Inorganic Chemistry Lecture in Radioactivity

Radioactivity

Most naturally occurring isotopes of elements up to atomic number 19 have stable nuclei. Elements with higher atomic numbers (20 to 83) consist of a mixture of isotopes, some of which may have unstable nuclei. When the nucleus of an isotope is unstable, it is radioactive, which means that it will spontaneously emit energy to become more stable. This energy, called radiation, may take the form of particles such as alpha (α) particles or beta (β) particles or pure energy such as gamma (γ) rays. Elements with atomic numbers of 84 and higher consist only of radioactive isotopes . So many protons and neutrons are crowded together in their nuclei that the strong repulsions between the protons makes those nuclei unstable.

Mass number (protons and neutrons)
Element
Atomic number (protons)

$$\boxed{{}^{131}_{53}I}$$

Types of radiation

Alpha (α)radiation

Alpha radiation involves the emission of particles from a radioactive nucleus. From a determination of the relative charge (+2) and relative mass (4) of α-particles, scientists were able to conclude that α-particles are identical to helium nuclei. Identity is symbolized

$$\alpha \quad \text{or} \quad {}^{4}_{2}He$$

Because α-particles are the heaviest of the three radiations, they are the slowest –moving and least-penetrating of the three types. They are readily stopped by a few pieces of paper or a layer of human skin. Therefore, α- radiation is usually not hazardous to living organisms unless swallowed or inhaled

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

Beta (β)radiation

Beta radiation is also particulate. The mass and charge of the β - particle indicate that it is identical to an electron:

$$\beta \equiv e^{-}$$

Because β-particles are smaller and faster-moving, they have about 100 times the penetrating power of α-particles. An aluminum plate, a block of wood, or heavy protective clothing is necessary to stop β-radiation. Although most β-radiation is not sufficiently energetic to reach the internal organs of the body, it goes deep enough within the outer layers of skin to cause damage (similar to severe sunburn) and represents a special hazard to your eyes .

$$^{131}_{53}I \longrightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e$$

Gamma radiation (γ)

Gamma radiation is pure energy; γ-rays are not particles. This high-energy radiation, which is similar to x-rays, travels at the speed of light and can be stopped only by a block of several layers of lead. Gamma radiation easily penetrates the skin and can cause sever internal damage. We assume you have an idea of the properties of x-rays and know about their ability to travel through space (or the body) from your contact with them in medical and dental diagnosis.

$$^{60m}_{27}Co \longrightarrow {}^{60}_{27}Co + \gamma$$

PHYSIOLOGICAL EFFECTS OF RADIATION

Ionizing radiation is most damaging to the nuclei of living cells. The cell nucleus contains the ' blueprints ' for producing more identical cells. Because the cell nucleus directs division and replication, cells that are dividing most rapidly are the first to show the effects of radiation. Genetic damage frequently occurs because the principal genetic material resides in the cell nucleus. The cells most susceptible to radiation damage are those in the lymphatic system, bone marrow, intestinal tract, reproductive organs, and lens of the eye.

The body can tolerate exposure to small amounts of ionizing radiation without apparent symptoms. Thus, background radiation (from the soil and outer space) and medical x-rays produce no noticeable harm . However, small doses may be cumulative, and it is important for persons who work near sources of radiation to monitor their exposure. A common device employed for this purpose is the film badge which makes use of the fact that photographic film detects radiation . film badges are developed periodically to determine the extent of exposure.

Average Annual Radiation Received by a Person in the United States

Source	Dose (mrem)
Natural	
The ground	15
Air, water, food	30
Cosmic rays	40
Wood, concrete, brick	50

Medical	
Chest X-ray	50
Dental X-ray	20
Upper gastrointestinal tract X-ray	200
Other	
Television	2
Air travel	1
Cigarette smoking	35

Medical applications of radioisotopes

Isotope	Medical application
Fe -59	Measure the rate of formation and lifetime of red blood cells .
Tc-99	Used to image the brain, heart, liver, skeleton, lungs, bone, spleen and other organ .
Na-24	Used to study the circulatory system .
C-14	Radioactive dating and labeling .
S-35	Protein label for metabolic studies .
Ce-141	Gastrointestinal tract diagnosis; measuring myocardial blood flow .
I-123	Imaging brain, thyroid, kidney, and heart; measuring cerebral blood flow; and detection of neurological disease .
I-125	Treatment of brain cancer; osteoporosis detection .
Sr-85	Detection of bone lesions; brain scans .
Sr-89	Alleviation of bone cancer pain; treatment of prostate cancer.

Ga-67 Abdominal imaging; tumor detection .

Ga-68 Detect pancreatic cancer .

Co-60 External radiation therapy; sterilize surgical instruments and medicines .

P-32 Treatment of leukemia , polycythemia vera (excess red blood cells) pancreatic cancer .

Ti-201 Heart imaging ; diagnosis and location of myocardial infarction .

Positron emission tomography

One of more useful (and expensive) tests is known as a PET (Positron emission Tomography) scan, which produces an image of a two-dimensional slice through a portion of body. The body is injected with a compounds(e.g., glucose) containing a radioactive isotope such as 11C . The glucose containing this isotope of carbon is metabolized along with glucose produced by the body containing the stable isotope 12C . The parts of the brain that are particularly active in metabolism of glucose will display increased radioactivity . Abnormal glucose metabolism in the brain can then be detected, which may indicate a tumor or Alzheimer's disease.

$$ {}^{11}_{6}C \longrightarrow {}^{11}_{5}B + {}^{0}_{+1}e $$

$$ {}^{0}_{+1}e + {}^{0}_{-1}e \longrightarrow 2\gamma $$