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ON

CHM 433: RADIO-NUCLEAR CHEMISTRY

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF AGRICULTURE,

ABEOKUTA(UNAAB)

LECTURER IN CHARGE

Dr. Amolegbe,S.A (Ph.D) **amolegbesaliu@gmail.com**

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COURSE DESCRIPTION

CHM 433: Radio-nuclear Chemistry 2units

Radionuclear methods; Natural radioactivity, fusion, fission, decay processes, nature of radiation. Nuclear models, energies of nuclear reactions. Principles and measurement of radioactivity. Application of radioactivity. Radiation hazards.

Introduction

The nuclear properties of an atom depend on the number of protons and neutrons in the nucleus both of which are called nucleons. Nuclear chemistry explains the science of nuclear reactions with emphasis on their uses in chemistry and their effects on biological systems. It deals with changes in matter originating in the nucleus of atoms or a nuclear reaction involves changes in the nucleus of an atom.

$^{A}_{z}X \rightarrow {}^{A'}_{z'}Y + Z$

When nuclei change spontaneously, emitting radiations(e.g α, β, γ..) , they are said to be radioactive and when they occur naturally such transformations of the nucleus lead to it being radioactive. Some atoms are naturally stable such are never undergoing further reactions while others are, " not stable isotopes". Nuclei that are radioactive are called radionuclides, and atoms containing these nuclei are called radioisotopes.

Besides, transformations may also be brought about artificially and the energy released in nuclear fission reactions is harnessed in the nuclear fuels industry. Emissions of radiation is one of the ways in which an unstable nucleus is transformed into a more stable one with less energy.

Natural Radioactivity

This is the spontaneous distingration of an atomic nucleus with emission of particles.

Summary of Properties of α, β, γ Radiations

	Type of Radiations		
Property	α	β	γ
Charge	2+	$^{1-}$	0
Mass	$6.64X\ 10^{-24}g$	$9.11X\ 10^{-28}g$	0
Relative penetrating power	1	100	10,000
Nature of radiation	$^{4}_{2}He$	$^{0}_{-1}\beta$	High energy photons
Absorber	Thin paper	Aluminium	Lead block

Measurement / Detection of Radioactivity

Becquerel detected and measured radioactivity by exposing photographic film to a source of radiation. Its detection could be obtained through:

1) Geiger muller counter
2) Scintillation counter
3) Diffusion cloud chamber
4) Electroscope

Rates of radioactive Decay

The rate at which a sample decays is called activity. The decomposition of a radioactive element is the simplest example of a true 1^{st} order (Unimolecular) reaction. In such a reaction, the rate of a decomposition is directly proportional to the amount of undecayed materials and may be exposed mathematically as $A \rightarrow P$ (where $R = K[N]$)

Tasks

Data: electron rest mass =9.10939 X 10-^{31} kg, proton rest mass =1.67262 X 10^{-27} kg, neutron rest mass =1.67493 X 10^{-27} kg and c=2.9979 X $10^{8}ms^{-1}$

1(a) Define the following and give example where necessary

(i) Radioisopes
(ii) Nucleons
(iii) Nuclear binding energy
(iv) Mass defects
(v) Half-life

(b) How much time is required for 5.75mg – sample of radionuclei to decay to 1.50mg if it has $t_{1/2}$ of 27.8days

(c) Would you expect stable isotope not to decay with reason(s).

2 (a) i Conceptualize the meaning of radionuclear from nuclear chemistry

ii Explain in short the trend of nuclear stability pattern with respect to n/p ratio for α and β decay.

(b) Draw a comparison between the **3** popular radiations under the followings:

(i) Charge (ii) absorber (iii) ionizing effect (iv) nature of radiation

(c) i State rate of radionulear decay

ii Interpret with equation these nuclear reactions:

(I) Postron emission of ^{11}C (II) $^{32}_{16}S(n,p)\ ^{32}_{15}S$

3 (a) Mention 4 devices that are used to detect and measure with clear explaination of the principle of any one.

(b) The half life of nuclei is 12.3yrs. If 48mg of it is released from a nuclear power plant.

During the course of an accident, what mass of this nuclide will remain after 49.2yrs.

(c) Account for the stability of :

(i) $^{14}_{7}N$ (ii) $^{32}_{15}N$ (iii) $^{3}_{1}H$

4 (a) List 7 applications of radioisotopes.

(b) Consider this nuclear reaction:

$^{238}_{92}U \rightarrow\ ^{234}_{90}Th + {}^{4}_{2}He$

Hints: $^{238}_{92}U$ has 238.0003amu, $^{234}_{90}Th$ has 233.9942amu and $^{4}_{2}He$ has 4.0015amu , cal the enegy changes of this reaction.

(c) How much energy must be supplied to break a single ^{31}P nucleus into separated protons and neutrons if the nucleus has a mass of 30.965533 amu? What is the nuclear binding

energy for 1 mol of the nuclei.

5 (a) Itemize 3 points of how α, β and γ radiations affect human bodies.

(b) How much energy is lost/gained when a mole of Co-60 undergoes β decay.

$^{60}_{27}Co \rightarrow {}^{60}_{28}Ni + {}^{0}_{-1}\beta$

The mass of the $^{60}_{27}Co$ atom is 59.933819amu, and that of a $^{60}_{28}Ni$ atom is 59.930788amu.

(c) What is the mass change (Δm) per mole of ^{11}C with nuclear binding energy of 2.87X 10^{11}J/mol.