MOHAMED KHIDER UNIVERSITY OF BISKRA.

FACULTY OF EXACT SCIENCES AND NATURAL AND LIFE SCIENCES

DEPARTMENT OF BIOLOGY

COURSE TITLE: General Chemistry I

CHAPTER II

Level: 1st year LMD

Dr: Ismail DAOUD

Academic year: 2023/2024

1.2. Radioactivity
1.2.1. Definition
1.2.2. Natural radioactivity: main types of radiation
1.2.3. Artificial radioactivity
1.2.4. Radioactive decay law
1.2.5. Different types of nuclear reaction

1.2. Radioactivity

1.2.1. Definition

An atom transformed into another atom of a different nature by nuclear reactions, the study of these transformations is called radioactivity

In nature there are stable nuclei and unstable nuclei, the latter are called "radioactive nuclei"

1.2.2. Some particles and their symbols

Nucleon: proton (symbolized ${}^{1}_{1}p$ (or ${}_{1}^{1}H$) or neutron (symbolized ${}^{1}_{0}n$).

Alpha (α) particle: a helium nucleus, symbolized ${}_{2}^{4}\alpha$ (${}_{2}^{4}He$)

Beta particle: an electron, usually symbolized ${}^{0}_{-1}\beta$, but sometimes also ${}^{0}_{-1}e$

Positive beta particle: a positron, symbolized ${}^{0}_{+1}\beta$

1.2.3. Natural radioactivity: main types of radiation

Radiation generally describes anything emitted from a material.

Ionizing radiation refers to radiation that can ionize matter (i.e. make ions by separating electrons from their atoms).

Alpha and beta radiation refer to the emission of α and β particles.

α radiation is easily stopped (can be stopped by a piece of paper) but can under certain circumstances be highly damaging (e.g. ingestion of an alpha emitter).

β radiation is somewhat harder to stop (can be stopped by a few millimeters of aluminium) and can cause radiation burns and other health effects.

Neutrons are harder to stop because they are neutral, so they are very hard to stop. They can induce fission or ionize matter directly by knocking light nuclei (esp. hydrogen) out of their molecules.

Gamma radiation consists of high-energy electromagnetic radiation (like light, but much higher in energy). Most gamma radiation passes right through matter, but when it does interact with matter it can cause serious damage (e.g. mutations).

Neutrinos carry away most of the energy in many nuclear reactions.

They are massless, chargeless particles that interact extremely weakly with matter. Accordingly, they have no biological effects.

1.2.4. Radioactive decay law

1st case: the nucleus produced is not radioactive:

Activity of a source:

If we present by N the number of radioactive atoms present at a time t, the activity of this radioactive can be represented by the variation in the number of atoms per unit of time to the nearest sign:

$$a = -\frac{dN}{dt}$$

Other unit: the curie, $1Ci = 3.7 * 10^{10}$ Bq, 1 Bq=1 disintegration/s. (becquerels (Bq))

Evolution over time:

The law relating to activity represents kinetics of order one. Its integration is therefore easy.

$$\frac{dN}{dt} = -\lambda N \quad \Rightarrow \quad LnN = Ln_0 - \lambda t, \qquad \text{où}: \quad N = N_0 * e^{-\lambda t}$$

N_0: number of atoms of the radioactive element at t=0.

λ: radioactive constant of the element.

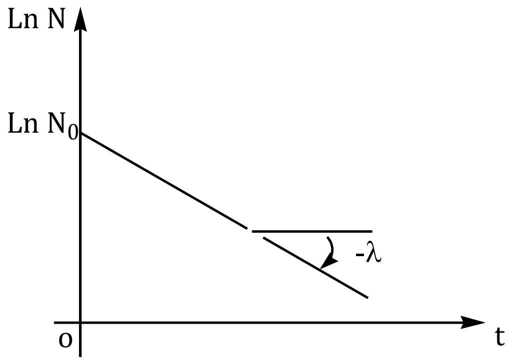

Figure : Determination of the radioactive constant

We call the period $T_{1/2}$ of the radioactive element the time interval necessary for N to be divided by 2. It is a constant for a given radioactive element.

The period and the radioactivity constant λ are linked by the relation: $T_{\frac{1}{2}} = \frac{ln2}{\lambda}$

We call average life the number $\tau = 1/\lambda$, we see that: $T = \tau * Ln2$.

Example :

$${}^{226}_{88}Ra \; : \; T_{1/2} = 1620\ ans, \; {}^{213}_{84}Po \; : \; T_{1/2} = 4.2 * 10^{-6}\ s, \; {}^{14}_{6}C \; : \; T_{1/2} = 5600\ ans.$$

1.2.5. Different types of nuclear reaction

a. **Alpha emission (or decay):** an α particle is ejected from a nucleus.

Example: alpha decay of $^{222}_{86}Rn$

b. **Beta emission (or decay):** a $^{0}_{-1}\beta$ particle is emitted, converting a neutron into a proton:

$$^{1}_{0}n \longrightarrow ^{1}_{1}p + ^{0}_{-1}\beta$$

Example: beta decay of $^{234}_{90}Th$

c. **Fission reaction:** splitting of a nucleus into two lighter nuclei Two types:

- Spontaneous

Example: fission of ^{240}Pu to produce ^{135}I and two neutrons

- Induced (usually by neutrons)

Example: fission of ^{235}U induced by a neutron, producing ^{133}Cs and three neutrons

d. **Fusion reaction:** combination of lighter nuclei to make a heavier nucleus

Example: fusion of ^{8}Be with ^{4}He

e. **Transmutation reaction:** These are reactions which produce nuclides whose A is equal to or close to that which served as the target.

Example: Rutherford carried out the first atomic transmutation in 1919

$$^{2}_{1}H + ^{6}_{3}Li \longrightarrow ^{7}_{3}Li + ^{1}_{1}H$$

1.2.6. Application of radioactivity

•Endowment: “determination of the age” of rocks and organic materials, method used in archaeology.

• In medicine: treatment of cancer (radiotherapy).

• In biology: study of the metabolism of elements by the body.

• In chemistry: analysis, rational mechanisms.

• In geology: analysis of the movement of watercourses.

Important notes:

➢ Ordinary chemical reactions do not involve the nuclei, so we can balance these reactions by making sure that the number of atoms of each type is conserved.

➢ In nuclear reactions on the other hand, the nuclei themselves change.

➢ Nuclear reactions generate enormously more energy (by many orders of magnitude) than chemical reactions.