Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Level Examination
January 2013

Applied Science SC08

Unit 8 Medical Physics

Wednesday 16 January 2013 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.

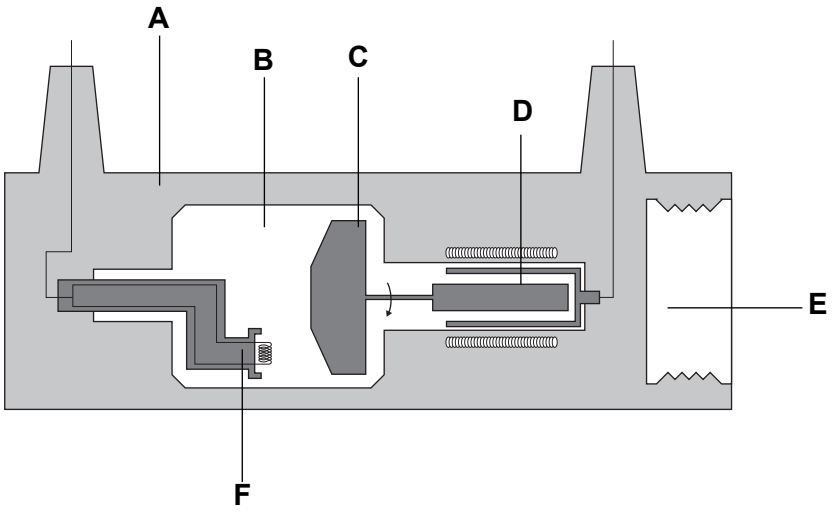
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.
- You will be marked on your ability to
  - use good English
  - organise information clearly
  - use specialist vocabulary where appropriate.
- You are expected to use a calculator where appropriate.

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

1 Radiographers use X-rays to help in the diagnosis of many medical conditions.

1 (a) A diagram of an X-ray machine is shown in **Figure 1**.

Figure 1



Complete **Table 1** to show the name of each part of the X-ray machine, a description of its function, and the correct label in **Figure 1**.

Table 1

Description	**Name of part**	**Correct label**
Allows electrons to move freely without colliding with air particles		
Produces X-rays		**C**
Produces electrons		
	Lead casing	**A**

(6 marks)

1 (b) If the anode becomes hot it will lose heat to its surroundings.

1 (b) (i) Explain why this heat can only be lost as infrared radiation and not by means of conduction or convection.

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(2 marks)

1 (b) (ii) What colour should the anode be in order to lose heat most efficiently?

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(1 mark)

9

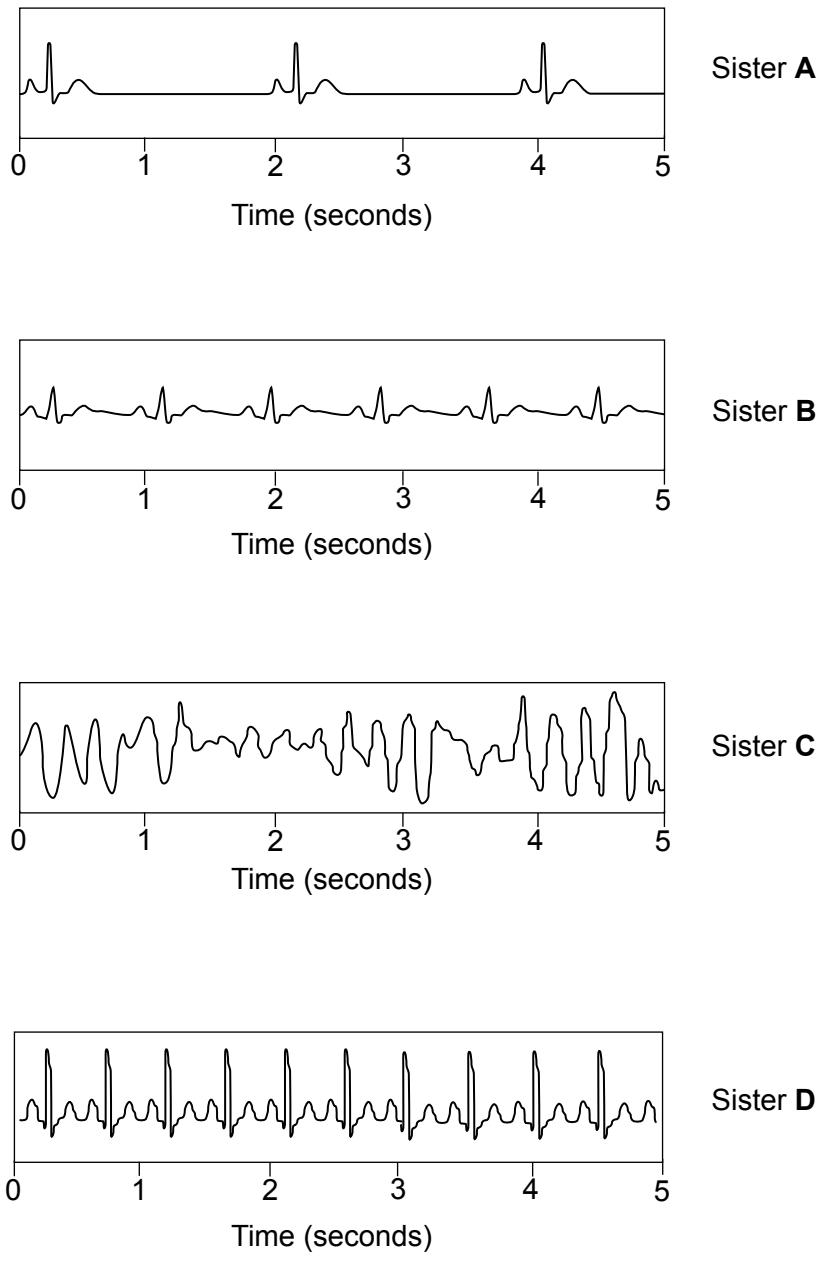
Turn over for the next question

2 A doctor has ordered some medical tests for four sisters, **A**, **B**, **C** and **D**, who have a family history of heart disease.

2 (a) Test 1 is an electrocardiogram (ECG) test.

Each sister's ECG trace is shown in **Figure 2**.

Figure 2



State which sister, **A, B**, **C** or **D**, has the following condition:

2 (a) (i) bradycardia

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(1 mark)

2 (a) (ii) ventricular fibrillation.

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(1 mark)

2 (b) Test 2 measures blood pressure.

2 (b) (i) What is the normal value of blood pressure for a healthy young female adult?

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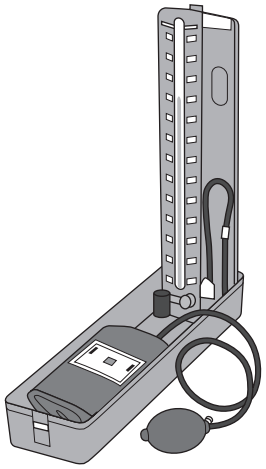
(1 mark)

Question 2 continues on the next page

2 (b) (ii) Describe how a nurse would use the equipment shown in **Figure 3** to measure the sisters' blood pressures.

Figure 3



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

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Extra space (if needed) .....

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(5 marks)

2 (c) Blood pressure can be measured using either invasive or non-invasive methods.

2 (c) (i) State and explain **one** reason why non-invasive methods are usually used to measure blood pressure even though invasive measurements give more accurate readings.

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(2 marks)

2 (c) (ii) Why are invasive methods likely to produce more accurate readings of blood pressure than non-invasive methods?

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(1 mark)

2 (d) The doctor also measured the sisters' pulse rates.

2 (d) (i) What is the normal resting pulse rate range for a healthy young adult?

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(1 mark)

2 (d) (ii) Describe briefly how the doctor would measure the sisters' resting pulse rates.

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(2 marks)

14

Turn over for the next question

3 Screening for breast cancer is normally carried out by directing low dose X-rays into breast tissue.

Researchers have investigated using *thermography* to screen for breast cancer.

3 (a) Why are X-rays able to detect breast cancer?

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(2 marks)

3 (b) (i) What is thermography?

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(2 marks)

3 (b) (ii) Suggest why thermography can detect breast cancer.

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(2 marks)

3 (c) Using thermography is a much safer way of detecting breast cancer than using X-rays.

3 (c) (i) Explain why thermography is safer.

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(3 marks)

3 (c) (ii) Suggest why doctors prefer to use X-rays rather than thermography, even though thermography is safer.

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(2 marks)

3 (d) CAT scans make use of X-rays.

State and explain **two** reasons why CAT scans are not used in routine screening for breast cancer.

Reason 1 .....

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Reason 2 .....

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(4 marks)

15

4 Both ultrasound and lasers can be used to treat gallstones.

Sound waves travel through air at a speed of $330\,m\,s^{-1}$.

4 (a) (i) Calculate the frequency of a sound wave which has a wavelength of 0.2 m when travelling through air.
State the correct unit in your answer.

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Frequency = ...

(3 marks)

4 (a) (ii) Explain why this sound wave cannot be described as 'ultrasound'.

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(1 mark)

4 (b) When lasers are used to treat gallstones, the laser light is sent along optical fibres.

4 (b) (i) Explain why these optical fibres must be made using glass that has a high refractive index.

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(4 marks)

4 (b) (ii) One type of glass used to make optical fibres has a refractive index of 1.3

Calculate the critical angle for this type of glass.

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Critical angle = ...

(3 marks)

4 (b) (iii) Explain what would happen to a ray of light that, when travelling from this glass into the air, hits the glass/air boundary at an angle of incidence of 25°.

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(2 marks)

4 (c) A patient has been given the choice of having his gallstones treated either by using ultrasound or a laser.
Critically evaluate the advantages and disadvantages of each of these methods in order to help the patient make his choice.

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(4 marks)

17

5 A medical equipment company in the USA is trialling an 'intelligent nightshirt' which is designed to help investigate sleep disorders.

The nightshirt contains a number of different sensors built into its material. These sensors respond to electrical and other signals generated in the patient's body during sleep.

5 (a) Suggest **two** advantages of using the 'intelligent nightshirt' rather than an electroencephalogram (EEG) to investigate sleep disorders.

Advantage 1.....

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Advantage 2.....

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(2 marks)

5 (b) Suggest **one** disadvantage of using the 'intelligent nightshirt' rather than an EEG to investigate sleep disorders.

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(1 mark)

3

6 A medical physics technician has been asked to check the penetration power of a new radioisotope. She is particularly interested in how the amount of radiation detected varies with the distance from the source.

She knows that the source emits beta radiation only.

6 (a) (i) Design an experiment that could be carried out in the laboratory to find the relationship between the amount of radiation detected by a sensor and the distance of the sensor from the source.

You will need to describe how the results will be obtained and how they will be used to determine the relationship.

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

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Extra space (if needed) .....

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(5 marks)

Question 6 continues on the next page

6 (a) (ii) State **two** precautions you would take to ensure that your experiment was safe.

Precaution 1.....

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Precaution 2.....

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(2 marks)

6 (a) (iii) State **two** possible sources of error in your experiment.

Source of error 1.....

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Source of error 2.....

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(2 marks)

6 (a) (iv) How would you ensure that your results were reliable?

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(1 mark)

6 (b) (i) Explain why a beta emitter would be more likely to be used as an implant than as a tracer.

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(3 marks)

6 (b) (ii) Suggest a suitable half-life for a beta emitter that would be used as an implant to treat breast cancer. Explain your choice.

Half-life.....

Explanation .....

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(3 marks)

6 (c) Technetium-99 is a very useful radioisotope. It is one of the most widely used radioisotopes for diagnosis.

6 (c) (i) Technetium-99 has a physical half-life of 6 hours.

A 12 g sample of active technetium-99 is placed in a store cupboard. Assuming none has been used, how much active technetium-99 will be left 24 hours later?

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(2 marks)

6 (c) (ii) Explain why the physical half-life of technetium-99 makes it suitable for use as a tracer.

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(2 marks)

Question 6 continues on the next page

6 (c) (iii) State **two** reasons, other than its physical half-life, why technetium-99 is one of the most widely used medical radioisotopes.

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

22

END OF QUESTIONS