Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2012

Applied Science SC08

Unit 8 Medical Physics

Thursday 24 May 2012 9.00 am to 10.30 am

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

Time allowed
- 1 hour 30 minutes

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 doctor is researching the sleep patterns of teenagers. She uses an electroencephalogram (EEG) machine to study a volunteer's brain activity during sleep.

The electrodes used are attached to the volunteer's skin. A layer of gel is placed between the electrodes and the skin.

1 (a) Why should the volunteer try to keep still while the EEG is taken?

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(2 marks)

1 (b) Why is a layer of gel placed between the electrodes and the volunteer's skin?

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(2 marks)

1 (c) State and explain **one** ethical issue the doctor would have to consider before carrying out this research.

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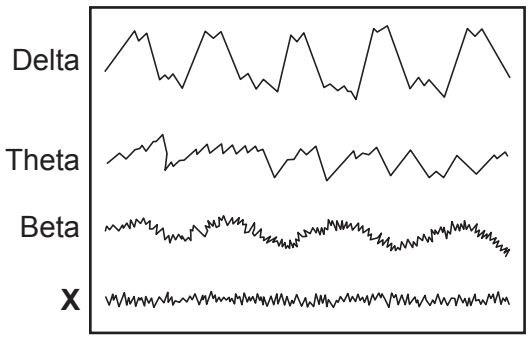
(2 marks)

1 (d) A typical set of EEG traces is shown in **Figure 1**:

Figure 1



1 (d) (i) What type of wave is shown by trace **X**?

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(1 mark)

1 (d) (ii) When do beta waves usually occur?

.....

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(1 mark)

1 (d) (iii) When do delta waves usually occur?

.....

.....

(1 mark)

9

Turn over for the next question

2 A medical physics technician takes measurements of the activity of a radioisotope, **A**. The results obtained are shown in **Table 1**. The technician can use these results to determine the half-life of radioisotope **A**.

Table 1

Time (hours)	Activity (counts per minute)
0	700
2	450
4	265
6	165
8	100

2 (a) (i) Explain what the term *half-life* means.

.....

.....

(1 mark)

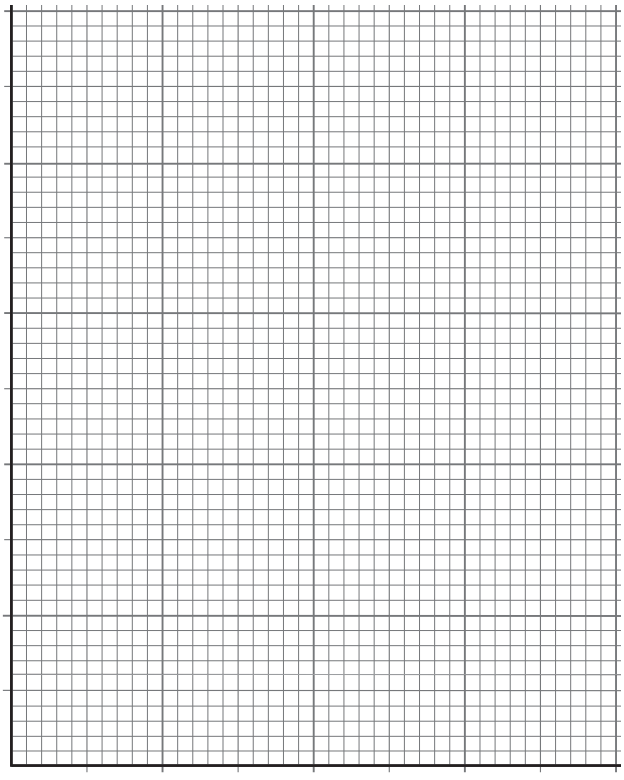
2 (a) (ii) Use the results in **Table 1** to estimate the half-life of radioisotope **A**.

Half-life is approximately ..... hours

(1 mark)

2 (b) (i) Plot the results from **Table 1** on the grid below. Draw a line of best fit.

Activity (counts per minute)



Time (hours)

(3 marks)

2 (b) (ii) Use your graph to find the activity of this radioisotope after 5 hours.

Activity = ... counts per minute
(1 mark)

2 (c) A different radioisotope, **B**, has a biological half-life of 8 days.
When this radioisotope is in the human body, its effective half-life is 6 days.
Use this information to calculate the physical half-life of radioisotope **B**.

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Physical half-life = ... days
(3 marks)

2 (d) Which radioisotope, **A** or **B**, is more likely to be suitable to use as an implant to treat cancer?

State the reasons for your answer.

Radioisotope.....

Reasons.....

.....

.....
(2 marks)

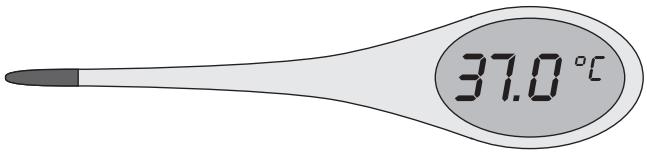
11

Turn over for the next question

3 A young child has been admitted to hospital because he has a very high fever. A nurse is responsible for monitoring his temperature.

The nurse decides to use an electronic clinical thermometer, similar to the one shown in **Figure 2**.

Figure 2



This thermometer has an 'autoreading' setting, where temperatures are automatically recorded at set time intervals. These readings can be stored so that they can be viewed later.

The full specification of this thermometer is shown below:

Precision: 0.5 °C Range: 28 °C–48 °C Number of readings stored: 12 Frequency of autoreadings: every 30 minutes Recommended method of use: attach to the skin under the armpit. Not for internal use.

3 (a) (i) Use this information to suggest **two** reasons why the nurse chose this electronic clinical thermometer, rather than a liquid-in-glass clinical thermometer.

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

3 (a) (ii) State **two** disadvantages of using this electronic clinical thermometer, rather than a liquid-in-glass clinical thermometer, for this patient.

Disadvantage 1 .....

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Disadvantage 2 .....

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(2 marks)

3 (a) (iii) Does the electronic clinical thermometer measure a suitable range of temperatures? Explain your answer.

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(1 mark)

3 (a) (iv) Most electronic thermometers use thermistors.
Explain how the change in the thermistor's properties enables it to be used to measure temperature.

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(4 marks)

Question 3 continues on the next page

3 (b) The nurse decides to place a fan near the child to help lower his temperature. Use your knowledge of how the body maintains its temperature to explain how the fan helps to cool the child.

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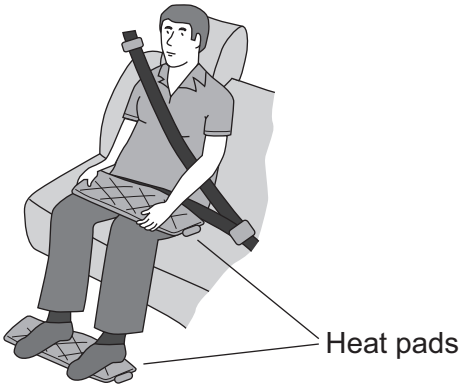
(2 marks)

3 (c) A young man has been admitted to hospital suffering from hypothermia. On the way to hospital, his friends have tried to help him by warming his hands and feet with heat pads, as shown in **Figure 3**. Explain why this is **not** a good idea.

Figure 3



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(2 marks)

13

4 Doctors use radioisotopes in the form of medical tracers to help in diagnosing illnesses.

4 (a) What is meant by the following terms?

Radioisotope .....

.....

Medical tracer .....

.....

(2 marks)

4 (b) The radioisotope technetium-99 is commonly used as a medical tracer. Technetium-99 has a physical half-life of 6 hours.

4 (b) (i) Explain why a physical half-life of 6 hours could make technetium-99 suitable for use as a medical tracer.

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(2 marks)

4 (b) (ii) Explain why technetium-99 is usually made on site, rather than being bought in and stored.

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(2 marks)

4 (b) (iii) Calculate how long it would take for a 400 g sample of active technetium-99 to decay to 25 g of active technetium-99.

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Time = ...hours

(2 marks)

Question 4 continues on the next page

4 (c) Other factors make technetium-99 suitable for use as a medical tracer.
Explain why each of the factors below is important for a radioisotope that is used as a medical tracer.

4 (c) (i) It emits gamma radiation.

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(2 marks)

4 (c) (ii) It does not emit alpha or beta radiation.

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(2 marks)

4 (c) (iii) Neither the radioisotope nor its 'daughter' products are toxic.

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(2 marks)

4 (d) Some radioisotopes have an organ affinity.

4 (d) (i) Explain what the term *organ affinity* means.

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(1 mark)

4 (d) (ii) State **one** disadvantage of using a medical tracer that has an organ affinity.

Disadvantage .....

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(1 mark)

4 (e) Different radioisotopes are used for different medical purposes.
Draw lines to match each radioisotope with how it is commonly used.

Cobalt-60	Treating thyroid cancer
Iodine-131	Implants to treat breast cancer
Iridium-192	General therapy

(2 marks)

18

Turn over for the next question

5 (a) A glass-manufacturing company has been asked to produce a new type of glass.

The glass will be used in the radiology department of a hospital. It will form part of a screen that radiologists can stand behind while patients receive radiotherapy.

The specification for the glass is shown below.

> The glass used for the screen must be able to stop alpha and beta radiation completely.
>
> It must also reduce gamma radiation by at least 50%.

Design an experiment that you could do in the laboratory to test whether or not a sample of glass meets this specification.

You must state the equipment you will use and what you will measure. You must also explain how you will know if the glass meets the specification.

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

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(5 marks)

5 (b) What would you do to ensure that your results were:

5 (b) (i) reliable

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(1 mark)

5 (b) (ii) accurate?

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(1 mark)

5 (c) State **two** precautions you would take to make sure your experiment was safe.

Precaution 1 .....

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Precaution 2 .....

.....

(2 marks)

9

Turn over for the next question

6 Medical physicists often use ultrasound to investigate soft-tissue problems. Ultrasound waves have a velocity of 330 m s^{-1} in air.

Ultrasound waves of frequency 6 MHz (6×10^6 Hz) are used to check the development of a foetus.

6 (a) (i) What is meant by the term *ultrasound*?

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(2 marks)

6 (a) (ii) Calculate the wavelength of the ultrasound waves above.

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Wavelength = ... m

(2 marks)

6 (b) Ultrasound scans rely on echoes produced when the ultrasound waves reflect off boundaries with different specific acoustic impedances.
The approximate values of specific acoustic impedance for fat and muscle tissues are given below:

Z (fat) = 1.38×10^6 kg m^{-2} s^{-1}

Z (muscle) = 1.7×10^6 kg m^{-2} s^{-1}

Calculate the intensity reflection coefficient (α) when ultrasound waves travel from fat into muscle.

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Intensity reflection coefficient = ...

(3 marks)

6 (c) (i) Explain why gel is placed on the patient's skin when carrying out an ultrasound scan.

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(2 marks)

6 (c) (ii) How should the size of the specific acoustic impedance of the gel compare with that of the skin?

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(1 mark)

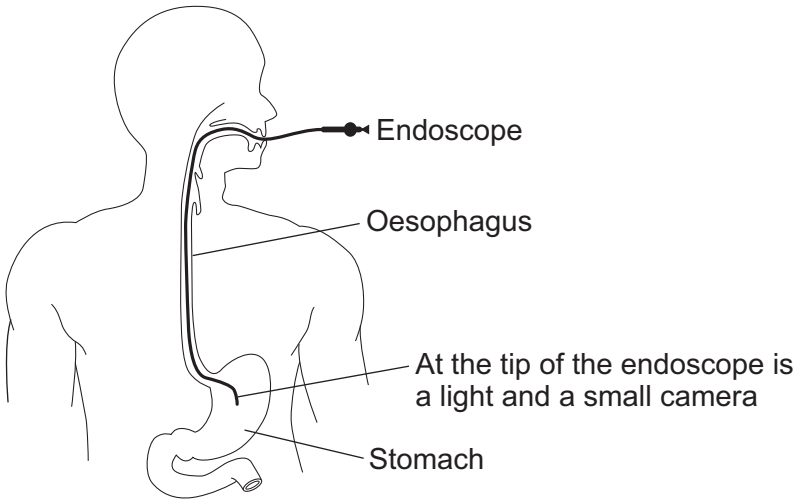
10

Turn over for the next question

7 Problems with the digestive system have traditionally been investigated by using endoscopy.

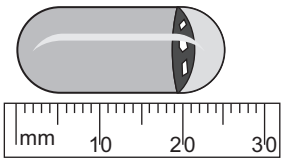
During traditional endoscopy, the patient swallows a very small fibre-optic camera. As the camera passes down, as shown in **Figure 4**, images of the oesophagus are transmitted through the fibre-optic cable. Doctors can then view these images and detect any abnormalities. The position of the camera can be manipulated to view any area the doctor is interested in seeing. Because the procedure can be uncomfortable, patients are sometimes sedated or given a local anaesthetic before the endoscopy takes place.

Figure 4



A new method called capsule endoscopy has been trialled. This method does not use optical fibres. Instead, the patient swallows a small capsule that contains a camera, as shown in **Figure 5**.

Figure 5



The patient must fast for at least two hours before swallowing the capsule. Once swallowed, the capsule makes its way through the digestive system, finally being excreted along with faeces.

The camera takes images as it moves through the digestive system. These images are sent as wireless signals. The signals are picked up by sensors attached to the patient's chest. They are then downloaded by the doctor. The latest versions being trialled have a wide-angle view, an automatic light control and can capture 18 images per second.

7 (a) Critically evaluate capsule endoscopy as a method for viewing the inside of the stomach.

In order to gain full marks you will need to consider both the advantages and the disadvantages of capsule endoscopy compared with traditional endoscopy.

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

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(5 marks)

Question 7 continues on the next page

7 (b) X-rays can also be used to investigate the digestive system. To do this, the patient must first swallow a contrast medium.

7 (b) (i) Other than not being toxic, state **one** important property of a contrast medium.

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(1 mark)

7 (b) (ii) Explain why a contrast medium has to be used when taking X-rays of the stomach.

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(2 marks)

7 (c) Explain why X-ray imaging is more dangerous than endoscopy.

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(2 marks)

10

END OF QUESTIONS

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