



**NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY**

FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE (MAJOR AND MINOR)	
QUALIFICATION CODE: 7BOSC	LEVEL: 7
COURSE CODE: BPH702S	COURSE NAME: BIOMEDICAL PHYSICS
SESSION: NOVEMBER 2022	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
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INSTRUCTIONS	
1.	Write all your answers in the answer booklet provided.
2.	Read the whole question before answering.
3.	Begin each question on a new page.

PERMISSIBLE MATERIALS

Non-programmable Scientific Calculator

THIS PAPER CONSISTS OF 4 PAGES

(INCLUDING THIS FRONT PAGE)

QUESTION 1

[20]

- 1.1 Explain the following terms: (i) cancer, (ii) oncology, and (iii) radio-resistivity. (6)
- 1.2 Differentiate, with at least two points each, between ultrasound and radiographic imaging modalities. (6)
- 1.3 The compressive strength of a bone is $1.8 \times 10^{10} \text{ N/m}^2$.
- (i) Estimate the compressive strain of the bone of length of 112 cm that was compressed by 0.12 cm. (2)
- (ii) Calculate the elasticity of the bone after the compression. (2)
- 1.4 Define diffusion and state Graham's law of diffusion. (4)

QUESTION 2

[20]

- 2.1 Differentiate between a systole and diastole pressures of the heart. (4)
- 2.3 A nozzle with a radius, r_n , of 20.00 mm was attached to a garden hose with a radius, $r_h = 4r_n$ mm. The flow rate through hose and nozzle is 45.00 L/s.
- (i) Calculate the speed of the water in the hose. (4)
- (ii) Estimate the cross-sectional area of a hose. (2)
- 2.4 Consider a Point Path at a height, $h = 1.5 \times 10^2 \text{ m}$, above the surface of a liquid of density $\rho = 1.7 \times 10^4 \text{ g/m}^3$. Assume the fluid is incompressible and frictionless. **Hint:** $1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$.
- (i) State Bernoulli's equation in mathematical form and define all the terms in the equations. (5)
- (ii) Show the mathematical expression for the hydrostatic pressure P at h . (2)
- (iii) Calculate the gravitational pressure of the liquid at h . (3)

QUESTION 3**[20]**

- 3.1 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 $2.2 \times 10^3 \text{ kg/m}^3$. (4)
- 3.2 If the intensity reflected coefficient of ultrasound is $= \left(\frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2$, show that the intensity transmitted coefficient of ultrasound wave is given by $T = \frac{4Z_1 Z_2}{[Z_1 + Z_2]^2}$. (6)
- 3.3 The relative sound intensity is measured on a logarithmic scale. Calculate the relative intensity of a sound beam is;
- (i) reduced by half. (5)
- (ii) a two-fold increase. (5)

QUESTION 4**[20]**

- 4.1 State two types of x-ray photons and discuss how they are produced in the x-ray tube. (6)
- 4.2 A radiation with a frequency of $4.13 \times 10^{15} \text{ Hz}$ releases an electron from a copper plate. The kinetic energy of the electron is $2.00 \times 10^{-18} \text{ J}$. Calculate the work function of the plate. Planck's constant $h = 6.63 \times 10^{-34} \text{ Js}$. (4)
- 4.3 Magnetic resonance imaging (MRI) is based on the absorption and emission of energy in the radio frequency range of the electromagnetic spectrum.
- (i) How do we call a picture element that form a magnetic resonance image? (1)
- (ii) What is the abbreviation for slice thickness in MRI? (1)
- 4.4 The signal in nuclear magnetic resonance (NMR) spectroscopy results from the difference between the energy absorbed by the spins which make a transition from the lower energy state to the higher energy state, and the energy emitted by the spins which simultaneously make a transition from the higher energy state to the lower energy state. Mention two factors that influence the MRI signal. (2)

4.5 A sample has a T_1 of 0.8 seconds. The net magnetization from the sample set equal to zero and then allowed to recover towards its equilibrium value. After 1.0 seconds, what fraction of the equilibrium magnetization value will be present? (3)

4.6 A hydrogen sample is at equilibrium in a 4.7 Tesla magnetic field. A constant B_1 field of 3.42×10^{-4} Tesla is applied along the +x-axis for 52 μs . What is the direction of the net magnetization vector after the B_1 field is turned off? Note: $\gamma = 42.58$ MHz/T. (3)

QUESTION 5

[20]

5.1 A radioactive equilibrium between $^{99\text{m}}\text{Mo}$ and its daughter is a transient equilibrium. The activity of $^{99\text{m}}\text{Mo}$ at time t_0 is 20 GBq. The parent radionuclide has a half-life of 67 hours and that of a daughter is 6.05 hours.

(i) Explain in short the term transient equilibrium. (2)

(ii) Calculate the activity of the parent after 7 days. (4)

(iii) Calculate the activity of the daughter nuclide after 7 days (4)

5.2 (i) Prove that the time (t) elapsed during transient equilibrium between parent and

daughter radionuclides can be expressed as $t = -\frac{\ln\left(\frac{A_d(\lambda_d - \lambda_p)}{A_0\lambda_d}\right)}{\lambda_p}$.

(ii) Estimate the time elapsed when activity of the daughter is 70% of the initial activity of the parent nuclide. (10)

END!!!