A-level
PHYSICS
7408/3BB

Paper 3 Section B Medical physics

Mark scheme

June 2025

Version: 1.0 Final

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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.

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/Guidance	Mark	AO
01.1	Both rays refracted towards optical axis at cornea $_1$✓ Rays refracted towards optical axis at lens and meets at the intersection of optical axis with back of eye and rays are continuous between lens and back of eye $_2$✓	Condone non-straight line for MP1 or MP2 but not both.	2	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
01.2	lens ✓	tick in 3rd box only; CAO	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
01.3	(A =) 8.8 (dioptres) $_1$✓ Correctly calculates d_1 from formula using their A $_2$✓ use of the lens formula $_3$✓ focal length correct $_4$✓	for $_1$✓ CAO Allow evidence of 8.8 on **Figure 2** for $_2$✓ expect to see d_1 = 114 (mm) allow 2 sf 110 (mm) must see appropriate working., e.g. allow $d_1 = \frac{1}{8.8}$ Or $d_1 = \frac{5}{44}$ Or $(A=)\ 8.8 = \frac{1}{d_1}$ for $_3$✓ allow one POT error **EITHER** Find v with object at far point, e.g. $\frac{1}{23} = \left(\frac{1}{\infty}\right) + \frac{1}{v}$ condone $\frac{1}{f} = \left(\frac{1}{\infty}\right) + \frac{1}{23}$ expect to see v = 23 (mm) **OR** Find focal length with object at near point, e.g. $\frac{1}{f} = \frac{1}{their\ u} + \frac{1}{their\ v}$ expect to their u = their d_1 Condone: • u, v mix up • allow either their u or their v but not both penalise incorrect signs in $_3$✓ for $_4$✓ allow 19(.1) for d_1 = 114 mm and 19(.0) for d_1 = 110 mm Must see correct working in MP3 to support this answer.	4	2 × AO2 2 × AO3

Question	Answers	Additional comments/Guidance	Mark	AO
01.4	explains hypermetropia Or Interprets **Figure 2** in terms of d_1 **OR** A and d_2 $_1$✓ Describes the relationship between A and d_1 therefore identifying how **Figure 2** suggests hypermetropia increases with age $_2$✓	for $_1$✓ accept • cannot focus on nearby objects • light from nearby objects focused behind retina • near point further away / near point increases • idea that d_1 increases • A decreases **and** d_2 does not change Treat each bullet point as independent. 'long-sighted' is neutral for $_2$✓ (**Figure 2** shows) A decreases (with age) **because** d_1 increases OR (**Figure 2** shows) A decreases (with age) **because** $\frac{1}{d_1}$ decreases. any suggestion that d_2 changes loses $_2$✓ For $_{12}$✓, allow A referred to as 'accommodation amplitude' but must refer to either d_1 or $\frac{1}{d_1}$ for $_2$✓	2	1 × AO1 1 × AO3

Total			**9**

Question	Answers	Additional comments/Guidance	Mark	AO

02.1	Max **one** from ✓
	• Reads off activities of 74($\times 10^9$) and 58 ($\times 10^9$) from the graph (and calculates the difference) (1)
	• Use of $A = -\lambda N$ to find number of nuclei at t=0 / t =24 / difference between t=0 and t =24 (2)
	• Use of $N = N_0\, e^{-\lambda t}$ (3)
	• Use of (Δ)$N = N_0\,(1 - e^{-\lambda t})$ (4)
	• determines area under ^{99}Mo graph between t = 0 and t = 24 hours. (5)
	
	5.7×10^{15} ✓
		Expect to see $74\ (\times 10^9) - 58\ (\times 10^9)$ (= 16×10^9)
		Condone consistent power of ten errors where attempt to find difference is seen
		Condone one other error in read offs where their difference is calculated.
		Expect to see one of
		• (N=) $\frac{74 \times 10^9}{2.8 \times 10^{-6}}$ (= 2.64×10^{16}) (a)
		• (N=) $\frac{58 \times 10^9}{2.8 \times 10^{-6}}$ (= 2.07×10^{16}) (b)
		• (N=) $\frac{16 \times 10^9}{2.8 \times 10^{-6}}$ (c)
		• $74(\times 10^9) - 58\ (\times 10^9) = 2.8\ (\times 10^{-6}) \times N$ (d)
		• $16\ (\times 10^9) = 2.8\ (\times 10^{-6}) \times N$ (e)
		• Finding difference of 2.64×10^{16} and 2.07×10^{16} seen (f)
		• Condone one error in $\frac{\text{difference in activity}}{2.8 \times 10^{-6}}$ (g)
		condone power of ten errors in (d) and (e) and (f)
		For Use of in (3) is by substitution of N (or N_0) and t = 24 ($\times 60^2$) , condone N (1.82 x10^{16}) from A = 51 GBq.
		For (3) $N_0 = 2.64\ (\times 10^{16})$ / N= $2.07\ (\times 10^{16})$ $t = 24\ (\times 60^2)$
		For (4) $N_0 = 2.64\ (\times 10^{16})$ $t = 24\ (\times 60^2)$
		allow area of a trapezium: expect base 24×3600 and parallel sides 74×10^9 and 58×10^9
		allow counting squares: expect 325 to 400 small squares (13 to 16 large squares) x by area of one square
		for MP2 accept > 2 sf, rounding to 5.7×10^{15}
		Must see MP1 to award MP2
			2	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
02.2	**Method 1**: calculates number of ^{99m}Tc (that have decayed between t = 0 and t = 24) $_1$✓ use of (0.9 ×) their **02.1** – their number of ^{99m}Tc (that have decayed between t = 0 and t = 24) $_2$✓ number of ^{99m}Tc extracted in range 1.4 to 2.4 × 10^{15} $_3$✓ **Method 2:** use of recognisable half-life to determine the decay constant for ^{99m}Tc $_1$✓ use of activity at t = 24 hours and a decay constant to determine number of ^{99m}Tc extracted $_2$✓ number of ^{99m}Tc extracted in range 1.50 to 1.63 × 10^{15} $_3$✓	for $_1$✓ number in range 3.0 to 3.7 × 10^{15} For $_2$✓ allow use of (0.9 ×) 6 × 10^{15} – their number of ^{99m}Tc for $_3$✓ must see use of 0.9 in a valid difference calculation for $_1$✓ evidence for half-life of 6(.0) hours seen in working; expect $\lambda = 3.2 \times 10^{-5}$ (s^{-1}) based on half-life = 2.2×10^4 s allow substitution of half-life in hours, eg $\lambda = \frac{\ln 2}{6(.0)}$ for $_2$✓ substitution of A in range 50(× 10^9) to 52(.2) (× 10^9), eg $N = \frac{51(\times 10^9)}{\text{their } \lambda}$ allow PoT on activity in MP2 for $_3$✓ allow 2 sf in range 1.5 to 1.6 × 10^{15} Where no other mark is scored, **Max 1** for: attempt to find area (under ^{99m}Tc curve) • 215 to 255 small squares (or 8 to 10 large) • allow area of triangle and trapezium • finds area of one small square = 1.4 × 10^{13}	3	1 × AO2 2 × AO3

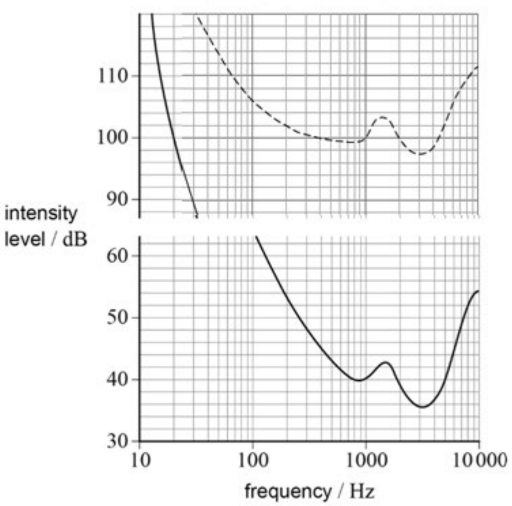
<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>02.3</td>
<td>
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas covered in some detail.
6 marks can be awarded even if there is an error and/or parts 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 while a detailed response covers at least two.
Area 1: How images obtained (MUGA scan)
• $^{(99m)}Tc$ is used as a tracer OR $^{(99m)}Tc$ is a gamma-emitter (do not award if annihilation mentioned)
• the imaging device is a gamma camera (mentioning a detector / scanner insufficient)
• details of gamma camera (collimator, photomultiplier, dynodes)
treat as neutral: $^{(99m)}Tc$ quickly removed from body (in about 24 hours) / has a short (effective) half-life
Area 2: Common advantages
• both are non-invasive
• both generate (2D) images that provide an animated view of the functioning heart or wtte
• no need to anaesthetise patient
• both are outpatient procedures
• patients do not have to remain still / allow ‘both may be used during stress testing’
'can be used if patient has pacemaker' is neutral
Area 3: Strength and weakness
• MUGA provides (both) quantitative (and qualitative) information / MUGA is more accurate / TTE provides only qualitative information / MUGA image intensity is related to number of red blood cells in region
• Interpretation of TTE images may be subjective / not reproducible
• TTE lower cost / allow ‘takes less time’
allow reverse argument
• TTE uses non-ionising radiation / no side effects / MUGA uses ionising radiation.
’MUGA produces higher resolution images’ is neutral</td>
<td>6</td>
<td>2 × AO2
4 × AO3</td>
</tr>
</table>

Total			**11**

Question	Answers	Additional comments/Guidance	Mark	AO
03.1	the minimum intensity that (a normal) ear can hear $_1$✓ at $1\ \mathrm{kHz}$ $_2$✓	word definition required: data sheet value is neutral allow 'power per m^2' for 'intensity' Do not accept 'minimum sound intensity level'	2	AO1

Question	Answers	Additional comments/Guidance	Mark	AO

03.2	Max **two** from✓✓
	
	• use of **Figure 4** to read intensity level at 50 Hz (1)
	
	• use of intensity level formula (2)
	
	• power = their intensity × area (3)
	
	(power =) 3.8×10^{-9} (W) ✓
		For (1) expect 78 ± 1 (dB)
		Allow evidence of 78 ± 1 (dB) on **Figure 4**
		Where only set equal to intensity withhold bp1 but can still score where 78 is seen as read-off in **Figure 4**.
		
		for (2) use of means
		their intensity level = $10 \times \log \dfrac{I}{1.0 \times 10^{-12}}$ (any subject) **OR**
		I evaluated using their intensity, correct to 2 sf;
		for 78 dB expect $I = 6.3 \times 10^{-5}$ (W m^{-2})
		
		For (3) Condone power of ten error in area.
		Do not accept 78 ± 1 (dB) or 50 (Hz) for their intensity
		
		Accept an answer that rounds to 3.8×10^{-9} (W)
		Condone an answer given to 1 significant figure where supporting working to greater sf seen.
			3	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
03.3	for $f < 1$ kHz curve of decreasing gradient, (flattening out) to pass through 1 kHz, 100 dB ₁✓ For $f > 1$ kHz one dip below 100 dB at about 3 kHz followed by an increase (towards a maximum turning point) ₂✓	sketch of one continuous line: for ₁✓ line should meet top of grid without meeting existing curve condone a curve with a shallow minimum for $f < 1$ kHz (as shown below) with an intensity level > intensity level at 3 kHz for ₂✓ where the line meets the right-hand edge of the grid, the intensity level must be greater than 100 db. Accept a single dip where the minimum occurs at frequencies in range greater than 2kHz and less than 4 kHz. don't insist on a peak between 1 kHz and 2 kHz 	2	AO2
Total			7	

Question	Answers	Additional comments/Guidance	Mark	AO
04.1	(small size of focal spot) to increase sharpness of image $_1$✓ Idea of (must not be too small otherwise) danger of overheating (the anode) $_2$✓	for $_1$✓ allow 'to reduce (size of) penumbra' / 'reduce region of geometric unsharpness' Condone: • improve (spatial) resolution • see finer detail • reduce blurring at edges (of image) Neutral statements include • more precise beam / more accurate beam • clearer image / better image • better focused for $_2$✓ allow: • to limit temperature increase (of anode) • to prevent it heating up too quickly	2	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
04.2	one correct method and one aspect of a relevant explanation 1✓ second correct method and one aspect of relevant explanation 2✓ third correct method and one aspect of relevant explanation 3✓	Where no other mark is scored allow **Max 1** for two correct methods	3	AO1

Method	**Explanation (how it works)**	**Explanation for limit exposure (why it is necessary)**
For reducing target area		
‘window’ defining target area / tube surrounded in lead (casing) / collimator / set aperture of diaphragm	Highly attenuating material that reduces x-ray propagation in undesired direction thereby producing a directed beam	Less exposure to surrounding tissue / body
use of a lead apron on patient (to shield area not being imaged)	Highly attenuating material reduces x-rays	Exposure to rest of body is reduced
reduce distance between source and patient	To reduce the divergence in beam	Less exposure for rest of body / healthy cells
keep the patient still	Only intended target is exposed to X-rays	Less exposure (for healthy cells) in other parts of body
For reducing X-ray intensity		
use of an (aluminium) filter / beam hardening	% of less energetic X-rays is reduced by filter	Idea of (unnecessary) exposure to ‘softer’ x-rays is reduced
use of intensifying screen / contrast medium / flat panel detector / FTP detector	To ensure adequate image quality (from a lower intensity beam)	Exposure (time) for (healthy cells) is minimised
For avoiding repeats		
correct tube voltage	to obtain best / appropriate X-ray (energy)	Image quality maximised without need to repeat so minimising exposure (for healthy cells)
keep the patient still	Reduces blurring in image.	The x-ray doesn’t need to be retaken therefore minimising exposure (for healthy cells)
reduce distance between source and patient	To reduce the divergence in beam	Image quality maximised without need to repeat so minimising exposure

Question	Answers	Additional comments/Guidance	Mark	AO

04.3	Max **Two** from✓✓
	
	• $\mu = 4.6(2) \times 10^{-2}$ (mm^{-1}) (1)
	
	• calculates thickness x (2)
	
	• Use of $\frac{I}{I_0} = e^{-\mu x}$ with their μ and their thickness x
	OR
	calculates $(\frac{1}{2})^{\frac{their\ thickness\ x}{15}}$ (3)
	
	(percentage=) 44 (%)✓
		for (1) and (2) allow working in m or cm
		$\mu = 46.2$ (m^{-1}) $\mu = 0.462$ (cm^{-1})
		for (1) accept $\mu = \frac{\ln 2}{15}$ or equivalent in m or cm
		for (2)
		thickness x in range 17 mm to 19 mm
		
		Expect to see a calculation based on scale diagram
		
		In (3), their x must be a distance, condone power of ten errors
		
		An answer for solid bone = 29% (28.7%) is worth 2 marks.
		accept an answer in range 41% to 46%
		reject decimal answer
		reject answer rounded to one significant figure
			3	1 × AO2
				2 × AO3

Total			**8**	