A-LEVEL
PHYSICS
7408/3BB

Paper 3 Section B Medical physics

Mark scheme

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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.

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. i.e. 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	Bright light uses only cones and very dim light uses only rods ✓ Comparison between high resolution in bright light and low resolution in low light ✓ Because cones have a nerve each, rods share nerves ✓ Comparison between coloured image in bright light and black and white image in low light ✓ Cones see in colour, rods see in black and white ✓	The first mark may be in either answer and is independent. Ignore clearer, more focused. If no comparison is given award one mark max for one valid statement about resolution and one about colour, eg bright light is in colour and high resolution. The explanation must match the description to gain credit.	5	2× AO1.1a 3× AO1.1b
01.2	Adaptation ✓		1	AO1.1a
01.3	Takes time for rods to adapt to the dark ✓ Time for rods to regenerate rhodopsin**/**visual purple/ reverse the effects of bleaching the rods ✓ It allows the pirate's eye to see immediately in low light levels / the pirate's eye is already dark-adapted ✓	Rods must be mentioned in answer for 3 marks. First marking point is for time taken, ignore wrong term for process.	3	AO3.1b
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Ossicles act like levers ✓ To increase the force ✓		2	AO1.1a
02.2	Area of ear drum = $\frac{\pi d^2}{4} = \frac{\pi 0.01^2}{4}$ ✓1 $= 7.85 \times 10^{-5}$ (m^2) Increase in pressure due to window size = $\frac{5.0 \times 10^{-2}}{2.5 \times 10^{-3} \times 1.5} = 13.3$ (or 1/13.3 = 0.075) ✓2 Area of oval window = $\frac{7.85 \times 10^{-5}}{13.3} = 5.9 \times 10^{-6}$ (m^2) ✓3	ignore PoT for ✓1 if mix up r and d ecf for ✓2 and ✓3 dividing gain or area by 1.5 or multiplying force by 1.5 gains ✓2 (allow a factor between 1.5 to 5) correct PoT needed for ✓3 (process mark for calculating area, answer may differ from that shown when a different factor for the effect of ossicles are used) ignoring 1.5 from ossicles and calculating A = 3.9×10^{-6} (m^2) scores ✓1 and ✓3 Alternative method for ✓2 and ✓3 Force on ear drum = PA = $2.5 \times 10^{-3} \times 7.85 \times 10^{-5} = 1.96 \times 10^{-7}$ N Force on oval window = $1.96 \times 10^{-7} \times 1.5$ ✓2 Area of oval window = $\frac{F}{P} = \frac{2.94 \times 10^{-7}}{5.0 \times 10^{-2}} =$ 5.9×10^{-6} ✓3 (m^2)	3	AO2.1b
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Attempt to use $I = I_0 e^{-\mu x}$ ✓1 Two correct answers 100 keV $\left(\frac{I}{I_0} = e^{-\mu x} = e^{-0.15\times 11} =\right) 0.19$ 500 keV $\left(\frac{I}{I_0} = e^{-\mu x} = e^{-0.087\times 11} =\right) 0.38$ ✓2 More of the 500 keV radiation reaches the tumour so is to be preferred or less radiation is absorbed by brain ✓3 Less damage to surrounding tissue. ✓4	Alternative approach for first two marks Use of $x_{1/2} = \frac{\ln 2}{\mu}$ ✓1 100 keV $\left(x_{1/2} = \frac{\ln 2}{\mu} = \frac{\ln 2}{0.15} =\right) 4.6$ cm 500 keV $\left(x_{1/2} = \frac{\ln 2}{\mu} = \frac{\ln 2}{0.087} =\right) 8.0$ cm ✓2 If use 100/500 keV for I_0 do not award ✓1 or ✓2	4	1× AO3.1a 3× AO3.1b
03.2	Copper better at removing 100 keV (damage cells)✓ Remove a larger <u>percentage</u> or <u>fraction</u> of the 100 keV radiation than the 500 keV ✓	Allow ecf argument if 03.1 specifies 100 keV should be preferred. 2nd marking point implies first (with metal identified)	2	AO3.1a

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Any one from: **Method**: Use of scans to locate the tumour ✓ **Reason**: Allows accurate targeting of the beam✓ **Method**: Multiple beam or rotating beam ✓ **Reason**: X-rays are spread out so each part receives a lower dose ✓ **Method**: (Fine) collimated beam ✓ **Reason**: X-rays don't spread beyond the size of the tumour / filter ✓ **Method**: lead shielding ✓ **Reason:** to block X-rays from healthy tissues ✓	Reason mark depends on method mark and must match. Do NOT credit techniques that are only applicable to X-ray imaging.	2	1× AO1.a 1× AO1.b
Total			**8**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>04.1</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 3 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 3 areas covered at least 2 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>None of the three areas covered without significant error.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table></td><td>Points to consider

How an ultrasound pulse is produced:
• alternating potential difference applied across the crystal
• causes crystal to expand and contract
• creating pressure waves in the crystal / plastic membrane
• frequency of alternating pd equal to that of crystal / resonant frequency of crystal
• which is above $20\ \text{kHz}$.

How the ultrasound reflection is detected:
• pressure wave in the crystal
• causes crystal to expand and contract
• which produces a potential difference across the crystal.

The same transducer acts as receiver as well as transmitter:

• short application of ac to produce short pulse
• use of backing material to damp and stop vibration of crystal
• crystal must stop vibrating before reflection reaches it.</td><td>6</td><td>2× AO1.1a

4× AO2.1b</td></tr>
</table>

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	$\lambda = \frac{c}{f} = \frac{1600}{1.0 \times 10^6} = 0.0016$ Resolution = 1.6 mm ✓	Allow 1 sf answer of 2 mm	1	AO2.1b
04.3	$Z_1 = \rho c = 1.3 \times 330\ (= 429)$ or $Z_2 = \rho c = 1075 \times 1580\ (= 1.70 \times 10^6)$ ✓ $\left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2 = \left(\frac{1.70 \times 10^6 - 4.29 \times 10^2}{1.70 \times 10^6 + 4.29 \times 10^2}\right)^2$ ✓ $= 0.999$ ✓ $100 - 99.9 = 0.1\%$ ✓	Allow ecf Allow 1 sf	4	AO2.1b
04.4	Not suitable as all/most/99.9% of the ultrasound would be reflected ✓ when going from the air inside the lungs to the lung tissue ✓	Allow correct argument based around transmission MP2 is for the direction where most is reflected.	2	AO3.1a
Total			**13**	