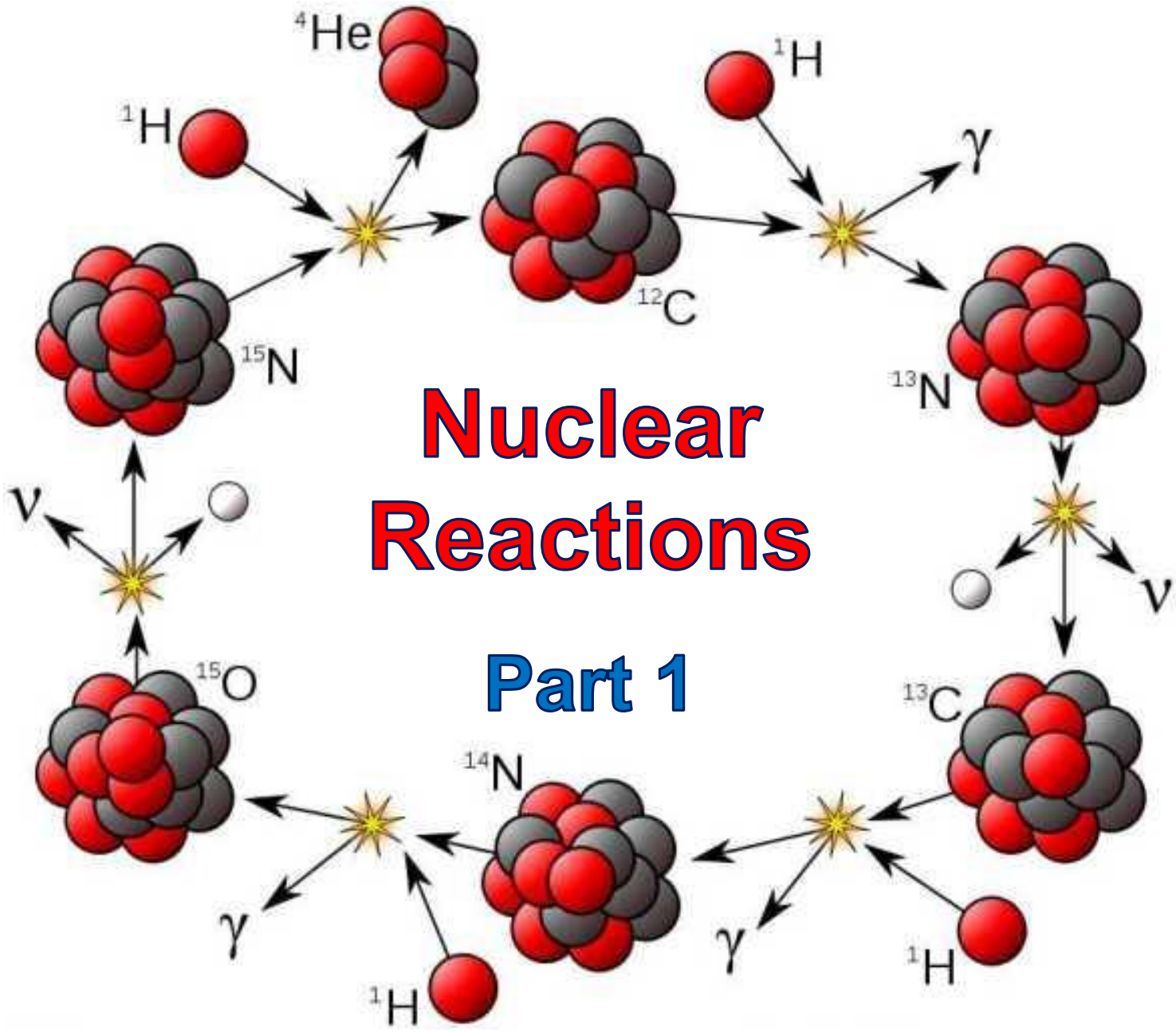


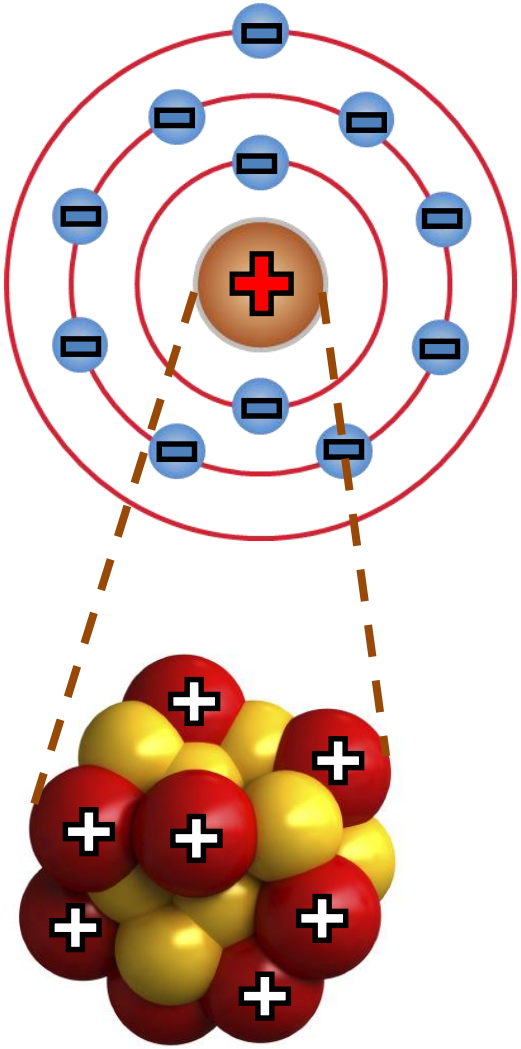
Nuclear Reactions

Part 1

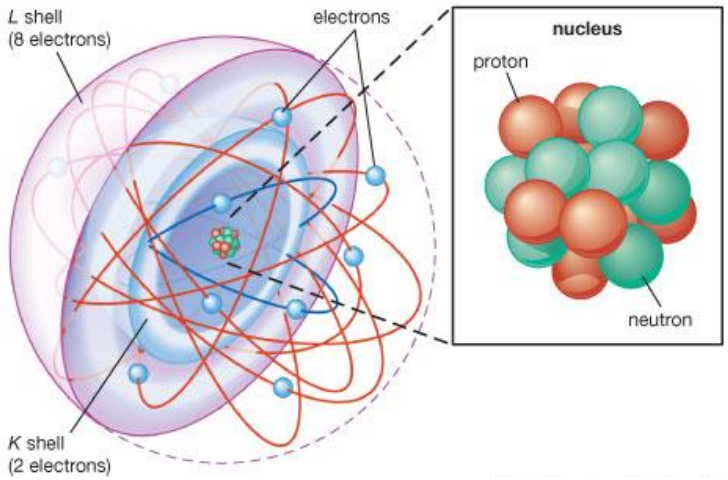
Atomic Structure Summary

- **All atoms have:**
  - a positively charged nucleus
  - and negatively charged electrons around it

- **Atomic nucleus consists of:**
  - positively charged protons
  - and neutrons that have no electric charge



Forces Inside the Atom

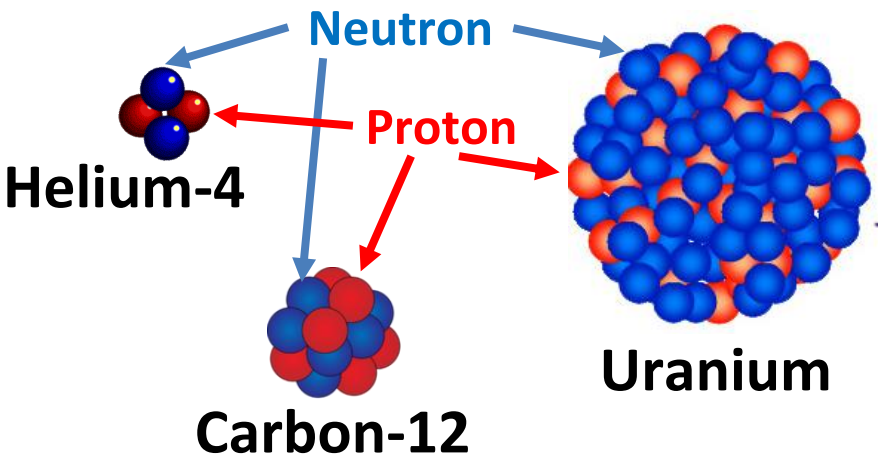


What holds an atom together?

- The electrons are kept in orbit around the nucleus due to an electromagnetic field of attraction between the positive charge of the protons and the negative charge of the electrons.
- The nucleus of protons and neutrons is kept together by the nuclear (strong) force, which *opposes and overcomes the electromagnetic repulsion when particles are very close to each other (~1 fm!).*

Nuclear (binding) energy is the energy associated with the nuclear force:

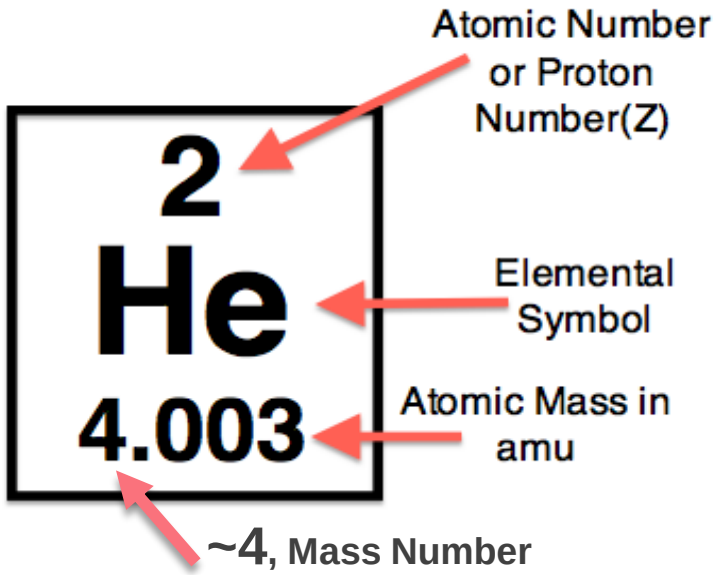
- A stable atom is an atom that has enough binding energy to hold the nucleus together permanently.
- An unstable atom does not have enough binding energy to hold the nucleus together permanently and will lose neutrons and/or protons as it attempts to become stable.



Understanding Elements

The number of protons and neutrons in the nucleus give the atoms their specific characteristics.

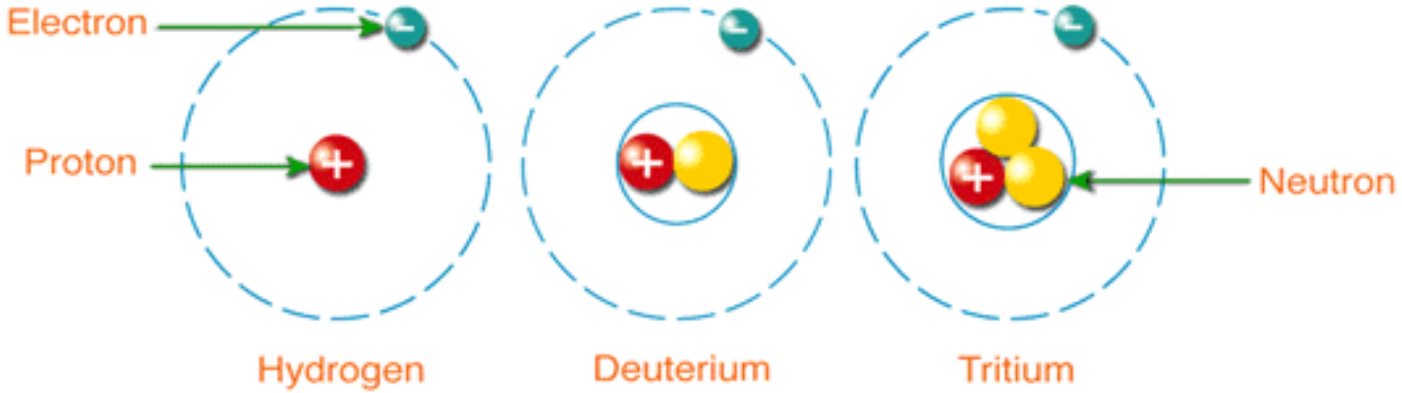
- **All atoms of the same chemical element contain the same number of protons, defined by a unique atomic number of that element.**
- **For example, all helium atoms, and only helium atoms, contain two protons and have an atomic number of 2.**



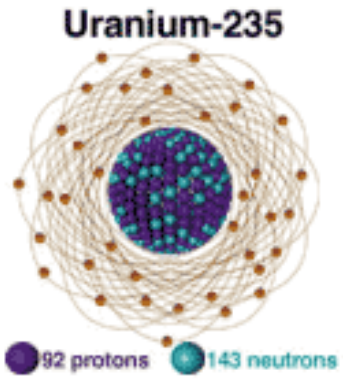
- **Atoms are also characterized by:**
  - **mass number, which is a sum of the number of protons and the number of neutrons in the nucleus (number of *nucleons*)**
  - **atomic mass, "relative isotopic mass" in *unified atomic mass units*, which is roughly (within 1%) equal to the whole mass number (since the mass of a proton and the mass of a neutron are almost the same and the mass of the atom's electrons is negligibly small)**

What is Isotope?

<u>Isotopes</u> are different forms of a given element that have the same number of *protons* in each atom but differ in number of *neutrons*.



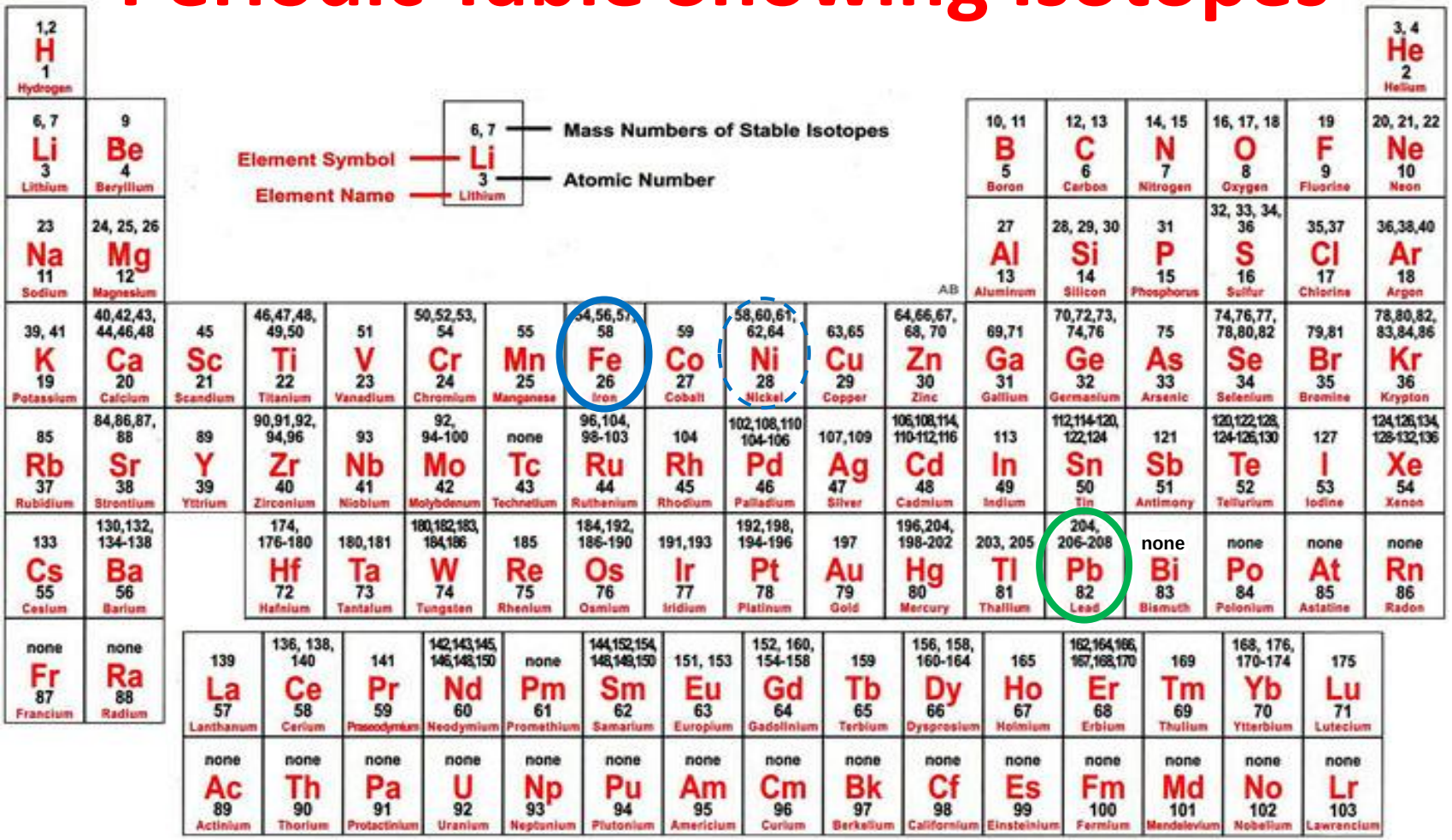
Most elements have more than one isotope.



There are 20 Plutonium isotopes, all of them unstable!

Pu^{228} ⟹ Pu^{247}

Periodic Table Showing Isotopes



- **The nucleus of an iron isotope with mass number 56 is more stable than any other element's nucleus (the farther from 56 an element's mass number is, the more unstable that element's nucleus tends to be).**
- **The heaviest element that still has stable isotopes is Lead.**

Three Types of Nuclear Reactions

1. **Radioactive decay** – an unstable nucleus spontaneously emits a small particle of radiation to become:
   - a **different isotope** of the **same element** **or**
   - a **different element** (such process is called ***transmutation***).
2. **Nuclear Fusion** – the joining of two atoms to form a larger one.
3. **Nuclear Fission** – the splitting of an atom into two smaller atoms.