RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE

Unit **G495:** Field and Particle Pictures

Mark Scheme for January 2012

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.

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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 equation

Annotations in 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

Question			Answer	Marks	Guidance
1	(a)		Wb m^{-2}	1	
	(b)		J C^{-1} Wb s^{-1}	1 1	
2	(a)		$E = m^2v^2/2m$ shown	1	**Allow:** any consistent method **Allow:** reverse argument
	(b)		$E_k = h^2/2m\lambda^2$ shown	1	**Allow:** any consistent method **Allow:** reverse argument
	(c)		wavelength = 3.5 x 10^{-10} m	1	
3	(a)		C	1	
	(b)		A	1	
4			E = 3000/4 x 10^{-4} = 7.5 x 10^{6} (V m^{-1})	1	
5			${}^{0}_{1}X$ positron/anti-electron (1)	2	**Allow:** beta-plus **Allow:** ecf from incorrect numbers **Allow:** positron etc as independent mark
6			Curving upwards between plates, straight (by eye) outside plates	1 1	Use Scoris marking tool if in doubt.
7	(a)		Same/ equal Φ	1	**Allow:** AW
	(b)		Half, B/2	1	**Allow:** Y is twice X **Not:** less
8			35 = 125 x $e^{-4.1x\ 10^{\wedge}-9t}$ ln 35/125 = -4.1 x $10^{-9}t$ t = 3.1 x 10^{8} s (= 9.7 years)	1 1	**Allow:** 1.84 half lives (1) so 9.7 years(1) **Allow:** Approx two half lives (1) so 10.6 years (1) **Allow:** Substitution (1) leading to 33.7kBq (1) after ten years Own value needed for second mark
9	(a)		C	1	
	(b)		r = 7 x 10^{-15} x $4^{0.33}/197^{0.33}$ = 7 x 10^{-15} x 0.27 r = 1.9 x 10^{-15}m	1 1	**Or:** r_0 = 1.2 x 10^{-15}m (1) Need own value
			Total	**20**	

Question			Answer	Marks	Guidance
10	(a)		Complete loop within iron Loop will shorten when coil moves anticlockwise	1 1	 **Allow:** straighten, AW **Ignore:** reference to N and S attracting
	(b)	(i)	Iron has high (relative) permeability Curved poles decrease air gap Flux is therefore increased	1 1 1	**Not:** permeance **Allow**: iron is a good conductor <u>of flux</u> **Allow:** curved faces provide for constant force/torque on rotor **Allow:** flux density/field strength increases
		(ii)	Laminations limit/ reduce eddy currents Eddy currents oppose (existing) flux	1 1	 **Not:** just eddy currents reduce flux **Not:** flux reduction as a consequence of eddy current heating **Allow:** eddy currents set up opposing flux
	(c)		Rate of change of flux (linkage) increases so induced emf increases in opposition to current (from supply)	1 1 1	**Allow:** rate of cutting flux increases **Allow:** answers in terms of back emf that demonstrate clear understanding of cause.
			Total	**10**	

Question			Answer	Marks	Guidance
11	(a)		Radial field Arrows pointing outwards	1 1	**Allow:** any four correct lines
	(b)		$V = 9 \times 10^9 \times 2.5 \times 10^{-9}/4 \times 10^{-3}$ $= 5625$ V	1 1	 Need own value
	(c)	(i)	Taking pairs of points, multiply x and y value values will be constant	1 1	**Allow:** replot data as V against 1/r (1) and showing straight line through origin (1) **Allow:** V halves as r doubles (1) for more than one pair of points (1) **Not:** V decreases as r increases **Not:** replot y against 1/x
		(ii)	$E = V/r$ $= 2800/0.0080 = 350 \times 10^3$ NC^{-1}	1 1	Method must clearly relate to radial field **Or:** gradient of graph at 0.0080m (1) calculation to value in range 300 to 400 kNC^{-1} (1) **Not:** E = V/d (0 marks)
	(d)		Charges will migrate towards outer edges of sphere increasing distance between the centres of charge	1 1	
			Total	**10**	

Question			Answer	Marks	Guidance
12	(a)		anti-(electron) neutrino	1	
	(b)	i	change of mass = 1.42×10^{-3}u = 2.36×10^{-30} kg Energy release = 2.12×10^{-13} J = 1.33 Mev	1 1 1 1	**Allow:** ecf from any stage to next
		(ii)	(Kinetic) energy taken away by (anti) neutrino	1	**Allow:** ecf for particle name only **Not:** energy to create antineutrino **Not:** heat/light (any mention = 0 marks)
	(c)	(i)	activity = $0.693 \times 2.2 \times 10^{20}/4.2 \times 10^{16}$ = 3.6 kBq	1 1	**Or:** $\lambda = 1.65 \times 10^{-17}$ (1) Must have own answer **Allow:** 3.7kBq
		(ii)	dose = $3600 \times 7 \times 10^{-14} \times 3.2 \times 10^{7}/60$ = 1.3×10^{-4} Gy Assumptions clearly stated e.g. All beta particles/energy absorbed by body; no other beta emitters present; level of potassium in body remains constant	1 1 1	**Allow:** 1.3 to 1.5×10^{-4} Gy **Not:** constant rate of decay
		(iii)	risk = $1.3 \times 10^{-4} \times 0.03 \times 50 \times 40 \times 10^{6}$ = 8100	1 1	**Allow:** 7800 to 9000 **Allow:** ecf from (c) (ii) POT error 1 max
			Total	**13**	

Question			Answer	Marks	Guidance
13	(a)	(i)	To stop collisions (taking energy away from protons)	1	**Allow**: AW
		(ii)	Force on protons from B -field is at right angles to their direction of motion	1 1	
	(b)		400 x 1.6 x 10^{-19} x 150 = 9.6 x 10^{-15} J	1	Method mark
	(c)		r = (2 x 1.7 x 10^{-27} x 9.6 x $10^{-15})^{1/2}$/(0.8 x 1.6 x 10^{-19}) = 0.045 m	1 1	 **Allow:** 0.04 **Not:** 0.040 or 0.05 (rounding errors)
	(d)		Any three from: • Gamma factor = (rest energy + kinetic energy)/rest energy • Kinetic energy of both particles the same but the proton rest energy is much greater so gamma factor is larger for electron • Calculation of gamma factors: electron = 1.12 • Calculation of gamma factors: proton = 1.00 • Larger gamma factor for electron means more relativistic behaviour	3	**Allow:** • Electron faster for same KE (1) • Gamma factor is larger explained using formula (1) First marking point can be implicit in correct calculations Last marking point dependent on previous argument
			Total	**9**	

Question			Answer	Marks	Guidance
14	(a)		Use of distance = (150/60) x 400 = 1000 m.	1	Method mark. **Allow:** reverse argument
	(b)		speed is not constant (1) One from: because it accelerates at the start (1) because buoyancy not constant (1) because drag varies (1) because density of atmosphere varies (1) because of vertical component of wind (1) OR: difficult to spot the exact moment of disappearance (1) AW because clouds are diffuse (1) AW	1 1	 **Allow:** other reasonable answers **Not:** variation of g with altitude **Not**: just wind
	(c)		Use of pV/T = constant Giving V = 0.033 m^3	1 1	**Or:** correct use of pV = nRT or pV = NkT **Allow:** 0.0326 **Not:** 0.032, 0.034 Correct bald answer scores both marks
			Total	**5**	

Question			Answer	Marks	Guidance
15	(a)	(i) & (ii)	Any two pairs from… Low density (1) reduces mass/ weight (1) OR Low stiffness/ low Young Modulus (1) Makes balloon flexible/easy to inflate (1) OR Strong/ sufficient breaking stress (1) Balloon must not burst too soon (1) OR Tough/ Not brittle (1) Fabric must not tear/split too soon/when cold (1)	4	Reason must relate to the property **Not:** light for property but BOD for reason **Not:** flexible for property but BOD for reason. **Not:** elastic **Not:** to lift heavy loads
	(b)		Use of circumference = π x D to establish increase in length = 6π or 18.8m strain = x/L = 18.8 / 6.28 = 3 or 300%	1 1	**Allow:** (8 - 2)/2 = 3 for second mark only
	(c)		$V = 4/3\ \pi\ r^3 = 4.19\ m^3$ $m = \rho V = 5.03$ kg B = 5.03 x 9.8 = 49.3 N	1 1 1	**Allow:** ecf from any stage to next **Allow:** 49, 49.26 N
	(d)		Resultant force = 49.3 – (1.25 x 9.8) = 37.0 N a = F / m = 29.6 m s^{-2}	1 1	**Not:** $39.4ms^{-2} – 9.8ms^{-2}$ (0 marks) **Allow:** 30.2 from 50N, 29.4 from 49N

Question			Answer	Marks	Guidance
	(e)		Examples: Balloon expands as it rises (1) so buoyancy increases (1) so larger acceleration (1) Balloon expands at it rises (1) so drag force increases (1) so smaller acceleration (1) Air density decreases with altitude (1) so buoyancy decreases (1) so smaller acceleration (1) Air density decreases with altitude (1) so drag decreases (1) so larger acceleration (1) Balloon is accelerating (1) so drag force increases (1) so acceleration decreases (1) Colder with altitude (1) so volume/buoyancy reduces (1) so acceleration reduces (1) Atmospheric pressure decreases with altitude (1) so volume/buoyancy increases (1) so acceleration increases (1)	3	**Allow:** reasonable alternatives **QWC:** Poorly marshalled arguments cannot lead to more than 2 marks.
			Total	**14**	

Question			Answer	Marks	Guidance
16	(a)		1100 m / 4352 pixels = 0.25 m / pixel	1	**Allow:** 0.253 **Not:** 0.252, 0.3
	(b)	(i)	8 bits required (per colour pixel) bits = 4352 x 3264 x 3 x 8 = 3.4×10^8 bits	1 1	
		(ii)	3.4×10^8 bits = 0.0426 G bytes (1) => 8 Gbytes / 0.0426 = 187.8, so 187 pictures (1) OR 8 Gbytes = 6.4×10^{10} bits (1) 6.4×10^{10} bits/3.4×10^8 bits = 187.8 so 187 pictures (1)	2	**Allow:** ecf from (b)(i) **Not:** 188
			Total	**5**	

Question			Answer	Marks	Guidance
17	(a)		$v = (2E/m)^{½}$ $= 4.3 \times 10^7$ m s^{-1}	1 1	Calculation in (M)eV = 0 marks POT error -1 e.g. 4.3×10^4 for missing M
	(b)		v = d/t = $3.5 \times 10^3 / 0.13 \times 10^{-3}$ = 2.69×10^8 ms^{-1} Then, v/c = 2.69/3.0 = 0.897 i.e 90%	1 1	**Allow:** reverse argument Needs own value or clear method
	(c)		$\gamma = 1/(1 - 0.897^2)^{-½}$ (=2.26 or 2.29) $t = 0.13 \times 10^{-3}/(1 - 0.897^2)^{-½}$ => $t = 5.7 \times 10^{-5}$ s	1 1 1	**Or:** Recognition that t = t'γ or t' = t/γ (1)
			Total	**7**	

Question			Answer	Marks	Guidance
18	(a)		$E = kT = h\,c / \lambda$ $\Rightarrow \lambda = h\,c / k\,T = 5.2 \times 10^{-3}$ m	1 1	**Or:** $E = kT = 3.8 \times 10^{-23}$ (1) **Allow:** use of 3kT/2 for full credit ($E = 5.7 \times 10^{-23}$, $\lambda = 3.5 \times 10^{-3}$)
	(b)		Range = 600 μK Then, 600 μK / 2.7 K = 2.2×10^{-4} = 0.022%	1 1	 Need own value or clear working
	(c)		Reference to early universe mass concentrations/density variation/coalescence of matter/gravity variation formation of galaxies	1 1 1	AW **Allow:** stars **QWC:** three marks only awarded if answer is carefully ordered and clear
			Total	**7**	

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