Report

* Mayur Dange

Estimate the average lifetime of a particular sample with the concept of Radioactivity decay, Exponential decay, and Radioactivity dating?

As we know, every material in the universe is made up of atomic elements, weather they’re polar, non-polar, acidic, basic, charged or neutral. These elements are usually stable in nature, which means they’ve balance nuclear charge, which means they’ve a stable nucleus. But some elements are unstable in nature due to presence of excess nuclear charge in it. So, these will go under radioactive decay, to form a stable nucleus. The process of getting this stability by emitting out the energy, in the form of radiation, is called, Radioactive elements decay process.

Radioactivity decay is the spontaneous breakup of an atomic nucleus of a radioactive material that results in the emission of radiation from the nucleus. The number of nuclei decaying per unit time in a radioactive substance is proportional to the total number of nuclei in the sample material. Three of the most common types of radioactive decays are alpha decay, beta decay and gamma decay. There is also a fourth type of decay called electron capture. Radioactive decay is a random process at a level of single atoms. It is impossible to predict when a particular atom will decay, no matter how long the matter has been into existence.

However, the overall decay rate can be expressed as a decay constant. A sample is subject to exponential decay if it decreases at a rate proportional to its current value. Symbolically, this process can be expressed by the following differential equation, where N is the quantity and λ (lambda) is a positive rate called the exponential decay constant:

By solving we get,

where N(t) is the quantity at time t, N0 = N (0), the quantity at time t = 0, and the constant λ is called the decay constant.

This radioactivity decay can be used for dating. Radioactive dating is a method of dating specimens using radioactive isotopes, either a whole specimen or a single mineral grain can be dated. Some techniques place the sample in a nuclear reactor first to excite the isotopes present, then measure these isotopes using a mass spectrometer (such as in the argon-argon scheme). Others place mineral grains under a special microscope, firing a laser beam at the grains which ionises the mineral and releases the isotopes. The isotopes are then measured within the same machine by an attached mass spectrometer (an example of this is SIMS analysis).

**Radiocarbon (14C) dating**

This is one of the common dating methods, it can only date geologically recent organic materials, usually carbon, but also bone and antlers. All living organisms take up carbon from their environment including a small proportion of the radioactive isotope 14C (formed from nitrogen-14 as a result of cosmic ray bombardment). The amount of carbon isotopes within living organisms reaches an equilibrium value, on death no more is taken up, and the 14C present starts to decay at a known rate. The amount of 14C present and the known rate of decay of 14C and the equilibrium value gives the length of time elapsed since the death of the organism.

Radiocarbon dating is normally suitable for organic materials less than 50 000 years old because beyond that time the amount of 14C becomes too small to be accurately measured.

Rubidium-Strontium dating (Rb-Sr), Potassium-Argon dating (K-Ar), Samarium-Neodymium (Sm-Nd), Rhenium-Osmium (Re-Os) system, Uranium-Lead (U-Pb) system, The SHRIMP technique, Fission track dating are some of the dating techniques are used by the industries.

While digging on one of the archaeological sites in Mexico, palaeontologists isolate a mummified animal. Since, it was in an intact condition, scientists discovered to find its age with radiocarbon dating. Upon taking samples from the site, we find out the decay probability rate () as:

As we have seen above, by solving the equation, we get,

Taking log on both sides,

By rearranging,

For getting the average lifetime estimation, we put the value in the further time spans, we get,

|  |  |
| --- | --- |
| 0.286 – 0.287 | 9887.547 years – 9859.977 years |
| 0.081 – 0.082 | 19852.339 years – 19755.419 years |
| 0.001 – 0.002 | 54563.628 years – 49088.532 years |

As we found out, the mummified animal is nearly around 55000 years old, which makes it really old, place it in bronze age.

So, from the above calculations we can find the approximate age from carbon dating method which is helpful and has many applications in geology as well.