Nuclear Chemistry and Radiation **Name**_____

Nuclear Decay

Read from **Lesson 1: Nuclear Decay** in the **Chemistry Tutorial** Section**, Chapter 19** of **The Physics Classroom**:
Part a: Nuclear Decay Processes Part b: Balancing Nuclear Equations
Part c: Nuclear Stability and Instability

Part 1. Introduction to Nuclear Chemistry

- Nuclear chemistry focuses on changes occurring **within the nucleus**—not the electrons.
- Chemical reactions rearrange electrons; **nuclear reactions change the identity of the atom**.
- Stability depends on the **neutron-to-proton ratio (N/Z)**.
- Unstable nuclei undergo **radioactive decay**, emitting particles or electromagnetic radiation to become more stable.

1. Isotopes & Radioisotopes

- **Isotopes**: atoms of the same element with different numbers of neutrons.
- **Stable isotopes**: do not decay.
- **Radioisotopes**: unstable; undergo spontaneous nuclear decay.

2. Types of Radioactive Particles and Decay

Decay / Particle Type	Symbol	Description	Relative Mass	Charge	Ionizing Capability	Penetrating Ability	Δ Atomic #	Δ Mass #
Alpha α	$^{4}_{2}\text{He}$	Emission of a helium nucleus ($2\ p^+, 2\ n^0$)	Large	+2	High	Low	Decrease by 2	Decrease by 4
Beta β^-	$^{0}_{-1}\text{e}$	A neutron converts to a proton; emits a high-speed electron	Negligible	−1	Medium	Medium	Increase by 1	No Change
Gamma γ	$^{0}_{0}\gamma$	Excited nucleus emits electro-magnetic radiation	None	0	Low	High	No Change	No Change
Positron Emission (β^+)	$^{0}_{1}\text{e}$	A proton converts to a neutron; emits a positron	Negligible	+1	Medium	Medium	Decrease by 1	No Change
Electron Capture		A proton captures an inner-shell electron and becomes a neutron					Decrease by 1	No Change

3. Balancing Nuclear Equations

- Nuclear equations must obey **conservation laws: mass number (A)** conserved and a**tomic number (Z)** conserved.
- Process:
  - Write known particles/isotopes.
  - Use A and Z to determine missing species.
  - Identify element using periodic table.

  Example (β decay of C-14): $^{14}_{6}\text{C} \rightarrow {}^{14}_{7}\text{N} + {}^{0}_{-1}\text{e}$

Nuclear Chemistry and Radiation

Part 1 Questions

1. Write the isotope symbol for the following isotopes and then identify the number of protons and neutrons in each.

   a. nitrogen-15

   b. cobalt-60

   c. plutonium-240

   d. iodine-131

2. Use appropriate isotope symbols and particle symbols to write balanced nuclear equations from the following word equations.

   a. Actinium-225 emits an alpha particle.

   b. Iodine-131 undergoes beta decay.

   c. A potassium-40 nucleus undergoes electron capture.

   d. Decay of phosphorus-30 by positron emission.

   e. A decay series begins with thorium-232 and ends with lead-208.
   - Write the **six alpha decay equations** starting with thorium-232.
   - Then write the **beta decay equations** needed to reach lead-208.
   - Determine the **number of beta emissions** required.

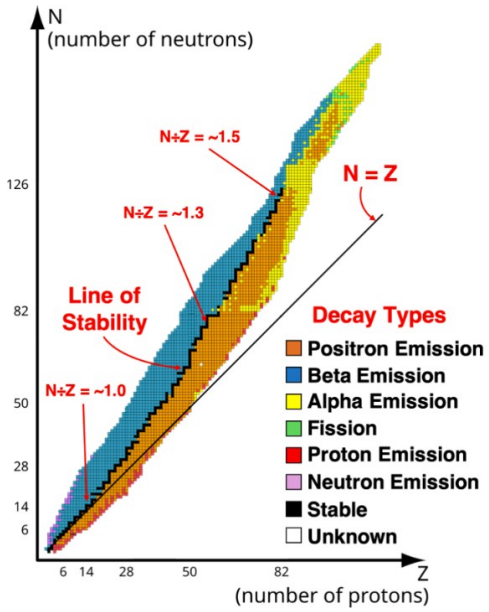
Part 2. Nuclear Stability

1. Nuclide Chart(as shown)

- A plot of the number of neutrons (**N**) vs. the number of protons (atomic number, **Z**) for the known isotopes.
- The **band of stability** shows where stable nuclei lie based on their N/Z ratio.
- **Above the band:** Too many neutrons → **beta decay**
- **Below the band:** Too many protons → **positron emission or electron capture**
- **Very heavy nuclei:** Often undergo **alpha decay**
- **No stable isotopes exist for Z ≥ 83**

2. Magic Numbers

Nuclei with **2, 8, 20, 28, 50, 82, 126** protons or neutrons are unusually stable.



Band of Stability Image from PC Study Card

Questions

Using the Band of Stability diagram provided, classify each of the following nuclei according to the type of radioactive emission they undergo: none, alpha decay, beta decay, or positron emission
Explain your reasoning and then write the balanced nuclear equation for each radioactive nucleus.

Nucleus	Predicted emission	Reason (Using Band of Stability)	Nuclear equation
Gold-201			
Strontium-83			
Plutonium-242			
Calcium-40			
Boron-11			
Copper-68			
Chlorine-39			
Americium-241			