AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level
APPLIED SCIENCE

Unit 8 Medical Physics

Tuesday 24 May 2016 Morning Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- a pencil
- a ruler
- a calculator.

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 the working of your calculations.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.
- You will be marked on your ability to
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.
- You are expected to use a calculator where appropriate.

Answer **all** questions in the spaces provided.

1 A student is preparing for an interview for a job as a medical physics assistant in a hospital. Before his interview, he decides to find out more about electrocardiograms (ECGs) and electroencephalograms (EEGs).

1 (a) Which organ can be investigated using an ECG?

[1 mark]

_____

1 (b) The student discusses EEGs with his friend. His friend makes three incorrect statements about EEGs. The three incorrect statements are shown below.

For each statement, write what the student would say to correct his friend's misunderstanding.

1 (b) (i) "Gel is used to connect the EEG probes to a patient's skin to make sure acoustic impedances are matched."

[1 mark]

_____

_____

1 (b) (ii) "EEGs are dangerous because electricity has to be passed into the patient's brain."

[1 mark]

_____

_____

1 (b) (iii) "Sleep researchers are most interested in studying beta waves."

[1 mark]

_____

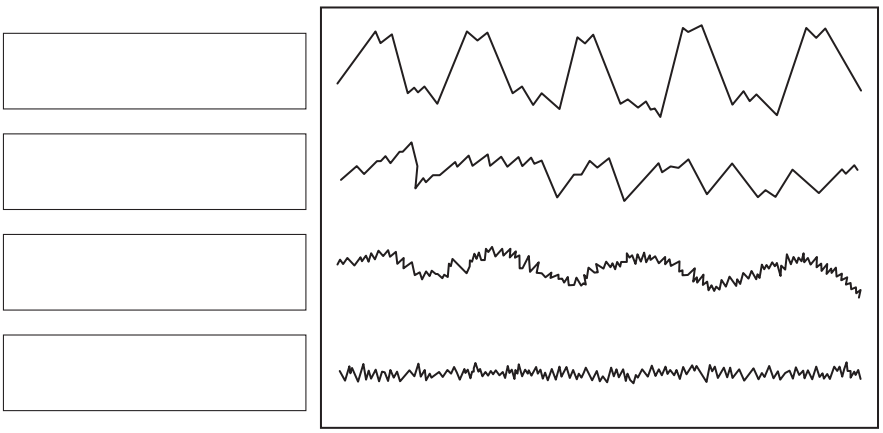
_____

1 (c) **Figure 1** shows traces obtained from an EEG.

Using the four boxes to the left of **Figure 1**, label each trace with the type of wave that the trace shows.

[3 marks]

Figure 1



7

Turn over for the next question

2 A hiker has been stranded in a snowdrift. She is being assessed and, if necessary, treated by a first aider.

2 (a) The first aider uses a liquid-in-glass clinical thermometer to measure the hiker's temperature. To do this, the first aider places the thermometer in the hiker's mouth.

The thermometer reads 31 °C. The first aider says that the hiker is suffering from hypothermia.

Which of the symptoms below is **not** a symptom of hypothermia?

Tick **one** box.

[1 mark]

- ☐ Loss of co-ordination
- ☐ Fast heartbeat
- ☐ Pale skin
- ☐ Drowsiness
- ☐ Weak pulse

2 (b) (i) Discuss whether or not the first aider's diagnosis of hypothermia is valid.

[2 marks]

2 (b) (ii) Is the hiker's core body temperature likely to be the same as the temperature measured in her mouth? Give a reason for your answer.

[1 mark]

2 (c) The first aider wraps the hiker in a shiny silver-coloured foil blanket as shown in **Figure 2.**

Figure 2

2 (c) (i) Which heat-transfer mechanism is the blanket designed to reduce most?

[1 mark]

_____

_____

2 (c) (ii) Why is the **inside** of the blanket coloured silver?

[1 mark]

_____

_____

2 (c) (iii) Why is the **outside** of the blanket coloured silver?

[1 mark]

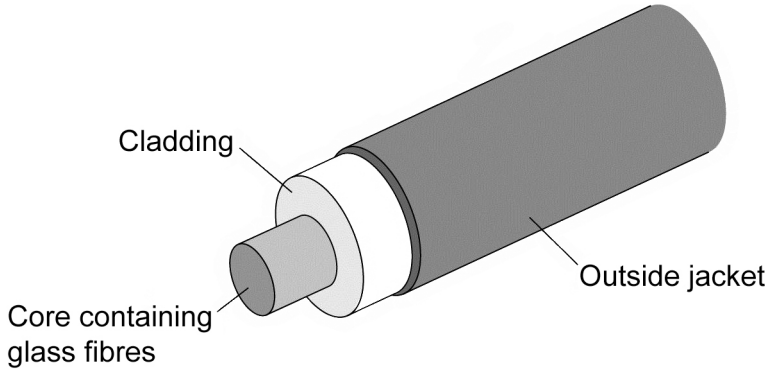
_____

_____

7

3 **Figure 3** shows the basic structure of part of an endoscope. Endoscopes use total internal reflection to transmit light along glass fibres.

Figure 3



3 (a) (i) Explain why cladding is used on these glass fibres.

[1 mark]

3 (a) (ii) How should the refractive index of the cladding compare with the refractive index of the glass fibres?

[1 mark]

3 (b) A medical equipment company is investigating a new type of glass. They want to know if it would be suitable to use in an endoscope.

To do this, a technician tests several samples of the glass to obtain an accurate value for its refractive index (*n*). Each sample is in the shape of a rectangular glass block.

Why does the technician need to test several samples of the glass to obtain an accurate value for its refractive index?

[1 mark]

Question 3 continues on page 8

Question 3 continues on the next page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

3 (c) The refractive index of a sample of glass shaped as a rectangular block can be determined in a school laboratory.

3 (c) (i) List the equipment you would need to do this experiment.

[1 mark]

_____

_____

3 (c) (ii) Describe how you would do the experiment. State which measurements you would make and explain how you would use these measurements to calculate the refractive index of the glass. You may use a diagram in your answer.

You will be assessed on the quality of written communication in your answer to this question.

[5 marks]

_____

_____

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_____

Extra space (if needed) _____

3 (c) (iii) Why should the experiment be done in a darkened room?

[1 mark]

3 (c) (iv) Why should you use large angles of incidence?

[1 mark]

3 (d) (i) What is meant by the term **critical angle**?

[1 mark]

3 (d) (ii) The technician determined that the new glass had a refractive index of 1.6

Calculate the critical angle for this glass.

[3 marks]

Critical angle = _____ °

Question 3 continues on the next page

3 (e) (i) Endoscopes have many uses during keyhole surgery. For example:

A illuminating the area being operated on

B photographing the area being operated on

C supplying heat to burn away ulcers and tumours.

Which use of an endoscope, **A**, **B**, or **C**, uses laser light?

Write the correct letter in the box.

[1 mark]

3 (e) (ii) Give **one** other use of lasers in surgery.

[1 mark]

3 (e) (iii) State and explain **one** advantage and **one** disadvantage of using traditional open surgery rather than keyhole surgery to treat a knee injury.

[4 marks]

Advantage of using open surgery

Explanation

Disadvantage of using open surgery

Explanation

21

4 Doctors can use thermography and ultrasound to diagnose a range of conditions.

4 (a) State and explain **one** advantage and **one** disadvantage of using thermography, instead of ultrasound, to diagnose a tumour on the kidney.

[4 marks]

Advantage of using thermography _____

_____

Explanation _____

_____

Disadvantage of using thermography _____

_____

Explanation _____

_____

4 (b) Ultrasound travels at a speed of approximately 330 $m\,s^{-1}$ in air.

Calculate the wavelength of an ultrasound wave that has a frequency of 3.0 MHz (3×10^6 Hz). State the correct unit in your answer.

[3 marks]

_____

_____

_____

_____

_____

Wavelength = _____

Question 4 continues on the next page

4 (c) The depth to which ultrasound waves will penetrate depends on the frequency of the ultrasound wave.

Table 1 gives approximate values for the penetration of ultrasound through soft tissue at different frequencies.

Table 1

Frequency / MHz	Approximate penetration / cm
2.5	15
4	7
5	5
7	4
10	3

4 (c) (i) What evidence is there in **Table 1** that frequency and penetration are **not** inversely proportional?

[1 mark]

_____

_____

4 (c) (ii) Plot the data in **Table 1** on the grid below. Plot frequency on the *x*-axis, approximate penetration on the *y*-axis and then draw a line of best fit.

[3 marks]

4 (c) (iii) Use your graph to find the penetration of ultrasound that has a frequency of 3 MHz.

[1 mark]

Penetration = _____

4 (c) (iv) If frequency and penetration were inversely proportional, what would you have to plot on the *y*-axis to obtain a straight-line graph?

[1 mark]

_____

_____

4 (d) The frequency of an ultrasound wave also determines the quality of the image formed. The higher the frequency, the greater the detail seen in the image.

Explain why ultrasound imaging is **not** always suitable for diagnosing stomach problems in an obese adult.

Use the information about frequency and quality of image given above and the information provided about the relationship between frequency and penetration in **Table 1**.

[2 marks]

_____

_____

_____

_____

Question 4 continues on the next page

4 (e) Ultrasound imaging relies on the reflection of ultrasound pulses when they hit different media. The amount of reflection depends on the difference in the acoustic impedances of the two media.

Table 2 shows some values of acoustic impedance.

Table 2

Medium	Acoustic impedance / kg m^{-2} s^{-1} × 10^6
Air	0.0004
Bone (average)	6.00
Muscle (average)	1.70
Soft tissue (average)	1.58
Fat	1.38

4 (e) (i) Calculate the reflection intensity coefficient (α) between air and soft tissue.

[3 marks]

Reflection intensity coefficient = _____

4 (e) (ii) Which pair of media shown in **Table 2** would give the most ultrasound reflection when ultrasound pulses travel from one medium to the other?

[1 mark]

19

5 X-rays are commonly used to diagnose whether or not a bone is broken.

5 (a) (i) What are **X-rays**?

[2 marks]

_____

_____

_____

_____

Question 5 continues on the next page

5 (a) (ii) Explain how an X-ray image of a bone is formed.

You will be assessed on the quality of written communication in your answer to this question.

[5 marks]

Extra space (if needed) _____

5 (b) A contrast medium may be needed when using X-rays to diagnose problems with soft tissue.

Explain how using a contrast medium allows a radiographer to get an X-ray image of soft tissue.

[2 marks]

5 (c) X-rays are dangerous.

5 (c) (i) The damage caused by X-rays may be stochastic.

What does **stochastic** mean?

[1 mark]

5 (c) (ii) The damage caused by X-rays may be somatic.

What does **somatic** mean?

[1 mark]

5 (c) (iii) Radiographers protect themselves by limiting the X-ray dose equivalent that they are exposed to.

What unit is used to measure dose equivalent?

[1 mark]

12

6 Radiographers and radiologists have to choose the most suitable radioisotope to use in diagnosis or therapy. This involves considering the half-life of the radioisotopes they use.

6 (a) (i) Suggest why radioisotopes with a long half-life could be considered to be more dangerous than radioisotopes with a short half-life.

[1 mark]

_____

_____

6 (a) (ii) Suggest why radioisotopes with a short half-life could be considered to be more dangerous than radioisotopes with a long half-life.

[1 mark]

_____

_____

6 (a) (iii) Radioisotope **X** has a physical half-life of 6 hours. A sample of the radioisotope has a mass of 4 g.

Assuming that none of radioisotope **X** is used, how much of the sample will remain after 1 day?

[2 marks]

_____ g

6 (a) (iv) Would radioisotope **X** be more likely to be used as a tracer or as an implant? Give a reason for your answer.

[1 mark]

_____

_____

6 (b) Radiographers and radiologists also have to consider the type of radiation emitted by a radioisotope.

6 (b) (i) Suggest why alpha radiation could be considered to be more dangerous than gamma radiation.

[1 mark]

_____

_____

6 (b) (ii) Suggest why gamma radiation could be considered to be more dangerous than alpha radiation.

[1 mark]

_____

_____

6 (c) (i) Radiographers have to consider the half-life and type of radioactivity of different radioisotopes.

State **one** other factor that must be considered when choosing a radioisotope to use in diagnosis or therapy.

[1 mark]

_____

_____

6 (c) (ii) Why is this factor important?

[1 mark]

_____

_____

Question 6 continues on the next page

6 (d) Many different types of radiotherapy are available. These include some types of external therapy such as X-ray therapy and proton beam therapy. Both of these can be used to treat cancerous tumours.

X-ray therapy involves X-rays being sent into the body and then being absorbed by the tumour. The X-ray beam spreads out as it travels. Not all the X-rays reach the tumour and not all X-rays that reach the tumour will be absorbed.

Proton beam therapy involves sending focused beams of protons into the body. Protons are even more ionising than X-rays. The proton beam does not spread out significantly, but the beam is much more easily stopped by tissue than X-rays are. However, the energy of proton beams can be adjusted so that the beams deliver almost all their energy at the required depth.

Use your own knowledge and the information above to answer the questions below.

6 (d) (i) Explain why proton beam therapy may be preferred for the treatment of cancerous tumours close to the surface of the body, but X-ray therapy may be preferred for the treatment of cancerous tumours deeper inside the body.

[4 marks]

6 (d) (ii) Why would a radiologist need to know if a female patient were pregnant before deciding to use these sorts of therapy?

[1 mark]

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END OF QUESTIONS