



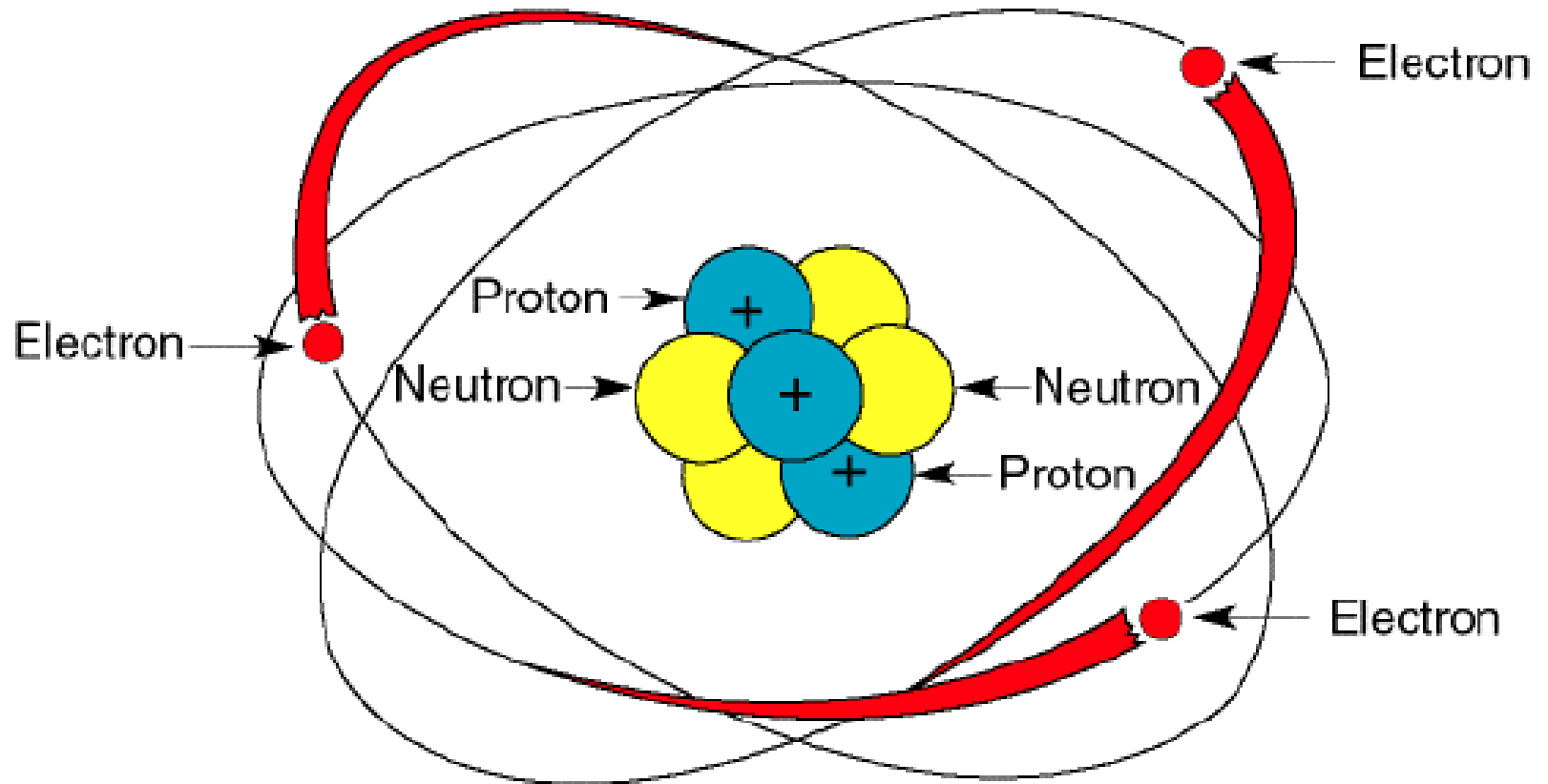
Basic Nuclear Physics

Introduction to WMD Science

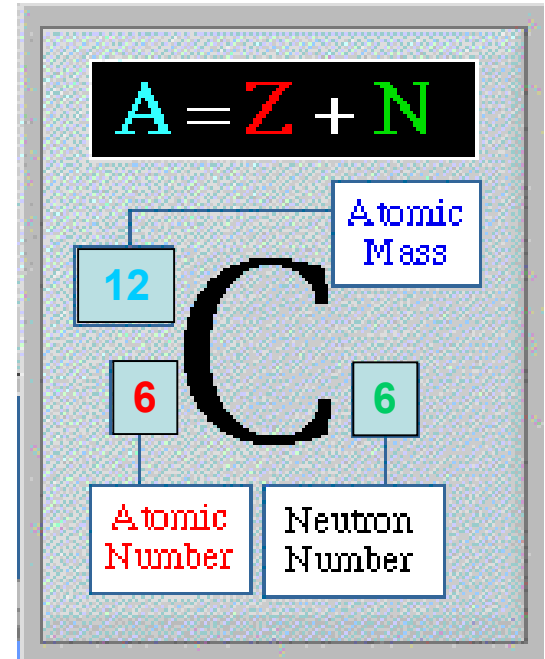
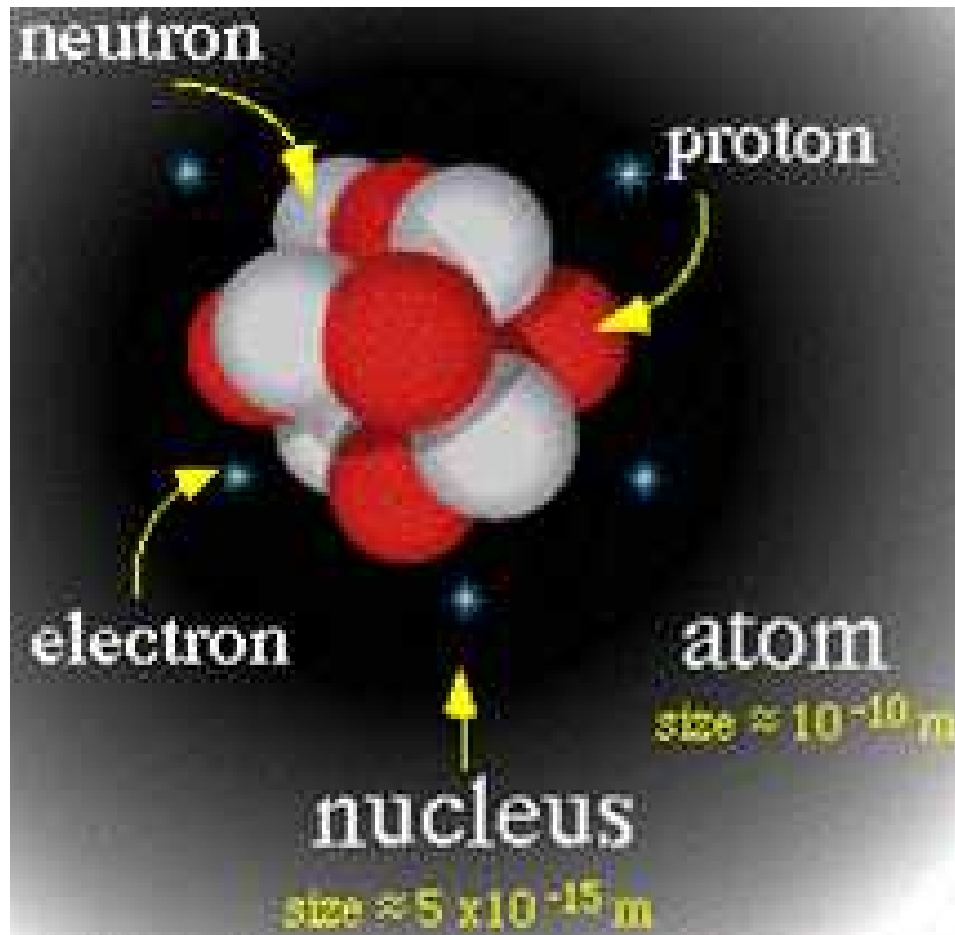
Enabling Objectives

- Describe the basic structure of atoms
- Explain what an isotope means
- Explain what the term half-life means
- Describe the four main types of radiation
- Describe the penetration capabilities of each type of radiation
- State the type of shielding necessary for each type of radiation

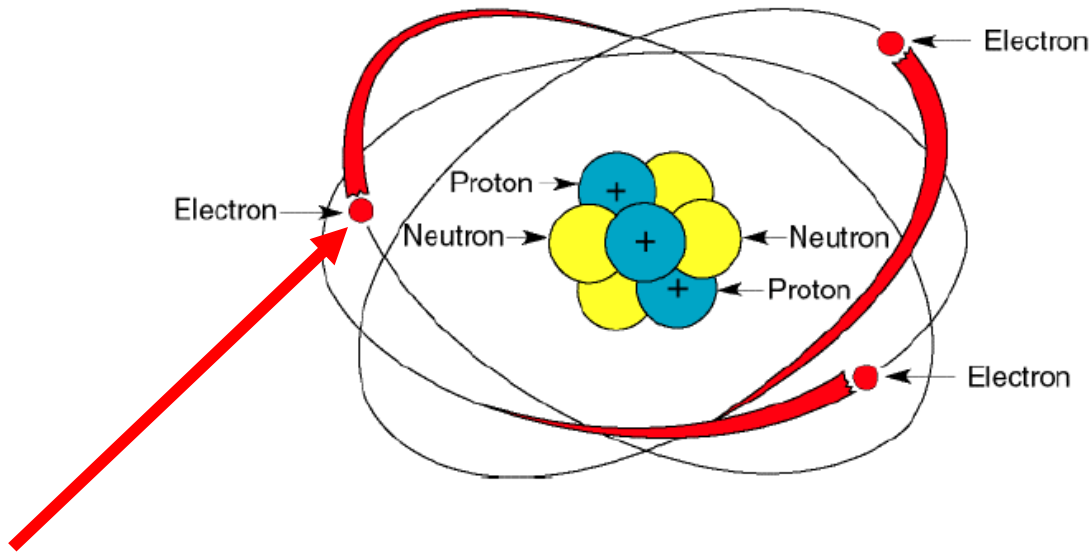
Atoms: Building Blocks of Matter



Basics of the Atom

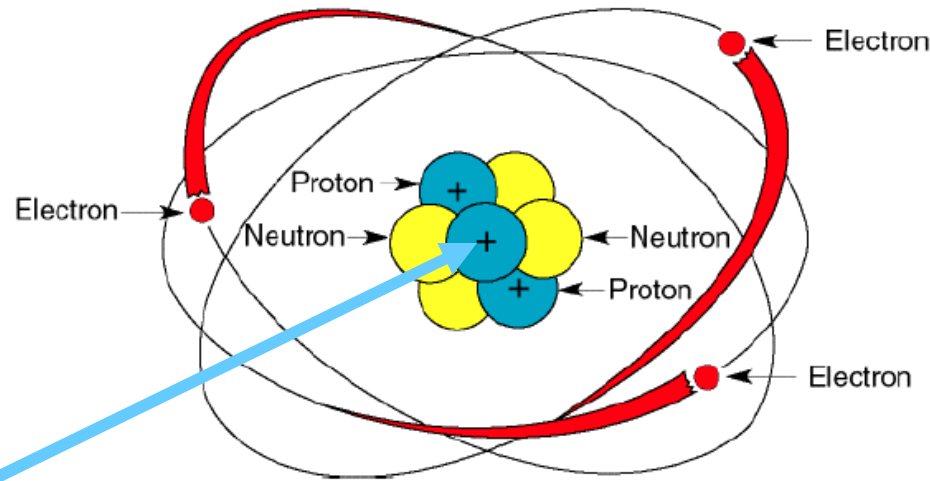


Electrons



- **Electrons** orbit the **nucleus** at a 'large' distance
- Have a **negative** electrical charge
- Have little mass
- Form the basis of chemical bonds
- Define the chemistry of the element
- Do not have a major role in nuclear properties

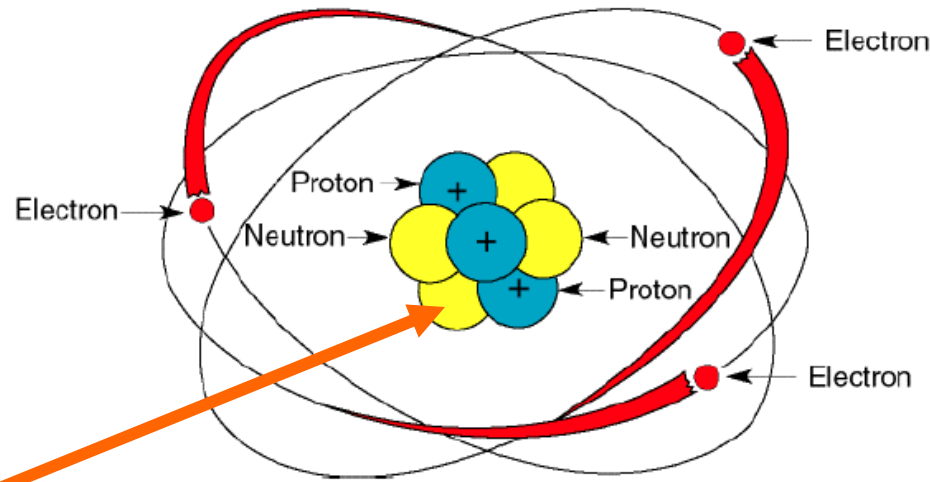
Protons



- **Protons** are located in the nucleus
- Have a **positive** electrical charge
- Have mass (~ 2000 times more massive than the electron)
- Define the chemistry of the element
- Have a major role in nuclear properties

Atoms are electrically neutral

Neutrons



- **Neutrons** are located in the nucleus
- Have no electrical charge
- Have mass (~ 2000 times more massive than the electron)
- Do not have a major impact on chemistry
- Have a major role in nuclear properties

Atom



- **Compared to size of electron cloud, nucleus is very small.**
 - ➔ **Atom is mostly empty space**
- **Atoms are electrically neutral**
 - ➔ **Electric force holds atom together, not gravity**
 - ➔ **Electric attraction between electron and nucleus is about 10^{40} times gravitational attraction**
- **Chemical properties of an atom (element) are determined by its valence (outer) electrons**

number of protons
“atomic number”

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108 different types of atoms known \Rightarrow elements

Isotopes

**Atoms with same number of protons,
but different number of neutrons.**

Example: Hydrogen has 3 isotopes:

1 proton + 0 neutrons



Basic Hydrogen (H)

1 proton + 1 neutron



Deuterium (D)

1 proton + 2 neutrons



Tritium (T)



Isotopes are chemically the same.

Isotopes (continued)

- The number of protons defines the element
- The number of neutrons defines the isotope

Isotopic number = number of neutrons + number of protons

^{239}Pu or Pu-239 or plutonium-239

- The isotopes of an element
 - have **similar chemical** properties
 - have **different nuclear** properties
- Some isotopes are stable
- Some isotopes have too much energy to stick and need to shed the extra energy

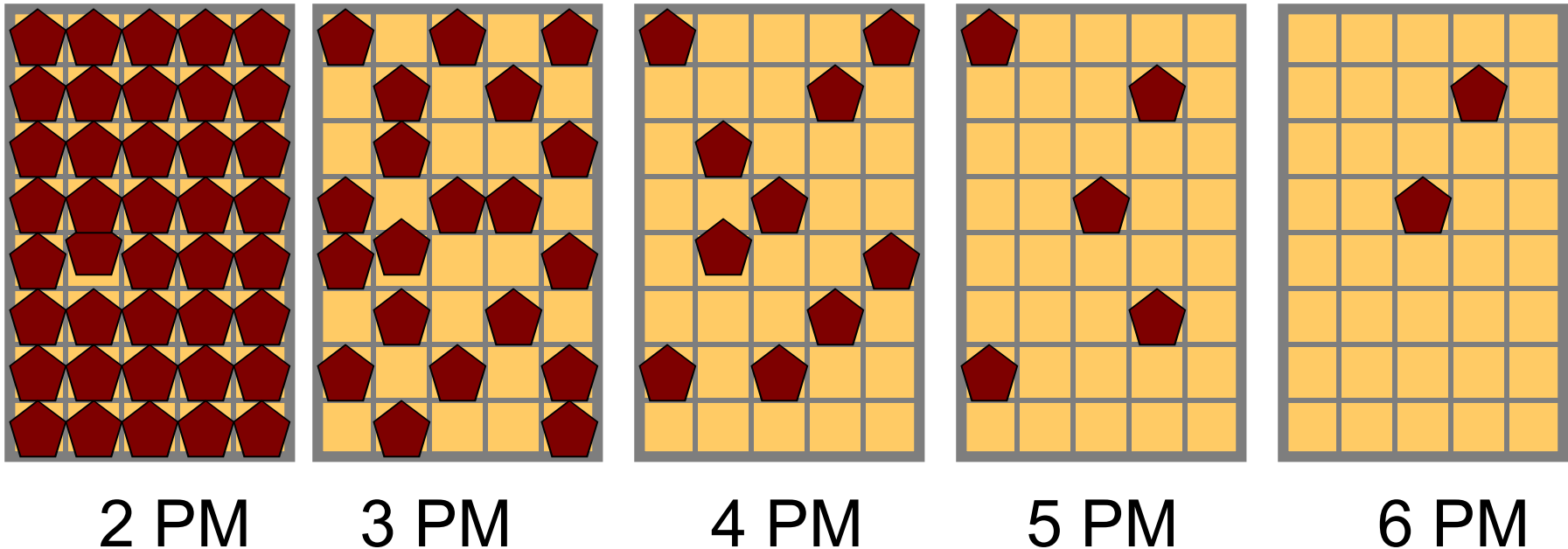


radioactivity

Radioactivity

+

Radioactive Half-Life - the time for $\frac{1}{2}$ of the radioactive atoms to decay

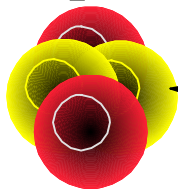


- This analogy is the half-life of a box of candy

Radioactivity

- Radioactive Decay
- Ionizing Radiation
(Interaction with Matter)

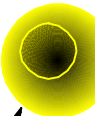
Alpha



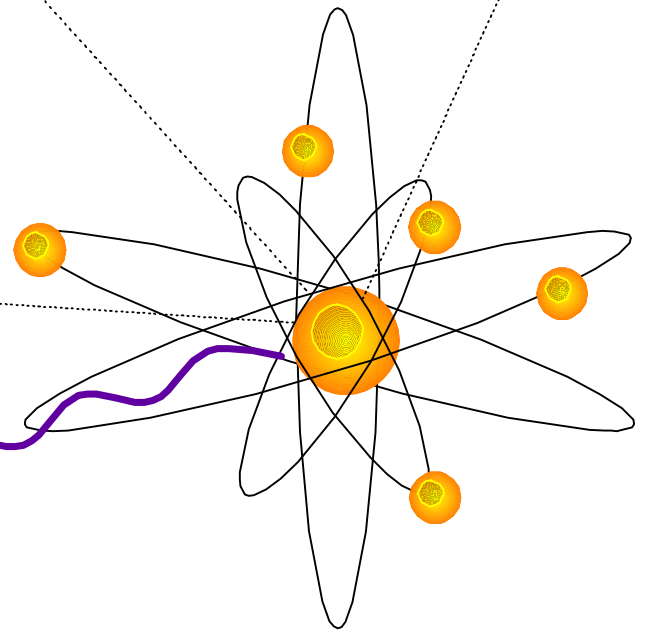
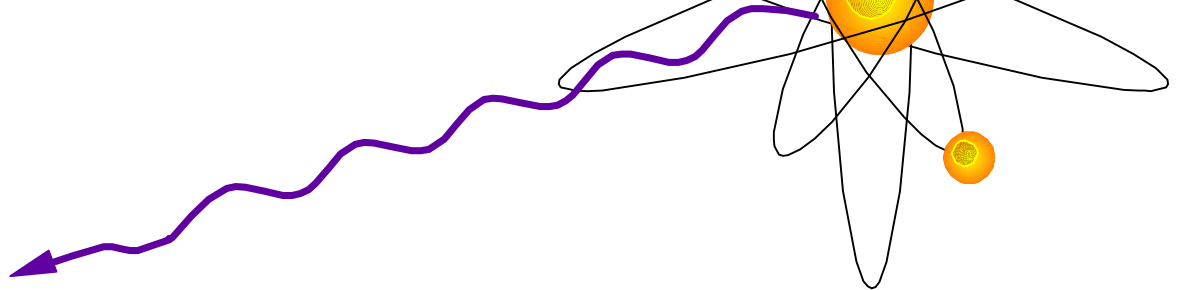
Beta



Neutron

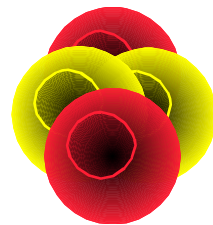


Gamma



Alpha Particles

- Heavy – Positively Charged
- Identical to a Helium atom
- Strong Interaction with Matter (Heavily Ionizing)
- Weak Penetration Power

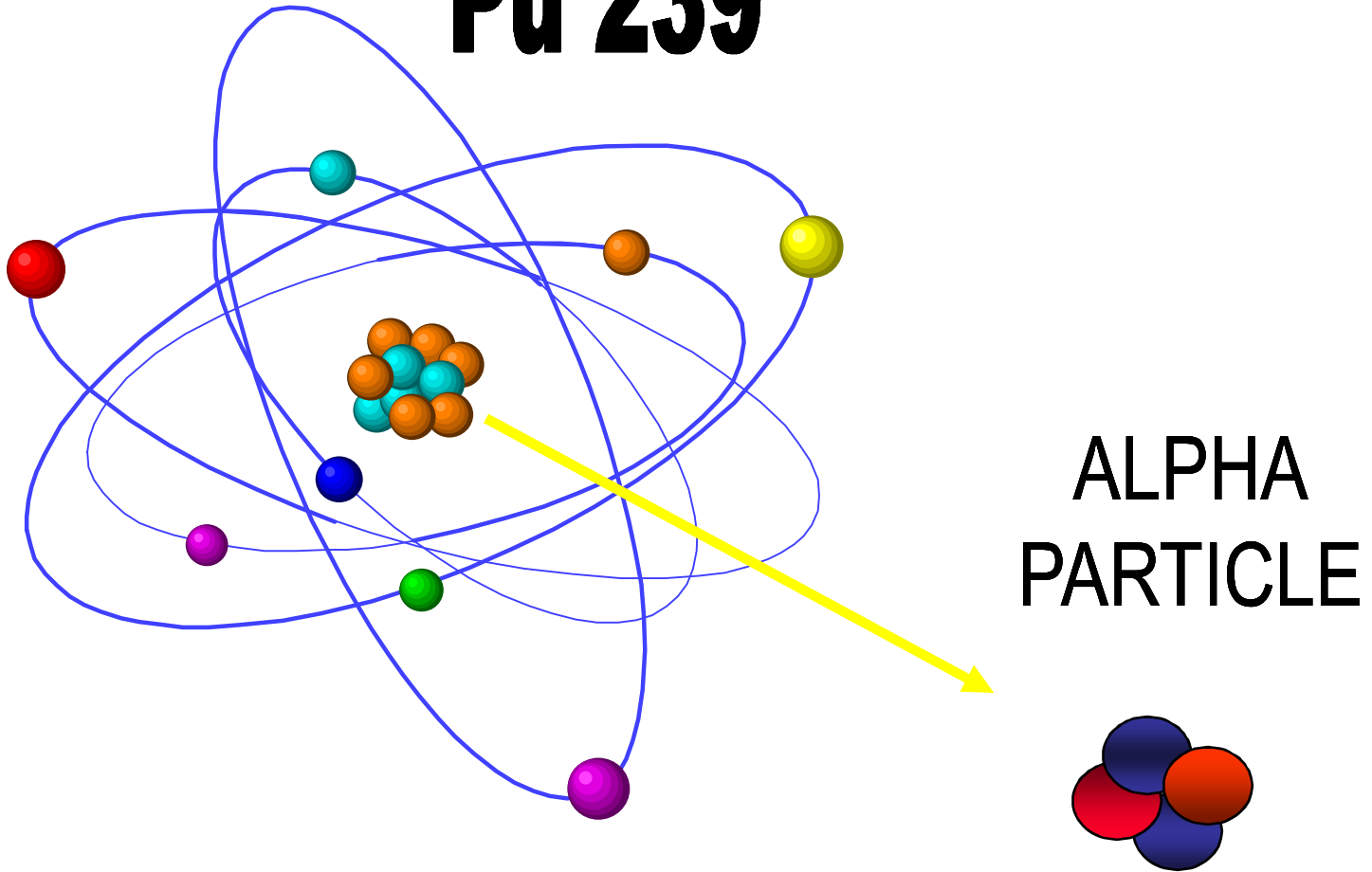


paper



Alpha Particles (continued)

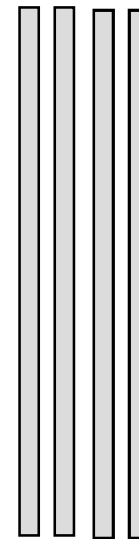
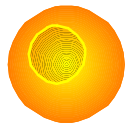
Pu 239



Always accompanied by X-ray or
gamma radiation!

Beta Particles

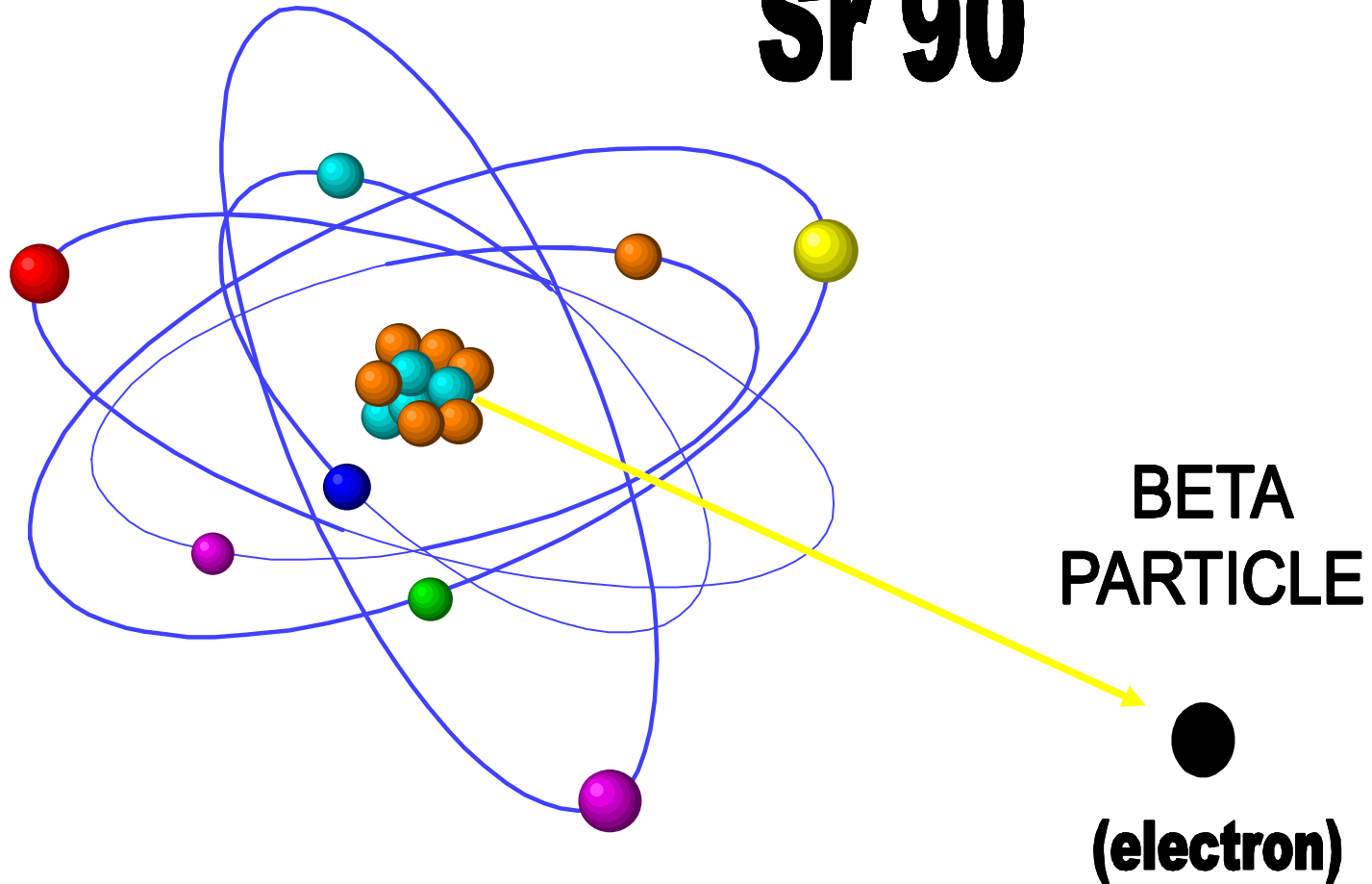
- Light – Negatively Charged; an electron
- Weak Interaction with Matter (Lightly Ionizing)
- Moderate Penetration Power



papers,
plastics
aluminum

Beta Particles (continued)

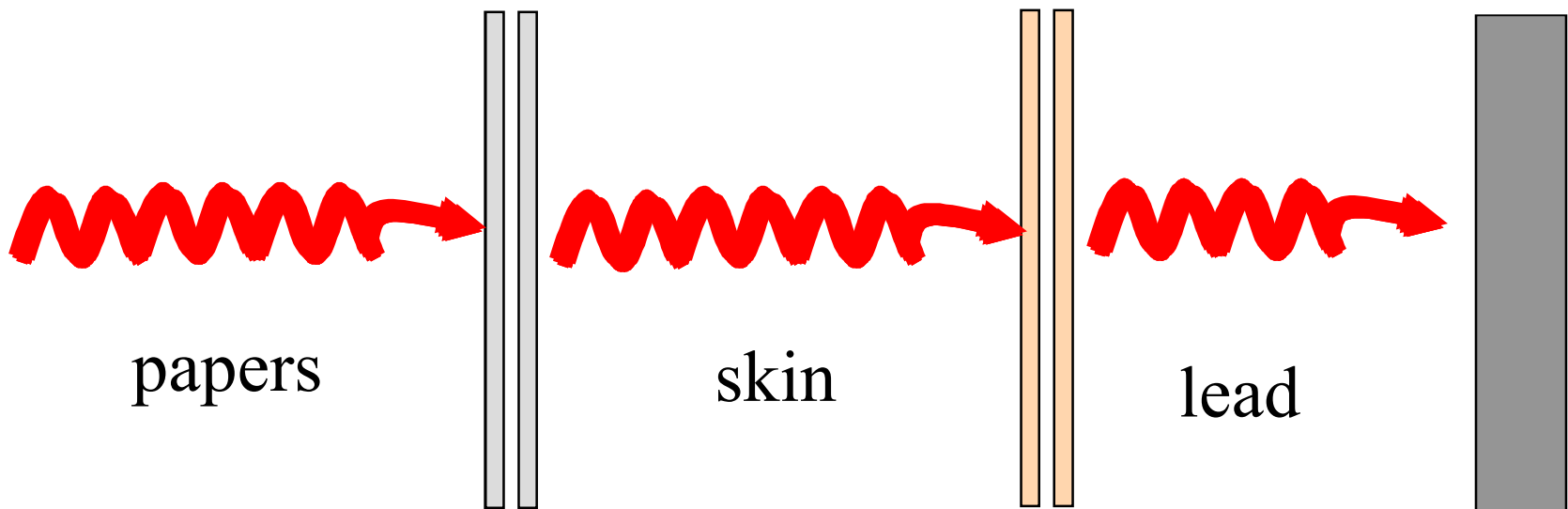
Sr 90



Accompanied by X-ray or gamma
radiation (6 exceptions)

Gamma Rays

- No Mass - No Charge; high energy electromagnetic waves
- Weak Interaction with Matter (Lightly Ionizing)
- Strong Penetration Power



Neutrons

- Heavy - No Charge
- Moderate Interaction with Matter (Moderately Ionizing)
- Strong Penetration Power

