

AQA A-LEVEL PHYSICS

PHYSICS



EXAM QUESTION PACK

UNIT 5B MEDICAL PHYSICS OLD SPECIFICATION PAPERS

STEMUP

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Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

A-level PHYSICS A

Unit 5B Medical Physics
Section B

Tuesday 28 June 2016

Morning

Time allowed: The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:

- a calculator
- a pencil and a ruler
- a Data and Formulae Booklet (enclosed).

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

- 1 (a)** Two bright point sources of light are just resolved as individual images when viewed by a naked eye.

- 1 (a) (i)** State the condition needed for the images to be resolved by the retina.

[1 mark]

- 1 (a) (ii)** The images are formed on the retina at the fovea.
Explain which type of receptor in the retina is being used to detect the images.

[1 mark]

- 1 (a) (iii)** The sources subtend an angle of 0.13 mrad at the naked eye. The eyeball may be assumed to be spherical with a diameter of 52 mm .
Calculate the maximum diameter of the receptor used.

[2 marks]

diameter of receptor = _____ m



- 1 (b) (i)** Describe the changes which occur in a normal eye when the eye changes from viewing a near object to viewing a distant object, both objects being viewed in bright light.

[2 marks]

- 1 (b) (ii)** Describe the changes which occur in a normal eye as the eye changes from viewing an object in bright light to viewing the same object in very dim light.

[3 marks]

Turn over for the next question

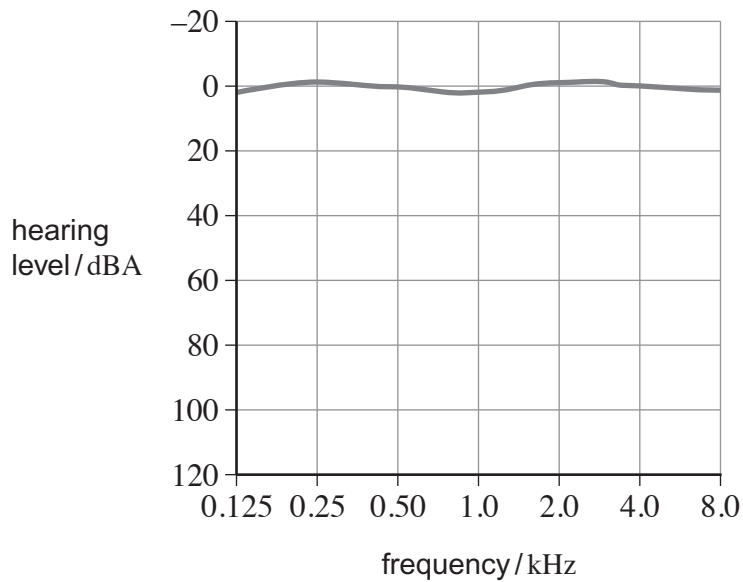
Turn over ►



- 2 Three people were given routine hearing tests. One person was found to have normal hearing and the other two were found to have defective hearing.

- 2 (a) **Figure 1** shows the variation of hearing level with frequency for the person found to have normal hearing.

Figure 1



It is known that the ear of a person with normal hearing is much more sensitive at 3 kHz than at other frequencies.

Explain why the graph indicates little variation with frequency.

[2 marks]

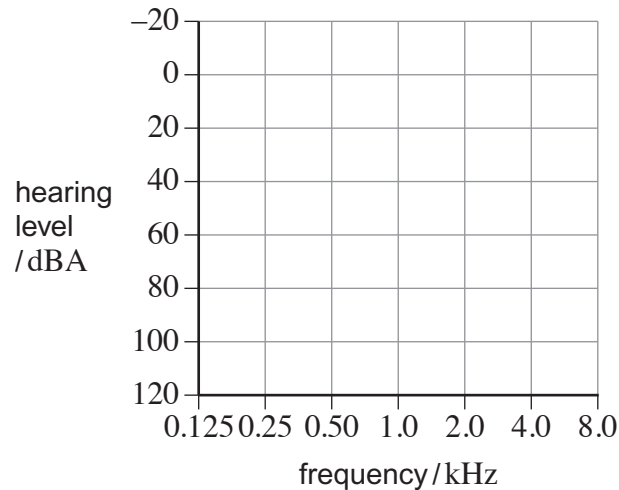


2 (b) Of the other two people, one was found to be suffering from age-related hearing loss and the other was found to be suffering from noise-related hearing loss.

2 (b) (i) Sketch on **Figure 2** the curve you would expect to see for the person suffering from age-related hearing loss.

[1 mark]

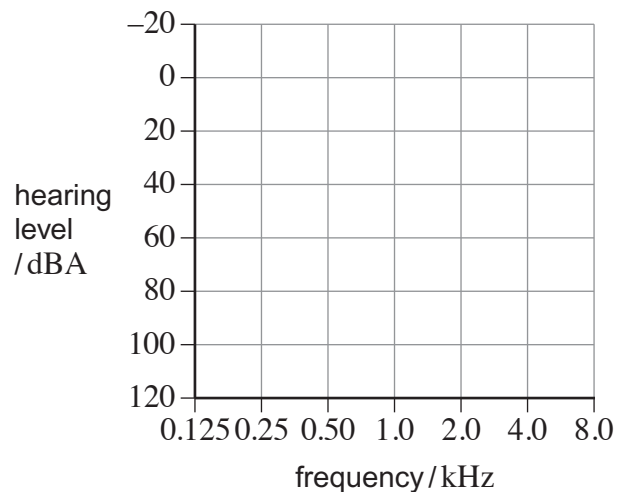
Figure 2



2 (b) (ii) Sketch on **Figure 3** the curve you would expect to see for the person suffering from noise-related hearing loss.

[2 marks]

Figure 3



Turn over ►



- 2 (c)** A foghorn at the top of a cliff produces a sound. A sound meter on the deck of a ship 400 m away from the cliff gives a reading of 92 dB.

- 2 (c) (i)** Calculate the intensity of the sound incident on the sound meter.

[2 marks]

$$I_0 = 1.0 \times 10^{-12} \text{ W m}^{-2}$$

intensity = _____ W m^{-2}

- 2 (c) (ii)** The sound from the foghorn is emitted equally in all directions. Assume that the sound is not reflected at the surface of the sea and that there is no attenuation of the sound.

Estimate the power emitted by the foghorn

[2 marks]

power = _____ W



Turn over for the next question

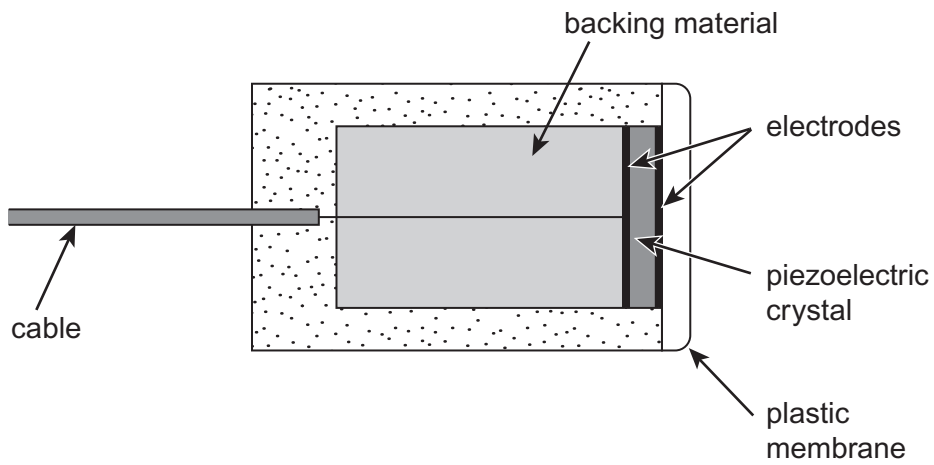
**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



3

Figure 4



3 (a)

[3 marks]

[illegible]

- 3 (b)** Why does the ultrasound pulse produced need to be short?
Place a tick (✓) in the right-hand column to show the correct answer.

[1 mark]

	✓ if correct
To reduce pulse spreading	
To stop the probe overheating	
To allow the probe to act as a receiver	
To reduce damage to cells in the patient	

- 3 (c)** A coupling gel is needed when performing an ultrasound scan.
Explain how and why a coupling gel is used.

[3 marks]

7

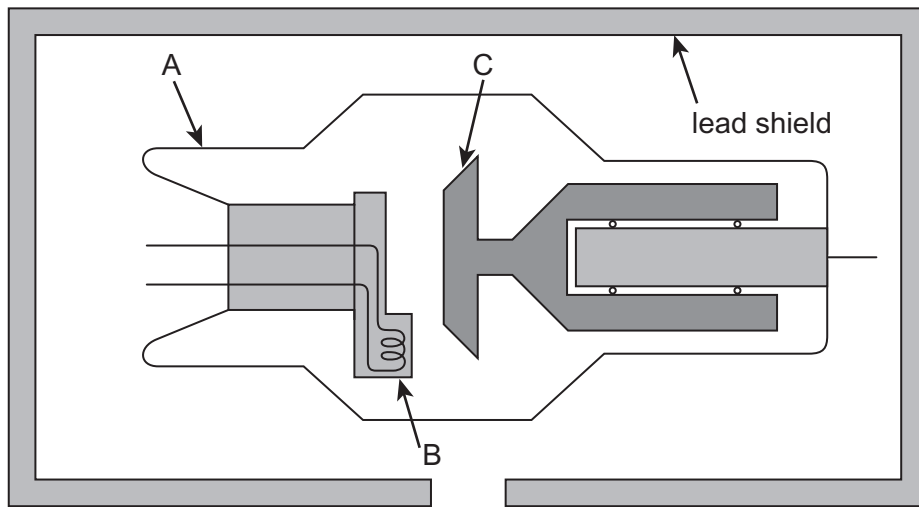
Turn over for the next question

Turn over ►



4 (a) **Figure 5** shows a simplified modern X-ray tube with a rotating anode.

Figure 5



Explain the design and operation of the X-ray tube and the purposes of the components labelled on the diagram.

In your answer you should include:

- reference to the components labelled A, B, C and the lead shield
- an explanation of the physical processes by which X-rays are produced.

The quality of your written communication will be assessed in your answer.

[6 marks]



Question 4 continues on the next page

4 (b) The X-ray tube produces photons of energy 50 keV. The half-value thickness of bone for photons of this energy is 15 mm.

4 (b) (i) Explain what is meant by half-value thickness.

[1 mark]

4 (b) (ii) Show that for 50 keV X-ray photons, the attenuation coefficient of bone μ is 0.046 mm^{-1} .

[1 mark]

4 (b) (iii) A beam of 50 keV X-ray photons is incident on a bone of thickness 12 mm. Calculate the percentage of the incident photons that leave the far side of the bone.

[2 marks]

percentage of incident photons = _____ %

END OF QUESTIONS



A-level Physics

PHYA5/2B – Medical Physics
Mark scheme

2450
June 2016

Version: 1.0 Final

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 Assessment Writer.

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Question	Answers	Additional Comments/Guidance	Mark	ID details
1(a)(i)	The two images are formed on receptors/cells separated by at least one unstimulated receptor/cell	Allow images separated by at least 2 cell diameters	1	
1(a)(ii)	Cones are used as ONLY cones at fovea		1	
1(a)(iii)	Distance images apart on retina = 2 x cone diameter Diameter = $(0.130 \times 10^{-3} \times 52 \times 10^{-3}) / 2 = 3.4 \times 10^{-6} \text{ m}$	Allow 1 mark for correct sep of images calc. ($0.130 \times 10^{-3} \times 52 \times 10^{-3}$) in calc Allow 1 mark for wrong distance calc divided by 2 for final answer/ angle divided by 2	1 1	
1(b)(i)	Ciliary muscles relax / suspensory ligaments contract Producing lens of less power / greater focal length	Allow decreasing the curvature of the lens/flatter/thinner/less spherical	1 1	
1(b)(ii)	Cones stop working and rods start enlarged pupil Then the third mark for either dark adaptation – takes some mins for rods to fully function / eye to adapt or (Iris) circular muscles relax / (iris) radial muscles contract	Accept dilated pupil Accept concentric for circular	1 1 1	
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
2(a)	(Intensity) measured on dBA scale / adjusted scale which mimics normal ear (so values around 0dBA) at all frequencies		1 1	
2(b)(i)	Figure 2 - falling to larger values as frequency increases	Start must be between 0 and 20 dBA must not consistently go above 0dBA must cover the 0.125 to 8 kHz range can go on after 8 kHz	1	
2(b)(ii)	Figure 3 – falling to larger values and then going up to smaller values as frequency increases Maximum value at $f = 4$ kHz	Start must be between 0 and 20 dBA must not consistently go above 0dBA must cover the 0.125 to 8 kHz range can go on after 8 kHz	1 1	
2(c)(i)	$I = I_0 \times 10^{9.2}$ or correct substitution in formula $I = 1.6 \times 10^{-3} \text{ W m}^{-2}$		1 1	
2(c)(ii)	Use of $4 \times \pi \times 400 \times 400$ Correct calc to give $3.2 \times 10^3 \text{ W}$	Allow ecf from previous calculation	1 1	
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3(a)	Alternating pd applied across the electrodes/crystal Causes crystal to expand and contract Produces (ultrasonic) vibrations at front of membrane Backing material damps vibration of the crystal when pd is removed	Max 3 Any reverse argument converting ultrasound to signal gains zero	3	
3(b)	To allow probe to act as a receiver	Auto marked	1	
3(c)	Needed between probe and skin If air present, large difference in acoustic impedance so little transmitted / Gel excludes air and has acoustic impedance close to that of skin Gel maximises transmission	Use of minimising/maximising pulses/waves penalises 1 mark from last 2 marks Accept minimises reflection	1 1 1	
Total			7	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4(a)	Points to be considered: A – glass envelope. This is needed to allow low pressure within the tube B – heated cathode. Heated to provide thermionic emission of electrons from the surface C – anode. Used to accelerate electrons across the gap between cathode and anode. lead shielding - Prevents much of the emission in unwanted directions. The anode rotates to allow heat to be dissipated over greater area and thus allows longer use without over-heating. The anode is bevelled to allow a larger ‘target’ area for the electrons, whilst also producing a smaller ‘source’ area for the photons in the required direction. Low pressure is required in the tube to allow the electrons to be accelerated across the gap without colliding with gas atoms and losing energy in the collision. Electrons colliding with anode material excite / ionise the atoms and as the atoms de-excite X-ray photons of specific energies are produced. Electrons can also be decelerated as they pass through the anode. The energy of the X-ray photon is equal to the energy lost by the decelerated electron. This can be any value from the max energy of the electron to zero. This produces a continuous background spectrum of X-ray photon energies. Good candidates will name and state the use of the labelled components and will expand on a property of the anode and suggest why some X-rays are produced.		6	

	Middle candidates will name and state the use of 3 or all of the labelled components. They may try to expand on the anode properties or the method of X-ray production. Poor candidates may be able to name some labelled components, but will fail to apply the ideas.			
4(b)(i)	Thickness of material needed to reduce (beam) intensity by half	Accept (beam) power NOT energy	1	
4(b)(ii)	$\ln 2 / 15 = 0.046$	Use of 50 and 25 is EOP	1	
4(b)(iii)	$\% I_T / I_0 = e^{-(0.046 \times 12)} \times 100$ $= 58 \%$	If 0.0462 is used, the answer 57.4 or 57 is correct	1 1	
Total			10	

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2015

Physics A

PHYA5/2B

Unit 5B Medical Physics Section B

Thursday 18 June 2015 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a pencil and a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

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 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 5 P H Y A 5 2 B 0 1

WMP/Jun15/PHYA5/2B/E4

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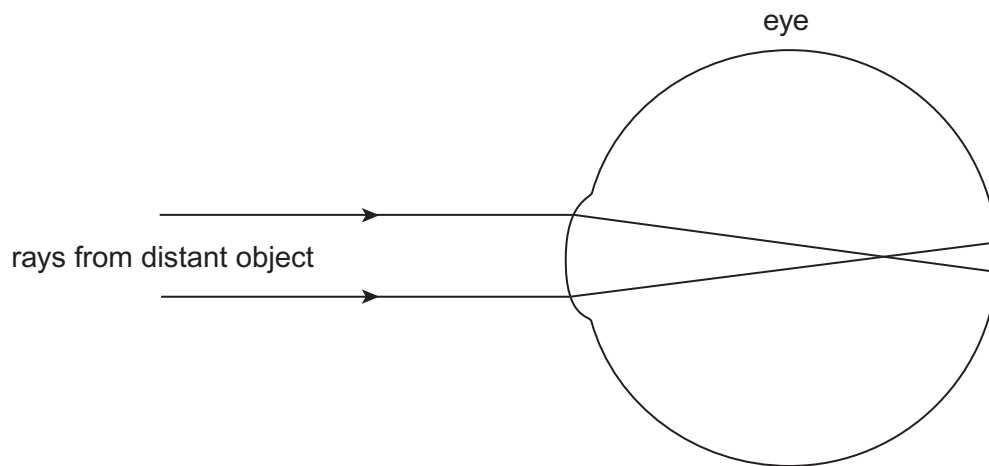
PHYA5/2B

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

- 1 (a)** **Figure 1** is a simplified ray diagram which shows light rays from a distant object being focused at a point in front of the retina.

Figure 1



- 1 (a) (i)** What is this defect of vision?
Tick (✓) the correct answer.

[1 mark]

astigmatism	
hypermetropia / long sight	
myopia / short sight	

- 1 (a) (ii)** On **Figure 1**, draw in front of the eye a suitable lens to correct this type of defect of vision.

[1 mark]

- 1 (a) (iii)** Complete the new diagram by drawing the path of the two rays from the distant object as they pass through the correcting lens and the eye.

[2 marks]



1 (b) The unaided far point of the defective eye is 0.75 m.

1 (b) (i) Explain why the focal length of the correcting lens used should be -0.75 m.

[1 mark]

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1 (b) (ii) Calculate the power of this correcting lens.

[1 mark]

power = ... D

1 (b) (iii) The unaided near point of the defective eye is 0.15 m.

Calculate the distance of the aided near point from the eye when the lens of focal length -0.75 m is used. Give your answer to a suitable number of significant figures.

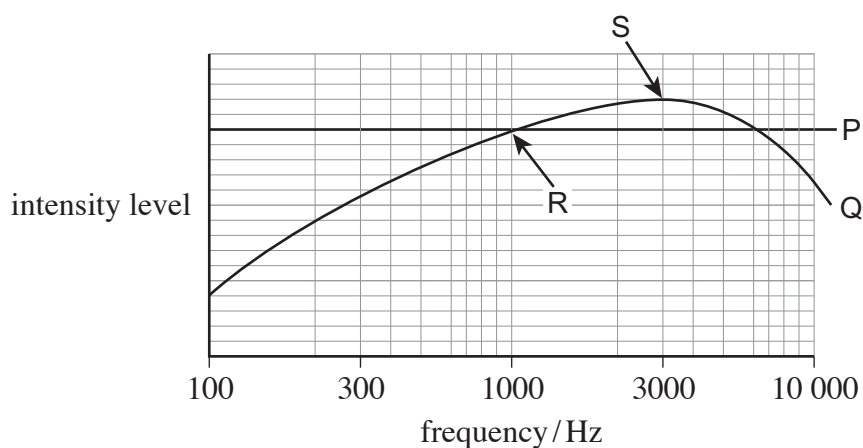
[3 marks]

aided near point distance = ... m



- 2 (a)** A variable-frequency sound source produces sound of equal intensity at all frequencies. Two sound meters are placed at equal distances from the source. The two meters are set on different scales. Lines P and Q on **Figure 2** show how the intensity level indicated by each meter varies with frequency.

Figure 2



- 2 (a) (i)** State and explain which sound meter scale is used for line P.

[2 marks]

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- 2 (a) (ii)** State and explain which sound meter scale is used for line Q.

[2 marks]

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2 (b) (i) Explain the significance of the point R.

[1 mark]

.....

.....

2 (b) (ii) Explain the significance of the point S.

[1 mark]

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2 (c) A sound of intensity level 95 dB is incident on a human ear.
Calculate the intensity incident on the ear drum.

$$I_0 = 1.0 \times 10^{-12} \text{ W m}^{-2}$$

[2 marks]

intensity = ... W m^{-2}

8

Turn over for the next question

Turn over ►



3 An ECG trace is to be obtained for a healthy patient. Describe the procedure involved to ensure that a good trace is obtained. Your answer should include reference to:

- connections to the body
- how unwanted signals are avoided
- some properties of the amplifier used.

The quality of your written communication will be assessed in your answer.

[6 marks]

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6

Turn over for the next question

Turn over ►



4 (a) An endoscope uses **coherent** and **non-coherent** fibre bundles.

4 (a) (i) State the use of the **coherent** bundle and describe its arrangement of fibres.

[2 marks]

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4 (a) (ii) State the use of the **non-coherent** bundle and describe its arrangement of fibres.

[2 marks]

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4 (b) Each fibre has a core surrounded by cladding.
Calculate the critical angle at the core–cladding interface.

refractive index of core = 1.52

refractive index of cladding = 1.49

[1 mark]

critical angle = ... degree



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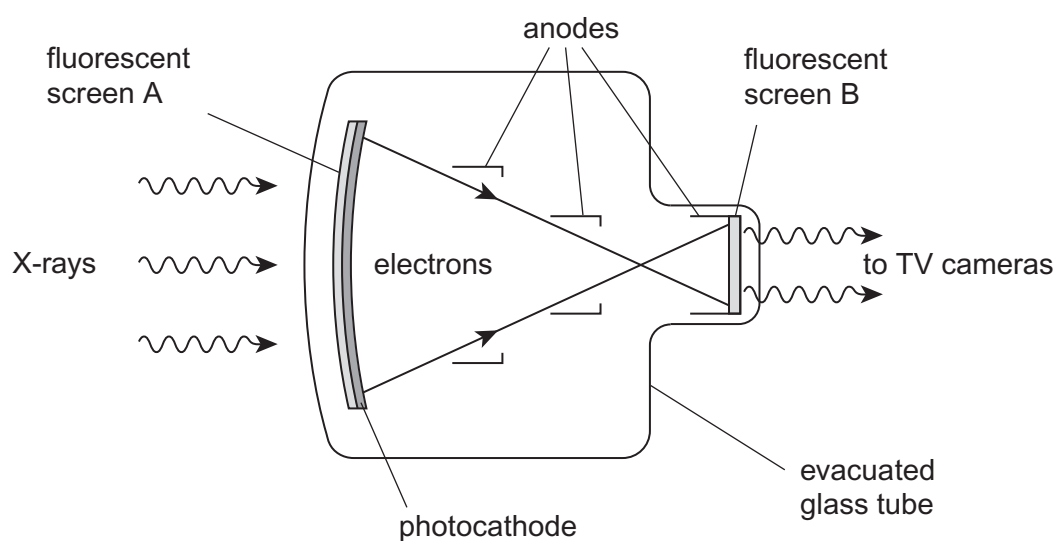
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ANSWER IN THE SPACES PROVIDED**

Turn over ►



5 (a) **Figure 3** shows a fluoroscopic image intensifier.

Figure 3



State the purpose of each of the following components of the intensifier.

5 (a) (i) fluorescent screen A,

[1 mark]

.....

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5 (a) (ii) photocathode,

[1 mark]

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5 (a) (iii) anodes,

[2 marks]

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5 (a) (iv) fluorescent screen B.

[1 mark]

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5 (b) A patient is asked to swallow a suspension of barium sulfate before X-ray images are to be obtained. This is known as a barium meal technique.
Explain why the patient needs to swallow the barium sulfate.

[2 marks]

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7

END OF QUESTIONS



There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED**



A-LEVEL

Physics

PHA5/2B – Medical Physics

Mark scheme

2450

June 2015

Version/Stage: 1 Final Mark Scheme

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Question	Answers	Additional Comments/Guidance	Mark	ID details
1ai	Ans C; Myopia or short sight	Auto marked	1	AO1
1aii	Concave/diverging lens drawn		1	AO1
1aiii	Rays diverge at correcting lens Rays converge at eye and are focussed at retina		1	AO2
			1	AO2
1bi	So that rays (from a distant object)appear to come from the far point (of the defective eye)	OR to form (virtual) image at the (unaided) far point	1	AO1
1bii	$f = -0.75$ $P = 1/f = -1.3 \text{ (D)}$	Do not accept – 4/3	1	AO2
1biii	$\frac{1}{u} = \frac{1}{f} - \frac{1}{v} = \frac{1}{-0.75} - \frac{1}{-0.15}$ $u = 0.19 \text{ (m)}$ 2 sig figs		1	AO2
			1	AO2
			1	AO2
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
2ai	The dB scale Equal response across all frequencies	Allow decibel scale Not DB Allow unaffected by / independent of frequency	1 1	AO1 AO2
2aii	The dBA scale Response depends upon frequency as ear's response does	Allow adjusted/adapted decibel scale Not DBA	1 1	AO1 AO2
2bi	Point R has equal values on both scales (as 1kHz) is the frequency used to define threshold value.	Allow reference frequency for dBA scale	1	AO1
2bii	Point S is at (3kHz as this is) the frequency at which the ear is most sensitive.	Allow most sensitive as at peak of curve	1	AO1
2c	$I = 1.0 \times 10^{-12} \times 10^{9.5}$ $I = 3.2 \times 10^{-3} \text{ (W m}^{-2}\text{)}$	First mark for any correct initial equation Only penalise 1 sig fig.	1 1	AO2 AO2
Total			8	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3	High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The student accurately describes measures to ensure good contact between the electrodes and the skin including the use of conducting gel. The student will mention the need for more than one electrode and the need for the patient to remain relaxed and still. They will need at least two properties of the amplifier.	Points which might be considered include attach more than one electrode To reduce contact resistance • sandpaper skin to remove hairs and some dead skin • apply conducting gel between electrode and skin • securely attach electrode and stick/tape in place To remove unwanted signals • electrodes should be non-reactive • patient to remain relaxed and still • shielded leads/reducing interference from ac sources Properties of amplifier • large input impedance • high gain • low noise or differential amp	6	AO1 x 2 AO2 x 2 AO3 x 2

	Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The student will include most measures to ensure good contact between electrodes and the skin. They should give a property of the amplifier and may mention the need for the patient to remain relaxed and still. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The student will mention electrodes connected to the skin and might make some other sensible comments on the arrangement.			
Total			6	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4ai	Coherent – used to transfer/transmit image (out of body) Coherent – same fibre arrangements at both ends of bundle	Allow same relative position Do not allow symmetrical	1 1	AO2 AO2
4aii	Non-coherent – used to transfer light into body (to illuminate) Non-coherent – random fibre arrangement along bundle	Do not allow not symmetrical	1 1	AO1 AO1
4b	$\sin \theta_c = 1.49/1.52$ $\theta_c = 79$ (degree)		1	AO2
Total			5	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5ai	Fluorescent screen A – converts X-ray (photon) to light (photons)/lower energy photon(s)		1	AO2
5aii	Photocathode – uses (energy of) each light photon to release an electron from surface of cathode	Do not allow converts light/photon into electron	1	AO2
5aiii	Anodes – accelerate (released) electrons focuses electron beams	Mention of negative anode disqualifies first mark awarded. Do not accept direct towards the screen as focussing	2	AO2
5aiv	Fluorescent screen B – converts energy of electron(s) into (many) light (photons)	Do not allow converts electrons into light/photons	1	AO2
5b	Without Barium poor contrast between area to be investigated and surrounding tissue. Barium meal proves high proton number/ high density/high attenuation material at site to be investigated which provides much better contrast Barium meal proves high proton number/ high density/high attenuation material at site to be investigated which provides much better contrast between area to be investigated and surrounding tissue.	This will get first mark	1	AO1
		This will gain the second mark	1	AO1
		But this will get both marks		
Total			7	

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2014

Physics A

PHYA5/2B

Unit 5B Medical Physics Section B

Thursday 19 June 2014 9.00 am to 10.45 am

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J U N 1 4 P H Y A 5 2 B 0 1

WMP/Jun14/PHYA5/2B/E7

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PHYA5/2B

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

- 1 (a)** A person views a flashing white light source in a darkened room. Each flash lasts for 0.01 s and initially the light is flashing at a frequency of 1 Hz. State how the person's perception of what is seen changes as the frequency at which the light flashes is slowly increased from 1 Hz to 40 Hz. Name the physiological process involved.

[3 marks]

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physiological process involved

- 1 (b)** A person with a defective eye wears spectacles to see clearly a small real object. The object is placed at the aided near point of the eye, 25.0 cm from the correcting lens. The power of the correcting lens is + 1.75 D.

- 1 (b) (i)** Find the image distance of the image formed by the correcting lens.

Give your answer to an appropriate number of significant figures.

[3 marks]

image distance cm



1 (b) (ii) State what this image distance represents.

[1 mark]

.....

.....

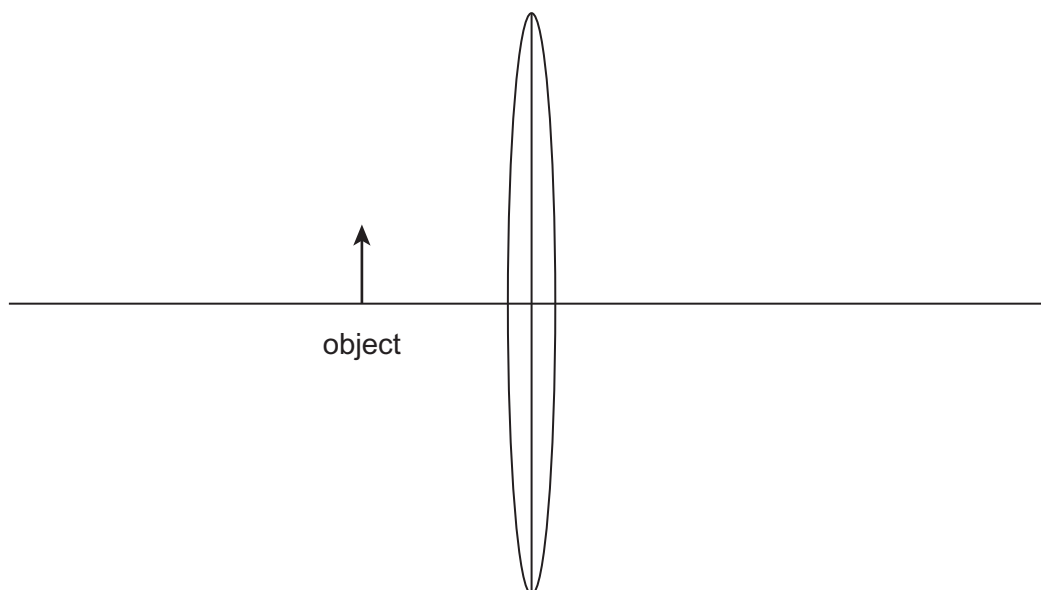
1 (c) State the defect of vision which is corrected using a converging lens.

[1 mark]

.....

1 (d) Draw a labelled ray diagram below to show how the lens in part (b) forms the image of the small real object. Clearly label the image and principal foci of the lens. Your diagram does not have to be to scale.

[2 marks]



2 (a) Define the threshold of hearing, I_0 .

[2 marks]

.....

.....

.....

.....

2 (b) Sound intensity levels are usually measured in decibels which is based on a logarithmic scale. State **two** reasons why this logarithmic scale is used.

[2 marks]

reason 1

.....

reason 2

.....

2 (c) Hearing loss might be due to ageing or exposure to excessive noise. For each cause, state how the hearing loss varies with frequency over the audible range.

2 (c) (i) Loss due to ageing.

[1 mark]

.....

.....

2 (c) (ii) Loss due to excessive noise.

[2 marks]

.....

.....

Turn to page 6 for the next question



Turn over for the next question

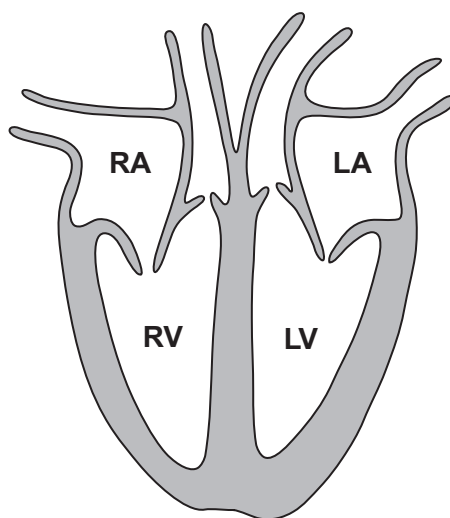
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Turn over ►



The quality of your written communication will be assessed in your answer.

Figure 1



RA = right atrium
RV = right ventricular
LA = left atrium
LV = left ventricular

This image shows a full page of primary-ruled paper. It features ten sets of horizontal dashed lines, each set consisting of three parallel lines. These lines are evenly spaced vertically across the entire page, providing a guide for handwriting practice. The background is white, and there are no margins or other markings present.

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6

Turn over for the next question

Turn over ►



- 4** A diagnostic X-ray tube produces a beam of X-rays. The beam passes through a diaphragm consisting of two pairs of lead sheets which can be moved at right angles to each other, and then through an aluminium filter.

4 (a) (i) State the use of the lead sheets.

[1 mark]

.....

.....

4 (a) (ii) State the use of the aluminium filter.

[1 mark]

.....

.....



- 4 (b)** When a monochromatic beam of X-ray photons is passed through an aluminium sheet of thickness 2.7 mm, its intensity is reduced by 8.3%.

Calculate the mass attenuation coefficient of aluminium for these X-rays.

State an appropriate unit for your answer.

density of aluminium = 2700 kg m^{-3}

[5 marks]

mass attenuation coefficient unit

7

Turn over for the next question

Turn over ►



- 5 (a)** During a magnetic resonance (MR) brain scan, the head of the patient is exposed to short pulses of radio frequency electromagnetic waves while in a strong magnetic field. Outline the basic principles of an MR scanner used to perform this scan.

[3 marks]

.....

.....

.....

.....

.....

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.....

.....

- 5 (b)** Ultrasound is thought to be more suitable than X-rays for scanning an unborn fetus. State **two** reasons why ultrasound is used for this application.

[2 marks]

reason 1.....

.....

reason 2.....

.....

5

END OF QUESTIONS



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A-LEVEL PHYSICS A

PHA5B – Medical Physics
Mark scheme

2450
June 2014

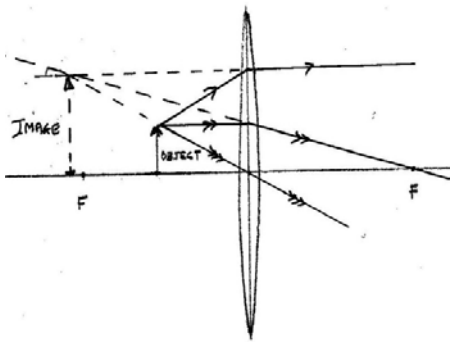
Version: 1.0 Final

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 Assessment Writer.

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

Question	Answers	Additional Comments/Guidance	Mark	ID details
1 (a)	At 1Hz, individual flashes of light seen ✓ At some frequency the flashes appear to join to form continuous light so that no flashing seen at 40Hz ✓ Process is called persistence of vision ✓	Need reference to change from flash to continuous around a given frequency Allow 'sight' for 'vision'	3	
1 (b)(i)	$(1/f = 1/u + 1/v)$ $1.75 = 1/0.250 + 1/v$ ✓ $v = (-)$ 44.4 cm ✓ 3 sig figs ✓	Sig fig mark stands alone. Allow 'x' for 'v'	3	
1 (b)(ii)	this is the (defective eye's) unaided near point ✓	Allow uncorrected near point	1	
1 (c)	long sight / presbyopia / hypermetropia ✓		1	
1 (d)	1 correct ray ✓ 2 nd correct ray with labelled image and foci ✓	Which refers to a virtual image	2	

				
2 (a)	Minimum intensity heard by normal/average ear ✓ At frequency of 1kHz ✓		2	
2 (b)	Response of ear is logarithmic ✓ Allows very <u>large range</u> of intensities to be on <u>sensible scale</u> ✓		2	
2 (c)(i)	Ageing; loss increases as f increases ✓	Allow higher frequencies are lost	1	
2 (c)(ii)	Noise; loss increases up to 4 kHz ✓ then decreases after this frequency ✓	Allow loss increases and then decreases for 1 mark Allow greatest loss at 4kHz for 2 marks	2	

question	answers	extra information	mark
3		The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.	6
Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 4 and apply a 'best-fit' approach to the marking.			
0 marks	Level 1 (1–2 marks)	Level 2 (3–4 marks)	Level 3 (5–6 marks)
	Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. There will be a few of the guidance points mentioned, but there will be little cohesion in the writing.	Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The answer may discuss the direction of blood flow, the delay from SA to SV and the need for valves or the compression and relaxation processes.	High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The answer will discuss the direction of blood flow and will mention the correct chambers, the time of the delay from SA to SV and the need for valves. They should write about compression and the relaxation processes. The names of valves may be included, but the use of the valves should be explained.
examples of the points made in the response The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their		extra information	

consequences in this case. pulse passes over both atria and causes them to contract forces blood into ventricles pulse passes to AV node and delayed for about 0.1 s AV node fires and causes ventricles to contract forcing blood around the body and to the lungs: atria relax Bicuspid and tricuspid valves prevent blood backflow from ventricles into atria as atria chambers relax draws blood into the atria Ventricles relax Semilunar valves stop blood backflow from body into ventricles right chambers deal with de-oxygenated blood from body to lungs left chambers deal with oxygenated blood from lungs to body depolarisation and reverse polarisation from movement of Na^+ into axon cause contraction Repolarisation of K^+ out of axon cause relaxation -70mV to +30mV	
---	--

Question	Answers	Additional Comments/Guidance	Mark	ID details
4 (a)(i)	Provide aperture through which X-rays may pass, stopping others ✓	Alternatives: provides collimation; produces narrow beam of X-rays; protects areas of the body not being scanned	1	
4 (a)(ii)	Filters out (most) low energy photons(but allows high energy photons to pass through) ✓	Allow 'soft' or underpower' for low energy Allow only high energy photons pass through	1	
4 (b)	$I/I_0 = 0.917$ ✓ $\ln(0.917) = -\mu \times 2.7 \times 10^{-3}$ ✓ $\mu = 32.1$ ✓	If 0.083 or 91.7 used, final 3 calc marks can be given If 0.83 or 8.3 or 9.17 used, final 2 calc marks can be	5	

	$\mu_m = \mu / 2700 = 0.012 \checkmark$ $\text{m}^2 \text{kg}^{-1} \checkmark$	given Unit mark is independent mark		
5 (a)	any three points from: supplied radio pulse excite H nuclei when H nuclei de-excite/change spin/change alignment they emit radio photon/signal/em radiation these signals are detected and passed to computer gradient in static magnetic field to allow location to be determined or magnetic field aligns nuclei	Allow Hydrogen protons for nuclei	Max 3	
5 (b)	any two reasons, eg (non-ionising) so no known harm caused to unborn baby, gives good images of soft tissue, relatively cheap	Accept correct reverse arguments for X-rays Do not allow better resolution	2	
Total			35	

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2013

Physics A

PHYA5/2B

Unit 5B Medical Physics Section B

Thursday 20 June 2013 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 3 P H Y A 5 2 B 0 1

WMP/Jun13/PHYA5/2B

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PHYA5/2B

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

1 In the eye, rods and cones are used to detect light incident on the retina.

1 (a) Describe how the rods and cones are distributed over the surface of the retina.

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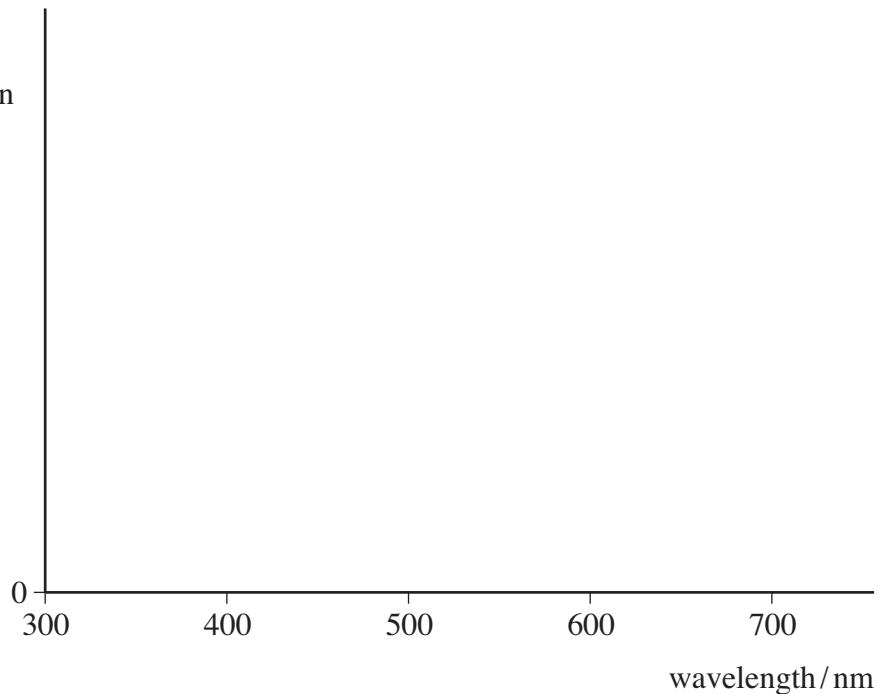
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(2 marks)

1 (b) On the axes below sketch **three** curves to show how the response of each of the three types of cone found in the retina varies with the wavelength of light.

Label each of the three curves with the cone colour to which it refers.

relative
light
absorption



(3 marks)



- 1 (c)** State the condition that must be satisfied for two objects to be resolved as individual images on the retina.

.....
.....
(1 mark)

- 1 (d)** Explain how the resolution of the image of an object seen in very dim white light compares to that of the image of the same object seen in bright white light.

.....
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.....
.....
.....
(2 marks)

8

Turn over for the next question

Turn over ►



Include an outline of how the variations in air pressure in the ear canal are amplified to produce greater pressure variations in the inner ear.

[illegible]

(6 marks)



2 (b) Define *intensity* of sound.

.....

.....

.....

.....

(2 marks)

2 (c) A human ear has a threshold of hearing of 54 dB at a given frequency. Calculate the intensity of sound incident on the ear at this frequency.

Give your answer to an appropriate number of significant figures.

$$I_0 = 1.0 \times 10^{-12} \text{ W m}^{-2}$$

intensity of sound W m^{-2}
(3 marks)

11

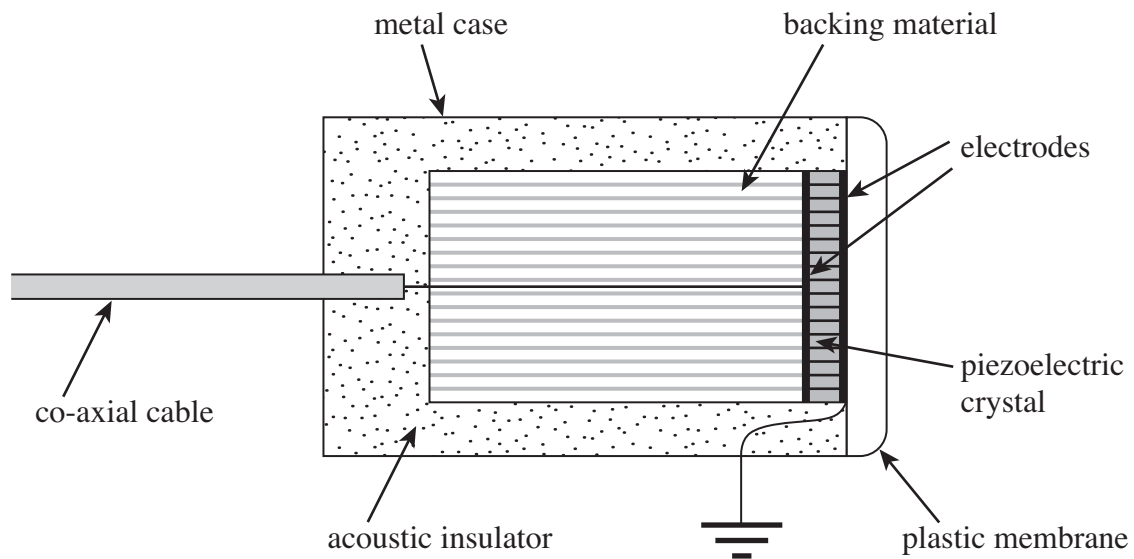
Turn over for the next question

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3 (a) **Figure 1** shows an ultrasound transducer used in an A-scan.

Figure 1



Outline, with reference to the diagram, the process by which the transducer produces a short pulse of ultrasound.

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(4 marks)



- 3 (b)** Ultrasound is incident on the boundary between two materials. Some of the ultrasound is reflected at the boundary and the remainder is transmitted across the boundary. The ratio of the intensity of the reflected ultrasound, I_r , to the intensity of the incident ultrasound, I_i , is given by the equation

$$\frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2$$

where Z_1 and Z_2 are the acoustic impedances of the two materials.

- 3 (b) (i)** Calculate the percentage of the incident ultrasound which would be transmitted into the skin when incident on an air-skin boundary.

acoustic impedance of air = $4.29 \times 10^2 \text{ kg m}^{-2} \text{ s}^{-1}$

acoustic impedance of skin = $1.65 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$

transmitted percentage %
(2 marks)

- 3 (b) (ii)** When obtaining the ultrasound image of an unborn foetus, a coupling gel is used. Explain why a coupling gel is needed and state the property of the gel that ensures a good quality image.

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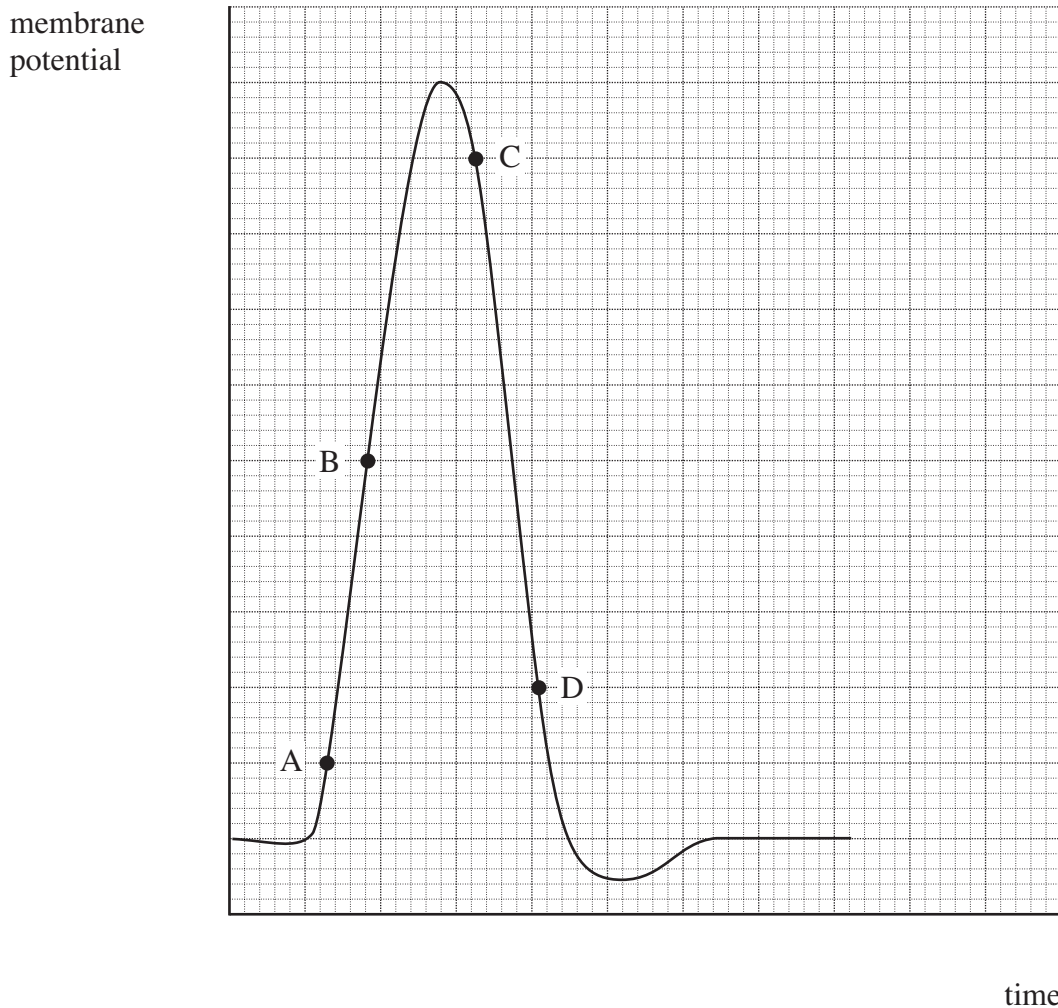
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(2 marks)



4 **Figure 2** shows how the membrane potential of a nerve cell varies with time.

Figure 2



4 (a) Complete **Figure 2** by adding units and values to both axes.

(3 marks)

4 (b) (i) State the value of the resting potential.

.....
(1 mark)

4 (b) (ii) Name the process involved between points A and B on the curve and describe the ion movement which produces this change.

process

ion movement

.....
(2 marks)



4 (b) (iii) Name the process involved between points C and D on the curve and describe the ion movement which produces this change.

process

ion movement

.....

(2 marks)

8

END OF QUESTIONS



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General Certificate of Education (A-level)
June 2013

Physics A

PHA5B

(Specification 2450)

Unit 5B: Nuclear and Thermal Physics

Medical Physics

Final

Mark Scheme

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Section A – Nuclear and Thermal Physics

Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	(a)	(i)	1/12 the mass of an (atom) of $^{12}_6\text{C}$ / carbon-12 / C12✓	1	a reference to a nucleus loses the mark
1	(a)	(ii)	separated nucleons have a greater mass ✓ (than when inside a nucleus) because of the (binding) energy added to separate the nucleons or energy is <u>released</u> when a nucleus is <u>formed</u> (owtte) ✓	2	an answer starting with 'its' implies the nucleus marks are independent direction of energy flow or work done must be explicit
1	(b)		nuclei need to be <u>close together</u> (owtte) for the Strong Nuclear Force to be involved or for fusion to take place✓ but the electrostatic/electromagnetic force is repulsive (and tries to prevent this) ✓ (if the temperature is high then) the nuclei have (high) kinetic energy/speed (to overcome the repulsion) ✓	3	e.g. first mark – within the range of the SNF 3 rd mark is for a simple link between temperature and speed/KE
1	(c)	(i)	15 ✓ e^+ ✓ (or β^+ , $^0_1\beta$, ^0_1e) 12 ✓	3	give the middle mark easily for any e or β with a + in any position

1	(c)	(ii)	$\Delta\text{mass} = 4 \times 1.00728 - 4.00150 - (2 \times 9.11 \times 10^{-31} / 1.661 \times 10^{-27})$ or $\Delta\text{mass} = \{4 \times 1.00728 - 4.00150 - 2 \times 0.00055\}(\text{u}) \checkmark$ $\Delta\text{mass} = 0.02652(\text{u}) \checkmark$ $\Delta\text{binding energy} (= 0.02652 \times 931.5) \quad \{\text{allow } 931.3\}$ $\Delta\text{binding energy} = 24.7 \text{ MeV} \checkmark$	3	$(4 \times 1.00728 = 4.02912)$ 1 st mark – correct subtractions in any consistent unit. use of $m_p = 1.67 \times 10^{-27} \text{ kg}$ will gain this mark but will not gain the 2 nd as it will not produce an accurate enough result 2 nd mark – for calculated value 0.02652u $4.405 \times 10^{-29} \text{ kg}$ $3.364 \times 10^{-12} \text{ J}$ 3 rd mark – conversion to MeV conversion mark stands alone award 3 marks for answer provided some working shown – no working gets 2 marks (2sf expected)
2	(a)		insert control rods (further) into the nuclear core/reactor $\checkmark$ which will absorb (more) neutrons (reducing further fission reactions) $\checkmark$	2	a change must be implied for 2 marks marks by use of (further) or (more) allow answers that discuss shut down as well as power reduction If a statement is made that is wrong but not asked for limit the score to 1 mark (e.g. wrong reference to moderator)
2	(b)		fission fragments/daughter products or <u>spent/used</u> fuel/uranium rods (allow) plutonium (produced from U-238) $\checkmark$	1	not uranium on its own
2	(c)	(i)	γ (electromagnetic radiation is emitted) $\checkmark$ as the energy gaps are large (in a nucleus) as the nucleus de-excites down discrete energy levels to allow the nucleus to get to the ground level/state $\checkmark$ mark for reason	2	A reference to α or β loses this first mark 2 nd mark must imply energy levels or states

2	(c)	(ii)	momentum/<u>kinetic energy</u> is transferred (to the moderator atoms) or a neutron slows down/loses <u>kinetic energy</u> (with each collision) ✓ (eventually) reaching speeds associated with thermal random motion or reaches speeds which can cause fission (owtte)✓	2	
3		(i)	(heat supplied by glass = heat gained by cola) (use of $m_g c_g \Delta T_g = m_c c_c \Delta T_c$) $0.250 \times 840 \times (30.0 - T_f) = 0.200 \times 4190 \times (T_f - 3.0)$ ✓ $(210 \times 30 - 210 T_f = 838 T_f - 838 \times 3)$ $T_f = 8.4(1) (^{\circ}\text{C})$ ✓	2	1st mark for RHS or LHS of substituted equation 2nd mark for 8.4°C Alternatives: 8°C is substituted into equation (on either side shown will get mark)✓ resulting in 4620J~4190J ✓ or 8°C substituted into LHS ✓ (produces $\Delta T = 5.5^{\circ}\text{C}$ and hence) = 8.5°C ~ 8°C ✓ 8°C substituted into RHS✓ (produces $\Delta T = 20^{\circ}\text{C}$ and hence) = 10°C ~ 8°C ✓

3		(ii)	(heat gained by ice = heat lost by glass + heat lost by cola) (heat gained by ice = $mc\Delta T + ml$) heat gained by ice = $m \times 4190 \times 3.0 + m \times 3.34 \times 10^5$ ✓ (heat gained by ice = $m \times 346600$) heat lost by glass + heat lost by cola = $0.250 \times 840 \times (8.41 - 3.0) + 0.200 \times 4190 \times (8.41 - 3.0)$ ✓ (= 5670 J) $m (=5670/346600) = 0.016$ (kg) ✓ or (using cola returning to its original temperature) (heat supplied by glass = heat gained by ice) (heat gained by glass = $0.250 \times 840 \times (30.0 - 3.0)$) heat gained by glass = 5670 (J) ✓ (heat used by ice = $mc\Delta T + ml$) heat used by ice = $m(4190 \times 3.0 + 3.34 \times 10^5)$ ✓ (= $m(346600)$) $m (=5670/346600) = 0.016$ (kg) ✓	3	NB correct answer does not necessarily get full marks 3rd mark is only given if the previous 2 marks are awarded (especially look for $m \times 4190 \times 3.0$) the first two marks are given for the formation of the substituted equation not the calculated values if 8°C is used the final answer is 0.015 kg
4	(a)		molecules have negligible volume collisions are elastic the gas cannot be liquified there are no interactions between molecules (except during collisions) the gas obeys the (ideal) gas law / obeys Boyles law etc. at all temperatures/pressures any two lines ✓✓	2	a gas laws may be given as a formula
4	(b)	(i)	$n (= PV / RT) = 1.60 \times 10^6 \times 0.200 / (8.31 \times (273 + 22))$ ✓ = 130 or 131 mol ✓ (130.5 mol)	2	

4	(b)	(ii)	$\text{mass} = 130.5 \times 0.043 = 5.6 \text{ (kg)} \checkmark$ (5.61kg) $\text{density (= mass/volume)} = 5.61 / 0.200 = 28 \checkmark (28.1 \text{ kg m}^{-3})$ $\text{kg m}^{-3} \checkmark$	3	allow ecf from bi a numerical answer without working can gain the first two marks
---	-----	------	--	---	--

4	(b)	(iii)	$(V_2 = P_1 V_1 T_2 / P_2 T_1)$ $V_2 = 1.6 \times 10^6 \times .200 \times (273 - 50) / 3.6 \times 10^4 \times (273 + 22) \text{ or } 6.7(2)$ $(\text{m}^3) \checkmark$ $\text{mass remaining} = 5.61 \times 0.20 / 6.72 = 0.17 \text{ (kg)} \checkmark (0.167 \text{ kg})$ or $n = (PV / RT = 3.6 \times 10^4 \times 0.200 / (8.31 \times (273 - 50))) = 3.88(5) \text{ (mol)}$ $\checkmark$ $\text{mass remaining} = 3.885 \times 4.3 \times 10^{-2} = 0.17 \text{ (kg)} \checkmark$ 2 sig figs $\checkmark$	3	allow ecf from bii [reminder must see bii] look out for any 2 sf answer gets the mark
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5		The mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC).		
	QWC	Descriptor	Mark range	
	High Level (Good to excellent)	The candidate refers to all the necessary apparatus and records the count-rate at various distances (or thicknesses of absorber). The background is accounted for and a safety precaution is taken. The presence of an α source is deduced from the rapid fall in the count rate at 2 – 5 cm in air. The presence of a γ source is deduced from the existence of a count-rate above background beyond 30 -50 cm in air (or a range in any absorber greater than that of beta particles, e.g. 3 – 6 mm in Al) or from the intensity in air falling as an inverse square of distance or from an exponential fall with the thickness of a material e.g. lead. <i>The information should be well organised using appropriate specialist vocabulary. There should only be one or two spelling or grammatical errors for this mark.</i>	5-6	If more than one source is used or a different experiment than the question set is answered limit the mark to 4

	Intermediate Level (Modest to adequate)	The candidate refers to all the necessary apparatus and records the count-rate at different distances (or thicknesses of absorber). A safety precaution is stated. The presence of an α source is deduced from the rapid fall in the count rate at 2 – 5 cm in air and the γ source is deduced from the existence of a count-rate beyond 30 -50 cm in air (or appropriate range in any absorber, e.g. 3 -6 mm in Al). Some safety aspect is described. One other aspect of the experiment is given such as the background. <i>The grammar and spelling may have a few shortcomings but the ideas must be clear.</i>	3-4	To get an idea of where to place candidate look for 6 items: 1. Background which must be used in some way either for a comparison or subtracted appropriately 2. Recording some data with a named instrument
	Low Level (Poor to limited)	The candidate describes recording some results at different distances (or thicknesses of absorber) and gives some indication of how the presence of α or γ may be deduced from their range. Some attempt is made to cover another aspect of the experiment, which might be safety or background. <i>There may be many grammatical and spelling errors and the information may be poorly organised.</i>	1 - 2	3. Safety reference appropriate to a school setting – not lead lined gown for example 4. Record data with more than one absorber or distances 5. α source determined from results taken 6. γ source determined
		The description expected in a competent answer should include a coherent selection of the following points. apparatus: source, lead screen, ruler, γ ray and α particle detector such as a Geiger Muller tube, rate-meter or counter and stopwatch, named absorber of varying thicknesses may be used. safety: examples include, do not have source out of storage longer than necessary, use long tongs, use a lead screen between source and experimenter. measurements: with no source present switch on the counter for a fixed period measured by the stopwatch and record the number of counts or record the rate-meter reading with the source present measure and record the distance between the source and detector (or thickness of absorber) then switch on the counter for a fixed period measured by the stopwatch and record the number of counts or record the rate-meter reading repeat the readings for different distances (or thicknesses of absorber).		from results taken this is a harder mark to achieve it may involve establishing an inverse square fall in intensity in air or an exponential fall using thicknesses of lead if a continuous distribution is not used an absorber or distance in air that would just eliminate β (30-50cm air / 3-6mm Al) must be used with and without the source being present or compared to background

		use of measurements: for each count find the rate by dividing by the time if a rate-meter was not used subtract the background count-rate from each measured count-rate to obtain the corrected count-rate longer recording times may be used at longer distances (or thickness of absorber). plot a graph of (corrected) count-rate against distance (or thickness of absorber) or refer to tabulated values plot a graph of (corrected) count-rate against reciprocal of distance squared or equivalent linear graph to show inverse square relationship in air analysis: the presence of an α source is shown by a rapid fall in the (corrected) count-rate when the source detector distance is between 2 – 5 cm in air the presence of a γ source is shown if the <u>corrected</u> count-rate is still present when the source detector distance is greater than 30 cm in air (or at a range beyond that of beta particles in any other absorber, e.g. 3 mm in Al) the presence of a γ source is best shown by the graph of (corrected) count-rate against reciprocal of distance squared being a straight line through the origin		
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Section B – Medical Physics

Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	(a)		Only cones at fovea ✓ as you move away from fovea fewer cones more rods ✓	2	Allow centre for fovea
1	(b)		three labelled curves blue, green, red in order from left to right ✓ roughly at correct height ✓ Green > Red >> Blue each curve covers the correct range of wavelengths Blue 375 to 500; Green 425 to 675; Red 475 to 725 (all + or – 30) ✓	3	Green>red>2/3green Blue<1/4green
1	(c)		the two images fall on receptors with at least one (unstimulated) receptor between them ✓	1	Allow 'separated by at least 2 cell diameters'
1	(d)		Cones used in bright light, rods used in dim light resolution in bright light better because size of cones smaller than size of rod: or resolution in dim light worse because several rods connected to 1 nerve (well away from fovea)	2	Do not accept, 'greater density of cones'
2	(a)		The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. Good to Excellent The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>The candidate explains the principles of transfer of vibrations, from mechanical vibration of the ear drum, through mechanical oscillations of</i>	Mark range 5-6	

		<i>the malleus, incus and stapes acting as a lever system, producing mechanical vibration of the oval window and then pressure waves in the fluid in the cochlea. They use the correct names of the relevant parts of the ear</i> <i>They then explain the increase in pressure with sensible use of numbers, reduction in area of about 20 and increase in force of about 1.5, resulting in pressure increase of about 30.</i> Modest to Adequate The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>The candidate explains some of the principles of transfer of vibrations and mentions some of the names of the relevant parts of the ear. They talk about the increase in pressure, but may fail to add relevant numbers</i> Poor to Limited The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>The candidate explains a principle of transfer of vibrations or explains the increase in pressure and mentions at least one of the names of the relevant parts of the ear</i> Incorrect, Inappropriate or No Response No answer at all or answer refers to unrelated, incorrect or inappropriate physics. The explanation expected could include the following: Outer ear acts as a funnel gathering waves into the ear canal pressure waves incident on eardrum eardrum vibrates, mechanical vibrations mechanical vibrations passed through a system of three bones acting as	3-4 2-1 0	
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			levers malleus, incus and stapes the last bone sets the oval window into mechanical vibration this produces pressure waves in the liquid in the cochlea. three bone lever system increase force by about 1.5 (1.3 to 1.7) times ✓ cross sectional area of the oval window about 20 (15 to 25) times less than the cross sectional area of the eardrum ✓ larger force / smaller area gives pressure about 30 times greater, (any answer for pressure, to agree with other values quoted)		
2	(b)		Intensity is the power per unit (cross-sectional) area (in path of the wave) ✓ At normal incidence ✓	2	
2	(c)		rearrange equation to give $I =$ ✓ correct answer $2.5(12) \times 10^{-7} \text{ W m}^{-2}$ ✓ correct to 2 sig figs ✓	3	
3	(a)		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 kHz ✓ short application of ac to produce short pulse ✓ use of backing material to damp and stop vibration of crystal ✓	Max 4	
3	(b)	(i)	correct calculation of ratio $I_r / I_i = 0.99896$ ✓ subtract from 1 and multiply by 100 to give 0.10% ✓	2	Do not give mark for 99.8 ecf from calc for 2 nd mark

3	(b)	(ii)	gel is between the probe and the skin to exclude air ✓ gel should have acoustic impedance equal/close to that of the skin/soft tissue ✓ to ensure maximum transmission/greatly increase transmission into the body: or to minimise reflection / greatly reduce reflection at body boundary ✓	Max 2	
4	(a)		both mV and ms labelled as units ✓ time scale 0 to 5 overall time for peak shape to be >0.75 ms and <4ms ✓ potential scale resting -70 to peak +30; (allow values between -90 and -70: +20 and +40) ✓	3	Allow any correct units, but then values on scales must match
4	(b)	(i)	-70mV ✓	1	Ecf from graph
4	(b)	(ii)	Depolarisation ✓ Na ⁺ ions <u>into</u> the membrane/cell/axon ✓	2	Need positive sodium ions
4	(b)	(iii)	Repolarisation ✓ K ⁺ ions out of the membrane/cell/axon ✓	2	Need positive potassium ions

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2012

Physics A

PHYA5/2B

Unit 5B Medical Physics Section B

Monday 18 June 2012 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 2 P H Y A 5 2 B 0 1

WMP/Jun12/PHYA5/2B

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PHYA5/2B

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

1 (a) State the changes which occur in a normal eye when

1 (a) (i) the eye changes from focussing on a distant object to focussing on a near object, both objects being viewed in bright light

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(2 marks)

1 (a) (ii) the eye changes from viewing an object in very dim light to viewing the same object in bright light.

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(2 marks)

1 (b) State **two** differences in the perceived image of a coloured object viewed in bright white light compared to the perceived image of the same object viewed in very dim white light.

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(2 marks)



- 1 (c) (i)** A patient's eye is astigmatic. State the effect of astigmatism on the image produced by the defective eye.

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(1 mark)

- 1 (c) (ii)** State the usual cause of astigmatism.

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(1 mark)

- 1 (c) (iii)** State the shape of lens used to correct astigmatism.

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(1 mark)

9

Turn over for the next question

Turn over ►



2 (a) A sound source of constant output power is used to generate a sound which is measured using a sound meter. When set to the dB scale, the sound meter displayed 60 dB as the reading when the frequency of the sound was 1 kHz.

2 (a) (i) State and explain what the reading would be for a sound of frequency 1 kHz if the meter was changed to the dBA scale.

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(1 mark)

2 (a) (ii) State and explain what would happen to the reading on **each** scale if the frequency of the sound was changed to 500 Hz.

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(2 marks)

2 (b) A drill is operated in an otherwise silent room. The drill produces sound of power 2.0 W which is given out equally in all directions. A sound meter is placed 5.0 m from the drill and is set to the dB scale.

Calculate the reading on the sound meter.

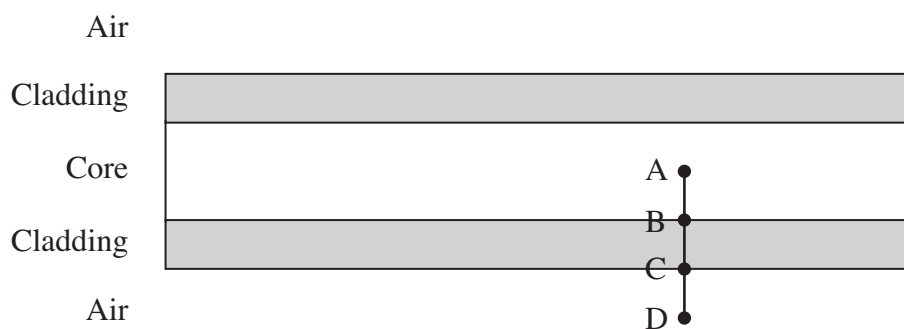
$$I_0 = 1.0 \times 10^{-12} \text{ W m}^{-2}$$

answer = ... dB
(3 marks)

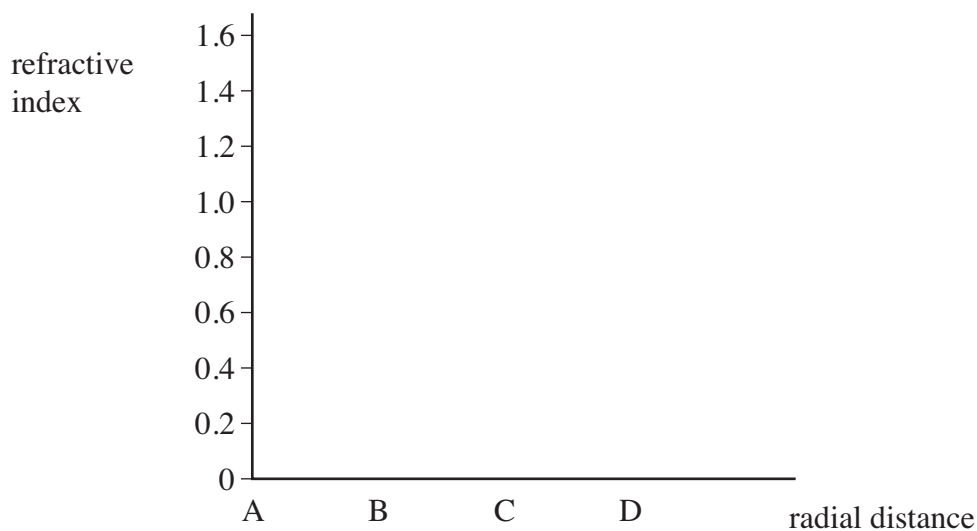


- 3 (a)** **Figure 1** shows the cross-section through a clad optical fibre which has a core of refractive index 1.50.

Figure 1



Complete the graph below to show how the refractive index changes with the radial distance along the line ABCD in **Figure 1**.



(3 marks)

- 3 (b)** In the optical system of a flexible endoscope there are two types of fibre bundles, coherent and non-coherent. Explain the purpose of each of these two types of bundle.

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(2 marks)



- the method of obtaining the image
- practical considerations for the scan
- safety issues.

This image shows a single page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 4 (b)** Explain why the pulses of ultrasound used in medical imaging must be of short duration.

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(2 marks)

8

Turn over for the next question

Turn over ►



- 5 (a)** In an X-ray tube, electrons are accelerated from rest through a pd of 72.4 kV before they hit the target anode.
- 5 (a) (i)** Calculate the kinetic energy of an electron as it reaches the anode. Give your answer to an appropriate number of significant figures.

answer = ... J
(2 marks)

- 5 (a) (ii)** Assuming that the electron gives up all this energy to form an X-ray photon, calculate the wavelength of the photon.

answer = ... m
(2 marks)



- 5 (b)** X-rays are used in a CT scanner. Describe briefly how a CT scanner produces an image.

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(3 marks)

7

END OF QUESTIONS



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General Certificate of Education (A-level)
June 2012

Physics A

PHYA5/2B

(Specification 2450)

Unit 5/2B: Medical Physics

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner 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 examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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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Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA5/1, Nuclear and Thermal Physics

1	a		$\Delta T = \left(\frac{\Delta Q}{mc} \right) = \frac{8.5 \times 10^3}{4200 \times 0.12} \checkmark$ 17 K $\checkmark$	2
1	b		$\left(\frac{\Delta T}{\Delta t} = \frac{\frac{\Delta Q}{\Delta t}}{mc} \right) = \frac{100 - 26}{\Delta t} = \frac{8.5 \times 10^3}{0.41 \times 4200} \checkmark$ $t = 15 \text{ s} \checkmark$	2
2	a		$({}^{206}_{76}\text{X} \rightarrow {}^{206}_{82}\text{Pb} + \beta + {}^0_{-1}\beta + \beta \times \overline{\nu}_e)$ $\beta = 6 \checkmark$	1
2	b	i	the energy required to split up the nucleus $\checkmark$ into its individual neutrons and protons/nucleons $\checkmark$ (or the energy released to form/hold the nucleus $\checkmark$ from its individual neutrons and protons/nucleons $\checkmark$)	2
2	b	ii	$7.88 \times 206 = 1620 \text{ MeV} \checkmark$ (allow 1600-1640 MeV)	1
2	c	i	U, a graph starting at 3×10^{22} showing exponential fall passing through 0.75×10^{22} near 9×10^9 years $\checkmark$ Pb, inverted graph of the above so that the graphs cross at 1.5×10^{22} near 4.5×10^9 years $\checkmark$	2
2	c	ii	(u represents the number of uranium atoms then) $\frac{u}{3 \times 10^{22} - u} = 2$ $u = 6 \times 10^{22} - 2u \checkmark$ $u = 2 \times 10^{22}$ atoms	1
2	c	iii	(use of $N = N_0 e^{-\lambda t}$) $2 \times 10^{22} = 3 \times 10^{22} \times e^{-\lambda t} \checkmark$ $t = \ln 1.5 / \lambda$ (use of $\lambda = \ln 2 / t_{1/2}$) $\lambda = \ln 2 / 4.5 \times 10^9 = 1.54 \times 10^{-10} \checkmark$ $t = 2.6 \times 10^9 \text{ years} \checkmark$ (or $2.7 \times 10^9 \text{ years}$)	3
3	a		any 2 from: the sun, cosmic rays, radon (in atmosphere), nuclear fallout (from previous weapon testing) , any radioactive leak(may be given by name of incident) nuclear waste, carbon-14 $\checkmark$	1

3	b	i	(ratio of area of detector to surface area of sphere) ratio = $\frac{0.0015}{4\pi(0.18)^2}$ ✓ 0.0037 ✓ (0.00368)	2
3	b	ii	activity = 0.62/(0.00368 × 1/400) give first mark if either factor is used. 67000 ✓ Bq accept s ⁻¹ or decay/photons/disintegrations s ⁻¹ but not counts s ⁻¹ ✓ (67400 Bq)	3
3	c		(use of the inverse square law) $\frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2$ or calculating k = 0.020 from I = k/x ² ✓ $I_2 = 0.62 \times \left(\frac{0.18}{0.28}\right)^2$ ✓ 0.26 counts s ⁻¹ ✓ (allow 0.24-0.26)	3
4	a	i	$n = PV/RT = 3.2 \times 10^5 \times 1.9 \times 10^{-3}/8.31 \times 285$ $n = 0.26$ mol ✓ (0.257 mol)	1
4	a	ii	$P_2 = \frac{T_2}{T_1} \times P_1 = \frac{295}{285} \times 3.20 \times 10^5$ ✓ 3.31×10^5 Pa ✓ (allow 3.30-3.35 × 10 ⁵ Pa) 3 sig figs ✓ sig fig mark stands alone even with incorrect answer	3
4	b		similar - (rapid) random motion - range of speeds different - mean kinetic energy - root mean square speed - frequency of collisions	2
5	a		graph starting (steeply) near/at the origin and decreasing in gradient ✓	1
5	b	i	(use of density = mass/volume) $\frac{197 \times 1.67 \times 10^{-27}}{\frac{4}{3}\pi(6.87 \times 10^{-15})^3}$ ✓✓ mark for top line and mark for bottom line (allow use of 1.66 × 10 ⁻²⁷) Lose mass line mark if reference is made to mass of electrons = 2.4(2) × 10 ¹⁷ kg m ⁻³	2

5	b	ii	$R_{A1} = R_{Au} \left(\frac{A_{A1}}{A_{Au}} \right)^{\frac{1}{3}} = 6.87 \times 10^{-15} \left(\frac{27}{197} \right)^{\frac{1}{3}} \checkmark$ $= 3.54 \times 10^{-15} \text{ m } \checkmark$ or $r_0 = \frac{R}{A^{\frac{1}{3}}} = \frac{6.87 \times 10^{-15}}{197^{\frac{1}{3}}} = 1.18 \times 10^{-15} \text{ m } \checkmark$ $R = 1.18 \times 10^{-15} \times 27^{\frac{1}{3}} = 3.54 \times 10^{-15} \text{ m } \checkmark$ or $\text{volume} = \text{mass/density} = \frac{27 \times 1.67 \times 10^{-27}}{2.42 \times 10^{17}} = \frac{4}{3} \pi \times R^3 \checkmark$ $= 3.54 \times 10^{-15} \text{ m } \checkmark$	2
5	c		The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>The candidate makes 5 to 6 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>The candidate makes 3 to 4 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>The candidate makes 1 to 2 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method</i>	max 6

			The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences. principles • α scattering involves coulomb or electrostatic repulsion • electron diffraction treats the electron as a wave having a de Broglie wavelength • some reference to an equation, for example $\lambda = h/mv$; $eV = mv^2/2$; $Qq/4\pi\epsilon_0 r = E_\alpha$; $\sin\theta = 0.61\lambda/R$ • reference to first minimum for electron diffraction accuracy • α's only measure the least distance of approach, not the radius • α's have a finite size which must be taken into account • electrons need to have high speed/kinetic energy • to have a small wavelength or wavelength comparable to nuclear diameter, the wavelength determines the resolution • the wavelength needs to be of the same order as the nuclear diameter for significant diffraction • requirement to have a small collision region in order to measure the scattering angle accurately • importance in obtaining monoenergetic beams • cannot detect alpha particles with exactly 180° scattering • need for a thin sample to prevent multiple scattering advantages and disadvantages • α-particle measurements are disturbed by the nuclear recoil • Mark for α-particle measurements are disturbed by the SNF when coming close to the nucleus or electrons are not subject to the strong nuclear force. • A second mark can be given for reference to SNF if they add electrons are leptons or alpha particles are hadrons. • α's are scattered only by the protons and not all the nucleons that make up the nucleus • visibility – the first minimum of the electron diffraction is often difficult to determine as it superposes on other scattering events	
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GCE Physics, Specification A, PHYA5/2B, Medical Physics

1	a	i	Ciliary muscles contract / suspensory ligaments relax Producing a lens of greater power / shorter focal length	2
1	a	ii	(Iris circular muscles contract and /or radial muscles relax produces) constricted pupil /pupil becomes smaller Cones turn on and rods become inactive	2
1	b		Colours seen in bright light, but black and white in very dim light Good detail in bright light, but much less detail in very dim light	2
1	c	i	Image is focussed in a given plane and out of focus in perpendicular plane	1
1	c	ii	non-spherical cornea	1
1	c	iii	cylindrical lens	1
2	a	i	Reading would be 60dBA as 1kHz is the reference frequency (at the threshold of hearing).	1
2	a	ii	dB reading would be 60dB as power is the same/not frequency dependent. dBA reading would be less than 60 as 500Hz has a higher threshold intensity / ear is less sensitive.	2
2	b		Intensity at meter = $2/(4\pi \times 5 \times 5)$ ($=6.37 \times 10^{-3}$) Intensity reading = $10 \log((2/(4\pi \times 5 \times 5))/1.0 \times 10^{-12})$ Intensity reading = 98 dB Allow ecf here from intensity calc. to get a 'correct' answer: Use of 2 as intensity gains 0 for 123dB Use of 2/5 as intensity gains 1 for 116dB or any use of 2 and a power of 5 multiplied also for 1 mark. Use of $2/5^2$ as intensity gains 2 for 109dB or use of $2/\pi 5^2$ gains 2 marks	3
3	a		horizontal line from A to B at 1.5 Vertical line at B from 1.5 to value between 1.5 and 1.4 and then horizontal line from B to C Vertical line at C from value to 1.0 (if possible) and then horizontal line from C to D	3

3	b		Use of non-coherent to transmit light into body/ provide illumination Use of coherent to transmit image/ light to form an image (from inside to viewer/camera)	2
4	a		The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The answer will discuss the multi-array of transducers in a linear formation and the use of gel between the skin and the probe will be explained. There will be mention of the transducers acting as receivers and why ultra sound echoes occur. There will be some discussion of the processing of the received signal to produce an image. The fact that this is non-ionising and thus has no known side effects will be included. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The answer will contain at least one property of the probe and either the use of gel or the transducer acting as a receiver should be discussed. The processing of the signal will be sketchy, but the reason that ultrasound is safe is likely to be mentioned. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. There will be a few of the guidance points mentioned, but there will be little cohesion in the writing.	Max 6

			The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. <u>Method of obtaining the image</u> Ultra sound reflected at interface between two different acoustic impedances Each transducer emits pulse in turn and receives the echoes from the interfaces directly in line with it Each echo displayed as a bright spot on screen The brightness is determined by the intensity of the echo The y position is determined by the time taken from transmission to the time of the echo The x position is determined by the position of the transducer Images are produced at about 25 per second and thus appear as a real time moving image <u>Practical considerations</u> Probe has line of transducers (approx 100) High frequency ac pulse applied to each transducer in turn Each transducer has piezoelectric crystal to generate ultra sound Use of gel between probe and skin to eliminate air Transducer acts as receiver <u>Safety</u> No harmful side effects known – does not use ionising radiation. Always allow details of other correct probes.	
4	b		The transducer to be damped/stop oscillating before the echo returns to allow the transducer to act as a receiver. (This time is very short) as distances travelled are short Emitted pulse must cease before echo arrives so that there is no overlapping at the transducer/ no interference	3
5	a	i	$1.60 \times 10^{-19} \times 72.5 \times 10^3 = 1.16 \times 10^{-14} \text{ (J)}$ Sig Fig mark for 3sf	2
5	a	ii	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / 1.16 \times 10^{-14}$ $= 1.71 \times 10^{-11} \text{ (m)}$	2

5	b		Narrow beam of X-rays X ray generator rotated(in circular path) around patient Detectors arranged around outside of the path Detector opposite generator registers transmitted intensity Detectors connected to computer which (over time) produces cross sectional image Any three relevant points.	Max 3
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UMS conversion calculator www.aqa.org.uk/umsconversion

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2011

Physics A

PHYA5/2B

Unit 5B Medical Physics Section B

Monday 27 June 2011 9.00am to 10.45am

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet.

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 1 P H Y A 5 2 B 0 1

WMP/Jun11/PHYA5/2B

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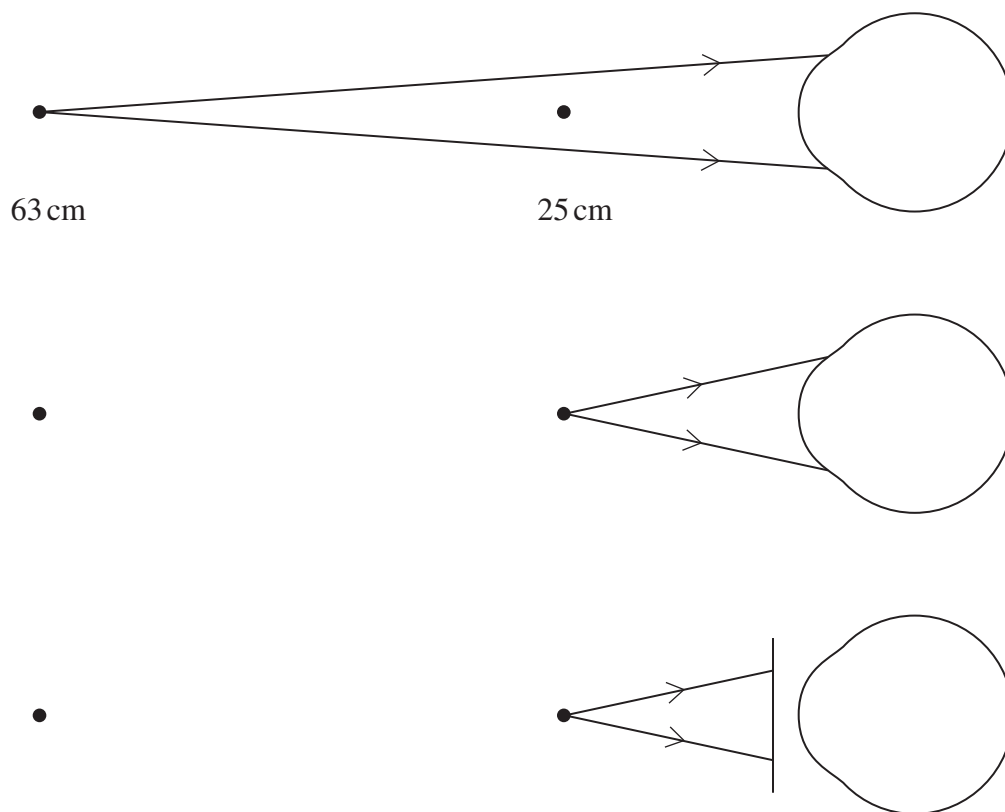
PHYA5/2B

Section B

The maximum mark for this section is 35 marks. You are advised to spend approximately 50 minutes on this section.

- 1 (a)** A person suffering from long sight has an unaided near point 63 cm from the eye. **Figure 1** shows three diagrams not drawn to scale. The first two diagrams show rays incident on the unaided eye. The third diagram shows rays incident on the correcting lens which will allow the person to have an aided near point 25 cm from the eye. Complete the diagrams to show the passage of the rays to the retina. You may assume that for the eye there is only a single refraction at the cornea of the eye.

Figure 1



(2 marks)

- 1 (b)** Calculate the focal length of the correcting lens, stating the answer to the appropriate number of significant figures.

answer = ... m
(3 marks)



- 1 (c)** Explain what is meant by persistence of vision and state a practical situation where it is important.

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(2 marks)

7

Turn over for the next question

Turn over ►



- 2 (a) Define the threshold of hearing, I_0 .

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(2 marks)

- 2 (b) A hearing test was used to obtain threshold hearing audiograms for several people. The audiogram shown in **Figure 2** was obtained for a person with normal hearing.

On the same axes:

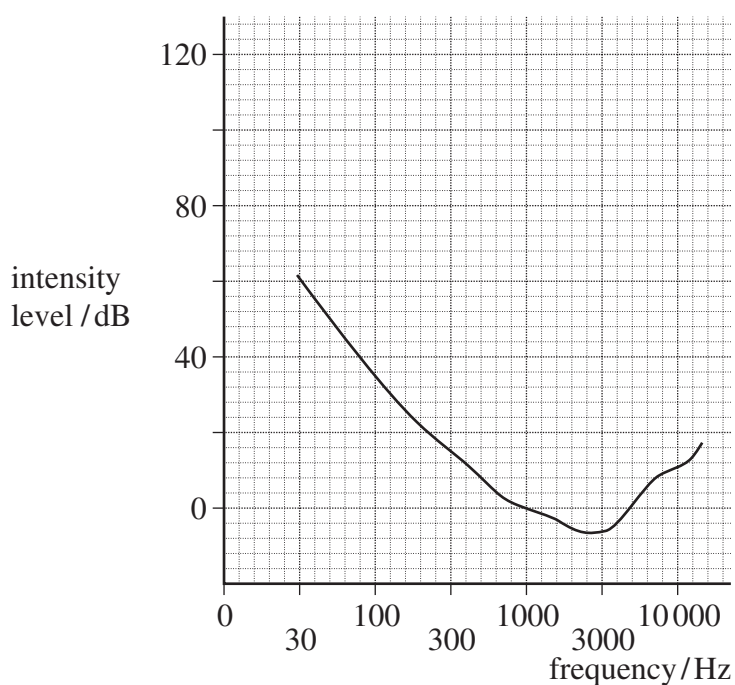
- 2 (b) (i) sketch a curve, labelled **A**, for a person suffering hearing loss due to old age

(1 mark)

- 2 (b) (ii) sketch a curve, labelled **B**, for a person suffering hearing loss due to excessive noise.

(2 marks)

Figure 2



3 An endoscope contains two bundles of optical fibres.

3 (a) Name the two bundles. For each bundle state clearly the arrangement of the fibres and explain its purpose in the operation of the endoscope.

Bundle 1

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Bundle 2

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(4 marks)

3 (b) Each fibre has a core surrounded by cladding.
Calculate the critical angle at the core – cladding interface of a fibre.

refractive index of core = 1.60

refractive index of cladding = 1.55

answer = ... degree
(1 mark)



- 4 (a)** An ECG trace is to be obtained for a patient. State and explain the procedure and some design features of the equipment needed to ensure a good trace is obtained.

The quality of your written communication will be assessed in this question.

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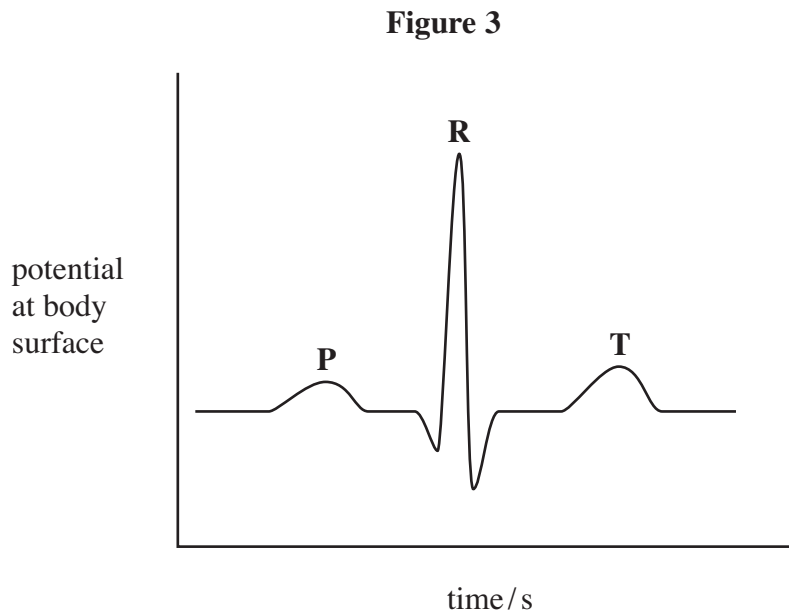
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(6 marks)



4 (b) **Figure 3** shows an ECG trace for a healthy person.



4 (b) (i) Add a suitable scale and unit to the potential axis.

(2 marks)

4 (b) (ii) Add a suitable scale to the time axis.

(1 mark)

4 (b) (iii) State the electrical events which give rise to the points:

P

R

T

(3 marks)

12

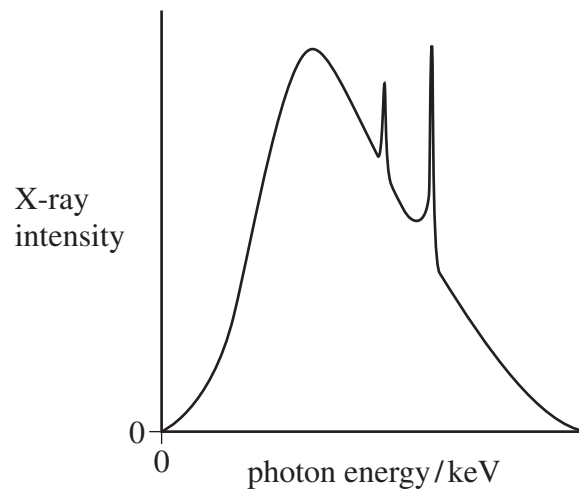
Turn over for the next question

Turn over ►



- 5 (a) The X-ray spectrum for a certain X-ray tube target is shown in **Figure 4**. Explain the process which gives rise to spikes at certain photon energies.

Figure 4



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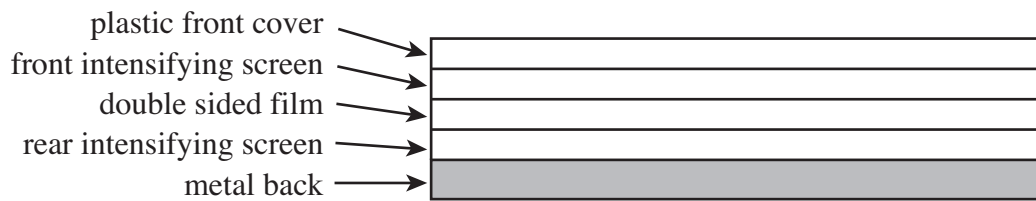
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(3 marks)



- 5 (b)** A film cassette, placed under a patient being X-rayed, is shown in **Figure 5**.

Figure 5



- 5 (b)** Explain how the intensifying screens in the film cassette achieve their purpose and state their benefit to the patient.

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(3 marks)

6

END OF QUESTIONS

Turn over ►



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General Certificate of Education (A-level)
June 2011

Physics A

PHYA5/2B

(Specification 2450)

Unit 5/2B: Medical Physics

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner 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 examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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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Instructions to Examiners

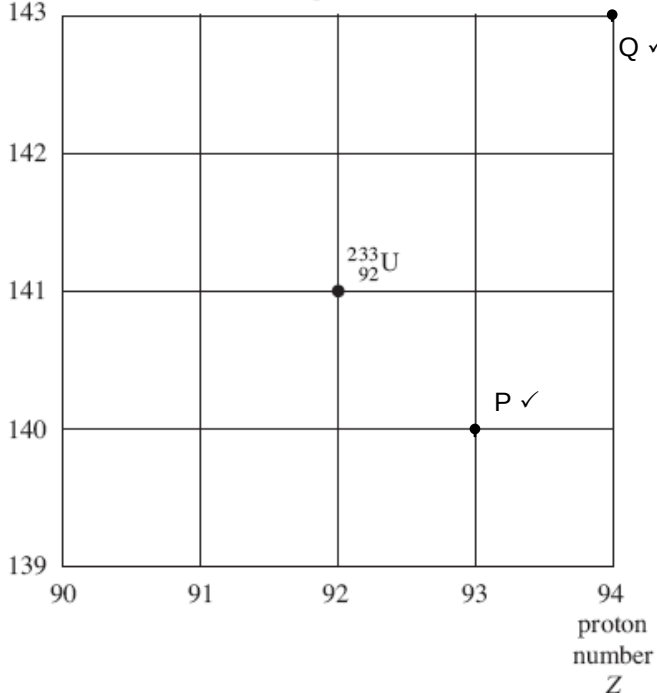
- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

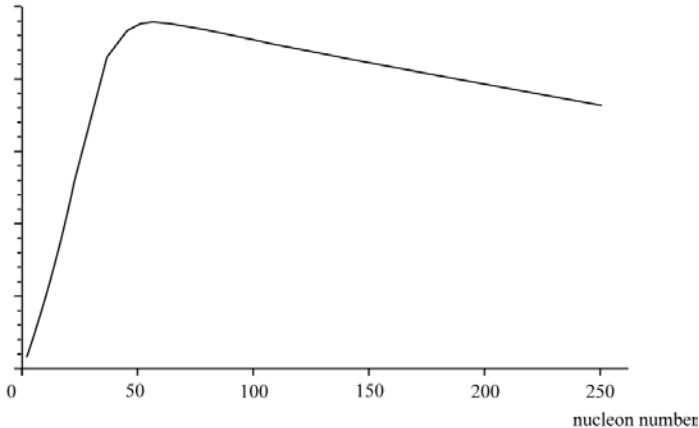
Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA5/1, Nuclear and Thermal Physics

Question 1		
a	${}_{91}^{233}\text{Pa}$ ✓ anti (electron) neutrino ✓	2
b		2
c i	$x = 4$ ✓	1
c ii	mass defect = $[(232.98915 + 1.00867) - (90.90368 + 138.87810 + 4 \times 1.00867)] \text{ u}$ ✓ $= 0.18136 \text{ u}$ ✓ energy released $(= 0.18136 \times 931) = 169 \text{ (MeV)}$ ✓	3
Total		8

Question 2		
a	${}_{13}^{27}\text{Al} + \alpha \rightarrow {}_{15}^{30}\text{P} + {}_0^{(1)}\text{n}$ ✓	1
b	kinetic energy lost by the α particle approaching the nucleus is equal to the potential energy gain ✓ $2.18 \times 10^{-12} = \frac{1}{4\pi \times 8.85 \times 10^{-12}} \times \frac{13 \times 1.6 \times 10^{-19} \times 2 \times 1.6 \times 10^{-19}}{r}$ ✓ $r = 2.75 \times 10^{-15} \text{ (m)}$ ✓	3
Total		4

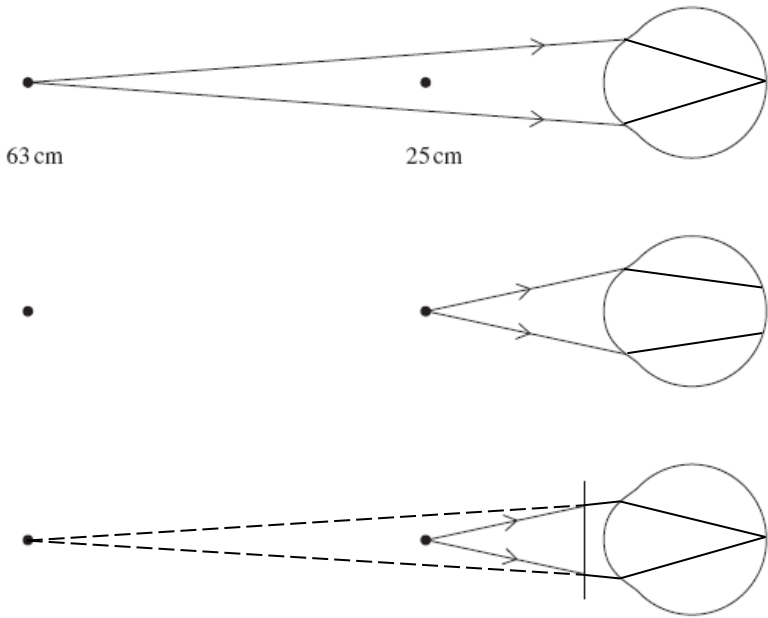
Question 3		
a	binding energy per nucleon  peak 8.7 (accept 8.0 – 9.2) ✓ in MeV ✓ (or peak 1.4×10^{-12} accept $1.3 - 1.5 \times 10^{-12}$ ✓ in J ✓) at nucleon number 50 – 60 ✓ accept 50 – 75 sharp rise from origin and moderate fall not below 2/3 of peak height ✓	4
b	energy is released/made available when binding energy per nucleon is increased ✓ in fission a (large) nucleus splits and in fusion (small) nuclei join ✓ the most stable nuclei are at a peak ✓ fusion occurs to the left of peak and fission to the right ✓	max 3
Total		7

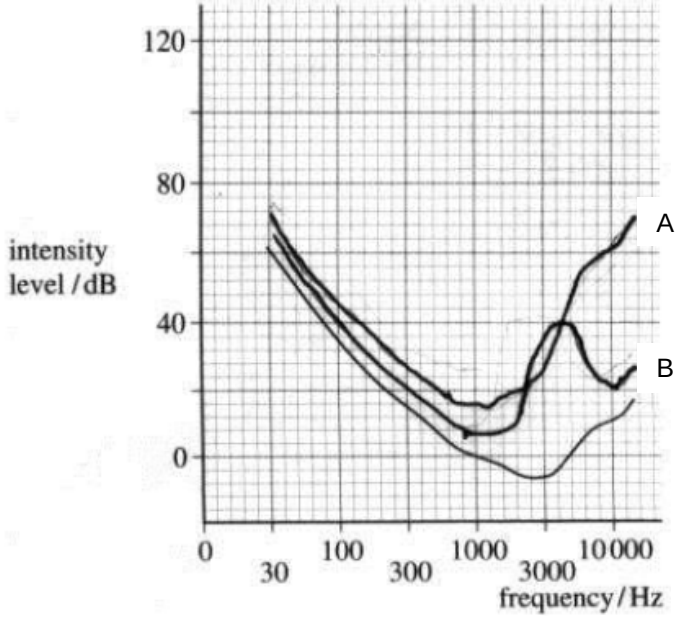
Question 4		
a	(use of $\Delta Q = mc\Delta T$) $30 \times 98 = 0.100 \times c \times 14$ ✓ $c = 2100 \text{ (J kg}^{-1} \text{ K}^{-1}\text{)}$ ✓	2
b	(use of $\Delta Q = ml + mc\Delta T$) $500 \times 98 = 0.100 \times 3.3 \times 10^5$ ✓ + $0.100 \times 4200 \times \Delta T$ ✓ $(\Delta T = 38^\circ\text{C})$ $T = 38^\circ\text{C}$ ✓	3
c	the temperature would be higher ✓ as the ice/water spends more time below 25°C or heat travels in the direction from hot to cold or ice/water first gains heat then loses heat any one line ✓	2
Total		7

Question 5		
a	graph passes through given point $2.2 \times 10^{-3} \text{ m}^3$ at 0°C straight line with positive gradient ✓ (straight) line to aim or pass through -273°C at zero volume ✓	2
b	(use of $n = P V / R T$) $1.00 \times 10^5 \times 2.20 \times 10^{-3} / 8.31 \times 273$ ✓ $n = 0.0970$ (moles) ✓	2
c	(use of mean kinetic energy = $3/2 K T$) $= 3/2 \times 1.38 \times 10^{-23} \times 323$ ✓ 6.69×10^{-21} (J) ✓ 3 sfs ✓	3
d	total internal energy = $6.69 \times 10^{-21} \times 0.0970 \times 6.02 \times 10^{23} = 390$ (J) ✓	1
e	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a comprehensive and coherent sequence of ideas linking the motion of molecules to the pressure they exert on a container. At least three of the first four points listed below must be given in a logical order. The description should also show awareness of how a balance is maintained between the increase in speed and shortening of the time interval between collisions with the wall to maintain a constant pressure. To be in this band, reference must be made to force being the rate of change of momentum or how, in detail, the volume compensates for the increase in temperature. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate provides a comprehensive list of ideas linking the motion of molecules to the pressure they exert on a container. At least three of the first four points listed below are given. The candidate also knows that the mean square speed of molecules is proportional to temperature. Using this knowledge, an attempt is made to explain how the pressure is constant.	max 6

	Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate attempts the question and refers to at least two of the points listed below. Incorrect, inappropriate or no response: 0 marks No answer or answer refers to unrelated, incorrect or inappropriate physics. Statements expected in a competent answer should include some of the following marking points. molecules are in rapid random motion/many molecules are involved molecules change their momentum or accelerate on collision with the walls reference to Newton's 2nd law either $F = ma$ or $F = \text{rate of change of momentum}$ reference to Newton's 3rd law between molecule and wall relate pressure to force $P = F/A$ mean square speed of molecules is proportional to temperature as temperature increases so does change of momentum or change in velocity compensated for by longer time between collisions as the temperature increases as the volume increases the surface area increases which reduces the pressure	
	Total	14

GCE Physics, Specification A, PHYA5/2B, Medical Physics

Question 1		
a	first two diagrams correct ✓ third diagram correct ✓ 	2
b	$1/f = 1/u + 1/v = 1/0.25 - 1/0.63$ ✓ $f = 0.41 \text{ m}$ ✓ correct sfs (independent mark) ✓	3
c	image remains after stimulus is removed ✓ eg cinema pictures, television, fluorescent lights, optical illusions ✓	2
	Total	7

Question 2		
a	minimum intensity heard by a normal ear ✓ at 1 kHz ✓	2
b i	increased loss with increased frequency ✓	1
b ii	increased loss followed by decreased loss ✓ max loss at 4 kHz ✓ 	2
Total		5

Question 3		
a	coherent same relative position of fibres at both ends ✓ coherent transfers picture from inside of body to viewer ✓ non-coherent no relative order to the fibres ✓ non-coherent carries light into body/for illumination ✓	4
b	$\sin \theta_c = 1.55/1.60$ $\theta_c = 76$ (75.6) (degree) ✓	1
Total		5

Question 4		
a	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate accurately describes measures to ensure good contact between the electrodes and the skin including the use of conducting gel. The candidate will mention the need for more than one electrode and the need for the patient to remain relaxed and still. They will need at least one property of the amplifier. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate will include most measures to ensure good contact between electrodes and the skin. They might give a property of the amplifier or mention the need for the patient to remain relaxed and still. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate will mention electrodes connected to the skin and might make another sensible comment on the arrangement. Statements expected in a competent answer should include some of the following marking points. To reduce contact resistance • sandpaper skin to remove hairs and some dead skin • apply conducting gel • securely attach more than one electrode To remove unwanted signals • electrodes should be non-reactive • patient to remain relaxed and still • shielded leads/reducing interference from ac sources Properties of amplifier • amplifier has large input impedance/high gain/low noise	max 6

b	i	0 marked where line meets axis with maximum value of 1 ✓ unit mark mV ✓	2
b	ii	uniform scale starts at 0 and has value 0.7 (0.9 to 0.5) at end of T wave ✓	1
b	iii	P depolarisation of atria ✓ R depolarisation of ventricles (and repolarisation of atria) ✓ T repolarisation of ventricles ✓	3
Total			12

Question 5			
a		electrons strike anode and ionise/excite the target atoms ✓ excited/higher electrons fall to inner energy level ✓ fixed energy gaps produce fixed energy photons ✓	3
b		convert X-ray (photons) to light (photons) ✓ light photons expose film in correct place due to closeness of the screens to the film ✓ reduces radiation dose to the patient/the exposure time is shorter ✓	3
Total			6

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Centre Number						Candidate Number				
Surname										
Other Names										
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2010

Physics A

PHYA5/2B

Unit 5B Medical Physics Section B

Tuesday 29 June 2010 1.30 pm to 3.15 pm

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet.

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



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WMP/Jun10/PHYA5/2B

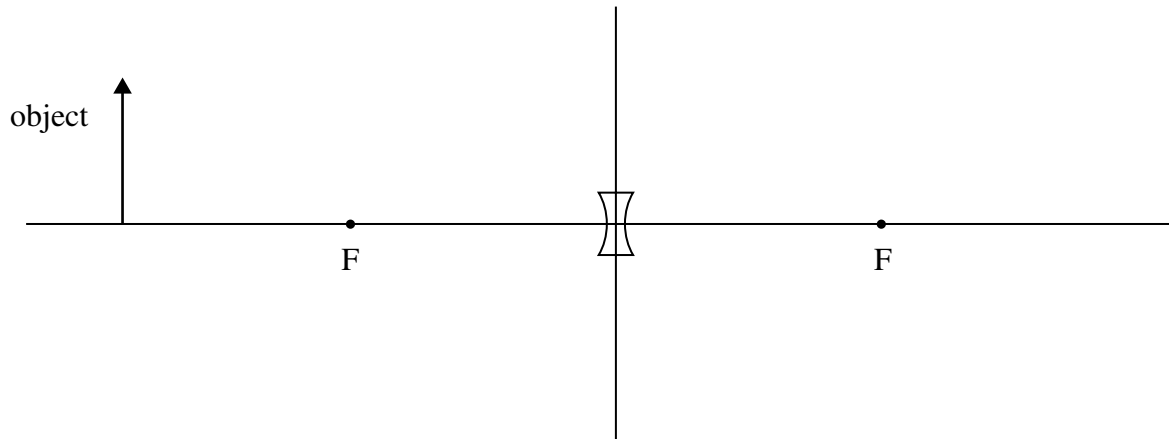
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PHYA5/2B

Section B

The maximum mark for this section is 35 marks. You are advised to spend approximately 50 minutes on this section.

- 1 (a)** Complete the ray diagram to show the formation of the image of a real object by a diverging lens.



(2 marks)

- 1 (b)** Define the power of a lens.

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(1 mark)



1 (c) A lens of focal length -0.56 m is used to correct a defect of vision of an eye.

1 (c) (i) Name this defect of vision.

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(1 mark)

1 (c) (ii) The defective eye has an unaided near point at 0.15 m from the eye.
Calculate the aided near point distance, giving your answer to an appropriate number of significant figures.

answer = ... m
(3 marks)

1 (d) Another person was found to suffer from astigmatism. State the format of the prescription to correct this defect.

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(1 mark)

8

Turn over for the next question

Turn over ►



- 2 (a) (i)** Describe how the vibrations of a sound wave are received by the outer ear and transmitted to the inner ear.

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(3 marks)

- 2 (a) (ii)** Explain how the pressure changes due to the sound wave are amplified by the ear.

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(2 marks)

- 2 (b)** An intensity meter, set to the dB scale, measures the intensity level of a sound as 46 dB. Calculate the intensity of the sound at the meter, giving an appropriate unit.

answer = ...

(3 marks)



- 2 (c)** The scale on the intensity meter is changed to the dBA scale and the new reading, for the same sound, is found to be 50 dBA. Explain this change.

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(2 marks)

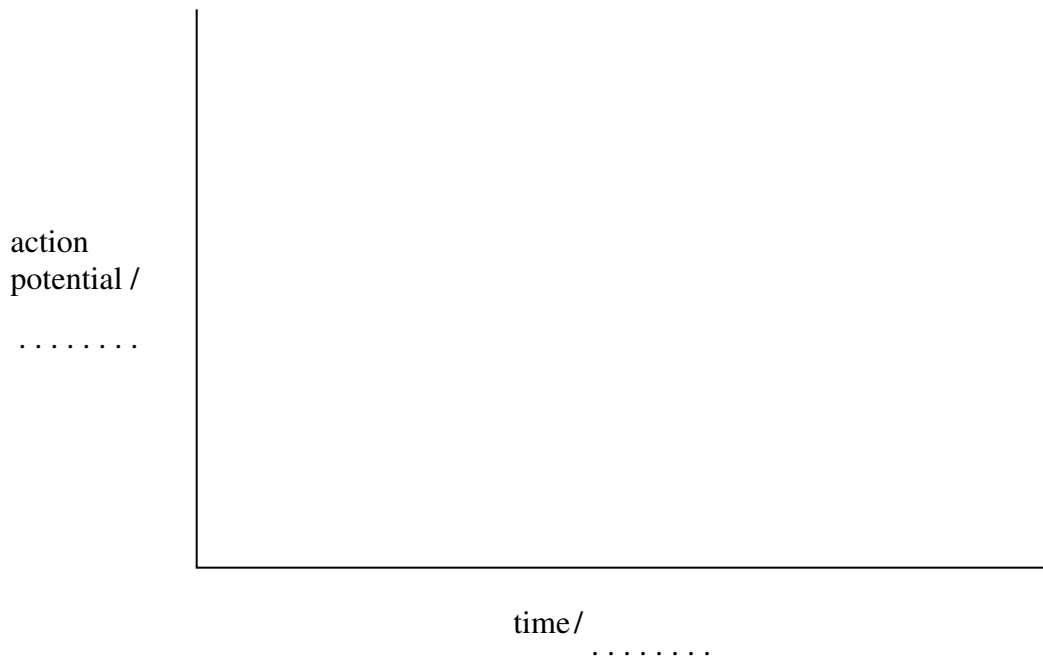
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Turn over for the next question

Turn over ►



- 3 (a)** On the axes below, sketch the action potential of a nerve cell. Indicate units and scales on both axes.



(3 marks)

- 3 (b)** Explain in terms of ion movement, starting at resting potential, how bioelectrical signals are produced in muscle fibres.
The quality of your written answer will be assessed in this question.

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(7 marks)

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- 4 (a)** Outline the basic principles of a magnetic resonance (MR) scanner used to scan a patient's brain.

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(3 marks)

- 4 (b)** State and explain **two** advantages of using an MR scanner to scan a patient's brain compared with a CT scanner.

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(4 marks)

END OF QUESTIONS

7



There are no questions printed on this page

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**General Certificate of Education
June 2010**

Physics A

PHYA5/2B

Medical Physics

Unit 5

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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.

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Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

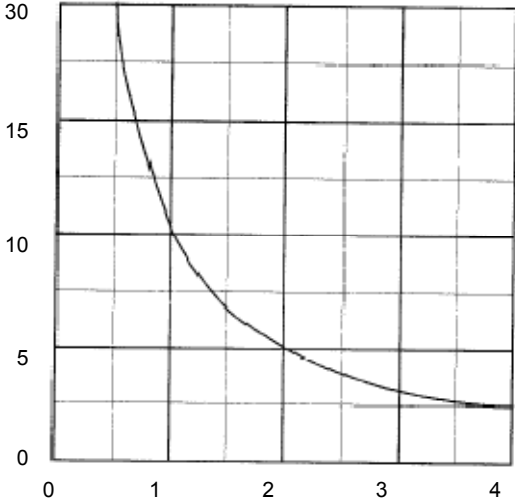
GCE Physics, Specification A, PHYA5/2B, Section A, Nuclear and Thermal Physics

Question 1		
(a)	using $Q = mc\Delta\theta$ $= 3.00 \times 440 \times (84-27) \checkmark$ $7.5 \times 10^4 \text{ (J)} \checkmark$	2
(b)	using $Q = ml$ $= 1.20 \times 2.5 \times 10^4$ $= 3.0 \times 10^4 \text{ (J)} \checkmark$	1
(c)	(heat supplied by lead changing state + heat supplied by cooling lead = heat gained by iron) $3.0 \times 10^4 + \text{heat supplied by cooling lead} = 7.5 \times 10^4 \checkmark$ heat supplied by cooling lead $= 4.5 \times 10^4 = mc\Delta\theta$ $c = 4.5 \times 10^4 / (1.2 \times (327 - 84)) \checkmark$ $c = 154 \text{ (J kg}^{-1} \text{ K}^{-1}) \checkmark$	3
(d)	any one idea $\checkmark$ no allowance has been made for heat loss to the surroundings or the specific heats may not be a constant over the range of temperatures calculated	1
	Total	7

Question 2		
(a)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate can explain the role of the moderator and control rods in maintaining a critical condition inside the reactor. The explanation is given in a clear sequence of events and the critical condition is defined in terms of neutrons. To obtain the top mark some other detail must be included. Such as, one of the alternative scattering or absorbing possibilities or appropriate reference to critical mass or detailed description of the feedback to adjust the position of the control rods etc. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate has a clear idea of two of the following: the role of the moderator, the role of the control rods or can explain the critical condition. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate explains that a released neutron is absorbed by uranium to cause a further fission. Alternatively the candidate may explain one of the following: the role of the moderator, the role of the control rods or can explain the critical condition. The explanation expected could include the following events that could happen to a released neutron. a neutron is slowed by the moderator taking about 50 collisions to reach thermal speeds then absorbed by uranium-235 to cause a fission event one neutron released goes on to cause a further fission is the critical condition a neutron may leave the reactor core without further interaction a neutron could be absorbed by uranium-238 a neutron could be absorbed by a control rod a neutron could be scattered by uranium-238 a neutron could be scattered by uranium-235	max 6

(b)	it is easy to stay out of range or easy to contain an α source or β/γ have greater range/are more difficult to screen ✓ most (fission fragments) are (more) radioactive/unstable ✓ and are initially most likely to be beta emitters/(which also) emit γ radiation/are neutron rich/heavy ✓ ionising radiation damages body tissue/is harmful ✓	max 3
	Total	9

Question 3		
(a)	probability of decay per unit time/given time period or fraction of atoms decaying per second or the rate of radioactive decay is proportional to the number of (unstable) nuclei and nuclear decay constant is the constant of proportionality ✓	1
(b)	use of $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ $T_{\frac{1}{2}} = \ln 2 / 3.84 \times 10^{-12} \text{ s} \checkmark (1.805 \times 10^{11} \text{ s})$ $= (1.805 \times 10^{11} / 3.15 \times 10^7) = 5730 \text{ y} \checkmark$ answer given to 3 sf ✓	3
(c)	number of nuclei = $N = 3.00 \times 10^{23} \times 1/10^{12} \checkmark$ $(= 3.00 \times 10^{11} \text{ nuclei})$ (using $\frac{\Delta N}{\Delta t} = -\lambda N$) rate of decay = $3.84 \times 10^{-12} \times 3.00 \times 10^{11} \checkmark$ $(= 1.15 \text{ Bq})$	2
(d)	$(N = N_0 e^{-\lambda t}$ and activity is proportional to the number of nuclei $A \propto N$ use of $A = A_0 e^{-\lambda t}$) $0.65 = 1.15 \times e^{-3.84 \times 10^{-12} t} \checkmark$ $t = \frac{\ln(\frac{1.15}{0.65})}{3.84 \times 10^{-12}}$ or $\frac{\ln(\frac{0.651}{1.15})}{-3.84 \times 10^{-12}} \checkmark$ $t = 4720 \text{ y} \checkmark$	3
(e)	the boat may have been made with the wood some time after the tree was cut down the background activity is high compared to the observed count rates the count rates are low or sample size/mass is small or there is statistical variation in the recorded results possible contamination uncertainty in the ratio of carbon-14 in carbon thousands of years ago any two ✓✓	2
	Total	11

Question 4														
(a)	pressure/10^4 Pa  curve with decreasing negative gradient that passes through the given point which does not touch the x axis ✓ <table border="1" data-bbox="410 952 873 1270"><thead><tr><th colspan="2">designated points</th></tr><tr><th>pressure/10^4 Pa</th><th>volume/10^{-3} m³</th></tr></thead><tbody><tr><td>10</td><td>1.0</td></tr><tr><td>5.0</td><td>2.0</td></tr><tr><td>4.0</td><td>2.5</td></tr><tr><td>2.5</td><td>4.0</td></tr></tbody></table> 2 of the designated points ✓✓ (one mark each)	designated points		pressure/ 10^4 Pa	volume/ 10^{-3} m ³	10	1.0	5.0	2.0	4.0	2.5	2.5	4.0	3
designated points														
pressure/ 10^4 Pa	volume/ 10^{-3} m ³													
10	1.0													
5.0	2.0													
4.0	2.5													
2.5	4.0													
(b) (i)	$N = PV/kT = 5 \times 10^4 \times 2 \times 10^{-3} / 1.38 \times 10^{-23} \times 290$ ✓ [or alternative use of $PV = nRT$ $5 \times 10^4 \times 2.0 \times 10^{-3} / 8.31 \times 290 = 0.0415$ moles] $= 2.50 \times 10^{22}$ molecules ✓	2												
(b) (ii)	(mean) kinetic energy of a molecule $= \frac{3}{2}kT = \frac{3}{2} \times 1.38 \times 10^{-23} \times 290$ ✓ ($= 6.00 \times 10^{-21}$ J) (total kinetic energy = mean kinetic energy $\times N$) $= 6.00 \times 10^{-21} \times 2.50 \times 10^{22}$ ✓ $= 150$ (J) ✓	3												

(c)	all molecules/atoms are identical molecules/atoms are in random motion Newtonian mechanics apply gas contains a large number of molecules the volume of gas molecules is negligible (compared to the volume occupied by the gas) or reference to point masses no force act between molecules except during collisions or the speed/velocity is constant between collisions or motion is in a straight line between collisions collisions are elastic or kinetic energy is conserved and of negligible duration any 4 ✓✓✓✓	max 4
	Total	12

GCE Physics, Specification A, PHYA5/2B, Section B, Medical Physics

Question 1		
(a)	first correct diverging ray ✓ second correct ray and image labelled or clearly shown (also CE mark) ✓	2
(b)	reciprocal of the focal length ✓	1
(c) (i)	myopia or shortsight ✓	1
(c) (ii)	$1/u + 1/(-0.15) = 1/(-0.56)$ ✓ $u = 0.2049(\text{m})$ ✓ correct sig figs – 2 sig figs correct answer 0.20 (m) ✓	3
(d)	power and axis of the cylindrical lens - any 2 bold terms to get the mark ✓	1
Total		8

Question 2		
(a) (i)	longitudinal/pressure waves in the ear canal ✓ forces eardrum into mechanical vibrations ✓ (mechanical) vibrations (passed through middle ear) by a lever system/series of bones/named bones to the oval window ✓ sets up pressure waves in fluid in cochlea ✓	max 3
(a) (ii)	force increased by the action of the lever system/series of bones/named bones; value $F \times 1.5$ ✓ area of oval window $\ll$ area of the eardrum ; value $A/20$ ✓ effect of pinna in increasing intensity in ear canal ✓	max 2
(b)	$46 = 10 \times \log (I/(1.0 \times 10^{-12}))$ ✓ $I = 4.0 \times 10^{-8}$ ✓ W m^{-2} ✓	3
(c)	dBA scale is frequency dependent to match the response of the ear ✓ ear more sensitive (than I_0) for a range of frequencies between 1 and about 6 kHz ✓	2
Total		10

Question 3		
(a)	general shape, must be both positive and negative values ✓ action potential axis scale and unit – allow -70 to +30, or -90 to +20 mV (these values will be consistent in part a and part b) minimum -90 maximum +45 ✓ time scale and unit 0 to 6 ms – this will depend on curve drawn, pulse lasting no less than 1 ms and no more than 6 ms ✓	3

(b)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a correct and detailed description of the movement of ions into and out of the fibre. They include the terms depolarisation and repolarisation with reference to change in potential. Final mention is made to the slower process to restore the equilibrium concentrations. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The description of ion movement and the terms depolarisation and repolarisation might not be clearly named, but the candidate refers to the change in potential, although actual values might not be included. There may be mention of a final movement restoring equilibrium. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. Some reference to ion movement and a resulting change in potential. One of the terms depolarisation or repolarisation might be included. The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. Points which can be used to support the explanation: • at resting potential, high concentration of K^+ ions inside and Na^+ outside • when stimulated, membrane becomes permeable to Na^+ ions entering the core increasing membrane potential • good answer will say depolarisation from -70 mV to 0 mV and reverse polarisation from 0 mV to + 30 mV; but allow depolarisation from -70 mV to + 30 mV • membrane becomes impermeable to Na^+ ions and permeable to K^+ ions leaving the core • reducing membrane potential to -70 mV, repolarisation • after this, a much slower process returns the axon to its initial state with Na^+ ions outside and K^+ ions inside	max 6
	Total	9

Question 4		
(a)	(head) placed in strong/high intensity/super conducting magnets magnetic field ✓ supplied radio pulse excite H nuclei ✓ when H nuclei de-excite/change spin/change alignment they emit radio signal/em radiation/photons ✓ these signals are detected and passed to computer ✓ gradient in static field to allow location to be determined/magnetic field aligns H nuclei ✓	max 3
(b)	example answers: MR non-ionising radiation – ionising radiation in CT more danger to living cells ✓ MR can give multi-plane images from same scan – CT needs new scan for each image ✓ MR gives better resolution between tissue types, better resolution picture ✓ MR gives real time image CT scan needs to rotate to produce final image ✓	4
	Total	7