# A-LEVEL
# PHYSICS
# 7408/3BB

Paper 3 Section B Medical physics

**Mark scheme**

June 2022

Version: 1.0 Final

226A7408/3BB/MS

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. 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** | hypermetropia ✓ | | 1 | AO2 |

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **01.2** | Use of $P = \frac{1}{u} + \frac{1}{v}$ correctly. Must see correct substitution for $u$ or calculation for $v$, $v = \left(4 - \frac{1}{0.75}\right)^{-1}$ $_1$✓ $(= 0.375\ m)$<br><br>Correct substitution in $m = \frac{v}{u}$ $_2$✓ $(= \frac{0.375}{0.75})$<br><br>$0.50$ $_3$✓ | Correct substitution may be inferred from using the answer as the top line in $m = \frac{v}{u}$<br><br>Allow PoT for $_1$✓ and $_2$✓<br><br>Allow ecf for $_2$✓ (allow ecf for mixing up $u$ and $v$ for this mark, expect to see an answer of 2 for magnification)<br><br>No ecf or PoT for $_3$✓<br>Condone 1SF<br>MAX 2 if incorrect negative sign seen. | 3 | 3 x AO2 |

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **01.3** | **X** – cornea, **Y** – lens, **Z** – iris ✓<br><br>**X** / cornea<br>form image (on retina) / (primary) refractor / (most of) refraction takes place ✓<br><br>**Y** / lens<br>Accommodation /<br>varies the focal length / power (of eye) ✓<br><br>**Z** / iris<br>Control the amount of light entering the eye ✓ | First mark is for correctly naming all three parts<br><br>Other marks can be gained for attaching the correct description to either the label or the name (if parts not correctly identified)<br><br>Treat non optical functions as neutral.<br><br>Do NOT allow “to direct the light” for refraction<br><br>Condone “change shape to view / focus on objects at different distances” for Y<br><br>Condone intensity if linked to retina or back of the eye. | 4 | 4 x AO1 |
| **Total** | | | **8** | |

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **02.1** | Flat panel detector ✓<br>If flat panel detector, **max 3** from:<br>Not moving, so fluoroscopic image intensity not required ✓<br>Saves a picture unlike an intensifying screen ✓<br>FTP digital image is easier to share or transfer unlike film ✓<br>Flat panel detector is more sensitive (than film) ✓<br>Faster than film / film is slower / doesn't have to be developed like film ✓<br>To minimise dose of X-rays to be used ✓<br>If film selected<br>Not moving, so film is preferred to intensifying screen ✓<br>Saves a picture unlike an intensifying screen ✓<br>Minimise dose of X-rays to be used (compared to moving image with intensifying screen) ✓<br>If image intensifier selected<br>Intensifying screen is more sensitive (than film) ✓<br>Does not need to be developed like film / real time image✓ | Ignore references to resolution / image quality<br>Treat cost / portability as neutral<br>Do NOT accept minimise dose compare to flat panel detector<br>Condone increases contrast (at low intensity) as an alternative to increase sensitivity<br>If no selection is made max 2 for correct comments. | 4 | 4 x AO3 |

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **02.2** | First mark is for calculating intensity (or power or energy if calculation done in a different order) transmitted through bone (allow thickness < $4\ \text{cm}$ if justified as mean eg $r\sqrt{\pi}$ accept $r = 0.02 <$ thickness $\leq d = 0.04$) must include a factor $e^{-\mu x}$ ✓<br><br>Second mark is for calculating intensity absorbed by bone (or power or energy if calculation done in a different order) ✓<br><br>Third mark is for calculating the area of the bone ✓<br><br>Fourth mark is for converting an intensity into a power (allow ecf for incorrect intensity, including $I_0$, or area) ✓<br><br>Fifth mark is for converting a power into an energy (allow ecf for incorrect energy) ✓ | Expected answer<br>$I = I_0 e^{-\mu x} = 0.013 \times e^{-58.3 \times 0.04}$ ✓ $(= 0.00126)$<br><br>Absorbed intensity = $I_0 - I = 0.013 - 0.00126$ ✓ $(= 0.0117)$<br><br>Area of bone = $\sqrt{0.25^2 + 0.09^2} \times 0.04$ ✓ $(= 0.0106\ \text{m}^2)$<br><br>$P = IA = 0.0117 \times 0.0106$ ✓ $(= 0.000124)$<br><br>$E = Pt = 0.000124 \times 0.8 = 1.0 \times 10^{-4}$ ✓ (J)<br>(allow $9.9 \times 10^{-5}$ or $1.1 \times 10^{-4}$)<br><br>Condone rounding of answers/values as estimate asked for.<br>Award max 4 if PoT error in final answer. | 5 | 4 × AO2<br>1 × AO3 |

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **02.3** | Assuming bone has constant thickness / bone is rectangular/cuboid ✓<br><br>Assuming none of the X-rays are absorbed by tissue before it reaches the bone ✓ | Allow any other sensible assumption that leads to a larger value<br>For the first mark it must be clear that the distance referred to is $x$ in the equation $I = I_0 e^{-\mu x}$ and not the mean diameter used to calculate the cross sectional areas.<br>First mark can also be gained from an attempt to use an average value for $x$ in **02.2**<br>Allow some X-rays are scattered (rather than being absorbed) ✓<br>Treat references to X-rays reflecting as neutral | 2 | 2 x AO3 |

| Total | | | 11 | |
|---|---|---|---|---|

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **03.1** | Frequency axis correctly labelled from $100$, $1000$, $10\,000$, including the location of 3000 Hz, if marked✓<br><br>Graph line showing a U shape ✓<br><br>Lowest point of graph at $3000$ Hz ✓ | Allow 1000, 10 000 and 100 000 if line ≤ 20 000<br><br>3rd mark depends on a valid scale or clear marking of 3000 Hz at the lowest point. | 3 | 3 x AO1 |

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **03.2** | (different) frequencies are played (through earphones) and compared to a 1kHz reference signal ✓<br><br>Volume is changed until it sounds the same loudness as the reference signal✓ | | 2 | 2 x AO1 |

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **03.3** | Correct substitution or correct rearrangement for $I$ ✓<br><br>$I\left(=I_0 10^{\frac{\text{intensity level}}{10}}\right) = 1 \times 10^{-12} \times 10^{\frac{30}{10}} = 1.0 \times 10^{-9}$ ✓ (W m$^{-2}$) | e.g. $30 = 10 \log \frac{I}{10^{-12}}$ | 2 | 2 x AO2 |

| Total | | | 7 | |
|---|---|---|---|---|

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th><th>AO</th></tr>
<tr><td>04</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.<br>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>Ultrasound or CT identified and justified, quality comments on all 3, at least 3 other factors. Must refer to resolution / detail for 6 marks.</td></tr>
<tr><td>5</td><td>Ultrasound or CT identified and justified, quality comments on all 3, at least 2 other factor<br>Must differentiate between the quality of CT and ultrasound for kidney stones.</td></tr>
<tr><td>4</td><td>Ultrasound or CT scanner identified.<br>Quality comments on all 3 or 2 quality comments and 1 other factor.</td></tr>
<tr><td>3</td><td>Ultrasound or CT scanner identified.<br>2 comments including at least 1 quality comment<br>Or<br>MR scanner identified and stated as highest resolution, with 2 quality comments and 2 others factors.</td></tr>
<tr><td>2</td><td>Any choice, with a relevant supporting argument (allow MR scanner as highest resolution provided one other relevant factor is provided).<br>Or<br>At least 3 valid comments with no choice made</td></tr>
<tr><td>1</td><td>Any valid comments (ignore MR scanner as highest resolution).</td></tr>
<tr><td>0</td><td>No relevant comments.</td></tr>
</table>
</td><td>
Points to consider:<br><br>
Relevant quality<br>
• MR scanner – low quality image of calcium / kidney stones (allow cannot see)<br>
• CT scanner – high resolution image of kidney stone<br>
• Ultrasound – low resolution image of kidney stone<br>
(Allow CT scanner and Ultrasound produce good images of kidney stone but not for 6 marks)<br>
Allow references to bone instead of kidney stone<br><br>
Other factors<br>
• (CT scanner / MRI is more expensive than ultrasound)<br>
• Ultrasound / MRI causes no harm<br>
• CT scanner emits ionising radiation<br>
• Ionising radiation damages cells<br>
• Do not have to remain still for ultrasound<br>
• Ultrasound is fastest / real time<br>
• MRI can cause claustrophobia<br><br>
Ignore references to metal / pace maker in the body for MRI<br>
Ignore references to 3D images<br><br>
Justified choice<br>
• Ultrasound<br>
• Quality is good enough, (cheaper) and safe<br><br>
• CT<br>
• Best quality image of kidney stones<br>
• (except for pregnant women and children)
</td><td>6</td><td>5 × AO3<br><br>1 × AO2</td></tr>
</table>

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **05.1** | Align spins of protons / hydrogen nuclei ✓ | Do NOT allow hydrogen atoms<br><br>Allow causes protons / hydrogen nuclei to precess around magnetic field / in one direction<br><br>Do NOT allow causes protons to spin | 1 | AO1 |

| Question | Answers | Additional comments/Guidelines | Mark | AO |
|---|---|---|---|---|
| **05.2** | (radio frequency photons) excite protons ✓<br><br>Flip the (spin of) protons ✓<br><br>(When pulse stopped) protons emit radio frequency signals when they relax ✓ | MAX 2<br>Condone RF<br>Condone atoms for protons<br>Condone move or make into antialignment with magnetic field for MP2 | 2 | 2 x AO1 |
| **Total** | | | **3** | |