NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH AND APPLIED SCIENCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE (MAJOR AND MINOR)	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 7
COURSE CODE: BPH702S	**COURSE NAME:** BIOMEDICAL PHYSICS
SESSION: JANUARY 2019	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

SUPLEMENTARY/SECOND OPPORTUNITY EXAMINATION PAPER	
EXAMINER(S)	MR. VAINO INDONGO
MODERATOR:	MRS. NDESHIHAFELA VERA UUSHONA

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.
4.	Useful constants are listed on the last page for this question paper.

PERMISSIBLE MATERIALS

Scientific Calculator

ATTACHMENTS

None

THIS EXAMINATION PAPER CONSISTS OF 5 PAGES

(INCLUDING THIS FRONT PAGE)

QUESTION 1 [20]

1.1 Explain the following terms: (i) oncology (ii) computed tomography. (4)

1.2 Differentiate between ultrasound and magnetic resonance imaging modalities. (6)

1.3 The compressive strength of a bone is $1.8\ x\ 10^{10}\ N/m^2$. Estimate the compressive strain of the bone which is 15 cm long and is compressed by 1.6 mm. Also calculate the elasticity of the bone after 1.6 mm compression. (6)

1.4 Define diffusion and state Graham's law of diffusion. (4)

QUESTION 2 [20]

2.1 Estimate the specific ionization resulting from the passage of a 0.25-MeV beta particle through standard air, given that the mean ionization for air is 34 eV/ip. (10)

2.2 From (2.1), what is the relative (to air) mass stopping power of graphite, density = 2.26 g/cm^3, for a 0.25 MeV beta particle.

The density of standard air is $1.293\ x\ 10^{-3}\ {}^{g}/_{cm^3}$. (4)

2.3 A nozzle with a radius of 0.250 cm is attached to a garden hose with a radius of 0.900 cm. The flow rate through hose and nozzle is 0.500 L/s.

a) Calculate the speed of the water in the hose, (4)

b) Write down Bernoulli's equation for an incompressible, frictionless fluid. (2)

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 x 10^3 kg/m^3. (4)

3.2 If the intensity of reflected ultrasound is $R = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$, show that the intensity for transmitted ultrasound wave is given by T= $\frac{4Z_1Z_2}{[Z_1+Z_2]^2}$. (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 45%. (5)

(ii) a two-fold increase. (5)

QUESTION 4 [20]

4.1 State and discuss the law of radioactive decay. (5)

4.2 Sodium (Na) has a half-life of 15 hours. Calculate the activity of a 30-MBq source of Na-24 after 2.5 days. What is its decay constant? (5)

4.3 Explain how do you understand the following terms: (4)

(i) Dose rate (D)

(ii) Equivalent dose (D_e)

4.4 A Mo99m/Tc99m Generator is in transient equilibrium. The radioactivity of Mo-99m at time t_o is 16 GBq. After 156 hrs the activity of mo-99m is 3.2 GBq if no milking takes place. Estimate the activity of the daughter nuclide. Note: Mo-99m $T_{1/2}$ = 67 hours and Tc-99m $T_{1/2}$ = 6 hours. (6)

QUESTION 5 [20]

5.1 During radiotherapy some non-radioactive sources may be used for efficient treatment of cancer, like **x-ray tube devices** and **Linear Accelerators**. Discuss the structures of these sources. (6)

5.2 In Windhoek Central Hospital a high-dose-rate remote after-loading brachytherapy machine is used. Explain how the after-loader machine operates. (4)

5.3 The human body is composed of 63% of hydrogen atoms. If we zoom into one of the hydrogens past the electron cloud we see a nucleus comprised of a single proton. The proton possesses a property called spin. State the properties of a spin. (4)

5.4 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 hydrogen nuclei in both magnetic fields? $\gamma = 42.58$ MHz/T (2)

5.5 A sample has a T_2 of 50 ms. The net magnetization is rotated into the xy-plane and allowed to decay. How much transverse magnetization will be present 12 ms after being placed in the plane? (3)

END!!!

Some useful constants/formulae:

- Speed of light c = 3.0 x 10^8 m/s
- The linear rate of energy loss due to excitation and ionization is ;
- $\frac{dE}{dx} = \frac{2\pi q^4 \, NZ \, (3 \, x \, 10^9)^4}{E_m \beta^2 (1.6 \, x \, 10^{-6})^2} \{\ln \left[\frac{E_m E_k \beta^2}{I^2(1-\beta^2)}\right] - \beta^2\} \frac{MeV}{cm}$ and $E_k = m_o c^2 \left[\frac{1}{\sqrt{(1-\beta^2)}} - 1\right]$, where
- q is the charge on the electron, $1.6 \, x \, 10^{-19} C$,
- N is the number of absorber atoms per cm^3,
- Z is the atomic number,
- NZ is of absorber electrons per $cm^3 = 3.88 \, x \, 10^{20}$ for air at 0^o and $76 \, cm \, Hg$,
- E_m is the energy equivalent of the electron mass, 0.51 MeV,
- E_k is the kinetic energy of the beta particle in MeV,
- β is the speed of the ionization particle/speed of light, $\beta = {}^v/_c$,
- I is the mean ionization and excitation potential of absorbing atoms (MeV), $I = 8.6 \, x \, 10^{-5}$ for air and $I = 1.35 \, x \, 10^{-5} Z$ for the substance.