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QUALIFICATION : **BACHELOR OF SCIENCE (MAJOR AND MINOR)**	
QUALIFICATION CODE: **07BOSC**	LEVEL: **7**
COURSE: **BIOMEDICAL PHYSICS**	COURSE CODE: **BPH702S**
DATE: **JANUARY 2024**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **100**

SECOND OPPORTUNITY / SUPPLEMENTARY: EXAMINATION QUESTION PAPER

EXAMINERS: *DR VAINO INDONGO*

MODERATOR: *DR ROSWITA HAMUNYELA*

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

Periodic Table

This paper consists of 4 pages including this front page and a Periodic Table.

QUESTION 1 [20]

1.1 Define the following medical physics terms:

(i) Chemotherapy (2)

(ii) Brachytherapy (2)

1.2 Differentiate between **malignant** and **benign** tumours. (6)

1.3 The compressive strength of a giraffe bone is $2.4E14\ N/m^2$. Estimate the compressive strain and elastic modulus of 84 *cm* long bone, when compressed by 2.6 *mm*. (6)

1.4 (i) State Wolf's Law. (2)

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

QUESTION 2 [20]

2.1 State and discuss the types of pressures of the heart essential for blood circulation. (4)

2.2 A nozzle with a radius, $r_n = 20.00\ mm$ was attached to a garden hose of radius, $r_h = 4r_n$.
The flow rate through hose and nozzle is 120.00 *L/s*.
Calculate the speed of the water in the hose. (4)

2.3 Figure 1 illustrates the steady (laminar) flow of **incompressible** fluid through an enclosed tube/pipe. Use the information on the diagram and derive the equation of continuity. (5)

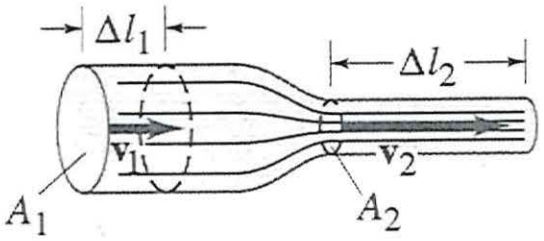

Figure. 1

2.4 Stipulate and discuss the two main essential circuit of the cardiovascular system. (4)

2.5 Write down an expression of hydrostatic pressure (dp) with respect to depth or height (dz). (3)

QUESTION 3 **[20]**

3.1 Estimate by calculating the pulse-echo period in μs when the depth of fetus from the ultrasound probe is 1.5 cm. (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 40%. (2)

(ii) A two-fold increase. (2)

3.4 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)

3.5 Calculate the total nuclear spins on the ^2H atom. (2)

QUESTION 4 **[20]**

4.1 An x-ray machine commissioned in Roman Catholic Hospital has tungsten ($^{184}_{74}W$) as a target material. One male patient with a fracture on the leg had to undergo radiographic procedure for medical practitioners to determine the severity of a fracture. The radiologist, oncologist and radiographer had to decide on the voltage of 95, 100 and 120 keV for settings during the procedure, respectively. All medical personnels mutually agreed for an average potential difference to be set on the instrument. Compute the energy of X-rays which passes through the leg this procedure. (5)

4.2 A radiation with a frequency of 3.13*E15 Hz* releases an electron from a copper plate. The kinetic energy of the electron is 1.70*E-18 J*. Calculate the work function of the plate. Planck's constant h = 6.63*E-34 Js*. (5)

4.3 Use the equation of linear attenuation to derive an equation of the form y = mx + c. (5)

4.4 The half-value thickness of a 100 keV X-ray photons passing through aluminium is 2.4*E-3 m*. If the initial intensity of the beam is 4.2*E*5 $W.m^{-2}$, what would be the intensity of the beam after passing through a 3 value layers? (3)

4.5 The increase in the X-ray tube current is proportional to the rate of thermionic emission from the cathode. List any two effects on the that can be observed with increase in tube current.(2)

QUESTION 5 **[20]**

5.1 A radionuclide with a *physical half life* and a *biological half-life of 8.0* and 5.6 *hours* , respectively, was administered to a patient in Nuclear Medicine Department for imaging.

(i) Use the relationship $\lambda_{eff} = \lambda_b + \lambda_p$ to show that $T_{eff} = \frac{T_p.T_b}{T_p+T_b}$. (3)

(ii) Estimate the effective half-life (in hours) of the radionuclide. (3)

5.2 Estimate the time elapsed (in seconds) for a radionuclide's activity of 30 *mBq* reduces with 15% of its initial activity and $t_{\frac{1}{2}} = 2.5$ days. (5)

5.3 During pair production a positron and electron with mass energies annihilates to produce photons with energy 0.61 MeV each. Both positron and electron have a mass of 9.109*E-31* kg. Estimate the total radiant energy (MeV) transferred into matter. Note: c = 3.00E8 m/s and 1 MeV = 1.602*E-13* J. (5)

5.4 Elucidate both the radical and target theories in terms biological effects of ionizing radiation. (4)

END