UNIVERSITY OF SWAZILAND

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF ENVIRONMENTAL HEALTH

BSc DEGREE IN ENVIRONMENTAL HEALTH SCIENCES

MAIN EXAMINATION, DECEMBER, 2016

TITLE OF PAPER : **RADIOACTIVITY AND RADIATION**

COURSE CODE : **EHM 417**

TIME : **2HOURS**

TOTAL MARKS : **100**

INSTRUCTIONS:

1. **QUESTION 1 IS COMPULSORY**
2. **ANSWER ANY OTHER THREE QUESTIONS**
3. **ALL QUESTIONS ARE WORTH 25 MARKS EACH**
4. **FORMULAE AND PERIODIC TABLE ARE PROVIDED**
5. **BEGIN THE ANSWER TO EACH QUESTION IN A SEPARATE SHEET OF PAPER.**

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

QUESTION 1

I. **Multiple choices: for the following statements as applied in radioactivity, radiation, health and safety write whether they are True or False.**

a) In ultrasonography, a transducer is a device that both emits receives sound waves.
b) Ultrasound frequencies used in diagnosis range from two million to fifteen million Hertz.
c) A special form of ultrasound imaging called echocardiography is used to monitor foetal heart problems.
d) An atom is the smallest potion of an element that retains all the properties of the element.
e) An atomic number indicates the number of neutrons in the nucleus of an atom of an element.
f) Isotopes are atoms of an element having the same atomic number but different mass numbers
g) The nucleus of an isotope is called a nuclide
h) The unified atomic unit is one twelfth than mass of carbon containing twelve nucleons.
i) Nuclear fission is the spontaneous breaking apart into isotopes of intermediate mass number.
j) One electron volt is the energy an electron receives when accelerated under the influence of one volt.

(20 marks)

II. Briefly describe nuclear fission.

(5 marks)

QUESTION 2

i. Define the following terms as applied in nuclear science:
   a) Rem [2]
   b) Rad [2]
   c) Ionization radiation. [2]
   d) Half-life period [2]
   e) Curie [2]

(10 marks)

ii. Isotopes with unstable atomic nuclei are said to be radioactive, explain why?

(2 marks)

iii. State the two rules for a balanced nuclear equation

(4 marks)

iv. Symbolize nuclear decay and construct a nuclear equation, which illustrate the alpha decay of uranium-238, $^{235}_{92}U$,to thorium.

(5 marks)

v. Radium-226, $^{226}_{88}Ra$, is an alpha and gamma emitter. Write a balanced nuclear equation for its decay.

(4 marks)

QUESTION 3

a) Describe beta radiation

(7 marks)

b) Answer the following questions concerning the nuclear binding energy of helium.

i) Write the symbol of a helium nucleus

(1 mark)

ii) What does helium nucleus consist of?

(1 mark)

iii) The mass of a proton is 1.00727252 u and that of a neutron is 1.008665 u. Calculate the total mass of the separated nucleons.

(3 marks)

iv) The total mass of the helium nucleus is 4.001506 u. Determine the difference between the calculated and measured masses for the helium-4 nucleus and also using Einstein's equation, calculate the energy equivalent of this mass difference.

(6 marks)

c) Briefly describe gamma radiation.

(7 marks)

QUESTION 4

i. Briefly describe magnetic resonance imaging (MRI)

(7 marks)

ii. Describe detection and measurement of radiation using the following devices.

a) The Geiger counter

(4 marks)

b) Scintillation counters

(3 marks)

c) Cloud chambers

(3 marks)

iii. Describe the process of fission and how it goes in a nuclear reactor

(8 marks)

QUESTION 5

a. Describe the use of radioisotopes in medicine.

(15 marks)

b. Briefly describe sources of radiation

(5 marks)

c. Briefly describe irradiation of food

(5 marks)

FORMULAE- ACOUSTIC AND HEALTH

1. $W = \sum_{i=1}^{4} \frac{p\ rms(I)S}{\rho C}$ where ρC = 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 $\log_{10}$ [Σ $10^{SPL/10}$]
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. $t = \frac{1}{1.21 \times 10^{-4}\ yr^{-1}} \ln(\frac{0.227}{s})$
17. Radiation Intensity $\propto \frac{1}{d^2}$

able

Atomic #
Symbol
Name
Weight

6	2, 4
C	
Carbon	
12.011	

Metalloids	Nonmetals: Other nonmetals	Halogens	Noble gases

Metals: Alkali metals	Alkaline earth metals	Lanthanoids / Actinoids	Transition metals	Post-transition metals

1	2	3	4											5	16	17	18
1 …gen																	2 **He** Helium 4.002602 (2)
2,1 …um	4 **Be** Beryllium 9.0121… (2,2)											5 **B** Boron 10.81 (2,3)	6 **C** Carbon 12.011 (2,4)	7 **N** Nitrogen 14.007 (2,5)	8 **O** Oxygen 15.999 (2,6)	9 **F** Fluorine 18.998… (2,7)	10 **Ne** Neon 20.1797 (2,8)
2,8,1 …um …89…	12 **Mg** Magnesium 24.305 (2,8,2)											13 **Al** Aluminium 26.981… (2,8,3)	14 **Si** Silicon 28.085 (2,8,4)	15 **P** Phosphorus 30.973… (2,8,5)	16 **S** Sulfur 32.06 (2,8,6)	17 **Cl** Chlorine 35.45 (2,8,7)	18 **Ar** Argon 39.948 (2,8,8)
2,8,8,1 …sium …083	20 **Ca** Calcium 40.078 (2,8,8,2)	21 **Sc** Scandium 44.955… (2,8,9,2)	22 **Ti** Titanium 47.867 (2,8,10,2)	23 **V** Vanadium 50.9415 (2,8,11,2)	24 **Cr** Chromium 51.9961 (2,8,13,1)	25 **Mn** Manganese 54.938… (2,8,13,2)	26 **Fe** Iron 55.845 (2,8,14,2)	27 **Co** Cobalt 58.933… (2,8,15,2)	28 **Ni** Nickel 58.6934 (2,8,16,2)	29 **Cu** Copper 63.546 (2,8,18,1)	30 **Zn** Zinc 65.38 (2,8,18,2)	31 **Ga** Gallium 69.723 (2,8,18,3)	32 **Ge** Germanium 72.63 (2,8,18,4)	33 **As** Arsenic 74.921… (2,8,18,5)	34 **Se** Selenium 78.971 (2,8,18,6)	35 **Br** Bromine 79.904 (2,8,18,7)	36 **Kr** Krypton 83.798 (2,8,18,8)
2,8,18,8,1 …dium …678	38 **Sr** Strontium 87.62 (2,8,18,8,2)	39 **Y** Yttrium 88.90584 (2,8,18,9,2)	40 **Zr** Zirconium 91.224 (2,8,18,10,2)	41 **Nb** Niobium 92.90637 (2,8,18,12,1)	42 **Mo** Molybdenum 95.95 (2,8,18,13,1)	43 **Tc** Technetium (98) (2,8,18,13,2)	44 **Ru** Ruthenium 101.07 (2,8,18,15,1)	45 **Rh** Rhodium 102.90… (2,8,18,16,1)	46 **Pd** Palladium 106.42 (2,8,18,18)	47 **Ag** Silver 107.8682 (2,8,18,18,1)	48 **Cd** Cadmium 112.414 (2,8,18,18,2)	49 **In** Indium 114.818 (2,8,18,18,3)	50 **Sn** Tin 118.710 (2,8,18,18,4)	51 **Sb** Antimony 121.760 (2,8,18,18,5)	52 **Te** Tellurium 127.60 (2,8,18,18,6)	53 **I** Iodine 126.90… (2,8,18,18,7)	54 **Xe** Xenon 131.293 (2,8,18,18,8)
2,8,18,18,8,1 …sium …90…	56 **Ba** Barium 137.327 (2,8,18,18,8,2)	57–71	72 **Hf** Hafnium 178.49 (2,8,18,32,10,2)	73 **Ta** Tantalum 180.94… (2,8,18,32,11,2)	74 **W** Tungsten 183.84 (2,8,18,32,12,2)	75 **Re** Rhenium 186.207 (2,8,18,32,13,2)	76 **Os** Osmium 190.23 (2,8,18,32,14,2)	77 **Ir** Iridium 192.217 (2,8,18,32,15,2)	78 **Pt** Platinum 195.084 (2,8,18,32,17,1)	79 **Au** Gold 196.96… (2,8,18,32,18,1)	80 **Hg** Mercury 200.59 (2,8,18,32,18,2)	81 **Tl** Thallium 204.38 (2,8,18,32,18,3)	82 **Pb** Lead 207.2 (2,8,18,32,18,4)	83 **Bi** Bismuth 208.98… (2,8,18,32,18,5)	84 **Po** Polonium (209) (2,8,18,32,18,6)	85 **At** Astatine (210) (2,8,18,32,18,7)	86 **Rn** Radon (222) (2,8,18,32,18,8)
2,8,18,32,18,8,1 …cium …)	88 **Ra** Radium (226) (2,8,18,32,18,8,2)	89–103	104 **Rf** Rutherfordiu (267) (2,8,18,32,32,10,2)	105 **Db** Dubnium (268) (2,8,18,32,32,11,2)	106 **Sg** Seaborgium (271) (2,8,18,32,32,12,2)	107 **Bh** Bohrium (272) (2,8,18,32,32,13,2)	108 **Hs** Hassium (270) (2,8,18,32,32,14,2)	109 **Mt** Meitnerium (276) (2,8,18,32,32,15,2)	110 **Ds** Darmstadtiu (281) (2,8,18,32,32,17,1)	111 **Rg** Roentgeniun (280) (2,8,18,32,32,18,1)	112 **Cn** Copernicium (285) (2,8,18,32,32,18,2)	113 **Nh** Nihonium (284) (2,8,18,32,32,18,3)	114 **Fl** Flerovium (289) (2,8,18,32,32,18,4)	115 **Mc** Moscovium (288) (2,8,18,32,32,18,5)	116 **Lv** Livermorium (293) (2,8,18,32,32,18,6)	117 **Ts** Tennessine (294) (2,8,18,32,32,18,7)	118 **Og** Oganesson (294) (2,8,18,32,32,18,8)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

57 **La** Lanthanum 138.90… (2,8,18,18,9,2)	58 **Ce** Cerium 140.116 (2,8,18,19,9,2)	59 **Pr** Praseodymi 140.90… (2,8,18,21,8,2)	60 **Nd** Neodymium 144.242 (2,8,18,22,8,2)	61 **Pm** Promethium (145) (2,8,18,23,8,2)	62 **Sm** Samarium 150.36 (2,8,18,24,8,2)	63 **Eu** Europium 151.964 (2,8,18,25,8,2)	64 **Gd** Gadolinium 157.25 (2,8,18,25,9,2)	65 **Tb** Terbium 158.92… (2,8,18,27,8,2)	66 **Dy** Dysprosium 162.500 (2,8,18,28,8,2)	67 **Ho** Holmium 164.93… (2,8,18,29,8,2)	68 **Er** Erbium 167.259 (2,8,18,30,8,2)	69 **Tm** Thulium 168.93… (2,8,18,31,8,2)	70 **Yb** Ytterbium 173.054 (2,8,18,32,8,2)	71 **Lu** Lutetium 174.9668 (2,8,18,32,9,2)
89 **Ac** Actinium (227) (2,8,18,32,18,9,2)	90 **Th** Thorium 232.0377 (2,8,18,32,18,10,2)	91 **Pa** Protactinium 231.03… (2,8,18,32,20,9,2)	92 **U** Uranium 238.02… (2,8,18,32,21,9,2)	93 **Np** Neptunium (237) (2,8,18,32,22,9,2)	94 **Pu** Plutonium (244) (2,8,18,32,24,8,2)	95 **Am** Americium (243) (2,8,18,32,25,8,2)	96 **Cm** Curium (247) (2,8,18,32,25,9,2)	97 **Bk** Berkelium (247) (2,8,18,32,27,8,2)	98 **Cf** Californium (251) (2,8,18,32,28,8,2)	99 **Es** Einsteinium (252) (2,8,18,32,29,8,2)	100 **Fm** Fermium (257) (2,8,18,32,30,8,2)	101 **Md** Mendelevium (258) (2,8,18,32,31,8,2)	102 **No** Nobelium (259) (2,8,18,32,32,8,2)	103 **Lr** Lawrencium (262) (2,8,18,32,32,8,3)