UNIVERSITY OF SWAZILAND

FACULTY OF HEALTH SCIENCES
DEPARTMENT OF ENVIRONMENTAL HEALTH
BSc DEGREE IN ENVIRONMENTAL HEALTH SCIENCES
MAIN EXAMINATION, DECEMBER, 2018

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

a) The uses of laser and radio-frequency radiation in industrial, scientific, military, consumer, and medical applications are examples of natural sources and application of non-ionization radiation.

b) Overexposure to non-ionizing radiation produces a number of serious health effects, but there are thresholds between safe exposures and over exposures

c) Electromagnetic radiation is the propagation, or transfer, of energy through space and matter by time-varying electric and magnetic fields.

d) Photons with energies less than 12.4 eV are considered to have sufficient energy to ionize matter, and are non-ionizing in nature.

e) Skin effects of importance from occupational exposure include; erythema, photosensitivity, ageing and cancer.

f) There are three skin cancers of concern; squamous cell carcinomas, basal cell carcinomas, and cutaneous malignant melanoma.

g) The nuclear strong force is unable to overcome the electrostatic force of repulsion between protons, and it binds the nucleons into a package

h) Electron capture does not change an atom's mass number, only its atomic number

i) Positrons are particles with the mass of an electron but have a positive instead of a negative charge.

j) Beta decay causes a nucleus to lose a neutron and gain a proton and thus decrease the neutron/proton ratio.

k) The net effect of positron emission is to gain a neutron and lose a proton.

l) There are five different types of ionising radiation, namely alpha (α), beta (β), neutrons (n), gamma (γ).

(24 marks)

II. Define One electron volt

(1 mark)

QUESTION 2

a) Describe the difference between a biological and a health effect.
(4 marks)

b) Describe the effects of exposure to Ultraviolet Radiation to the skin
(10 marks)

c) Describe the nuclear strong force.
(4 marks)

d) By means of a balanced equation, illustrate the alpha decay of uranium-238
(7 marks)

QUESTION 3

a. Describe alpha radiation
(8 marks)

b. Describe beta radiation
(6 marks)

c. The rest mass of one helium-3 nucleus is known to be 3.0011295 u. Calculate the sum of the rest masses of its three separated nucleons. The rest mass of a proton is 1.00727252 u, and that of a neutron 1.008665 u.
Using Einstein's equation, calculate the nuclear binding energy of the nucleus from the nuclear reaction and the energy per nucleon.
(11 marks)

QUESTION 4

i. Describe radioactive decay.
(5 marks)

ii. Cobalt -54 is a positron emitter. Write a balanced nuclear equation for its decay and also describe how a positron is made.
(12 marks)

iii. Briefly describe electron capture in the case of Vanadium – 50 nuclei.
(8 marks)

QUESTION 5

a) Distinguish between external radiation and internal radiation.
(7 marks)

b) Describe uses of radiation in industry and medicine
(6 marks)

c) DescribeRadiological Protection
(12 marks)

FORMULAE- ACOUSTIC AND HEALTH/RADIOACTIVITY AND RADIATION

1. $W = \sum_{i=1}^{4} \frac{p\,rms(I)S}{\rho C}$ where ρC = 420 RAYLS
2. $SPL = 10 \log (p_l/p_0)^2$
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 $\propto \frac{1}{d^2}$

PERIODIC TABLE OF THE ELEMENTS

GROUPS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PERIODS	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1.008 H 1																	4.003 He 2
2	6.941 Li 3	9.012 Be 4											10.811 B 5	12.011 C 6	14.007 N 7	15.999 O 8	18.998 F 9	20.180 Ne 10
3	22.990 Na 11	24.305 Mg 12											26.982 Al 13	28.0855 Si 14	30.9738 P 15	32.06 S 16	35.453 Cl 17	39.948 Ar 18
4	39.0983 K 19	40.078 Ca 20	44.956 Sc 21	47.88 Ti 22	50.9415 V 23	51.996 Cr 24	54.938 Mn 25	55.847 Fe 26	58.933 Co 27	58.69 Ni 28	63.546 Cu 29	65.39 Zn 30	69.723 Ga 31	72.61 Ge 32	74.922 As 33	78.96 Se 34	79.904 Br 35	83.80 Kr 36
5	85.468 Rb 37	87.62 Sr 38	88.906 Y 39	91.224 Zr 40	92.9064 Nb 41	95.94 Mo 42	98.907 Tc 43	101.07 Ru 44	102.906 Rh 45	106.42 Pd 46	107.868 Ag 47	112.41 Cd 48	114.82 In 49	118.71 Sn 50	121.75 Sb 51	127.60 Te 52	126.904 I 53	131.29 Xe 54
6	132.905 Cs 55	137.33 Ba 56	138.906 *La 57	178.49 Hf 72	180.948 Ta 73	183.85 W 74	186.207 Re 75	190.2 Os 76	192.22 Ir 77	195.08 Pt 78	196.967 Au 79	200.59 Hg 80	204.383 Tl 81	207.2 Pb 82	208.980 Bi 83	(209) Po 84	(210) At 85	(222) Rn 86
7	(223) Fr 87	226.025 Ra 88	(227) **Ac 89	(261) Rf 104	(262) Ha 105	(263) Unh 106	(262) Uns 107	(265) Uno 108	(266) Une 109									

TRANSITION ELEMENTS

* Lanthanide series	140.115 Ce 58	140.908 Pr 59	144.24 Nd 60	(145) Pm 61	150.36 Sm 62	151.96 Eu 63	157.25 Gd 64	158.925 Tb 65	162.50 Dy 66	164.930 Ho 67	167.26 Er 68	168.934 Tm 69	173.04 Yb 70	174.967 Lu 71
** Actinide series	232.038 Th 90	231.036 Pa 91	238.029 U 92	237.048 Np 93	(244) Pu 94	(243) Am 95	(247) Cm 96	(247) Bk 97	(251) Cf 98	(252) Es 99	(257) Fm 100	(258) Md 101	(259) No 102	(260) Lr 103

Numbers below the symbol of the element indicates the atomic numbers. Atomic masses, above the symbol of the element, are based on the assigned relative atomic mass of ^{12}C = exactly 12: ( ) indicates the mass number of the isotope with the longest half-life.

SOURCE: International Union of Pure and Applied Chemistry, J. Mills, ed., *Quantities, Units, and Symbols in Physical Chemistry*, Blackwell Scientific Publications, Boston, 1988, pp 86-98.