A-level
PHYSICS
7408/3BB

Paper 3 Section B Medical physics

Mark scheme

June 2024

Version: 1.0 Final

2 4 6 A 7 4 0 8 / 3 B B / M S

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' 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.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

Physics - Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.
2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.
2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution / working and this is shown in the 'extra information' column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do <u>not</u> allow

'Ignore' or 'insufficient' is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

'Do **not** allow' means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, an A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf -1).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word 'Show that…', the answer should be quoted to **one more** sf than the sf quoted in the question eg 'Show that X is equal to about 2.1 cm' –

answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of 'Give your answer to an appropriate number of significant figures'.

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of 'State an appropriate SI unit for your answer'. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 Wb m^{-2} would both be acceptable units for magnetic flux density but 1 kg m^2 s^{-2} A^{-1} would not.

3.10 Level of response marking instructions

Level of response mark schemes are broken down into three levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are two marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level. ie if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01.1	myopia ✓	Allow short sightedness	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Max one from ✓ • Evidence of with $u = \infty$ and $v = -6$ ✓a • Correct use of a power equation ✓b $P\left(=\frac{1}{f}\right) = -0.17\,(\text{D})$ ✓	✓b $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ with: • $u = \infty$, v = (-)6 • $u = \infty$, v = 0.02 • $u = 6$, v = 0.02 Where $u = \infty$, condone missing $\frac{1}{u}$ Allow $\frac{1}{(-)6} + \left(\frac{1}{\infty}\right)$ if u and v not defined Correct answer ✓✓ Max 1 mark for correct answer where clear statement that v = ∞ and u =-6 ECF for hypermetropia/ long sightedness on **01.1** $\frac{1}{f} = \frac{1}{0.25} + \frac{1}{(-)6}$ ✓ = 3.83 ✓ (D)	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	spherical cylinder axis ✓		1	AO1

Total			4

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Max 3 from ✓✓✓ Use of $I = I_0 10^{\frac{IL}{10}}$ to find intensity ✓a Intensity reduction factor of 0.40 ✓b Multiply the **intensity** by 0.40 or 0.60 ✓c Use of $IL = 10\log\left(\frac{I}{I_0}\right)$ to find intensity level ✓d 106 (dB) ✓	✓a $I\left(=I_0 10^{\frac{IL}{10}}\right) = 10^{-12}10^{\frac{110}{10}} (= 0.10\ \text{W m}^{-2})$ ✓b condone reduction of intensity level ✓c $I = 0.10 \times 0.40$ ($= 0.040\ \text{W m}^{-2}$) ✓d $IL = \left(10\log\left(\frac{I}{I_0}\right) = 10\log\left(\frac{0.040}{10^{-12}}\right)\right) = 106\,(\text{dB})$ ✓d substitution for I must be an intensity, not an intensity level 1 mark for answer of 108 (dB) with no supporting working **Alternative method** Max 3 from ✓✓✓ Reduction factor of 0.40 seen ✓a Use of their reducing factor in ΔIL equation ✓b eg $\Delta IL = 10\log\left(\frac{I_2}{I_1}\right) = 10\log(0.40)$ Value of ΔIL consistent with their reduction factor eg $\Delta IL = (-)\ 3.98$ ✓c Subtraction of their ΔIL from 110 eg new $IL = 110 - 3.98$ ✓d 106 (dB) ✓	4	AO3.1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Idea of reduction in sensitivity at all frequencies ✓$_1$ Most loss occurs at $4\ \text{kHz}$ ✓$_2$	✓$_1$ for idea of reduction in sensitivity accept: hearing loss/ perceives sounds to be quieter/ drop in perceived loudness/ higher intensity required for same loudness ✓$_2$ accept a range of $\pm 1\ \text{kHz}$ provided that $4\ \text{kHz}$ lies in the range ✓$_2$ Do not award for any suggestion that this is due to the loud noise being at $4\ \text{kHz}$ If no other mark given award 1 mark for suggestion that person will suffer from tinnitus	2	AO1
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Name coherent and non-coherent bundle ✓$_1$ Coherent bundle transmits images OR non-coherent bundle transmits light for illumination/ into the body ✓$_2$ Bundle that transmits light for illumination requires no cladding ✓$_3$ Cladding is required in bundle that transmits images so that light does not pass from one fibre to another (which would destroy the image) ✓$_4$	✓$_1$ Accept 'incoherent' ✓$_2$ 'transmits light' insufficient for function of non-coherent bundle ✓$_3$ and ✓$_4$ are for linking the function to the requirement for cladding and can be awarded if names are missing, incorrect or mixed up so long as function clear. ✓$_{3\,4}$ 1 mark for stating coherent need cladding and non-coherent do not	4	2×AO1 2×AO3

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>03.2</td><td>The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer.
Guidance provided in section 3.10 of the ‘Mark Scheme Instructions’ document should be used to assist in marking this question.
<table><tr><th>Mark</th><th>Criteria</th></tr><tr><td>6</td><td>All three areas covered in some detail.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr><tr><td>5</td><td>All three areas covered, at least two in detail.
Whilst there will be gaps, there should only be an occasional error.</td></tr><tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be several gaps, there should only be an occasional error.</td></tr><tr><td>3</td><td>One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.</td></tr><tr><td>2</td><td>Only one area discussed, or makes a partial attempt at two areas.</td></tr><tr><td>1</td><td>Only one area covered and that partially.</td></tr><tr><td>0</td><td>No relevant comments.</td></tr></table></td><td>In each area, a partial response covers one bullet point, a detailed response requires two.

Methods used to reduce dispersion
Mentions either mono-mode fibre (mod), monochromatic light (mat), small difference in refractive indices of core and cladding (mod) or repeaters (both)
Mentions two methods with at least one linked to correct type of dispersion (name or description)
Why the methods are not required
Short distance of the endoscope
Reason given for why this results in insignificant dispersion
No pulse broadening due to analogue signal
Idea that function of non-coherent bundle is unaffected by dispersion
Comparison of (lower) data transfer rate for endoscope compared to high speed data transfer for communications. Means dispersion is not noticeable
How the methods affect the function
Refractive index of core close to refractive index of cladding – lots of light escapes. Reduces intensity of image (which makes it harder to see)
Mono-mode fibre reduces amount of light transmitted. Reduces intensity of image
Monochromatic light – image is monochrome (which makes diagnosis harder)
Narrower fibres therefore more fibres can fit in the bundle therefore better resolution
Discussion of impact of any one of these changes on diagnosis/ treatments
Repeaters would make the endoscope too wide to go inside patient.</td><td>6</td><td>2×AO1
2×AO2
2×AO3</td></tr>
<tr><td>Total</td><td></td><td></td><td>10</td><td></td></tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	the time taken to halve the amount of fluorine-18/ number of particles is 6 hours ✓1 by excretion of fluorine-18 from the body (by biological means)✓2	✓1 Condone 'mass' as alternative to 'amount'. Condone 'activity' ✓2 must include the idea that the fluorine is removed from the body Do not allow decay in MP1 or in MP2	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Max 2 from ✓✓ Correct use of $\left(\frac{1}{T_E}\right) = \frac{1}{T_P} + \frac{1}{T_B}$ to find T_E ✓a Use of their $T_E = \frac{ln2}{\lambda}$ to find their λ ✓b Use of $N = N_0 e^{-their\lambda \times t}$ to find their % remaining with consistent units ✓c 14 (%) ✓	✓a Expect: $\frac{1}{T_E} = \frac{1}{110} + \frac{1}{6\times60} \therefore T_E = 84$ mins (1.4 hours, 5055 s) ✓b $\lambda = \frac{\ln 2}{84} = 8.3\times10^{-3}$ mins^{-1} (0.50 hours^{-1}, 1.4 × 10^{-4} s^{-1}) ✓b Condone use of T_B or T_P ✓c $\frac{N}{N_0} = e^{-\lambda t} = e^{-8.3\times10^{-3}\times4.0\times60} = 0.14$ Or $N = N_0 e^{-\lambda t} = 100e^{-8.3\times10^{-3}\times4.0\times60} = 14\%$ Calculator value = 13.88419224 **Alternative Method** Calculation of effective half-life ✓a Uses their T_E to find number of half-lives in 4.0 hours with consistent units (e.g. 4.0/ 1.4 = 2.85) ✓b ✓b Condone use of T_B or T_P Calculation of percentage remaining $\frac{1}{2^{their\ number\ of\ half-lives}} \times 100$ OR $0.5^{\text{their number of half -lives}} \times 100$ ✓c	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Beta plus/positron and (electron) neutrino ✓	Ignore (incorrect) symbols. Reference to emission of anti-neutrino, gamma, protons, neutrons or daughter nucleus scores zero.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Use of $3 \times 10^8\ \text{m s}^{-1}$ (as speed of photons) ✓$_1$ Use of Pythagoras to determine AB or half AB OR appropriate use of scale ✓$_2$ Extra distance to travel to B = $(3 \times 10^8 \times 0.79 \times 10^{-9}) = 23.7 \times 10^{-2}\ (\text{m})$ OR calculates time for light to travel from A to B $(2.36\ \text{ns})$ ✓$_3$ H5 from some correct working ✓$_4$	✓$_2$ Ignore POT. ✓$_2$ AB = $\sqrt{10^2 + 70^2}\ (= 70.7\ \text{cm})$ Allow calculation in cm or number of squares (AB = 14.1 squares) ✓$_2$ Appropriate use of scale e.g. $23.7 \div 5 = 4.7$ squares ✓$_3$ Allow use of half the time to work out distance from centre ✓$_4$ Allow credit for any method which uniquely identifies square H5 (Any grid reference takes precedence.) If no use of $3 \times 10^8\ \text{m s}^{-1}$ then a mark can be awarded for any square along the line AB that is closer to A (H1 – H7)	4	1×AO1 2×AO3 1×AO3
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	To damp the vibrations (of the piezoelectric crystal) (after the pulse has been transmitted) ✓ To allow the crystal to serve as receiver (as well as transmitter)/ so reflected and transmitted pulses remain separate (at the transducer)/ so pulses can be short ✓		2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Max 2 from ✓✓ (Muscle $Z = \rho c =$) 1100×1600 OR 1.76×10^6 ($\text{kg s}^{-1}\ \text{m}^{-2}$) ✓a Use of $\left(\frac{I_r}{I_i} =\right)\left(\frac{Z_2 - their\ Z_1}{Z_2 + their\ Z_1}\right)^2$ to find reflected ratio OR 0.25 ✓b Conversion of their ratio to % and subtraction from 100 ✓c 75 (%) ✓	✓b Accept Z_1 and Z_2 in either order Expect $\left(\frac{5.3\times10^6 - 1.76\times10^6}{5.3\times10^6 + 1.76\times10^6}\right)^2$ do not accept use of ρ or c as Z Calc value 74.85815631	3	AO2

Total			5	