



Rewarding Learning

**ADVANCED**  
**General Certificate of Education**  
**2025**

Centre Number

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Candidate Number

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# Life and Health Sciences

Assessment Unit A2 3  
assessing  
Medical Physics



**[AZ031]**

\*AZ031\*

**MONDAY 9 JUNE, AFTERNOON**

## TIME

1 hour 45 minutes.

## INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

**You must answer the questions in the spaces provided.**

**Do not write outside the boxed area on each page or on blank pages.**

Complete questions in black ink and use a dark HB pencil for drawings and graphs.

**Do not write with a gel pen.**

Answer **all nine** questions.

## INFORMATION FOR CANDIDATES

The total mark for this paper is 100.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

You may use a scientific calculator.

Quality of written communication will be assessed in question 3.





**(b)** Medical grade X-rays are produced using an X-ray tube.

**(i)** Explain the purpose of each of the following parts of the X-ray tube in producing medical grade X-rays.

Metal filament \_\_\_\_\_  
\_\_\_\_\_

High voltage supply \_\_\_\_\_  
\_\_\_\_\_

Metal target \_\_\_\_\_  
\_\_\_\_\_

[3]

**(ii)** The metal often used for the target is tungsten. Suggest a reason why tungsten is used.

\_\_\_\_\_  
\_\_\_\_\_

[1]

X-rays of various energies are produced in the X-ray tube.

**(iii)** How are medical grade X-rays selected?

\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_ [2]

The components in the X-ray tube are housed in a glass envelope which contains a vacuum.

**(iv)** Why is it necessary to have a vacuum in the X-ray tube?

\_\_\_\_\_  
\_\_\_\_\_

[1]

**[Turn over**



During X-ray production, the metal target heats up.

(v) State **one** method by which heat is removed from the metal target.

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[1]

(c) Prolonged X-ray exposure can cause cell damage.  
A radiographer working in a hospital can be exposed daily to a large dose of X-rays.

(i) Describe how X-rays cause cell damage.

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[1]

(ii) State **one** method radiographers can use to protect themselves from too much X-ray exposure.

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[1]





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**(Questions continue overleaf)**

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**[Turn over**



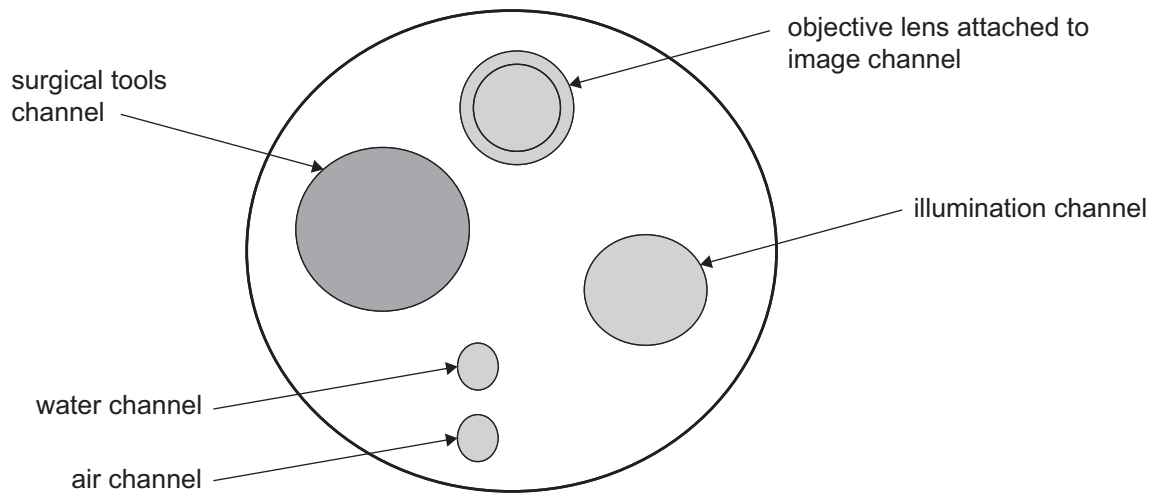
\*20AZ03105\*

2 An endoscope can be used to examine the bladder without surgery.

(a) Suggest two advantages of having an endoscopic scan compared to investigative open surgery.

1. \_\_\_\_\_  
\_\_\_\_\_
  2. \_\_\_\_\_  
\_\_\_\_\_
- [2]

(b) Below is a labelled sketch showing the tip of the endoscope and some of its channels.



Source: Principal Examiner

Light travels through the endoscope using optical fibres.

(i) What is the physical principle by which light travels through the full length of the optical fibre?

\_\_\_\_\_ [1]









4 Body temperature is a physiological measurement taken by a medical practitioner to determine how well the body is functioning.

(i) What is normal human body temperature?

\_\_\_\_\_ °C [1]

(ii) What is the temperature above which the human body can no longer stay alive?

\_\_\_\_\_ °C [1]

(iii) A thermometer is a device which can measure body temperature. The table opposite compares three different thermometers. Complete the table to describe how each thermometer works, how to take a temperature reading and one limitation associated with its use. Give a different limitation for each thermometer. The first thermometer has been completed for you.

Write your answers in the blank boxes.





<b>Thermometer</b>	<b>How it works</b>	<b>How to take a temperature reading</b>	<b>Limitation</b>
Underarm digital thermometer	The electrical sensor changes resistance at different temperatures	Place under the armpit and wait for the thermometer to beep	The temperature measurement will be lower than core body temperature
Contactless thermometer			
Tympanic thermometer			

[6]

[Turn over

14680



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**5** Thallium-201 and rubidium-82 are radiopharmaceuticals used routinely in nuclear medicine.

**(i)** State the type of radiation emitted by thallium-201.

\_\_\_\_\_ [1]

**(ii)** State two medical uses for thallium-201.

1. \_\_\_\_\_

2. \_\_\_\_\_ [2]

Rubidium-82 is routinely used in PET scans.

**(iii)** Discuss the use of rubidium-82 in PET scans.

In your discussion include the following:

- what the letters PET represent;
- how the rubidium-82 is administered to the patient;
- the name of the particle emitted during the radioactive decay of rubidium-82
- the process of annihilation; and
- how the radiation emitted during the PET scan is detected outside the body.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [6]





(b) Ultrasound can be used to check the carotid artery for blockages or narrowing.

(i) What is ultrasound?

\_\_\_\_\_ [1]

(ii) Suggest a suitable **range** of frequencies to be used to obtain an image of the carotid artery.

\_\_\_\_\_ Hz to \_\_\_\_\_ Hz [2]

(iii) Why is the range of frequencies suggested in (ii) suitable for obtaining an image of the carotid artery?

\_\_\_\_\_  
\_\_\_\_\_ [2]

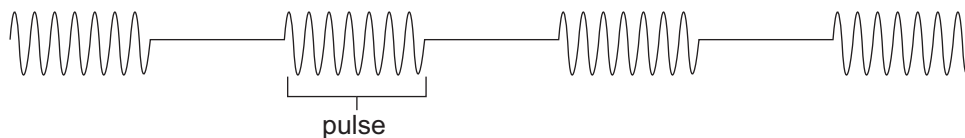
(iv) Describe how a blockage in the carotid artery would be identified using the image observed in an ultrasonic B-scan.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]



7 Ultrasound waves are transmitted into the body using an ultrasound transducer probe.

The transducer produces short pulses of ultrasound.  
This is shown in the diagram below.



Source: Principal Examiner

(a) (i) Explain why gel is placed between the transducer probe and the skin during an ultrasound scan.

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[2]

(ii) Explain in detail why the transducer probe is designed to produce pulses rather than continuous ultrasound waves.

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[4]

[Turn over



**(b) (i) Define specific acoustic impedance.**

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[2]

Ultrasound travels at a speed of  $1.57 \text{ km s}^{-1}$  in tissue A.  
The specific acoustic impedance ( $Z_A$ ) of ultrasound in tissue A is  
 $1.60 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$ .

**(ii) Calculate the density of tissue A.**  
Include a unit with your answer.

**Show your working out.**

Density of tissue A = \_\_\_\_\_ Unit = \_\_\_\_\_ [4]

Ultrasound is transmitted from tissue A into a different body tissue B.  
The density of tissue B is 1.29 times greater than that of tissue A.  
The speed of ultrasound in tissue B is 2.68 times greater than in tissue A.

**(iii) Calculate the specific acoustic impedance ( $Z_B$ ) in tissue B.**

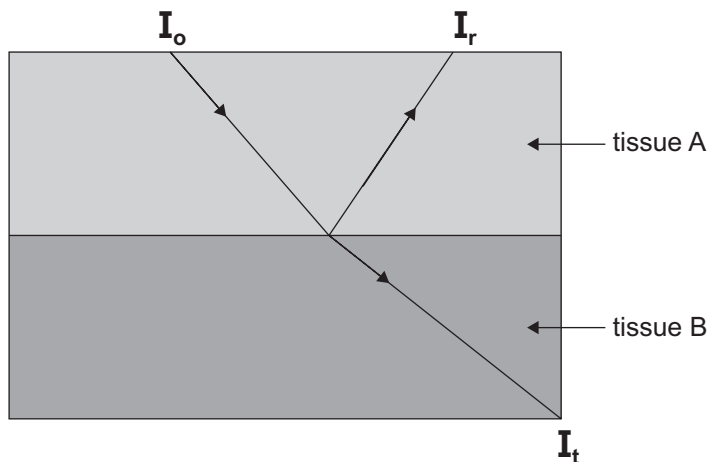
**Show your working out.**

Specific acoustic impedance in tissue B = \_\_\_\_\_  $\text{kg m}^{-2} \text{ s}^{-1}$  [2]



The diagram below shows what happens to the ultrasound at the boundary between the two body tissues.

$I_o$  is the incident ultrasound intensity,  $I_r$  is the reflected ultrasound intensity and  $I_t$  is the transmitted ultrasound intensity.



(iv) Write an equation which describes  $I_r$  in terms of  $I_o$  and  $I_t$ .

\_\_\_\_\_ [1]

(v) Write an equation which describes the intensity reflection coefficient,  $R$ , in terms of  $Z_A$  and  $Z_B$ .

\_\_\_\_\_ [1]

(vi) By first calculating the intensity reflection coefficient,  $R$ , determine the percentage of the initial intensity  $I_o$  which is transmitted.

**Show your working out.**

Intensity reflection coefficient = \_\_\_\_\_

Percentage of ultrasound transmitted = \_\_\_\_\_ %

[3]

**[Turn over**



8 This question is about background radiation.

(i) Define **background radiation**.

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[1]

(ii) Describe the procedure used to measure accurately background radiation in a laboratory.  
In your description, include all the equipment required to measure the background activity.

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[5]

(iii) How is the value for background radiation taken into consideration when measuring the activity of a source?

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[1]

(iv) State two **man-made** sources of background radiation.

1. \_\_\_\_\_

2. \_\_\_\_\_

[2]



9 Americium-241 is a radioactive source used in smoke detectors.  
The decay constant of americium-241 is  $1.61 \times 10^{-3} \text{ yr}^{-1}$ .

(a) (i) Write down the equation which shows the relationship between the decay constant and the half-life.

\_\_\_\_\_ [1]

(ii) Calculate the half-life of americium-241.  
Give your answer to three significant figures.

**Show your working out.**

Half-life = \_\_\_\_\_ yr [2]

(b) The activity of a source of americium-241 was measured as 12.2 Bq.

(i) What is meant by the **activity is 12.2 Bq**?

\_\_\_\_\_  
\_\_\_\_\_ [2]

(ii) How many years would it take for the activity of this source to reduce by 10%?

**Show your working out.**

Number of years = \_\_\_\_\_ [5]



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**THIS IS THE END OF THE QUESTION PAPER**

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**DO NOT WRITE ON THIS PAGE**

**For Examiner's  
use only**

<b>Question Number</b>	<b>Marks</b>
1	
2	
3	
4	
5	
6	
7	
8	
9	

<b>Total Marks</b>	
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**Examiner Number**

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