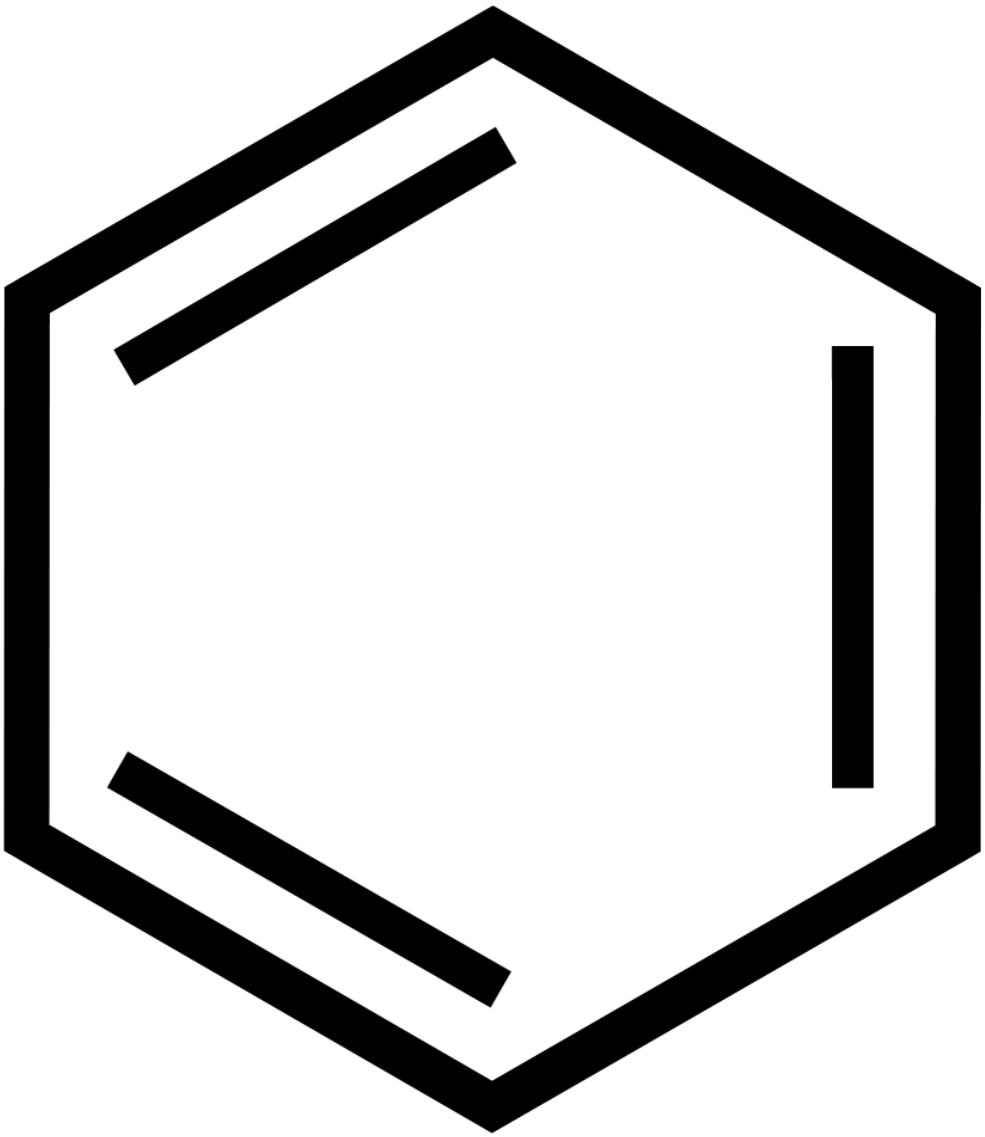

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CONCEPT: NUCLEAR REACTIONS

Nuclear Reactions deal with chemical processes in _____ nuclei atoms.

Unlike normal chemical reactions where the identity of the elements stay the same, nuclear reactions often result in elements changing into _____ elements.

Early studies of radioactive nuclei by the British physicist Ernest Rutherford in 1897 shows that there are three common types of radiation and nuclear reactions:

- _____
- _____
- _____

CONCEPT: ALPHA (α) DECAY

Alpha decay occurs when an unstable nucleus emits a particle composed of _____ protons and _____ neutrons.

An alpha particle can be represented by _____ or _____.

In terms of the size of radioactive particles, alpha particles are the _____.

- It is the most damaging to biological cells because it has the _____ ionizing power.
- Has the _____ penetrating power and can be stopped by clothing and the air of our environment.

EXAMPLE: Write balanced nuclear equations for each of the following alpha emissions.

a) Curium (Cm) – 248

b) Bismuth (Bi) – 207

CONCEPT: BETA (β) DECAY

Beta (β) decay occurs when an unstable nucleus emits a(n) _____.

- A beta particle can be represented by _____

Beta decay can be represented by the following reaction:

In terms of the size of radioactive particles, beta particles are _____ than alpha particles.

- It is the not as damaging to biological cells and so has a _____ ionizing power.
- _____ penetrating power and can only be stopped by a sheet of metal or a large block of wood.

EXAMPLE 1: Write balanced nuclear equations for each of the following beta emissions.

a) Magnesium (Mg) – 25

b) Ruthenium (Ru) – 102

EXAMPLE 2: Pb – 208 is formed from Th -232. How many alpha and beta decays have occurred?

a. 6, 2
b. 6, 6
c. 6, 4
d. 4, 6
e. 8, 2

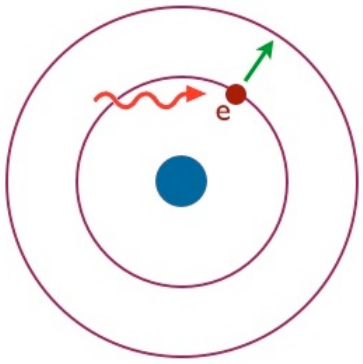
CONCEPT: GAMMA RAY EMISSION

Gamma radiation is related to the electromagnetic spectrum. Gamma rays have the highest energy and therefore they have

_____ wavelength and _____ frequency.

A gamma particle can be represented by _____.

- It causes no change in the atomic mass or atomic number and usually happens with alpha or beta decay.
- Gamma particles have the _____ ionizing power.
- Gamma particles have the _____ penetrating power so thick layers of lead shielding are needed.



EXAMPLE: Which of the following represents an element that has experienced a gamma emission?

a) Cl: $1s^2 2s^2 2p^6 3s^2 3p^5$
b) Be: $1s^2 2s^2$
c) Na: $1s^2 2s^2 2p^6 3p^1$
d) N: $1s^2 2s^2 2p^3$

CONCEPT: ELECTRON CAPTURE

Electron capture involves the absorption of an electron by an unstable nucleus and is represented by the following reaction:

EXAMPLE: Write balanced nuclear equations for each of the following elements after undergoing electron capture.

a) Rutherfordium (Rf) – 263

b) Nobelium (No) – 260

c) Lead (Pb) – 207

CONCEPT: POSITRON EMISSION

Positron emission occurs when an unstable nucleus emits a positron. The positron is the antiparticle of the electron, with the same mass as an electron, but with the opposite sign.

A positron particle can be represented by _____ and in the overall reaction a proton is converted into a neutron and emits a positron.

EXAMPLE 1: Write balanced nuclear equations for each of the following positron emissions.

a) Uranium (U) – 235

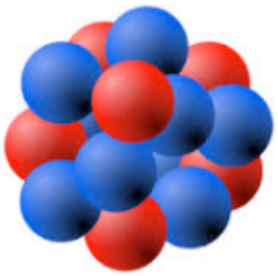
b) Radon (Rn) – 222

EXAMPLE 2: A nuclide of Th – 225 undergoes 3 alpha decays, 4 beta decays and a gamma emission. What is the product?

a. Radium
b. Radon
c. Actinium
d. Cadmium
e. Antimony

CONCEPT: VALLEY OF STABILITY

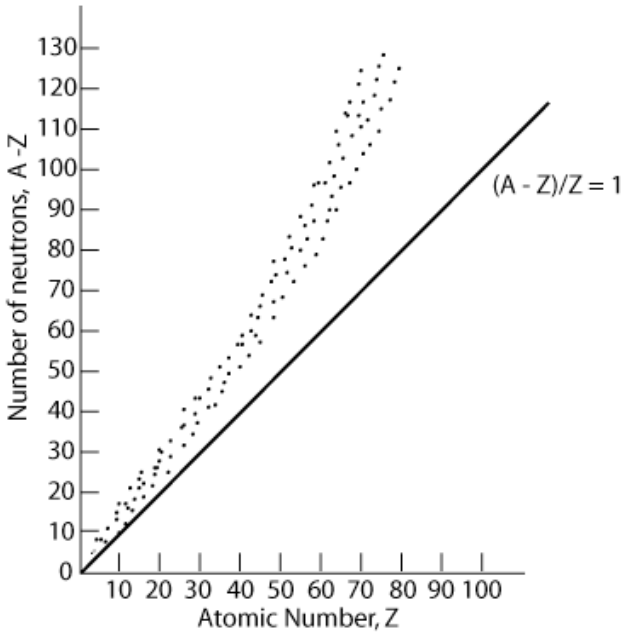
The central idea of nuclear chemistry is that unstable nuclei will give off radiation.



- At the center of every atom resides the nucleus, which contains both protons and neutrons.
- Within the nucleus there exists two forces: _____ force and _____ force.
- Analyzing the neutron to proton ratio of an element is a good way for determining its nuclear stability.

At Z ≤ 20 the N/Z Ratio is most stable at _____**.** Between Z = above 20 and up to 40 the N/Z Ratio is most stable at _____**.** Between Z = above 40 and up to 80 the N/Z Ratio is most stable at _____**.**

Above Z = _____ stable nuclei do not exist. _____ is the heaviest element with stable (nonradioactive) isotopes.



Above the Valley of Stability

- There are too many neutrons:

_____ force will be greater than _____ force.

- To decrease the # of neutrons or increase the # of protons:

_____ & _____.

Below the Valley of Stability

- There are too many protons:

_____ force will be greater than _____ force.

- To increase the # of neutrons or decrease the # of protons:

_____ & _____.

Top Right Corner

- Elements with atomic masses equal to or greater than _____ amu have too many protons and neutrons.

- To increase the # of neutrons or decrease the # of protons: _____ or _____.

PRACTICE: VALLEY OF STABILITY

EXAMPLE 1: Determine if the following nuclide will undergo alpha decay, beta decay or positron emission.

Hydrogen-3

EXAMPLE 2: Determine if the following nuclides will undergo alpha decay, beta decay or positron emission.

Radon-222

EXAMPLE 3: Determine if the following nuclides will undergo alpha decay, beta decay or positron emission.

Magnesium-50

CONCEPT: MAGIC NUMBERS

Besides the ratio of neutrons to protons, the actual number of neutrons and protons will also affect the overall stability of the nucleus.

Stable Nuclides

Protons (Z)	Neutrons (N)	Number of Nuclides
		163
		53
		50
		5

In terms of electrons and stability:

- The noble gases have the ideal number of electrons (_____ , _____ , _____ , _____ , _____ , _____ & _____).

Just as elements with the ideal number of electrons depict unusually high stability so do elements with the ideal number of nucleons (# of protons and neutrons). These ideal numbers for the nucleons are referred to as ***magic numbers***.

In terms of nucleons and stability:

The magic numbers include:

Protons (Z): _____, _____, _____, _____, _____, _____ & _____

Neutrons(N): _____, _____, _____, _____, _____, _____, _____ & _____

EXAMPLE: Based on your knowledge of nuclide stability determine which of the following nuclides will be most stable.

a) $^{115}_{49}\mathrm{In}$ b) $^{138}_{57}\mathrm{La}$ c) $^{40}_{20}\mathrm{Ca}$ d) $^{144}_{60}\mathrm{Nd}$

CONCEPT: RADIOACTIVE DECAY RATES

Radioactive decay is kinetically a first – order process, whose rate is proportional to the number of radioactive nuclei N, where *k* is a first – order rate constant called the _____ constant.

Decay Rate = k x N

Radioactive decay rates follow a _____ order process so we can reuse the _____ order Integrated Rate Law from the Chapter on _____.

EXAMPLE: A sample of radon-222 has an initial α particle activity (A_0) of 8.5 x10**4** dps (disintegrations per second). After 7.3 days, its activity (A) is 3.7 x 10**4** dps. What is the half-life of radon-222?

CONCEPT: RADIOACTIVE DECAY RATES (CALCULATIONS)

EXAMPLE 1: Gallium citrate, containing the radioactive isotope gallium – 67, is used medically as a tumor seeking agent. It has a half – life of 78.2 hours. How long will it take for a sample of gallium citrate to decay to 20.0% of its original activity?

EXAMPLE 2: What percentage of carbon – 14 ($t_{1/2}$ = 5715 years) remains in a sample estimated to be 16,230 years old?