ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme June 2002

GCE

Physics A

Unit PHA6/W

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales 3644723 and a registered charity number 1073334
Registered address: Addleshaw Booth & Co., Sovereign House, PO Box 8, Sovereign Street, Leeds LS1 1HQ
Kathleen Tattersall: *Director General*

Unit 6: Medical Physics

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 Awards meeting 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 who fail to reach the threshold for the award of one mark.

3 An arithmetical error in an answer should be marked A.E. 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 C.E. (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 S.F. and, in addition, write S.F. 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

1(a)(i) α (radiation) ✓

(ii) γ (radiation) ✓ (*2*)

(b)(i) the radiation needs to pass through the body (to be detected) ✓

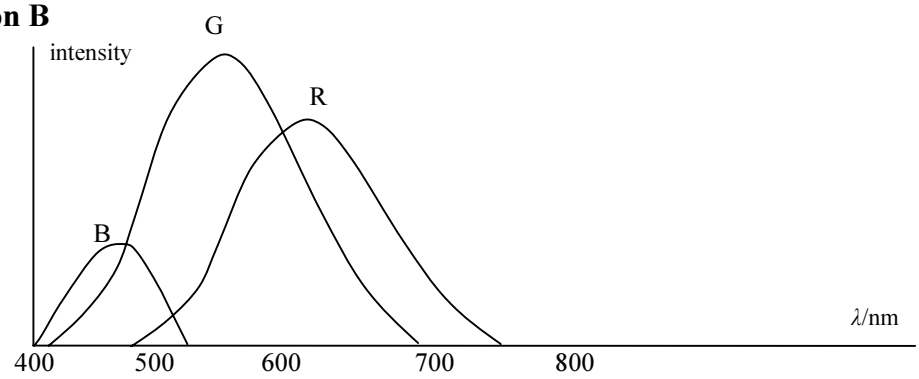
(ii) (otherwise) the activity of the source becomes too weak (during measurements) ✓

(iii) the decaying source may remain in the body for a long time and could cause damage ✓
[or the activity of the source will be low unless a large quantity is used ($T_{1/2} \propto 1/\lambda$)] (*3*)

(c) corrected count rate at 0.2 m (= 2550 − 50) = 2500 (c min^{-1}) ✓
corrected count rate at least distance (= 6000 − 50) = 5950 (c min^{-1}) ✓
use of $I = k\frac{I_o}{x^2}$ (or in the form $\frac{I_1}{I_2} = \left(\frac{x_2}{x_1}\right)^2$) ✓
(allow C.E. for using uncorrected count rate)
gives least distance = $0.20 \times \left(\frac{2500}{5950}\right)^{1/2}$ ✓
least distance = 0.13 m ✓ (*5*)
(*10*)

Section B

2(a)



three overlapping colour curves labelled blue, green and red ✓
unit and scale on wavelength axis ✓
peaks at ≈ 430 (blue), 520 (green), 570 (red) ✓(± 30 for each)
ranges ≈ 400 - 520 (blue), 430 -670 (green), 480 - 730 (red) ✓ (± 30) (*4*)

(b)(i) two stimulated receptors must be separated by
(at least) one unstimulated receptor ✓

(ii) (in bright light) cones activated ✓
cones smaller than rods ✓
angular separation thus smaller ✓ $_{max}$(3)

(c)(i) lights flashing at ≥ 20 Hz appear steady
[or image appears steady although stimulus is flashing] ✓

(ii) any correct example e.g. cine films, television ✓ (*2*)
(*9*)

3(a) 1: vacuum/evacuated (tube) ✓
2: lead (lined shield) ✓
3: electrons (beam) ✓ (*3*)

(b)(i) heat is spread over a greater volume/area/section ✓
thus allows more energetic X-rays to be produced
[or allows X-rays to be generated for longer] ✓

(ii) (bevelled edge) gives larger target area ✓
but small source area (to produce sharp image) ✓ $_{max}$(*3*)

(c)(i) the fraction of X-rays removed per unit thickness of the material ✓

(ii) the thickness of the material which will reduce the intensity
to half its original level ✓
for a specified energy of the X-rays (in either (i) or (ii)) ✓ $_{max}$(*2*)

(d) (use of $\mu = \frac{\ln 2}{t_{1/2}}$ gives) $\mu = \frac{\ln 2}{3.2} = 0.22\ \text{mm}^{-1}$ ✓ ($0.217\ \text{mm}^{-1}$)
(use of $I = I_o\, e^{-\mu x}$ gives) $I = 6.0 \times e^{-0.217 \times 2}$ ✓
(allow C.E. for value of μ)
$= 3.9\ \text{W m}^{-2}$ ✓ (*3*)
(*11*)

4(a)(i) $Z_{air} = 330 \times 1.3 = 430$ kg m^{-2} s^{-1} ✓

(ii) $Z_{tissue} = 1540 \times 1100 = 1.7 \times 10^6$ (kg m^{-2} s^{-1}) ✓

(iii) (use of $\frac{I_r}{I_i} = \left[\frac{(Z_2 - Z_1)}{(Z_2 + Z_1)}\right]^2$ gives) $\frac{I_r}{I_i} = \left[\frac{1700000 - 430}{1700000 + 430}\right]^2 = 0.999$ ✓ (*3*)

(allow C.E. for values from (i) and (ii))

(b) without gel, air between probe and tissue ✓
reflects nearly all the ultrasound or very little enters the body ✓
with gel air excluded and require $I_r = 0$ ✓
$\therefore Z_{gel} = 1.7 \times 10^6$ or equals that of skin/tissue ✓ $_{max}$(*3*)

(c)(i) transmitter produces <u>short</u> pulses
at internal boundary some reflected, rest transmitted to next boundary
reflected pulse received by probe and signal sent to oscilloscope
oscilloscope sweep started when pulse is first transmitted
(any two) ✓ ✓

(ii) time taken between pulses from front and back of organ
(from oscilloscope) ✓
distance = speed $\times \frac{\text{time}}{2}$ ✓ <u>(*4*)</u>

<u>(*10*)</u>

The Quality of Written Communication marks are awarded primarily for the quality of answers to Q4(b)(c) and Q3(b)