Mark scheme January 2002

GCE

Physics A

Unit PA08

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Instructions to Examiners

1 Give due credit to alternative treatments which are correct. Give marks for what is correct; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the script to the Awardsmeeting if poor presentation forbids a proper assessment. In each paper candidates may be awarded up to two marks for the Quality of Written Communication in cases of required explanation or description. However, no candidate may be awarded more than the total mark for the paper. Use the following criteria to award marks:

2 marks: Candidates write with almost faultless accuracy (including grammar, spelling and appropriate punctuation); specialist terms are used confidently, accurately and with precision.

1 mark: Candidates write with reasonable and generally accurate expression (including grammar, spelling and appropriate punctuation); specialist terms are used with reasonable accuracy.

0 marks: Candidates fail to reach the threshold for the award of one mark.

3 An arithmetical error in an answer should be marked 'AE' thus causing the candidate to lose one mark. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks (indicated by ticks). These subsequent ticks should be marked 'CE' (consequential error).

4 With regard to incorrect use of significant figures, normally a penalty is imposed if the number of significant figures used by the candidate is one less, or two more, than the number of significant figures used in the data given in the question. The maximum penalty for an error in significant figures is **one mark per paper**. When the penalty is imposed, indicate the error in the script by 'SF' and, in addition, write 'SF' opposite the mark for that question on the front cover of the paper to obviate imposing the penalty more than once per paper.

5 No penalties should be imposed for incorrect or omitted units at intermediate stages in a calculation or which are contained in brackets in the marking scheme. Penalties for unit errors (incorrect or omitted units) are imposed only at the stage when the final answer to a calculation is considered. The maximum penalty is **one mark per question**.

6 All other procedures, including the entering of marks, transferring marks to the front cover and referrals of scripts (other than those mentioned above) will be clarified at the standardising meeting of examiners.

Section A: Nuclear Instability

1(a)(i) (inner) orbiting electron [or electron surrounding the nucleus] ✓
captured by a <u>proton</u> (in the nucleus) ✓
converted into a neutron ✓

(ii) daughter nuclide/nucleus/atom might be excited and
energy given up as electromagnetic radiation
[or orbiting electrons drop down to fill space (left by captured electron)] ✓

(iii) ${}^{203}_{83}\text{Bi} \rightarrow {}^{203}_{82}\text{Pb} + {}_{1}\beta^{+}$ ✓ $+ \nu_{(e)}$ ✓ ($+Q$) [allow ${}^{0}_{1}e^{+}$ for ${}_{1}\beta^{+}$] max (5)

(b)(i) (use of $N = N_0 e^{-\lambda t}$ and $N \propto$ activity gives)
$290 = 1200 \exp(-\lambda \times 24 \times 60 \times 60)$ ✓
$\lambda = \dfrac{\ln(1200/290)}{24 \times 60 \times 60}$ ✓ $(= 1.64 \times 10^{-5}\ \text{s}^{-1})$

(ii) (use of $T_{½} = \ln 2/\lambda$ gives) $T_{½} = \dfrac{\ln 2}{1.64 \times 10^{-5}}$ ✓
$= 4.2(3) \times 10^{4}$ s ✓ (= 11.(7) hr)
(use of $\lambda = 1.6 \times 10^{-5}\text{s}^{-1}$ gives $T_{½} = 4.3 \times 10^{4}$ s or 12 hr)

(iii) (use of $\dfrac{\Delta N}{\Delta t} = -\lambda N$ gives) $(-)1200 = (-)1.64 \times 10^{-5}\ N$ ✓
$N = 7.3(2) \times 10^{7}$ (nuclei) ✓
(use of $\lambda = 1.6 \times 10^{-5}\ \text{s}^{-1}$ gives $N = 7.5 \times 10^{7}$ (nuclei)) max (5)

<u>(10)</u>

Section B: Turning Points in Physics

2(a) two waves in phase in planes perpendicular to each other ✓
waves labelled E and B (or similar) ✓
direction of propagation shown or stated ✓ (*3*)

(b)(i) magnetic wave causes alternating magnetic field (or flux) through loop ✓
induced emf in loop due to changing magnetic flux (in loop) ✓

(ii) radio wave is polarised ✓
no magnetic flux passes through the loop in new position ✓ (*4*)

(*7*)

3(a) as speed $\rightarrow c$, mass $\rightarrow$ infinite ✓
gain of E_k causes large gain of mass when speed is close to c ✓
gain of E_k causes small gain of speed when speed is close to c ✓
$E_k = \frac{1}{2}mv^2$ valid at speeds $<<c$ ✓ max (*3*)

(b)(i) $E_k = eV = 1.6 \times 10^{-19} \times 2.1 \times 10^{10}$ ✓ $(= 3.3(6) \times 10^{-9}$ J)

(ii) (use of $m = \frac{E_k}{c^2}$ gives) gain of mass $= \frac{3.36 \times 10^{-9}}{(3 \times 10^8)^2} = 3.7 \times 10^{-26}$ (kg) ✓

$$= \frac{3.7 \times 10^{-26}}{1.67 \times 10^{-27}} m_0 = 22\, m_0$$ ✓

mass of proton $= 22\, m_0 + m_0$ ✓ $(= 23\, m_0)$

(using $E_k = 3.4 \times 10^{-9}$ gives gain of mass $= 3.8 \times 10^{-26}$ (kg) $\equiv 23\, m_0$
and mass of proton $= 24\, m_0$) (*4*)

(c) $$23 = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}$$ ✓

$$\frac{v^2}{c^2} = \left(1 - \frac{1}{23^2}\right) = 0.998$$ ✓

$v = 0.999\, c = 2.99(7) \times 10^8$ m s^{-1} ✓ (*3*)

(*10*)

4(a) (use of $v = \frac{s}{t}$ gives) $v = \frac{2.0 \times 10^{-3}}{18.3} = 1.11 \times 10^{-4}\,\text{m s}^{-1}$ ✓ (*1*)

(b) $^4/_3\, \pi r^3 \rho g = 6\pi\eta v r$ ✓

$r = \left(\frac{9\eta v}{2\rho g}\right)^{1/2}$ ✓

$= \left(\frac{9 \times 1.8 \times 10^{-5} \times 1.11 \times 10^{-4}}{2 \times 970 \times 9.81}\right)^{1/2}$ ✓ $(= 9.7 \times 10^{-7}\,\text{m})$

(allow C.E. for v from (a)) (*3*)

(c) $qE = mg$ ✓

$m = {}^4/_3\pi r^3 \rho = {}^4/_3\pi (9.7 \times 10^{-7})^3 \times 970 = 3.7 \times 10^{-15}\,\text{kg}$ ✓

$q\ (= \frac{mg}{E}) = \frac{3.7 \times 10^{-15} \times 9.81}{57 \times 10^3} = 6.37 \times 10^{-19}\,\text{C}$ ✓

(allow C.E. for value of mass m) (*3*)

(*7*)

5(a)(i) $E_k = eV = 1.6 \times 10^{-19} \times 20 \times 10^3 = 3.2 \times 10^{-15}$ (J) ✓

$v = \left(\frac{2E_k}{m}\right)^{1/2} = \left(\frac{2 \times 3.2 \times 10^{-15}}{9.11 \times 10^{-31}}\right)^{1/2} = 8.4 \times 10^7\,\text{m s}^{-1}$ ✓

(ii) (use of $\lambda = \frac{h}{p}$ gives) $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 8.4 \times 10^7}$ ✓

$= 8.7 \times 10^{-12}\,\text{m}$ ✓

(allow C.E. for value of ν from (i))

[or $\lambda = \frac{h}{(2meV)^{1/2}}$ with ✓ for correct substitution and

✓ for correct answer] (*4*)

(b) image would be brighter because more electrons reach the screen per sec ✓
image would be more detailed because de Broglie wavelength would be reduced ✓
and because speed of the electrons is increased ✓ max (*2*)

(*6*)

The Quality of Written Communication marks are awarded primarily for the quality of answers to Q1(a)(i)(ii) and Q3(a).