P

NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Faculty of Health, Natural Resources and Applied Sciences

School of Natural and Applied Sciences

Department of Biology, Chemistry and Physics

13 Jackson Kaujeua Street
Private Bag 13388
Windhoek
NAMIBIA

T: +264 61 207 2012
F: +264 61 207 9012
E: dbcp@nust.na
W: www.nust.na

QUALIFICATION: **BACHELOR OF SCIENCE**	
QUALIFICATION CODE: **07BOSC**	LEVEL: **7**
COURSE: **BIOMEDICAL PHYSICS**	COURSE CODE: **BPH702S**
DATE: **NOVEMBER 2024**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **100**

FIRST OPPORTUNITY: EXAMINATION QUESTION PAPER

EXAMINER: *Dr Vaino Indongo*

MODERATOR: *Dr Vera Uushona-Mikka*

INSTRUCTIONS:

1. Answer all questions on the separate answer sheet.
2. Please write neatly and legibly.
3. Do not use the left side margin of the exam paper. This must be allowed for the examiner.
4. No books, notes and other additional aids are allowed.
5. Mark all answers clearly with their respective question numbers.

PERMISSIBLE MATERIAL:

Non-Programmable Calculator

ATTACHEMENT

None

This paper consists of 4 pages including this front page.

QUESTION 1 [20]

1.1 Briefly explain the terms: (i) tomography, (ii) radio-sensitivity. (4)

1.2 State two tomographic imaging modalities whose performances are based on detections of photons from the patient's body and the inner structures are obtained as a result of spontaneous decays of radioisotopes. (2)

1.3 Explain, in short, why *lubrication* is essential on mechanical or human machines? (2)

1.4 A collagen of cross-sectional of $1.2 \times 10^{-4}\ m^2$ and mass ***m*** kg has a tensile strength of $2.3 \times 10^{4}\ Nm^{-2}$. Calculate the;

(i) breaking force of the collagen, and (3)

(ii) value of its mass, $g = 9.8\ m/s^2$. (2)

1.5 State two physical use of bones in the skeletal system. (2)

1.6 The application of physics is an important phenomenon in observing electrical activities of a biological material. Discuss, in short, the use for each of the following instruments:

(i) Electrocardiogram (1)

(ii) Electroencephalogram (1)

iii) Sphygmanometer (1)

1.7 Discuss briefly the application of physics on a newborn baby. (2)

QUESTION 2 [20]

2.1 Define flow rate, Q, and write down its mathematical formula in terms of cross-sectional area, A, of a channel and velocity, $\bar{v}$, of fluid under consideration. (3)

2.2 Given that the ultrasound frequency of 2 *MHz* and wavelengths of 6.5 *nm* was used to take an image of a bone. Calculate the acoustic impedance of a bone if the density of a bone is $2.2 \times 10^{3}\ kg/m^3$. (3)

2.3 Calculate the amplitude reflection coefficient for a fat–liver interface.

Z (fat) = 1.62×10^{6} *Rayls* ; Z (liver) = 1.41×10^{6} *Rayls*. (3)

2.4 The relative sound intensity is measured on a logarithmic scale. Calculate the relative intensity of a sound beam when it is:

(i) reduced by a quarter. (2)

(ii) a seven-fold increase. (2)

2.5 What are the two main causes of attenuation of a beam of intensity? (2)

2.6 Estimate by calculating the pulse-echo period in μs when the depth of the interface from the ultrasound probe is 0.3 *mm*. Note: v = 1540 *m/s* (2)

QUESTION 3 **[20]**

3.1 Define a spin state. Which nucleic particle possesses a spin? And what are the two microscopic properties of this particle responsible for magnetic resonance imaging? (4)

3.2 Determine the total nuclear spins following atoms;

(i) Protium (2)

It's total nuclear spin is ½ for a proton.

(ii) Deuterium (2)

3.3 Many magnetic resonance imagers operate at a magnetic field strength of 1.5 *Tesla*. A few research units operate at 4.7 *Tesla*. What is the resonance frequency of the phosphorus nuclei in both magnetic fields? $\gamma = 17.24$ MHz/T (2)

3.4 A group of spins was placed into a magnetic field with the number of spins in the lower energy level of 5 and that in the upper level as 25. Given the Boltzmann's constant, k = $1.3805 \times 10^{-23}\ J.K^{-1}$; the temperature, T = 27°C and 1 $eV = 1.602 \times 10^{-19}\ J$, calculate the energy difference ΔE between the spin states. Give your answer in eV. (7)

3.5 A sample has a T_2 of 50 *ms*. The net magnetization of 200 μT is rotated into the xy-plane and allowed to decay. How much transverse magnetization will be present 22 *ms* after being placed in the plane? (3)

QUESTION 4 **[20]**

4.1 An X-ray machine mounted in private medical centre has molybdenum ($^{96}_{42}Mo$) as a target material. A female patient with a complain had to undergo mammography examination. The radiologist has decided on the voltage of 20 keV and the radiographer recommended for 25 keV for settings during the procedure. These two medical personnel mutually agreed for an average potential difference to be set on the instrument. Determine the energy of X-ray photons produced in eV. (5)

4.2 A beam intensity of 150 $\mu W/m^2$ was focused to pass through aluminium material of half-value thickness $t_{1/2} = 2.1\ cm$. Determine the;

(i) attenuation coefficient, μ, of the material (3)

(ii) strength of intensity after passing through a thickness of 1.5 cm a material (3)

(iii) beam intensity after the 6^{th} value layer. (3)

4.3 Explain the attenuation by means of *absorption* and *scattering* of X-ray beam when passed through a human body for imaging purposes. (2)

4.4 The intensity of X-ray beam passing through a material decreases exponentially. Use the equation of attenuation and derive the equation in the form of $y = mx + c$. (4)

QUESTION 5 **[20]**

5.1 State and discuss the law of radioactive decay. (4)

5.2 Explain, in short, the term *biological half-life*. (2)

5.3 A radionuclide has a half-life of 5 *hours*.

(i) Estimate its decay constant (s^{-1}) (2)

(ii) Calculate the activity of a radionuclide after 24 *hours*, when its initial activity is 5 mBq. (3)

5.4 The half-life of ^{99m}Tc is 6 *hours*. After how much time will 1/16*th* of the radioisotope remain? (5)

4.5 During radiotherapy, either radioactive or non-radioactive sources are used for efficient treatment of cancer. Give two reasons why collimators are crucial in the gantry of a radiotherapy equipment. (4)

END!!!