Surname

Other Names

Candidate Signature

AQA

General Certificate of Education
Advanced Level Examination
June 2013

Applied Science   SC08

Unit 8   Medical Physics

Wednesday 22 May 2013   9.00 am to 10.30 am

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

A

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   Nurses monitor core body temperature to track the progress of a disease.

1 (a) (i)   Circle the answer below that best represents the range of normal core body temperature.

35.2 – 38 °C   35.2 – 37.2 °C   36.5 – 37.2 °C   36.5 – 38 °C

(1 mark)

1 (a) (ii)   What name is given to the medical condition in which a patient's core body temperature is too high?

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(1 mark)

1 (a) (iii)   Why is a patient's core body temperature usually different from their skin temperature?

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(2 marks)

1 (b)   A liquid-in-glass clinical thermometer can be used to measure core body temperature.

1 (b) (i)   Explain the scientific principles behind how a liquid-in-glass thermometer works.

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(3 marks)

1 (b) (ii) Why does a liquid-in-glass clinical thermometer have an inner tube with a much narrower bore than a laboratory thermometer?

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(2 marks)

1 (c) Most electronic thermometers use thermistors.

1 (c) (i) What property of a thermistor changes with temperature?

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(1 mark)

1 (c) (ii) Explain how this change enables the thermistor to measure different temperatures.

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(2 marks)

1 (c) (iii) Electronic thermometers are not necessarily more accurate or more precise than liquid-in-glass thermometers.

State **one** factor that determines how precise the temperature reading given by an electronic thermometer is.

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(1 mark)

13

Turn over ▶

2 There are many different ways to treat soft tissue cancers such as kidney cancer. Two of these methods are described below.

Microwave treatment:
A small probe is inserted into the area to be treated. Microwaves are sent along this probe into the cancer cells. The energy from the microwaves destroys the cancer cells. This technique can be carried out using keyhole surgery.

External radiotherapy:
The tumour is irradiated by gamma radiation emitted by an external source. The radiation destroys the cancer cells.

2 (a) State and explain **two** advantages of using microwave treatment rather than external radiotherapy to treat kidney cancer.

Advantage 1...

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Explanation ....

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Advantage 2...

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Explanation ....

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(6 marks)

2 (b) A third possible method of treating soft tissue cancers is to implant a radioisotope.

2 (b) (i) Explain why the radioisotope implant should emit **only** alpha or beta radiation and should **not** emit any gamma radiation.

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(4 marks)

2 (b) (ii) State and explain **one** advantage of using a radioisotope implant rather than external radiotherapy for treating soft tissue cancers.

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(2 marks)

2 (b) (iii) State and explain **one** disadvantage of using a radioisotope implant rather than external radiotherapy for treating soft tissue cancers.

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(2 marks)

2 (c) A radioisotope implant is likely to be inserted using keyhole surgery.
In traditional surgery, one incision is usually made.
Why does the surgeon usually have to make two incisions when carrying out keyhole surgery?

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(1 mark)

15

Turn over ▶

3 Physiotherapists sometimes use ultrasound to treat soft tissue problems such as muscle damage. Ultrasound waves have a velocity of $330\,\text{m s}^{-1}$ in air.

An ultrasound wave of wavelength $1.65 \times 10^{-3}\,\text{m}$ is used to treat a muscle injury.

3 (a) (i) Write down the equation that links the velocity, frequency and wavelength of a wave.

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(1 mark)

3 (a) (ii) Calculate the frequency of this ultrasound wave.

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Frequency = ... Hz
(2 marks)

3 (b) Ultrasound can also be used for diagnosis.

Diagnosis relies on echoes being produced when the ultrasound waves reflect off boundaries between tissues with different specific acoustic impedances.

The values of specific acoustic impedance for bone and for one type of soft tissue are given below:

Z (bone) = $7.78 \times 10^{6}\,\text{kg m}^{-2}\text{s}^{-1}$

Z (soft tissue) = $1.50 \times 10^{6}\,\text{kg m}^{-2}\text{s}^{-1}$

Calculate the intensity reflection coefficient (α) when ultrasound waves travel from bone into this soft tissue.

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Intensity reflection coefficient = ...
(3 marks)

3 (c) When using ultrasound to investigate internal soft tissue, a gel is placed on the patient's skin.

3 (c) (i) Explain why this gel is used.

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(2 marks)

3 (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)

9

Turn over for the next question

Turn over ▶

4 (a) What is the main difference between how X-ray images and ultrasound images are produced?

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(2 marks)

4 (b) Both X-rays and ultrasound can be used for diagnosis.

Compare the advantages and disadvantages of using X-rays and of using ultrasound to investigate whether a leg injury is due to a broken bone or a damaged muscle.

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

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Extra space (if needed) ....

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(5 marks)

7

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

Turn over ▶

5 Medical physicists consider the *half-life* of radioisotopes before recommending which isotope to use for diagnosis or therapy.

5 (a) What does half-life mean?

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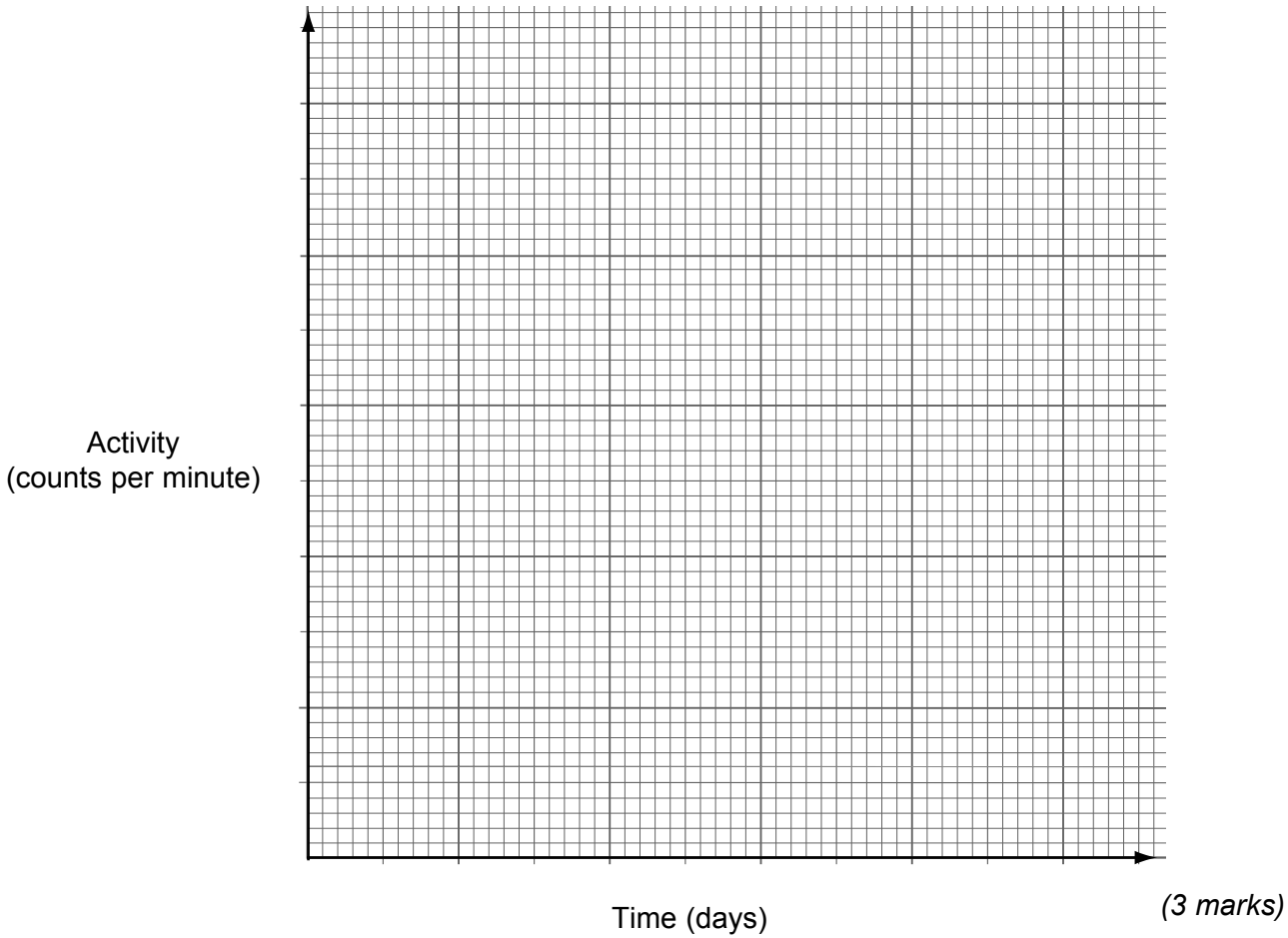
(1 mark)

5 (b) A technician performed an experiment to check the physical half-life of radioisotope **A**. Her results, after correcting for background radiation, are shown in **Table 1**.

Table 1

Time (days)	Activity (counts per minute)
0	190
1	140
2	100
3	75
4	55
5	40

5 (b) (i) Plot the results in **Table 1** on the axes below and draw a line of best fit.

Activity
(counts per minute)

Time (days)

(3 marks)

5 (b) (ii) Use your graph to find an accurate half-life for radioisotope **A**.

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

(2 marks)

5 (c) (i) Radioisotope **B** has a physical half-life of 3 months. A hospital has bought 200 g of active radioisotope **B**. Assuming none has been used, how much active radioisotope **B** will be left after 1 year?

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Radioisotope **B** = ...g

(2 marks)

Turn over ▶

5 (c) (ii) Radioisotope **C** has a physical half-life of 6 hours and a biological half-life of 12 hours. Calculate the effective half-life of radioisotope **C**.

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Effective half-life = ... hours

(3 marks)

5 (d) A doctor and a medical physicist are discussing whether or not radioisotope **C** is suitable for use as a tracer.

5 (d) (i) Does radioisotope **C** have a suitable physical half-life for use as a tracer?

Explain your answer.

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(2 marks)

5 (d) (ii) What type of radiation must radioisotope **C** emit if it is suitable to use as a tracer?

Explain your answer.

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(3 marks)

5 (d) (iii) The medical physicist tells the doctor that radioisotope **C** has limited use because of its *organ affinity*.
What does organ affinity mean?

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(1 mark)

5 (e) (i) The terms below describe some of the types of effects radioactivity can have on tissue.
Explain what each term means.

Stochastic ....

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Somatic..

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(2 marks)

5 (e) (ii) State **two** factors that can affect the amount of damage caused by exposure to radioactivity.

Factor 1...

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Factor 2...

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(2 marks)

5 (e) (iii) State **one** safety precaution you would take to protect yourself if you were working with radioactive sources in a school laboratory.

Explain how this precaution would protect you.

Precaution...

Explanation ....

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(2 marks)

23

Turn over ▶

6 A medical physics technician has been asked to check the refractive index of a new type of glass.

6 (a) (i) Design an experiment that you could perform in the laboratory to find the refractive index of a rectangular block of glass.

You will need to state the equipment you will use, describe how the results will be obtained and explain how the results will be used to determine the refractive index. You may use a diagram to support your written answer.

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

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Extra space (if needed) ....

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(5 marks)

6 (a) (ii) State and explain **two** precautions you would take to ensure that your experiment was accurate and reliable.

Precaution 1 ....

Explanation ....

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Precaution 2 ....

Explanation ....

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(4 marks)

6 (b) The new glass was found to have a refractive index of 1.2. Most types of glass have a refractive index of about 1.4.

Use this information to explain whether or not the new glass is likely to be suitable for use in an endoscope.

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(4 marks)

13

END OF QUESTIONS

There are no questions printed on this page

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