Inside the Nucleus

Trace how competing forces shape nuclear stability and decay.

HS-PSII-10.2 "Explain the stability of the nucleus considering the electromagnetic repulsion in the nucleus and how forces govern binding energy and radioactive decay for different elements."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline statements about electric repulsion, circle statements about the strong nuclear force, and number the two decay paths. Use your marks to trace how forces and energy affect stability.

Why Some Nuclei Change

1. In a smoke detector, a tiny sample of americium releases alpha particles. Inside each americium nucleus, positively charged protons repel one another through the electromagnetic force. Yet protons and neutrons can remain together because the strong nuclear force attracts nearby nucleons, the particles in the nucleus. This attraction acts across a very short distance. Neutrons add strong-force attraction without adding electric repulsion. A nucleus stays intact when its forces and energy favor a bound arrangement.

2. For small nuclei, roughly equal numbers of protons and neutrons often produce stable arrangements. As proton number rises, repulsion increases, so many stable heavier nuclei need more neutrons than protons. Adding neutrons cannot solve every problem: the strong force reaches only nearby nucleons, while electric repulsion acts across the nucleus. Binding energy is the energy needed to pull a nucleus apart. A more tightly bound arrangement is generally harder to disrupt, but binding energy alone does not predict every decay.

3. If a nucleus can move to a lower-energy arrangement by emitting particles or radiation, it may decay. A very heavy nucleus may emit an alpha particle, which contains two protons and two neutrons, reducing its size and charge. A neutron-rich nucleus may undergo beta-minus decay: one neutron becomes a proton, and an electron and an antineutrino leave. Decay occurs only when the change is energetically allowed; a favorable change does not reveal exactly when one nucleus will decay.

2 ANSWER WITH EVIDENCE

Use the passage

1. How can neutrons help hold a nucleus together without increasing electric repulsion?

2. Why do many stable heavier nuclei need more neutrons than stable small nuclei?

3. A nucleus with 90 protons emits an alpha particle. How many protons remain, and why might this decay occur?

4. In beta-minus decay, how do a nucleus's proton and neutron counts change? What energy condition must be met?

3 YOUR TURN

Your own words

Two oxygen nuclei each have 8 protons. One has 8 neutrons; the other has 14. In three or four sentences, identify which is more likely to be unstable and explain a possible decay using forces and energy.

ANSWER KEY

Inside the Nucleus

PART 1 · READ AND MARK

Underline statements about electric repulsion, circle statements about the strong nuclear force, and number the two decay paths. Use your marks to trace how forces and energy affect stability. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	How can neutrons help hold a nucleus together without increasing electric repulsion?	**Neutrons contribute to strong-force attraction but have no positive charge, so they do not add proton repulsion.**
2	Why do many stable heavier nuclei need more neutrons than stable small nuclei?	**More protons create more electric repulsion. Extra neutrons add strong-force attraction without adding repulsion.**
3	A nucleus with 90 protons emits an alpha particle. How many protons remain, and why might this decay occur?	**It has 88 protons. Losing two protons reduces electric repulsion, and the decay can occur if the resulting arrangement is lower in energy.**
4	In beta-minus decay, how do a nucleus's proton and neutron counts change? What energy condition must be met?	**The proton count rises by one and the neutron count falls by one. The decay must be energetically allowed.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The oxygen nucleus with 8 protons and 14 neutrons is more likely to be unstable than the one with 8 protons and 8 neutrons. Neutrons add strong-force attraction without adding electric repulsion, but too many neutrons can make a different arrangement lower in energy. The neutron-rich nucleus can undergo beta-minus decay, changing a neutron into a proton, because this change is energetically allowed.

Accept explanations that distinguish short-range strong-force attraction from electric repulsion. For the open task, accept beta-minus decay for the neutron-rich oxygen nucleus; students should not claim that neutron count alone determines every nucleus's stability.