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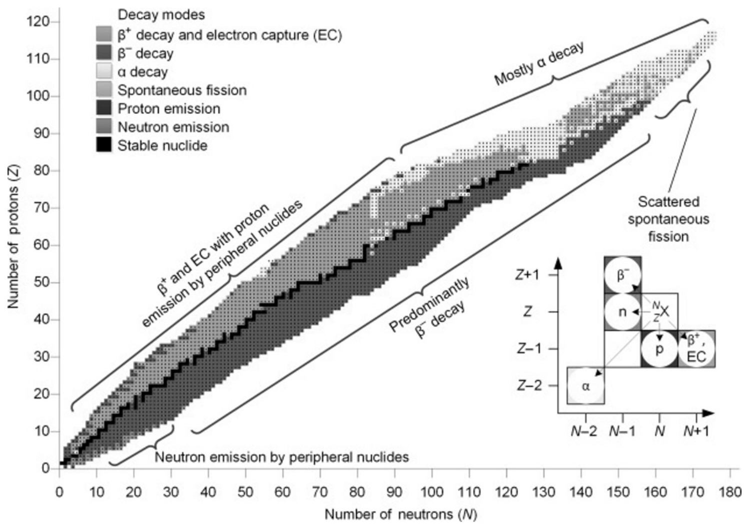
Z-Ratio (n^o:p^+ ratio) Graph



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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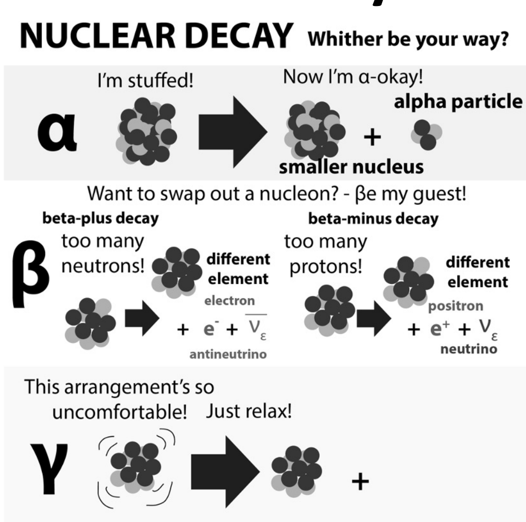
Nuclear Decay Processes



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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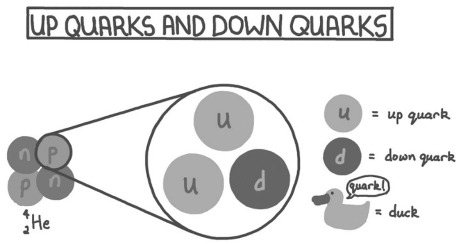
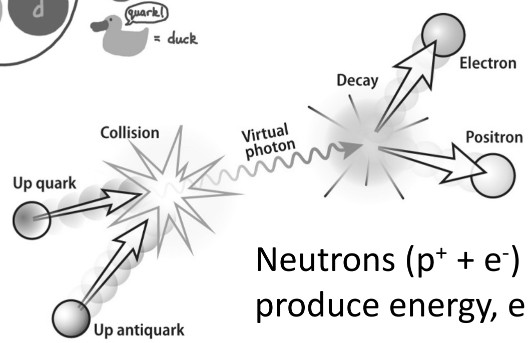
Energy of Subatomic Particles



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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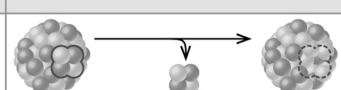
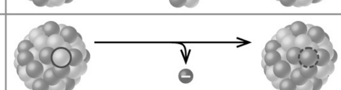
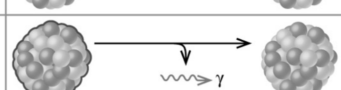
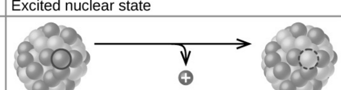
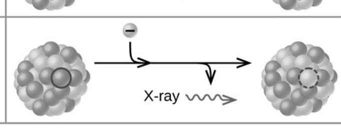
Nuclear Decay Processes

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 Z: decrease by 2
Beta decay	$^{A}_{Z}X \quad ^{0}_{-1}e + ^{A}_{Z+1}Y$		A: unchanged Z: increase by 1
Gamma decay	$^{A}_{Z}X \quad ^{0}_{0}\gamma + ^{A}_{Z}Y$	 Excited nuclear state	A: unchanged Z: unchanged
Positron emission	$^{A}_{Z}X \quad ^{0}_{+1}e + ^{A}_{Y-1}Y$		A: unchanged Z: decrease by 1
Electron capture	$^{A}_{Z}X \quad ^{0}_{-1}e + ^{A}_{Y-1}Y$	 X-ray	A: unchanged 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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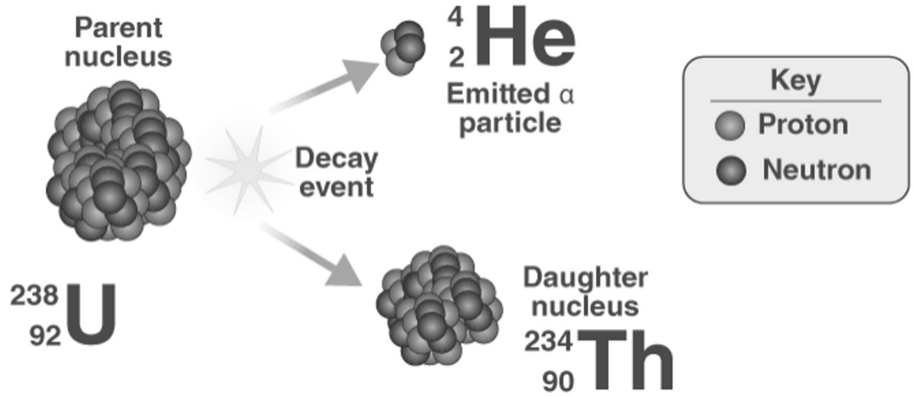
Alpha Nuclear Decay

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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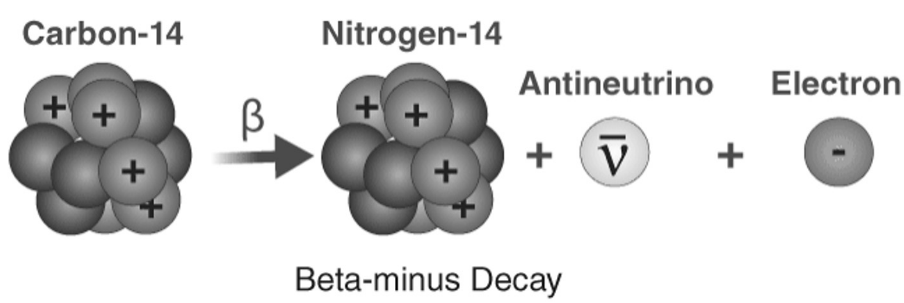
Beta (-) Nuclear Decay

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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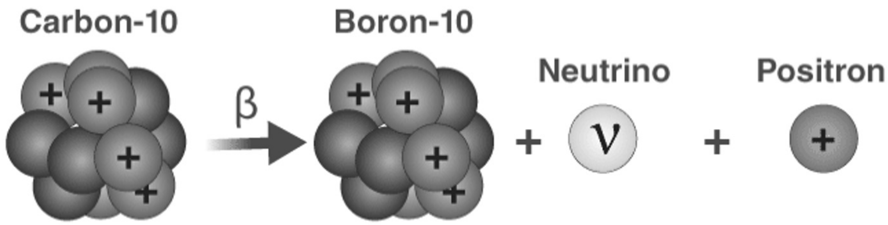
Beta (+) Nuclear Decay

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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