Rewarding Learning

ADVANCED
General Certificate of Education
2024

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit A2 3
assessing
Medical Physics

MV18

[AZ031]

WEDNESDAY 12 JUNE, MORNING

Time

1 hour 45 minutes, plus your additional time allowance.

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 on blank pages.
Complete in black ink only.
Answer **all seven** questions.

Information for Candidates

The total mark for this paper is 100.
Figures in brackets printed at the end of each question 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)**.

1 Measuring body temperature is very important in modern medicine. For example, some diseases are characterised by a change in body temperature.

(i) State the normal body temperature for a healthy adult. [1 mark]

_____

(ii) The table below lists some suggested ranges of temperatures for a human body to survive.
Tick the appropriate box to indicate the correct range of temperatures. [1 mark]

Lowest body temperature /°C	**Highest body temperature /°C**	✓
21	43	
26	44	
23	42	
29	47	
24	43	

(iii) Provide an example of a medical condition where a person might exhibit a higher than normal body temperature and state a **visible** symptom of this higher temperature. [2 marks]

Medical condition _____

Visible symptom _____

A parent takes the temperature of a child using a **digital** thermometer. The temperature is measured **orally**, and the reading is displayed on the thermometer as 33°C.
The parent suspects that the reading is incorrect.

(iv) Suggest what might have happened before or when taking the reading to make it incorrect. [1 mark]

_____

(v) Suggest a different type of thermometer which could be used to measure accurately the temperature of the child.

State one advantage and one disadvantage of **using** this thermometer to record the temperature of a child. [3 marks]

Thermometer _____

Advantage _____

_____

Disadvantage _____

_____

2 (a) Discuss the use of an EEG to monitor or provide a diagnosis for a patient. [6 marks]

Include the following in your discussion:

- what the letters EEG stand for;
- what an EEG measures;
- how an EEG scan is conducted;
- an example of a medical condition which can be detected using an EEG; and
- a non-medical factor which might affect the outcome of an EEG.

Quality of written communication will be assessed in this question.

What EEG stands for _____

_____

What an EEG measures _____

_____

_____

How an EEG scan is conducted _____

_____

_____

Medical condition _____

_____

Non-medical factor _____

_____

_____

(b) (i) Brain waves can be identified based on their frequency ranges. In the table below, indicate the type of brain wave for each of the frequency ranges. [3 marks]

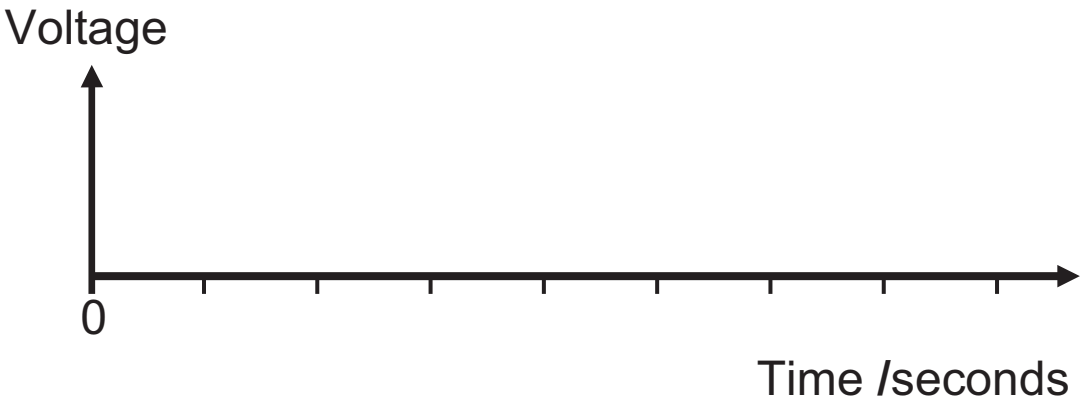
One of the examples has been completed for you.

Brain waves	**Delta**				
Frequency range /Hz	**0.5 – 3.5**	**4 – 8**	**8 – 12**	**12 – 38**	**38 – 42**

(ii) Suggest what a person might be doing when the delta waves are observed. [1 mark]

_____

(iii) On the following graph, sketch a delta wave trace over a time of 2 seconds.
Choose a suitable scale for the x-axis. [3 marks]



3 The activity of a weak radioactive source was recorded as 250 Bq. The decay constant of this source is $1.33 \times 10^{-2}\,s^{-1}$.

(a) (i) What is meant by the term decay constant? [2 marks]

_____

_____

_____

(ii) Calculate the activity of this source 120 seconds **before** this reading was taken. [3 marks]

You are advised to show your working.

Activity = _____ Bq

(b) The initial activity of a different radioactive isotope is 24.70 GBq. After a time of 10.5 hours the activity reduces by 26**%**.
1 GBq = 1×10^{9} Bq

(i) Explain fully what is meant by the statement **initial activity is 24.70 GBq**. [3 marks]

_____

_____

_____

_____

_____

(ii) Calculate the activity after 10.5 hours have passed. [2 marks]

Give your answer correct to **2 decimal places**.

You are advised to show your working.

Activity = _____ GBq

(iii) Calculate the decay constant for this radioactive isotope in s^{-1}. [5 marks]

You are advised to show your working.

Decay constant = _____ s^{-1}

(iv) Define the term **physical half-life**. [2 marks]

_____

_____

_____

(c) A different radioactive isotope has a decay constant of $4.00 \times 10^{-6}\ s^{-1}$.

Show the physical half-life of this radioactive isotope is approximately two days. [4 marks]

There are 86400 seconds in one day.

Show your working.

4 **(a)** X-rays are used routinely in dental practices to examine the oral health of patients.
A sensitive film is placed inside the mouth and an X-ray machine is used to produce an image.

(i) What are **X-rays**? [1 mark]

_____

(ii) What properties of X-rays make them suitable to image teeth? [2 marks]

_____

_____

(iii) State **one** example of a use of X-rays in diagnosing oral health. [1 mark]

_____

(iv) The dentist moves away from the patient when the X-ray machine is operating.
Explain fully why the dentist moves away from the patient during the procedure. [3 marks]

_____

_____

_____

_____

_____

(b) Discuss how medical grade X-rays are produced using an X-ray tube. In your discussion include information on the following aspects of the X-ray tube: [8 marks]

- cathode;
- anode;
- cooling;
- aluminium filter; and
- vacuum.

Cathode

Anode

Cooling

Aluminium filter

Vacuum

5 A pulmonary embolism is a blocked blood vessel in the lungs.

It can be life-threatening if not treated quickly.

Two different diagnostic techniques that can be used to investigate this medical condition are:

- magnetic resonance imaging (MRI) scans; and
- gamma ray imaging.

(a) Describe briefly how each of the imaging techniques above is performed on a patient and the type of waves detected in each procedure. [6 marks]

MRI scan _____

_____

_____

_____

_____

_____

_____

Gamma ray imaging _____

_____

_____

_____

_____

_____

_____

_____

(b) (i) Some patients are not permitted to have an MRI scan.

Provide an example of a condition that might prevent a patient having an MRI scan.

Explain why the scan is not permitted. [2 marks]

_____

_____

(ii) Describe the difference between the **nature** of the images of the lungs produced by MRI scans and gamma ray imaging. [2 marks]

_____

_____

_____

(c) Gamma rays are ionising and their use in medicine contributes to background radiation.

(i) Define **background radiation**. [1 mark]

_____

_____

(ii) State another source of background radiation. [1 mark]

_____

(iii) Medical physicists need to take precautions when using sources which emit gamma rays.
State **one** precaution they might take. [1 mark]

_____

_____

6 **(a)** Rubidium-82 is a radiopharmaceutical used in PET perfusion imaging.

(i) What do the letters PET represent? [1 mark]

_____

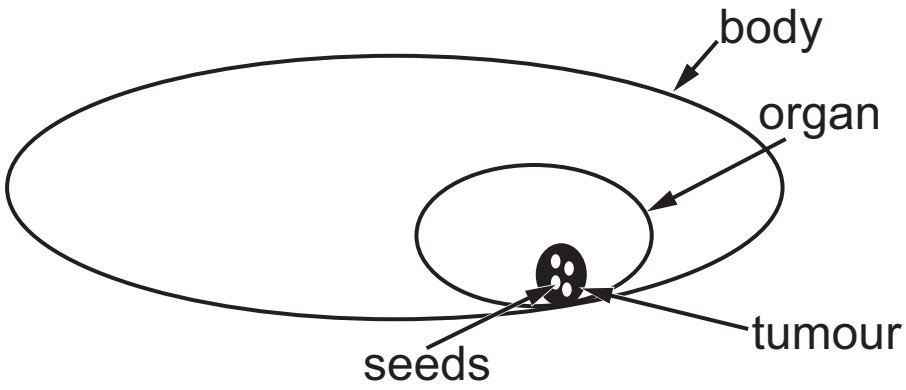
(ii) Which body organ is usually imaged using a Rubidium-82 PET scan? [1 mark]

_____

(iii) Which type of radiation is detected by the PET scanner? [1 mark]

_____

(b) Iridium-192 is often used in the treatment of cancer during a procedure called brachytherapy.
During this procedure, small capsules of Iridium-192 called seeds are inserted into the body near the tumour.
A dose of ionising radiation is delivered to the tumour without causing damage to other healthy tissue nearby.



(i) Iridium-192 is predominantly a **beta** emitter.

What is beta emission, and what property of beta emission makes it suitable for brachytherapy?
[2 marks]

(ii) An isotope which emits only alpha radiation would be unsuitable for brachytherapy.

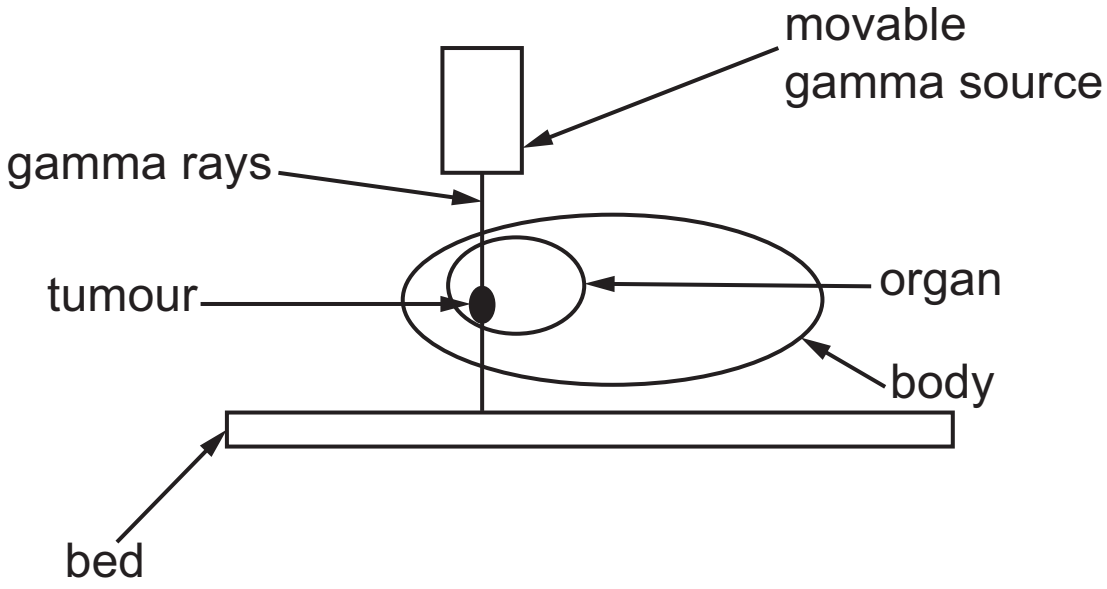
What is alpha radiation, and why would this radiation be unsuitable for brachytherapy? [2 marks]

In low-dose rate (LDR) brachytherapy treatments, the seeds remain permanently in the body after the treatment is finished.

(iii) Why must the physical half-life of the seeds used in the LDR treatments be short? [2 marks]

Radiotherapy is a different type of cancer treatment which uses gamma radiation.

In this treatment a source, which is external to the body, is used to direct a narrow beam of gamma rays towards the tumour.



(iv) Suggest one advantage and one disadvantage of using radiotherapy to treat a tumour. [2 marks]

Advantage _____

_____

Disadvantage _____

_____

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(Questions continue overleaf)

7 A foetal ultrasound scan is an imaging technique that uses ultrasound waves to produce images of a foetus in the uterus.

The first foetal ultrasound scan is used to confirm the pregnancy and estimate how many weeks the woman has been pregnant.

During the second ultrasound scan, physical details are viewed to check for abnormalities.

(a) (i) State the frequency range of medical ultrasound waves. [1 mark]

_____

(ii) Ultrasound waves of frequency 3.5×10^{6} Hz are used to image a foetus. [2 marks]

Give one advantage and one disadvantage of imaging a foetus at this frequency.

Advantage _____

_____

Disadvantage _____

_____

(iii) The results of a foetal scan are usually displayed as a B-scan. What is a **B-scan**? [1 mark]

(iv) Describe briefly how the operator conducts a B-scan on a pregnant woman. [2 marks]

(v) How does the operator identify a stronger reflection of ultrasound from the foetus using the B-scan image displayed on the screen? [1 mark]

(b) Reflection of ultrasound occurs at the boundary between two different media due to the difference in the specific acoustic impedance of each material.

(i) Define **specific acoustic impedance** for a particular body tissue. [1 mark]

_____

_____

_____

(ii) What are the units of specific acoustic impedance? [1 mark]

_____

(iii) Define **intensity reflection coefficient**. [1 mark]

_____

_____

The largest and smallest values for the intensity reflection coefficient are 1 and 0.

(iv) What will happen to the ultrasound at the boundary between two different tissues if the intensity reflection coefficient is 1? [1 mark]

_____

(v) The table below provides information on density and the speed of ultrasound in muscle and bone.
By first calculating the specific acoustic impedance for each medium, calculate the percentage of ultrasound transmitted at the boundary between muscle and bone. [8 marks]

Medium	**Density /kgm^{-3}**	**Speed of ultrasound /ms^{-1}**
Muscle	1075	1590
Bone	1900	4080

You are advised to show your working.

Percentage of ultrasound transmitted

= _____ **%**

This is the end of the question paper

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

Examiner Number