OCR
Oxford Cambridge and RSA

GCE

Physics B (Advancing Physics)

Unit **G495**: Field and Particle Pictures

Advanced GCE

Mark Scheme for June 2014

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

Annotations available in Scoris

Annotation	Meaning
BP	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.
BOD	Benefit of doubt given
CON	Contradiction
✗	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
✓	Correct response
AE	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 x 1.7 x 10^7 x 1.6 x 10^{-19} (1) = 1.2 x 10^{-12} N (1)	2	Allow correct bald answer for 2 marks
4	(a)	1 (1)	1	Allow 1:1
	(b)	12 x 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: $\lambda = \frac{h}{\sqrt{2mE}}$ (1) $= 6.6 \times 10^{-34}/(2 \times 1.7 \times 10^{-27} \times 2.8 \times 10^{-15})^{0.5}$ (1) $= 2.1(4) \times 10^{-13}$ m (1) Or: calculate momentum to 3.09×10^{-21} kg m s^{-1} (1) $\lambda = 6.6 \times 10^{-34}/3.09 \times 10^{-21}$ (1) $= 2.1(4) \times 10^{-13}$ m (1)	3	Accept correct bald answer. Accept answers in the range 2.1 – 2.2 x 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)		$6 \times 1.6 \times 10^{-13} = 9 \times 10^9 \times 79 \times 2 \times (1.6 \times 10^{-19})^2/r$ (1) $r = 9 \times 10^9 \times 79 \times 2 \times (1.6 \times 10^{-19})^2/6 \times 1.6 \times 10^{-13}$ (1) $= 3.8 \times 10^{-14}$ m (1)	3	Accept bald figure Two marks if 6×10^6 used for energy giving answer 6.1×10^{-33}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 3.8×10^{-8} 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)	$197^{1/3}/27^{1/3}$ (1) = 1.9(4) (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)	$E = (1.6749 \times 10^{-27} - 1.6726 \times 10^{-27} - 9 \times 10^{-31}) \times 9 \times 10^{16}$ (1) $= 1.3 \times 10^{-13}$ J (1)	2	For information: $\Delta m = 1.4 \times 10^{-30}$ 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 $m_p < m_n$ (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)	$m = E/c^2$ (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)	$2\frac{eV}{c^2} = \frac{2 \times 1.6 \times 10^{-19}}{(3 \times 10^8)^2} = \frac{3.2 \times 10^{-19}}{9 \times 10^{16}}$ (1) $= 3.6 \times 10^{-36}$ 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 x 7.5 x 10^{-2}) = 3.6 x 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 x 10^{-3} to 3.8 x 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 sin2πft = 1 (can be implicit) leading to Emf = 0.054 x 2 x π x 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 Δx/Δy instead of Δy/Δx 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 sin2πft, 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) = 8.0×10^{-14} 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 = 4.2×10^8 (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)	$m_ec^2 = 8.19 \times 10^{-14}$ 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 x 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} x 5.4 x 10^{20} = 5.4 x 10^{17}(1)	**4**	Only credit rearranged equation – not quoting directly from data sheet Reward mass = 2.34 x 10^{-5} kg Reward number of moles = 9 x 10^{-4} Reward number of particles = 5.4 x 10^{20} Must give own value
	(b)		No. promoted = 5 x 10^{17} / 10^{6} = 5 x 10^{11} (1) Energy used = 0.5% x 6 x 10^{-5} = 3 x 10^{-7} J (1) Energy per transition = 3 x 10^{-7} / 5 x 10^{11} = 6 x 10^{-19}J (1) = 6 x 10^{-19} / 1.6 x 10^{-19} = 3.75 eV (1)	**4**	If 5.4 x 10^{17} used from (a) number promoted = 5.4x 10^{11} If 5.4 x 10^{17} used from (a) Energy per transition = 5.56 x 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)		λ= 6.6 x 10^{-34} x 3.0 x 10^{8} / 6 x 10^{-19} (1) = 3.3 x 10^{-7} m (1)	**2**	Credit using 4 eV (6.4 x 10^{-19}), 3.5 eV (5.6 x 10^{-19}) leading to 3.1 x 10^{-7}, 3.5 or 3.6 x 10^{-7} m. Calculating frequency as 9.7 x 10^{14}, 9.1 x 10^{14}, 8.5 x 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 both sides (1)		Allow “ln both sides”
	3		(Re-arrange and) substitute t = 3 months (1)		
	4		Use half-life = ln 2 / λ (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)	**2**	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 x 10^{-13} / 1.6 x 10^{-19} (1) = 3.1 x 10^{6} (1)	**2**	Need own value
	(b)		10 stages so 3^{10} x N per second (1) N = 3.1 x 10^{6} / 3^{10} (1) = 52 (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**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553