CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE, BACHELOR OF EDUCATION SCIENCE

CHEM 417: RADIATION AND NUCLEAR CHEMISTRY

STREAMS: BED (SCI), BSC **TIME: 2 HOURS**

DAY/DATE: TUESDAY 03/12/2019 **8.30 AM – 10.30 AM**

INSTRUCTIONS:

Answer Question One and any other two Questions

QUESTION ONE (30 MARKS)

(a) (i) Why is it necessary for a chemist to have knowledge of the radiation interaction process related to the energy transfer to the irradiated target? [1 mark]

(ii) Briefly discuss brem – strahlung. [2 marks]

(iii) Name the five characteristics of photoelectric emission. [2 ½ marks]

(b) (i) State three precautions which a chemist should take while using radioisotopes as tracers in order to obtain good results. [1 ½ marks]

(ii) Explain how isotopes can be used in elucidating reaction mechanism of the freidal – crafts reaction given below:

AlC

(c) (i) Describe how the age of the rock can be estimated using the ratio of lead to uranium. [3 marks]

(ii) A sample of a radioactive material contains atoms. The half-life of the materials is 2.0 days. Calculate;

(I) The fraction remaining after 5 days. [1 ½ marks]

(II) The activity of the sample after 5.0 days (answer should be given interms of){1

(iii) is a emitter and Ra is an what will be the atomic masses and atomic numbers of daughter elements of these radioactive elements? Predict the position of daughter elements in the periodic table. [1 mark]

(d) (i) Describe with help of a suitable diagram how alpha and particles can be determined using scintillation counter. [2 marks]

(ii) A sample of radioactive gave with a Gieger counter 3100 counts per minute at a certain time and 3000 counts per minute exactly one hour later. Calculate the half-life period of . [1 mark]

QUESTION TWO (20 MARKS)

(a) (i) Derive the general expression for the activity of a daughter nuclide in terms of half-life. [4 ½ marks]

(ii) It is known that 1g of emits atoms of random per year. Given the half-life period of Ra to be 1600 years; compute the value of the Avogadro constant. [1 mark]

(iii) A bone taken from a garbage plie buried under a hill-side had ratio of 0.477 times the ratio in a living animal. Calculate the date when the animal was buried (half-life of carbon -14 is 5730 years) [2 marks]

(b) (i) Explain what is meant by binding energy of a nucleus. [2 marks]

(ii) With the help of a binding energy curve explain the stability of the nucleus. [2 ½ marks]

(iii) Calculate the binding energy per nucleon (in mer) in He atom which has a mass of 4.0026 amu. Mass of a neuton = and mass of 1 hydrogen atom = 1.007825 [3 marks]

(c) (i) Explain the differences between a nuclear reaction and a chemical reaction. [4 marks]

(ii) The streptomycin in 500g of a broth was determined by addition of 1.34 mg of the pure antibiotic containing The specific activity of this preparation was found to be 223 cpm/mg for a 30 min count. From the mixture, 0.112 mg of purified streptomycin was isolated, which produced 654 counts in 60.0 min. calculate the concentration in parts per million of streptomycin in the sample. [1 mark]

QUESTION THREE (20 MARKS)

(a) (i) Describe the principle of operation of semiconductor detectors. [2 ½ marks]

(ii) Compare semiconductors and gas detectors. [1 ½ marks]

(iii) Outline the principle of the gas-filled electrode system which is designed for saturation collection in radiation detection. [3 ½ marks]

(b) List five characteristics of an ideal scintillator. [2 ½ marks]

(c) (i) Explain how unknown substance in a sample can be determined using sub-stoichiometric isotope dilution analysis (SSIA) [2 marks]

(ii) To a sample of a protein hydrolysate, an analyst added 1.00mg of tryptophan which was labelled with and exhibited a counting rate of 584 CPM above background. After the labelled compound was thoroughly mixed with the sample, the mixer was passed through an ion exchange column. The fraction of the effluent containing only tryptophan was collected and from it an 18.0mg sample of pure tryptophan was isolated. The isolated sample had a counting rate of 204 cpm in the same counter. Determine the weight of tryptophan in the original sample. [2 marks]

(d) (i) Write short notes on counting efficiency and quenching in liquid scintillation counting. [4 marks]

(ii) Explain how sample counting efficiency and quenching in liquid scintillation counter can be determined using internal standard techniques. [4 marks]

QUESTION FOUR (20 MARKS)

(a) (i) Outline the disposal procedures for solid radioactive waste. [3 ½ marks]

(ii) Give the stages which are involved in developing a geological repository within any national programme. [4 marks]

(b) (i) Consider the decay of a ci sample of pure . Use the Bateman equations to estimate the activity of its daughter B/A.
[4 ½ marks]

(ii) Consider the nucleus is known to decay by electron capture (61%) and (39%). Calculate the particle half-lives for electron capture (EC) and decay and also calculate the partial width for EC decay { [3 marks]

(c) (i) Explain how you can access the volume of blood in a patient using isotope dilution technique. [2 marks]

(ii) To access the volume of blood in a patient one of his/her blood was withdrawn, labelled with and reinjected into his/her body. After adequate time for homogenization one of his / her blood was again withdrawn and the sample showed a total activity of 250 net counts in 10min. find the volume of blood in the patient given that $0.1cm^3$ of the labelled blood before injection corresponded to an activity of 14000 counts per min.
[2 marks]
