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***Radioactive decay and half-lives***

Radioactive decay is the process where the nucleus of an atom changes into another type of nucleus and produces a particle at the same time. Nuclei which change like this are called radioactive or unstable. This change happens to the nucleus of an atom. Most atoms on earth are not radioactive, but atoms with more or less neutrons than a stable atom, that is, different isotopes of the same element, can be radioactive. For example, most carbon atoms in the world have six protons and six neutrons in their nucleus. This carbon is called carbon-12, because 12 is the number of protons and neutrons. Carbon's atomic weight is 12. If two more neutrons are added to carbon-12, it becomes carbon-14. Carbon-14 is still chemically carbon, because carbon is defined by having six protons, which it still does even after the addition of more neutrons. In fact, carbon-14 exists in all living things that contain carbon, such as animals and plants. However, it is radioactive.

Radioactive decay always changes the type of atom from an isotope that has higher energy inside its nucleus to an isotope with lower energy in its nucleus. The difference in energy between the nucleus before and after the decay is given to the particles created in the decay to increase their speed, or kinetic energy. Energy is never created or destroyed in radioactive decay.

Alpha decay, beta decay and gamma decay are the most common types of radioactive decay. They are different from each other because different types of decay produce different particles. The starting radioactive nucleus is called the parent nucleus and the nucleus that it changes into is called the daughter nucleus. The high-energy particles produced by radioactive materials are called radiation.

**Alpha decay**

During alpha decay, the atomic nucleus releases an alpha particle. The nucleus will lose two protons and two neutrons when this happens. After the decay, the atom will change to another element, because the atom loses two protons. For example, if Americium were to go through alpha decay it would change into Neptunium because Neptunium is defined by having two protons fewer than Americium. Alpha decay usually happens in heavy elements, those containing more neutrons and protons, such as uranium, thorium, plutonium, and radium.

Alpha particles cannot even go through a few centimeters of air. Alpha irradiation cannot hurt humans when the alpha source is outside the human body, because human skin does not let the alpha particles go through. Alpha radiation can be very harmful if the source is inside the body, such as when people breathe dust or gas containing materials which decay by emitting alpha particles.

**Beta decay**

There are two kinds of beta decay, beta-plus and beta-minus.In beta-minus decay, the nucleus gives out a negatively charged electron and a neutron changes into a proton: Beta-minus decay happens in nuclear reactors.In beta-plus decay, the nucleus releases a positron, which is like an electron but positively charged, and a proton changes into a neutron: Beta-plus decay happens inside the sun and in some types of particle accelerators.

**Gamma decay**

Gamma decay happens when a nucleus produces a high-energy packet of energy called a gamma ray. Gamma rays do not have electrical charge, but they do have angular momentum. Gamma rays are usually emitted from nuclei immediately after other types of decay. Gamma rays can be used to analyze radioactive materials, to kill bacteria in food, to find some types of disease, and to treat some kinds of cancer. Gamma rays have the highest energy of any electromagnetic wave, and gamma ray bursts in space are the most energetic releases of energy known to people, even more than supernovas.

**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. The original term, dating to 1907, was "half-life period", which was later shortened to "half-life" in the early 1950s.

Half-lives are very often used to describe quantities undergoing exponential decay—for example radioactive decay—where the half-life is constant over the whole life of the decay, and is a characteristic unit (a natural unit of scale) for the exponential decay equation.

**APES Nuclear Decay Half-Life Practice**

1. How many grams of iodine 131 (half-life- 5 days) would be left after 20 days if you start with 25 grams?

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| **Number of half-lives passed** | **Amount of Matter** | **Time** |
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1. How long will it take 600 grams of Plutonium 239 (half-life 24,000 years) to decay to 18.75 grams?
2. K-42 has a half-life of 15.5 hrs. If 13.125g of K-42 remains undecayed after 62.0 hours, what was the original sample size?
3. An isotope of cesium (cesium-137 has a half -life of 30 years. If 20 mg of cesium-137 disintegrates over a period of 90 years, how many mg of cesium-137 would remain?
4. Thallium-208 has a half-life of 3 min. How long will it take for 120.0 g to decay to 7.50 g?
5. If 60 g of Lithium-9 has a half-life of 100 years, how long will it take for lithium-9 to decay to 15 g?

7. Plutonium-239 has a half-life of 24,000 years. How long must it be stored before it will be at a safe level?

8. Iodine-131 has a half-life of 8 days. After 4 half-lives, what fraction of the sample is still radioactive?

9. A bone is found to have only 1/128th of its Carbon-14 remaining. The half-life of Carbon 14 is 5,370 years. How old is that bone?

10. Uranium-235 has a half-life of 710 million years. If the sample is considered safe when it is at .10 percent of the original, how many years would that take?

11. List the fraction amounts for each half-life up to 10 half-lives.