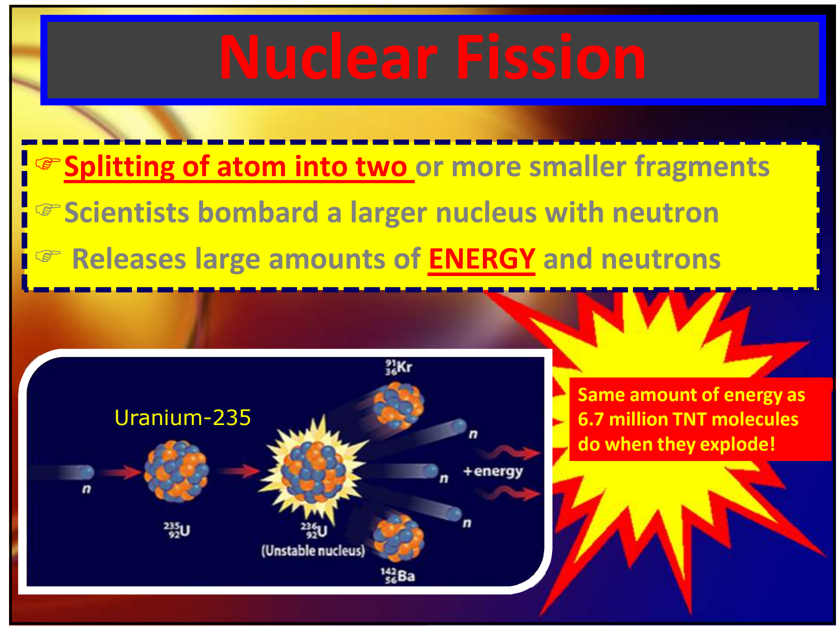
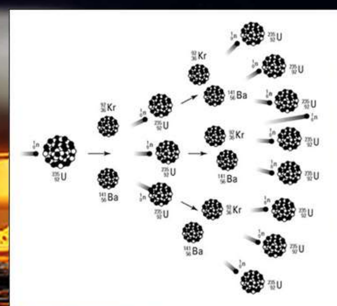

Nuclear Energy Review


Nuclear Fission
Splitting of atom into two or more smaller fragments
Scientists bombard a larger nucleus with neutron
Releases large amounts of ENERGY and neutrons
Uranium-235
n
$^{235}_{92}U$
$^{236}_{92}U$
(Unstable nucleus)
$^{91}_{36}Kr$
$^{142}_{56}Ba$
+energy
Same amount of energy as 6.7 million TNT molecules do when they explode!

# Nuclear Fission

- Nuclear chain reaction - the continuous series of nuclear fission due to neutrons dividing other nucleus from the same sample.



The chain reaction principle is used in the atomic bomb.

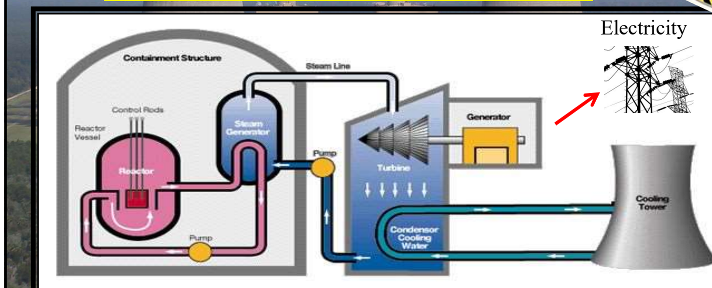
Mouse trap Video

# Nuclear Fission

Energy produced from fission is used to provide electrical energy to millions of homes and businesses. (Nuclear Power Plant)

**Issues**

- High levels of exposure cause radiation sickness.
- Radiation toxic waste (storage)

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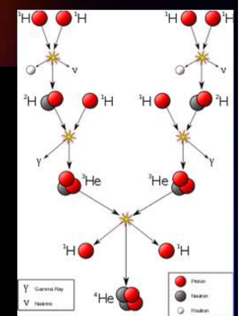
# Applications of Nuclear Reactions

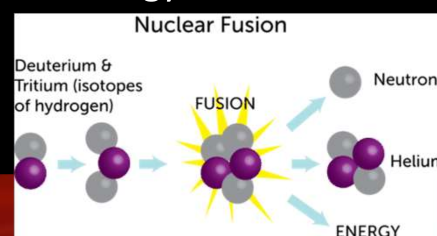
- **Dating of ancient artifacts** (Carbon-14).
- **Smoke detectors** (Americium-241).
- **Radioactive tracers in medicine** (Iodine-131, barium-140, phosphorus-32).
- **Cancer treatment** (Cobalt-60).
- **Electricity generation** (Uranium-235).
- **Bombs** (Uranium-235).

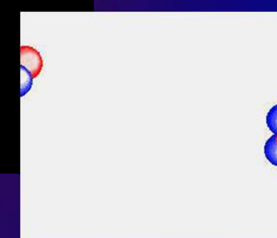
# Nuclear Fusion

☞ Two or more nuclei (Hydrogens) combining to form a nucleus of larger mass.

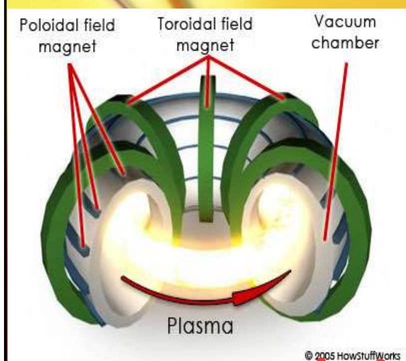
☞ Produces even larger amount of energy than fission.





# Why aren't we using Fusion instead of Fission?

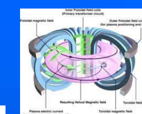



- Ignition temperatures are 100 million Kelvin, and no manmade container can hold this without melting.
- Not yet sustainable

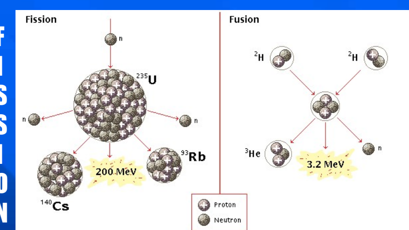
**The reactants are hydrogen, a very abundant gas, and the product is helium, which is harmless.**

Runaway reactions aren't a problem.

# Fission vs. Fusion



FISSION




FUSION

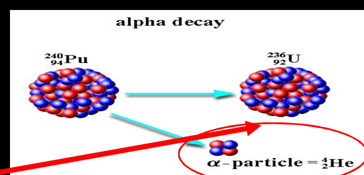
1. $^{235}$U is limited
2. danger of meltdown
3. toxic waste
4. thermal pollution

1. fuel is abundant (Hydrogen)
2. no danger of meltdown
3. no toxic waste (Helium)
4. not yet sustainable

# Nuclear Radiation

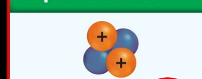
## Alpha Particles

- Made of two protons and two neutrons
- Alpha particle =helium nucleus   Same symbol




- Electric charge of +2
- Atomic mass of 4

**Alpha Particles**

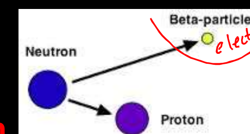


| | |
|---|---|
| Symbol | $^{4}_{2}He$ |
| Mass | 4 |
| Charge | +2 |

New element: decreased by an atomic number by 2 and the mass number by 4

# Nuclear Radiation

## Beta Particles



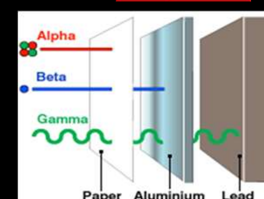

- A neutron decays into a proton
- Emits a fast moving electron (beta particle).

**Beta Particles**

| | |
|---|---|
| Symbol | $^{0}_{-1}e$ |
| Mass | 0.0005 |
| Charge | −1 |

- Not as massive as alpha particles, so they can pass through thicker substances

$^{0}_{-1}e$

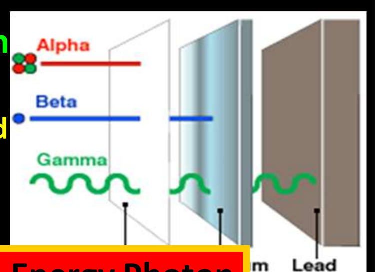


# Nuclear Radiation

## Gamma Rays

**Photon**

- They have <u>no mass</u> and no charge and travel at the speed of light.
- The most penetrating form of nuclear radiation.
- Lead and concrete, are required to stop gamma rays.

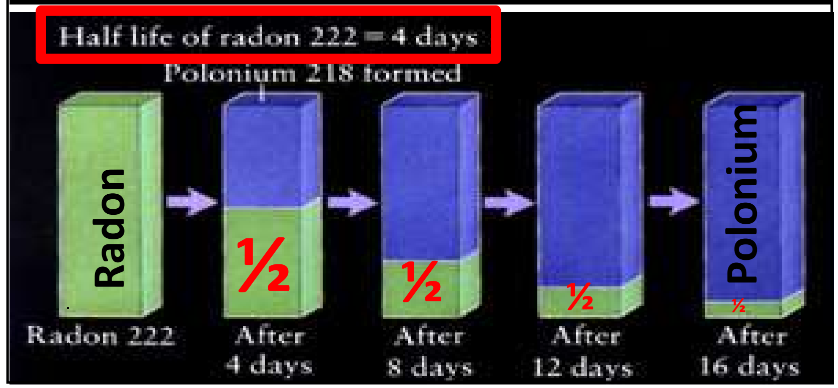



**Gamma Ray=High Energy Photon**

# Radioactive Decay Rates

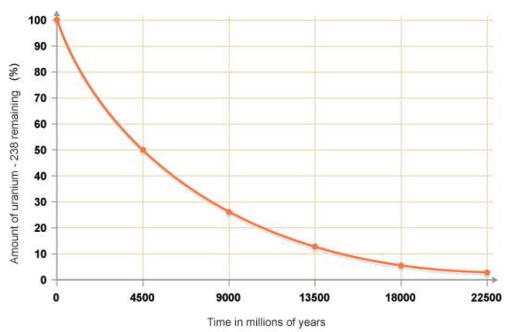
## Half-Life

- The <u>"half-life"</u> (h) is the <u>*TIME*</u> it takes for *half the atoms* of a radioactive substance to decay.



## Radioactive Decay of a Sample of Uranium-238

1. How many half-lives does it take for Uranium-238 to decay to only 12.5%?
2. How long did it take for Uranium-238 to decay to 6.25%?
3. How much Uranium-238 is still left over after 4500 million years?
4. In fraction form, how much of the original sample of Uranium-238 is still left over after 22,500 million years?




## Half-Life Math Problem

•For example, suppose we had **20,000** atoms of a radioactive substance. If the half-life is 1 hour, how many atoms of that substance would be left after:

| Half-lives | #atoms remaining | % of atoms remaining | Time | Fraction |
|---|---|---|---|---|
| 0 | 20,000 | 100% | 0 hours | 1/1 |
| 1 | 10,000 | 50% | 1 hour | 1/2 |
| 2 | 5,000 | 25% | 2 hours | 1/4 |
| 3 | 2,500 | 12.5% | 3 hours | 1/8 |

## Radioactive Half-Life Practice Problems

1. How many grams of iodine 131 (half life- 5 days) would be left after 20 days if you start with 25 grams?

Answer: 1.56 g

| The half life is | | | 5 days |
|---|---|---|---|
| Number of half-lives passed | Amount of Matter | | Time |
| 0 | Started with | 25 g | 0 { days} |
| 1 | How Much is left | 12.5g | 5 days |
| 2 | How Much is left | 6.25 g | 10 days |
| 3 | How Much is left | 3.12 g | 15 days |
| 4 | How Much is left | 1.56 g | 20 days |
| 5 | How Much is left | | |

2. How long will it take 600 grams of Plutonium 239 (half life 24,000 years) to decay to 18.75 grams?

120,000 yrs

| The half life is | | | 24,000 yrs |
|---|---|---|---|
| Number of half-lives passed | Amount of Matter | | Time |
| 0 | Started with | 600 g | 0 yrs |
| 1 | How Much is left | 300 g | 24,000 yrs |
| 2 | How Much is left | 150 g | 48,000 yrs |
| 3 | How Much is left | 75 g | 72,000 yrs |
| 4 | How Much is left | 37.5 g | 96,000 yrs |
| 5 | How Much is left | 18.75 g | 120,000 yrs |

3. K-42 has a half-life of 15.5 hrs. If 13.125g of K-42 remains undecayed after 62.0 hours, what was the original sample size?

210 g

| The half life is | | | 15.5 hrs |
|---|---|---|---|
| **Number of half-lives passed** | **Amount of Matter** | | **Time** |
| **0** | **Started with** | 210 g | 0 hrs |
| 1 | How Much is left | 105 g | 15.5 hrs |
| 2 | How Much is left | 52.5 g | 31 hrs |
| 3 | How Much is left | 26.25 g | 46.5 hrs |
| 4 | How Much is left | 13.125 g | 62 hrs |
| 5 | How Much is left | | |