

GCE

Physics B (Advancing Physics)

Unit **G495**: Field and Particle Pictures

Advanced GCE

Mark Scheme for June 2014

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations available in Scoris

Annotation	Meaning
	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

All questions should be annotated with ticks to show where marks have been awarded in the body of the text.

Question	Answer	Marks	Guidance
1 (a)	J m^{-1} (1)	1	
(b)	J kg^{-1} (1)	1	
(c)	J C^{-1} (1)	1	
2	B (1)	1	
3 (a)	Opposite curvature/deflection (1)	1	Accept implication of opposite e.g. “one curves left, the other curves right”. Reject “different curvature”; reject reference to movement or travel.
(b)	Same radius/ same curvature (1)	1	Allow symmetrical paths. Credit indication of equal deviation.
(c)	$F = 0.45 \times 1.7 \times 10^7 \times 1.6 \times 10^{-19}$ (1) $= 1.2 \times 10^{-12} \text{ N}$ (1)	2	Allow correct bald answer for 2 marks
4 (a)	1 (1)	1	Allow 1:1
(b)	$12 \times 10\,000 / 230$ (1) $= 520$ (1)	2	Allow use of $10\,000/19.2$ Accept 522, 521. Allow correct bald answer. SF penalty for more than 3 SF. NB: this is the only SF penalty on the paper.

Question	Answer	Marks	Guidance
5	All of ring to the left of the minimum (1)	1	
6	Any 3 from: • Changing magnetic field/flux in <u>copper / tube</u> (1) • Currents produced in copper / tube (1) • Currents set up their own magnetic fields/flux (1) • Two fields interact (1) • (Providing) an upwards force on magnet / force acting against weight of the magnet (1) • Change in net force leads to deceleration / reduced acceleration / reduced relative motion between magnet and tube (1)	3	No mark for stating that emf induced in copper (in the stem) No credit for bald statement of Lenz's Law Allow field / flux lines cut by the copper tube Must be clear that current is in the copper Accept arguments in terms of magnetic force on current Don't credit 'two fields repel' because they don't repel when the magnet is leaving the tube.

Question	Answer	Marks	Guidance
7	Either: $\lambda = \frac{h}{\sqrt{2 m E}}$ (1) $= 6.6 \times 10^{-34} / (2 \times 1.7 \times 10^{-27} \times 2.8 \times 10^{-15})^{0.5}$ (1) $= 2.1(4) \times 10^{-13} \text{ m}$ (1) Or: calculate momentum to $3.09 \times 10^{-21} \text{ kg m s}^{-1}$ (1) $\lambda = 6.6 \times 10^{-34} / 3.09 \times 10^{-21}$ (1) $= 2.1(4) \times 10^{-13} \text{ m}$ (1)	3	Accept correct bald answer. Accept answers in the range $2.1 - 2.2 \times 10^{-13}$
8	4 (1)	1	
Section A Total		19	

Question	Answer	Marks	Guidance
9 (a)	1st 3 marks Number of scattered particles decreases with angle (1) Most particles show little scatter/decrease with angle is great(1)AW Gold scatters more than silver(1) Fourth mark: clear reference to quantitative data from graph with data pairs (1)	4	Accept log scale implies large range of values (1) Synonyms for 'great' include dramatic, drastic, significant etc. Not 'sudden' or 'exponential'. requires statement of at least two pairs of x and y values. Fourth mark only achievable if other 3 marks awarded [QWC]
(b)	$6 \times 1.6 \times 10^{-13} = 9 \times 10^9 \times 79 \times 2 \times (1.6 \times 10^{-19})^2 / r \quad (1)$ $r = 9 \times 10^9 \times 79 \times 2 \times (1.6 \times 10^{-19})^2 / 6 \times 1.6 \times 10^{-13} \quad (1)$ $= 3.8 \times 10^{-14} \text{ m} \quad (1)$	3	Accept bald figure Two marks if 6×10^6 used for energy giving answer $6.1 \times 10^{-33} \text{ m}$ Two marks if $(6 \times 10^6 / 1.6 \times 10^{-19})$ used for energy giving answer 9.7×10^{-52}. Annotation, two ticks and ecf. Two marks if original energy miscalculated in other ways if leading to consistent ecf. Two marks if POT missing out 10^6 gives $3.8 \times 10^{-8} \text{ m}$.
(c) (i)	Volume of nuclei is proportional to A (1) mass of the nucleus is proportional to A (1)	2	Mass (of nucleus) proportional to volume is given one mark. Algebraic statement of proportionality acceptable
(c) (ii)	$197^{1/3} / 27^{1/3} \quad (1) = 1.9(4) \quad (1)$	2	Accept bald answer. 1.93 is a rounding error and should be penalised one mark. Accept rounding to 2 only if working shown. Accept 1.9:1 or 2:1 but do not accept unevaluated ratios such as 5.8/3 or 5.8:3
Total Question 9		11	

Question	Answer	Marks	Guidance
10 (a)	Any two from: • mass- energy • momentum; • angular momentum • charge • lepton number • hadron / baryon / mass / nucleon / quark <u>number</u>	2	Mark first two answers Not just mass or just energy. Don't accept 'mass and energy' in place of mass-energy.
(b) (i)	$E = (1.6749 \times 10^{-27} - 1.6726 \times 10^{-27} - 9 \times 10^{-31}) \times 9 \times 10^{16} \text{ (1)}$ $= 1.3 \times 10^{-13} \text{ J (1)}$	2	For information: $\Delta m = 1.4 \times 10^{-30} \text{ kg}$ Accept 1.26×10^{-13} Ecf for arithmetic error in Δm , one mark maximum Accept correct bald answers Accept negative answers
(b) (ii)	$m_p < m_n + m_e$, accept $m_p < m_n \text{ (1)}$	1	Accept as BOD, $m_n > m_p$ Accept "because there would be an increase in mass" Accept rest energy instead of mass
(c) (i)	$m = E/c^2 \text{ (1)}$ Substitution of eV for E (1) OR eV/c ² is an equivalent unit to J/m ² s ⁻² (1) J/m ² s ⁻² = N/m s ⁻² = kg (1)	2	Complete derivation required for two marks Allow any other dimensionally consistent routes.
(c) (ii)	$2 \frac{\text{eV}}{c^2} = \frac{2 \times 1.6 \times 10^{-19}}{(3 \times 10^8)^2} = \frac{3.2 \times 10^{-19}}{9 \times 10^{16}} \text{ (1)}$ $= 3.6 \times 10^{-36} \text{ kg (1)}$	2	Bald answer gains two marks. Penalise rounding error (e.g. 3.5×10^{-36} , 3.55×10^{-36}) Penalise recurring decimal in final answer
Total Question 10		9	

Question	Answer	Marks	Guidance
11 (a)	Flux linkage= NBA $A = 0.054 / (200 \times 7.5 \times 10^{-2}) = 3.6 \times 10^{-3}$ (1) Side = $A^{1/2} = 0.06$ m (1)	2	Correct bald answer 2 marks Accept range of flux linkages from 0.053 to 0.057 giving A range of 3.5×10^{-3} to 3.8×10^{-3} giving side range 0.059 to 0.062 No ecf for correctly square rooting incorrect area unless POT error
(b)	Method 1 : Evidence of gradient at maximum slope (1) Data consistent with maximum slope substituted correctly (1) Answer in range 16 – 18 V (1) Method 2 Identification of $f = 50$ Hz (may be implicit) (1) Recognising max emf is when $\sin 2\pi ft = 1$ (can be implicit) leading to $\text{Emf} = 0.054 \times 2 \times \pi \times 50$ (1) = 17.0 V (1) (range 16.6 to 17.9) Comments Most confident in method 2 because the uncertainty in measuring the gradient (1) is greater than the uncertainty in the value of the maximum flux linkage used in method 2. (1)	8	Do not allow bald answers for either method. Ignore sign of the answer in both methods. Look at graph in fig. 11.2, annotate tangent if present Evidence on graph not needed if data clearly shows method. Zero marks for method 1 if evaluating gradients other than the maximum Using $\Delta x / \Delta y$ instead of $\Delta y / \Delta x$ only gains mark for identifying greatest slope. Lose one mark if failing to convert correctly from milliseconds to seconds (giving answers in range 0.016 V to 0.018 V) 3 marks for using 0.05 Hz as frequency leading to answers in range 0.0166 to 0.0179 V IF this is consistent with same mistake in method 1. (i.e. two answers of approx. 0.017 V can gain 5 marks) Penalise a new POT error -1. If values substituted into $\sin 2\pi ft$, t must be 5, 15 or 25 ms otherwise one mark max for correct frequency
Question 11 Total		10	

Question	Answer	Marks	Guidance
12 (a)	Uniformly spaced straight lines, perpendicular to electrodes (1) Arrow right to left(1)	2	Lines must be symmetrical about electron path and extend from plate to plate
(b) (i)	$5.0 \times 10^5 \times 1.6 \times 10^{-19} (1) = 8.0 \times 10^{-14} \text{ J}$	1	
(b) (ii)	Algebraic rearrangement to give $v^2 = 2E/m$ OR $v^2 = (2 \times 8 \times 10^{-14}/9.1 \times 10^{-31}) (1)$ evaluation = $4.2 \times 10^8 (1)$	2	Do not accept bald answer for both marks. For information $v^2 = 1.76 \times 10^{17}$ Own value required. Reverse argument acceptable.
(c)	$v = 8.4/3.2 \times 10^{-8} (1) = 2.6 \times 10^8$	1	
(d) (i)	$m_e c^2 = 8.19 \times 10^{-14} \text{ J} (1)$ $\gamma = (8.0 \times 10^{-14} + 8.19 \times 10^{-14}) / 8.19 \times 10^{-14} = 1.98 (1)$	2	Don't accept calculation of gamma from velocity calculated in (c) 1 mark max for rounding incorrectly to 1.97 Accept '2 x rest energy/ rest energy = 2' and similar arguments for second mark. Rest energy must be calculated for both marks
(d) (ii)	substitution of γ value into $= 1/(1-v^2/c^2)^{0.5}$ or into a correctly rearranged formula (1) $v = 2.6 \times 10^8 (1)$	2	Ecf from d(i) Evidence of calculation required. Bald answers score zero in this part of the question
(d) (iii)	Agrees with measured velocity (so supports Einstein's prediction) (1)	1	Do not accept 'they are the same' as it is not clear which velocities are being referred to. No ecf.
(e)	Any two from: - Protons are more massive - Protons have a lower gamma factor for same k.e. - Protons would behave classically at this energy - Experiment would not be a suitable test of Special Relativity - Protons require higher energy or p.d for relativistic/the same speed	2	O.R.A. throughout Allow "heavier", "weigh more", higher rest energy Don't credit comments just about acceleration
Total Question 12		13	

Question			Answer	Marks	Guidance
13			Any three pairs from • TL effect is repeatable/electrons return to ground state after heating (1), So chips can be re-used (1) • Wide range of doses can be monitored/can cope with a wide range of exposure levels (1) useful for more situations (in which monitoring is needed)(1) • Similar absorption characteristics to soft tissue/similar absorbed dose to the wearer of the TLD chip (1) Measurement of Absorbed Dose easier (1) • TL gives linear response to dose(1) Easier to determine the dose/calibrate the chip (1)	6	Within each pair, the second marking point cannot be credited without the first marking point being awarded. Do no credit properties that do not make direct comparisons with photographic film. Eg do not credit: hardness, brittleness, density, solubility, transparency, crystal structure. Ignore cost implications.

Question			Answer	Marks	Guidance
14	(a)		Dose equivalent includes (effect of) quality factor(1) Different radiations have different effects on tissue(1)	2	Do not credit bald statement $Sv = QF \times Gy$ though this can be used as part of an explanation. Reference to tissue(AW) is needed for mark.
	(b)		Marks awarded for: Division by 62 kg (1) 0.75 and 0.25 of dose applied correctly (1) Quality factor 10 applied correctly for neutron dose (1) Final answer = 6.3×10^{-3} Sv (1)	4	Correct bald answer worth four marks These steps may occur in any order Allow methods using weighted quality factor (3.25) Penalise rounding error (giving 6.2×10^{-3})
15			LiF <u>brittle</u> – so snapping risk/cracks will propagate (1) due to LiF being an ionic lattice structure/ has directional bonds (1) so there is a lack of (mobile) dislocations (1)	3	Brittle alone does not gain mark. Accept fractures as alternative to cracks propagating Award three marks only if there is a clear link from micro properties via dislocations to brittle behaviour (QWC)

Question			Answer	Marks	Guidance
16	(a)		Mass of chip = density x volume (1) No. of moles = mass of chip / relative atomic mass (1) No. of particles = no. of moles x Avogadro (1) No. of defect centres = $10^{-3} \times 5.4 \times 10^{20}$ $= 5.4 \times 10^{17}$ (1)	4	Only credit rearranged equation – not quoting directly from data sheet Reward mass = 2.34×10^{-5} kg Reward number of moles = 9×10^{-4} Reward number of particles = 5.4×10^{20} Must give own value
	(b)		No. promoted = $5 \times 10^{17} / 10^6 = 5 \times 10^{11}$ (1) Energy used = $0.5\% \times 6 \times 10^{-5} = 3 \times 10^{-7}$ J (1) Energy per transition = $3 \times 10^{-7} / 5 \times 10^{11} = 6 \times 10^{-19}$ J (1) $= 6 \times 10^{-19} / 1.6 \times 10^{-19} = 3.75$ eV (1)	4	If 5.4×10^{17} used from (a) number promoted = 5.4×10^{11} If 5.4×10^{17} used from (a) Energy per transition = 5.56×10^{-19} J = 3.5 eV (2sf) Need own answer. If candidate misses out 10^6 factor, 2 marks maximum. If candidate miss out 0.5%, 2 marks maximum.
	(c)		$\lambda = 6.6 \times 10^{-34} \times 3.0 \times 10^8 / 6 \times 10^{-19}$ (1) $= 3.3 \times 10^{-7}$ m (1)	2	Credit using 4 eV (6.4×10^{-19}), 3.5 eV (5.6×10^{-19}) leading to 3.1×10^{-7}, 3.5 or 3.6×10^{-7} m. Calculating frequency as 9.7×10^{14}, 9.1×10^{14}, 8.5×10^{14} Hz gains one mark. Accept correct bald answers

Question			Answer	Marks	Guidance
17	1		5% decayed leaving 95% i.e. 0.95 (1)	4	Correct justification for use of 0.95 e.g $1 - 0.05 = 0.95$
	2		Take (natural) logs of <u>both sides</u> (1)		Allow "ln both sides"
	3		(Re-arrange and) substitute <u>$t = 3 \text{ months}$</u> (1)		
	4		Use half-life = $\ln 2 / \lambda$ (1)		Need to see ln 2 rather than 0.69(3)
18	(a)		Any two from: Zero initial KE/ speed/ velocity/ starts from rest No collisions/in a vacuum Dynode fields independent of one another Non-relativistic behaviour/mass remains constant	2	Mark the first two assumptions NOT "no energy is lost" Accept speed of electron not close to speed of light
	(b)		Electrons start with same/zero KE/speed at each stage (1) Accelerated through same potential difference each stage (1)		Need indication of 'each stage' or 'first and last stage' eg "each dynode", "first and last electrode" etc . Allow velocity as alternative to speed Allow same energy gain through each stage

Question			Answer	Marks	Guidance
19	(a)		$n = 5 \times 10^{-13} / 1.6 \times 10^{-19} \text{ (1)}$ $= 3.1 \times 10^6 \text{ (1)}$	2	Need own value
	(b)		10 stages so $3^{10} \times N$ per second (1) $N = 3.1 \times 10^6 / 3^{10} \text{ (1)}$ $= 52 \text{ (1)}$	3	Ecf 2 marks max for choosing 9 or 11 stages (3^9 gives 159, 3^{11} gives 17) Other number of stages score zero Accept 51, 53 to allow for different values of number of electrons reaching anode. Allow non-integer values (as the final answer is an average) Give two marks max if response suggests that 4 electrons (3 new + incident) emitted for each incident electron.
			Section C Total	38	

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