$58.82 - 59.86$	1
	$= -1.04 \text{ D}$ allow alternative routes	
	bifocals / varifocals	1
		Total: 14

Question	Expected Answers	Marks
3	<p>any 7 e.g. atoms with unequal nos. of neutrons and protons, spin act like tiny magnets <u>strong</u> external magnetic field applied atoms align in this magnetic field they precess / wobble when a RF radiation (pulse) is applied resonance occurs / atoms flip RF is emitted as atoms return to their equilibrium state the time taken for the atoms to return to their equilibrium state is measured</p> <p>allow one detail mark from the following (up to max 7): two relaxation times hydrogen atoms usually used magnetic field gradient across the length and width of the body</p> <p>any 2 e.g. it is non-ionising differentiates well between tissues of similar density MRI not affected by the bone of the skull allow response if corresponding disadvantages given</p>	<p>1 1 1 1 1 1 1 1</p> <p>1 1 1</p> <p>1 1 1</p> <p>Total: 9</p>

Question	Expected Answers	Marks
4(a)	6 points plotted correctly +/- ½ a small square	1
	remaining point plotted correctly	1
	sensible continuous smooth graph drawn	1
	sensible scales	1
(b)	1.0 +/- 0.10 mm	1
(c)	$I / I_0 = e^{-\mu x}$	1
	$0.50 = e^{-\mu 0.00100}$	1
	$\mu = 690$	1
	m^{-1}	1
	(allow 0.690 mm^{-1})	
		Total: 9

Question	Expected Answers	Marks
5(a)	$I = P / A$	1
	$I = 3.0 / 16 \times 10^{-4}$	1
	$I = 1.88 \times 10^3 \text{ W m}^{-2}$	1
(b)(i)	$II = 10 \lg (1.00 \times 10^{-7}) / (1.0 \times 10^{-12}) = 50.0 \text{ dB}$	1
	$II = 10 \lg (2.00 \times 10^{-7}) / (1.0 \times 10^{-12}) = 53.0 \text{ dB}$	1
	$53.0 - 51.0 = 3.0 \text{ dB}$	1
(ii)	$53.0 - 54.8 = 1.8 \text{ dB}$	1
(iii)	The intensity changes are the same	1
	The first change is louder than the second change	1
(c)	$33 = 10 \lg I / 10^{-12}$	1
	$I = 2.00 \times 10^{-9}$	1
	$78 = 10 \lg I / 10^{-12} \quad I = 6.31 \times 10^{-5}$	1
	$6.31 \times 10^{-5} / 2.00 \times 10^{-9} = 3.16 \times 10^{-4}$	1
		Total: 12

Question	Expected Answers	Marks
6(a)(i)	$24 \times 10^{-6} / 1.6 \times 10^{-19} = \underline{1.5 \times 10^{14}}$ = number of ion pairs	1
(ii)	$1.5 \times 10^{14} \times 34 = 5.1 \times 10^{15}$ eV	1
	$\times 1.6 \times 10^{-19} = 8.16 \times 10^{-4}$	1
	Gy or J kg ⁻¹	1
(ii)	absorbed dose = $f \times$ exposure (in air) = $38 \times 24 \times 10^{-6}$ = 9.12×10^{-4} (Gy)	1 1 ignore unit
(b)	Any 3 e.g. <ul style="list-style-type: none"> • more attenuation in bone (than at 200 keV) • bone absorbs more than surrounding tissue • bone can be targeted / less damage to surrounding healthy tissue / treatment of malignant cells / tumours in bone 	1 1 1 (max. 3)
(c)	dose equivalent = $Q \times$ absorbed dose or $H = QD$ $1.71 \times 10^{-3} / 9.12 \times 10^{-4} = Q$ $Q = 1.9$	1 1
		Total: 11

Question	Expected Answers	Marks
	any from the following up to a maximum of 4	1
	<ul style="list-style-type: none"> • Ear is most sensitive at a frequency of 1-3kHz.... • where it can detect an intensity of around 10^{-12} Wm⁻² •due to resonance in outer ear. • Lower frequency limit 20 ± 4 Hz. • Upper frequency limit 20 ± 4 kHz. • If graph is drawn, the audible and inaudible regions are labelled. 	1 1 1 1 1 1
	Plus any 2 up to a maximum of 6:-	
	<ul style="list-style-type: none"> • With older people, the range of frequencies gets less. • With older people, the minimum intensity gets greater. • Reason, e.g. ear drum less elastic. 	1 1 1
		Total: 6

Question	Expected Answers	Marks
8	Common question mark scheme as other 2825 papers	

2825/03 Materials

- 1 (a) Elastic: Atoms increase separation due to / in direction of applied force and return to original separation when force removed. (1)
 Plastic: Layers of atoms slide over each other when force applied but do not return to original positions when force removed. (1) [2]
 No reference to atoms / No reference to return: 1 max
- (b) (i) Square shape of figure becomes tilted to the right; (1)
 Displacement from one row to the next less than one atomic diameter; (1)
 Atoms remain touching. (1) max [2]
- (ii) Square 'tilts' as in (i); (1)
 Some relative displacement of two adjacent horizontal layers; (1)
 (Only) two adjacent rows displaced by at least one atomic diameter; (1)
 atoms remain touching. (1) max [3]
- (c) (i) Dislocation: the presence of an extra half / part plane of atoms OR is a linear defect caused by the misalignment of atoms. [1]
- (ii) Dislocations move (through the structure) (1)
 Dislocations allow adjacent planes of atoms to slip relative to each other; (1)
 Many dislocations so this process takes place with small stretching force; (1) max [2]
- 2 (a) (i) x_e (equilibrium separation) = 0.22 nm [1]
- (ii) maximum resultant attractive force (F_{\max}) = 1.5×10^{-8} N [1]
- (b) (i) Values for ΔF and Δx from relevant triangle; (1)
 Magnitude of k (gradient) between 420 and 470; (1)
 negative gradient. (1) [3]
- (ii) Value for E calculated from candidate's k and x_e / correct values; (1)
 Unit: Pa / N m^{-2} (1) [2]
- (c) (i) Use of F_{\max} (e.c.f.) (1)
 Maximum breaking force = $1.5 \times 10^{-8} \times 4.8 \times 10^{12} = 72000$ N (1) [2]
- (ii) Bonds do not all break simultaneously; (1)
 Defects / impurities / vacancies weaken the structure; (1)
 Necking of the wire just magnifies the stress; (1)
 Surface cracks. (1) max [2]

- 3 (a)** $\sigma = L / RA$ (any subject) / $R = \rho L / A$ / $\sigma = 1/\rho$ (1)
 $R = 0.008 / (1.7 \times \pi \times 0.0012^2) = 1040 \, \Omega$ (1)
 $I = V/R = 2.5 / 1040 = 2.40 \, \text{mA}$ (1) [3]
- (b)** Semiconductor:
 At low temperatures few electrons in conduction band; (1)
 Energy gap exists between valence band and conduction band; (1)
 Electrons require energy to cross from valence band to conduction band; (1)
 Rise in temperature provides energy to allow more electrons to cross energy gap; (1)
 Hence more current (for same p.d.) so resistance is less. (1) max[3]
- Platinum:
 Conduction and valence bands overlap; (1)
 Electrons exist permanently in conduction band; (1)
 Number of electrons in conduction band does not change with temperature; (1)
 Higher temperature Increases lattice / atomic vibration impeding movement of electrons / reducing drift velocity; (1)
 Hence less current (for same p.d.) so resistance is more. (1) max[3]
- (c) (i)** The change of resistance with temperature is not linear / not proportional temp. [1]
- (ii)** The change of resistance with temperature is small. [1]
- 4 (a)** Volume of length v of foil = vdt (1)
 No of free electrons in length v of foil = $nvdt$ (1)
 Current = charge transferred per second / $I = Q/t$ / $I = nvdt$ (1)
 $v = I / ndte$ (1) [4]
 [Accept other approaches with steps adequately explained.]
 If starting is $I = nAve$: 2 max.
- (b) (i)** $v = 0.025 / (8.7 \times 10^{28} \times 0.0075 \times 0.000080 \times 1.6 \times 10^{-19})$ (1)
 $= 2.99 \times 10^{-6} \, \text{m s}^{-1}$ (1) [2]
- (ii)** $V_H = Bvd$ (1)
 $= 0.25 \times 2.99 \times 10^{-6} \times 0.0075$ (1)
 $= 5.6 \times 10^{-9} \, \text{V}$ (1) [3]
- (c)** No of free electrons per m^3 is much smaller; (1)
 For same current drift velocity is much higher; (1)
 Hall voltage is much higher and more easily measured. (1) [3]

- 5 (a) (i)** $P = IV$ (1)
 $= 2.5 \times 12 = 30 \text{ W}$ (1) [2]
- (ii)** output power = 96 % of primary power / $I_s V_s = 0.96 I_p V_p$ (1)
 $30 = 0.96 \times 230 \times I_p$ (1)
 $I_p = 0.136 \text{ A}$ (1) [3]
- (b)** Any correct reference to heat loss; (1)
- Coils made of thick copper wire / low resistivity material / low resistance material; (1)
 (to make resistance as low as possible). (1)
- Core is laminated; (1)
 to reduce eddy currents; (1)
 generated by induced voltage in core. (1)
- Core is made of soft iron / soft magnetic material; (1)
 with hysteresis loop of small area; (1)
 Area represents / is proportional to work done in magnetising and demagnetising core; (1)
 in opposite directions in one cycle of A.C.; (1) max[8]
- 6 (a) (i)** $E = hf$ OR $E = hc/\lambda$ (1)
 $= 6.63 \times 10^{-34} \times 3.0 \times 10^8 / 1.3 \times 10^{-6} = 1.53 \times 10^{-19} \text{ J}$ (1) [2]
- (ii)** $1.53 \times 10^{-19} \text{ J} = 1.53 \times 10^{-19} / 1.6 \times 10^{-19} = 0.956 \text{ eV}$ (e.c.f.) (1)
 This energy is greater than the band-gap energy; (1)
 so will be absorbed by the insulator. (1) [3]
 [Last mark only available if reasoning correct]
- (b) (i)** The transmitted white light is a mixture of all (visible) wavelength; (1)
 Energy gap is greater than the photon energy of the shortest wavelength / violet light so no visible light is absorbed. (1) [2]
- (ii)** Energy gap is less than the photon energy of all the colours in white light except red; (1)
 [This mark required for second mark to be gained] (1)
 so photon energy of red light is too low to be absorbed (and passes through). (1) [2]
- (ii)** Metals have very many energy levels in the conduction band with small energy differences; (1)
 Many of these levels are empty; (1)
 All photons of visible and infra-red have sufficient energy to promote electrons through the small energy gaps (and are absorbed). (1) [3]

2825/04 Nuclear and Particle Physics

Question	Expected Answers	Marks
1 (a)(i)	r : radius of nucleus / nuclei r_0 : radius of nucleon / proton / neutron / hydrogen nucleus; A : number of nucleons / (protons + neutrons) / mass number; each omission (-1)	2 [2]
(ii)	line curves in correct sense from origin but doesn't become horizontal; any part drawn with ruler loses this mark	1 [1]
(b)(i)	$r = r_0 A^{1/3} = 1.41 \times 10^{-15} \times 59^{1/3}$ $= 5.49 \times 10^{-15} \text{ m}$ do not allow $5.5 \times 10^{-15} \text{ m}$	1 1 [2]
(ii)	$m = V\rho$ or $\rho = m/V$ allow $m = \frac{4}{3}\pi r^3 \rho$ $= \frac{4}{3}\pi (5.49 \times 10^{-15})^3 \times 1.44 \times 10^{17} (= 9.98 \times 10^{-26} \text{ kg})$	1 1 [2]
(c)(i)	protons: 27, neutrons: 32;	1 [1]
(ii)	mass = $27 \times 1.673 \times 10^{-27} + 32 \times 1.675 \times 10^{-27} = 9.88 \times 10^{-26} \text{ kg}$ (9.877 $\times 10^{-26}$) allow ecf from (c)(i) allow 2 sf	1 [1]
(d)	difference in mass = $0.1(0) \times 10^{-26} = 1 \times 10^{-27} \text{ (kg)}$ allow ecf from (b)(ii) and (c)(ii) $E = (\Delta)mc^2$ $= 1 \times 10^{-27} \times (3 \times 10^8)^2 = 9 \times 10^{-11} \text{ J}$	1 1 1 [3]
		12

Question	Expected Answers	Marks
2(a)(i)	${}^{238}_{92}\text{U} + {}^1_0\text{n} \rightarrow {}^{239}_{92}\text{U}$	1
(ii)	${}^{239}_{92}\text{U} \rightarrow {}^{239}_{93}\text{X} + {}^0_{-1}\text{e} + {}^{(0)}_{(0)}\bar{\nu}$	2
(iii)	${}^{239}_{93}\text{X} \rightarrow {}^{239}_{94}\text{Pu} + {}^0_{-1}\text{e} + {}^{(0)}_{(0)}\bar{\nu}$ wrong neutrinos: 1,1,1 = 3/4 omits one neutrino: (1,2,0) or (1,1,1) = 3/4 max. omits both neutrinos (1,1,0) = 2/4 max. use of ${}^0_{+1}\text{e}$ gets 0 for equation	1 [4]
(b)(i)	24 000 year / >24 000 year	1 [1]
(ii)	$\lambda = \ln 2 / T_{1/2} = \ln 2 / (24000 \times 365 \times 24 \times 3600)$ subs. $= 9.16 \times 10^{-13} \text{ s}^{-1}$ or $< 9.16 \times 10^{-13} \text{ s}^{-1}$ ans. 1. $\times 10^{-5} \text{ y}^{-1}$ gets 1 / 2 2.89 $\times 10^{-5} \text{ s}^{-1}$ gets 0 / 2 allow memorised years to seconds conversion factor	1 1 1 [2]
(c)(i)	<i>either</i> 239 g of Pu contain 6.02×10^{23} atoms $N = (0.05 \times 3.5 / 0.239) \times 6.02 \times 10^{23}$ includes expression for no. of moles $= 4.41 \times 10^{23}$ (atoms) answer <i>or</i> mass of Pu-239 = $\frac{5 \times 3.5}{100} = 0.175 \text{ kg}$ no. of Pu-239 atoms = $\frac{0.175}{239 \times 1.67 \times 10^{-27}}$ includes expression for atom mass (1) $= 4.385 \times 10^{23}$ answer (1)	1 1 [2]
(ii)	activity = λN $= 9.16 \times 10^{-13} \times 4.41 \times 10^{23}$ $= 4.04 \times 10^{11}$ ans. Bq / s^{-1} unit	1 1 1 1 [3]

Question	Expected Answers	Marks
3(a)	nuclei must overcome (electrostatic) repulsion (to get close enough) to fuse; (1) (gravity) confines / pulls together plasma / nuclei / ions / nucleons / protons; (1) increases density/ concentration / number per unit volume; (1) and increases frequency / number of collisions among nuclei; (1) condensation/collapse under gravity or AW heats plasma / gravitational p.e. changed to heat; (1) any 4	4 [4]
(b)	<i>either</i> area is potential / stored energy / work done / energy to overcome coulomb barrier / bring nuclei to their critical separation <i>or</i> (minimum) k.e. at infinity or AW; it is minimum energy needed for fusion;	1 1 [2]
(c)	$E_k = 2.07 \times 10^{-23} \times 15 \times 10^6 = 3.1 \times 10^{-16} \text{ J}$	1 [1]
(d)	combined (mean) k.e. << required p.e. / energy needed for fusion; (1) aware there is a range / spread of (nuclear) k.e.s; (1) (very) small proportion of ^1_1H nuclei have enough energy to cause fusion;(1) aware (quantum) tunnelling can occur so fusion at distances $> x_0$ or AW;(1) any 3	3 [3]
(e)(i)	reactant mass = $2 \times 1.007\,276 = 2.014\,552 \text{ u}$ product mass = $2.013\,553 + 0.000\,549 = 2.014\,102 \text{ u}$ so $\Delta m = 4.5 \times 10^{-4} \text{ u}$ $E = \Delta m c^2$ $= 4.5 \times 10^{-4} \times (1.66 \times 10^{-27}) \times (3.0 \times 10^8)^2 = 6.7 \times 10^{-14} \text{ J}$ allow conversion using $1 \text{ u} = 931 \text{ MeV}$	1 1 [2]
(ii)	positron and electron annihilate	1 [1] 13
4(a)	mass (of proton) increases with speed; so proton/particle gets out of synch. with alternating electric field / voltage;	1 1 [2]

Question	Expected Answers	Marks
(b)(i)	$\frac{1}{2} m v^2 = V e$ $\frac{1}{2} \times 1.67 \times 10^{-27} v^2 = 800 \times 1000 \times 1.6 \times 10^{-19}$ so $v = 1.24 \times 10^7 \text{ m s}^{-1}$ uses electron mass - gives $5.30 \times 10^8 \text{ m s}^{-1}$ gets 1,0,1 = 2/3 $\frac{1}{2} \times 1.67 \times 10^{-27} v^2 = 800$ gets 1,0,0 = 1/3 max.	1 1 1 [3]
(ii)	time interval = $\pi r / v$ or clear from calculation = $\pi \times 0.394 / (1.24 \times 10^7)$ (= $1.00 \times 10^{-7} \text{ s}$) allow ecf for 2/2 gets $2 \times 10^{-7} \text{ s}$, then divides by 2 without justification, gets 1/2 max.	1 1 [2]
(iii)	no. of times = $800 / 10 = 80$	1 [1]
(iv)	horizontal steps from 20 correct ΔE steps at each 10^{-7} s , starting at $1.0 \times 10^{-7} \text{ s}$ straight line through points gets 0,1,0 = 1/3	1 1 1 [3] 11

Question	Expected Answers	Marks
5(a)	<p>fixed target: beam of accelerated / high speed / high energy particles; collide with (stationary) protons / nuclei;</p> <p>colliding beam: two beams of accelerated / high speed / high energy particles; collide them head-on / from opposite directions;</p> <p>'fired at' / 'aimed at' / 'directed at' instead of accelerated etc, (-1) once</p> <p>Advantages:</p> <p>fixed target: high probability of collisions / many collisions because high density of particles in fixed target;</p> <p>colliding beam: (total) initial mtm. (can be) zero so final (overall) mtm. (can be) zero; <i>either</i> so <u>all</u> k.e. can contribute to making new particles <i>or</i> two beams means twice as much energy available;</p> <p>allow any other relevant point up to appropriate max.</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>[7]</p>
(b)(i)	$m_e c \approx m_Z c$ so $m_e \approx m_Z$	<p>1</p> <p>1 [2]</p>
(ii)	ratio = $(1.6 \times 10^{-25}) / (9.11 \times 10^{-31}) = 1.8 \times 10^5$	1 [1]
(iii)	<p>mass increases with speed</p> <p>positron and 0_0Z have different speeds (so masses have changed by different amounts)</p>	<p>1</p> <p>1 [2]</p>
(c)	much / most of input energy goes into k.e. of 0_0Z particle (so less energy available to create 0_0Z)	1 [1]
		13

2825/05 Telecommunications

(a) Silence Spectrum Q [1]

The power spectrum is of an unmodulated carrier (wtte) [1]

Pilot Tone Spectrum R [1]

The carrier is modulated by a single frequency [1]

Music Spectrum P [1]

The sidebands contain a spectrum/range of audio frequencies [1]

(b) (i) 220kHz [1]

(ii) 2kHz [1]

(iii) 8kHz [1]

(iv) Long Wave (Low Frequency) [1]

(v) Maximum number = $(300 - 30) \text{ kHz} / 8 \text{ kHz}$ [1]

 = 33 stations [1]

(c) Broadcast FM radio produces a large bandwidth (180kHz) [1]

If FM were used only one station could operate within the waveband (wtte) [1]

- (a) (i) Op-amp. [1]
- (ii) Output = R Non-inverting input = Q Inverting input = P [1]
- (iii) The difference between the voltages at Q and P [1]
- is amplified by huge amount (open loop gain) to provide the voltage at R [1]
- (b) (i) As the op-amp is not saturated, ($V_Q - V_P$) must be extremely small [1]
- because open loop gain is so large
- or
- amplifier tries to keep two inputs Q and P at (roughly) the same voltage [1]
- Q is directly connected to 0V so P is virtually also 0V [1]
- (ii) Current = $0 - -6 / 24 \text{ k}$ [1]
- = 0.25 mA [1]
- (iii) Voltmeter $V_1 = V_2 \div \text{voltage gain}$ [1]
- = $-6 \div -24 / 8$ [1]
- = +2 V (deduct mark if negative sign) [1]
- (c) Graph of V_2 against V_1 Linear graph through origin [1]
- of negative gradient [1]
- of slope – 3 (allow ecf from b (iii)) [1]
- saturation at $\pm 14\text{V}$ (approx.) [1]

- (a) An analogue signal is analogous / (wtte) with the physical property which generated it
 An analogue signal varies continuously in time
 An analogue signal can have any value between two limits any two [1][1]

- (b) A digital signal is a coded piece of information
 A digital signal does not vary continuously with time (on/off)
 A digital signal can have only two values any two [1][1]

- (c) Pulse Code Modulation [1]

- (d) Sampling occurs at repeated intervals
 Each sample is converted to digital by ADC (must have these two points) [1][1]

Voice frequencies must be filtered / limited before sampling (300Hz – 3.4 kHz)

To avoid alias signals

Sampling frequency is 8000 Hz

Output of ADC is a parallel word

Each word is made up of 8 bits

Thus $8000 \times 8 = 64000 \text{ bits sec}^{-1}$ produced by call

Bits are sent individually / one at a time by parallel-to-serial converter any two [1][1]

Receiver amplifies and removes noise

Receiver swallows bits as they arrive and pass into serial-to-parallel converter

Parallel outputs passed to DAC

Output of DAC filtered smooth and passed to loudspeaker

(must make at least two points) [1][1]

- (e) Disadvantages Complex / expensive
 Consumes larger bandwidth than direct analogue transmission

Advantages Digital can have noise removed
 Digital can be easily stored in memories
 Digital can be easily manipulated by computer
 Digital can be encrypted
 Digital can be companded
 Allow comment on Time Division Multiplexing
 (must make at least one disadvantage to score all three) [1] [1] [1]

- (a) (i) Current in lamp $= P / V$ [1]
 $= 36 / 12 = 3A$ [1]
- (ii) Resistance of cable $= \rho l / A$ [1]
 $= 1.8 \times 10^{-8} \times 2 \times 150 / 0.15 \times 10^{-6}$ [1]
 $= 36 \Omega$ [1]
- (iii) Battery voltage $= 12V \text{ (for lamp) } + IR \text{ (for cable)}$
 $= 12 + 3 \times 36$ [1]
 $= 120 V$ [1]
 (Allow 1 mark for an answer of $3 \times 36 = 108V$)
- (iv) Attenuation $= 10 \log P_1 / P_2$ [1]
 $= 10 \log (12 \times 3) / (120 \times 3)$ [1]
 $= -10 \text{ dB}$ [1]

- (b) Coding all 26 letters of alphabet with an n bit (ie light pulse) code, requires that

$$2^n = 26 \quad [1]$$

where $n = 4.7$

$$= 5 \text{ pulses per letter} \quad [1]$$

Thus there will be an average time of about $5 \times (0.5 + 1) / 2$

$$= 3.75 \text{ seconds per letter} \quad [1]$$

So time to transmit an 72 letter message $= 72 \times 3.75$

$$= 270 \text{ seconds} \quad [1]$$

$$= 4.5 \text{ minutes !}$$

<u>Space waves</u>	VHF	UHF	SHF	EHF (allow, any waveband where $f > 30 \text{ MHz}$)	[1]
	Propagates by line of sight				[1]
	Maximum terrestrial range		allow 20km to 100km		[1]
	VHF FM radio				
	TV				
	Radar				
	Aircraft communication/navigation				
	Microwave links				
	Satellite communications				
	Mobile phone network		any one		[1]
<u>Surface waves</u>	VLF	LF	MF (allow, any waveband where $f < 3 \text{ MHz}$)		[1]
	Propagates by long wavelengths bending round curvature of Earth				[1]
	Maximum terrestrial range		1000 km (in MF) (but can be world wide in LF)		[1]
	AM radio broadcasting				
	Long range navigation				
	Submarine communication		any one		[1]
<u>Sky waves</u>	HF	(allow, waveband where $30\text{MHz} > f > 3 \text{ MHz}$)			[1]
	Propagates by reflections between Earth's surface and ionosphere				[1]
	Maximum terrestrial range		world wide		[1]
	International radio broadcasts				
	Amateur radio				
	Ship to shore communications		any one		[1]

2825 Common Question

Question	Expected Answers	Marks
(a)(i)	$\text{area} = 1000 / (0.10 \times 800)$ $= 12.5 \text{ m}^2$ omits efficiency to get 1.25 m^2 gets 1/2 0.1×800 but not completed gets 1/2	1 1 [2]
(ii)	$\text{number of cells} = 12.5 / (5.0 \times 10^{-4}) \quad (= 25\,000)$ allow ecf from (i)	1 [1]
(iii)	$\text{for } 125 \text{ V, number of cells in series} = (125 / 0.50) = 250$ $\text{so number of branches of parallel circuit} = (25\,000 / 250) = 100$ or by correct sketch	1 1 [2]
(iv)	$\text{total current } I = P / V = 1000 / 125 = (8.0 \text{ A})$ $\text{so current in each series circuit} = 8.0 / 100 = 0.080 \text{ A}$	1 1 [2]
(b)(i)	$\text{rate of gain of energy by water} = (70 / 100) \times 800 (= 560 \text{ W})$ for each 1.0 m^2 $\text{so area needed to gain } 1000 \text{ W} = 1000 / 560 = 1.8 \text{ m}^2$ ignore > 3 sf omits efficiency to get 1.25 m^2 gets 1/2	1 1 [2]
(ii)	$Q = mc\theta$ or $(Q/t) = (m/t)c\theta$ equation $1000 = (m/t) \times 4200 \times (75 - 20)$ subs. $(m/t) = 4.3 \times 10^{-3} \text{ kg s}^{-1} (= 0.258 \text{ kg min}^{-1})$ ans. use of 273 for $\Delta\theta$ gets max. of 1/3	1 1 1 [3]
(c)(i)	$(40 / 100) \times E_k = 1000$ $E_k = 1000 \times (100 / 40) (= 2500 \text{ J})$	1 [1]
(ii)	$E_k = \frac{1}{2} m v^2$ $2500 = \frac{1}{2} m \times 5^2$ so $m = 200 \text{ kg}$	1 1 [2]
(iii)	$m = \pi R^2 v \rho$ or $200 = \pi R^2 \times 5 \times 1.3$ so $R = 3.1 \text{ m}$	1 1 [2]

Question	Expected Answers	Marks
(d)	<p>3 points from ONE section:</p> <p>Photocells</p> <p>photocell produces electrical energy (which is a more versatile form of energy than heat); (1)</p> <p>area of photocells makes it inconvenient; (1)</p> <p>photocells require south-facing roof (may not be one); (1)</p> <p><i>either</i> output varies with cloud cover / time of day / angle of sun's rays / shading by buildings etc. or AW <i>or</i> photocells produce no output at night; (1)</p> <p>no noise (1)</p> <p>Solar panel</p> <p>solar panels require south-facing roof (may not be one); (1)</p> <p><i>either</i> solar panel collects only heat (so limited application) <i>or</i> solar panel produces hot water which household needs or AW (1)</p> <p><i>either</i> output varies with cloud cover / time of day / angle of sun's rays / shading by buildings etc. <i>or</i> solar panel produces no output at night; (1)</p> <p>no noise; (1)</p> <p><i>either</i> high efficiency <i>or</i> small area compared with PE cells; (1)</p> <p>Aerogenerator</p> <p>aerogenerator produces electrical energy (which is a more versatile form of energy than heat); (1)</p> <p>(radius of) aerogenerator is too big to be practical; (1)</p> <p><i>either</i> power from aerogenerator (very) variable with wind speed <i>or</i> aerogenerator produces no power when wind is not blowing; (1)</p> <p>danger of damage / destruction in high wind; (1)</p> <p>unsightly appearance; (1)</p> <p>possible noise pollution / nuisance; (1)</p> <p>any (3) from one section</p>	<p>3</p> <p>[3]</p> <p>20</p>

2826/01 Unifying Concepts in Physics

Candidates are expected to answer **all** the questions

- 1 (a) e.g. room volume = $3\text{ m} \times 10\text{ m} \times 15\text{ m} = 450\text{ m}^3$ (1)
 density of air of the order of 1 kg m^{-3} (1)
 equation and correct arithmetic (1) [3]
- (b) e.g. 80% of the speed of sound (1)
 $= 0.8 \times 330 = 264\text{ m s}^{-1}$ (1)
 OR $5000\text{ km in } 5\text{ h} = 1000\text{ kph}$ (1)
 $\approx 300\text{ m s}^{-1}$ (1) [2]
- (c) top speed $\approx 40\text{ m s}^{-1}$ (1)
 power = force \times velocity so drag force = $80\,000\text{ kW} / 40\text{ m s}^{-1} = 2000\text{ N}$ (1) [2]
- (d) $\phi = BA$ (1)
 magnet's field ≈ 100 times stronger = $5 \times 10^{-3}\text{ T}$
 area $3 - 30\text{ cm}^2$ therefore flux = $5 \times 10^{-3}\text{ T} \times 10^{-3}\text{ m}^2 = 5 \times 10^{-6}\text{ Wb}$ (1) [2]

In order of importance method, conversion of units, actual values used, unless they are nonsensical

[Total: 9]

- 2 (a) (i) The (stored) ability to do work (1) [1]
 OR in terms of force \times distance moved in direction of force
- (ii) Considers a force F to stop body with deceleration given by $0^2 = u^2 + 2as$ (1)
 $F = ma = mu^2/2s$ (1)
 work done = k.e. = $Fd = mu^2 d/2d = \frac{1}{2} mu^2$ (1) [3]
- (b) $\frac{1}{2} mv^2 = 480$; $mv = 120$ (1)
 divide to get $\frac{1}{2} v = 4$, (OR manipulate) $v = 8\text{ (m s}^{-1}\text{)}$ (1)
 $m = 120/8 = 15\text{ kg}$ (1) [3]
- (c) k.e. at 40 = $k \times \frac{1}{2} m (40)^2$ (1)
 k.e. at 30 = $k \times \frac{1}{2} m (30)^2$ (1)
 ratio = $16/9$ (1)
 this is an increase of $7/9$, i.e. 78% (1) [3]
- (d) kinetic energy changes to thermal energy (1)
 Newton 3 ensures that momentum must be conserved OR
 Ft must be the same/opposite for the two bodies (1)
 Fd is not necessarily the same for the two bodies TWO of (1) [2]

[Total: 12]

3. (a)(i) distance/time = $1200\text{ m} / 500\text{ s} = 2.4\text{ (m s}^{-1}\text{)}$ (1) [1]
- (ii) total mass = $18\,800\text{ kg}$ (1)
 k.e. = $\frac{1}{2} \times 18\,800 \times (2.4)^2 = 54\,100\text{ J}$ (1) [2]
- (b) F (more or less) in line of cable (1)
 S at an angle to vertical (1)
 triangle showing zero resultant force (1) [3]

- (c)(i) time to rise 400 m = 500 m / 2.4 m s⁻¹ = 208.3 s (1)
 load rising = 18 800 kg x 9.81 N kg⁻¹ = 184 400 N (1)
 gain in p.e. during this time = 184 400 x 400 = 7.38 x 10⁷ J (1)
 rate of gain of p.e. = 7.38 x 10⁷ / 208.3 = 354 000 W (1) [4]
- (ii) net gain in p.e. = 16 000 kg x 9.81 N kg⁻¹ x 400 m (1)
 = 6.28 x 10⁷ J (1)
 power = 6.28 x 10⁷ J / 208.3 s = 3.01 x 10⁵ W (1) [3]
- (d)(i) power = V x I (1)
 = 2000 V x 170 A = 340 000 W (1) [2]
- (ii) e.g. friction, wind resistance, losses in motor (1)
 the cables will not be straight so some parts of the journey will be extra steep (1)
 therefore a greater rate of increase of p.e. (1) [3]
 i.e. 1 mark for each bald statement, third mark for logical deduction
- (iii) when motor is slowed down by the extra load (1)
 it will draw more current from the supply / less back e.m.f. (1) [2]

[Total: 20]

- 4 (a) e.m.f. is energy per unit charge changed into electrical energy (1)
 p.d. is also energy per unit charge but the change is from electrical energy
 into some other form of energy (1) [2]
- (b) 5 Ω resistor must have 12 V across it
 so current in 5 Ω resistor is 2.4 A (1)
 drop in voltage across 2.0 Ω resistor must be 3 V (1)
 so current in it is 1.5 A (1)
 (Kirchhoff's 1st law) gives current of 0.9 A from 12 V battery (1)
 power from 12 V battery = 12 x 0.9 = 10.8 W (1) [5]

[Total: 7]

- 5 (a) v_1 proportional to $\sqrt{273}$, $331 = k \sqrt{273}$ (1)
 $v_2 = 331 \times \sqrt{(281/273)} = 335.8 = 336$ to 3 sig. figs. (1) [2]
- (b)(i) $T = 1/480 = 2.08 \times 10^{-3}$ s (1) [1]
- (ii) wavelength = 336/480 = 0.70 m (1) [1]
- (c)(i) 30 / 480 = 0.0625 m (1) [1]
- (ii) idea of adding or subtracting to 0.70 m (1)
 values: maximum 0.7625; minimum 0.6375 (1) [2]
- (iii) speed unaltered, wavelength changed OR different frequency (1)
 at P $336 / 0.7625 = 440$ Hz (1)
 at Q $336 / 0.6375 = 530$ Hz (1) [3]
- (d) frequency of light would decrease (1)
 light becomes redder / red shift (1) [2]

[Total: 12]

2826/03 Experimental Skills 2 Practical Examination

(a)	Circuit correctly set up without help Minor help –1. Major help, i.e. complete circuit set up for candidate, -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.	2/1/0
(b) (iv)	Sensible value for $t_{1/2}$ (17.7 s in trials for 47 k Ω)	1
(c)	Percentage uncertainty in $t_{1/2}$ One mark for sensible Δt (0.2s to 0.5s) One mark for correct ratio idea and 'x 100'. No need to check calculation.	2/1/0
(d)	Readings Write the number of readings as a ringed total by the results table. 6 or 7 sets of readings scores 3 marks. 5 sets, 2 marks. 4 sets, 1 mark. (R in k Ω : 15.7, 23.5, 31.3, 47.0, 70.5, 94.0, 141.0)	3/2/1/0
(d)	Repeated readings of $t_{1/2}$, one mark. Do not award this mark if all the repeats are the same.	1
(d)	Column headings There must be some distinguishing mark between the quantity and its unit. E.g. R/k Ω , R(k Ω), R in k Ω (or kOhms), are OK, but not (R)k Ω , R k Ω , or just "k Ω "	1
(d)	Consistency of raw readings All values of R should either be to the nearest k Ω or 0.1 k Ω . One mark All values of $t_{1/2}$ should either be to the nearest 0.1s or 0.01s. One mark.	2/1/0
(d)	Values of R (for the series/parallel combinations) One mark for the 70.5 k Ω (or 70 k Ω) value One mark for the 31.3 k Ω (or 31 k Ω) value	2/1/0
(e) (i)	Axes. Each axis must be labelled with a quantity. Ignore unit. One mark for each axis. 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.).	2/1/0
(e) (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. The number of plots must correspond with the number of observations. 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 plots should have been. Allow errors up to half a small square. Do not allow 'blobs' of diameter greater than $\frac{1}{2}$ small square.	1

(e) (i)	Quality of results Judge by scatter of points about your line of best fit. At least 5 or 6 good trend points, within $2k\Omega$ of best fit line, needed. Large scatter/no trend scores zero.	1
(e) (ii)	Line of best fit There must be a reasonable balance of points about the line of best fit. If one of the points is a long way from the trend of the other plots then allow this plot to be ignored when the line is drawn. The mark can be awarded if the line of best fit is 'reasonable' but not quite right. This mark can only be awarded if a straight line has been drawn through a linear trend. Do not allow thick or "hairy" lines.	1
(e) (ii)	Measurement of gradient. Read-offs must be accurate to half a small square and the ratio must be correct, one mark. Please indicate the vertices of the triangle used by labelling with Δ . The hypotenuse of the triangle must be greater than half the length of the drawn line, one mark. Do not allow a line of thickness greater than $\frac{1}{2}$ a small square.	2/1/0
(e) (ii)	y-intercept Check the read-off. Allow errors up to and including half a small square for one mark. If a read-off is not possible, correct substitution from a point on the line into $y = mx + c$ scores one mark. If the point is not on the line, or the answer is not the same as the graph read-off (no false origin), then this method scores no marks. A read-off taken from a graph with an x-axis false origin scores zero. A bald intercept with no working/possible read-off from graph scores zero.	1
(f)	Awareness that $I / I_0 = \frac{1}{2}$. One mark. <u>Correct</u> working to give $t_{\frac{1}{2}} = CR \ln 2$. One mark	2/1/0
(g)	Gradient = $C \ln 2$. One mark Calculation of C, <u>from gradient</u> , to be checked. Penalise POT errors. One mark. Correct units for C, which must be consistent with numerical answer (allow ecf). Allow $s\Omega^{-1}$. One mark. (nominal $C = 470 \mu F$) Significant figures for C. Allow 2 or 3	4/3/2/1

28 marks in total

Mark Scheme for Question 2

(a) (iii)	Raw time > 10 s recorded to at least 1 d.p. and T correct (= t/n).	1
(a) (iv)	Justification for number of s.f. in T . i.e. same s.f. as t (allow “raw data” ideas) or sensible reference to human reaction time. Do not allow d.p. ideas. Answer must be consistent with (a) (iii).	1
(b)	New value of T , < first value of T , one mark. Repeated readings of raw times for first or second value of T , and <u>averaging</u> , one mark.	2/1/0
(c)	To show that $T \propto 1/d$. One mark for ratio idea, or calculation of k 's One mark for conclusion that $T \propto 1/d$ which follows from the reasoning (only if k values are within 10% of each other. The second mark cannot be earned if the first is not given, but allow ecf.	2/1/0
(d)	Evaluation of procedure. Relevant points must be underlined and ticked. One mark for each line.. Some of these might be: P = problem S = solution 1 P 2 sets of readings are not enough 2 S Take more sets of readings of T and d , and plot a <u>graph</u> 3 S The graph plotted should be T against $1/d$, and it should be a straight line 4 P Raw time too small 5 S Time more oscillations 6 S Use <u>correctly positioned</u> motion sensor / <u>correctly positioned</u> light gates 7 P Oscillations may not be completely torsional; allow “swaying” or “wobbling”, or hitting clamp stand. 8 S Use small amplitude. 9 S Avoid draughts by closing windows and doors 10 P Human error in timing/ hard to see beginning and end of oscillation 11 S Use a (fiducial) marker, at centre of oscillation 12 S Video the ruler, with clock in view, and replay in <u>slow</u> motion. 13 P Metre rule may not be horizontal 14 S Check with a spirit level / measure from bench Do not give marks for repeating readings of T for the same d (already credited in part (b)). Do not allow vague “light gates”, “use a computer”, or “video the mass”, unless further clarification is given. Allow other relevant points (8 maximum).	8
	2 marks are reserved for quality of written communication	2

16 marks maximum to be awarded.

Planning Exercise Mark Scheme

A1	Diagram of apparatus, including Hall probe, and: diagram of solenoid or , diagram of Helmholtz coils, separated by radius r (this may be in A2) or , other sensible method, (allow magnets of fixed B) Supply circuit marked in D.	1
A2	Correct formula for magnetic field B , in solenoid $B = \mu n I$ or Helmholtz coils $B = 0.72 \mu n I / r$. Meanings of letters needed	1
A3	Alignment of Hall probe Insertion into field, correctly orientated at 90° to field. This must be shown explicitly in the diagram, or mentioned in the text.	1
B1	Method for altering the temperature of the probe. There are several possible methods, e.g. <ul style="list-style-type: none"> external electrical heating with probe (enclosed in a protective insulating cover), or in an oven immersion of probe in a small beaker of water, heated externally, or with an immersion heater. good extra practical detail, with a labelled diagram, could earn an extra mark (see D)	1
B2	Method for measuring the temperature of the probe Thermocouple or sensor attached to probe, or mercury thermometer in water bath	1
C1	Procedure 1 Calibration, using known magnetic field (not Earth's), then: 2 at each temperature Hall voltage to be measured for a fixed B , or a calibration graph drawn 3 Repeat at say 10°C intervals	1 1 1
C2	To obtain temperatures outside the range Below 0°C . Freezing mixture, solid CO_2	1
D	Any further relevant detail, e.g. (one mark per line, up to 3 marks maximum) 1 details of use of thermocouple 2 extra detail on heating of probe (see B1) 3 Insulation of probe from water 4 evidence of preliminary work 5 zero adjustment of probe away from magnetic fields/ awareness of Earth's field 6 supply circuits (see A1) including ammeter and power supply 7 Details of Hall effect	3
R	Evidence of research of material. More than one different source (books or internet), with chapter and page numbers, for 2 marks. Two vague sources, one mark. One vague source, no marks.	2
Q	2 marks are reserved for quality of written communication (organisation). Rambling and poorly presented material cannot score both marks.	2

Total 16 marks

Grade Thresholds

Advanced GCE Physics A (3883/7883)
January 2010 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2824	Raw	90	62	56	50	44	39	0
	UMS	90	72	63	54	45	36	0
2825A	Raw	90	64	58	52	47	42	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	71	63	55	48	41	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	65	58	51	44	38	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	60	54	49	44	39	0
	UMS	90	72	63	54	45	36	0
2825E	Raw	90	64	57	50	44	38	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	87	78	69	60	51	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	87	78	69	60	51	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	85	78	71	64	58	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

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

	Maximum Mark	A	B	C	D	E	U
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:

	A	B	C	D	E	U	Total Number of Candidates
3883	9.1	27.3	63.6	77.3	100.0	100.0	25
7883	13.4	38.4	68.1	86.1	96.3	100.0	226

For a description of how UMS marks are calculated see:

http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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