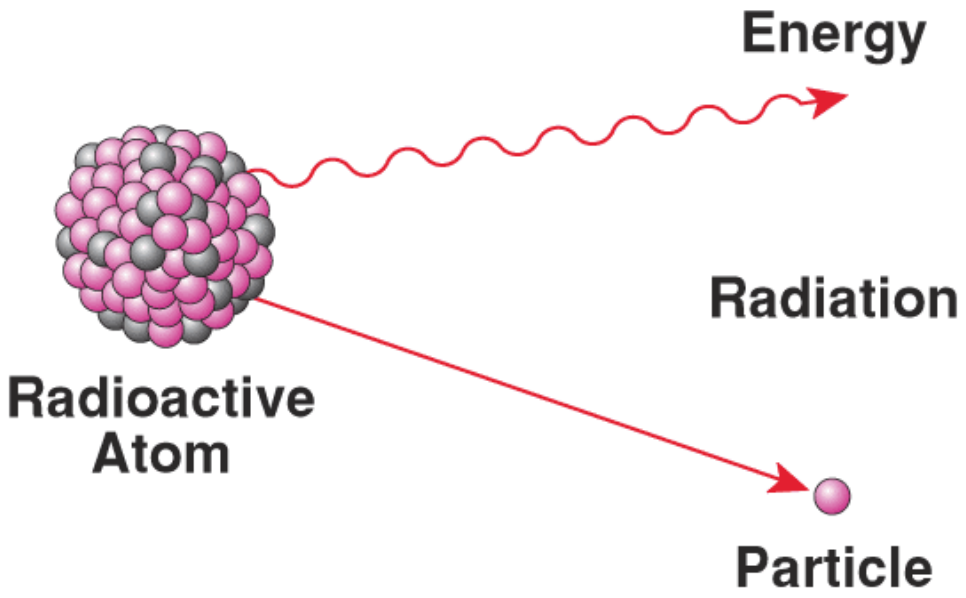
NOTES: 25.1 - Nuclear Chemistry & Types of Radiation

$\alpha \ \beta \ \gamma$

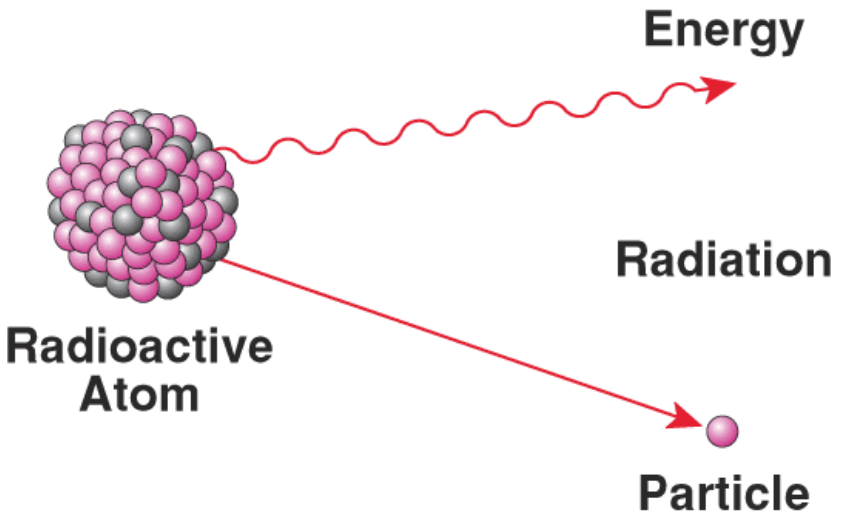
NUCLEAR CHEMISTRY:

- branch of chemistry dealing with the **decay of unstable isotopes** to form a stable nucleus



Nuclear Reactions:

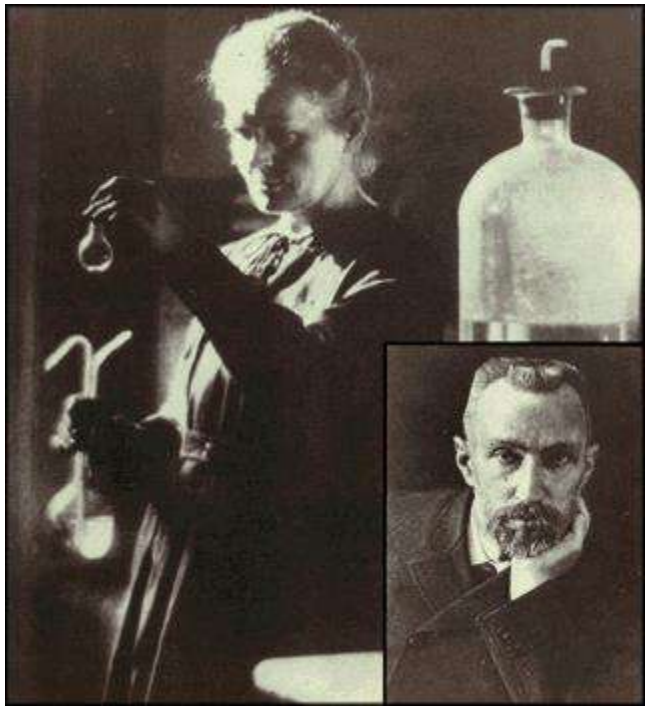
- Involve changes in the composition of nuclei
- Accompanied by the release of tremendous amounts of energy



FYI: Historical Perspective

- **Henri Becquerel**
- 1896 - Discovers natural radioactivity

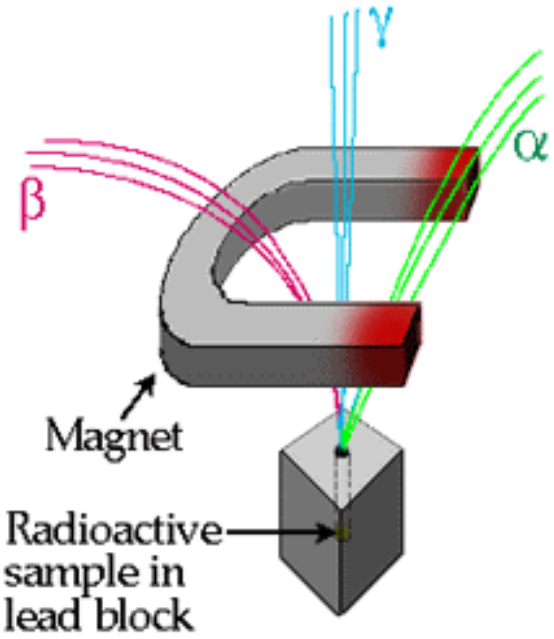
FYI: Historical Perspective



- **Marie Sklodowska,** Polish chemist marries **Pierre Curie,** French physicist
- Marie died from leukemia caused by her exposure to radiation (1934)
- Pierre was killed while crossing the street when he was hit by a vegetable wagon in 1906
- with Becquerel, they won the Nobel Prize in 1903

FYI: Historical Perspective

- **Ernest Rutherford**
- 1899 – Discovers alpha, beta and gamma radiation



RADIATION:

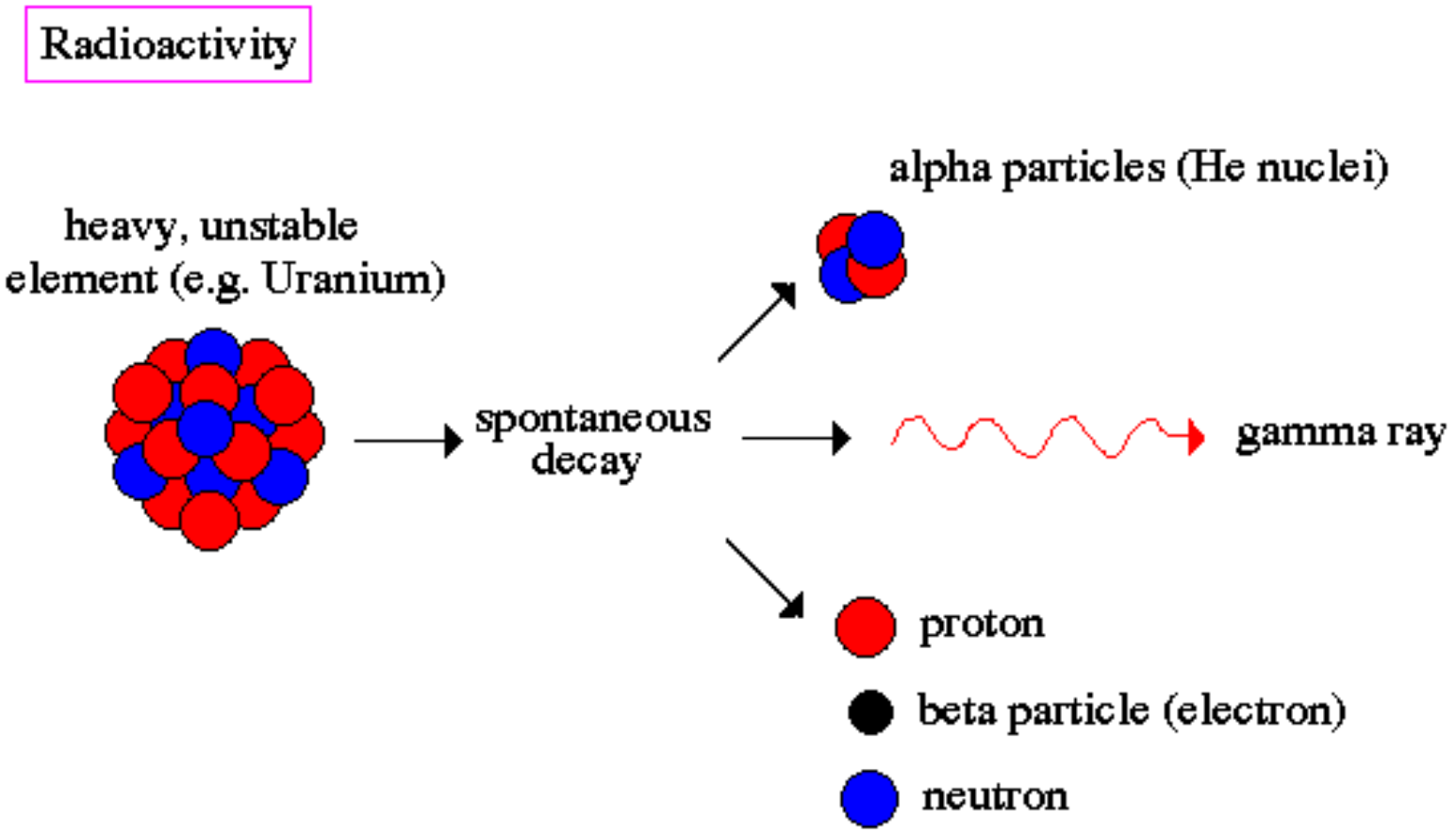
- The penetrating rays and particles emitted by a radioactive source
- **Radioactive decay** – the spontaneous emission of radiation by an unstable nucleus; the rate of decay is unaffected by temperature, pressure, or catalyst
- **Radioisotope** – an isotope that has an unstable nucleus and undergoes radioactive decay

The neutron-to-proton ratio determines the stability of the nucleus:

- **For low atomic #'s**: equal #'s of protons and neutrons

- **Above atomic #20**: more neutrons than protons

Nuclei whose neutron-to-proton ratio is unstable undergo radioactive decay by emitting 1 or more particles and/or electromagnetic rays:



Types of Radiation:

Type:	Alpha	Beta	Gamma
Composition	Alpha Particle (helium nucleus)		
Symbol	α, ^{4}He		
Charge	2+		
Mass	4		
Penetrating Power	Low (0.05 mm)		
Shielding	Paper, clothing		

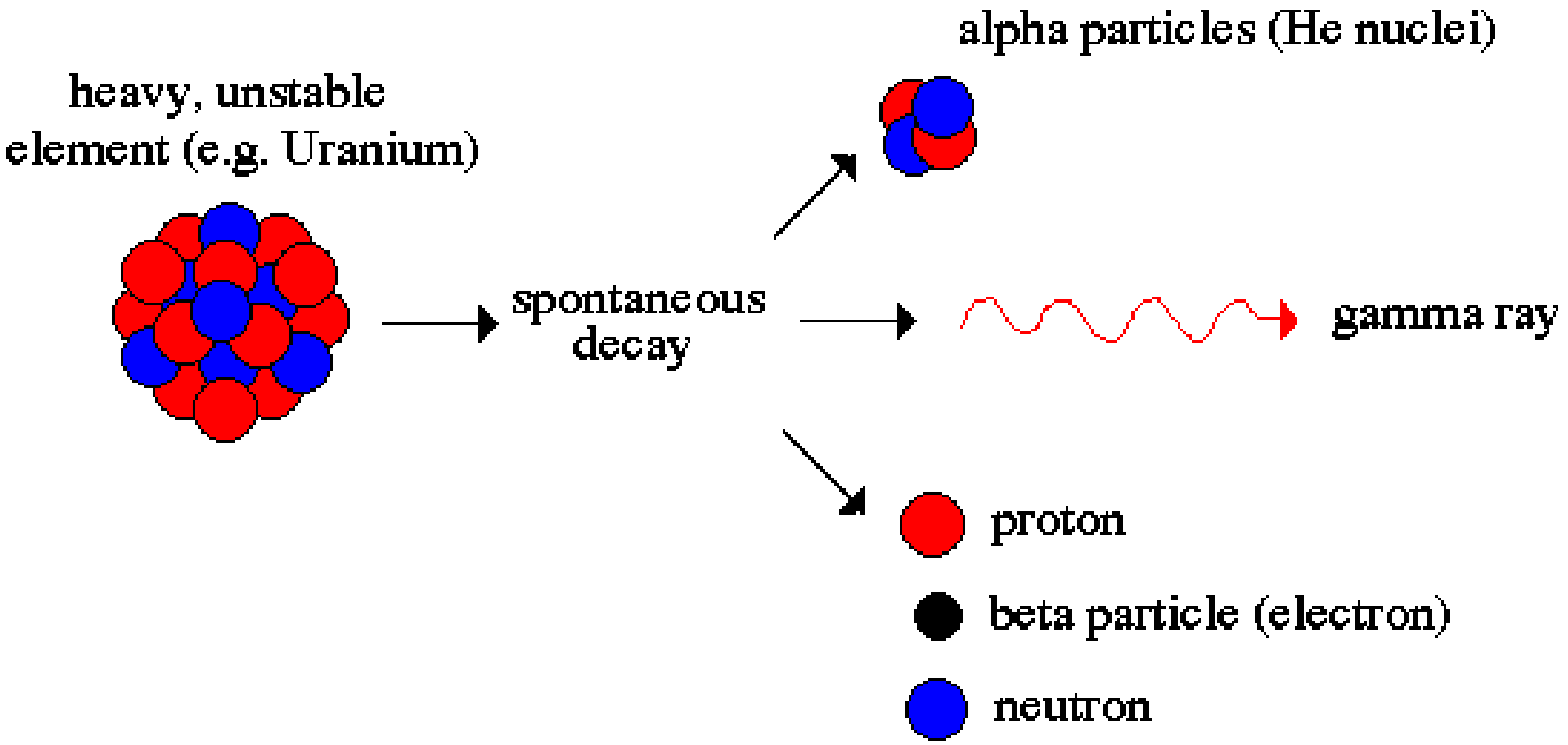
Types of Radiation:

Type:	Alpha	Beta	Gamma
Composition	Alpha Particle (helium nucleus)	Beta Particle (electron)	
Symbol	α, ^{4}He	β	
Charge	2+	1-	
Mass	4	1/1837	
Penetrating Power	Low (0.05 mm)	Moderate (4 mm)	
Shielding	Paper, clothing	Metal foil	

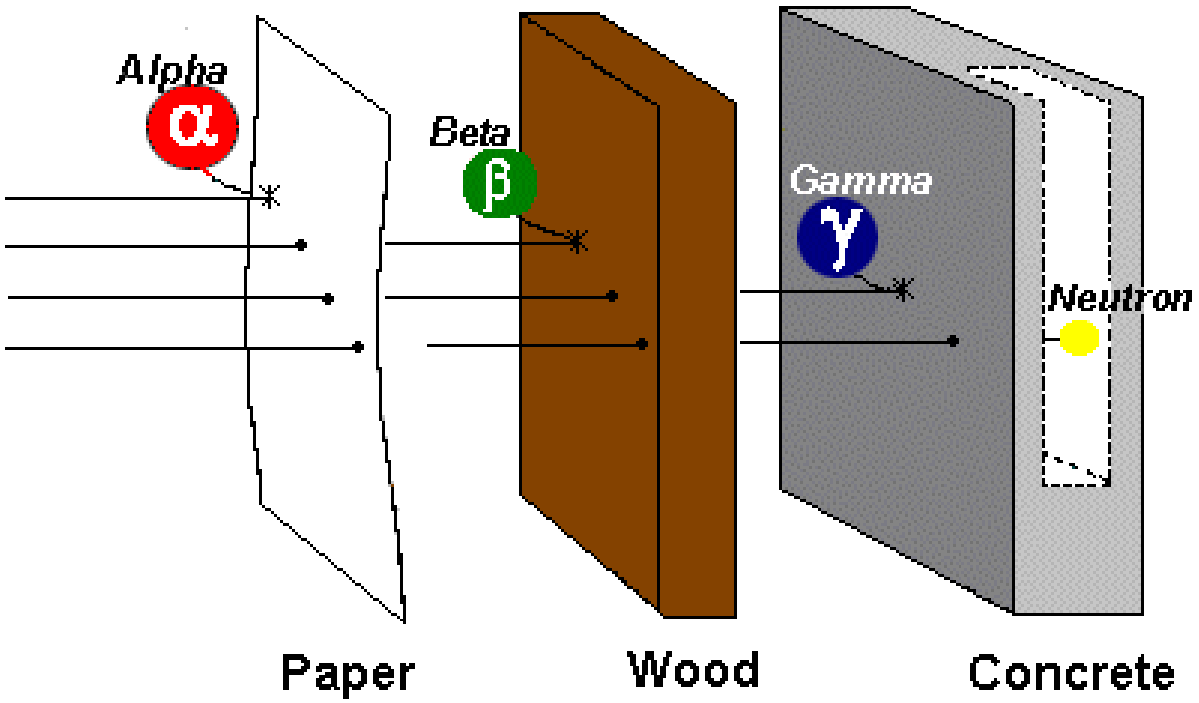
Types of Radiation:

Type:	Alpha	Beta	Gamma
Composition	Alpha Particle (helium nucleus)	Beta Particle (electron)	High-Energy Radiation
Symbol	α, ^{4}He	β	γ
Charge	2+	1-	0
Mass	4	1/1837	0
Penetrating Power	Low (0.05 mm)	Moderate (4 mm)	Very high Entire body
Shielding	Paper, clothing	Metal foil	Lead, concrete (incomplete)

Radioactivity



Comparing penetrating ability…



Balancing Nuclear Equations:

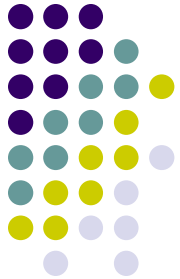
- Transmutation – conversion from one element to another
- Examples:

Nitrogen-14 + _____ ➔ _____

Fluorine-18 ➔ _____ + _____

Uranium-239 ➔ _____ + _____

Balancing Nuclear Equations:



- Transmutation – conversion from one element to another
- Examples:

Nitrogen-14 + Alpha particle → Fluorine-18

Fluorine-18 → Oxygen-17 + Proton

Uranium-239 → Neptunium-239 + Beta particle

Examples:

- **Alpha**:

  Uranium-238 ➔ _____+ α particle

- **Beta**:

  1 Neutron ➔ 1 Proton + 1 Electron

  ^{14}C ➔ _____ + _____

- **Gamma (and Alpha at the same time)**:

  Thorium-230 ➔ _____+ α + γ

Examples:

- **Alpha**:

  Uranium-238 ➔ Thorium-234 + α particle

- **Beta**:

  1 Neutron ➔ 1 Proton + 1 Electron

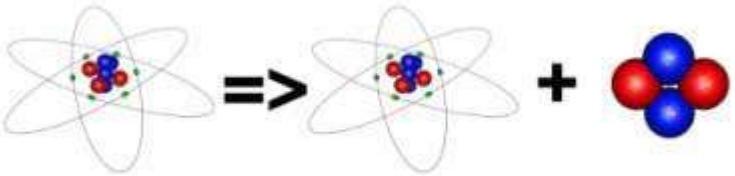
  ^{14}C ➔ **^{14}N** + β emission

- **Gamma (and Alpha at the same time)**:

  Thorium-230 ➔ Radium-226 + α + γ

Alpha Particle Decay:

- Example 1: Radium-226 transmutates by alpha decay. Write the nuclear equation that represents this process.



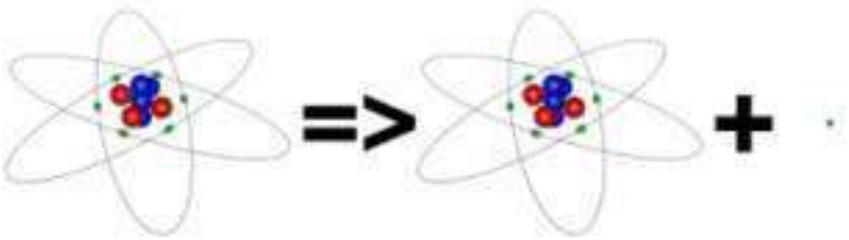
$$^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + \alpha$$

or

$$^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$$

Beta Particle Decay:

- Example 2: Write the nuclear equation for the beta-decay of boron-12.



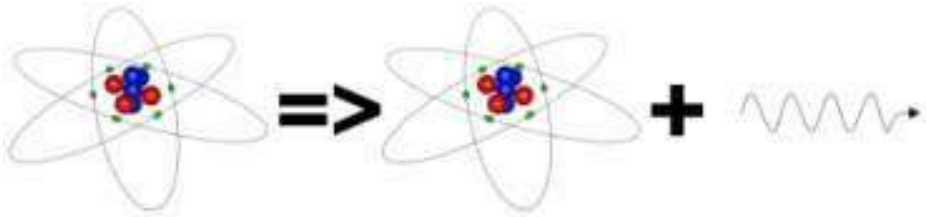
$$^{12}_{5}\mathrm{B} \rightarrow {}^{12}_{6}\mathrm{C} + \beta$$

or

$$^{12}_{5}\mathrm{B} \rightarrow {}^{12}_{6}\mathrm{C} + {}^{0}_{-1}\mathrm{e}$$

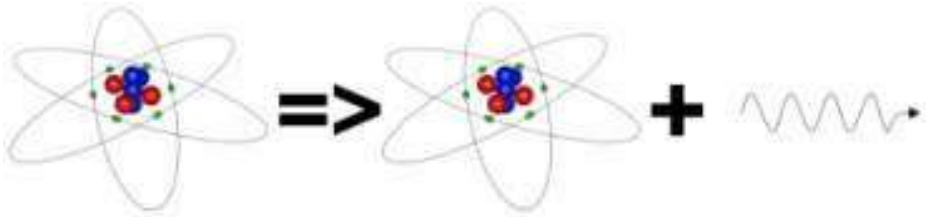
Gamma Radiation:

- Example 3: Write the nuclear equation representing gamma radiation given off by the unstable radionuclide cobalt-60.



Gamma Radiation:

- Example 3: Write the nuclear equation representing gamma radiation given off by the unstable radionuclide cobalt-60.



$$^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{27}\mathrm{Co} + \gamma$$

Examples:

Silicon-27 ➔ _____ + β

Bismuth-214 ➔ _____ + α

Gallium-70 + α ➔ _____

Iridium-193 ➔ _____ + γ

Examples:

Silicon-27 ➔ Phosphorus-27 + β

Bismuth-214 ➔ _____ + α

Gallium-70 + α ➔ _____

Iridium-193 ➔ _____ + γ **(energy!)**

Examples:

Silicon-27 ➔ Phosphorus-27 + β

Bismuth-214 ➔ Thallium-210 + α

Gallium-70 + α ➔ _____

Iridium-193 ➔ _____ + γ **(energy!)**

Examples:

Silicon-27 ➔ Phosphorus-27 + β

Bismuth-214 ➔ Thallium-210 + α

Gallium-70 + α ➔ Arsenic-74

Iridium-193 ➔ _____ + γ **(energy!)**

Examples:

Silicon-27 ➔ Phosphorus-27 + β

Bismuth-214 ➔ Thallium-210 + α

Gallium-70 + α ➔ Arsenic-74

Iridium-193 ➔ Iridium-193 + γ **(energy!)**