NUCLEAR CHEMISTRY

Alpha decay

$$^{238}_{92}\mathrm{U} \longrightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He} \qquad (\alpha \text{ decay})$$

Beta decay

$$^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}\mathrm{e}$$

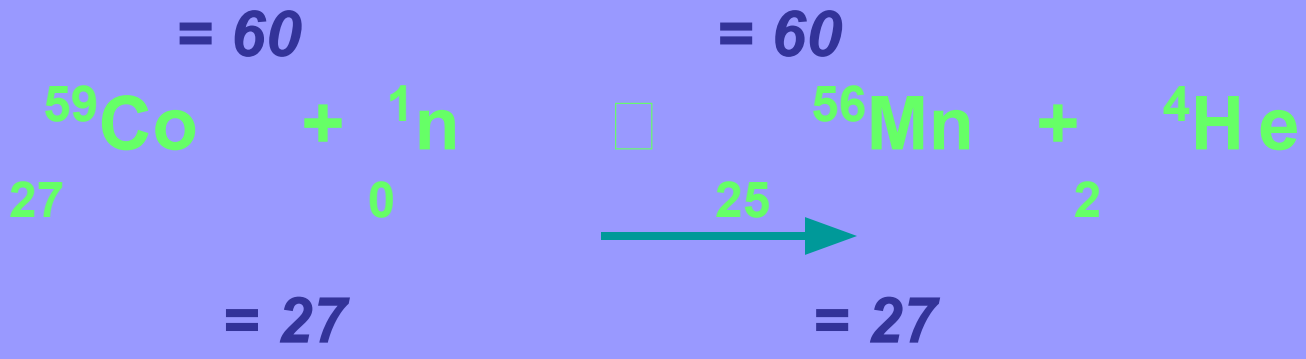
beta particle

Problems:

- Write the nuclear equation for the natural decay of Co-60.

Producing Radioactive Isotopes

Bombardment of atoms produces radioisotopes



cobalt neutron manganese alpha
atom radioisotope particle

Problems:

- Write the nuclear equation for the bombardment of Calcium – 40 with a positron, forcing the emission of an alpha particle as one of the products.

Half-Life of a Radioisotope

- the time required for half the mass of a sample of atoms of a radioactive nuclide to decay

- USEFUL HALF-LIVES CAN BE FOUND ON TABLE N**

# of half lives occurred = T/t

Where T= total time

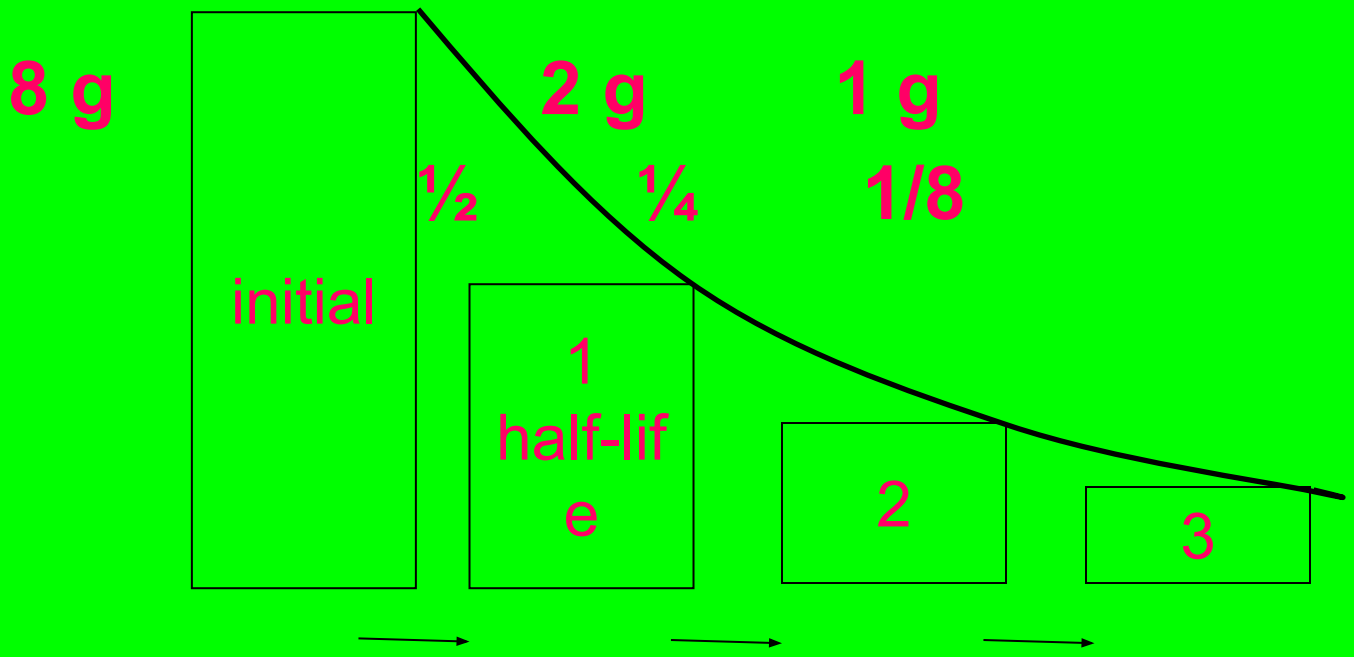
t= half life

Examples of ½ Lives

Francium – 220	27.5 s
Fe – 53	8.51 min
^{42}K	12.4 h
^{131}I	8.07 d
Strontium – 90	28.1 y
U – 238	4.51×10^{9} y

Half-Life of a Radioisotope

decay curve



Half-Lives

- In order to solve these problems a table like the one below is useful, **the first two columns are constant**, the last two you fill in with the problem's data.
- PRACTICE: For instance, with 40 grams of an original sample of Radium -226 and we want to find out how much is left 8000 years.

½ life period	% original remaining	Time Elapsed	Amount left
0	100	0	
1	50		
2	25		
3	12.5		
4	6.25		
5	3.125		

Problem:

- **What is the fraction of I -131 remaining after 32.3 days ?**

Problem:

- **What is the original amount of a sample of Hydrogen – 3 if after 36.8years 2.0g are left ?**

Problem:

- **How many ½ life periods have passed if a sample has decayed to 1/16 of its original amount?**

- **Phosphorus-32 has a half-life of 14.3 days. How many grams of phosphorus-32 remain after 57.2 days if you start with 4.0 g of the isotope?**

Problem:

- What is the ½ life of a sample if after 40 years 25 grams of an original 400 gram sample is left ?

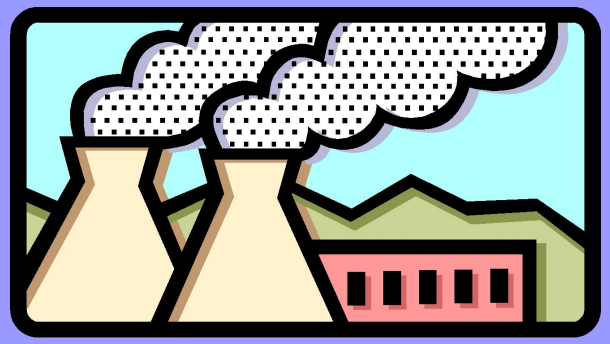
Nuclear Fission

Fission– Atomic Bomb

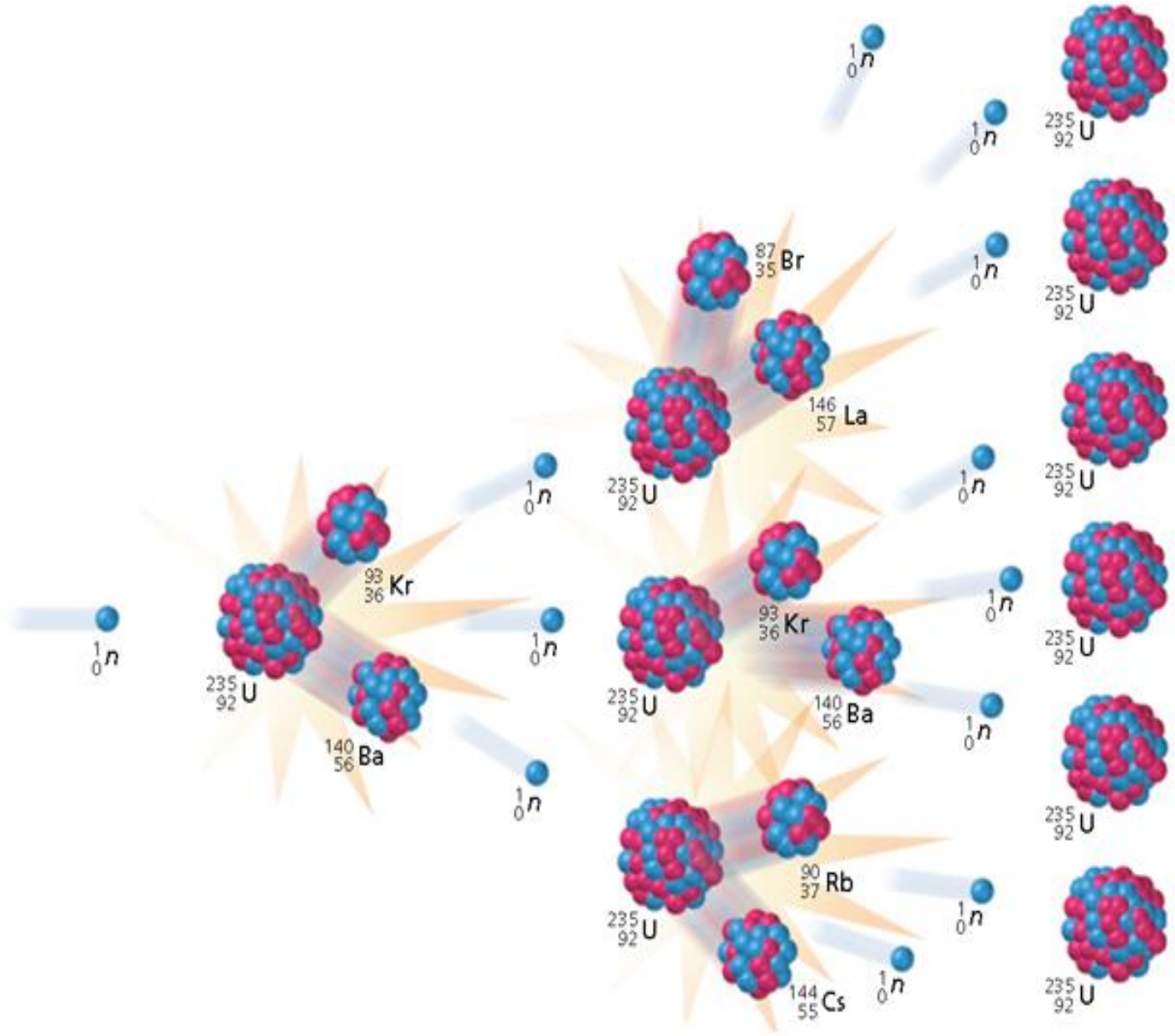
large nuclei break up

https://www.history.com/embed/21097602#

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3\,^{1}_{0}n + Energy$$



Fission



Fission induction of uranium-235 by bombardment with neutrons can lead to a chain reaction when a critical mass of uranium-235 is present.

Nuclear Fusion

Fusion

small nuclei combine

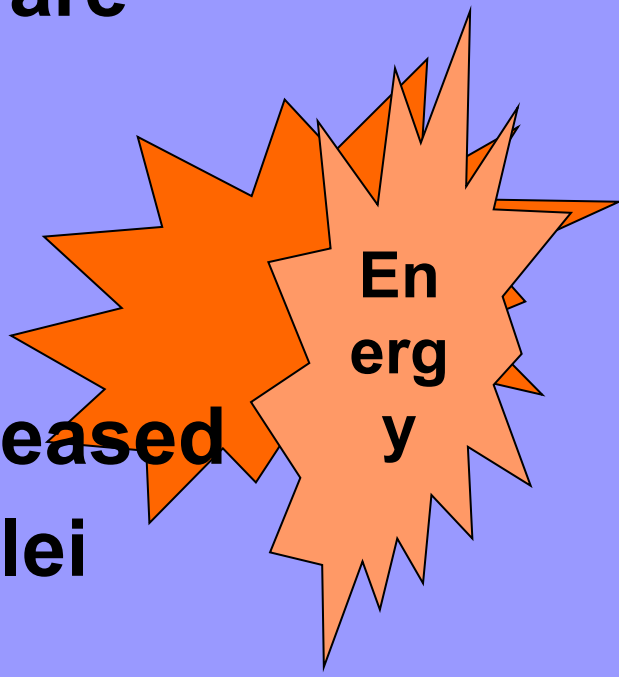
$$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}He + ^{1}_{0}n +$$

Occurs in the sun and other stars

Problems:

Indicate if each of the following are

(1) Fission (2) fusion



A. Nucleus splits

B. Large amounts of energy released

C. Small nuclei form larger nuclei

D. Hydrogen nuclei react

Nuclear Power Plants

- They have five main components: shielding, fuel, control rods, moderator, and coolant.
  - **1. Shielding: Concrete and Steel:** is radiation-absorbing material that is used to decrease exposure to radiation, especially gamma rays, from nuclear reactors.
  - **2. Fuel Rods -** Uranium-235 is typically used as the fission fuel.

3. Coolant: Water or Heavy Water - The coolant absorbs the energy as heat that is produced

4. Control rods: cadmium or boron: are neutron-absorbing rods that help control the reaction by limiting the number of free neutrons

5. Moderator: Graphite or beryllium: is used to slow down the fast neutrons produced by fission.

Uses of Radioactivity

- **Radioactive dating** is the process by which the approximate age of an object is determined based on the amount of certain radioactive nuclides present.

Carbon-14 is used to date organic things that were once alive.

Uranium-238 is used to geologically date rocks

Radioactive Nuclides in Medicine

- **cobalt-60** - In medicine, radioactive nuclides are used to destroy certain types of cancer cells.

- **Iodine-131 is used to detect and treat thyroid disorders**

- **Tc-99** is given to patients with cancerous tumors. It accumulates in the tumor and can be easily detected by a scan.

- **Radioisotopes used in the body must have a short half life so they are quickly eliminated from the body.**

- **Radioactive Nuclides in Agriculture**
- **Phosphorus-31** - Radioactive tracers in fertilizers are used to determine the effectiveness of the fertilizer.

- **Gamma radiation** from Co-60 is used to prolong the shelf life of food. The gamma radiation kills bacteria. This form of preservation is used on many spices and some meats.

- Cs-137 along with Co-60 are used to destroy Anthrax.

Radiation Risks

- Biological Damage (possible gene mutations)
- Long-Term Storage
- Accidents
- Pollution
- Why is Sr-90 bad to ingest?

Important Points

- Nuclear equations
- Transmutations
- Tables N and O
- ½ Lives
- Risks
- Tracers
- Parts of a Nuclear Reactor and their functions