A-level
PHYSICS
7408/3BB

Paper 3 Section B Medical physics

Mark scheme

June 2023

Version: 1.0 Final

2 3 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.

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

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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	beta is more ionising/less penetrating than gamma 1✓ One from✓ • will produce localised ionisation of the tumour without reaching neighbouring healthy tissue (whereas the gamma will produce more extended ionisation) • lower activity source can be used as more ionisation of the tumour per emission (whereas a more active gamma source will be required to produce the same level of ionisation in the tumour) • the tumour is small so the ionisation will occur only in the tumour • will cause less damage to healthy tissue (due to low penetration of beta) • Will be more effective (at treating the tumour as) it will ionise/damage it to a greater extent than gamma	For two marks there must be a comparison implied and MP1 and MP2 must correlate For two marks mention of ionisation must be seen Accept 'damage' for 'ionise' in MP2 provided 'ionise' seen in MP1 For MP2 Condone: gamma could escape the body and pose a risk to others (beta cannot)	2	2 × AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Use of ratio or tan used consistently ✓ $d = 7.14 \times 10^{-5}$ m or 3.57×10^{-5} m OR image size 4.2 x 10^{-4} OR their number of pixels = $\frac{0.01}{their\ d}$ OR number of cones= $\frac{their\ image\ size}{(2\times)1.5\times10^{-6}}$ ✓ 140 (pixels per cm) ✓	Condone POT error in MP1 and MP2 For MP3 allow 280 pixels per cm only when d represents the distance from the centre of one dark pixel to the centre of the next dark pixel. Expect to see $\frac{2\times1.5\times10^{-6}}{21\times10^{-3}} = \frac{d}{0.5}$ $d = 7.14 \times 10^{-5}$ m Answer $= \frac{0.01}{7.14\times10^{-5}} = 140$ (pixels per cm)	3	3 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Viewed by rods not cones ✓ Multiple rods share a nerve ✓ Idea that there must be one unstimulated receptor between stimulated ones OR separation on retina needs to be larger for resolution OR Idea that it will be impossible to determine which rod was activated (with MP2) ✓	Max 2 if suggests rods are larger Allow 'only rods'; do not allow 'fewer cones' Ignore references to the spacing of rods For MP3 allow idea that the light receptors have an increased **effective** diameter Alternative for 1 mark: Correct reference to change in pupil size (increase in dark) and less diffraction OR correct reference to pupil size and eye's ability to focus is further reduced✓	3	3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	0.875/0.500 = 1.75 (≥ 2 sf) OR 0.500 x 2 compared to 0.875 OR 0.875 ÷ 2 compared to 0.500✓	Allow 0.850-0.900 for red; 0.450-0.525 for green (gives range 1.62- 2.00)	1	1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Green (520): Green cone 0.80 OR Red cone 0.15 OR Red (650): Red cone 0.25 ✓$_1$ Green = 0.80 and Red = 0.15 + 0.25 = 0.40 OR Green = 2 × Red ✓$_2$ Leading to wavelength = 546 ✓$_3$ nm	If average red cone value can award ✓$_1$ and ✓$_3$ e.g. 0.20 Red, Green = 4 × Red, leading to answer in range 520 to 530 nm If no recognition that green LED contributes to red cone value can award ✓$_1$ and ✓$_3$ e.g. Green = 3.2 x Red, leading to answer in range 530 to 540 nm allow 540 to 550 nm. Bald answer receives zero marks.	3	3 × AO3
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Power (of sound) per unit area **OR** Energy (of source) per unit area per second ✓	allow 'per m^2' for 'per unit area'	1	1 × AO1

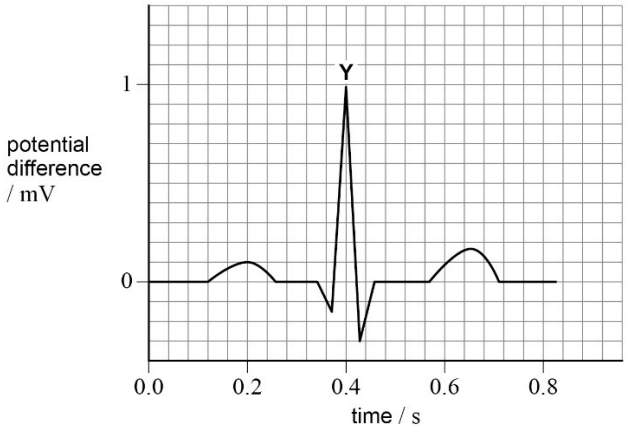
Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	$I + 3$		1	1 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Division of areas seen OR correct use of factor of 20 (20 x 5.9 x 10^{-6}) ✓ 1.6 ✓	Use of incorrect relationship between pressure, force and area receives zero marks. Expect to see $\frac{20 \times 5.9 \times 10^{-6}}{7.2 \times 10^{-5}}$ Condone $1.6: 1$ for MP2	2	2 × AO2

Total			4

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	B scan because it is an image (rather than a graph) ✓	Allow 'brightness scan' for B scan	1	1 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Determines accurate time for a whole number of heartbeats OR $\frac{their\ number\ of\ beats}{their\ time}$ OR $\frac{their\ time}{their\ number\ of\ beats}$ OR converts their bps to bpm ✓ Evidence of T taken from 3, 4 or 5 heartbeats OR repeat and mean for at least three measurements ✓ Leading to answers that round to 56 or 57 bpm ✓	Accept correct use of frequency for MP2	3	1 × AO2 1 × AO3 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	mV on y-axis and s on x-axis ✓ values of y-axis with at least 2 values labelled, consistent with 0 at start of line and 1 at peak✓ values on x-axis with end point between 0.55 and 1.0 s. At least three evenly spaced values seen including 0✓ position of **Y** indicated to be within one square of the highest peak ✓	 Allow for alternative correct units and values eg 0.001 V, time of 400–750 ms For MP3 ticks on x-axis required; do not accept awkward scales	4	3 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	**Why backing is needed**: Idea that gels improves electrical contact ✓ **Property of backing**: gel should have low (electrical) resistance or non-irritating to skin or shouldn't react to chemicals produced by skin ✓ **How skin is prepared**: skin is shaved / rubbed with abrasive paper/ hair removed ✓	For MP2 do not allow reference to or implication of acoustic resistance / impedance MP3 - allow skin is dried or cleaned	3	2 × AO1 1 × AO2
Total			**11**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>05.1</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 three areas covered with at least two aspects covered in some detail.
There should be at least one statement from the conclusions.
Can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>A fair attempt to analyse all three areas, with two areas discussed successfully and one are partially.</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 comments</td></tr>
</table>
</td>
<td>
Ignore references to body parts other than ribs, heart, lung.

Statements can be in terms of transmission or absorption.

Area 1: Brightness
Film is darkened by X-rays.
More X-rays darker film / lighter areas have fewer X-rays.

Brightness:
Heart > ribs >> lungs
Lungs allows the most X-rays to be transmitted and are darkest.
Heart allows the fewest X-rays to be transmitted and is lightest.
Rib allows more X-rays than the heart but fewer than lungs to be transmitted and is medium brightness.

Area 2: Thickness
Thicker tissue decreases the amount of X-rays transmitted.
Reference to exponential decrease in X-rays transmitted with thickness.

Rib<< heart < lungs
Rib - very thin, so transmits more X-rays than heart.
Heart - much thicker than rib transmits less X-rays.
Lung - very thick (but transmit most X-rays).
</td>
<td>6</td>
<td>2 × AO1

4 × AO3</td>
</tr>
</table>

		Area 3: Half-value thickness Half-value thickness is the thickness needed to reduce intensity by half. Larger $x_{1/2}$ increases the amount of X-rays transmitted for the same thickness. Half value thickness: Lungs >> heart > ribs Rib has smallest $x_{1/2}$ (most dense) Heart has medium $x_{1/2}$ (medium density) Lung has largest $x_{1/2}$ (least dense) **Conclusions** Ideas that: Heart brightest as it has medium $x_{1/2}$ but is thick Rib almost as bright as heart as it has smallest $x_{1/2}$ but is much thinner. Lung darkest as although thicker, it has highest $x_{1/2}$		

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Idea of ingestion of barium meal/ contrast medium ✓ To improve contrast of image / to increase the number of X-rays absorbed (by contents of stomach) / barium is a good absorber of X-rays/ barium has high attenuation (coefficient) ✓	Do not allow any response suggesting ingestion of a radioisotope Do not award MP2 without MP1 being given. MP2: ignore 'has higher atomic number' Do not allow reference to increased reflection.	2	2 × AO2
Total			**8**	