UNIVERSITY OF SWAZILAND

FACULTY OF HEALTH SCIENCES
DEPARTMENT OF ENVIRONMENTAL HEALTH
BSc DEGREE IN ENVIRONMENTAL HEALTH SCIENCES
MAIN EXAMINATION, DECEMBER, 2017

TITLE OF PAPER : **RADIATION AND RADIOACTIVITY**

COURSE CODE : **EHM 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 THE ANSWER TO EACH QUESTION IN A SEPARATE SHEET OF PAPER.**

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QUESTION 1

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

a) In radiation therapy, selected cells or tissues are to be destroyed without damage to nearby healthy tissues.

b) When a radioisotope is to be used for therapy, alpha as well as Beta and gamma emitters can be used.

c) A given isotope should not be able to concentrate in the desired area or preferably emit alpha or beta particles because they have limited penetration power and will not damage adjacent tissues

d) Ultrasound frequencies are those above 20 000 Hz

e) Ultrasonography employs very high frequency sound waves in place of X-rays.

f) Ultrasound can be used to monitor foetal growth.

g) A special form of ultrasound imaging called echocardiography is used to monitor foetal heart problems.

h) When bombarded with neutrons, the nuclei of several heavy elements split into smaller pieces.

i) Uranium (235) can be split by a neutron into smaller pieces, such as strontium and xenon, accompanied by the release of more neutrons and a tremendous amount of energy.

j) The sum of the masses of the products is less than the masses of the reactants, that is, nuclear reactions do follow the law of conservation of energy.

k) Nuclear reactions obey the combined law of conservation of mass and energy.

l) The amount of mass that disappears is converted into an equivalent amount of energy.

(24 marks)

II. There are how many types of ionising radiation and what are they?

(1 mark)

QUESTION 2

I. Describe the uses of radioactivity under the following topics:

a) Tracers [2]

b) Checking the function of thyroid gland [4]

c) Radiotherapy [6]

d) Carbon dating [6]

II. Describe Magnetic resonance imaging (MRI) [7]

(25 marks)

QUESTION 3

i. Describebiological effects of radiation

(12 marks)

ii. Describe a nuclear reaction

(5 marks)

iii. Describenuclear waste and methods of its disposal.

(8 marks)

QUESTION 4

a) Describe alpha radiation.

(7 marks)

b) Cesium – 137, $^{137}_{55}Cs$ is one of the radioactive wastes from a nuclear power plant or an atomic bomb explosion, emits beta and gamma radiation. Write a nuclear equation for the decay of Cesium – 137,

(6 marks)

c) Describe the arrangement of electrons in an atom and the importance attached to such an arrangement.

(6 marks)

d) Strontium – 90, a beta emitter, is one of many radionuclides present in the wastes of operating nuclear power plants. Write a balanced nuclear equation for the decay.

(6 marks)

QUESTION 5

i) Describe the helium nucleus by answering the following questions:
   a) What is its symbol? [1]
   b) What does it consist of [1]
   c) The mass of a proton is 1.0072752 , the neutron is 1.008665: Calculate the total mass of four (4) nucleons [5]

d) Determine the difference between the calculated and measured mass for the helium – 4 nucleuses. [3]

e) Using Einstein's equation, calculate the energy equivalent of this mass difference. [3]

(13 marks)

ii) ii) If a nurse standing 0.6m from a patient with a radium implant receives an exposure of 32 mrem, what would be the exposure level at 2.4 m away?

(8 marks)

iii) In the 1940s scrolls were found in the Dead Sea. Some were made up of copper and others were made of parchment, when one parchment scroll was analyzed by the carbon-14 dating method, its specific activity was found to be 0.175 Bqg^{-1}. Calculate the age of the scroll to two significant figures.

(4 marks)

FORMULAE- ACOUSTIC AND HEALTH/RADIOACTIVITY AND RADIATION

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

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Atomic #
Symbol
Name
Weight

6
C
Carbon
12.011

Metalloids
Nonmetals
Other nonmetals
Halogens
Noble gases
Metals
Alkali metals
Alkaline earth metals
Lanthanoids
Actinoids
Transition metals
Post-transition metals

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

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