

What are Nuclear Reactions and Decay?

Worksheet

Radioactive decay follows $N(t) = N_0 (1/2)^{(t/t_{1/2})}$, where N_0 is initial nuclei, t is time, and $t_{1/2}$ is half-life. Each decay type (α , β , γ) involves different particles and conserves mass and charge numbers.

$$N(t) = N_0 (1/2)^{(t/t_{1/2})}$$

Questions

- After 3 half-lives, what percentage of the original sample remains?
A) 50%
B) 25%
C) 12.5%
D) 6.25%
- In alpha decay, what is emitted?
A) An electron
B) A positron
C) A helium nucleus
D) A gamma ray
- If a sample's half-life is 10 days and you start with 1000 nuclei, how many remain after 30 days?
A) 250 nuclei
B) 125 nuclei
C) 500 nuclei
D) 100 nuclei
- What is conserved in all nuclear reactions?
A) Kinetic energy only
B) Mass number and atomic number
C) Velocity of particles
D) Temperature
- Carbon-14 has a half-life of 5,730 years. A fossil contains 12.5% of its original C. How old is it?
- A sample starts with 8,000 nuclei. After 20 days, 500 remain. Find the half-life.
- Uranium-235 has a half-life of 704 million years. What fraction decays in 1 million years?
- Define: What is half-life?
- Define: What are the three main types of radioactive decay?
- Define: What is the decay equation?

Answer Key

1. C) $12.5\% - (1/2) = 1/8 = 0.125 = 12.5\%$. After each half-life, the amount halves.
2. C) A helium nucleus - Alpha decay emits an alpha particle, which is a helium-4 nucleus (He).
3. B) 125 nuclei - 30 days = 3 half-lives. $(1/2)^3 1000 = 1/8 1000 = 125$ nuclei.
4. B) Mass number and atomic number - Mass number (total nucleons) and atomic number (protons) are conserved in all nuclear reactions, by the nuclear conservation laws.
5. $12.5\% = 1/8$ of original $(1/2)^3 = 1/8$ So the sample has gone through 3 half-lives. Age = $3 \times 5,730 = 17,190$ years.
6. Use $N(t) = N_0 (1/2)^{(t/t_{1/2})}$ $500 = 8000 (1/2)^{(20/t)}$ $0.0625 = (1/2)^{(20/t)}$ $(1/2)^4 = (1/2)^{(20/t)}$ $4 = 20/t$ $t = 5$ days
7. $N(t)/N_0 = (1/2)^{(1,000,000 / 704,000,000)} = (1/2)^{(0.00142)}$ 0.9990 About 99.9% remains; only 0.1% ($1/1000$) decays in 1 million years.
8. The time required for a radioactive sample to decay to half its original amount. After one half-life, 50% of nuclei remain; after two, 25%; after three, 12.5%.
9. Alpha (α): helium nucleus (He) emitted. Beta (β^-): electron (e^-) or positron (β^+) emitted. Gamma (γ): high-energy photon emitted.
10. $N(t) = N_0 (1/2)^{(t/t_{1/2})}$, describing exponential decay. $N(t)$ = remaining nuclei, N_0 = initial, t = time, $t_{1/2}$ = half-life.

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