RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE

Unit **G495:** Field and Particle Pictures

Mark Scheme for June 2013

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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

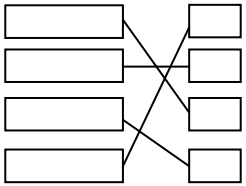
Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

Annotations used in the detailed mark scheme

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

Annotations should be made as follows:

For both QWC questions12 (d) and 16 (e) put a x next to the pencil icon if QWC not awarded
In any question part where not all the marks are awarded, put a tick at point of award for each mark awarded so that number of ticks = mark total for that part
For any question part with a candidate response which does not gain full marks or zero, put x or ^ as appropriate
Any additional objects must be annotated and marked with ^ if they are blank

Question			Answer	Marks	Guidance
1	(a)		J kg^{-1}	1	
	(b)		J C^{-1}	1	
2			Two correct (1) All correct (1) 	2	
3			1.2	1	
4			F = 0.12 x 0.41 x 0.15 (1) = 7.4 x 10^{-3} (1)	2	0.0074, 0.00738, 7.38 x 10^{-3}, 7 x 10^{-3}, 0.007 acceptable. Correct bald answer gains two marks. Zero for incorrect bald answer, including POT error.

Question			Answer	Marks	Guidance
5			EITHER: method = appropriate area under graph/evidence of counting squares (1) = use of 10 V per square/ correct calculation based on scaled area (1) = consistent answer in range 80 V to 90 V (1) OR use of $E = V/r$ (1) two potentials evaluated as 150V & in range 56V– 67V (1) consistent answer in range 83 V – 94 V (1) OR: Method = calculation of charge = 5 nC (1) pd = $9 \times 10^9 \times 5 \times 10^{-9}$ (1/0.3 – 1/0.7) (1) = 86 V (1)	3	2 marks for correct bald answer within range 80 – 94 V Use of area can be indicated on graph for first mark. 2nd mark is free standing Credit any acceptable method for calculating area. Do not accept $E = V/d$ for the first mark unless derived from radial field formulae. Allow access to remaining two marks. Accept calculation of constant of proportionality from $E = constant/r^2$ so $constant$ = 45 N m^2 C^{-1} (1)

Question			Answer	Marks	Guidance
6	(a)		Arrow pointing towards 11 o clock from position Y, along line from nucleus to Y.	1	Ignore starting position of arrow
	(b)		Less angular deflection (1) Smooth trajectory symmetrical about line joining nucleus and point of closest approach. (1)	2	Poorly drawn line max 1. (e.g. if line drops below horizontal) Second mark is dependent on first.
7	(a)		8	1	Accept 8.3
	(b)		12	1	Accept 11.5
8	(a)		Complete method including intermediate step $p^2 = (h/\lambda)^2$ (1)	1	Or clear evidence of manipulation of the two equations.
	(b)		4.0 (1)	1	Accept 4
9	(a)		Greater distance between (equipotential) lines (at A) (1) of equal potential difference AW(1)	2	Do not accept field lines. Accept numerical description for second mark. Eg 'the distance between the 100 V and 200 V is more than that between 200 V and 300 V'.
	(b)		Line at right angles to equipotential direction to the left.	1	Extrapolation should track back through 400 V arc.
			Section A Total	**20**	

Question			Answer	Marks	Guidance
10	(a)	(i)	North pole of rotor/magnet attracted to South pole of stator AW(1)	1	NOT just North attracts South
		(ii)	Flux lines tend to become straighter/shorter AW (1)	1	e.g. flux lines take shortest path.
	(b)		Two from (1 mark each) Greater csa (of stator/rotor/both) Smaller air gap Use material/iron of higher permeability	2	Do not allow just 'area' . Allow thicker, fatter, for csa 'decrease separation' alone does not get a mark as it is too vague NOT 'decrease the length of the rotor' Allow shorter stator. NOT lamination
	(c)	(i)	Flux is proportional to current (1) At t = 0 ms max flux from Y coil, at t = 10 ms zero from Y (1) (AW)	2	must be a clear statement of proportionality must have times or time interval could use equivalent argument for coil X If the first mark has been awarded, candidates can gain second mark for description of current variation.
		(ii)	Any two from: Net flux is sum of flux from Y and X (1) (direction of net) flux goes from Y to X in 10 ms (1) (and) back to Y but in the opposite direction after 20 ms (1) (direction of net) flux returns to starting position after 40 ms (1)	2	NB 'flux rotates by one turn' is in stem of question.

Question			Answer	Marks	Guidance
	(d)		flux in rotor/copper changes (1) inducing emf/ current in rotor/copper (1) current in rotor interacts with flux (1)	3	accept 'field' for 'flux'. Accept rotor cutting flux lines. accept magnetic force (LHR) on current accept rotor follows flux to minimise flux change
			Total	**11**	

Question			Answer	Marks	Guidance
11	(a)	(i)	2.0135 + 3.0155 – 4.0015 – 1.0087 (1)= 0.0188 (0.0188 x u =) 3.12 x 10^{-29} kg (1)	2	Must have own answer and clear method. Accept 3.15 x 10^{-29} kg (from 0.019), 3.32 x 10^{-29} kg (from 0.02) Ignore sign
		(ii)	E = 3.12 x 10^{-29} x 9.0 x 10^{16} (1)= 2.81 x 10^{-12} J (1)	2	Accept ecfs/answers derived from (i). Δm = 3 x 10^{-29} kg -> 2.7x 10^{-12} J
	(b)		E = (1.6 X10^{-19} x 1.6 X10^{-19} x 9 x 10^{9})/ 1 x 10^{-14} (1) = 2.3 x 10^{-14} (J) (1)	2	must have own value and clear method. Do not accept solutions from work done = force x distance BOD (can access both marks) 'work done = Fr' as it implies algebraic combination of radial field equations.
	(c)	(i)	1 x 10^{-14}/ 1.4 x 10^{-23} = 7 x 10^{8} K (1)	1	Allow 7.1 x 10^{8} , 7.2 x 10^{8} Do not penalise s.f.
		(ii)	Either • This estimate gives an average ke /range of energies (1) • Some of the particles with more than the average energy will have sufficient energy for fusion(1) Or • particles exchange energy in collisions (1) AW • Successive energy gains lead to particles with sufficient energy/particles 'getting lucky' (1)	2	To gain both marks for this method, at least one reference to average is needed.
			Total	**9**	

Question			Answer	Marks	Guidance
12	(a)		λ= 0.693/(6 x 60 x 60)(1) = 3.21 x 10^{-5} s (1)	2	Need working and own answer
	(b)		9.3 x 10^{8} = (-) 3.2 x 10^{-5} N (1) N = 2.9 x 10^{13} (1) Total energy = 140x10^{3} x 1.6 x 10^{-19} x2.9 x 10^{13} (1) = 0.65 J (1)	4	3.1 x 10^{13} if 3 x 10^{-5} used. 0.69 if 3 x 10^{-5} used.
	(c)		(0.65 x 0.01 (1) x 1)/77(1) = 8.4 x 10^{-5} (1) Sv	3	Accept implicit quality factor allow ecf from (b) accept use of 0.7 J -> 9.1 x 10^{-5} Sv 2 marks for ignoring % giving value of 8.4 x 10^{-3} (For marking consistency) 2 marks for using 99% absorption giving 8.4 x 10^{-3} 3 x 10^{-5} -> 9.018 x 10^{-5}, 8.96 x 10^{-5} (dependent on intermediate rounding)
	(d)		Risk per person per annum = 0.05 x 8.4 x 10^{-5} = 4.2 x 10^{-6} (1) (4.48 x 10^{-6} or 4.51 x 10^{-6} if 3 x 10^{-5} used) Estimate of number of cases = 4.2 x 10^{-6} x 20 x 10^{6} (1) = 84 per annum (1) appropriate risk-benefit comment on global effect (1)	4	accept a percentage risk of 4.2 x 10^{-4} % for first mark. Ecf from POT error in (c) will give about 8 400 cases per annum. Eg. More people likely to be helped by procedure than harmed by it. Don't credit use of phrase 'risk-benefit' alone QWC: Only award all four marks if clear calculation and argument linking individual and global effect
			Total	**13**	

Question			Answer	Marks	Guidance
13	(a)	(i)	$F = qE = qV/d$ = 1.6 x 10^{-19}x 440/0.022 (1) (= 3.2 x 10^{-15} N)	1	Mark is a substitution mark. Equation can be implicit. E field value = 20 000 V m^{-1}
		(ii)	$F = qvB$ = 3.2 x 10^{-15} N (1) This is acting in <u>opposite direction</u> to electrical force (1) Hence zero net force (1)	3	ORA calculating field strength or velocity and matching to data. For third mark point: allow 'balanced forces', 'forces cancelling'. Allow 'equal forces' for third mark only if clear statement that these are acting in opposition.
	(b)	(i)	$qvB = mv^2/r$ (1)	1	
		(ii)	r = 2.0 x 10^{-25} x 1.8 x 10^5/(1.6 x 10^{-19} x 0.70) (1) = 0.32 m (1)	2	accept correct bald answer for two marks
		(iii)	Deflection will be less/ radius will increase (1) Either: as r is <u>proportional</u> to m when all other variables are held constant (1) AW Or: correct use of equation stating all other variables held constant(1)	2	 Allow momentum for mass. accept 'numerator larger and denominator the same' with equation (1)
			Total	**9**	

Question			Answer	Marks	Guidance
14	(a)		2 x 0.32 = 0.64 m (1)	1	
	(b)		$v = f\lambda$ = 440 Hz x 0.64 m (1) = 280 (282) m s^{-1} (1)	2	Sf penalise 281.6 Ecf from 0.32 m = 141 m s^{-1} sf. penalise 140.8
	(c)		T/μ shown as N/(kg m^{-1}) (1) OR kg m s^{-2} / (kg m^{-1}) (1) $(T/\mu)^{1/2}$ = $\sqrt{}$ m^2 s^{-2} (1) = m s^{-1}	2	Second mark is dependent on the first.
	(d)	(i)	Substitution of $\lambda = 2L$ and v = $(T/\mu)^{1/2}$ into $v = f\lambda$ (1)	1	
		(ii)	($f \propto \sqrt{T}$) new f = 440 x $\sqrt{1.1}$ (1) = 461 Hz (1)	2	allow complete recalculation need to see own value
		(iii)	Wire gets longer (1) Same mass divided by greater *L* gives smaller μ (1) OR: constant length of wire between bridge and nut (1) lower mass (in that length) gives smaller μ (1) OR: Wire gets thinner (under tension) (1) lower mass (in given length) gives smaller μ (1)	2	NOT just 'same mass'
		(iv)	$f \propto \sqrt{\frac{1}{\mu}}$ (1) Smaller μ gives larger f (1) ORA	2	Allow use of the equation as part of a coherent argument.

Question			Answer	Marks	Guidance
15	(a)		Suitable example identifying oscillator and driver (1) Increased amplitude of oscillation when driver frequency = natural frequency (1)	2	Eg oscillations of violin body driven by string, oscillations of air in body driven by string/body. NOT violin string oscillating driven by bow.
	(b)		Either: Grains of sand gather in the nodes (1) where there are no oscillations of the medium (1) Or grains of sand move away from antinodes (1) where there is (most) oscillation (1)	2	accept alternative wording for oscillations eg vibration, amplitude, displacement
	(c)		Larger (restoring) force for given deflection /Wood will accelerate faster towards equilibrium (1) Stiffer material would have higher resonant frequency. (1)	2	Credit use of higher value of k in $f = 1/2\pi\ (k/m)^{1/2}$

Question			Answer	Marks	Guidance
16	(a)		Correct, smooth, continuous loops (two) (1) Deviation of flux in wire (1)	2	2nd mark dependent on first
	(b)		$\phi = B\,A$ = 0.1 x (0.003^2 x π) (1) = 2.8 x 10^{-6} Wb (1)	2	Need own value and working Reverse argument leading to 0.106 T or 6.18 mm diameter
	(c)		length = no. of turns x circumference = 8200 x π x 6 x 10^{-3} (1) = 155 m (1)	2	Need own value and working accept reverse argument leading to 7960 turns or 5.8 mm diameter Accept 154 m
	(d)		total resistance = 150 m x 50 Ω m^{-1} = 7500 Ω (1) $I = V/R$ = 1.60 x 10^{-5} A (1)	2	155 gives 7750 Ω , calculator value from (c) gives 7728 Ω 7750 gives 1.548 x 10^{-5} Ω, 7728 gives 1.553 x 10^{-5} Ω Omission of 150 m gives zero marks
	(e)		Any four from: Steel has a high permeability/higher than air ORA (1) Changing air gap between wire and magnet (1) The permeance of the magnetic circuit changes as the steel moves (1) This changes the flux (linkage in the coil) (1) A change in flux (linkage) produces an emf (in the coil) (1)	4	Do not credit change of flux experienced by wire cutting through field or emf induced in wire. QWC: only award four marks if clear and logical argument

Question			Answer	Marks	Guidance
17	(a)		The vibrations of the strings/body are transferred to the pick up (1) The crystal suffers deformation/is squeezed AW (1) which produces a (change in) voltage/emf (1) AW voltage/emf is generated by vibration (of the crystal) rather than by electromagnetic induction, (so string does not need to be steel) (1) AW	4	Needs to convey transferred, not just detected as too close to root of question Deformation must link to this context, not just general statement Third mark dependent on second Requires reference to e-m induction for 4th marking point
	(b)		Any one of : greater choice of strings for player less obtrusive/smaller less massive Amplifies vibrations of whole instrument not just those of the string AW Less prone to interference from external magnetic fields	1	
18	(a)		Frequency = 1/0.0025 = 400 Hz (1)	1	
	(b)		Both notes have same (time period hence) frequency (1) More complex note has higher frequency components present (1)	2	Accept 'fundamental', 'lowest/first harmonic' for implied frequency. For 2nd marking point must clearly indicate 'higher'. Accept 'overtones' as implying higher frequency. Accept 2nd , 3rd, … harmonics as higher frequency but not just 'harmonic'
			Total	**38**	

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