Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Level Examination
June 2014

Applied Science SC08

Unit 8 Medical Physics

Tuesday 20 May 2014 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

A

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 Doctors use electroencephalograms (EEGs) to study brain activity.

1 (a) Explain why a layer of gel is placed between the electrodes and a patient's skin when making an EEG.

[2 marks]

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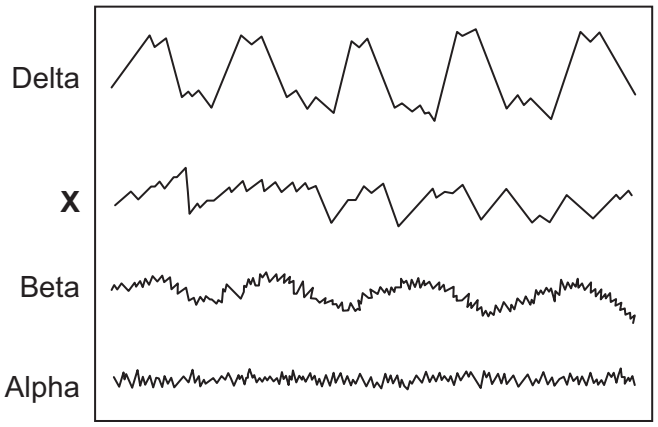
1 (b) A typical set of EEG traces is shown in **Figure 1**.

Figure 1



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

[1 mark]

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

[1 mark]

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

[1 mark]

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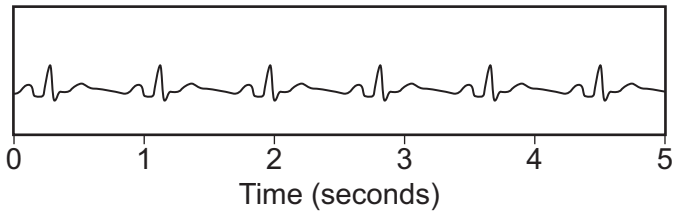
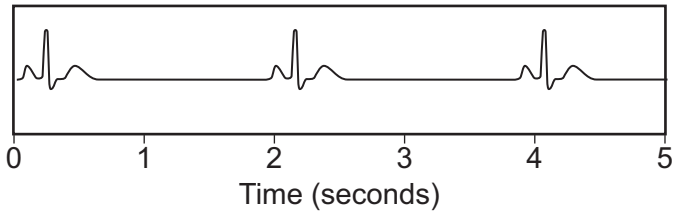
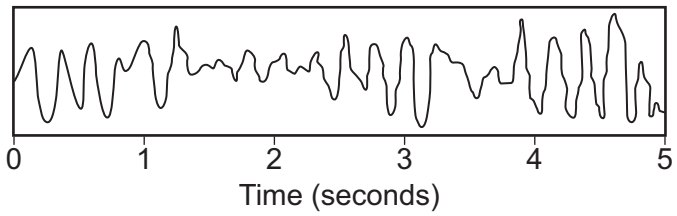
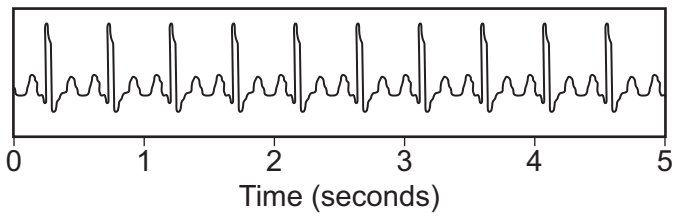
1 (c) Doctors use electrocardiograms (ECGs) to study heart activity.

1 (c) (i) Draw **one** line from each ECG trace below to the condition it shows.

[3 marks]

Trace	Condition
A 	Ventricular fibrillation
B 	Normal heart activity
C 	Bradycardia
D 	Tachycardia

Question 1 continues on the next page

1 (c) (ii) Which of the traces **A**, **B**, **C** or **D** is most likely to show the heart activity of a patient who is suffering from hypothermia?

State the reason for your choice.

[2 marks]

Trace .....

Reason .....

.....

1 (c) (iii) Below what value of core body temperature does hypothermia occur?

[1 mark]

..... °C

11

2 An A-level Physics student is measuring the half-life of a radioisotope, **X**.

2 (a) What does the term **half-life** mean?

[1 mark]

.....

.....

2 (b) (i) Describe an experiment that she could perform to measure the half-life of the radioisotope. You will need to include the equipment she would use, how she would use it, the results she would measure and how she would use these results to calculate an accurate value of the half-life of the radioisotope.

The quality of your written communication will be assessed in your answer.

[5 marks]

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Extra space (if needed) .....

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Question 2 continues on the next page

2 (b) (ii) State **two** safety precautions the A-level student would take while performing this experiment in a school laboratory.

[2 marks]

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2 .....

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2 (b) (iii) From initial trials, the student knows that radioisotope **X** has a half-life longer than 1 hour but shorter than 3 hours. She uses this information to decide how frequently she should take readings.

What interval between readings would you recommend?
State a reason for your answer.

[2 marks]

Interval .....

Reason.....

.....

2 (c) A different radioisotope, **Y**, has a physical half-life of 4 days and a biological half-life of 2 days.

2 (c) (i) State what is meant by the **biological half-life** of a radioisotope and explain why its biological half-life is different from its physical half-life.

[2 marks]

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2 (c) (ii) Calculate the effective half-life of radioisotope **Y**.

[3 marks]

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Effective half-life = ... days

2 (d) The half-thickness of a material is a measure of how thick that material needs to be to stop half the radiation present penetrating through it.

When you research the half-thickness of any material in a data book, different values are given for alpha, beta and gamma radiations.

For which **one** of these types of radiation is the half-thickness of a material likely to be thickest?

Explain your answer.

[2 marks]

Type of radiation .....

Explanation .....

.....

17

Turn over for the next question

3 Medical physicists identify suitable radioisotopes for radiologists to use as medical implants and medical tracers.

3 (a) State the meaning of each of the following terms:

3 (a) (i) radioisotope

[1 mark]

.....

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3 (a) (ii) medical implant

[1 mark]

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3 (a) (iii) medical tracer.

[1 mark]

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3 (b) **Table 1** gives information about some radioisotopes.

Table 1

Radioisotope	Half-life	Type(s) of radiation emitted
A	2 years	α, β
B	6 minutes	β, γ
C	4 years	α, β
D	4 hours	γ
E	6 months	β, γ
F	4 years	α, γ

3 (b) (i) Using the information in **Table 1**, a trainee radiologist suggests that radioisotope **D** would be most suitable to use as a **tracer** to investigate a possible problem with a person's blood circulatory system.

Explain why.

[4 marks]

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3 (b) (ii) A consultant radiologist says that radioisotope **D** is **not** suitable to be used as a tracer because it has an organ affinity for the liver.

Explain why having this organ affinity would make it unsuitable.

[2 marks]

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Question 3 continues on the next page

3 (b) (iii) The trainee radiologist then suggests that radioisotope **C** would be most suitable to use as an **implant** to treat breast cancer.

Explain why the trainee radiologist suggested that radioisotope **C** would be most suitable.

[4 marks]

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3 (b) (iv) The consultant radiologist says that radioisotope **C** is **not** suitable to be used as an implant because it is toxic.

What does **toxic** mean?

[1 mark]

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3 (b) (v) Assuming that none of the other radioisotopes listed in **Table 1** has an unsuitable organ affinity or is toxic, which radioisotope, **A**, **B**, **E** or **F**, is most likely to be the best to use as an implant to treat breast cancer?

[1 mark]

Radioisotope

15

4 Cardiologists use a range of diagnostic techniques to identify the causes of heart problems.
One such technique is the echocardiogram.

In making an echocardiogram, ultrasound waves are used to create a real-time image of the heart so that any problems can be seen clearly and be identified.

4 (a) There are two main types of echocardiogram.

In a basic echocardiogram, gel is rubbed on the patient's chest. A pulse of ultrasound is then passed through the skin.
A probe detects the echoes reflected from various parts of the heart.
The echoes are then processed and an image of the heart is formed on a screen.

In a transoesophageal echocardiogram, the patient swallows a probe attached to the end of a long, flexible tube. When the probe is in the patient's oesophagus, it emits pulses of ultrasound towards the heart.
The probe detects the echoes reflected from various parts of the heart.
The echoes are then processed and an image of the heart is formed on a screen.
The tube and probe are slowly withdrawn once the procedure has finished.
A local anaesthetic is used to numb the throat and a sedative may be given to help the patient relax.

4 (a) (i) Explain why a transoesophageal echocardiogram is likely to produce a clearer image of the heart than a basic echocardiogram.

[3 marks]

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Question 4 continues on the next page

4 (a) (ii) The main advantage of using a transoesophageal echocardiogram, rather than a basic echocardiogram, is that it will produce a clearer image and you are therefore less likely to have to repeat the procedure and more likely to be able to detect the problem.

Discuss the possible disadvantages of using a transoesophageal echocardiogram to investigate possible serious heart defects in young children.

The quality of your written communication will be assessed in your answer.

[5 marks]

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Extra space (if needed) .....

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4 (b) X-rays can also be used to investigate heart defects. Many doctors prefer not to use them because X-rays are dangerous and usually produce poor quality images.

4 (b) (i) Explain why X-rays are dangerous.

[2 marks]

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4 (b) (ii) State **one** precaution that radiographers take to minimise the risk of a patient being harmed while having an X-ray taken.

Explain how this precaution protects the patient.

[2 marks]

Precaution.....

Explanation .....

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4 (b) (iii) Explain why X-ray images of the heart do **not** usually produce high-contrast images.

[3 marks]

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Question 4 continues on the next page

4 (c) A medical equipment manufacturer is demonstrating a new ultrasound machine. The machine is capable of producing sound waves with any wavelength between 1 mm and 1 m.

4 (c) (i) Assuming that sound travels at a speed of 330 $m\,s^{-1}$ in air, calculate the frequency of a sound wave with a wavelength of 5 mm.

[2 marks]

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Frequency = ... Hz

4 (c) (ii) One sound wave produced by the new machine has a frequency of 2000 Hz. Is this an ultrasound wave? Explain your answer.

[1 mark]

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18

5 Doctors use optical fibres to view inside patients' bodies. Optical fibres are made of glass.

5 (a) Explain why the glass used to make optical fibres must have a high refractive index.

[4 marks]

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5 (b) A technician at a glass-making company performs an experiment to determine the refractive index of a sample of glass.

To do this, he measures the angles of incidence, *i*, and refraction, *r*, for rays of light as they enter the glass sample. He then looks up the sines of these angles and draws a graph of sin *i* against sin *r*.

State **two** precautions the technician could take to ensure that his results were accurate.
Explain how each of these precautions increases the accuracy of the results.

[4 marks]

Precaution 1.....

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Explanation .....

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Precaution 2.....

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Explanation .....

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Question 5 continues on the next page

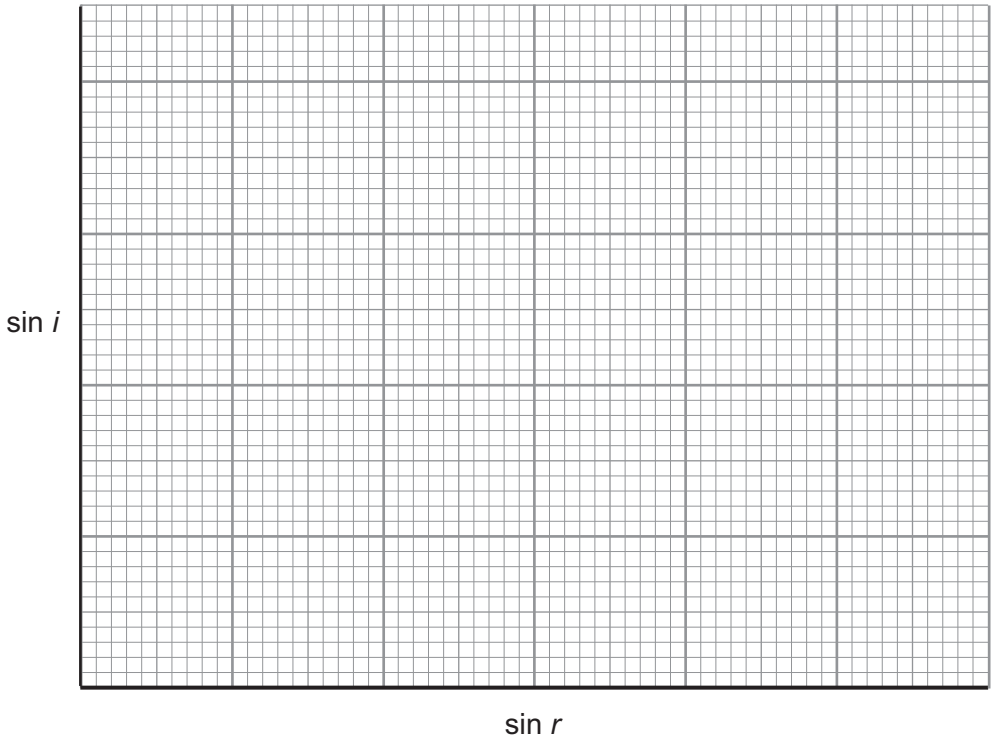
5 (c) The technician's results (given to 2 significant figures) are shown in **Table 2**.

Table 2

sin *i*	**sin *r***
0.24	0.16
0.33	0.22
0.42	0.28
0.60	0.44
0.72	0.48
0.78	0.52

5 (c) (i) Plot these results on the grid below.
Draw a line of best fit.

[3 marks]



5 (c) (ii) Describe the relationship between sin *i* and sin *r* shown by your graph.

[1 mark]

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5 (c) (iii) Which of the results shown is anomalous? How do you know?

[1 mark]

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5 (c) (iv) Use the first pair of values in **Table 2** to calculate the refractive index, *n*, of the glass sample.

[2 marks]

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n =.....

5 (c) (v) Describe how you would use your graph to calculate an accurate value for the refractive index of the glass sample.

[1 mark]

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Question 5 continues on the next page

5 (d) The technician decided to measure the refractive index of a different type of glass using the critical angle method.
He discovered that this sample of glass had a refractive index of 1.6

Calculate the critical angle, *c*, for this type of glass.

[3 marks]

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c = ...°

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END OF QUESTIONS

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