OCR
Oxford Cambridge and RSA

GCE

Physics B (Advancing Physics)

Unit **G495**: Field and Particle Pictures

Advanced GCE

Mark Scheme for June 2017

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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

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
(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.

Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	Guidance
1	(a)		neutrino (1)	1	
	(b)		alpha (1)	1	
	(c)		neutrino (1)	1	
2	(a)		B (1)	1	
	(b)		C (1)	1	
3	a		N_s = 800 x 12/240 (1) = 40 turns (1)	2	Accept bare correct answer for 2 marks.
	b		I_p = 4.8/20 (1) OR I_p = 4.8 x (N_s)/800 (1) = 0.24 (A) (1)	2	Accept ECF from (a) for N_s. Accept bare correct answer for 2 marks.
4	a		F = 500 x 10^{-3} x 480 x 10^{-3} x 11.0 x 10^{-2} (1) = 0.026 (N) (1)	2	Accept bare correct answer for 2 marks.
	b		*(B = F/IL or B = F/qv)*: units = kg m s^{-2}/C s^{-1} m (1) Cancellation to kg C^{-1} s^{-1} (1)	2	Must be clear
5	a		v = (2 x 2000 x 1.6 x 10^{-19}/9.1 x 10^{-31})$^{1/2}$ (1) = 2.7 x 10^7 (m s^{-1}) (1)	2	Can calculate value of k.e. and substitute.
	b		rel factor = (0.51 + 0.002)/0.51 = 1.004 (1) this is close to 1 (1) (hence calculation in (a) is reasonable)	2	
6			Any three from: • p.e. of electron is negative, k.e. is positive • k.e. of electron increases with decreasing wavelength • .. more quickly than p.e. becomes more negative • atom unstable when (magnitude of) k.e. greater than p.e.	3	
			Section A Total	20	

Question			Answer	Marks	Guidance
7	a		Continuous loop passing through the letters N and S, with correct arrow. (1) Threading the coil, mostly within the iron core (1)	2	Independent mark.
	b	i	Sinusoidal shape centred on 0 V, correct period, constant amplitude, at least one cycle (1) 90^{o} ahead or behind of printed line. (1)	2	Judge by eye
	b	ii	Number of revolutions s^{-1} = 1/15 x 10^{-3} (1) = 67 (1)	2	Accept 1/15.1 x 10^{-3} (1) leading to 66 (1)
	b	iii	0.8/320 (1) = 2.5 x 10^{-3} Wb s^{-1} (1)	2	
	c		Any four of: • reduces eddy currents • caused by change of flux (linkage)(in the core) • by increasing (electrical) resistance of the core • eddy currents create magnetic field or flux • which reduce field or flux of rotor (in the core) • eddy currents dissipate energy in the core • laminations increase flux/flux density/flux linkage	4	or decreasing conductance
			Total	12	

Question			Answer	Marks	Guidance
8	a		Equally-spaced vertical lines (1) Downwards arrow on each line (1)	2	Allow some curvature near edge of plate.
	b		$4.6 \times 10^{-14}/1.6 \times 10^{-19}$ (1) = 2.9×10^{5} electrons (1) Electrons have been added because they / the sphere are attracted to top plate (1) as force is equal and opposite to weight acting downwards (1)	4	Accept 'force balances weight'
	c		Weight calculated = 7.1×10^{-8} N (1) Equating weight with qV/d (1) $V = 7.1 \times 10^{-8} \times 10 \times 10^{-3}/4.6 \times 10^{-14}$ (1) $= 1.5 \times 10^{4}$ (V) (1)	4	Correct bare answer gains all marks
	d		Three from: • beta particles are identified as electrons/charged particles • which cause ionisation • (opposite) ions attracted to charged sphere • Transferring charge to it • Reducing charge on sphere p.d. must be increased to keep sphere stationary as less charge on sphere produces lower upward force (for given p.d.) (1)	4	Final mark only available if explanation is clear.
			Total	14	

Question			Answer	Marks	Guidance
9	a		nucleon number = 218, (1) proton number = 84 (1)	2	
	b	i	Two from • Gammas ionise less (than alphas) • Most gammas will pass through body • All alphas will be absorbed by small mass of tissue	2	Accept lower quality factor
	b	ii	Energy from one cascade $= 6.3 \times 10^{6} \times 1.6 \times 10^{-19} = 1.0 \times 10^{-12}$ J (1) Effective dose from one cascade $= 1.0 \times 10^{-12}$ J x 20 /70kg $= 2.88 \times 10^{-13}$ Sv (1) Matched dose rate = 47% x 2.5 mSv per year $= 47\% \times 2.5$ mSv $/ 3.2 \times 10^{7}$ s $= 3.67 \times 10^{-11}$ Sv s^{-1} (1) Activity = 3.67×10^{-11} Sv s^{-1} / 2.88×10^{-13} Sv = 127 (Bq) (1)	4	There are other valid ways to work through this question, including the reverse argument. .
	c		Calculation of decay constant = 2.1×10^{-6} s^{-1} (1) $N = 130/2.1 \times 10^{-6}$ (1) $= 6.2 \times 10^{7}$ (1)	3	Allow ecf from bii for activity
			Total	11	

Question			Answer	Marks	Guidance
10	a		Two pairs from: nucleus is much more massive than proton (1) linked to little energy loss in collision (1) nucleus is small compared with atom / atom mostly empty space (1) linked to most protons pass straight through (1) nucleus is positive (1) linked to a few protons are reflected (1)	4	The second mark of each pair to be awarded only if linkage is clear.
	b		potential energy of proton at closest approach = $9.0 \times 10^{9} \times 1.6 \times 10^{-19} \times 4.2 \times 10^{-18} / 3.2 \times 10^{-14}$ (1) = 1.89×10^{-13} J (1) = 1.2×10^{6} eV (1) Proton must have at least this energy because it has K.E. at the point of closest approach (1)	4	
			Total	8	

Question			Answer	Marks	Guidance
11			[photon energy/sec] = J s^{-1} = W (1) [area] = m^2 (1) So [intensity] = W m^{-2}	2	
12			E/kT = 13.6 x 1.6 x 10^{-19}/ 1.38 x 10^{-23} x 15 x 10^6 (1) So BF = $e^{-(E/kT)}$ =0.99 (1) Which is significant for the BF as largest possible value is 1.0 (1) High BF means high probability of ionisation occurring (1)	4	Third mark requires clear statement that 0.99 represents a high Boltzmann factor. AW Fourth mark requires a clear link between *f* and the likelihood of ionisation occurring.
13			Area under curve represents total radiation (1) The area increases with T (1)	2	
14			Each equal spatial increment on axis (1) represents a factor change of 2x (1)	2	Allow factor of x 0.5 because decreasing left to right. Allow an unspecified 'constant factor'. Do not allow a factor of x10 or x100.
15	a		Along the R = 1 line (1) As T increases (from right to left), L increases (1)	2	Accept 'line of constant R' Must refer to the line to gain this mark.
	b		Betelgeuse is cooler than the Sun yet more luminous (1) Must have a larger surface area from which photons are emitted (1)	2	Accept any other suitable argument eg reference to Fig 3, comparison with another star.
16			tan θ = 1 AU / d (1) Thus, d = 1 AU / tan θ = 7.16 x 10^5 AU / 1.1 x10^{17}m (1) Distance in light years = 7.16 x 10^5 x 1.5 x 10^{11}/(3.0 x 10^8 x 3.2 x 10^7) (1) = 11 (light years) (1)	4	Accept any suitable small angle approximation. Allow ecf within question

17	**a**		$v = (2\pi \times 2.25 \times 10^{12} / 3.2 \times 10^{7} \times 41) = 10800$ m s^{-1} (1) $a = v^2/r = (10800)^2/2.25 \times 10^{12}$ (1) $= 5.2 \times 10^{-5}$ (m s^{-2}) (1)	**3**	
	b		$GMm/r^2 = m v^2 / r$ (1) $M = (10800)^2 \times 2.25 \times 10^{12} / 6.67 \times 10^{-11}$ $= 3.9 \times 10^{30}$ (kg) (1)	**2**	Accept M = ar^2/G with substitution of a from (a)
18			Recognition that $I \propto L / r^2$ (1) Statement $I_1/I_2 = L_1 r_2^2 / L_2 r_1^2$ (1) ratio = $1.3 \times 10^{26} \times (6.9 \times 10^{17})^2 / 2.4 \times 10^{28} \times (9.5 \times 10^{16})^2$ (1) $= 0.29$ (1)	**4**	Other routes are possible e.g. separate calculations of L_1 / r_1^2 and L_2 / r_2^2. Calculation for a single factor (L or r) 1 mark max.
19	**a**		Any 4 from: • Electrostatic repulsion between protons • Force varies with $1/r^2$ • High potential energy barrier to overcome • Before strong nuclear force binds nucleons • Protons have greater kinetic energy at higher temperatures • Use of Boltzman factor	**4**	e.g. 'At higher temperatures a higher proportion of protons have enough energy to overcome the repulsion'
	b		$P = \Delta E / \Delta t$ and $\Delta E = \Delta m c^2$ (1) Current rate of mass conversion = $3.9 \times 10^{26} / (3 \times 10^8)^2$ $= 4.3 \times 10^9$ kg s^{-1} (1) Δm = 15% of $2 \times 10^{30} = 3 \times 10^{29}$ kg (1) So $\Delta t = 3 \times 10^{29}$ kg / 4.3×10^9 kg s^{-1} $= 6.92 \times 10^{19}$ s $= 2.2 \times 10^{12}$ years (1)	**4**	
			Section C Total	**35**	

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