

The dating of older, but nonliving, things is accomplished with radioactive minerals, such as uranium. The naturally occurring isotopes U-238 and U-235 decay very slowly and ultimately become isotopes of lead—but not the common lead isotope Pb-208. For example, U-238 decays through several stages to finally become Pb-206, whereas U-235 finally becomes the isotope Pb-207. Lead isotopes 206 and 207 that now exist were at one time uranium. The older the uranium-bearing rock, the higher the percentage of these remnant isotopes. From the half-lives of uranium isotopes, and the percentage of lead isotopes in uranium-bearing rock, it is possible to calculate the date at which the rock was formed.

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SUMMARY OF TERMS (KNOWLEDGE)

X-ray Electromagnetic radiation of higher frequencies than ultraviolet; emitted by electron transitions to the lowest energy states in atoms.

Radioactivity The spontaneous emission of energetic particles by an atomic nucleus.

Alpha ray A stream of alpha particles (helium nuclei) ejected by certain radioactive elements.

Beta ray A stream of electrons (or positrons) emitted during the radioactive decay of certain nuclei.

Gamma ray High-frequency electromagnetic radiation emitted by the nuclei of radioactive atoms.

Rad The acronym (*radiation absorbed dose*) for a unit of absorbed energy. One rad is equal to 0.01 J of energy absorbed per kilogram of tissue.

Rem The acronym (*roentgen equivalent man*) for a unit used to measure the effect of ionizing radiation on humans.

Nucleon A nuclear proton or neutron; the collective name for either or both.

Quarks The elementary constituent particles or building blocks of nuclear matter.

Strong force The force that attracts nucleons to each other within the atomic nucleus; a force that is very strong at close distances and greatly weakens as distance increases.

Half-life The time required for half the atoms in a sample of a radioactive isotope to decay.

Transmutation The conversion of an atomic nucleus of one element into an atomic nucleus of another element through a loss or gain in the number of protons.

Carbon dating The process of determining the time that has elapsed since death by measuring the radioactivity of carbon from a sample due to the carbon-14 it contains.

READING CHECK QUESTIONS (COMPREHENSION)

33.1 X-Rays and Radioactivity

1. What did Roentgen discover about a cathode-ray beam striking a glass surface?
2. What kind of rays are X-rays?
3. What did the Becquerel discover about uranium?
4. What two elements did Pierre and Marie Curie discover?

33.2 Alpha, Beta, and Gamma Rays

5. Why aren't gamma rays deflected in a magnetic field?
6. Which has the higher frequency: X-rays or gamma rays?

33.3 Environmental Radiation

7. Distinguish between a rad and a rem.
8. Do humans receive more radiation from artificial or from natural sources of radiation?
9. Is the human body radioactive? Explain.
10. What is a radioactive tracer?

33.4 The Atomic Nucleus and the Strong Force

11. Name the two different nucleons.
12. Why doesn't the repulsive electrical force of protons in the atomic nucleus cause the protons to fly apart?
13. Why is a larger nucleus generally less stable than a smaller nucleus?
14. What is the role of neutrons in the atomic nucleus?
15. Which contains the higher percentage of neutrons: large nuclei or small nuclei?

33.5 Radioactive Half-Life

16. How does the rate of decay of a long-half-life material normally compare with the rate of decay of a short-half-life material?
17. What is the half-life of Ra-226?

33.6 Radiation Detectors

18. What kind of trail is left when an energetic particle shoots through matter?