Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

For Examiner's Use

General Certificate of Education
January 2009
Advanced Level Examination

APPLIED SCIENCE **SC08**
Unit 8 Medical Physics

Wednesday 21 January 2009 9.00 am to 10.30 am

For this paper you must have:
- a pencil and 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. Answers written in margins or on blank pages will not be marked.
- 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 maximum mark for this paper is 80.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.

For Examiner's Use			
Question	Mark	Question	Mark
1		5	
2		6	
3			
4			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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

1 In order to help diagnose an illness, doctors can monitor the electrical activity of a patient's brain and heart.

1 (a) (i) What name is given to a trace of brain activity?

.....

(1 mark)

1 (a) (ii) Give **two** reasons for monitoring brain activity.

Reason 1 .....

Reason 2 .....

(2 marks)

1 (b) The diagram below shows a trace of the electrical activity of a healthy person's heart.

1 (b) (i) What name is given to a trace of heart activity?

.....

(1 mark)

1 (b) (ii) Explain why it is important that the patient keeps as still as possible when having their heart activity monitored.

.....

.....

(2 marks)

1 (b) (iii) Why is a gel smeared onto the patient's skin before the electrodes used to obtain a trace are put in place?

.....

.....

(2 marks)

1 (b) (iv) Describe how you would expect the trace of the electrical activity of the heart to differ if the patient had the following medical conditions.

A heart attack

.....

.....

Ventricular fibrillation

.....

.....

Sinus tachycardia

.....

.....

(3 marks)

11

Turn over for the next question

2 Midwives use ultrasound scans to monitor foetal development.

2 (a) Explain, in detail, how an ultrasound image is formed.

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(5 marks)

2 (b) The table provides information on the specific acoustic impedance (Z) of different materials.

Material	Z **(kg m^{-2} s^{-1})**
Air	4.3×10^{2}
Bone	7.8×10^{6}
Fat	1.4×10^{6}
Muscle	1.7×10^{6}
Soft tissue	1.6×10^{6}

Use this information to answer the following questions.

2 (b) (i) Explain why ultrasound techniques can produce high contrast images of soft tissue.

.....

.....

.....

(2 marks)

2 (b) (ii) Calculate the intensity reflection coefficient (α) between soft tissue and bone.

.....

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.....

.....

(4 marks)

2 (c) State and explain **two** reasons why X-rays are **not** used to monitor foetal development.

Reason 1 .....

Explanation .....

.....

Reason 2 .....

Explanation .....

.....

(4 marks)

15

Turn over for the next question

3 Optical fibres can be used in the diagnosis and treatment of illnesses.
For example, stomach ulcers are commonly diagnosed and treated using optical fibres rather than using traditional surgical methods.

3 (a) (i) Describe how optical fibres are used to help to diagnose a stomach ulcer.

.....

.....

.....

.....

.....

(4 marks)

3 (a) (ii) State and explain **one** advantage of using optical fibres, rather than X-rays, to diagnose stomach ulcers.

.....

.....

(2 marks)

3 (b) When stomach ulcers are treated, laser light is transmitted along the optical fibres and is directed at the stomach ulcer.

3 (b) (i) State and explain **one** advantage of treating stomach ulcers using optical fibres rather than using traditional surgery.

.....

.....

.....

(2 marks)

3 (b) (ii) State and explain **two** precautions that should be taken when using laser light.

Precaution 1 .....

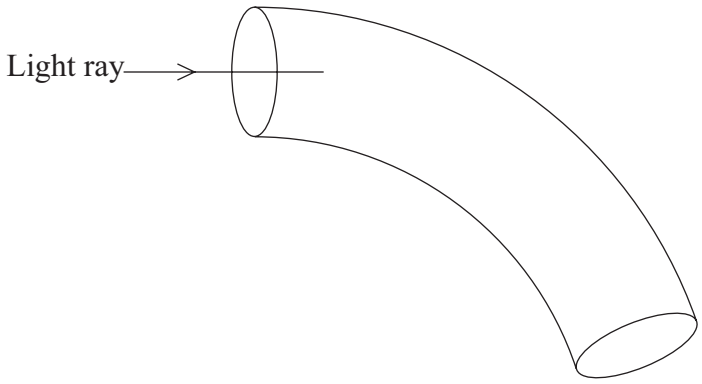
.....

Precaution 2 .....

.....

(2 marks)

3 (b) (iii) The diagram below shows a beam of laser light entering an optical fibre.



Complete the path of the light ray until it leaves the optical fibre.

(2 marks)

3 (c) Optical fibres are usually made of glass.
Two different types of glass, **X** and **Y**, have different values of refractive index (n) as shown below.

Refractive index of **X**, $n_X = 1.2$
Refractive index of **Y**, $n_Y = 1.25$

The critical angle (c) for glass **X** is 56°.

3 (c) (i) Calculate the critical angle (c) for glass **Y**.

.....

.....

Critical angle for **Y** = ...

(3 marks)

3 (c) (ii) Which type of glass, **X** or **Y**, would be more suitable for use in an optical fibre? Explain your answer.

.....

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.....

.....

(4 marks)

4 Radiographers use radioisotopes as medical tracers to diagnose, for example, digestive problems. The radioisotope used must emit the correct type of radiation and have a suitable half-life.

What is meant by

4 (a) (i) to *diagnose* an illness

.....

(1 mark)

4 (a) (ii) a *medical tracer*

.....

(1 mark)

4 (a) (iii) *half-life*?

.....

(1 mark)

4 (b) (i) Which type of radiation should a medical tracer emit?
Explain your answer in detail.

Type of radiation .....

Explanation .....

.....

.....

.....

.....

(5 marks)

4 (b) (ii) Suggest a suitable half-life for a medical tracer.
State a reason for your suggestion.

Half-life .....

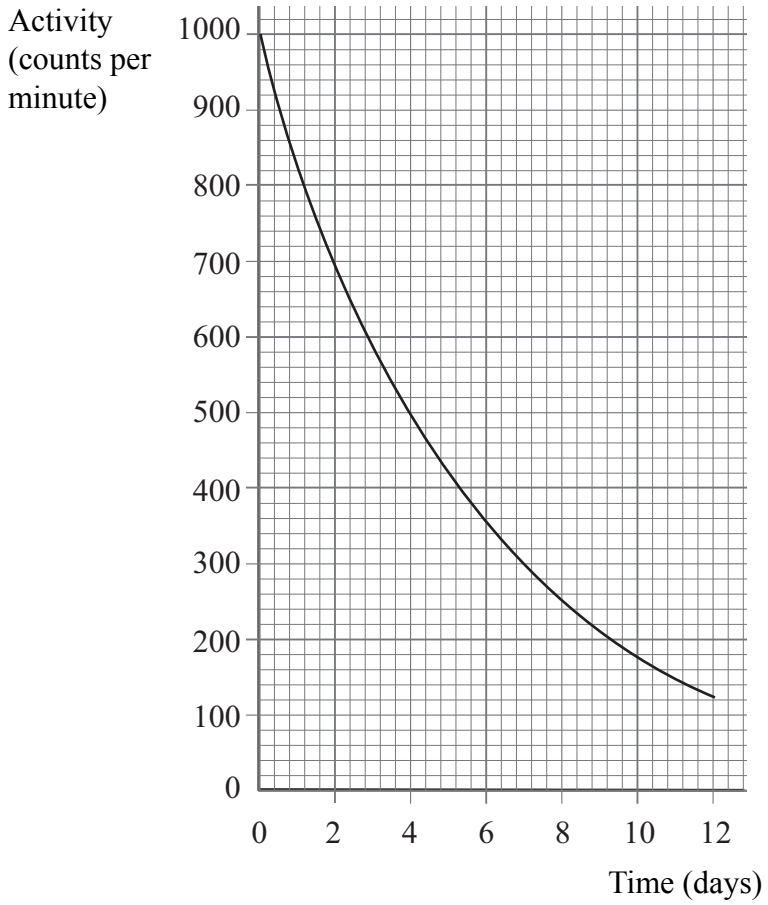
Reason .....

.....

.....

(3 marks)

4 (c) A technician checks the half-life of a radioisotope, **A**.
To do this, he measures its activity every 24 hours.
The results are shown in the graph below.



4 (c) (i) Use the graph to calculate an accurate value for the half-life of radioisotope **A**.

Half-life of **A** = ...

(2 marks)

4 (c) (ii) Comment on the technician's decision to measure the activity every 24 hours.

.....

.....

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.....

(2 marks)

Question 4 continues on the next page

4 (d) (i) Radioisotope **B** has a half-life of four weeks.
A 2 g sample of active radioisotope **B** is stored in a medical physics laboratory for 12 weeks.
Assuming that none of the sample was used, how much active radioisotope **B** would be left after 12 weeks?

.....

.....

..... g

(2 marks)

4 (d) (ii) During the treatment for prostate cancer, 2 g of active radioisotope **B** was implanted in a patient and left for 12 weeks rather than stored in the laboratory.
How would you expect the amount of active radioisotope **B** remaining in the patient to compare with your answer to part (d)(i).
Explain your answer.

The amount of active radioisotope **B** remaining would be .....

Explanation .....

.....

.....

.....

(3 marks)

4 (d) (iii) Comment on the suitability of radioisotope **B**'s half-life for use as an implant.

.....

.....

(2 marks)

4 (d) (iv) State **two** other pieces of information you would need to have about radioisotope **B** in order to decide whether it was suitable for use as an implant.

1 .....

2 .....

(2 marks)

24

5 (a) You have been asked to measure the refractive index of a sample of glass. You are provided with a rectangular block of the glass.

5 (a) (i) List the additional equipment you will need.

.....

.....

(1 mark)

5 (a) (ii) Draw a diagram to show how you would set up the equipment.

(1 mark)

5 (a) (iii) Label the following on your diagram:

- the angle of incidence
- the angle of refraction
- the normal.

(1 mark)

5 (b) (i) Explain how you would ensure that your results were reliable.

.....

.....

(1 mark)

5 (b) (ii) Explain how you would ensure that your results were as accurate as possible.

.....

.....

.....

.....

(2 marks)

Turn over for the next question

6

6 Surgeons need to be able to pinpoint the position of veins before carrying out surgery on them. Some veins can be difficult to detect.
Medical researchers are trialling a new method of viewing veins.
This method involves beaming infrared radiation onto the part of the body to be viewed. The veins reflect this back to a special digital camera which produces an image.
This technique is also able to detect the depth of the veins and can therefore guide a surgeon accurately.

6 (a) In what way is this technique similar to:

6 (a) (i) ultrasound imaging

.....

.....

(1 mark)

6 (a) (ii) thermography?

.....

.....

(1 mark)

6 (b) State and explain **three** advantages of using this new method, rather than a CAT scan, to image veins.

Advantage 1 .....

.....

Advantage 2 .....

.....

Advantage 3 .....

.....

(3 marks)

5

END OF QUESTIONS