RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE

Unit **G495:** Field and Particle Pictures

Mark Scheme for January 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.

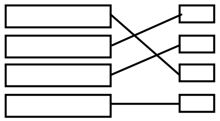
Annotations

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

Annotations used in 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

Question			Answer	Marks	Guidance
1			Two correct (1) All correct (1) 	2	
2			D	1	
3	**(a)**		horizontal line in middle of gap	1	
	(b)		$E = 7 \times 10^7/500 = 1.4 \times 10^5$ ($V\ m^{-1}$) (1)	1	accept 140 000 (Vm^{-1}) ; accept bald answer
4			$mv = h/\lambda\ = 6.6 \times 10^{-34}/1 \times 10^{-10}$ (1) $= 6.6 \times 10^{-24}$ ($kg\ m\ s^{-1}$) (1)	2	accept bald answer for 2 marks Do not accept arguments from $E = hf$
5			neutron (1) gluon (1) electron and neutrino (1)	3	
6	**(a)**		turns ratio = 230/12 = 19.(2) (1)	1	As this is a one mark question do not penalise rounding error. Accept bald answer. Do not accept fractional ratios. Accept 19:1
	(b)		50 Hz (1)	1	
7	**(a)**		(difference) in energy per unit charge(1) of a charge at a given point and at infinity (1)	2	Accept energy per coulomb/one coulomb. Accept work done in moving unit charge from infinity to a point (in the field). Accept statement that potential at infinity is zero for standalone mark.
	(b)		(electric) field strength (at X) (1)	1	Accept electric field. Do not accept 'field'

Question			Answer	Marks	Guidance
8	**(a)**		235 x -7.6 MeV = -1786 MeV (1)	1	Accept -1790, -1800. Do not penalise lack of negative sign.
	(b)		-1786 – (-8.5 x 233) (1)= 194.5 MeV (1)	2	method mark for (233 x 8.5) evaluation of correct difference from part (a) Allow 1 mark for use of 235 correctly evaluated.(eg 207.5, 211.5) Accept bald answer for (2)
9			energy = 18 x 10^{-3} x 65 x 25 (1) = 29(.3) J(1)	2	Accept bald answer for (2) If obviously multiplying by quality factor, 1 mark max.
			Section A Total	**20**	

Question			Answer	Marks	Guidance
10	(a)		Asymptotic to $v/c = 1$ AW (1)	1	Accept 'graph never reaches 1'. Accept 'v asymptotic to c' Accept 'infinite energy required to reach c' (as this implies asymptote). Do not accept 'v never reaches c' but accept 'v never reaches 1 c' as this refers to the graph.
	(b)	(i)	$\gamma = 4 \times 10^{12} + 938 \times 10^{6}/938 \times 10^{6}$ (1) = 4,300 (1)	2	For second mark accept 4265, 4264 Accept bald 4265 for 2 marks. Accept bald 4300 or 4264 for 1 mark
		(ii)	$4300 = 1/(1 - v^2/c^2)^{1/2}$ (1) $1 - v^2/c^2 = 5.4 \times 10^{-8}$ $v/c = (1 - 5.4 \times 10^{-8})^{1/2}$ (1) v/c evaluated to show that it is more than 0.99 (1)	3	or alternative method 2nd mark can be calculated value of v. Do not penalise rounding error. Can calculate gamma for v/c = 0.99 and show that it is less than value from (b)(i) ORA
	(c)		$v^2 = 2 \times 4 \times 10^{12} \times 1.6 \times 10^{-19} / 2 \times 10^{-6}$ (1) $v = 0.8\ \mathrm{m\ s^{-1}}$ (1)	2	
	(d)	(i)	$T = \mathrm{J/m\ s^{-1}C\ m}$ (1) $= \mathrm{Nm/m^2\ \ s^{-1}C} = \mathrm{Nm/m^2\ A}$ (1) $= \mathrm{N\ A^{-1}\ m^{-1}}$	2	Must be clear
		(ii)	$B = 4 \times 10^{12} \times 1.6 \times 10^{-19}/(3 \times 10^{8} \times 1.6 \times 10^{-19} \times 4250)$ (1) = 3.1 T (1)	2	Accept implicit cancelling of 1.6×10^{-19} Do not accept rounding error of 3.13 Accept 3.14
			Total	**12**	

Question			Answer	Marks	Guidance
11	(a)		Mass defect = 0.0060 u (1) E = 0.006 x 1.7 x 10^{-27} x 9 x 10^{16} (1) = 9.2 x 10^{-13} J (1)	3	Need own value. Allow other routes through. Must show working.
	(b)	(i)	6 x 10^{10} x 9.2 x 10^{-13} (1) = 5.5 x 10^{-2} (1)W	2	Allow 5.4 for two marks. Allow ecf from (a) Allow 1 sf answer
		(ii)	N = A/λ = 6 x 10^{10}/2.5 x 10^{-10} = 2.4 x 10 ^{20} (1) mass = 0.238 x 2.4 x 10^{20}/6 x 10^{23} = 0.095 x 10^{-3} kg (1)	2	Need own value. Alternative method: number of nuclei x 238 x 1.7 x 10^{-27} = 9.7 x 10^{-5}.
	(c)		Any four from: • Alpha source so no penetration into the patient (of ionising radiation) (1) • Long half life so can remain in the body/ doesn't need replacing often • Power output fairly constant (over 20 year period)/calculation of power output after twenty years = 4.6 x 10^{-2} W (1) • Calculation of 20 year dose of mSv or risk per year of 0.005%(1) • 20 year risk = 0.1%	4	Do not allow references to penetration through skin. Allow answers based on 3% per sievert.
			Total	**11**	

Question			Answer	Marks	Guidance
12	**(a)**	**(i)**	Q = VR/k = 230 x 90 x 10^{-3}/9 x 10^{9} (1) = 2.3 x 10^{-9} C (1)	2	
		(ii)	r = (230/4000) x 90 (1)= 5.2 mm	1	Accept: r = kQ/V calculations
	(b)		F = 9 x 10^{9} x (5.2 x 10^{-9})^{2}/(14 x 10^{-3})^{2} (1) = 1.2(4) x 10^{-3} N (1)	2	Need own value Using charge of 2.3 x 10^{-9} C scores no marks
	(c)		F = K/r^{2} so increase in force = 14^{2}/11^{2} (1) = factor of 1.62 Therefore new force = 1.24 x 10^{-3} x 1.62 = 0.002(01) N (1) Reason for lower reading is that charge moves over the conducting sphere (1) making the effective separation greater (1)	4	Can calculate force from primary data again for two marks: F = 9 x 10^{9} x (5.2 x 10^{-9})^{2}/(11 x 10^{-3})^{2} (1) = 2.0(01)x 10^{-3} N (1)(bald answer worth two as not show that) Stating that ΔF is resolvable by balance (1) Using charge of 2.3 x 10^{-9} C can score 2 marks for calculation (ecf) and 1 for stating that change is not resolvable by instrument.
			Total	**9**	

Question			Answer	Marks	Guidance
13	(a)		Loops of correct shape (1)	1	Accept complete loop through magnet. Loops must be symmetrical. Penalise incorrect direction.
	(b)		Line marked when passing through X axis (1)	1	
	(c)	(i)	rate of change of flux = 1.4/1500 (1) = 9.3×10^{-4} (1) Wb s^{-1}	2	Penalise more than 3 sf
		(ii)	Any four from: • Either: Induced emf related to change of flux (linkage)/flux cutting/ cutting field lines OR link between induced emf and speed of magnet (since $E = (-)N\, d\phi/dt$) (1) • Induced emf falls as more of the magnet is inside coil as rate of change of flux decreases (1) • When the magnet is in the centre of the coil there is instantaneously zero rate of change of flux / equal and opposite emfs induced in series. (1) • As magnet leaves coil emf induced in opposite direction as flux is decreasing rather than increasing AW • Maximum negative voltage greater than maximum positive voltage due to acceleration of magnet.	4	Fourth mark dependent on linking arguments to graph. Clear explanation in terms of Lenz's Law acceptable for the fourth bullet point.
	(d)		Similar curve (1) Same phase (1)	2	
			Total	**10**	
			Section B Total	**42**	

Question			Answer	Marks	Guidance
14	(a)	(i)	$1.96 \times 1.6 \times 10^{-19}$ (1) = $3.1(36) \times 10^{-19}$ J	1	
		(ii)	E =hf = hc/λ (1) = $6.6 \times 10^{-34} \times 3.0 \times 10^{8}/3.14 \times 10^{-19}$ = 6.31×10^{-7} m (1)	2	Need own value Allow ecf from show that value of 3×10^{-19} (=6.6×10^{-9} m) If 3.1×10^{-19} used = 6.39×10^{-9} m Allow calculation of frequency as intermediate mark (giving 4.76×10^{14}, 4.69×10^{14} or 4.55×10^{14} Hz) Or reverse argument leading to energy (3.14×10^{-19}) from 630 nm.
		(iii)	number = $3 \times 10^{-3}/3.14 \times 10^{-19}$ (1) = 9.55×10^{15} (1)	2	1×10^{16} if 3×10^{-19} used. 9.68×10^{15} if 3.1×10^{-19} used
		(iv)	Input power = 230 x 2 = 460 W (1) efficiency = (3×10^{-3}/460) x 100 % = 6.5×10^{-4} % (1)	2	POT error 1 mark
	(b)	(i)	f = exp -($3 \times 10^{-19}/1.38 \times 10^{-23} \times 300$) (1) = 3.38×10^{-32} (1)	2	Expect to see: 3.14×10^{-19} gives 1.15×10^{-33} 3.1×10^{-19} gives 3.02×10^{-33} 3.136×10^{-19} gives 1.27×10^{-33}
		(ii)	more atoms in excited state than ground state (1) Very small value of BF (1) Implies very few atoms in excited state (at 300K) (1) majority of atoms need to be in excited state to sustain (stimulated) emission of photons(1)	4	Fourth mark only available if explanation is in logical order and technical language used. Must have three from: excited state, ground state, stimulated emission, Boltzmann factor, photon, energy level.
			Total	**13**	

Question			Answer	Marks	Guidance
15	(a)		Energy = power x time = $3.0 \times 10^{11} \times 10^{-9}$ = 300 J	1	Accept bald answer
	(b)		$\Delta\theta$ = E/m c = 300/(1.5 x 10^{-3} x 4200) (1) = 50 K (1)	2	ecf accept bald answer allow 48 K
16	(a)		one $\lambda/2$ loop	1	
	(b)		λ = 2 x 1.1 x 10^{-7} m (1) => f = c/λ = 0.83 x 10^{8}/2.2 x 10^{-7} = 3.77 x 10^{14} Hz (1)	2	Need own answer Ecf one mark max if λ = 1.1 x 10^{-7} leading to 7.54 x 10^{14} Hz. Dividing this answer by two cancels this mark.
17	(a)		Large range (of wavelength and absorption) (1) Points not be usefully distributed on linear axes (1)	2	
	(b)		From graph, absorb coeff = 0.01 cm^{-1} (1) $I = I_0 e^{-\mu x} = I_0 e^{-0.01 \times 300}$ (1) I/I_0 = 0.0498 (1) = 4.98 % (1)	4	Need own value Or From graph, absorb coeff = 0.01 cm^{-1} (1) So penetration depth = 100 cm (1) 3m is 3 penetration depths (1) So I => I x $(0.37)^3$ = 0.05 (ie 5%) (1) Pot error leading to incorrect value 2 marks max. Rounding error if round to 4.9%
18	(a)	(i)	Same energy (needed to produce same effect) (1) Energy = power x time - time less so more power needed (1)	2	
		(ii)	less time for energy to be conducted/thermal energy to transfer AW	1	
	(b)		No. of molecules in 1 cm^3 = 6.0 x 10^{23}/18(1) = 3.3 x 10^{22}(1) In one cm^3, 10^{21}/3.3 x 10^{22} (1) = 0.03(1) = 3%	4	Number of moles = 0.056 (1)

Question			Answer	Marks	Guidance
19	**(a)**		minimises attenuation of beam AW (1)	1	Energy not absorbed Intensity not lost No scattering
	(b)	**(i)**	speed of light in glass = $3 \times 10^8/1.2 = 2.5 \times 10^8$ m s^{-1} (1) $t = d/v = 0.75/2.5 \times 10^8$ $= 3.0 \times 10^{-9}$ s (1)	2	Bald answer acceptable.
		(ii)	shortest possible distance along fibre AW	1	Accept straight fibre
		(iii)	Calculation of two times: 2.975 ns & 3.025 ns (1) Gives % difference of 1.7%	2	Calculation (1) e.g. based on refractive indices alone gives difference of 1.7 % (1) Or percentage difference of speeds. Look for rounding variation. Accept bald answer
			Section C Total	**38**	

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