## Atomic Structure Review

### Roles of Subatomic Particles

Protons ($p^+$): Particle that identifies the atom and pulls the inner and outer electrons towards the center of the atom.

Neutrons ($n^o$): Provide balance between the protons ($p^+$) themselves and the proton/electron interaction.

Electrons ($e^-$): Communication and bonding in the atomic structure

### Isotopes

Every element is made up of multiple *isotopes*, forms of atom based on the relationship of neutrons and protons. All atoms of the same element have the same protons and electrons, but different numbers of neutrons.

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## Atomic Stability – Z-Ratio ($n^o$:$p^+$ Ratio)

The Stability of an isotope of an atom is based on the relationship between protons ($p^+$) and neutrons ($n^o$) in an atom. Atoms with too many or too new $n^o$ will become unstable.

### Z-Ratio

Ratio between the protons ($p^+$) and neutrons ($n^o$) in the atom.

$$\text{Z-Ratio} = \frac{\#n^o\ (\textit{neutrons})}{\#p^+\ (\textit{protons})}$$

Most stable isotopes of elements have the following ratios:

Small (1 – 20): 1.0 – 1.2

Medium (1 – 54): 1.2 – 1.3

Large (55 – 82): 1.4 – 1.5

No Stable Isotopes Above 82

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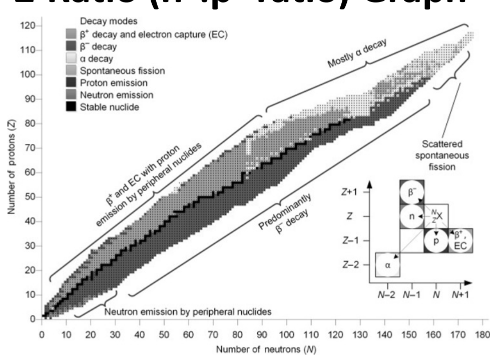
## Z-Ratio ($n^o$:$p^+$ ratio) Graph




**Nuclear Isotope Ratio Diagram**

The chart shown to the left show the potential isotopes of a radioactive atom's isotopes. The colors indicate the type of decay process that occurs to make atom stable.

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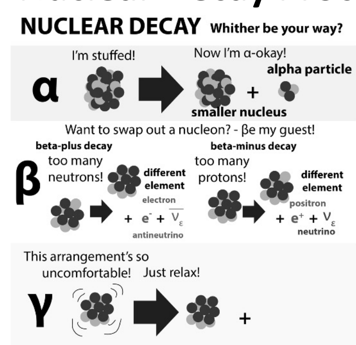
## Nuclear Decay Processes




**Nuclear Decay**

Unstable Isotopes are isotopes that have a z-ratio outside the stable range for the element.

Most common nuclear decay processes include:

**Alpha Decay** – Atom too large
**Beta Decay** (+) – Too many $n^o$
**Beta Decay** (-) – Too many $p^+$

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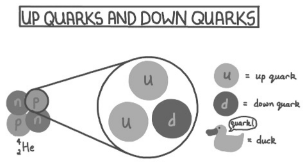
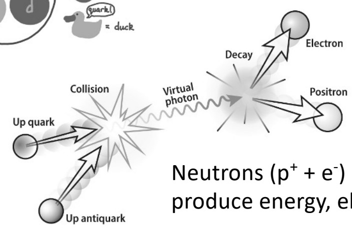
# Energy of Subatomic Particles




**Subatomic Particles Contain Energy**

All particles are made of individual particles called quarks and antiquarks.




Neutrons ($p^+ + e^-$) break down to produce energy, electrons, and protons

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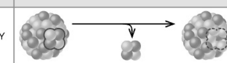
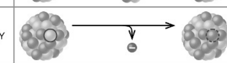
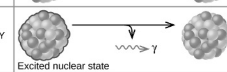
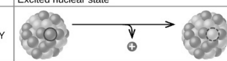
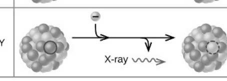
# Nuclear Decay Processes

| Type | Nuclear equation | Representation | Change in mass/atomic numbers |
|---|---|---|---|
| Alpha decay | ${}^{A}_{Z}X \quad {}^{4}_{2}He + {}^{A-4}_{Z-2}Y$ |  | A: decrease by 4<br>Z: decrease by 2 |
| Beta decay | ${}^{A}_{Z}X \quad {}^{0}_{-1}e + {}^{A}_{Z+1}Y$ |  | A: unchanged<br>Z: increase by 1 |
| Gamma decay | ${}^{A}_{Z}X \quad {}^{0}_{0}\gamma + {}^{A}_{Z}Y$ |   | A: unchanged<br>Z: unchanged |
| Positron emission | ${}^{A}_{Z}X \quad {}^{0}_{+1}e + {}^{A}_{Y-1}Y$ |  | A: unchanged<br>Z: decrease by 1 |
| Electron capture | ${}^{A}_{Z}X \quad {}^{0}_{-1}e + {}^{A}_{Y-1}Y$ |   | A: unchanged<br>Z: decrease by 1 |

**Additional Decay Processes**

In addition to Alpha and Beta decay additional decay processes can occur including **gamma radiation**, **positron emission**, and **electron capture**

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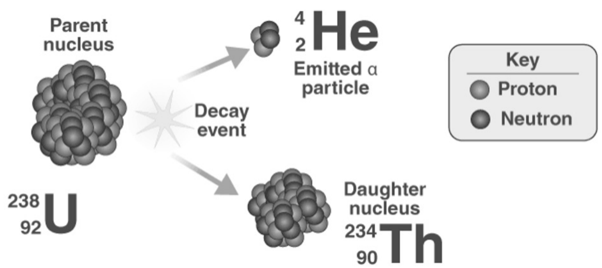
# Alpha Nuclear Decay

Breakdown of a large unstable atomic isotope by removing 2 protons and 2 neutrons ($2p^+ + 2n^o$) producing an alpha particle and a smaller isotope

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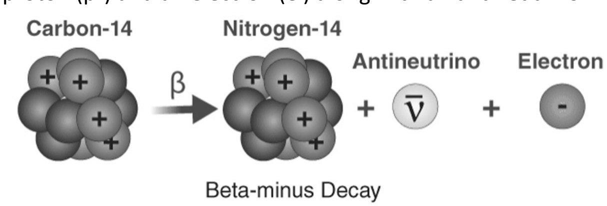
# Beta (-) Nuclear Decay

An atom with too many neutrons ($n^o$) will transmute the extra neutron into a proton ($p^+$) and an electron ($e^-$) along with an antineutrino.




Carbon-14 is an important isotope that is used for radioactive dating of older carbon samples. (*The ratio of C-12 and C-14 gives the approx. age*)

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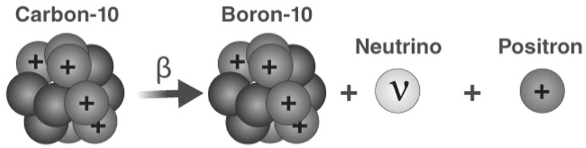
# Beta (+) Nuclear Decay

An atom with too few neutrons ($n^o$) will transmute the extra proton into a neutron ($n^o$) and a positron ($e^+$) (+ electron) and a neutrino.




Beta-plus Decay

Unstable Carbon-10 has too new neutrons ($4n^o$) and decays into the larger Boron-10 isotope which is the main stable isotope.

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