NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 4260 - MEDICAL PHYSICS II

EXAMINATION

BSC HONOURS PART IV: MAY 2003 DURATION: 3 HOURS

ANSWER ALL PARTS OF QUESTION 1 IN SECTION A AND ANY THREE QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

SECTION A

1. (a) By considering the interactions with matter of both x-ray photons and electrons, explain why a beam of x-rays produced by a 4 MV linear accelerator can cause damage to cells. [4]

(b) Using clear diagrams, show the difference between unipolar and multipolar neurons. [4]

(c) What are the normal characteristics of the QRS complex? [4]

(d) Doses to patients undergoing radiotherapy are commonly measured using thermoluminescence dosimetry (TLD). Explain the physical principles of this technique with reference to a TLD material which you would expect to use in practice and outline its advantages and disadvantages compared with ionisation chamber techniques. [6]

(e) Sketch the central axis dose to water as a function of depth for

(i) a 10 MeV electron beam [4]

(ii) a 4 MV x-ray beam and [4]

(iii) a 200kV x-ray beam each normally incident on a large tank of water and each 10x10 cm at the surface. [4]

(f) Derive a relationship between *absorbed dose to air* and *air kerma*. [5]

(g) Using the Nernst equation, show that the membrane potential of K+ ions is -88 *mV* if the K+ concentration outside the cell is 140 $molm^{-3}$ and 5 $molm^{-3}$ inside. [5]

SECTION B

2. (a) Define the following terms as they are used in the AAPM dose measurement protocols:

(i) Cobalt-60 chamber exposure calibration factor, N_X [4]

(ii) Electrometer calibration factor P_{elec}, and [4]

(iii) pressure/temperature correction factor, P_{TP}. [3]

(b) A hospital received your secondary standard dosimeter from the Standards Laboratory with a calibration certificate stating ND = 9.1377×10^{-3} Gy/nC. Calibration measurements of 6 MV photon beam was carried out in your hospital in a water phantom under standard calibration set-up. Using the data provided,

Electrometer: 2560/199
Ion Chamber: 2561/242
Measurement depth: 50 mm
F.S. 10 x 10 cm
FSD = 100.0 cm
MU set = 1.00 per measurement
Average meter reading = 83.04 nC
P = 1013 hPa
T = 22.3°C
Ionic Recombination = 1.005
D_{20}/D_{10} = 0.58
PDD = 86.6%

Calculate:

(i) the temperature/pressure correction factor [4]

(ii) the quantity of dose delivered at the point of measurement? [5]

3. (a) Discuss the engineering problems in the design of a pacemaker and heart valves. [10]

(b) Describe the various stages of an action potential. [5]

(c) Compare the propagation of an action potential of an unmyelinated and a myelinated fibre. [5]

4. (a) Draw the functional diagram of a medical linear accelerator. [5]

(b) Choose any **one major** component in each of the systems below and write brief notes on the options for implementation in a typical medical linear accelerator.

(i) LINAC waveguide, [5]
(ii) Beam bending system, and [5]
(iii) Electron gun system. [5]

5. (a) Write short notes on the following:

(i) quality assurance, and [5]
(ii) machine interlocks. [5]

(b) Using a typical design layout for a medical linear accelerator building, discuss the different factors required to be considered in its design. [10]

6. (a) Sketch with brief notes on the characteristics of the following ECG functions. Explain what is happening in the heart during each period:

(i) P wave, and [5]
(ii) S-T segment. [5]

(b) Describe, outlining technical design aspect, an instrument that can be used to monitor the process of labour in a maternity ward. [10]

- END OF EXAMINATION -