Version 1.2: 0607

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6451
Specification A

PHA5/W Astrophysics

Mark Scheme

2004 examination - January series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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. Use the following criteria to award marks:

2 marks: Candidates write legibly with accurate spelling, grammar and punctuation; the answer containing information that bears some relevance to the question and being organised clearly and coherently. The vocabulary should be appropriate to the topic being examined.

1 mark: Candidates write with reasonably accurate spelling, grammar and punctuation; the answer containing some information that bears some relevance to the question and being reasonably well organised. Some of the vocabulary should be appropriate to the topic being examined.

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 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 two, three or four significant figures will be acceptable. Exceptions to this rule occur if the data in the question is given to, for example, five significant figures as in values of wavelength or frequency in questions dealing with the Doppler effect, or in atomic data. In these cases up to two further significant figures will be acceptable. 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.

Units 5 - 9 : Section A

(this question is common to all Option Modules PHA5/W - PHA9/W)

1

(a) (on grid: first arrow to start from $^{210}_{82}Pb$; arrows must be consecutive;
last arrow must end on $^{206}_{82}Pb$)
arrow showing the change for an α emission ✓
arrow showing the change for a β emission ✓
correct α and two β emissions in any order ✓ (*3*)

(b) (positron emission) $^{64}_{29}Cu \rightarrow ^{64}_{28}Ni + \beta^{+} + \nu_e$ (+Q) ✓✓

(electron capture) $^{64}_{29}Cu + ^{0}_{-1}e \rightarrow ^{64}_{28}Ni + \nu_{(e)}$ (+Q) ✓✓ (*4*)

(c) (the following examples may be included)

α particles ✓
coulomb/electrostatic/electromagnetic repulsion
[or K.E. converted to P.E. (as α particle approaches nucleus)] ✓
information:
any of the following: proton number, nuclear charge,
upper limit to nuclear radius
mass of nucleus is most of the mass of atom ✓

[alternative
(high energy) electron (scattering) ✓
diffraction of de Broglie Waves by nucleus ✓
information:
any of the following: nuclear radius, nuclear density ✓] (*3*)
(*10*)

Unit 5: Section B

2

(i) real ✓
inverted ✓

(ii) diagram to show :
ray parallel to axis through F with F labelled ✓
ray through centre of lens to give (indicated) magnified image ✓

(iii) (use of $P = \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ gives) $P = \frac{1}{0.17} + \frac{1}{1.62}$ ✓
$= 6.5$ D ✓ *(6)*

(6)

3

(a)(i) light year : distance travelled by light in one year ✓

(ii) parsec : distance to an object subtending 1 sec of arc to Earth's orbit ✓ *(2)*

(b)(i) $d = \left(\frac{450}{3.26}\right) = 138$ pc ✓
$m - M$ (= 5 log(d/10)) = 5 log(138/10) = 5.7 ✓ (5.45)
$M = (5.1 - 5.7) = -0.6$ ✓
(allow C.E. for value of d)

(ii) A OBAFGKM is order of spectra for decreasing temperature
(or similar reference to spectral class related to temperature) ✓

(iii) A same brightness/power, but A is hotter ✓
∴ since $P = \sigma AT^4$, area must be smaller for larger T ✓ max(*5*)

(c) θ ($= 1.8 \times 10^{-3}$ °) $= 3.1 \times 10^{-5}$ rad ✓
(use of $\theta = \frac{\lambda}{d}$ gives) $d = \frac{5.0 \times 10^{-7}}{3.1 \times 10^{-5}} = 1.6 \times 10^{-2}$ m ✓ *(2)*

(9)

4

(a)(i) correct shape of graph (steeper on left of peak) ✓

(ii) region to left of peak ✓

(iii) ozone ✓

(iv) lower temperature, hits peak (λ_{max}) to longer wavelengths ✓
$\lambda_{max} T$ = constant ✓ $_{max}$(*4*)

(b)(i) (use of $f = \frac{c}{\lambda}$ gives) $f\left(= \frac{3 \times 10^8}{2.7}\right) = 1.1 \times 10^8$ Hz, (in range) ✓

(ii) (double) Doppler ✓

(iii) (reflection off moving object gives double Doppler), frequency shift = 150 Hz ✓
$v = \frac{150 \times 3 \times 10^8}{1.1 \times 10^8}$ ✓
(allow C.E. for shift = 300 Hz)
$= 4.1 \times 10^2$ m s^{-1} (towards each other) ✓ (*5*)
(*9*)

5

main features :
expanding Universe (from single point) ✓
suggest about 15 billion years ago ✓
'explosion' - creation of space/matter/time ✓

evidence :
red shift of distant galaxies ✓
in keeping with Hubble's law ✓
Hubble's law can be used to age Universe ✓ $_{max}$(*4*)
(*4*)

Quality of Written Communication (Q1(c) and Q5) ✓✓ (*2*)
(*2*)