DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

UNIVERSITY EXAMINATIONS 2015/2016

YEAR TWO SEMISTER II SPECIAL/SUPPLEMENTARY EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN INDUSTRIAL CHEMISTRY

BACHELOR OF SCIENCE IN LEATHER TECHNOLOGY

SCH 2203: NUCLEAR AND RADIOCHEMISTRY

DATE: 15TH MARCH 2016 **TIME: 11 AM -1PM**

INSTRUCTIONS:

1. Answer question **ONE** and any other **TWO** questions.
2. You may use electronic calculators, but borrowing will not be allowed.

USEFUL DATA:

1 J = 1 Kg·m^2·s^{-2}

1 MeV = 1.60 × 10^{-13} J

1 amu = 1.6605 × 10^{-27} Kg

1 amu= 931 MeV

Avogadro's constant = 6.022× 10^{23}/mol

c = 2.9989 × 10^8 m/s = 2.9989 × 10^{10} cm/s

1 erg (g-cm^2/sec^2) = 2.778 × 10^{-14} KWhr

1 eV = 1.602176 × 10^{-19} J

1 amu = 1.6605655x10^{-24} g

^1_0n *= 1.008665 amu*

^2_1H *= 2.0140102 amu*

^3_2He *= 3.016029 amu*

$^{235}_{92}U$ *= 235.0439 amu*

$^{92}_{36}Kr$ *= 91.8976 amu*

$^{141}_{56}Ba$ *= 140.9136 amu*

QUESTION ONE [30 MARKS]

a) Define the following terms. [5 Marks]

i. Fusion

ii. Fission

iii. Chain reaction

iv. Moderator

v. Control rods

b) Describe the two opposing forces between particles in the nucleus, and with reference to these forces, explain why uneven numbers of neutrons and proton the nucleus is unstable.

[3 Marks]

c) Balance the following nuclear reactions: [4 Marks]

i. Alpha Decay of uranium-238

ii. Beta Decay of iodine-131

iii. Positron Emission of sodium-22

iv. Electron Capture of Bismuth-207

d) Classify each nuclide as stable or radioactive. [4 Marks]

i. ^{30}P-

ii. ^{98}Tc-

iii. ^{118}Sn-

iv. ^{239}Pu-

e) Write a balanced nuclear reaction for the alpha particle bombardment of plutonium-239. The reaction products include a hydrogen atom and two neutrons. [2 Marks]

f) Describe the penetration power of alpha, beta and gamma radiation. [3 Marks]

g) State and explain the kind of nuclear change the following unstable nuclide undergoes when it decays. [6 Marks]

i. ^{45}Ti

ii. ^{242}Pu

iii. ^{12}B

h) The half-life of plutonium-239 is 24,000 years. What percentage of nuclear energy waste generated in the year 2004 will be present in the year 2100? [3 Marks]

QUESTION TWO (20 MARKS)

a) The reaction of two carbon-12 nuclei in a carbon-burning star can produce elements other than sodium. With the aid of a balanced nuclear equation describe the formation of;

i. Magnesium-24 from carbon-12 nuclei.

ii. Neon-20 from carbon-12 nuclei.

[6 marks]

b) Determine the thermodynamic stability (binding energy) of ^{16}O. [1 amu = $1.6605655 \times 10^{-24}$ g; $m_n = 1.67496 \times 10^{-24}$ g; $m_p = 1.67265 \times 10^{-24}$ g; $m_e = 9.109535 \times 10^{-28}$ g; m(^{16}O) = 15.99491 amu]. [8 Marks]

c) Describe any three reactors used in the production of nuclear energy. [6 marks]

QUESTION THREE [20 MARKS]

a) A sample of radioactive ^{133}I gave with a Geiger counter 3150 counts per minute at a certain time and 3055 counts per unit exactly after one hour later. Calculate the half-life period of 133I. [5 Marks]

b) What is the binding energy for ^{11}B nucleus if its mass defect is 0.08181 amu ? [5 Marks]

c) Discuss two factors that influence the extent to which an ionization radiation affects a biological organism [4 Marks].

d) Explain any three practical applications of radiochemistry in life. [6 Marks]

QUESTION FOUR [20 MARKS]

a) Discuss any six sources of radiations. [6 Marks]

b) Sketch a diagram to show the components of the nuclear reactor. [4 Marks]

c) Explain the following terms: [4 marks]

i. Subcritical:

ii. Supercritical:

d) A fission reactor is based on the following reaction

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

Calculate the weight of ^{239}Pu that would be required to produce 1 million kilowatt-hours (KWhr) of electrical energy. Assume the conversion of nuclear energy to electrical energy is 60% efficient. [6 Marks]

QUESTION FIVE [20 MARKS]

a) How much time would it take for a sample of cobalt-60 to disintegrate to the extent that only 2.0 per cent remains? The disintegration constant λ is 0.13 yr^{-1}. [5 Marks]

b) A rock once contained 1.0 mg of uranium-238, but now contains only 0.257 mg. given that the half-life for uranium-238 is 4.5×10^9 years, how old is the rock? [4 Marks]

c) A breeder reactor undergoes the following mechanism

(i) A "fertile" ^{238}U nucleus collides with a neutron to provide ^{239}U.

(ii) ^{239}U decays by β-emission ($t_{1/2}$ = 24 min) to give an isotope of neptunium.

(iii) This neptunium isotope decays by β-emission to give plutonium isotope.

(iv) On collision of this plutonium isotope with a neutron, fission occurs to yield $^{94}_{39}Y$, $^{138}_{99}Cs$, neutrons and energy

Explain the principle of a breeder reactor and write equations for each step. [5 Marks]

d) $^{222}_{86}Rn$ is a natural alpha particle emitter. Due to its noble gas characteristic, it can cause damage to tissues as it can be easily inhaled into the body. $^{222}_{86}Rn$ can be found quite easily in uranium mine because it is a decay product of $^{238}_{92}U$. In an analysis, 50.0 mg $^{222}_{86}Rn$ decayed to 45.7 mg in 24 hours. Determine the half-life of $^{222}_{86}Rn$ and its rate constant. [6 marks]

Period																	
1	1 H															1 H	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112						

6	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
7	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr