Nuclear Chemistry

Chemical Reactions

- Occur when bonds are broken and formed
- Involve only valence electron
- Atoms keep their identity throughout although they may gain, lose, or share valence electrons.
- Associated with small energy changes
- Catalyst, temperature, volume, pressure, and concentrations can all have an effect on the rate a reaction occurs.

VS

Nuclear Reactions

- Occur when nuclei combine (fuse), split (fission), and emit radiation.
- Involves protons, neutrons, and electrons (everything)
- Atoms of one element are often converted into atoms of another element.
- Associated with large changes in energy (the sun)
- Normally, nothing can affect nuclear reactions.

Radiation

Isotopes - an atom with a different # of neutrons.

mass # / #p+ X charges

$^{238}_{92}U$ $^{235}_{92}U$

Radioisotope - isotope with unstable nuclei.

Radioactive decay - the process by which unstable nuclei emit radiation to attain more stable atomic configurations.

Property	Alpha	Beta	Gamma
Symbol	α	β	γ
Composition	Helium nucleus $^{4}_{2}He^{2+}$	electrons (-)	high energy electromagnetic radiation (photons)
Relative Penetrating Power	Blocked by paper, skin, clothes, etc. (Easy to block.)	Blocked by skin (mostly), foils, metals etc. (Pretty easy)	Blocked by lead, really thick concrete. (Difficult to block)

Types of Radiation (Atoms use/undergo to become more stable)

1. Alpha radiation

↳ stream of alpha particles

Helium nuclei - $^{4}_{2}He^{2+}$

Radium-226 undergoes alpha radiation.

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

* lose 2 p^+ and 2n°
  mass # decrease by 4
  atomic # decrease by 2

* Occurs when atom is too big to control itself

Beta Radiation

↳ very fast moving electron emitted when an neutron is converted to a proton.

Iodine-131 undergoes Beta radiation

A proton is converted to

$^{131}_{53}I \rightarrow \beta + {}^{131}_{54}Xe$

$^{131}_{53}I \rightarrow e^{-} + {}^{131}_{54}Xe$

* Occurs when there are too many neutrons.
* mass # stays the same
* # p^{+} increases by 1.

Positron Emission - a positron is emitted from the nucleus with a low neutron : proton ratio (need more neutrons)

Positron - has the same mass as electron, but its positive.

→ a proton is converted to a neutron and a positron is emitted.

Carbon-11 undergoes positron emission.

$^{11}_{6}C \rightarrow \beta^{+} + {}^{11}_{5}B$

$^{11}_{6}C \rightarrow$ positron $+ {}^{11}_{5}B$

* mass # stays the same
* atomic # decreases by 1.

Electron capture – occurs when the nucleus of an atom draws in a surrounding electron and combines with a proton to form a neutron.

Rubidium-81 undergoes electron capture

$$^{81}_{37}Rb + e^- \longrightarrow {}^{81}_{36}Kr + \text{X-Ray}$$

X-Rays are high energy electromagnetic radiation that can be dangerous in high doses.

Nuclear Stability

- As the atomic number increases, more and more neutrons are needed to produce a strong nuclear force that is sufficient to balance the electrostatic repulsion between protons.

Strong Nuclear Force

– neutrons provide a sort of "glue" to help overcome electrostatic repulsion.

The ratio of $1.5n^\circ$ to $1p^+$ is generally stable for large elements

Band of Stability

- All elements w/ an appropriate $n^0 : p^+$ ratio are stable
- elements outside the band of stability can be/ are radioactive

* Any element w/ an atomic number greater than 82 (Pb) can be radioactive.

Nuclear Fusion

- The combining to atomic nuclei
  - Cannot be done on earth (yet)
  - Takes place inside of stars + stars explode.
    * Our sun combines hydrogens to create helium

Transmutation

- the conversion of an element into another element during radio active decay
  * can be induced or occur naturally.