King's College London

UNIVERSITY OF LONDON

This paper is part of an examination of the College counting towards the award of a degree. Examinations are governed by the College Regulations under the authority of the Academic Board.

B.Sc. EXAMINATION

CP/MP10 Introductory Medical Physics

Summer 1998

Time allowed: THREE Hours

Candidates must answer SIX parts of SECTION A, and TWO questions from SECTION B.

Separate answer books must be used for each Section of the paper.

The approximate mark for each part of a question is indicated in square brackets.

You must not use your own calculator for this paper. Where necessary, a College Calculator will have been supplied.

TURN OVER WHEN INSTRUCTED

Planck constant $h = 4.1 \times 10^{-15}$ eV s = 6.6×10^{-19} J s

SECTION A: Answer **SIX** parts of this section

1.1) Describe the components of a typical physiological measurement system. List three electrical signals which may be detected in the human body, giving typical magnitudes, frequencies and bandwidths for each one.

[7 marks]

1.2) Describe, with the aid of a diagram the principal components of the ear. What is meant by

(a) the threshold of hearing?

(b) a sound intensity of 120 dB in relation to the threshold of hearing?

[7 marks]

1.3) Describe the essential features of the NHS management system, indicating the location of medical physics support in the structure. Give four NHS activities in which a medical physicist might be engaged.

[7 marks]

1.4) Describe, with the aid of simple diagrams, the essential features of the normal gait cycle. Which joints are principally involved in locomotion? How might the gait pattern be affected in a unilateral-lower-limb amputee who is wearing a prosthesis?

[7 marks]

1.5) A 9 MHz ultrasound transducer detects a 1.2 kHz Doppler shift from a blood vessel oriented at 0° to the ultrasound beam. Estimate the velocity of blood flow in the vessel. (The ultrasound wave velocity in blood is 1500 m s^{-1}.)

[7 marks]

1.6) A radionuclide has a decay constant of 7.2×10^{-3} h^{-1}. How many atoms of the substance are required to produce an activity of 2×10^{4} Bq ?

[7 marks]

1.7) List the methods used in a medical environment to control external radiation hazards to both patients and occupationally-exposed persons.

[7 marks]

1.8) The minimum wavelength of the X-rays emitted from a radiographic device is 0.0124 nm. At what kVp is the device being operated?

[7 marks]

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SECTION B - Answer **ONE** question from this section

2) Describe, with the aid of annotated diagrams, the structure of the circulatory system.

[10 marks]

Describe three physical differences between arteries and veins.

[6 marks]

Explain how you could use ultrasound to measure blood velocity and estimate blood pressure in an artery. Give typical values for the two parameters.

[8 marks]

Describe how central and peripheral blood pressure are affected by exercise.

[6 marks]

3) Describe the five main parameters associated with the assessment of lung function, giving typical values for each.

[15 marks]

With the aid of diagrams, explain how an assessment can be made of lung function. Describe the electrical circuit needed to operate a pneumotachograph.

[15 marks]

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SECTION C - Answer **ONE** question from this section

4) Describe, with the help of a labelled sketch, the design of a modern diagnostic X-ray tube. Include those features which are introduced for the radiation protection of the patient.

[12 marks]

Use a labelled sketch to describe the design of a portable scintillation counter for radiation monitoring.

[10 marks]

1000 Bq of a radio-active pharmaceutical, with a half-life of 6 hours, is injected into a patient's blood-stream at 11.00 a.m. The next day, at 2.00 p.m., a 10 ml blood sample is taken, and is found to have an activity of 0.1 Bq. Estimate the patient's blood volume, stating any approximations made.

[8 marks]

5) Describe the main characteristics of the propagation and interaction of (longitudinal) ultrasound waves in human (soft) tissues, and indicate one way in which each feature is exploited in medical applications.

[12 marks]

Derive an expression for the effective half-life of a radioactive substance in the body, in terms of its physical and biological half-lives. If the physical half-life of the material is known to be 6 h, and its effective half-life is measured to be 3 h, what is its biological half-life ?

[6 marks]

Explain the following terms and state, where appropriate, the units employed for their measurement: dose equivalent; the ALARA principle; half-value layer.

[6 marks]

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