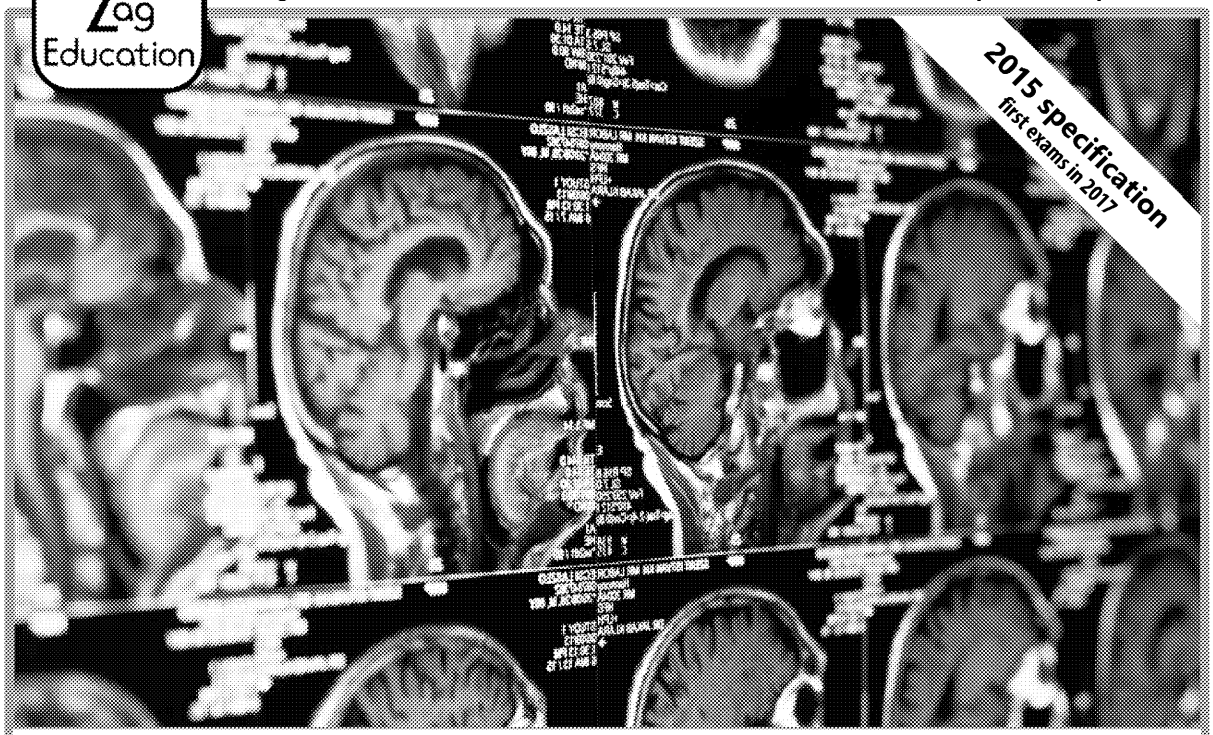
Zig Zag Education

Physics

A Level | AQA | 7408



Practice Exams for A Level AQA Physics

Paper 3B Option B: Medical Physics

zigzageducation.co.uk

POD 7636

Contents

Teacher's Introduction

This collection of four practice papers has been written to support the AQA A Level Physics specification 7408 (first examination 2016). The pack consists of four sets of Paper 3B Option B: Medical Physics.

Remember!
Always check the exam board website for new information, including changes to the specification and sample assessment material.

Each paper consists of 35 marks, covering the content in the Medical Physics optional unit, including a 6-mark question testing communication skills. Paper 3 section A (Paper 3A) and Paper 3 section B (Paper 3B) are sat at the same time. Students are given two hours to complete both Papers 3A and 3B, for a combined total of 80 marks.

Each paper follows a similar format to the AQA papers. Every item listed in the specification is covered, with most aspects visited several times in the pack. Each set of papers matches the weightings of assessment objectives, maths skills and practical skills set out by the exam board.

The mark schemes are written in a similar format to those written by AQA. The individual marking points are on separate lines, with additional guidance to clarify points and indicate alternative acceptable answers.

Suggested Uses

1. Set as a mock examination under exam conditions, marked by the teacher. This provides the most reliable summative assessment.
2. Set as a complete paper under exam conditions which is then marked by the student. This provides a good formative assessment as the student gets a good understanding of how the mark schemes work and what they need to do to score. Such a session could be reinforced by a lesson on exam technique.
3. Set as a complete paper under exam conditions which is then peer-marked. This could be by the teacher assigning scripts to students to mark or by students swapping among themselves. Group-marking can be particularly helpful as the students get the chance to develop their ideas by discussing why things do and don't score.
4. Go through a question at a time in a lesson. Get students to discuss their answers before revealing the mark scheme for that question.
5. Set a paper as a homework for the student to answer and mark. This would be an ideal activity for study leave, when the student could come to a tutorial to go through their script. They should be briefed to list questions that need addressing as a result of their marking of their script.

T Brown, May 2017

Specification Cross-reference: Me

	3B (A)	3B (B)
10 Medical Physics		
10.1 Physics of the eye		
10.1.1 Physics of vision	1	
10.1.2 Defects of vision and their correction using le[illegible]		1
10.2 Physics of the ear		
10.2.1 Ear as a so[illegible]tio[illegible]		
10.2.2 Sensitivity [illegible]ncy response		
10.2.3 Defects of h[illegible]ng		
10.3 Biological measurement		
10.3.1 Simple ECG machines and the normal ECG waveform	2	
10.4 Non-ionising imaging		
10.4.1 Ultrasound imaging		
10.4.2 Fibre optics and endoscopy		3
10.4.3 Magnetic resonance (MR) scanning		2
10.5 X-ray imaging		
10.5.1 The physics of diagnostic X-rays		
10.5.2 Image detection and enhancement	3	
10.5.3 Absorption of X-rays		
10.5.4 CT scanner		
10.6 Radionuclide imaging and therapy		
10.6.1 Imaging techniques	4	
10.6.2 Half-life	4	4
10.6.3 Gamma ca[illegible]		
10.6.4 Use of high-energy X-rays		
10.6.5 Use of radioactive implants		
10.6.6 Imaging comparisons		2, 3, 4

ZigZag Practice Exam Papers

Supporting A Level AQA Physics

Practice Exam Paper 3B

Option B: Medical Physics – Se

Name	

Time allowed

2 hours (for 3A and 3B)

Instructions

Answer **all** of the questions and use the space provided.

Information

The total marks available for this paper is **35**. The number of marks available for each question is shown on the right.

For this paper, you will need:

- Data and formulae booklet

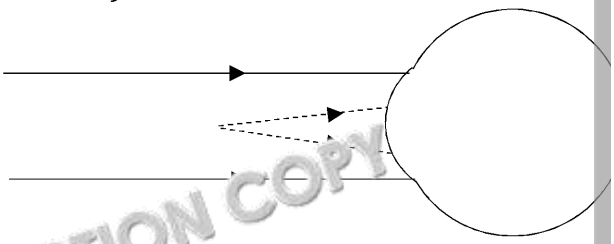
Additional materials required

- Pencil
- Electronic calculator
- Ruler (cm/mm)

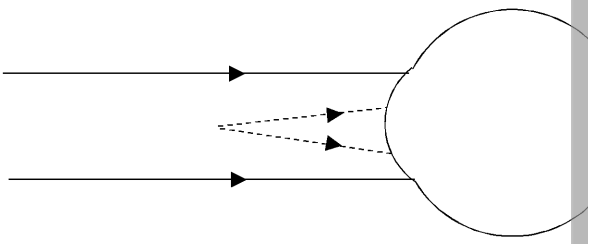
1. The human eye can develop a number of defects of vision.
The typical distance between the retina and lens of an eye is 20 mm.

1.1 Complete the diagrams below to show how the eye of someone with
and that of someone with hypermetropia (long-sightedness) focuses
solid lines) and a near point (the dashed lines).

Myopia (short-sightedness)



Hypermetro[illegible]g-sightedness)



1.2 A person with short-sightedness has a far point of 42.0 cm.

Calculate the power of lens required to correct the vision of this eye.

1.3 Calculate the focal point of th[illegible]cting lens in 1.2.

1.4 Describe the cause and effect of astigmatism, and describe the forma
used to correct for astigmatism.

2. Magnetic resonance (MR) scanners are used to image processes in a pati

2.1 Describe the basic principles of an MR scan.

Include in your answer a description of the signals produced by the M
body is affected, and how the image is produced.

2.2 State two reasons why MR scans are more suitable for imaging brain

1 .....

.....

2 .....

.....

3. Endoscopes are comprised of fibre optic cables which are inserted into a

The fibre optic cables are grouped as either coherent or non-coherent bu

3.1 Describe the arrangement in cases of coherent bundles and non-cohe

Coherent: .....

.....

.....

Non-coherent: .....

.....

.....

3.2 Describe an application of endoscopes, explaining **one** reason why e this application than other possible methods.

.....

.....

.....

3.3 Calculate the angle of total internal reflection at the core–cladding in

- Refractive index of core = 1.444
- Refractive index of cladding = 1.448

.....

.....

.....

4. When considering the use of radionuclide tracers for medical diagnosis tr
consider the half-lives of the tracer.

4.1 Explain what is meant by the terms 'physical half-life' and 'biological

Physical half-life: .....

.....

Biological half-life: .....

.....

4.2 Explain why the effective half-life of a substance is shorter than eithe
half-life of the substance.

.....

.....

4.3 The physical half-life of a radionuclide is 3.54 days.

The initial activity of the radionuclide is 2800 Bq.

After one week, the activity of the radionuclide is measured to be 32

Calculate the biological half-life of the radionuclide.

4.4 Explain the benefit of imaging a patient's b using X-rays given off
other X-ray imaging techniques.

.....

.....

.....

ZigZag Practice Exam Papers

Supporting A Level AQA Physics

Practice Exam Paper 3B

Option B: Medical Physics – Se

Name	

Time allowed

2 hours (for 3A and 3B)

Instructions

Answer **all** of the questions.

Information

The total marks available for this paper is **35**. The number of marks available for each question is shown on the right.

For this paper, you will need:

- Data and formulae booklet

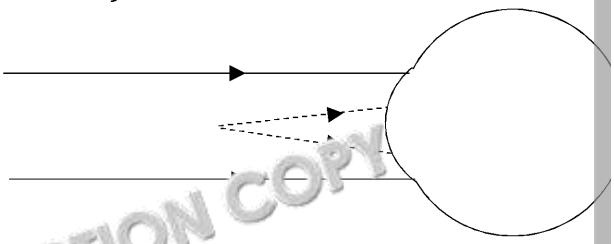
Additional materials required

- Pencil
- Electronic calculator
- Ruler (cm/mm)

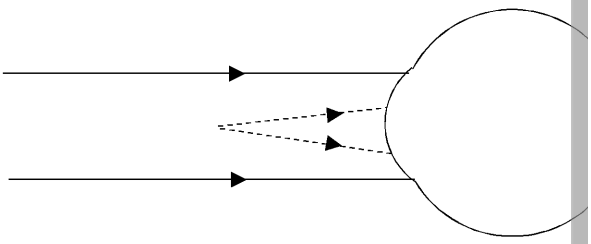
1. The human eye can develop a number of defects of vision.
The typical distance between the retina and lens of an eye is 20 mm.

1.1 Copy and complete the diagrams below to show how the eye of some
sightedness) and that of someone with hypermetropia (long-sighted
point and a near point.

Myopia (short-sightedness)



Hypermetro[illegible]g-sightedness)



1.2 A person with short-sightedness has a far point of 42.0 cm.

Calculate the power of lens required to correct the vision of this eye.

1.3 Calculate the focal point of the correcting lens in 1.2.

1.4 Describe the cause and effect of astigmatism, and describe the forma
used to correct for astigmatism.

2. Magnetic resonance (MR) scanners are used to image processes in a patie

2.1 Describe the basic principles of an MR scan.

Include in your answer a description of the signals produced by the M
body is affected, and how the image is pro[illegible].

2.2 State two reasons why M[illegible]s are more suitable for imaging brain

3. Endos[illegible]re comprised of fibre optic cables which are inserted into a

The fibre optic cables are grouped as either coherent or non-coherent bu

3.1 Describe the arrangement and uses of coherent bundles and non-coh
endoscope.

3.2 Describe an application of endoscopes, explaining **one** reason why e
this application than other possible methods.

3.3 Calculate the angle of total internal reflection at the core–cladding int
- Refractive index of core = 1.444
- Refractive index of cladding = 1.448

4. When considering the use of radionuclide tracers for medical diagnosis tr consider the half-lives of the tracer.

4.1 Explain what is meant by the terms 'physical half-life' and 'biological

4.2 Explain why the effective half-life of a substance is shorter than either half-life of the substance.

4.3 The physical half-life of a radionuclide is 3.54 days.

The initial activity of the radionuclide is 2800 Bq.

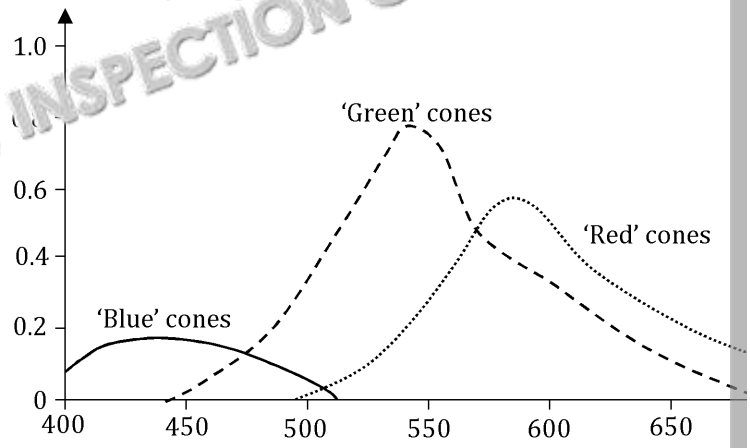
After one week, the activity of the radionuclide is measured to be 326

Calculate the biological half-life of the radionuclide.

4.4 Explain the benefit of imaging a patient's body using X-rays given off other X-ray imaging techniques.

Preview of Questions Ends Here

Mark Scheme: Set A

Question	Answer	Marks
1.1	Dark to light Restricts amount of light entering eye (avoiding harm to retina) ✓ Brought closer Focuses light onto retina ✓	1 1
1.2	Blue cones with lowest intensity around 400 nm to 500 nm region ✓ Green cones with highest intensity and with peak around 550 nm region ✓ Red cones with peak around 600 nm region ✓ **Relative intensity of light absorbed**  	1 1 1
1.3	At least one unstimulated cell between stimulated cells ✓	1
1.4	Average cone spacing $= \frac{1}{\sqrt{147000}} = \frac{1}{383.4} = 2.608 \times 10^{-3}$ mm ✓ $(= 2.608 \times 10^{-6}$ m) Use small angle approximation $\theta \approx \tan\theta$ ✓ Resolution $= 2 \times \frac{2.608 \times 10^{-3}}{17.1}$ ✓ (Resolution $= 3.05 \times 10^{-4}$ rad)	1 1 1

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2.</td><td colspan="2">The guidance below outlines the features of a 1-, 2-, 3-, 4-, 5- and 6-mark a</td></tr>
<tr><td></td><td colspan="2"><table>
<tr><th>Mark</th><th>Criteria</th><th></th></tr>
<tr><td>6</td><td>A detailed discussion of ion movement in the heart, including values and how signals spreading across the skin allow the ECG to be obtained.</td><td rowspan="2">Releva
cohere
and cle
gramm
is legib</td></tr>
<tr><td>5</td><td>A detailed discussion of the shape of ECGs, including typical values and the spreading of electrical signals across skin.</td></tr>
<tr><td>4</td><td>A discussion that includes the majority of main points about the shape, including typical value
information about spreading si</td><td rowspan="2">Inform
is suffi
Spellin
and ha</td></tr>
<tr><td>3</td><td>A discussion that i
shape and
si
are gaps in knowledge and missing details.</td></tr>
<tr><td></td><td>Only a couple of points made correctly; significant knowledge is missing.</td><td rowspan="2">Some i
presen
gramm
but the</td></tr>
<tr><td>1</td><td>Only one correct point made about the operation, such as electrical signals spreading across the heart.</td></tr>
<tr><td>0</td><td>No relevant information provided.</td><td>Presen
seriou
Unders</td></tr>
</table>
Max 6 marks – The following statements are likely to be included:

• P wave corresponds to depolarisation of muscle cells in atria
• QRS due to depolarisation of muscle cells in ventricles. Ventricles cont
• Repolarisation of atria at same time as QRS wave (not seen, as QRS is
• T wave corresponds to repolarisation of muscle cells in ventricles. Ve

• Typical baseline ~ 0.1 mV, peak (at R) ~1 mV (at skin)
• (Within cells, resting potential of ~-70 mV, peak of ~+35 mV)
• Takes roughly 0.2 s

• During depolarisation, sodium channels open and sodium ions (Na^+) f
• During repolarisation, potassium channels open and potassium ions (

• Electrical signal spreads through surrounding tissues (and fluid)
• Spread to skin
• Electrodes on skin pick up potential difference change

• All electrical cables screened to avoid em
ion</td></tr>
<tr><td>3.1</td><td>Different materials absorb X-rays b
di
amounts ✓</td><td>1</td></tr>
<tr><td>3.2</td><td>Light hits photodio
s, r
ng electrons ✓
Scintillator
into visible light ✓</td><td>1
1</td></tr>
<tr><td>3.3</td><td>tw
om: ✓✓
nage produced instantly – no wait for processing and developing image, and doctors can react quickly (e.g. if additional X-rays are needed)
• Much more sensitive, so much lower dose delivered to patient
• Easy storage and communication of digital files
• Low exposure time reduces both dose to patient and risk of unfocused image</td><td>Max 2</td></tr>
</table>

Question	Answer	Marks
3.4	Fluorescent screens multiply light produced from each X-ray ✓ So a smaller dose is needed ✓ Image is focused by anodes ✓ So a sharper image can be collected (and better diagnosis achieved) ✓	1 1 1 1
3.5	$\mu_m = \frac{\mu}{\rho}$ $\mu = \mu_m \rho$ $\mu = 3.75 \times 4.51$ $\mu = 16.91\ \text{cm}^{-1}$ ✓ $\frac{I}{I_0} = e^{-\mu x}$ $\ln\left(\frac{I}{I_0}\right) = -\mu x_1$ $x_{\frac{1}{2}} = -\frac{\ln\frac{1}{2}}{\mu}$ $x_{\frac{1}{2}} = -\frac{\ln\frac{1}{2}}{16.9}$ ✓ $x_{\frac{1}{2}} = 0.0410\ \text{cm}$ ✓	1 1 1
3.6	Barium sulphate is opaque to X-rays ✓ Increases contrast of image collected (without increasing dose) ✓	1 1
4.1	(Indium-111) Explanation to include at least **two** from: ✓✓ • Shortest half-life so presents lowest dose • Gamma decay less ionising than beta-minus decay (so less damaging than iodine-131) • Lowest maximum decay energy and lowest decay energy less likely to ionise (so less damaging) • (Accumulates in bone) so will image bones more clearly	Max 2
4.2	^{99m}Tc could not be transported to the facilites due to its short half-life ✓ Generator allows constant supply of ^{99m}Tc in usable amounts ✓	1 1
4.3	Positrons produced by radionuclides and annihilates with electron ✓ Gamma rays produced and detected outside body ✓	1 1

Preview of Answers Ends Here