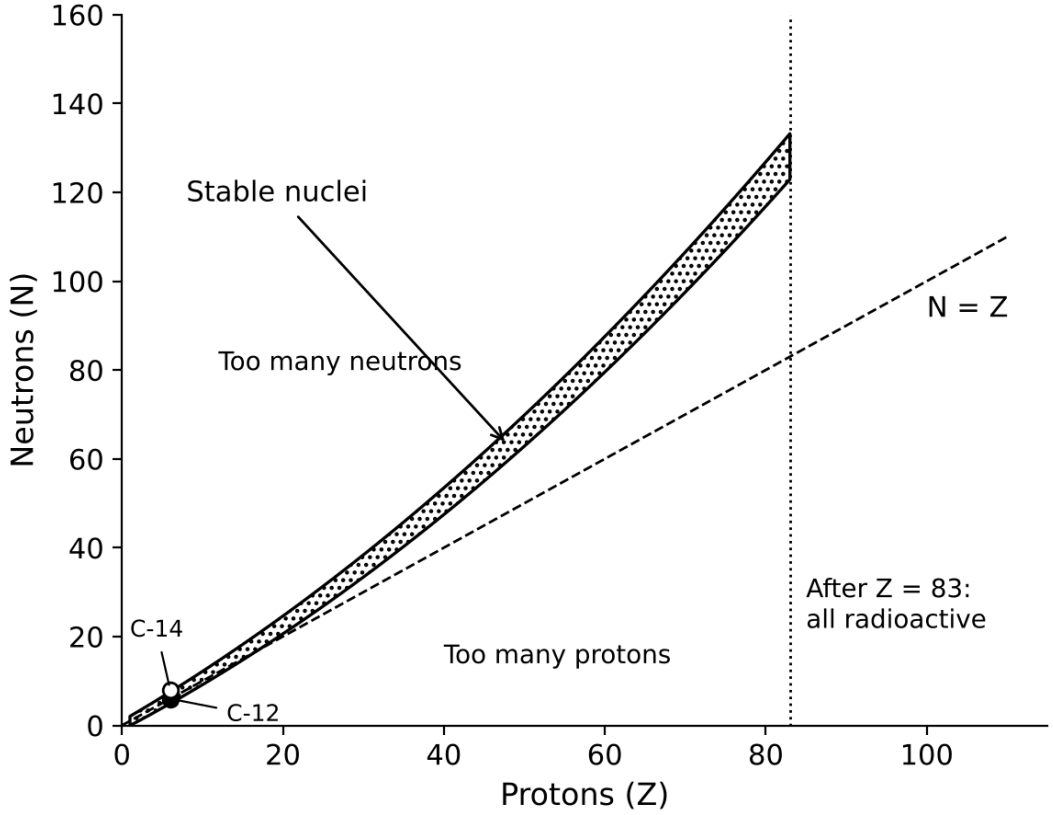
Essential Question

How can changes in the nucleus release energy that people use?

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Stable and Unstable Nuclei

- Protons repel each other
- The strong force holds the nucleus together
- Large nuclei need more neutrons
- After Z = 83, every isotope is radioactive



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Three Kinds of Radioactive Decay

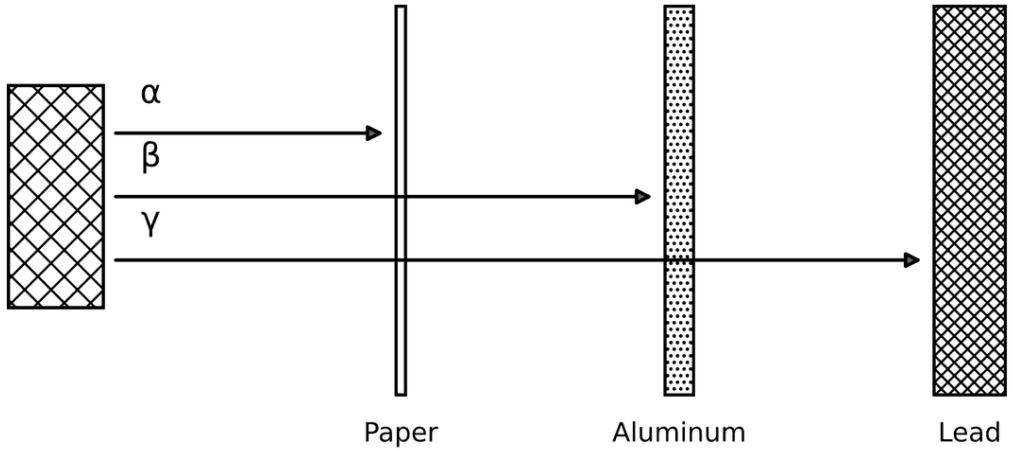
- An unstable nucleus gives off radiation
- The nucleus changes as it decays

Decay	Particle	Symbol	Charge
Alpha	Helium-4 nucleus	$^{4}_{2}\mathrm{He}$	2+
Beta	Fast electron	$^{0}_{-1}\mathrm{e}$	1−
Gamma	High-energy light	$^{0}_{0}\gamma$	0

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Stopping Radiation

- Alpha: stopped by paper
- Beta: stopped by aluminum
- Gamma: needs thick lead
- Safety: distance, shielding, short time



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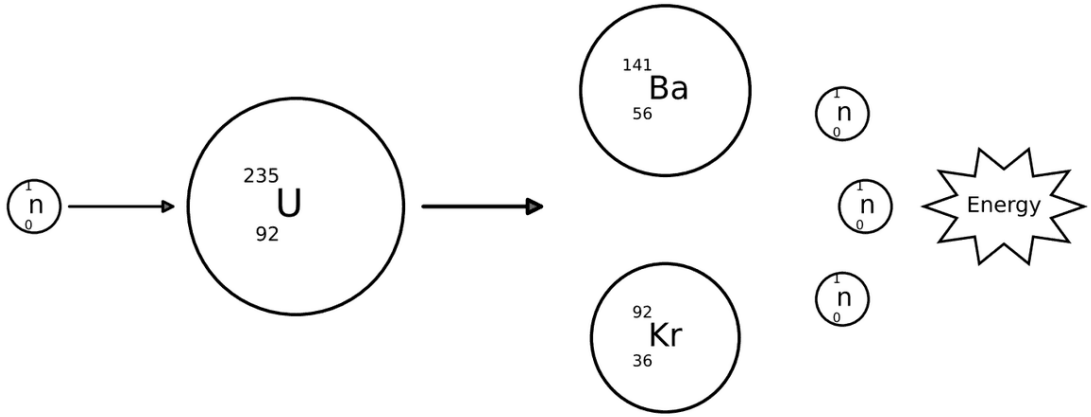
Balancing Nuclear Equations

- Top numbers (mass numbers) add up on both sides
- Bottom numbers (atomic numbers) add up on both sides
- Alpha: mass − 4, atomic number − 2
- Beta: same mass, atomic number + 1

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Fission

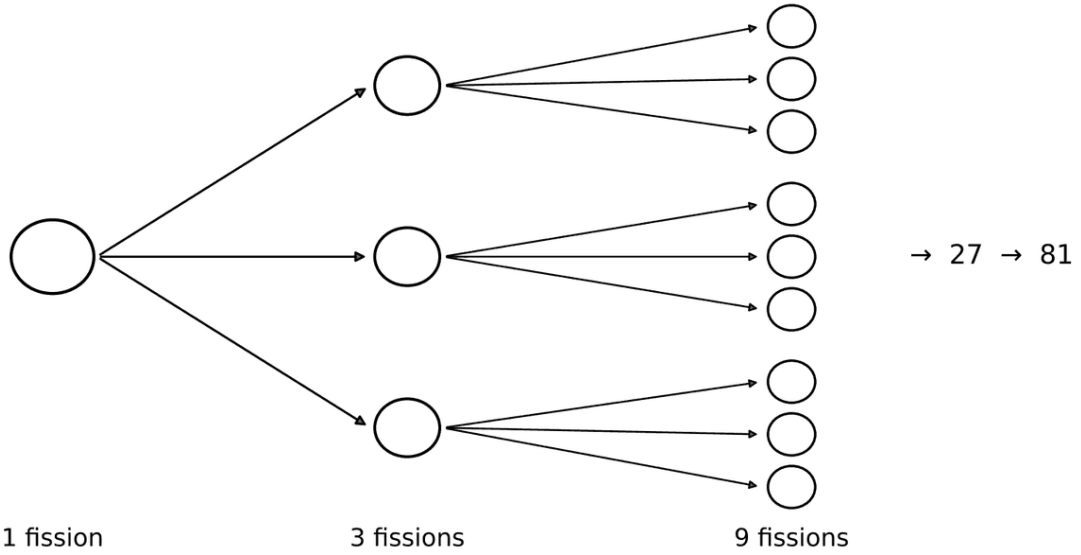
- A large nucleus splits in two
- A neutron starts it
- Releases neutrons and energy



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Chain Reactions

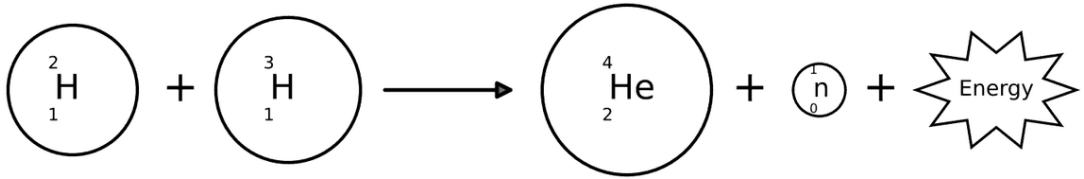
- Each fission releases 2 or 3 neutrons
- Each neutron can split another nucleus
- Control rods absorb extra neutrons



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Fusion

- Two small nuclei join
- Needs millions of degrees
- Powers the sun



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Nuclear vs. Chemical Energy

- Chemical changes rearrange electrons
- Nuclear changes rearrange protons and neutrons
- One fission: about 50 million times the energy of burning one carbon atom
- Used fuel stays radioactive for thousands of years

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Uses of Nuclear Changes

- Electricity from fission
- Sunlight from fusion
- Medical imaging and cancer treatment
- Smoke detectors and carbon-14 dating

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Example: Alpha Decay

Radium-226, $^{226}_{88}Ra$, undergoes alpha decay. Write the nuclear equation and identify the new element.

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Example: Beta Decay

Carbon-14, $^{14}_{6}C$, undergoes beta decay. What does it become?

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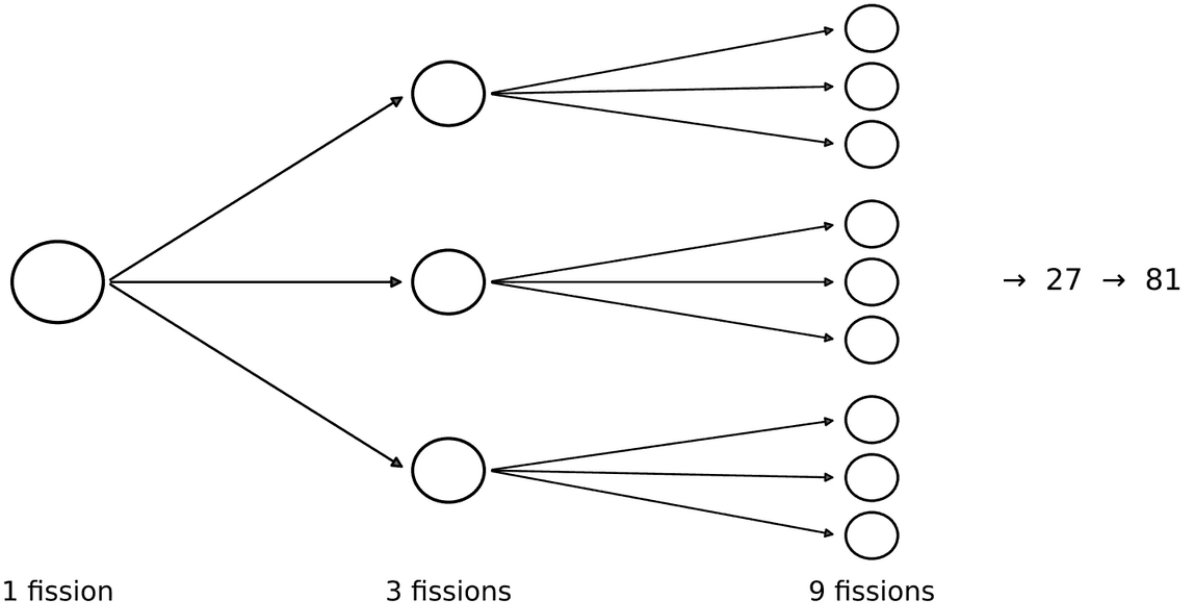
Example: Fission or Fusion?

Classify each reaction. (a) ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{94}_{38}Sr + {}^{140}_{54}Xe + 2\ {}^{1}_{0}n$ (b) ${}^{3}_{2}He + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + 2\ {}^{1}_{1}H$

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Example: Controlling a Chain Reaction

Explain why a fission chain reaction must be controlled in a power plant.



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Big Ideas

- An unstable nucleus changes by radioactive decay
- Mass numbers and atomic numbers balance in a nuclear equation
- Fission splits a large nucleus; fusion joins small nuclei
- Nuclear changes release millions of times more energy than chemical changes

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