Name: ______________________ Date: __________

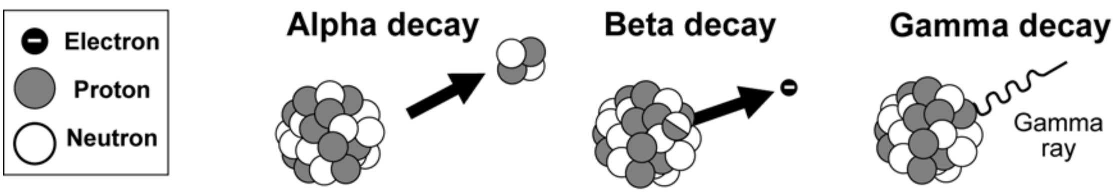
Skill and Practice

10F Radioactivity

Read:

There are three main types of radiation that involve the decay of the nucleus of an atom:

- **alpha radiation** (α): release of a helium-4 nucleus (two protons and two neutrons). We can represent helium-4 using isotope notation: ${}^{4}_{2}\mathrm{He}$. The top number, 4, represents the mass number, and the bottom number represents the atomic number for helium, 2.
- **beta radiation** (β): release of an electron.
- **gamma radiation** (γ): release of an electromagnetic wave.



Protons	Decrease by 2	Increase by 1	Unchanged
Neutrons	Decrease by 2	Decrease by 1	Unchanged

Example:

Half-life

The time it takes for half of the atoms in a sample to decay is called the half-life. Four kilograms of a certain substance undergo radioactive decay. Let's calculate the amount of substance left over after 1, 2, and 3 half-lives.

- After one half-life, the substance will be reduced by half, to 2 kilograms.
- After two half-lives, the substance will be reduced by another half, to 1 kilogram.
- After three half-lives, the substance will be reduced by another half, to 0.5 kilogram.

So, if we start with a sample of mass *m* that decays, after a few half-lives, the mass of the sample will be:

Number of half-lives	Mass left	
1	$\frac{1}{2^1}m =$	$\frac{1}{2}m$
2	$\frac{1}{2^2}m =$	$\frac{1}{4}m$
3	$\frac{1}{2^3}m =$	$\frac{1}{8}m$
4	$\frac{1}{2^4}m =$	$\frac{1}{16}m$

Practice:

1. The decay series for uranium-238 and plutonium-240 are listed below. Above each arrow, write "a" for alpha decay or "b" for beta decay to indicate which type of decay took place at each step.

a. $^{238}_{92}U \rightarrow ^{234}_{90}Th \rightarrow ^{234}_{91}Pa \rightarrow ^{234}_{92}U \rightarrow ^{230}_{90}Th \rightarrow$

$^{226}_{88}Ra \rightarrow ^{222}_{86}Rn \rightarrow ^{218}_{84}Po \rightarrow ^{214}_{82}Pb \rightarrow ^{214}_{83}Bi \rightarrow$

$^{214}_{84}Po \rightarrow ^{210}_{82}Pb \rightarrow ^{210}_{83}Bi \rightarrow ^{210}_{84}Po \rightarrow ^{206}_{82}Pb$

b. $^{240}_{94}Pu \rightarrow ^{240}_{95}Am \rightarrow ^{236}_{93}Np \rightarrow ^{232}_{91}Pa \rightarrow ^{232}_{92}U \rightarrow$

$^{228}_{90}Bi \rightarrow ^{224}_{88}Ra \rightarrow ^{224}_{89}Ac \rightarrow ^{220}_{87}Fr \rightarrow ^{216}_{85}At \rightarrow$

$^{212}_{83}Bi \rightarrow ^{212}_{84}Po \rightarrow ^{208}_{82}Pb \rightarrow ^{208}_{83}Bi$

2. Fluorine-18 ($^{18}_{9}F$) has a half-life of 110 seconds. This material is used extensively in medicine. The hospital laboratory starts the day at 9 a.m. with 10 grams of $^{18}_{9}F$.

   a. How many half-lives for fluorine-18 occur in 11 minutes (660 seconds)?

   b. How much of the 10-gram sample of fluorine-18 would be left after 11 minutes?

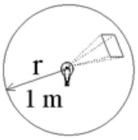
3. The isotope $^{14}_{6}C$ has a half-life of 5,730 years. What is the fraction of $^{14}_{6}C$ in a sample with mass, *m*, after 28,650 years?

4. What is the half-life of this radioactive isotope that decreases to one-fourth its original amount in 18 months?

5. This diagram illustrates a formula that is used to calculate the intensity of radiation from a radioactive source. Radiation "radiates" from a source into a spherical area. Therefore, you can calculate intensity using the area of a sphere ($4\pi r^2$). Use the formula and the diagram to help you answer the questions below.

Intensity

Intensity (W/m²) $I = \frac{P}{A}$ Power (W) / Area (m²)



Area, $A = 4\pi r^2 = 12.6 \text{ m}^2$

Intensity, $I = \frac{100 \text{ W}}{12.6 \text{ m}^2} = 7.96 \text{ W/m}^2$

a. A radiation source with a power of 1,000. watts is located at a point in space. What is the intensity of radiation at a distance of 10. meters from the source?

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b. The fusion reaction ${}^{2}_{1}\text{H} + {}^{3}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + n + \text{energy}$ releases 2.8×10^{-12} joules of energy. How many such reactions must occur every second in order to light a 100-watt light bulb? Note that one watt equals one joule per second.
