Name: ____ Period:______ Date:____________

Isotopes Guided Notes – Teacher Edition

Definition:
Isotopes are different forms of the same element which have the same number of protons but differ in their number of neutrons. A variation in the number of neutrons in the nucleus causes the atom's mass to change. Many elements on the periodic table have naturally occurring isotopes.

Chemical Properties:
With the exception of hydrogen, the chemical properties of isotopes are very similar, if not identical to one another. This is due to the number of electrons in each isotope of an atom remaining the same. Electrons determine the way an element behaves.

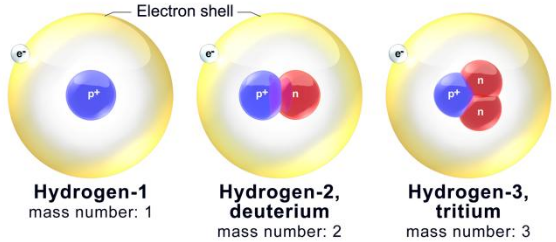
Physical Properties of Isotopes:
The physical properties of isotopes vary to each other since these properties often depend on mass. This difference may be used to separate isotopes of an element from each other by using fractional distillation and diffusion.

Isotope Notation:
There are two ways to write isotopes:

1. Element Name - Mass Number.
   For example, carbon has an isotope with 6 protons and 6 neutrons called carbon-12 or C-12. The isotope of carbon with 6 protons and 7 neutrons is carbon-13 or C-13.

2. The mass number (A) is written in superscript in the upper left corner of an element symbol, while the atomic number (Z) is placed below it. For example, the isotopes of hydrogen are written: ${}^{1}_{1}H, {}^{2}_{1}H, {}^{3}_{1}H$

Isotope Names:
In most cases, the isotopes of an element have the same name and are recognized with a different mass number on the suffix. For example, oxygen has three isotopes – oxygen-16, oxygen-17 and oxygen-18. One exception to this is hydrogen, which has distinct names for each of its three isotopes:



Name: ____ Period:______ Date:____________

Isotopes Guided Notes – Teacher Edition

Stable Isotopes:

The ratio of protons to neutrons in the nucleus of an atom determines its stability. Isotopes which are unstable are radioactive. There are 275 isotopes of the 81 stable elements in the periodic table. In a few cases, stable isotopes are able to undergo radioactive decay; however, this occurs at a very, very slow rate. For example, Bismuth-209 is known to be a stable radioactive isotope. It undergoes alpha-decay but has an extremely long half-life of 1.9×10^{19} years (more than a billion times longer than the estimated age of the universe).

Radioactive Isotopes:

Radioisotopes undergo radioactive decay by emitting, or kicking out, subatomic particles to reach a more stable, lower-energy, configuration. This may lead to a change in the number of protons in the nucleus which then causes the identity of the atom to change (for example, carbon-14 decays to nitrogen-14). The initial isotope is termed the parent isotope and the resulting isotope is called the daughter isotope. For example, when Uranium-238 decays into Thorium-234, the uranium atom is the parent isotope, while the thorium atom is the daughter isotope. In some instances, more than one type of daughter isotope can occur depending on the type of radioactive decay that occurs.

Where do isotopes come from?

Other than via radioactive decay, it has been hypothesized that lighter isotopes came together sometime soon after the Big Bang, while heavier ones were made in the cores of stars. The interaction between cosmic rays and energetic nuclei in the upper-most atmospheric layers can also sometimes lead to the formation of isotopes.

Uses of isotopes

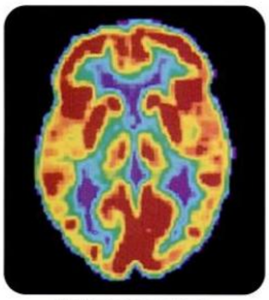
- Isotopes are often used for dating objects e.g. carbon dating. This is possible since unstable isotopes are able to decay into stable ones at a predictable rate (this is known as their half-life).

  For example, the half-life of Carbon-14 (C-14) is 5,730 years. C-14 is originally formed in the atmosphere and is then ingested by living organisms in the form of plant tissue through photosynthesis. An animal ingests about one C-14 atom for every trillion stable C-12 isotopes through the food it eats. While the organism is alive the ratio of C-12 to C-14 remains stable, however once it dies, it stops ingesting C-14. Scientists can use mass spectroscopy to look at how many C-14 atoms a sample has and can, therefore, calculate how far through C-14's half-life it is, which then allows them to calculate an organism's age.

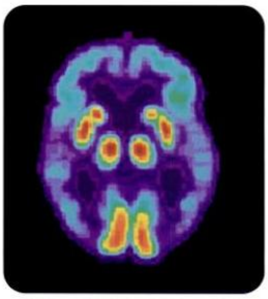
- PET (Positron-emission tomography) scans use the decay of 'medical isotopes' contained in special dyes to look inside the human body. The scan is able to identify differences in tissues

Isotopes Guided Notes – Teacher Edition

at the molecular level and can assist doctors in diagnosing diseases as well as monitor body functions such as blood flow, oxygen usage and the uptake of glucose (sugar) molecules.



PET Scan of Normal Brain



PET Scan of Alzheimer's Disease Brain

https://commons.wikimedia.org/wiki/File:PET_scan-normal_brain-alzheimers_disease_brain.PNG

- Creating 'enriched' materials, such as enriched Uranium, for use in nuclear reactors. This process involves separating naturally-occurring uranium atoms from heavier, more unstable and thus more radioactive isotopes. The metal which has been sifted through for heavier isotopes is called 'depleted uranium'.