GCE

Physics B (Advancing Physics)

Unit **G495**: Field and Particle Pictures

Advanced GCE

Mark Scheme for June 2015

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**
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

The following questions should be annotated with ticks to show where marks have been awarded in the body of the text: all questions.

Question	Answer	Marks	Guidance
1 (a)	lepton and neutral (1)	1	order irrelevant
(b)	hadron and nucleon (1)	1	order irrelevant
2	second path never below original path and shows greater deflection less than 180^o(1) Smooth curve which finishes in a clear straight line (1). Reason: force acts for longer time/longer interaction time /longer time near nucleus (1)	3	If the second track does not start on the same original path, NAQ. Second mark can only be given if the first marking point has been awarded.
3	Straight line therefore uniform field (1) (Field strength =) gradient of line = 3000/0.07 (1) = 4.3×10^4 V m^{-1} or N C^{-1} (1)	3	Not just 'uniform field'. Accept 'straight line therefore constant field' Alternative for first mark: field is right to left as potential increases from left to right Do not penalise E = V/r Range 4.2 - 4.5 x 10^4 V m^{-1}. Units required for 3rd mark.
4 (a)	mass (1)	1	
(b)	alpha particles have short range/stopped by skin/low penetration (1) (because they are) highly ionising/high quality factor(1)	2	Marks are for properties rather than the conclusion drawn.
5	C	1	
6 (a)	No change in flux (1) Flux density <u>twice/double</u> (than that in the 'rest of the core')(1)	2	Independent marking points.
(b)	Both values will decrease (1). Air has lower permeability (than iron)/ permeance (of magnetic circuit) has decreased (1)	2	Accept 'air is less permeable'. Accept 'reluctance (of magnetic circuit) has increased'. Reject 'permeance of air has decreased'.

Question		Answer	Marks	Guidance
7		f = $(1.9 \times 1.6 \times 10^{-19}) / 6.6 \times 10^{-34}$ (1) = 4.6×10^{14} (Hz) (1)	2	Correct bald answer acceptable for two marks. Use of 6.63×10^{-34} gives 4.59×10^{14}. SF penalty for more than 3 SF. THIS IS THE ONLY SF PENALTY ON THE PAPER
8	a	E = $3.1 \times 10^{-29} \times (3.0 \times 10^{8})^{2}$ (1) = 2.8×10^{-12} (J) (1)	2	Correct bald answer acceptable for two marks. 2.7×10^{-12} only gains one mark as rounding error
8	b	(energy for work done in) overcoming repulsive force of nuclei. AW	1	Allow reference to 'a strong repulsive force' but not ' strong (nuclear) force'. Allow closest distance of approach argument if well-reasoned in terms of PE and KE. Reference to 'high energy' alone not sufficient. Reference to 'high activation energy' alone not sufficient.
		Section A total	**21**	

Question			Answer	Marks	Guidance
9	(a)	(i)	(Field) lines closer together (at X) /field lines are further apart <u>at Y</u> (1)	1	Do not accept 'arrows closer together'.
		(ii)	Approximately circular (by eye) through X centred on charge	1	
	(b)	(i)	450 (V) (1)	1	
		(ii)	6.1×10^3 (N C^{-1})	1	Calculator value = 6.0625×10^3 (N C^{-1}) Ignore sign
	(c)	(i)	Fig. 9.3 a: <u>forces/fields</u> from the charges are equal and opposite at the midpoint (1) Fig. 9.3b : Calculation of field due to a single charge: E = $k.3.5 \times 10^{-9}/(1 \times 10^{-3})^2$ (1) (= 3.15×10^7) forces from the charges act in the same direction so net force = $3.15 \times 10^7 + 3.15 \times 10^7 = 6.30 \times 10^7$. (1)	3	can be shown by calculation ($3.15 \times 10^7 - 3.15 \times 10^7 = 0$) Not arguments based on resultant charge = zero. Allow field = $\dfrac{2\times k\times3.5\times10^{-9}}{(1\times10^{-3})^2}$ = 6.3×10^7 NC^{-1} for two marks Allow arguments based on an equivalent single charge of 7.0×10^{-9} C at range 1×10^{-3} m for two marks. Not any arguments based on distance = 2×10^{-3} m
		(ii)	Potential due to both charges at midpoint is the same magnitude (1) but opposite sign (1)	2	Accept 'equal' to mean 'the same magnitude' Not 'opposite direction' 'equal and opposite potentials' worth one mark only Calculation of 3.15×10^4 V and - 3.15×10^4 V (1) showing these add to zero (1) Give benefit of doubt for 3.15×10^4 V - 3.15×10^4 V = 0 for both marks
			Total question 9	9	

Question			Answer	Marks	Guidance
10	(a)	(i)	F = 0.57 x 0.06 x 0.09x 75 = 0.23 (N) (1)	**1**	Correct bald answer worth one mark
		(ii)	Force on the coil/on AB is halved/half answer to a(i) (1) Rotation rate also depends on named factor(s) (other than the force on the coil or length of coil) (1)	**2**	Ecf from (a) (i) if numerical value used. e.g.:drag force/friction, mass of coil, torque. Accept any suggested change in rotation rate linked to other factor.
	(b)	(i)	Max flux linkage = $(6.0 \times 10^{-2})^2 \times 75 \times 90 \times 10^{-3}$ = 0.024 (1)	**1**	Correct bald answer worth one mark. No ecf from a(i)
		(ii)	Average emf = 0.024/0.2 = 0.12 V	**1**	Correct bald answer worth one mark. Ecf from (b) (i) Ignore sign
		(iii)	Flux in coil changes when coil rotates/ coil cuts flux when rotating (1) Induced emf related to speed of rotation/emf is rate of change of flux (linkage) (1) Induced emf/ back emf opposes supply p.d.(1) So, current is lower when coil is turning/ current increases as the <u>induced emf</u> reduces (to zero) (1)	**4**	Reverse argument acceptable (i.e. 'when coil is not rotating there is no change of flux' AW) R.A. acceptable: 'no emf when not rotating' BOD 'Induced emf opposes current' NOT 'induced current opposes supply current' Argument needs to be complete and correctly sequenced to gain QWC mark. (The fourth mark is dependent on the first three marks)
			Total question 10	**9**	

Question			Answer	Marks	Guidance
11	(a)	(i)	(Constant) force acts at right angles to velocity/direction of motion. (1)	1	AW force at right angles to momentum/motion Not 'perpendicular to field' Not 'perpendicular to particle'. Not just 'centripetal force'
		(ii)	$\frac{mv^2}{r} = Bqv$(1) $(\therefore r = \frac{mv}{Bq})$	1	
	(b)		Beta particle has less mass/less momentum (than alpha particle) ORA (1). Gamma is uncharged (1)	2	Not 'lighter' or 'heavier' or more/less weight Not 'gamma is a wave not a particle'
	(c)		$r_\alpha = 6.6 \times 10^{-27} \times 1 \times 10^7/(B \times 3.2 \times 10^{-19})$ (1) = 0.21/B $r_\beta = 9.1 \times 10^{-31} \times 2 \times 10^8/(B \times 1.6 \times 10^{-19})$ (1) = 1.1×10^{-3}/B Statement of ratio of radii, eg. 0.21: 1.1×10^{-3} or 'alpha radius of path is about 180 times that of the beta particle' (1) Comment that the diagram shows a much smaller difference in the two radii AW (1)	4	Accept arbitrary values of B (including B = 1 explicitly stated or explicitly subsituted) for the first two marks. Penalise one mark only for ignoring B or using it inconsistently in explanation. Accept ratio of about 200 (or inverse ratios = 0.054 and 0.005) Allow ecf from r_α and r_β . This is a QWC mark: comment must be clear and consistent with ratio of radii as calculated and with the diagram
			Question 11 total	**8**	

Question	Answer	Marks	Guidance
12 (a)	iodine (nucleus) has zero lepton number/lhs of equation has zero lepton number(1) Electron is a lepton, anti-neutrino is an anti-lepton (1)	**2**	Accept zero lepton number on both sides for first mark Accept eg 0 = 0 + 1 -1 (2 marks) 0 = 0 -1 + 1 (1 mark)
(b) (i)	N = 1.2 x 10^{-13}/2.18 x 10^{-25} = 5.50x 10^{11} (1) λ = ln 2/6.95 x 10^{5} = 9.97 x 10^{-7} (1) activity = 9.97 x 10^{-7} x 5.50 x 10^{11} = 5.49 x 10^{5} (1)	**3**	Don't penalise rounding error Need own value to 2 s.f. or more and clear working, but stages can be conflated. Correct bald answer to 2 s.f. or more worth one mark only. Ignore sign in the final answer
(b) (ii)	A = 5 x 10^{5} x $e^{-((0.693/8) \times 84)}$(1) = 350 (1) OR A = 5 x 10^{5} x $0.5^{10.5}$ (1) = 345 (1)	2	Correct bald answer worth two marks Expect and accept answers in range 340 – 400 dependent on data used and rounding Allow one mark only for rounding to ten or eleven half-lives with consistent answer.
(c)	dose = 5 x 10^{11} x 2.9 x 10^{-14}/1.8 x 10^{-2} (1) = 0.81 (1) Assumes all energy/beta particles deposited in gland (1)	3	Expect (and accept) 0.89 if 5.5 x 10^{11} used. No credit for calculation if mixing up initial number of nuclei with initial activity. (This is not a POT error) Don't accept 'dose' for 'energy'
(d)	Gamma passes through tissue (1) Iodine also emits β particles (1) which damage tissue/cells/dna/causes cancer (1) AW	3	Property of gamma must be linked to passage through body/tissue/possibility of external detection. Don't accept 'passes through skin'. Not simply 'causes damage'
	Total question 12	**13**	

Question			Answer	Marks	Guidance
13	(a)		M = 89/5.3 = 16.8 or 17 (1)	1	Ignore sign and spurious unit. Allow 17 x (for 17 times) Don't allow 16 or 16.7 (RE)
	(b)		(1/f = 1/v – 1/u) = 1/0.089 + 1/(5.3 x10^{-3}) (1) = 200 dioptre (1)	2	Correct bald answer 2 marks 0.2 dioptre POT 1 Zero marks for 1/200 on answer line (or calculated value)
14	(a)		(5.0 cm / 2.0 cm) x 100 x 10^{-6} / 480 (1) = 5.2 x 10^{-7} m/pixel (1)	2	Accept +/- 1 mm on each measurement Acceptable range = 5.6 x 10^{-7} to 4.8 x 10^{-7} m/pixel Correct, in-range bald answer 2 marks
	(b)		Area of single lens in range 250 – 350 μm^2 (1) Number in eye = total area/area of single lens = range 17000 - 25000 lenses (1)	2	Alternative methods e.g. 30 – 40 lenses per $(100\ \mu m)^2$ (1) => 17000 - 25000 lenses on the whole eye (1) In range bald answer worth one mark only. No ecf from incorrect single lens area or number of lenses in any given area
15	(a)		2 x 10^{-12} / 1.6 x 10^{-19} = 1.3 x 10^{7} (1)	1	Accept correct bald answer Calculator answer = 1.25 x 10^{7} Do not accept 1.2 x 10^{7} (RE)
	(b)		1 cm^3 = 10^{-6} m^3 (1) pV = NkT So, 10^{-5} x 10^{-6} = N x 1.4 x 10^{-23} x 300 (1) N = 2.4 x 10^{9} (1)	3	POT error (-1) for incorrect conversion of cm^3 to m^3 Accept correct bald answer Allow use of pV = nRT (reaching 4 x 10^{-15} mol gains two marks)
	(c)	(i)	Beam current linked to number of electrons emitted per second(1) Electrons escape (boil off) when they have sufficient energy/get lucky in random collisions(1) BF gives the probability of an electron escaping/fraction of electrons that can escape (at any given instant)(1)	3	Penalise confusion with filament current e.g. 'the greater the current the more electrons boil off.'. Allow 'rate of …' for 'per second' 'BF gives probability of an electron having enough energy to escape' is worth two marks (energy mark and probability mark)

	(ii)		$BF_{2200} = e^{-(7 \times 10^{-19}/k.2200)}$ (1) $= 1.35 \times 10^{-10}$ $BF_T = 4.04 \times 10^{-10} = e^{-(7 \times 10^{-19}/kT)}$ (1) Evaluation to T = 2310 (K) (1)	3	Alternative methods possible. For example: $I_2/I_1 = 3$ (1) $= \exp(E/k\,(1/T_1 - 1/T_2))$ (1) to give $T_2 = 2310$ (1) Correct bald answer gains all marks
16	(a)	(i)	$40000 \times 1.6 \times 10^{-19} = 6.4 \times 10^{-15}$ (1)	1	Must have own value
		(ii)	Re-arrange $KE = p^2 / 2m$ to give $p = (2mE_k)^{1/2}$ (1) $p = 1.08 \times 10^{-22}$ kg m s^{-1} (1)	2	Correct bald answer worth two Calculation of $v = 1.19 \times 10^8$ m s^{-1}(1) $p=mv$= 1.08×10^{-22} kg ms^{-1}(1) If 6×10^{-15} used, $v = 1.15 \times 10^8$ m s^{-1} and $p = 1.04 \times 10^{-22}$

	b		$\lambda = h/p = 6.6 \times 10^{-34} / 1.08 \times 10^{-22}$ (1) $= 6.1 \times 10^{-12}$ So max theoretical resolution = $6.1 \times 10^{12} / 2$ $= 3.1 \times 10^{-12}$ m (1)	2	Accept rounded values carried over from (a)(ii) leading to slight variation in answer. Correct bald answer worth two NB incorrect use of E =hf or E = hc/λ or E = hv/λ score 0 ecf from a (ii) No ecf from wavelength to resolution
	c		Energy required = $mc\Delta\theta$ $= 0.25 \times 10^{-6} \times 3000 \times 1$ (1) $= 7.5 \times 10^{-4}$ J No. of electrons required = $7.5 \times 10^{-4} / 6 \times 10^{-15}$ $= 1.25 \times 10^{11}$ (1)	2	Correct bald answer worth two No ecf from energy to number of electrons
	d		$\lambda = \frac{6.6\times10^{-34}\times3.0\times10^{8}}{6\times10^{-15}}$ (1) $= 3.3 \times 10^{-11}$ m (1)	2	Calculation of $f = 9.09 \times 10^{18}$ Hz worth one mark Correct bald answer worth two

Question			Answer	Marks	Guidance
17	(a)		From given equation, $N = Bd / \mu_o I$ $= 1 \times 0.01/(1.3 \times 10^{-6} \times 2)$ (1) = 3846 (1)	2	Condone missing 1 (T) in substitution Need own value to at least 2 sf
	(b)		R = πd x N x resistance per unit length = 201 Ω (1) V = IR = 2 x 201 = 402 V (400V) (1)	2	R = 193 Ω if calculator value used giving V = 387 V Accept different roundings from (a) Allow ecf from R to V
			Total	**4**	
18	(a)		$E = V/d = 200 / 1.8 \times 10^{-3} = 1.1 \times 10^5$	1	Need own value Allow $E = V/r$
	(b)		$F = Eq = 1.1 \times 10^5 \times 1.6 \times 10^{-19} = 1.78 \times 10^{-14}$ (1) $a = F/m = 1.78 \times 10^{-14} / 9.1 \times 10^{-31} = 1.96 \times 10^{16}$ m s^{-2} (1) Then from $s = ½ at^2$, $t = 2.26 \times 10^{-10}$ s since s = 0.5 mm (1) And so $x = vt = 0.4 \times 3 \times 10^8 \times 2.4 \times 10^{-10} = 27.1 \times 10^{-3}$ m (1)	4	Can use 1×10^5 to give a force = 1.6×10^{-14} N; acceleration= 1.75×10^{16} m s^{-2} $t = 2.38 \times 10^{-10}$ $s = 2.86 \times 10^{-2}$ m allow ecf from wrong force/wrong acceleration Credit answers which take relativistic factor (1.1) into consideration. Correct bald answer worth 4.
	(c)		Uniform electric field (1) Force (or acceleration) would be the same (1)	2	AW : constant field strength 2nd mark is dependent on the first
			Total	7	
19			γ = total energy / rest energy = (0.511 + 0.2)/0.511 = 1.39 (1) substitution of gamma value into $\gamma = 1/ (1 - v^2/c^2)^{1/2}$ or into rearranged equation (1) $v = 2.1 \times 10^8$ ms^{-1} (1)	3	Correct bald answer greater than 1 s.f. worth three marks Allow ecf from wrong gamma Do not award second or third marks for 2.65×10^8 (using ke = ½ mv^2) NOW SCROLL THROUGH ADDITIONAL PAGES INSERTING ‘BP’
			Total	**3**	

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

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored