Rewarding Learning

ADVANCED
General Certificate of Education

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit A2 3
assessing

MV18

Medical Physics

[AZ031]
Assessment

Assessment Level of Control	Tick the relevant box (✓)
Controlled Conditions	
Other	

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.
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 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(b)**.

1 Magnetic resonance imaging, **MRI**, is a diagnostic procedure that makes use of nuclear magnetic resonance to produce a three dimensional image of the body.

(a) (i) Nuclei of which element within the body are targeted during an MRI scan?
Provide a reason for your answer. [2 marks]

_____

_____

(ii) Nuclei with an uneven number of protons and neutrons have a magnetic moment and can therefore interact with a magnetic field. A very large magnetic field is used to cause this interaction.
How is this very large magnetic field created in the MRI scanner? [1 mark]

_____

(iii) These magnetic nuclei now align their nuclear spins in a direction which is parallel or antiparallel to this large magnetic field.
This makes some nuclei have a higher energy state than others.
A piece of equipment is used to excite the low energy nuclei to a higher energy state. State the name of this piece of equipment. [1 mark]

_____

(iv) The nuclei only absorb energy provided at a certain frequency. What is the name given to this frequency? [1 mark]

_____

(v) The previously excited nuclei relax to a lower energy state and emit energy. In what form is this energy emitted? [1 mark]

_____

(vi) In order to create an image, it is necessary to locate the origin of the emitted energy. Which piece of equipment is used for this purpose? [1 mark]

_____

(b) MRI scanners can be very dangerous due to the very large magnetic field they produce. State **two** different precautions that need to be taken by staff or patients entering the MRI scanner room. [2 marks]

1. _____

2. _____

(c) An MRI scan can be an uncomfortable experience for a patient. State a reason for a patient's possible discomfort. [1 mark]

_____

(d) Give **two** features of MRI scanning that make the technique particularly useful in medical diagnostics. [2 marks]

1. _____

2. _____

2 A patient's body temperature is to be monitored over a period of time as part of a routine diagnostic investigation.

(a) Name two different types of **digital** thermometers and describe how each is used to measure body temperature. [4 marks]

1. _____

_____

_____

2. _____

_____

_____

(b) Discuss the range of body temperatures over which a body can survive and factors which might affect body temperature. [8 marks]

Include in your discussion:

- A range of body temperatures over which a body can survive.
- A value for normal body temperature.
- The medical term given to temperatures above normal body temperature and symptoms a patient may exhibit.
- The medical term given to temperatures below normal body temperature and symptoms a patient may exhibit.
- **Two** factors which could cause an incorrect body temperature reading to be taken.

Quality of written communication will be assessed in this question.

3 (a) (i) State the similarity in the method by which both electrocardiogram (ECG) and electroencephalogram (EEG) scans are obtained. [1 mark]

_____

(ii) Which piece of equipment is used to collect this information during both ECG and EEG scans? [1 mark]

_____

(iii) The table below lists some medical conditions.

Patient information	**Type of scan**
Patient has an epileptic seizure	
Patient displays a slower than normal heart rate (bradycardia)	
Alpha waves are emitted from a relaxed patient	
Delta waves are emitted from a sleeping patient	
Patient exhibits brain death	**EEG**

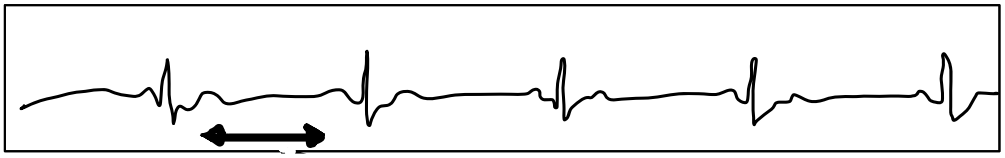
Complete the table by stating whether an ECG or EEG scan should be completed. One answer has been entered for you. [2 marks]

Blank Page

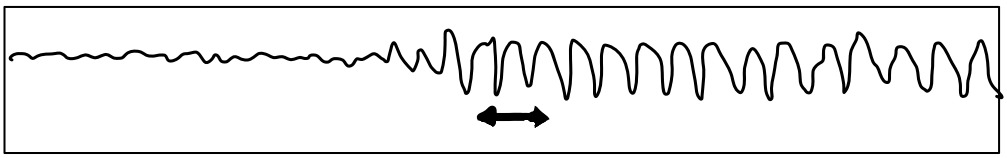
(Questions continue overleaf)

(b) Below is a series of images, A, B, C, D, E, F and G, which demonstrate either an ECG examination or EEG examination.

A double headed arrow has been placed beside each image to indicate a time of 1 second.

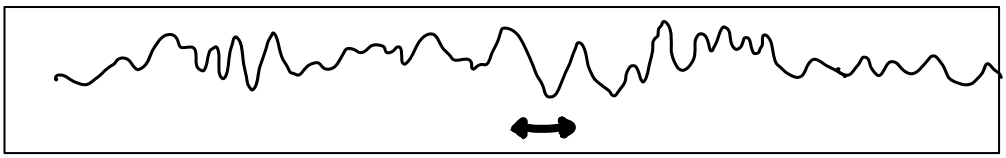


A



B

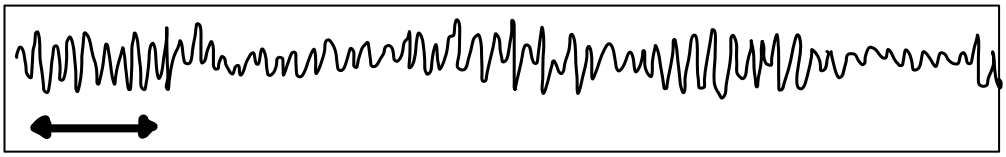
C



D

E

F

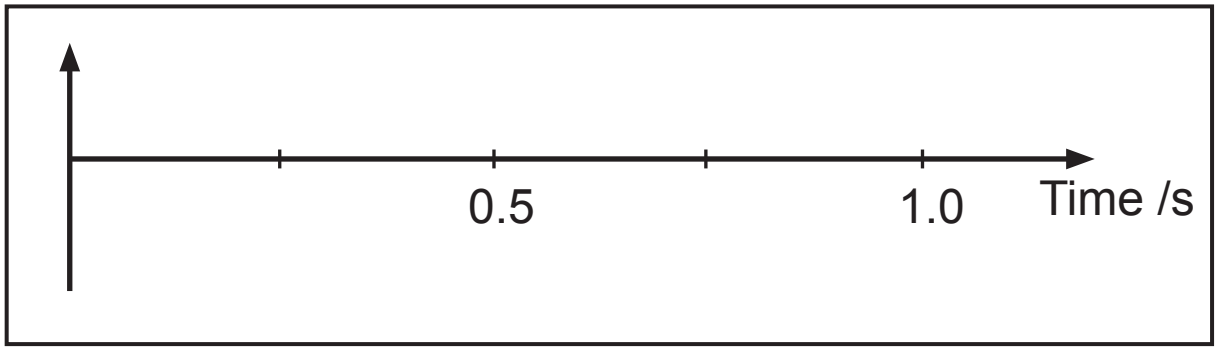


G

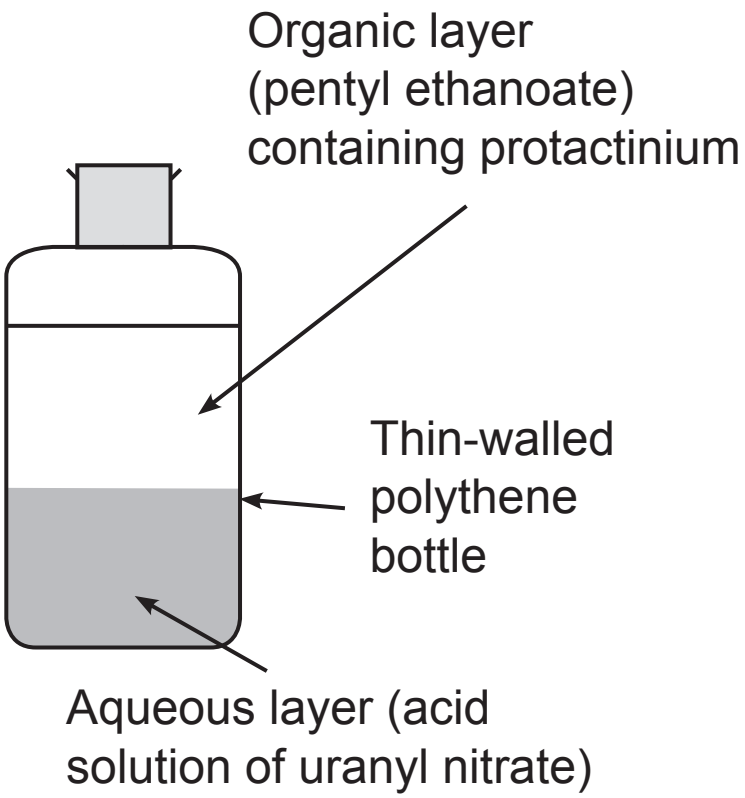
Read each statement below and use the information to match the correct image with the following patient information provided.
One answer has been entered for you. [4 marks]

- The heart rate of a normal patient is typically recorded at 60–80 beats per minute _____
- An adult patient displays a heart rate of over 100 beats per minute (tachycardia) _____
- A patient exhibits brain death ___F___
- Alpha waves have a frequency of 7.5–12 waves in one second _____
- Delta waves have a frequency of 0.5–4 waves in one second _____

(c) Beta waves are observed in normal individuals who are alert and working. Beta waves have a frequency of 12.5–30 waves in one second.
In the diagram below, sketch typical beta waves.
[2 marks]



4 (a) (i) Describe in detail an experiment a teacher could carry out in a laboratory to find the half-life of a prepared sample of radioactive protactinium, as shown below. [6 marks]



(ii) State a precaution that the teacher should take when handling radioactive material. [1 mark]

_____

_____

(b) The experiment is completed and a set of results are obtained.
Some of these are shown in the table below.

Time /s	20	40	60	80	100	120	140
Activity /Bq	360	297	245	200	165	137	113

Complete a graph of Activity against Time as follows:

(i) Choose a suitable scale for the x-axis and label the axis. [1 mark]

(ii) Plot a graph of Activity against Time. [2 marks]

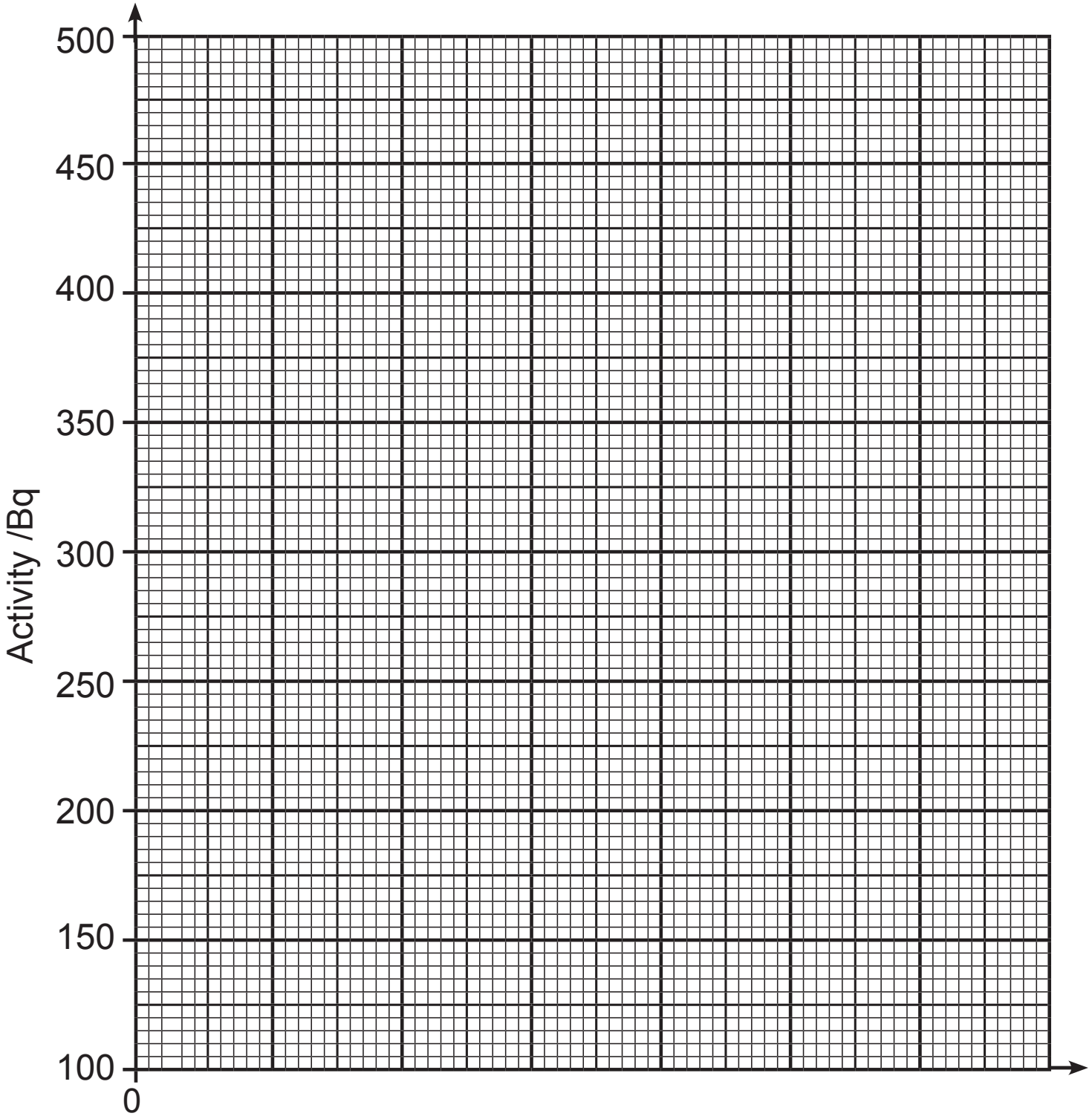
(iii) Draw a best fit line. [1 mark]

(iv) Use the graph to estimate a value for the initial activity.
Show evidence on the graph. [2 marks]

_____

(v) Use the graph to estimate the half-life of the sample of protactinium.
Show evidence on the graph. [2 marks]

Half-life = _____ s


500
450
400
350
300
250
200
150
100
0
Activity /Bq

5 **(a)** **(i)** Explain briefly how medical X-rays are produced.
[3 marks]

_____

_____

_____

(ii) X-rays are produced with a large range of energies.
How are weak X-rays removed after production?
Suggest a reason why this is necessary.
[2 marks]

How they are removed: _____

_____

Reason: _____

_____

CT scans are detailed scans which make use of X-rays.

(b) Suggest **two** reasons why CT scans are not used in routine diagnostics in a **minor injury clinic**.
[2 marks]

1. _____

_____

2. _____

_____

(c) (i) X-rays can also be used to investigate heart defects. However, they usually produce poor quality images.

Explain why X-rays of the heart do **not** usually produce good images. [2 marks]

(ii) Describe **one** precaution that radiographers must take to minimise the risk of a patient being harmed while having an X-ray taken. [1 mark]

(d) An alternative method of investigating the heart is by using ultrasound. Discuss the advantages of using ultrasound to investigate the heart as compared to other methods. [2 marks]

6 Kidney stones are small, hard, crystalline lumps within the kidney or urinary tract. Small stones can be passed out in the urine. Larger stones require a medical procedure to remove them.

One of the ways kidney stones can be located and treated is with an endoscope.

(a) (i) Describe the structure and function of the endoscope used to create a clear image of kidney stones. [4 marks]

(ii) Name the part of the endoscope that can be used to remove small kidney stones. [1 mark]

(b) Ultrasound can also be used to shatter large kidney stones into small pieces. An ultrasound probe is first used to detect the stones.

Describe the procedure by which the stones can be **detected** using ultrasound.

Name the type of ultrasound scan required and state the frequency range used. [4 marks]

(c) A third medical procedure for removing kidney stones is open surgery, where an incision is made in the patient's back to allow the surgeon to access the kidney. The stones are then completely removed from the patient's kidney.

Critically evaluate the advantages and disadvantages of each of the three procedures for removal of kidney stones. [6 marks]

Endoscope Procedure: _____

_____

_____

_____

Ultrasound Procedure: _____

_____

_____

_____

Open Surgery: _____

_____

_____

_____

7 The ease with which ultrasound can travel through a material depends on a property of the material called acoustic impedance.

(a) (i) Define specific acoustic impedance. [1 mark]

_____

_____

(ii) Choose values from the table below to calculate the specific acoustic impedance of water. Include a unit. [3 marks]

Material	**Density /kg m^{-3}**	**Speed of sound /m s^{-1}**
Air	1.2	330
Water	1000	1450
Bone	1500	4000

You are advised to show your working.

Specific acoustic impedance = _____

(b) (i) Using the values in the table below, choose the two materials which would produce the maximum reflection of ultrasound. [1 mark]

_____

(ii) Using the values in the table below, choose the two materials which would produce the maximum transmission of ultrasound. [1 mark]

_____

Material	**Acoustic impedance**
Bone	6.00×10^{6}
Blood	1.59×10^{6}
Muscle	1.70×10^{6}
Soft tissue	1.58×10^{6}
Fat	1.38×10^{6}

(iii) Calculate the intensity reflection coefficient between muscle and bone. Give your answer to 3 significant figures. [3 marks]

You are advised to show your working.

Intensity reflection coefficient = _____

(iv) Use your answer to part **(iii)** to calculate the percentage of incident ultrasound energy that would be transmitted at the boundary between muscle and bone. Give your answer to 3 significant figures. [2 marks]

You are advised to show your working.

Percentage energy transmitted = _____ **%**

8 Thallium-201 in the form of thallium chloride is a radioactive isotope, having a physical half-life of 3.05 days.

(a) (i) What purpose is the radiopharmaceutical thallium-201 used for in nuclear medicine? [1 mark]

_____

(ii) Name the type of radiation that is emitted during the decay of thallium-201 and give the name of the piece of equipment used to detect it. [1 mark]

_____

(b) (i) Show that the decay constant of thallium-201 is approximately 0.23 day^{-1}. [3 marks]

You are advised to show your working.

Decay constant = _____ day^{-1}

(ii) A sample of thallium-201 has an initial activity of 2.22×10^{9} disintegrations per minute. Calculate the activity of the sample after 90 hours. [5 marks]

You are advised to show your working.

Activity = _____ Bq

(iii) How many days will it take for the sample to register an activity of one-tenth of its initial value?
[3 marks]

You are advised to show your working.

Time = _____ days

This is the end of the question paper

Source

Q3(b).....Source: Principal Examiner

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