UNIVERSITY OF ESWATINI

FACULTY OF HEALTH SCIENCES
DEPARTMENT OF ENVIRONMENTAL HEALTH
BSc DEGREE IN ENVIRONMENTAL HEALTH SCIENCE
MAIN EXAMINATION, 2021

TITLE OF PAPER	**: RADIATION AND RADIOACTIVITY**
COURSE CODE	**: EHS 417**
TIME	**: 2HOURS**
TOTAL MARKS	**: 100**

INSTRUCTIONS:

- **QUESTION 1 IS COMPULSORY**
- **ANSWER ANY OTHER THREE QUESTIONS**
- **ALL QUESTIONS ARE WORTH 25 MARKS EACH**
- **FORMULAE AND PERIODIC TABLE ARE PROVIDED**
- **BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER.**

DO NO OPEN THIS EXAMINATION PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR.

QUESTION 1

I. Multiple Choices: Write True or False against each letter corresponding to the following statements as they apply to radiation and radioactivity

a) The nuclei of all atoms of a particular element must contain the same number of protons, but may contain different number of neutrons.

b) The isotopes of an element have the same N value but different Z and A values.

c) The occupational radiation exposure limit(whole body) is 5rem per year.

d) The degree of biological damage produced by radiation only depends on the dose.

e) The most dangerous form of exposure is ingestion or inhalation of radio isotopes.

f) Nuclear fission occurs when a heavy nucleus splits into two smaller nuclei.

g) When a particle meets its antiparticle, both are annihilated, resulting in high-energy photons.

h) In radiation therapy, selected cells or tissues are to be destroyed with damage to nearby healthy tissues.

i) The process of electron-positron annihilation is in the medical diagnostic technique of positron-emission tomography (PET)

j) The half-life of a radioactive substance is the time it takes for half of a given number of radioactive nuclei to decay.

(20 marks)

II.

Describe the general rule or order that electrons fill up an atom's sub-shell.

(5 marks)

QUESTION 2

a) Illustrate the exclusion principle and show it, using the arrangement of electrons in hydrogen and helium atoms.

(6 marks)

b) Describe characteristic x-rays and how they are formed.

(7 marks)

c) Describe how nuclear stability is achieved.

(7 marks)

d) Calculate the binding energy of a nucleus.
N.B: the mass of a proton is: 1.007 825 u and that of a neutron is 1.008 665 u

(5 marks)

QUESTION 3

i. Describe the types of radiation and how they can be distinguished.

(9 marks)

ii. A sample of carbon mass 7.60 g taken from an animal jaw bone has an activity of 4.00 decays per minute. How old is the jaw bone?

(6 marks)

iii. Describe how radiation can cause damage to human life.

(6 marks)

iv. Describe the atomic spectra.

(4 marks)

QUESTION 4

a) Describe Radiological Protection

(11 marks)

b) Describe beta radiation

(6 marks

c) Describe the difference between a biological and a health effect.

(4 marks)

d) Find the shortest wavelength photon emitted in the Balmer series.
N.B: $\frac{1}{\lambda} = R_H = (1/ n_f^2 - 1/n_i^2)$; and $n_i = 0$

(4 marks)

QUESTION 5

i. Describe carbon dating.

(7 marks)

ii. The fission of $^{235}_{92}U$ begins with a slow moving neutron that produces an unstable nucleus of $^{236}_{92}U$. The $^{236}_{92}U$ nucleus quickly decays into two heavy fragments moving at high speed as well as the neutrons. Most of the kinetic energy released is carried off by the two fragments.

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\ {}^{1}_{0}n$$

a. Calculate the kinetic energy in MeV carried off by the fission fragments, neglecting the kinetic energy of the reactants.

b. What percentage of the initial energy is converted into kinetic energy?
N.B: The atomic masses involved, given in atomic mass units are:
$^{1}_{0}n$ = 1.008665 u; $^{141}_{56}Ba$ = 140. 903 496 u ; $^{235}_{92}U$ = 235.043 923 u;
$^{92}_{36}Kr$ = 91.907 936 u.

(18 marks)

FORMULAE- ACOUSTIC AND HEALTH/RADIOACTIVITY AND RADIATION

1. $W = \sum_{i=1}^{4} \frac{p\ rms(I)S}{\rho C}$ where $\rho C = 420$ RAYLS
2. $SPL = 10 \log (p_1/p_0)^2$
3. $NR = 10 \log_{10} = \frac{TA_2}{TA_1}$
4. $SPL_t = 10 \log_{10} [\Sigma\, 10^{SPL/10}]$
5. $SWL = 10 \log W/W_0$
6. $I = \frac{W}{A}$
7. $I = \frac{p^2_{rms}}{\rho C}$ or $p_{rms} = (I\, \rho C)^{1/2}$
8. $S.I.L = 10 \log_{10} (I/I_{ref})$
9. $R = \frac{S\bar{\alpha}}{1-\bar{\alpha}}$
10. $\bar{\alpha} = \frac{S_i\bar{\alpha}_i + S_2\,\bar{\alpha}_2 + \ldots}{S_i + S_2}$
11. $SPL_t = SWL + 10 \log_{10} \{ \frac{Q}{4\pi r} 2 + \frac{4}{R} \}$
12. $T = \frac{0.161\ V}{S\bar{\alpha}}$
13. $T = \frac{0.161\ V}{-S[\ln(1-\bar{\alpha})] + 4mV}$
14. $\tau = \frac{p_t^2/\rho C^2}{p_i^2/\rho C^2}$
15. $TL = 10 \log_{10} [\frac{1}{\tau}]$
16. $t = \frac{1}{1.21\, x\, 10^{-4}\ yr^{-1}} \ln(\frac{0.227}{s})$
17. Radiation Intensity $\propto \frac{1}{d^2}$