LESSON MAKER PRO

Decay Detectives

Balance nuclear equations to identify what escapes.

HIGH SCHOOL · PS.4.f

PS.4.f "Use mathematics and computational thinking to identify types of radioactive decay based on balanced chemical equations, penetrating power, identity of emitted particles, and charge."

NAME _____ DATE _____

BALANCE BOTH NUMBERS

In a nuclear equation, the mass numbers balance, and the atomic numbers balance separately. An alpha particle is $^{4}_{2}He$ with charge +2, a beta-minus particle is $^{0}_{-1}e$ with charge -1, and a positron is $^{0}_{+1}e$ with charge +1. Gamma radiation has no mass number or charge; alpha is stopped most easily, while gamma generally penetrates farthest.

WORKED EXAMPLE

Identify x in $^{148}_{64}Gd \rightarrow {}^{144}_{62}Sm + x$.

1. Balance mass numbers: 148 - 144 = 4.
2. Balance atomic numbers: 64 - 62 = 2.
3. The particle with mass number 4 and atomic number 2 is $^{4}_{2}He$.

Answer: x is an alpha particle, $^{4}_{2}He$.

PRACTICE 6 problems

1 Identify x in $^{238}_{92}U \rightarrow {}^{234}_{90}Th + x$. Name the decay type and give the emitted particle's charge.

ANSWER _____

2 Identify x in $^{32}_{15}P \rightarrow {}^{32}_{16}S + x$. Name the decay type and give the emitted particle's charge.

ANSWER _____

3 Identify x in $^{18}_{9}F \rightarrow {}^{18}_{8}O + x$. Name the decay type and give the emitted particle's charge.

ANSWER _____

4 The * marks an excited nucleus. Identify x in $^{99}_{43}Tc^{*} \rightarrow {}^{99}_{43}Tc + x$. Which type of emission is it, and how does its penetrating power compare with alpha and beta radiation?

ANSWER _____

5 Find x in $^{131}_{53}I \rightarrow {}^{131}_{x}Xe + {}^{0}_{-1}e$. Name the decay type.

ANSWER _____

6 Find x in $^{226}_{88}Ra \rightarrow {}^{x}_{86}Rn + {}^{4}_{2}He$. Name the decay type.

ANSWER _____

APPLY IT Show your work

1 A PET scanner can use carbon-11 as a tracer. Its decay equation is $^{11}_{6}C \rightarrow {}^{11}_{5}B + x$. Identify the particle emitted directly by the nucleus and give its charge.

WORK SPACE

ANSWER _____

2 An ionization smoke alarm contains americium-241. Its decay equation is $^{241}_{95}Am \rightarrow {}^{237}_{93}Np + x$. Identify x and its charge. The table shows extra detector counts through different barriers. Which listed barrier stops this emission while using the least material?

EXTRA DETECTOR COUNTS IN 1 MINUTE

Barrier	Extra counts
None	100
Paper	0
Aluminum	0
Thick lead	0

ANSWER _____

CHALLENGE One step up

A decay chain has two steps: $^{212}_{83}Bi \rightarrow {}^{212}_{84}Po + x$, then $^{212}_{84}Po \rightarrow {}^{208}_{82}Pb + y$. Identify x and y, give each one's charge, and explain which emitted particle generally penetrates farther through matter.

WORK SPACE AND ANSWER

Decay Detectives

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	Identify x in $^{238}_{92}U \rightarrow {}^{234}_{90}Th + x$. Name the decay type and give the emitted particle's charge.	**Alpha decay; x = $^{4}_{2}He$; charge +2.**
2	Identify x in $^{32}_{15}P \rightarrow {}^{32}_{16}S + x$. Name the decay type and give the emitted particle's charge.	**Beta-minus decay; x = $^{0}_{-1}e$; charge -1.**
3	Identify x in $^{18}_{9}F \rightarrow {}^{18}_{8}O + x$. Name the decay type and give the emitted particle's charge.	**Positron emission, also called beta-plus decay; x = $^{0}_{+1}e$; charge +1.**
4	The * marks an excited nucleus. Identify x in $^{99}_{43}Tc^* \rightarrow {}^{99}_{43}Tc + x$. Which type of emission is it, and how does its penetrating power compare with alpha and beta radiation?	**Gamma emission; x = $^{0}_{0}\gamma$. Gamma generally penetrates farther than alpha or beta radiation.**
5	Find x in $^{131}_{53}I \rightarrow {}^{131}_{x}Xe + {}^{0}_{-1}e$. Name the decay type.	**x = 54; beta-minus decay.**
6	Find x in $^{226}_{88}Ra \rightarrow {}^{x}_{86}Rn + {}^{4}_{2}He$. Name the decay type.	**x = 222; alpha decay.**

PART 2 · APPLY IT

1. **A positron, $^{0}_{+1}e$; charge +1.** The mass number stays 11, so x has mass number 0. The atomic number drops from 6 to 5, so x has atomic number +1.
2. **x is an alpha particle, $^{4}_{2}He$, with charge +2. Paper is the least substantial listed barrier that stops it.** Subtract the daughter numbers from the parent numbers: 241 - 237 = 4 and 95 - 93 = 2. The table shows zero extra counts with paper, so a thicker barrier is unnecessary.

CHALLENGE

x is a beta-minus particle, $^{0}_{-1}e$, with charge -1. y is an alpha particle, $^{4}_{2}He$, with charge +2. Beta-minus radiation generally penetrates farther than alpha radiation. In the first step, the mass number is unchanged and the atomic number rises by 1; in the second, both numbers drop by the amounts carried by an alpha particle.

Accept beta particle or electron for beta-minus, and beta-plus for positron emission. A charge stated in units of the elementary charge is equivalent.