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RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS B (ADVANCING PHYSICS) G495 MS

Unit G495: Field and Particle Pictures and Advances in Physics

Specimen Mark Scheme

The maximum mark for this paper is **100**.

SPECIMEN

This document consists of **10** printed pages and **2** blank pages.

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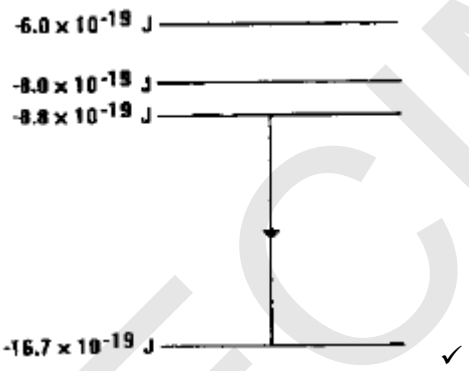
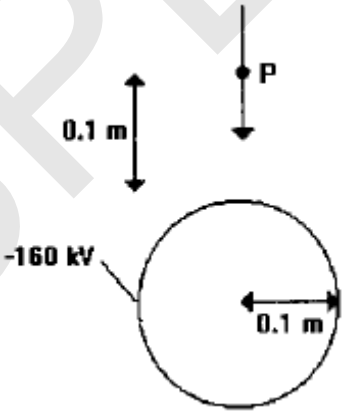
Section A		
Question Number	**Answer**	**Max Mark**
1(a)	In any order: uud ✓ Accept +2/3e, +2/3e,-1/3e	**[1]**
(b)	In any order: udd ✓ Accept +2/3e, -1/3e,-1/3e	**[1]**
2	mass change = 3.0001 60 – 2.001 41 – 1.008 67 = -0.008 48 ✓ m = 0.008 48 × 1.7 × 10^{-27} = 1.44 × 10^{-29} kg ✓ E (=mc^2) = 1.44 × 10^{-29} × (3 × 10^8)^2 = 1.3 × 10^{-12} J ✓ ecf from previous stage throughout Accept reverse calculation	**[3]**
3(a)	$E = hf$ = 6.6 × 10^{-34} × 1.2 × 10^{15} = 7.9 × 10^{-19} J ✓	**[1]**
(b)	Ignore direction of arrow  ✓	**[1]**
(c)	A ✓	
4(a)	 Vertical <u>and</u> downwards ✓	**[1]**
(b)	-80 kV ✓	**[1]**
(c)	At right angles to field arrow ✓ Complete circle through P centred on sphere ✓ Ignore arrows on equipotential	**[2]**

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Section A		
Question Number	**Answer**	**Max Mark**
5(a)	5 cm = 5×10^{-2} m, 25 mT = 25×10^{-3} T ✓ $F = ILB = 2.0 \times 5 \times 10^{-2} \times 25 \times 10^{-3} = 2.5 \times 10^{-3}$ N ✓ Ecf incorrect conversion	**[2]**
(b)	C ✓	**[1]**
6(a)	B ✓	**[1]**
(b)	A ✓	**[1]**
(c)	C ✓	**[1]**
7	C ✓	**[1]**
	Section A Total	**[19]**

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Section B		
Question Number	**Answer**	**Max Mark**
8(a)	Flux lines stay within iron ✓ Two complete and separate loops which do not overlap.✓ Ignore breaks where loops cross coils	**[2]**
(b)	Correct shape (sinusoidal) and period (by eye), any constant amplitude ✓ Correct phase (90° ahead or behind)	**[2]**
(c)	$V_p = N_p \frac{d\Phi}{dt}, V_s = N_s \frac{d\Phi}{dt}$ owtte✓ $\frac{d\Phi}{dt} = \frac{V_p}{N_p} = \frac{V_s}{N_s}$ owtte✓	**[2]**
(d)	any of the following, maximum [3 ✓✓✓] • Change of flux/field in the core • Sets up emf across core • Causing current to flow • Creating flux/field in core • Which opposes original change of flux/statement of Lenz's Law 'Reduces the flux' is neutral. QWC: clear organised answer	**[3]**
	Total	**[9]**
9(a)	Alpha (particle) / helium (nucleus) / α ✓	**[1]**
(b)	mass of nucleus = 178 ×1.7×10^{-27} kg = 3.0×10^{-25} kg ✓ $\text{nuclei} = \frac{\text{mass of sample}}{\text{mass of nucleus}}$ eor ✓ e.g. nuclei = 5 × 10^{-12}/3.0 × 10^{-25} = 1.7 × 10^{13} $A = \lambda N$ ✓ EITHER A = 7.1 × 10^{-10} × 2 × 10^{16} = 1.4 × 10^{7} OR A = 7.1 × 10^{-10} × 1.7 × 10^{16} = 1.2 × 10^{7} ✓ Bq✓ Accept 2.98×10^{-25}, or 2.97×10^{-25}, or 2.96×10^{-25} Award mark for eor, not final answer Ecf 9 b ii Accept s^{-1} but not Hz for Bq	**[5]**
(c)(i)	$f = c/\lambda$ = 3 × 10^{8} / 6.2 × 10^{-11} = 4.8 × 10^{18} Hz ✓ $E = hf$ =6.6 × 10^{-34} × 4.8 × 10^{18} = 3.2 × 10^{-15} J ✓ E= 3.2 × 10^{-15} / 1.6 ×10^{-19} (= 2 × 10^{4} eV) ✓ ecf incorrect f ecf incorrect E	**[3]**

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Section B		
Question Number	**Answer**	**Max Mark**
9(c)(ii)	larger decay constant ⇒ greater probability of decay ✓ (Can discuss in term of $A = \lambda N$) Nuclei in level K will decay at a greater rate than those in level M. ✓ (Can refer to shorter half-life) Overall activity of sample will increase✓ Needs comparison with nuclei in level M stated or implied	**[3]**
	Total	**[12]**
10(a)	Calculation of energy from mass: $E = mc^2$ ✓ Conversion of J to eV ✓ Comparison of mass or energy ✓ EITHER $1.7 \times 10^{-27} \times (3.0 \times 10^8)^2 = 1.53 \times 10^{-10}$ J $1.53 \times 10^{-10} / 1.6 \times 10^{-19} = 9.56 \times 10^8$ eV $270 \times 10^9 / = 282 \approx 300$ OR $300 \times 1.7 \times 10^{-27} = 5.10 \times 10^{-10}$ J $5.10 \times 10^{-10} \times (3.0 \times 10^8)^2 = 4.59 \times 10^{-8}$ J $4.59 \times 10^{-8} / 1.6 \times 10^{-19} = 2.87 \times 10^{11}$ eV (287 GeV) Accept correct alternative calculation	**[3]**
(b)(i)	$F = mv^2/r$ ✓ $F = qvB$ so $qvB = mv^2/r$ ✓ $R = mv/Bq$ $qvB = mv^2/r$ is ✓✓	**[3]**
(ii)	$B = E/cqr = 4.3\times10^8 / 3 \times10^8 \times 1.8\times10^3 \times 1.6\times10^{-19}$ = 0.5 T ✓m✓e	**[2]**
(c)(i)	Opposite charges (allow magnetic force to be in opposite directions) ✓ NOT different charge	**[1]**
(ii)	${}^{0}_{0}Z \rightarrow {}^{0}_{-1}e + {}^{0}_{+1}e$ ✓✓ Award [✓] if one error. Accept β for e	**[2]**
(iii)	EITHER find the energies of electron and positron and finding that they add to 93 GeV ✓ OR energy of proton and antiproton / colliding particles must add to (at least) 93 GeV ✓ Any plausible technique	**[1]**
	Total	**[12]**
11(a)(i)	$2.4 \times 10^{16} / 4\pi \times 100 = \underline{1.9} \times 10^{13}$ ✓	**[1]**

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Section B		
Question Number	**Answer**	**Max Mark**
11(a)(ii)	any of the following, maximum [2✓] • Photons fired out from source in all directions • Getting more spread out as they travel out • So photons passing through unit area decreases with increasing distance from source • All photons per second pass through surface of sphere radius *d* • Fraction per unit area through this surface is $1/4\pi d^2$ NOT photons are absorbed / lose energy / decay NOT inverse square law	**[2]**
(iii)	beta absorbed by air / have limited range owtte ✓	**[1]**
(b)(i)	Number of half-thicknesses = 1.2 / 4.0 × 10^{-2} = 30✓ $I = I_0(0.5)^n$ eor I = 1.9 × 10^{13} × $(0.5)^{30}$ = 1.8 × 10^4 Bq m^{-2} ✓ Accept calculation using $I = I_0 e^{-\mu x}$ 2×10^{13}⇒1.9×10^4 Bq m^{-2}	**[2]**
(ii)	energy= intensity × area × time× photon energy eor✓ 1.8 × 10^4 × 0.8 × 3600 × 8 × 1.8 × 10^{-13} = 7.5 × 10^{-5} J ≈ 1 × 10^{-4} J ✓ $\text{dose} = \frac{\text{energy} \times \text{quality factor}}{\text{mass}}$ eor✓ dose = 7.5 × 10^{-5} / 75 = 1.0 × 10^{-6} Sv ✓ 2 ×10^4 Bq m^{-2} gives 8.3×10^{-5} J 1.9 ×10^4 Bq m^{-2} gives 7.9×10^{-5} J ecf incorrect energy 1×10^{-4}J ⇒1.3×10^{-6} Sv accept reverse calculation	**[4]**
	Total	**[10]**
	Section B Total	**[43]**

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Section C		
Question Number	**Answer**	**Max Mark**
12 (a)	½mv^2 = 8.6× 10^{-13} J $\Rightarrow v = \sqrt{\frac{2\times 8.6\times 10^{-13}}{6.6\times 10^{-27}}}$ ✓m = 1.6 × 10^7 m s^{-1} ✓e Evidence of calculation required for second mark ora from v=2× 10^7 m s^{-1}	**[2]**
(b)(i)	206✓	**[1]**
(ii)	0=206v + 4× 2 × 10^7 m s^{-1}✓ $\Rightarrow$ v = (-) 3.9× 10^5 m s^{-1}✓ (Evidence of calculation required for second mark.) First mark is application of conservation of momentum Using 1.6×10^7 m s^{-1} $\Rightarrow$ v =3.1× 10^5 m s^{-1} Can use masses in kg Can refer to same p to justify m/v relationship Arithmetic method OK	**[2]**
(iii)	v smaller, m bigger ✓ (this factor occurs) twice in v^2 and once in m so ½mv^2 smaller ✓	**[2]**
	Total	**[7]**
13(a)	Reference to proton-electron (beta) charge balance✓	**[1]**
(b)	Not ionising (and detectors observe ionisation)✓	**[1]**
(c)(i)	Up to three of the following points: [3✓] Or other : • Principle of Conservation of Energy was established by respected physicists • Using Conservation of Energy had previously always given good predictions/ explanations of phenomena owtte (Can give specific example) • Calculations using Conservation of Energy had always been successful (Can give specific example) • Removing a fundamental foundation of theoretical physics is extremely unsettling • It is difficult to abandon something that you have grown up with and become used to	
(ii)	Up to three of the following points: [3✓] Or other : • Difficult to imagine any particle smaller than the (tiny) electron • Neutron/proton/electron model of the atom had been successful without it • You shouldn't just invent imaginary particles to fudge a solution to a problem • It takes a long time to adjust to new ideas **Mark both parts together with a maximum of five marks** QWC: SPG	**[6]**
	Total	**[8]**

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Section C		
Question Number	**Answer**	**Max Mark**
14(a)	annihilation produces 2 photons in opposite directions ✓ Could refer to coincidence counting	**[1]**
(b)(i)	'Noise' count is recorded over a time which is about 10 × smaller than signal graph. ✓	**[1]**
(ii)	Values on signal graph significantly greater than / >> 10 × largest value on 'noise' ✓ 'Noise' graph does not show any (significant) peak ✓ Time delay (2 μs) corresponds to prediction ✓	**[3]**
(c)(i)	(Both) reactors were built to produce nuclear weapons✓ Further development, e.g. too expensive to construct separate experiment, could use equipment already there, could discuss with fellow scientists working there.	**[2]**
(ii)	Any two distinct points, or any one point developed • The pure scientists may be opposed to military research✓for personal pacifist reasons✓ • The public may be opposed to military research✓ as above✓ or may be opposed to pure science✓ as waste of public money✓ • Military research needs to be secret ✓so pure science could compromise national security✓ • Pure science experiments / reporting could be limited✓ by security restrictions in military establishments✓ Other distinct valid suggestions or explanations should be credited similarly in (ii)	**[2]**
	Total	**[9]**
15(a)	$T_{½}$ = ln 2/2.3×10^{-7} s^{-1} =3.0×10^{6} s (= 34.9 days) ≈ 2.6 ×10^{6} s ✓	**[1]**
(b)	Very little Ar-37 present Extremely low count rate✓ Hard to distinguish from background ✓ Possible noise present (from radioactive minerals) ✓ vast volume of C_2Cl_4 dilutes/spreads out owtte Ar-37✓ QWC: appropriate form and style Any three valid distinct points.	**[1]** **[3]**
	Total	**[5]**

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Section C		
Question Number	**Answer**	**Max Mark**
16(a)	Distance = $3.0 \times 10^8 \times 3.2 \times 10^7 \times 40\,000$ m = 3.8×10^{20} m ✓m✓e Evidence of calculation required for second ✓	**[2]**
(b)	Neutrinos and photons travel at similar speed in vacuo ✓ Neutrinos not slowed by travel through Sun ✓ Photons slowed by about 40 00 years (from part a) ✓ Any **two** points	**[2]**
(c)	Any of the following points: *Paradigm related:* Scientists reluctant to abandon theoretical model ✓ Theoretical model previously successful ✓ No alternative solar model available ✓ *Data related* Experiments have very low count rates ✓ (Low count) implies low signal:noise ratio (Q15) ✓ (Low signal:noise ratio) suggests large uncertainty ✓ *Consequence related:* If current core activity is low, future output will be low ✓ One-third output is huge reduction✓ Life on Earth will cease to exist with such low solar power✓ Any five points Other distinct valid suggestions or explanations should be credited similarly	**[5]**
	Total	**[9]**
	Section C Total	**[38]**
	Paper Total	**[100]**

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