Uses of Isotopes in Hydrology

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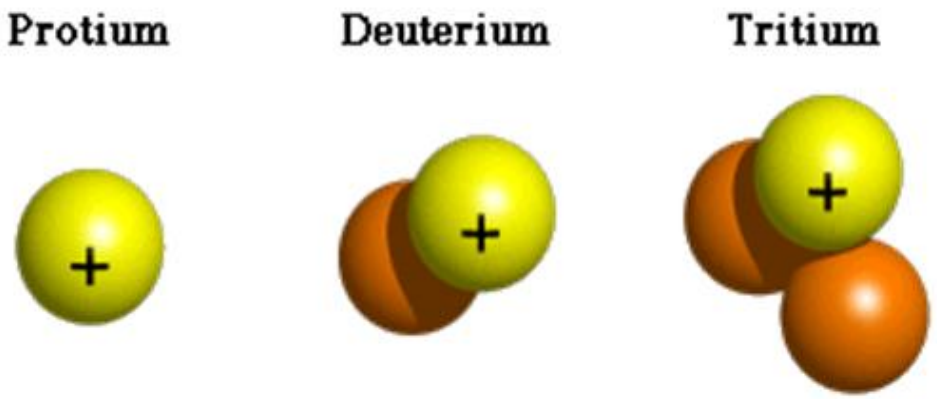
Isotopes

- What is an Isotopes ?

  Isotopes are different types of atoms (nuclides) of the same chemical element, each having a different number of neutrons. In a corresponding manner, isotopes differ in mass number (or number of nucleons) but not in atomic number.

The Nuclei of the Three Isotopes of Hydrogen



Occurrence in nature

- Scientists estimate that the elements that occur naturally on Earth (some only as radioisotopes) occur as 339 isotopes (nuclides) in total Only 256 of these naturally occurring isotopes are stable in the sense of never having been observed to decay as of the present time. All the known stable isotopes occur naturally on Earth; the other 85 naturally occurring isotopes are radioactive, but occur on Earth due to their relatively long half-lives, or else due to other means of ongoing natural production.

Half Life

- Half-life is the period of time it takes for a substance undergoing decay to decrease by half. The name was originally used to describe a characteristic of unstable atoms (radioactive decay), but may apply to any quantity which follows a set-rate decay.

$$t_{1/2} = \frac{\ln(2)}{\lambda} = \tau \ln(2)$$

where..

τ is a positive number called the mean lifetime of the decaying quantity,

λ is a positive number called the decay constant of the decaying quantity.

Applications of Isotopes

- isotopic labeling, the use of unusual isotopes as tracers or markers in chemical reaction.
- radiometric dating: using the known half-life of an unstable element. The most widely known example is radiocarbon dating used to determine the age of carbonaceous materials.
- Isotopic substitution can be used to determine the mechanism of a reaction via the kinetic isotope effect.
- Nuclear power and nuclear weapons development require relatively large quantities of specific isotopes
- Isotope hydrology!

Isotope hydrology

- Isotope hydrology is a field of hydrology that uses isotopic dating to estimate the age and origins of water and of movement within the hydrologic cycle. The techniques are used for water-use policy, mapping aquifers, conserving water supplies, and controlling pollution. It replaces or supplements past methods of measuring rain, river levels and other bodies of water over many decades.

Myth behind Isotope hydrology

- Water molecules carry unique fingerprints, based in part on differing proportions of the oxygen and hydrogen isotopes that constitute all water. Oxygen 18 (^{18}O) occurs in approximately one oxygen atom in every five hundred and is a bit heavier than oxygen 16, as it has two extra neutrons. From a simple energy standpoint this results in a preference for evaporating the lighter ^{16}O containing water and leaving more of the ^{18}O water behind in the liquid state (called fractionation). Thus seawater tends to be richer in ^{18}O and rain and snow relatively depleted in ^{18}O.

- Carbon 14 dating is also used as part of isotope hydrology as all natural water contains dissolved carbon dioxide

Applications in Hydrology

- One commonly cited application involves the use of stable isotopes to determine the age of ice or snow, which can help indicate the conditions of the climate in the past. Higher average global temperature would provide more energy and thus an increase in atmospheric ^{18}O water, while lower than normal amounts of ^{18}O in groundwater or an ice layer would imply that the water or ice represents an evaporation origin during cooler climatic eras or even ice ages.

- Another application involves the separation of ground waterflow and baseflow from streamflow in the field of catchment hydrology (i.e. a method of hydrograph separation). Since precipitation in each rain or snowfall event has a specific isotopic signature, and the signatures of subsurface water can also be identified by well sampling, the composite signature in the stream is an indicator of, at any given time, what portion of the stream flow comes from overland flow and what portion comes from subsurface flow

- The isotope hydrology program at the International Atomic Energy Agency works to aid developing states (including 84 projects in more than 50 countries) and to create a detailed portrait of Earth's water resources. An arsenic pollution crisis in Bangladesh that the World Health Organization calls the "largest mass poisoning of a population in history" has been investigated using this technique.

References

- www.wikipedia.org
- www.iaea.org

Questions

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Thanks