

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.

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Annotations

| 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 |

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 | $N_s = 800 \times 12/240$ (1) = 40 turns (1) | 2 | Accept bare correct answer for 2 marks. |
| | b | $I_p = 4.8/20$ (1) OR $I_p = 4.8 \times (N_s)/800$ (1) = 0.24 (A) (1) | 2 | Accept ECF from (a) for N_s . Accept bare correct answer for 2 marks. |
| 4 | a | $F = 500 \times 10^{-3} \times 480 \times 10^{-3} \times 11.0 \times 10^{-2}$ (1) = 0.026 (N) (1) | 2 | Accept bare correct answer for 2 marks. |
| | b | ($B = F/IL$ or $B = F/qv$): units = $\text{kg m s}^{-2}/\text{C s}^{-1} \text{ m}$ (1) Cancellation to $\text{kg C}^{-1} \text{ s}^{-1}$ (1) | 2 | Must be clear |
| 5 | a | $v = (2 \times 2000 \times 1.6 \times 10^{-19}/9.1 \times 10^{-31})^{1/2}$ (1) = 2.7×10^7 (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: <ul style="list-style-type: none"> • 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° ahead or behind of printed line. (1) | 2 | Judge by eye |
| | b | ii | Number of revolutions $s^{-1} = 1/15 \times 10^{-3}$ (1) = 67 (1) | 2 | Accept $1/15.1 \times 10^{-3}$ (1) leading to 66 (1) |
| | b | iii | $0.8/320$ (1) = $2.5 \times 10^{-3} \text{ Wb s}^{-1}$ (1) | 2 | |
| | c | Any four of: <ul style="list-style-type: none"> • 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) = 1.5×10^4 (V) (1) | 4 | Correct bare answer gains all marks |
| | d | Three from: <ul style="list-style-type: none"> • 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>p.d. must be increased to keep sphere stationary as less charge on sphere produces lower upward force (for given p.d.) (1)</p> | 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 | 2 | Accept lower quality factor |
| | | Two from <ul style="list-style-type: none"> • Gammas ionise less (than alphas) • Most gammas will pass through body • All alphas will be absorbed by small mass of tissue | | |
| | b | ii | 4 | There are other valid ways to work through this question, including the reverse argument. . |
| | | Energy from one cascade $= 6.3 \times 10^6 \times 1.6 \times 10^{-19} = 1.0 \times 10^{-12} \text{ J}$ (1) Effective dose from one cascade $= 1.0 \times 10^{-12} \text{ J} \times 20 / 70 \text{ kg} = 2.88 \times 10^{-13} \text{ Sv}$ (1) Matched dose rate = 47% x 2.5 mSv per year $= 47\% \times 2.5 \text{ mSv} / 3.2 \times 10^7 \text{ s} = 3.67 \times 10^{-11} \text{ Sv s}^{-1}$ (1) Activity = $3.67 \times 10^{-11} \text{ Sv s}^{-1} / 2.88 \times 10^{-13} \text{ Sv}$ $= 127 \text{ (Bq)}$ (1) | | |
| | c | Calculation of decay constant = $2.1 \times 10^{-6} \text{ s}^{-1}$ (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 | <p>Two pairs from:</p> <p>nucleus is much more massive than proton (1) linked to little energy loss in collision (1)</p> <p>nucleus is small compared with atom / atom mostly empty space (1) linked to most protons pass straight through (1)</p> <p>nucleus is positive (1) linked to a few protons are reflected (1)</p> | 4 | The second mark of each pair to be awarded only if linkage is clear. |
| | b | <p>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) $= 1.89 \times 10^{-13} \text{ J}$ (1) $= 1.2 \times 10^6 \text{ eV}$ (1)</p> <p>Proton must have at least this energy because it has K.E. at the point of closest approach (1)</p> | 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 | | $E/kT = 13.6 \times 1.6 \times 10^{-19} / 1.38 \times 10^{-23} \times 15 \times 10^6$ (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 $\times 0.5$ because decreasing left to right. Allow an unspecified 'constant factor'. Do not allow a factor of $\times 10$ or $\times 100$. |
| 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 | | $\tan \theta = 1 AU / d$ (1) Thus, $d = 1 AU / \tan \theta = 7.16 \times 10^5 AU / 1.1 \times 10^{-7} rad$ (1) Distance in light years = $7.16 \times 10^5 \times 1.5 \times 10^{11} / (3.0 \times 10^8 \times 3.2 \times 10^7)$ (1) = 11 (light years) (1) | 4 | Accept any suitable small angle approximation. Allow ecf within question |

| | | | | |
|------------------------|---|---|-----------|---|
| 17 | a | $v = (2\pi \times 2.25 \times 10^{12} / 3.2 \times 10^7 \times 41) = 10800 \text{ m s}^{-1} \text{ (1)}$ $a = v^2/r = (10800)^2 / 2.25 \times 10^{12} \text{ (1)}$ $= 5.2 \times 10^{-5} \text{ (m s}^{-2}\text{) (1)}$ | 3 | |
| | b | $GMm/r^2 = m v^2 / r \text{ (1)}$ $M = (10800)^2 \times 2.25 \times 10^{12} / 6.67 \times 10^{-11}$ $= 3.9 \times 10^{30} \text{ (kg) (1)}$ | 2 | Accept $M = ar^2/G$ with substitution of a from (a) |
| 18 | | Recognition that $I \propto L / r^2 \text{ (1)}$ Statement $I_1/I_2 = L_1 r_2^2 / L_2 r_1^2 \text{ (1)}$ $\text{ratio} = 1.3 \times 10^{26} \times (6.9 \times 10^{17})^2 / 2.4 \times 10^{28} \times (9.5 \times 10^{16})^2 \text{ (1)}$ $= 0.29 \text{ (1)}$ | 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: <ul style="list-style-type: none"> • 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 | $P = \Delta E / \Delta t \text{ and } \Delta E = \Delta m c^2 \text{ (1)}$ Current rate of mass conversion $= 3.9 \times 10^{26} / (3 \times 10^8)^2$ $= 4.3 \times 10^9 \text{ kg s}^{-1} \text{ (1)}$ $\Delta m = 15\% \text{ of } 2 \times 10^{30} = 3 \times 10^{29} \text{ kg (1)}$ So $\Delta t = 3 \times 10^{29} \text{ kg} / 4.3 \times 10^9 \text{ kg s}^{-1}$ $= 6.92 \times 10^{19} \text{ s}$ $= 2.2 \times 10^{12} \text{ years (1)}$ | 4 | |
| Section C Total | | | 35 | |

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