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General Certificate of Education

2018

Centre Number

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Candidate Number

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Life and Health Sciences

Assessment Unit A2 3

assessing

Medical Physics

[AZ031]

TUESDAY 29 MAY, AFTERNOON



AZ031

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.

Write your answers in the spaces provided in this question paper.

Answer **all eight** 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 an electronic calculator.

Quality of written communication will be assessed in question **2(a)(ii)**.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	

Total Marks	
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- 1 Ultrasound waves are used in the medical field for diagnostic purposes. **Fig. 1.1** shows a radiographer using an ultrasound probe.



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Fig. 1.1

- (a) (i) State the lower frequency limit of ultrasound.

_____ [1]

- (ii) Briefly outline how ultrasound is used to obtain an image.

 _____ [2]

Examiner Only	
Marks	Remark

Table 1.1 below provides information required to perform calculations used in ultrasound imaging.

Table 1.1

Medium	Density/kg m ⁻³	Ultrasound velocity/ms ⁻¹
Air	1.3	330
Fat	952	1450
Blood	1060	1570
Brain	1025	1544

- (c) (i) Calculate the specific acoustic impedance of **fat**.
You are advised to show your working.

Specific acoustic impedance = _____ kg m⁻²s⁻¹ [3]

- (ii) The specific acoustic impedance for tissue is 1.63 kg m⁻²s⁻¹. Calculate the intensity reflection coefficient between **air** and **tissue**.
You are advised to show your working.

Intensity reflection coefficient = _____ [4]

Examiner Only

Marks Remark

All pregnant women have their blood pressure routinely checked as a precaution.

High blood pressure is one of the symptoms of pre-eclampsia, a condition where the placenta does not function properly.

- (b) (i) State the values **above** which blood pressure is diagnosed to be high in a normal adult.

_____ [1]

- (ii) What are the limitations of using a sphygmomanometer to diagnose pre-eclampsia?

_____ [2]

Examiner Only	
Marks	Remark

- 3 Hospitals use devices to make physical observations and measurements of patients to find out the cause of illness and disorders.

Table 3.1 contains a list of imaging techniques.

Table 3.1

Imaging Technique
Conventional X-ray
Computerised tomography (CT) scans
Endoscopy
Ultrasonic A scan
Ultrasonic B scan
Magnetic resonance imaging (MRI) scan
Gamma ray imaging

- (a) Use the imaging techniques listed in **Table 3.1** to answer the following questions.

- (i) Choose the best imaging technique to observe a foetal heartbeat.

_____ [1]

- (ii) Which imaging technique is the only one which can be used to observe and remove a bowel tissue sample in cases of suspected bowel cancer?

_____ [1]

- (iii) Which imaging technique involves injecting a tracer into the body?

_____ [1]

- (iv) For which imaging technique does a patient have to remain very still for up to 1 hour?

_____ [1]

- (v) Which imaging technique is used to detect bleeding in the brain associated with a stroke?

_____ [1]

Examiner Only

Marks

Remark

(iii) In what way is the waveform from an EEG different to that from an ECG (electrocardiogram)?

EEG _____

ECG _____ [2]

(iv) State the similarity in the method by which both ECG and EEG scans are obtained.

_____ [1]

Examiner Only	
Marks	Remark

- 5 The half-life of technetium-99 (^{99}Tc), a commonly used radioisotope, is 6 hours.

(a) (i) What is the meaning of the term half-life?

_____ [2]

(ii) Calculate the decay constant of technetium-99.
You are advised to show your working.

Decay constant _____ s^{-1} [4]

(b) (i) Describe how **data may be collected** from which the half-life of **protactinium** may be determined.
Include in your description the equipment used to collect the data.

_____ [6]

Examiner Only	
Marks	Remark

- 6 A group of students is asked to measure background radiation. They measure the number of counts when **no radioactive source** is present. They each take a measurement of the number of counts emitted and the time over which the counts were observed. **Table 6.1** shows the results obtained from each of their experiments.

Table 6.1

Student	Time/s	Number of counts observed
A	90	73
B	10	4
C	60	48
D	180	141

- (a) (i) Which student has collected the result which is likely to be least accurate? Explain your answer fully.

[3]

Examiner Only

Marks

Remark

The results from the student with the least accurate results were discounted, and the remaining three sets of results were used to calculate an accurate value for background radiation.

- (ii) Verify that the background radiation calculated in this experiment was 0.798 Bq.

[3]

Hundreds of radioisotopes, used in medical physics, can be produced 'artificially' by a variety of methods, including the bombardment of certain stable nuclei by high energy particles such as neutrons, protons and α -particles.

During a debate, a student argues that radioactivity is dangerous and poses a threat to the public. The student argues that we should not be creating artificial radioactive sources for any purpose.

- (b) (i) Why are radioactive sources considered dangerous?

_____ [1]

- (ii) State two precautions that a medical physicist should take when working with radioactive sources.

1. _____

2. _____ [2]

Examiner Only	
Marks	Remark

- 7 Rubidium-82 (^{82}Rb) is a radioactive isotope of rubidium and is used in medical imaging.
Fig. 7.1 shows a graph, not drawn to scale, of $\ln(A/\text{Bq})$ against **time in minutes** for ^{82}Rb .

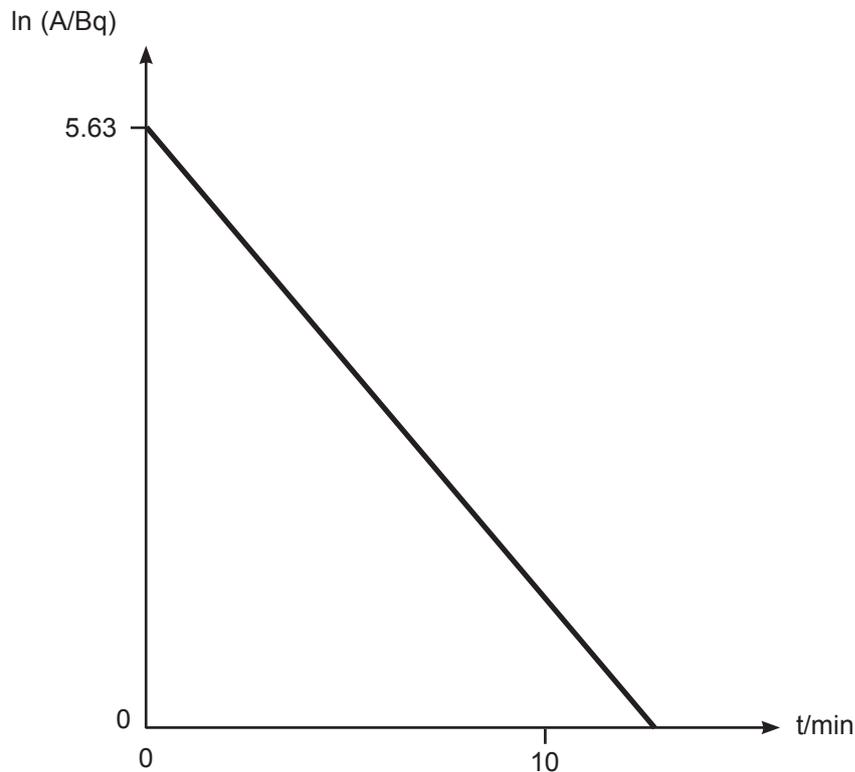


Fig. 7.1

- (i) Using the values provided in **Fig. 7.1**, show that the initial activity, at time $t = 0$, is approximately 280 Bq.
You are advised to show your working.

[2]

Examiner Only	
Marks	Remark

- (ii) The decay constant, λ , for ^{82}Rb is 0.00907 s^{-1} . Use this, together with the answer to (i), to calculate the activity of rubidium-82 after 10 minutes.

You are advised to show your working.

Activity = _____ Bq [4]

- (iii) State a specific use of rubidium-82 in medical imaging.

_____ [2]

- (iv) State **two** properties of rubidium-82 that make it suitable for the use stated in (iii).

_____ [2]

Examiner Only

Marks Remark

- 8 **Alpha (α) particles** are helium nuclei, and consist of two protons and two neutrons. They are charged (2^+) and **can travel only a few centimetres in air**.

Alpha particles **readily ionise other atoms**. They are stopped by a thin piece of paper and so have a **very low penetrating power**.

- (i) Write a short paragraph on each of **beta (β)** and **gamma (γ)** radiations, outlining the properties that make them suitable for the detection and treatment of cancers.

Beta _____

_____ [2]

Gamma _____

_____ [2]

Examiner Only	
Marks	Remark

- (ii) Complete **Table 8.1** to indicate the type of radiation α , β , or γ that is used in the following medical procedures.

Table 8.1

Type of medical procedure	Type of radiation α , β , or γ
Technetium-99 is injected into the patient	
Thallium-201 is used for cardiac imaging	
Iridium-192 wire is inserted into the body for short periods of time to provide short-range treatment of early stage prostate cancer	

[3]

Examiner Only

Marks Remark

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