MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

SAN 309: NUCLEAR AND RADIATION CHEMISTRY

DATE: **TIME:**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

SECTION A

QUESTION ONE (COMPUOLSORY) (30 MARKS)

a) Define the following terms as used in Nuclear and Radiation Chemistry. (4 marks)

(i) Nucleons
(ii) Isotopes
(iii) Isomers
(iv) Half-life

b) Differentiate between the terms Excited state and Metastable state. (2 marks)

c) State and explain the two types of nuclear transformations. (4 marks)

d) Complete and balance the following equations and identify each as nuclear decay or reaction. (8 marks)

(i) $^{81}_{37}\text{Rb} \rightarrow {}^{81}_{36}\text{Kr} + \_\_\_$ (ii) $^{14}_{7}\text{N} + \_\_\_ \rightarrow {}^{1}_{1}\text{H} + {}^{14}_{6}\text{C}$

(iii) $^{235}_{92}\text{U} \rightarrow {}^{231}_{90}\text{Th} + \_\_\_$ (iv) $^{98}_{42}\text{Mo} + {}^{1}_{0}\text{n} \rightarrow {}^{99}_{42}\text{Mo} + \_\_$

e) Explain three reasons why a nuclide may be stable. (3 marks)

f) Explain why $^{32}_{15}\text{P}$, $^{20}_{8}\text{O}$, and $^{100}_{44}\text{Ru}^*$ unstable nuclides. Write out a possible decay equation for each. (6 marks)

g) Naturally occurring rubidium is a mixture of only two isotopes: ^{85}Rb (84.9118 u) and ^{87}Rb (86.9092 u). If the average atomic mass for Rb is 85.4678 u, calculate the percent abundance of its two isotopes. (3 marks)

SECTION B

QUESTION TWO (20 MARKS)

a) Explain why radioactive decay is an exponential process. (2 marks)

b) One of the naturally occurring decay series begins with $^{232}_{90}$Th and ends with $^{208}_{82}$Pb. What is the minimum number of alpha and beta decays required for this series? (4 marks)

c) A radioactive nuclide had an activity of 1.38×10^5 dpm exactly 60 days ago, but now has an activity of 6.05×10^4 dpm. Calculate its half-life? (3 marks)

d) Explain radioactive dating. (2 marks)

e) A ^{90}Sr source was calibrated to emit 1.00 μCi of radiation. If its activity today is measured at 5.76×10^5 dpm and its half-life is 28.8 a, how long ago was it calibrated? ($1\mu Ci = 2.22 \times 10^6$ dpm). (4 marks)

f) It was determined that the plants that used to make the Shroud of Turin was killed 740 years ago. If the half-life and the activity of carbon then are 5715a and 14 dpm/g respectively. Determine the specific activity of carbon from the Shroud of Turin today? (3 marks)

QUESTION THREE (20 MARKS)

a) Explain mass defect and how it can be converted into binding energy. (3 marks)

b) Calculate the mass defect and the binding energy for $^{56}_{26}$Fe (actual atomic mass = 55.934937 u), if the combined mass of proton and electron are 1.007825 u, while that of neutron is 1.008665 u (1u = 931 MeV). (5 marks)

c) Explain the following terms. (4 marks)

(i) Nuclear fission

(ii) Fissile

d) ^{235}U is one of the three commonly known fissile. Provide the other two. (2 marks)

e) Explain the following types of radiation detectors. (6 marks)

(i) Gas-filled

(ii) Scintillation

(iii) Semiconductor

QUESTION FOUR (20 MARKS)

a) Explain briefly how nuclear waste is handled after reaction. (2 marks)

b) Nuclear reprocessing is highly encouraged to save the environment from impacts of spent nuclear fuels, however, it remains unpopular. Explain the reason. (2 marks)

c) Obtaining medical radionuclides from spent nuclear fuel is usually undesirable. Explain. (2 marks)

d) Describe the following terms. (4 marks)

(i) Nuclear medicine

(ii) Radiopharmaceuticals

e) Explain five qualities of a good diagnostic radiopharmaceutical (also called a radiodiagnostic agent). (10 marks)

QUESTION FIVE (20 MARKS)

a) Explain the following models of the nucleus. (6 marks)

(i) Liquid drop model

(ii) Shells model

(iii) Collective model

b) Differentiate between the following terms. (4 marks)

(i) Parent and daughter nuclide

(ii) LET and stopping power

c) With help of schematic diagram explain the stopping power of α, β, and γ radiations. (6 marks)

d) Briefly explain two biological effects of nuclear radiations. (4 marks)