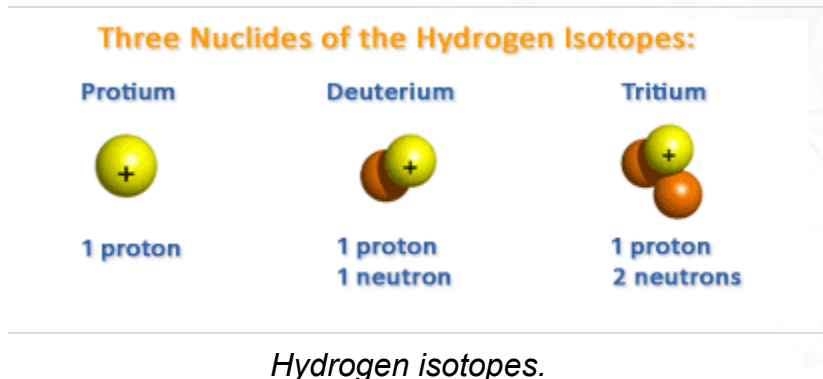


BLM – Radioactive Half-Life: The Whole Story

Isotopes Info Sheet

When we look at the periodic table of elements we see a catalogue of all the elements known to exist. Each element has a unique atomic number which is equal to the number of protons in its nucleus. Hydrogen has 1 proton, helium has 2, and so on. What the periodic table of elements doesn't tell us is that each element comes in a variety of forms, called isotopes.

Isotopes of an element have the same number of protons, but different numbers of neutrons in their nuclei. For example, hydrogen, which has 1 proton, occurs naturally with 0, 1 or 2 neutrons. Since neutrons have no electrical charge, the number of neutrons in a nucleus can be changed without changing the charge of the nucleus. A single element can therefore consist of many isotopes which are all chemically similar (since this is determined mainly by number of electrons) but differ slightly in mass. The element mass you see on the periodic table is an average mass of all the isotopes of that element that are found in nature.



Isotopes vs. Nuclides

A nuclide is any particular atomic nucleus with a specific atomic number Z (the number of protons) and mass number A (the number of protons plus the number of neutrons). Collectively, all the isotopes of all the elements form the set of nuclides. There are more than 3,100 nuclides identified in the [Chart of Nuclides](#).

A chart or table of nuclides is a simple map that distinguishes the isotopes of the elements. Nuclide charts organize isotopes along the X (horizontal) axis by their numbers of neutrons and along the Y (vertical) axis by their numbers of protons.

The names of isotopes and nuclides are specified by the name of the particular element, followed by a hyphen and the mass number (e.g. helium-3, carbon-12, carbon-13, iodine-131 and uranium-238). In symbolic form, the mass number is denoted as a superscripted prefix to the chemical symbol (e.g. ^3He , ^{12}C , ^{13}C , ^{131}I and ^{238}U).

The difference between the terms isotope and nuclide can be confusing, and they are often used interchangeably. The term nuclide is more generic and is used when referring to nuclei of different elements. Isotope is best used when referring to several different nuclides of the same element.

Radioisotopes

Although one can imagine many isotopes of a given element being constructed by simply adding more and more neutral neutrons to the nucleus, in reality nature prefers not to vary the ratio of protons to neutrons too widely. Because of this only a small subset of the more than 3,000 known nuclides are actually stable. The vast majority will exist for only a short time before undergoing a transformation that brings their proton-to-neutron ratio more into line with what nature expects of a stable nuclide. This transformation is called radioactive decay, and results in the release of energy. Isotopes that undergo radioactive decay are called radioisotopes.

Some radioisotopes are so unstable that they do not exist naturally on earth and can only be created for fractions of a second in laboratories. Others, such as ^3H (called tritium), are continuously generated by natural processes in the upper atmosphere, and so are found in nature despite their short lifetimes. Still others, like ^{238}U (uranium-238) and ^{40}K (potassium-40), have such long lifetimes (up to many billions of years in some cases), that they are found in abundance on earth and considered to be effectively stable as far as day-to-day activity is concerned.

It turns out that the energy that radioisotopes emit through radioactive decay has thousands of applications in medicine, industry and scientific investigation. One of the most common uses of radioisotopes is in product quality assurance. Industry has used radioisotopes to develop highly sensitive gauges to measure the thickness and density of many materials. It also has used radioisotopes as imaging devices to inspect finished goods for weaknesses and flaws.

Radioisotopes can be manufactured by placing a substance called a target material into a nuclear reactor or a particle accelerator. Nuclear reactors are used where neutrons are needed, and particle accelerators are used when protons or electrons are needed. When the target material is bombarded with nuclear particles, it becomes a radioisotope. The radioisotope produced depends upon the target material and the particles with which it is bombarded.

Manufacturers commonly use small amounts of radioisotopes as tracers in process materials. The tracers make it possible to track leakage from piping systems and monitor the rate of engine wear and corrosion of processing equipment. They also make it possible to observe the velocity of materials through pipes and to gauge the efficiency of filtration systems.

Industries that Use Radioisotopes

- The automobile industry, to test the quality of steel in vehicles.
- Aircraft manufacturers, to check for flaws in jet engines.
- Mining and petroleum companies, to locate and quantify oil, natural gas and mineral deposits.
- Automobile manufacturers, to obtain the proper thickness of tin and aluminum (here's your tomato soup example).
- Pipeline companies, to look for defects in welds.
- Construction crews, to gauge the density of road surfaces and subsurfaces.