OCR
Oxford Cambridge and RSA

GCE

Physics B (Advancing Physics)

Unit **G495**: Field and Particle Pictures

Advanced GCE

Mark Scheme for June 2016

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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.

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

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
MP	Marking point
(1)m	a method mark, awarded if a correct method is used
(1)e	an evaluation mark, awarded for correct substitution and evaluation

All marks awarded must be awarded with a tick such that the paper total corresponds to the total number of ticks.
The s.f. penalty on this paper is on question 9 (ii).

Question			Answer	Marks	Guidance
1			C	1	
2			(electrical) potential difference (1) Between A and B (1)	2	Accept: p.d. ;'work done **per unit charge/per coulomb;** 'voltage' ; 'energy difference **per unit charge/per coulomb'** 'potential' alone does not get the mark. Second mark dependent on first
3	a		$E = 500 \times 10^{-6} \times 0.8/20$ (1) = 2×10^{-5} J (1)	2	2 marks for correct bald answer
	(b)		Number of cases = $50 \times 10^{6} \times 500 \times 10^{-6} \times 0.03$ (1) = 750 (1)	2	2 marks for correct bald answer Accept POT error for one mark if working shown and consistent with answer
4	(a)		Correct lines meeting plate at right angles by eye, symmetrical	1	Accept right angle symbol if the line is reasonable. In cases difficult to judge, use protractor tool, angles greater than 80^{o} acceptable.
	(b)		It is weaker (closer to the plate) or it is stronger near the sphere (1) (as) Field lines are further apart (at the plate) or closer together at the sphere	2	Don't accept radial field arguments Accept 'lines are closer together near sphere' but not 'equipotential lines' unless drawn. Second mark dependent on first
5			Changing flux (in the core) (1) Induced **emf** produces eddy currents(1) Laminations reduce eddy currents AW (1) As the laminations are (layers) separated by a poor conductor AW (1)	4	Accept changing field. Quoting Faraday equation alone is not creditworthy. Accept voltage for emf Ignore reference to emf or current in coils 'Laminating with an insulator' is insufficient for two marks.
6			$(938 + E_k) / 938 = 2.5$ (1) E_k= 1400 MeV(1)	2	One mark for total energy identified as 2345 MeV Two marks for correct bald answer Accept 1407, 1410

Question			Answer	Marks	Guidance
7			Flux linkage = 0.07 x 2.4x 10^{-5} x 200 (1) = 3.4 x 10^{-4} (1) Wb turns (1)	3	2 marks for correct bald value Accept Wb, T m^2, T m^2 turns
8			Greater charge on gold <u>nucleus</u>	1	Ignore references to nuclear diameter
			Section A total	20	

Question			Answer	Marks	Guidance
9	(a)	(i)	$\lambda = 4r$ or $\lambda/2 = 2r$	1	Or $r = \lambda/4$ etc
		(ii)	Showing $\frac{p^2}{2m}$ or $E_k = \frac{h^2}{2m\lambda^2}$ (1) Consistent analysis leading to final relationship (1)	2	Ist mark accept: $p^2 = \frac{h^2}{16r^2}$ Accept ecf from(i) for first mark only.
		(iii)	k.e. increases by a factor of 4 (1)	1	Accept '4' or 'increases by 4'
	(b)		p.e. increases by a factor of 2 (1)	1	Accept '2' or 'increases by 2'
	(c)	(i)	$\frac{h^2}{32\, m_e\, r^2} = \frac{e^2}{4\pi\varepsilon_0 r}$ (1) -> Consistent analysis leading to final relationship (1)	2	Penalise inconsistent use of negative sign for one mark.
		(ii)	r = $(6.6 \times 10^{-34})^2 \times 8.9 \times 10^{-12} \times \pi / (8 \times (1.6 \times 10^{-19})^2 \times 9.1 \times 10^{-31})$ (1) = 6.5 x 10^{-11} (1)	2	Correct bald answer to 2 s.f. worth two marks s.f penalty 2 s.f. only
	(d)		Smaller radius, k.e. would be greater than (modulus of) p.e. AW (1) because k.e. has a greater change than p.e. with change of radius AW(1)	2	Do not credit k.e + p.e. > 0 (repeating stem) Accept comparison of inverse square and inverse relationship. Accept 'k.e. changes more quickly'.
			Total	11	

Question			Answer	Marks	Guidance
10	(a)		<table><tr><td>Pion</td><td>π^+</td><td>π^-</td></tr><tr><td>Pion Charge</td><td>+e</td><td>-e</td></tr><tr><td>Quarks</td><td>$u\bar{d}$</td><td>$\bar{u}d$</td></tr></table>	2	+ve sign not required
	(b)	(i)	Momentum must be conserved (1) Initial momentum is zero and as photons have momentum there must be at least two produced (1)	2	Ignore statements about energy and/or charge conservation. AW: two photons have equal and opposite momenta. Need a clear statement showing understanding that photons possess momentum.
		(ii)	$hf = mc^2$ (1) $f = \frac{2.5\times10^{-28}\times(3\times10^8)^2}{6.6\times10^{-34}}$ (1) $= 3.4 \times 10^{22}$ Hz (1)	3	Bald correct answer three marks Do not credit working or answer using de Broglie relationship (via wavelength 8.8 x 10^{-15} m) One mark (out of three) for 1.7×10^{22} Hz or 6.8×10^{22} Hz
	(c)	(i)	ΔE = 1.6 x 10^{-19} x 50 = 0.80 x 10^{-17} J (1)	1	Or 8.0 x 10^{-18} (1 sf OK)
		(ii)	$\frac{1}{2}mv^2 = \frac{1}{2}mu^2 + \Delta E$ 1 $v^2 = u^2 + \frac{2\Delta E}{m}$ = (1.0x10^5)^2 + $\frac{2\times8\times10^{-18}}{2.5\times10^{-28}}$ (1) $v = \sqrt{7.4257\cdots\times10^{10}}$ = 2.7(25) x 10^5 (1) ms^{-1}	3	Or: initial k.e. = 1.25 x 10^{-18} (J) (1) final k.e. = 9.25 x 10^{-18} (J) (1) ΔE = 1 x 10^{-17} gives 11.25 x 10^{-18} (J) v = 2.7(25) x 10^5 (ms^{-1}) (1) ΔE = 1 x 10^{-17} gives 3.0 x 10^5 (m s^{-1}) v = 3.53 x 10^5 scores zero Bald correct answer of 2.7 x 10^5 or 3.0 x 10^5 worth 3 marks
			Total	**11**	

Question			Answer	Marks	Guidance
11	(a)		Energy required to separate the nucleons in a nucleus (divided by the number of nucleons) (1) Calculate the total mass of individual protons and neutrons. (1) Subtract this value from the mass of the (U-235) nucleus (1) Calculate energy from $E = \Delta mc^2$ **and** divide energy calculated by number of nucleons in uranium 235/divide by 235 (1)	**4**	NB 'per nucleon' is not required at this stage as it is in stem of question. Or difference in (rest) energy between nucleons when bound in a nucleus and when separated. Don't accept: energy to remove one nucleon; energy to bind nucleus together or contradictory statements. Don't accept 'uranium atom' Allow mass of nucleons – mass of bound nucleus Credit use of individual rest energies rather than masses. QWC mark awarded for complete and logically presented argument. 4th annotation (if required) goes against the pencil icon.
	(b)		56 (1)	**1**	
	(c)		Total binding energy of U-235 = 235 x – 7.6 = -1786 MeV (1) Binding energy of daughters = (-8.3 x 141) + (-8.5 x 92) = -1952 MeV (1) Change in energy =(-)166 MeV (1)	**3**	Accept treatment of all binding energies as positive. Any clear, complete working to correct value gains three marks Working must be shown.. Bald correct answer to more than two s.f. gains one mark. Using: (-8.3 x 92) + (-8.5 x 141) leading to a value of 176.1 MeV gains first mark only.
	(d)	(i)	reactions per second = $1500 \times 10^6/(170 \times 10^6 \times 1.6 \times 10^{-19})$ (1) = 5.5×10^{19} (1)	**2**	Allow 166 MeV giving 5.6×10^{19} Ecf allow 176 MeV giving 5.3×10^{19} Correct bald answer gains two marks.
		(ii)	$5.5 \times 10^{19} \times 3.2 \times 10^{7} \times 4 \times 10^{-25}$ (1) = 700 kg (1)	**2**	ecf from (d)(i) accept 704 kg allow 5.6×10^{19} giving 720 kg 5.51×10^{19} gives 705 kg Calculator answer from d (i) gives 706 kg allow this even if 5.5×10^{19} is written in working (710 to 2 .s.f)
			Total	**12**	

Question			Answer	Marks	Guidance
12	(a)		F = q v B = 1.6 x 10^{-19} x 1.2 x 0.18 (1) = 3.5 x 10^{-20} N	1	Clear substitution required. Calculator value = 3.456 x 10^{-20} N
	(b)		Four equally spaced vertical lines across shaded area spaced at least two charge symbols apart(1) with arrows directed upwards.(1)	2	Field uniform throughout shaded region
	(c)		V= 0.18 x 1.2 x 1.3 x 10^{-3} (1) = 2.8 x 10^{-4} (1)	2	POT error -1 Correct bald answer two marks
	(d)		Charge carriers have lower velocity (1) by a factor of 10^4(1) the number of charge carriers (m^{-3})must increase by factor of 10^4 (1) as the current is the same and I = $\Delta Q/\Delta t$ (1)	4	Or: to deliver (AW) the same number of electrons per second to provide the same current Or: because *n = I/veA* and *I* is the same.
			Total	**9**	

Question			Answer	Marks	Guidance
13	(a)		130 x 51 x 3600 (1) = 24 x 10^6 J (1)	2	Must see working Own answer required Calculation of intermediate value accepted.
	(b)		P =E/t = 24 MJ / (22 x 24 x 3600 s) (1) = 12.6 W (13 W) (1)	2	25 MJ gives 13.15 W 23.9 MJ gives 12.6 W Allow ecf from (a) on values less than 25 MJ Correct bald answer gains two marks
14	(a)		2800 W / 9 kg = 311 W kg^{-1} (1) which is similar to the "typical" value of 300 in line 24 (1)	2	310 allowed as 2 sf answer Any statement suggesting that the calculated value is near the typical value eg small (4%) difference gains the mark. Accept 'same to one sf.' Second mark dependent on correct first mark.
	(b)		power = (power/area) x total area of panels = 1400 x (2.5 x 7.6 x 2) (1) = 53.2 x 10^3 W i.e. about 50 kJ per sec (1)	2	Working required Own value needed
	(c)		(2 x 2.8) kW / 50kW (1) = 0.11 0.11 x 100 = 11% (1)	2	Using 53.2 kW gives 10.52% = 11% Acceptable alternative approach: output power = mass of panel x answer to (a) no credit for only using one panel (giving 5.5 %) Allow 2.8 kW/26.6 kW = 11% (or 10.52 %) for two marks.
	(d)		(7 x 60) / 97 (1) = 4.3 orbits (1)	2	 Allow 4
	(e)		Inverse sq law so 5.6 kW x 1^2 = P x 5.2^2 (1) So P = 5.6 kW / (5.2^2) = 0.21 kW (1)	2	Or: 14000/5.2^2 = 52 W m^{-2} (1) 52 Wm^{-2} X 38 m^2 X 11% = 0.21kW (1) Accept: 300 W kg^{-1} x 18 kg power calculation giving 199.7 W Own value needed
			Total	**14**	

Question			Answer	Marks	Guidance
15	(a)		Activity = 4400J / ($5.5 \times 10^{6} \times 1.6 \times 10^{-19}$) (1) = 5.0×10^{15} Bq (1)	2	Correct bald answer gains both marks Accept 1sf
	(b)		λ = ln 2 / 88 (= $7.88 \times 10^{-3}\ y^{-1}$)(1) t = ln(4.4/2.5) x 88/ ln 2 (1) = 71.8 years (1)	3	$\lambda = 2.46 \times 10^{-10}\ s^{-1}$ $t = 2.30 \times 10^{9}$ s = 71.8 yrs Credit using different yr -> s conversions for slightly different answers. Or: $0.5^{n} = 2500/4400$ (1) So n = 0.816 half-lives (1) So t = 0.816 x 88 = 71.8yrs (1) Correct bald answer gains three marks
	(c)		Reasons to be concerned: • Alpha **emitting materials** would enter respiratory system or be ingested AW (1) • Alpha particles have large quality factor / are very ionising (1) Shorter half life: max 3 from : • Initial activity would be higher so initially more dangerous • (Activity fades more quickly so) hazard reduces more quickly • Power output reduces more quickly/would not provide power for so long • Needs more of the isotope in order to last lifetime of spacecraft	5	Do not credit answers which confuse inhalation/ingestion of alpha-emitting materials (which can travel large distances) with inhalation/ ingestion of short-range alpha particles. Don't credit 'needs more isotope to provide the same power' unless qualified by 'in the long term' AW Don't credit answers discussing more satellites being launched. QWC mark for clear link of arguments to properties of isotopes.
			Total	**10**	

Question			Answer	Marks	Guidance
16	(a)		Any two pairs from: Factor: conductivity/resistivity (1) Reason: high conductivity/low resistivity produces smaller heating effect/bigger current (1) Factor: density (1) Reason: low density reduces mass (1) Factor: UTS (1) Reason: high UTS won't break easily (1) Factor: toughness (1) Reason: tough material will absorb energy when deforming/won't shatter (1)	4	Not permeance/permeability Or any other sensible factor + reason Not conductance/resistance but can still access reason mark Accept arguments about voltage drop across the resistance of the cable. Not low mass Accept 'strength'
	(b)		r = (6400 + 1000) km (1) So v = 2 π x 7400 x 10^3 / (100 x 60) = 7750 m s^{-1} (1)	2	Ignore rounding errors Accept 7.7 x 10^3 m s^{-1} and 7.8 x 10^3 m s^{-1} Need clear working and own value
	(c)	(i)	Area per second = speed x length = 8000 m s^{-1} x 20000 m = 1.6 x 10^8 m^2 (1)	1	Zero if POT error 7750 m s^{-1} gives 1.55 x 10^8 m^2
		(ii)	Induced emf = rate of change of flux linkage (1) = d(BA) /dt = B dA/dt = 1.6 x 10^8 x 2.1 x 10^{-5} = 3360 V (1)	2	Ecf from ci. First mark can be credited in working if dt = 1 s is explicit 1.6 x 10^8 x 2.1 x 10^{-5} = 3360 V alone gains one mark only
	d		Any four from: (induced) current in tether produces magnetic field (1) Force (= ILB) acts to oppose motion/slow satellite (Lenz's Law)(1) power loss in system due to current in cable (1) Energy transferred from satellite (1) Moves to a lower orbit (1)	4	
			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

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553