



**KISII UNIVERSITY**  
**UNIVERSITY EXAMINATIONS**  
**SPECIAL EXAMINATION**  
**FOURTH YEAR EXAMINATION FOR THE AWARD OF**  
**THE DEGREE OF BACHELOR IN EDUCATION SCIENCE**  
**SECOND SEMESTER 2021/2022**  
**(JULY, 2022)**

**CHEM 417: RADIATION AND NUCLEAR CHEMISTRY**

**STREAM: Y4 S2**

**TIME: 2 HOURS**

**DAY: THURSDAY, 11.30 AM – 1.30 PM**

**DATE: 21/07/2022**

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**INSTRUCTIONS:**

- 1. Do not write anything on this question paper.***
- 2. Answer ALL Questions.***

**Important information**

Scientific calculator

C-14 half-life = 5730years

Activity of fresh carbon sample = 0.255 Bq or 15dpmg<sup>-1</sup>

Avogadro's constant =  $6.02 \times 10^{23}$

Speed of light =  $2.9998 \times 10^8 \text{ms}^{-1}$

- Define
  - Nuclear Binding Energy (NBE) [2mks]
- Discuss the three basic methods used to reduce exposure from external radiation. [3mks]
- Given that the mass defect for a  ${}^4_2\text{He}$  nucleus is 0.0305 amu, determine the binding energy for the nuclide  ${}^4_2\text{He}$  in:
  - joules per mole of nuclei [3mks]
  - joules per nucleus [3mks]
- The concentration of insulin in a production vat is determined by isotope dilution. A 1.00-mg sample of insulin labeled with  ${}^{14}\text{C}$  having an activity of 549 cpm is added to a 10.0-mL sample taken from the production vat. After homogenizing the sample, a portion

- of the insulin is separated and purified, yielding 18.3 mg of pure insulin. The activity for the isolated insulin is measured at 148 cpm. How many mg of insulin are in the original sample? [6mks]
- e) Discuss Direct and Indirect effects of ionizing radiation on the body. [3mks]
- f) Define
- i) Threshold radiation dose. [2mks]
  - ii) "Stay time" as applied to external radiation protection. [2mks]
- g) A wooden tool has a radioactivity of 0.195 Bq per gram of carbon. How old is it? [4mks]
- h) Define relative biological effectiveness in relation to radiation exposure. [2mks]
- i) How long can a radiation worker stay in a 1.5 rem/hr radiation field if we wish to limit his dose to 100 mrem? [3mks]
- j) 'Living cells can be classified according to their rate of reproduction, which also indicates their relative sensitivity to radiation'. Discuss. [6mks]
- k) The exposure rate one foot from a source is 500 mR/hr. What would be the exposure rate three feet from the source? [3mks]
- l) Briefly discuss somatic and genetic damage caused by ionizing radiation. [4mks]
- m) In 1990, the remains of an apparently prehistoric man were found in a melting glacier in the Italian Alps. Analysis of the  $^{14}\text{C}$  content of samples of wood from his tools gave a decay rate of 8.0 dpm/g carbon. How long ago did the man die? (half-life of  $\text{C-14} = 5730\text{years}$ ) [4mks]
- n)  $^{35}\text{S}$  is a beta emitter. In one experiment, the following radioactivity measurements were obtained: 4280 disintegrations per minute (dpm) at  $t = 0$ , and 3798 dpm at  $t = 15$  days. Find the decay constant for  $^{35}\text{S}$ . [3mks]
- o) Discuss acute and chronic effects of radiation. [4mks]
- p)  $^{60}\text{Co}$  decays with a half-life of 5.27 years to produce  $^{60}\text{Ni}$ .
- i) What is the decay constant for the radioactive disintegration of cobalt-60? [3mks]
  - ii) Calculate the percentage fraction of a sample of the  $^{60}\text{Co}$  isotope that will remain after 15 years. [5mks]
  - iii) How long does it take for a sample of  $^{60}\text{Co}$  to disintegrate to the extent that only 2.0% of the original amount remains? [5mks]