



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.

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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

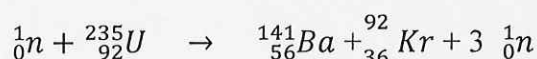
- i. Describe the types of radiation and how they can be distinguished. (9 marks)
- ii. A sample of carbon mass 7.60 g taken from an animal jaw bone has an activity of 4.00 decays per minute. How old is the jaw bone? (6 marks)
- iii. Describe how radiation can cause damage to human life. (6 marks)
- 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 ${}^{235}_{92}\text{U}$ begins with a slow moving neutron that produces an unstable nucleus of ${}^{236}_{92}\text{U}$. The ${}^{236}_{92}\text{U}$ 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.



- 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:

$${}_0^1n = 1.008665 \text{ u}; {}_{56}^{141}\text{Ba} = 140.903496 \text{ u}; {}_{92}^{235}\text{U} = 235.043923 \text{ u};$$

$${}_{36}^{92}\text{Kr} = 91.907936 \text{ u}.$$

(18 marks)

FORMULAE- ACOUSTIC AND HEALTH/RADIOACTIVITY AND RADIATION

1. $W = \sum_{i=1}^4 \frac{p_{rms(i)}^2}{\rho C}$ where $\rho C = 420 \text{ RAYLS}$
2. $SPL = 10 \log (p_1/p_0)^2$
3. $NR = 10 \log_{10} = \frac{TA_2}{TA_1}$
4. $SPL_t = 10 \log_{10} [\sum 10^{SPL/10}]$
5. $SWL = 10 \log W/W_0$
6. $I = \frac{W}{A}$
7. $I = \frac{p_{rms}^2}{\rho C}$ 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. $\bar{\alpha} = \frac{S_1\bar{\alpha}_1 + S_2\bar{\alpha}_2 + \dots}{S_1 + S_2}$
11. $SPL_t = SWL + 10 \log_{10} \left\{ \frac{Q}{4\pi r^2} + \frac{4}{R} \right\}$
12. $T = \frac{0.161 V}{S\bar{\alpha}}$
13. $T = \frac{0.161 V}{-S[\ln(1-\bar{\alpha})] + 4mV}$
14. $\tau = \frac{p_i^2/\rho C^2}{p_i^2/\rho C^2}$
15. $TL = 10 \log_{10} \left[\frac{1}{\tau} \right]$
16. $t = \frac{1}{1.21 \times 10^{-4} \text{ yr}^{-1}} \ln\left(\frac{0.227}{s}\right)$
17. Radiation Intensity $\propto \frac{1}{d^2}$