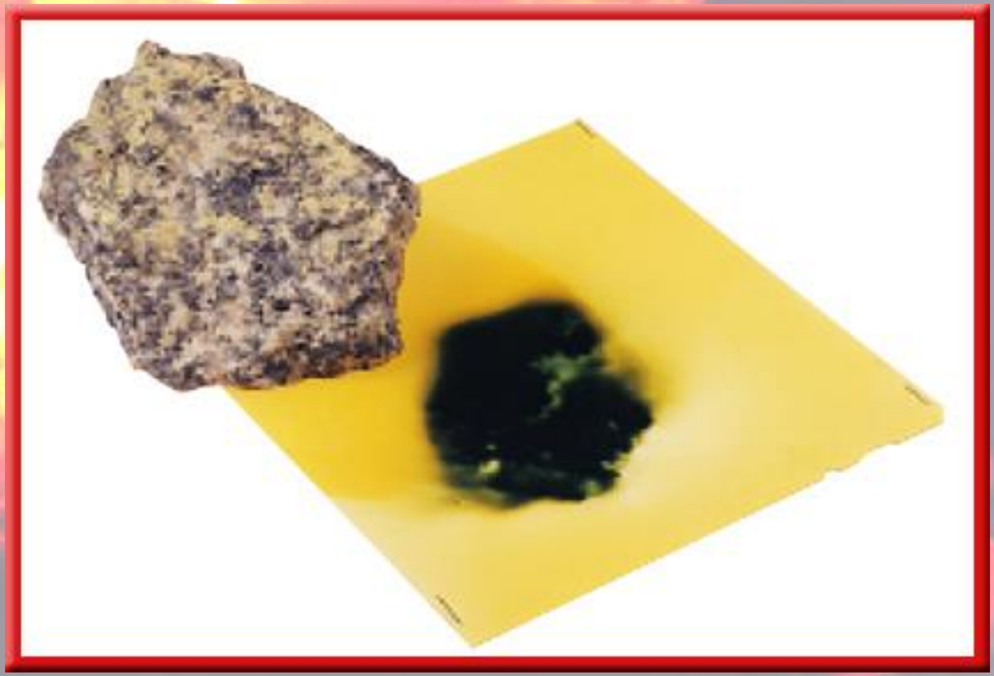
The Discovery of Radioactivity

- **Henri Becquerel** (1852–1908)
  - studied **minerals that emit** light after being exposed to sunlight
    - *Phosphorescence*
  - Studied phosphorescent minerals to see if they emitted X rays.

The Discovery of Radioactivity

- **Becquerel** accidentally discovered that phosphorescent uranium salts—even when not exposed to light—produced **spontaneous emissions.**



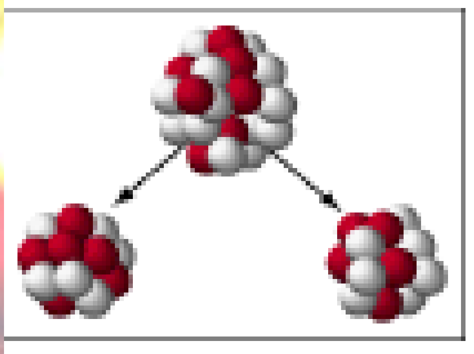
The Discovery of Radioactivity

- **Marie & Pierre Curie**
- studied Becquerel's mineral sample (called pitchblende)
- isolated the components **emitting the rays**
- **Uranium!**
- She called it **radioactivity.**

Review Notes:
4.4 and 25.1 pt.1
Nuclear Chemistry

Nuclear Reactions vs. Normal Chemical Changes

- Nuclear reactions involve the nucleus
- The opening of the nucleus releases a tremendous amount of "*binding energy*"



- "Normal" chemistry involves electrons, not protons and neutrons

Mass Defect

- **Some of the mass can be converted into energy**
- **Shown by a very famous equation!**

$$E=mc^2$$

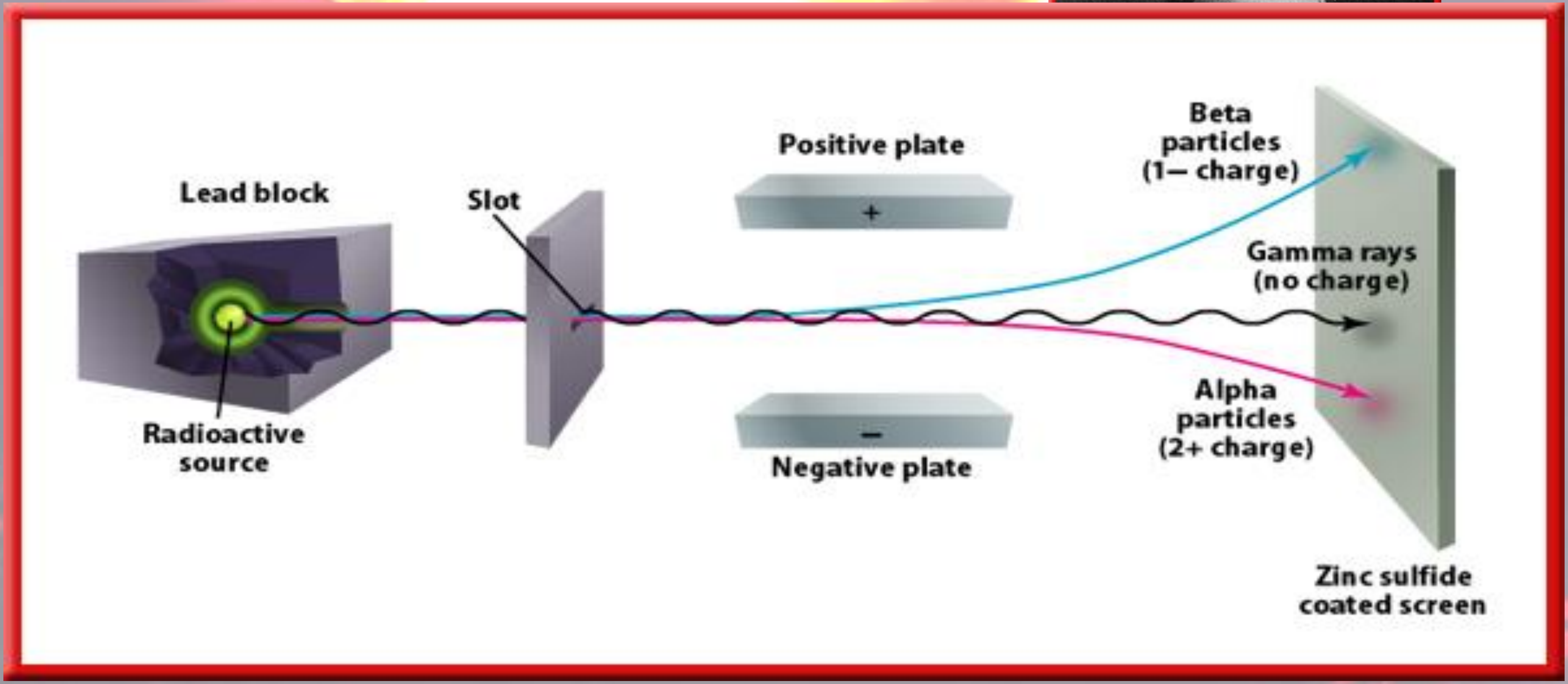
Energy → E

Mass → m

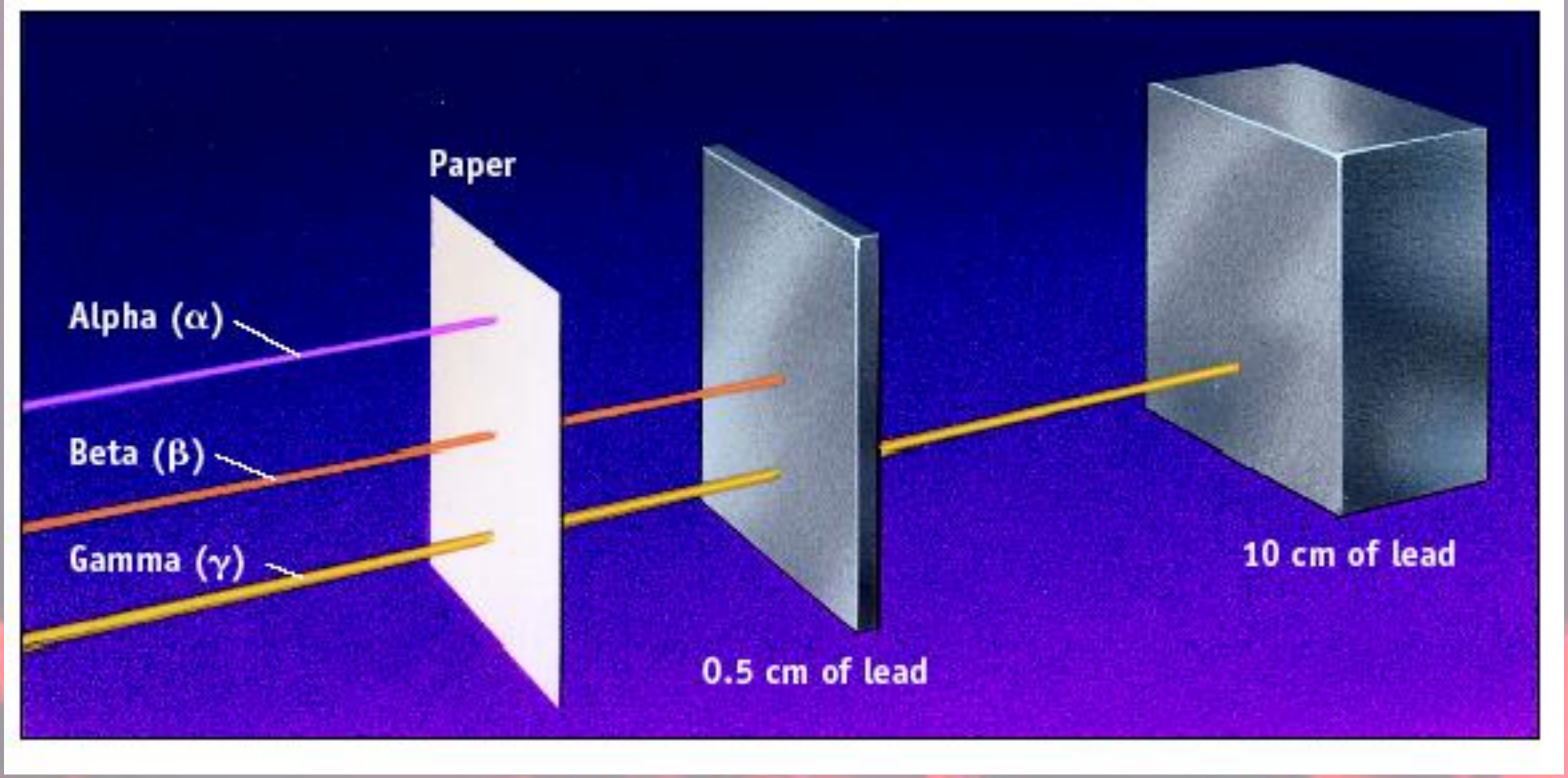
Speed of light → c

Types of Radiation

Ernest Rutherford



Penetrating Ability



Types of Radiation

- Alpha (α) – a helium isotope $^{4}_{2}He$
- Beta (β) – an electron $^{0}_{-1}e$ $^{0}_{-1}\beta$
- Gamma (γ) – pure energy; no mass- a ray not a particle $^{0}_{0}\gamma$
- Neutron $^{1}_{0}n$
- Positron – a positive electron $^{0}_{+1}e$
- Proton – Hydrogen-1 *(minus the electron)* $^{1}_{1}H$

Review Notes:
4.4 and 25.1 (pt.2)
Nuclear Chemistry

Alpha Radiation

- Alpha particles are **relatively slow-moving**.
- **Not very penetrating.**
- Stopped by **paper**

Alpha Decay: Loss of an α-particle

$$^{238}_{92}\mathrm{U} \longrightarrow \quad \boxed{} \quad + \, ^{4}_{2}\mathrm{He}$$

Beta Radiation

- A **Beta particle** is a *very-fast* moving electron
- **Neutron** changes into a **proton** and a **beta particle** is released.
- A thin **metal foil** is required to **stop beta** particles.

Beta Decay: Loss of a *β*-particle

$$^{131}_{53}\mathrm{I} \longrightarrow \boxed{} + \,^{0}_{-1}\mathrm{e}$$

Gamma Radiation

- **Gamma rays** are high-energy electromagnetic radiation.
- **Emitted with alpha and beta radiation**.
- They are the **energy released.**

$$^{238}_{92}U \longrightarrow \, ^{234}_{90}Th + \, ^{4}_{2}He + \, ^{0}_{0}\gamma$$

$$^{131}_{53}I \longrightarrow \, ^{131}_{54}Xe + \, ^{0}_{-1}e + \, ^{0}_{0}\gamma$$

Balancing a Nuclear Equation

- Write a balanced nuclear equation for the alpha decay of thorium-230 ($^{230}_{90}\text{Th}$).

$$^{230}_{90}\text{Th} \longrightarrow \, ^{226}_{88}\text{Ra} + \, ^{4}_{2}\text{He} + \, ^{0}_{0}\gamma$$

Review Notes:
4.4 and 25.1 (pt.3)
Nuclear Chemistry

Positron Emmision

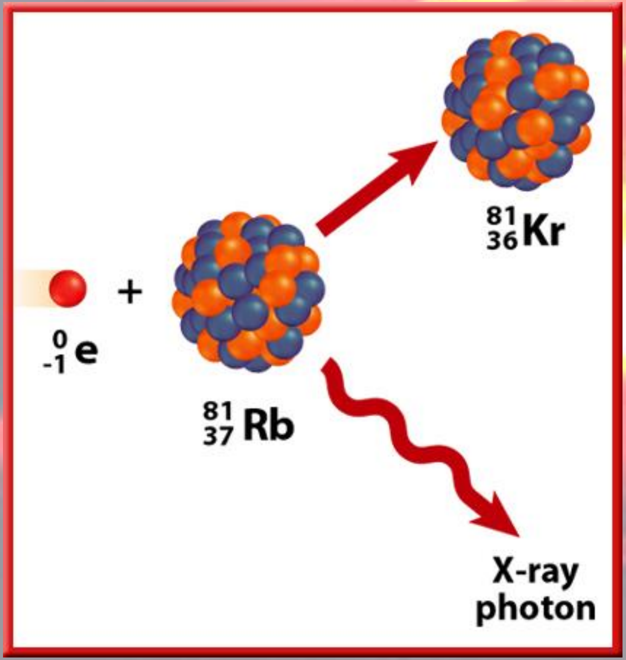
Loss of a positron: a **proton** in the nucleus is converted into a **neutron** and a **positron**

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

$$^{11}_{6}C \longrightarrow \square + {}^{0}_{+1}e$$

Electron Capture

- Nucleus of an atom **draws in** an electron!
- Electron is added to a **proton** to form a **neutron**.



$$^{1}_{1}H + ^{0}_{-1}e \longrightarrow \square$$

Question 1

What element is formed when polonium-214 ($^{214}_{84}Po$) radioisotope undergoes alpha decay? Give the atomic number and mass number of the element.

$$^{214}_{84}Po \longrightarrow {}^{210}_{82}Pb + {}^{4}_{2}He + {}^{0}_{0}\gamma$$

Question 2

What element is formed when $^{60}_{26}\mathrm{Fe}$ undergoes beta decay? Give the atomic number and mass number of the element.

$$^{60}_{26}\mathrm{Fe} \longrightarrow {}^{60}_{27}\mathrm{Co} + {}^{0}_{-1}\mathrm{e} + {}^{0}_{0}\gamma$$

Question 3

Write the balanced nuclear equation for the positron emitter Co-60.

$$^{60}_{27}\mathrm{Co} \longrightarrow {}^{60}_{26}\mathrm{Fe} + {}^{0}_{+1}\mathrm{e} + {}^{0}_{0}\gamma$$

Question 4

Write a balanced nuclear equation for the beta decay of the following radioisotope.

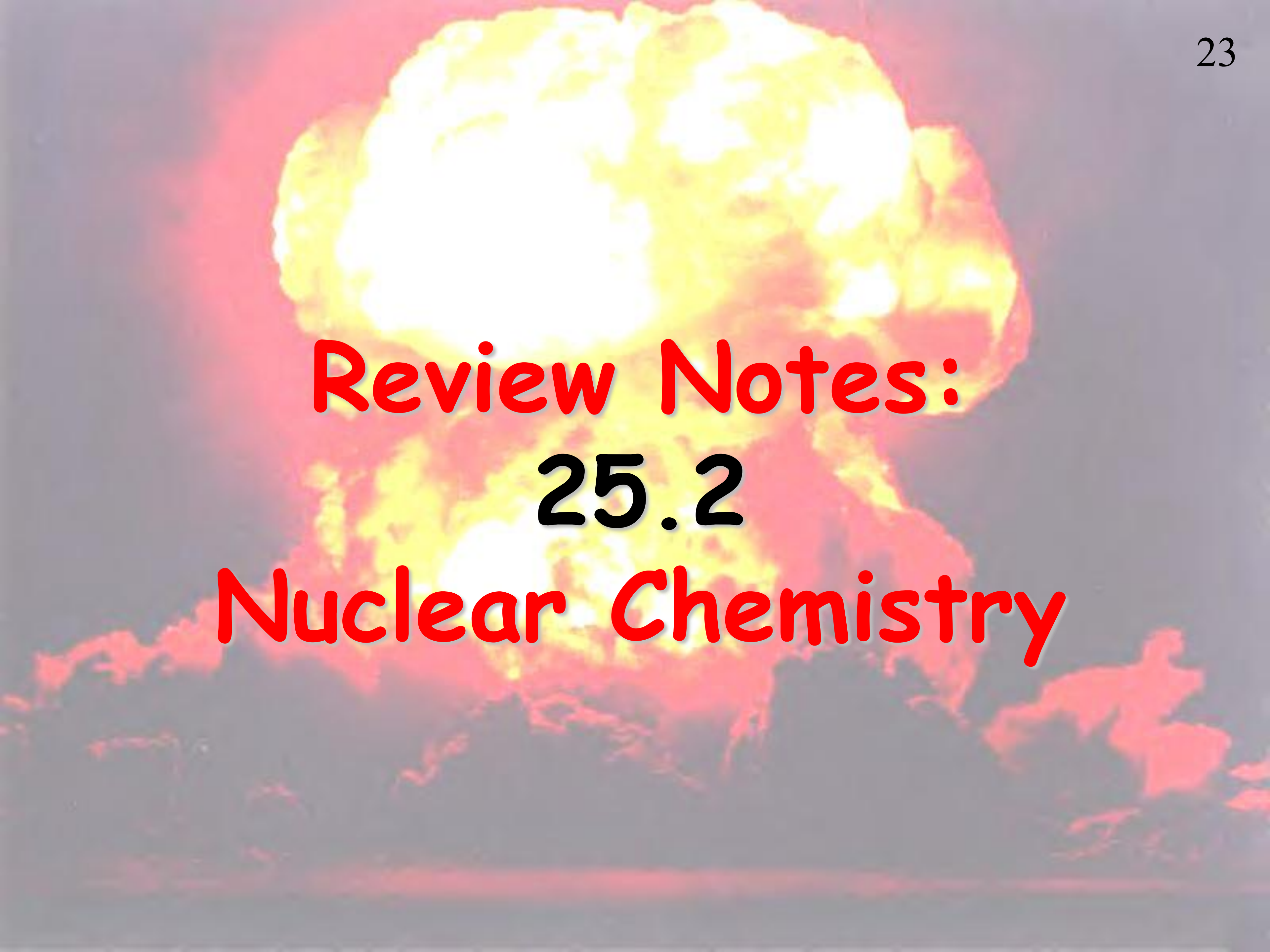
$^{235}_{92}\mathrm{U}$

$$^{235}_{92}\mathrm{U} \longrightarrow {}^{235}_{93}\mathrm{Np} + {}^{0}_{-1}\mathrm{e} + {}^{0}_{0}\gamma$$

Question 5

Write a balanced nuclear equation showing Rubidium-81 in an electron capture.

$$ {}^{81}_{37}\mathrm{Rb} + {}^{0}_{-1}\mathrm{e} \longrightarrow {}^{81}_{36}\mathrm{Kr} $$



Review Notes:
25.2
Nuclear Chemistry

The Discovery of Radioactivity

- In 1895, ***Wilhelm Roentgen*** (1845–1923)
  - Some materials **emit invisible rays.**
  - He called these **X rays**.

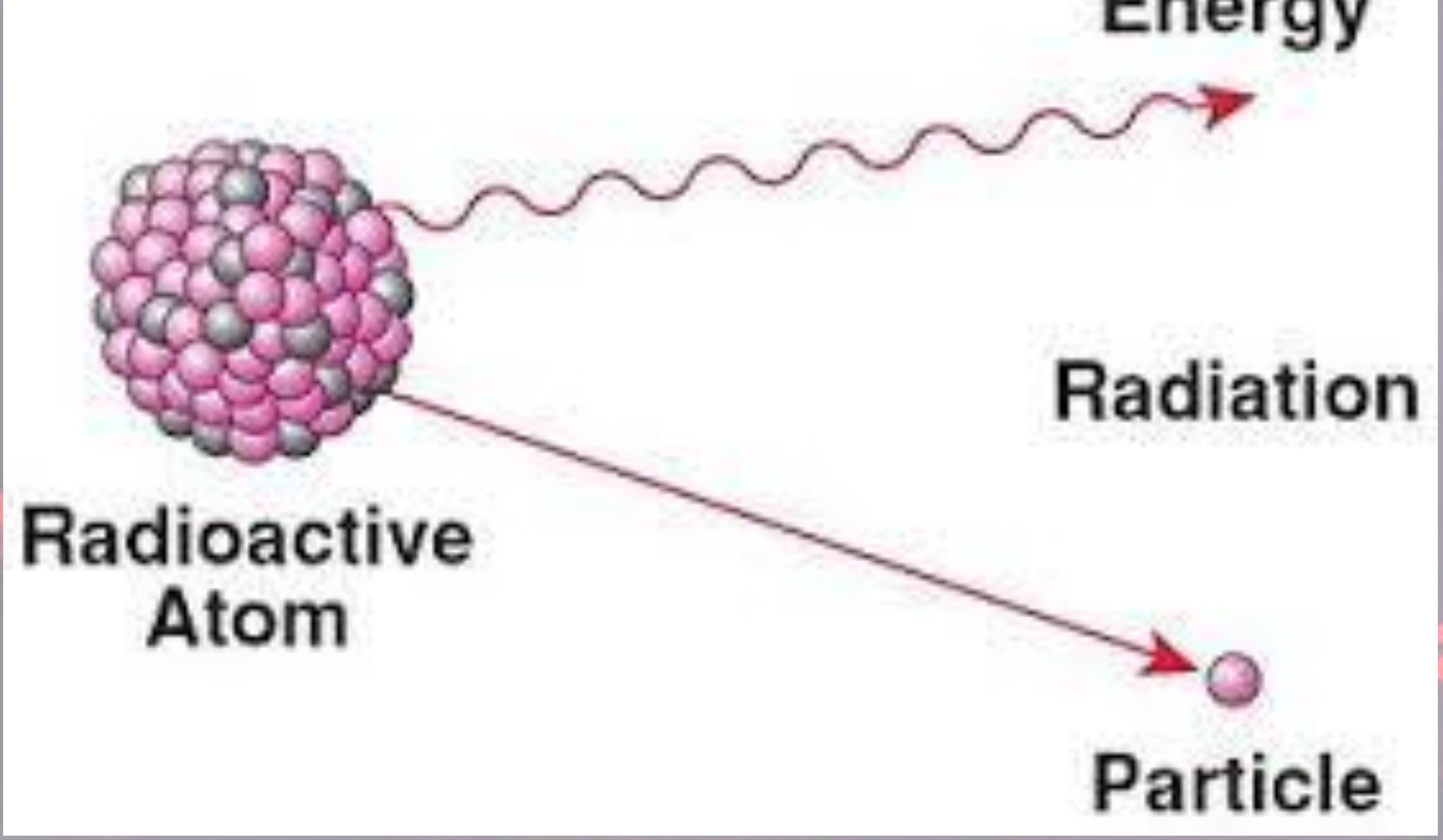
- *Roentgen's discovery of X rays created excitement within the scientific community and stimulated further research.*

Radiation Terms

- *The rays and particles emitted* → **radiation**.
- Isotopes of **unstable nuclei**→**radioisotopes**.
- **Unstable nuclei** emit radiation to become stable →**radioactive decay.**

Radioactive Decay

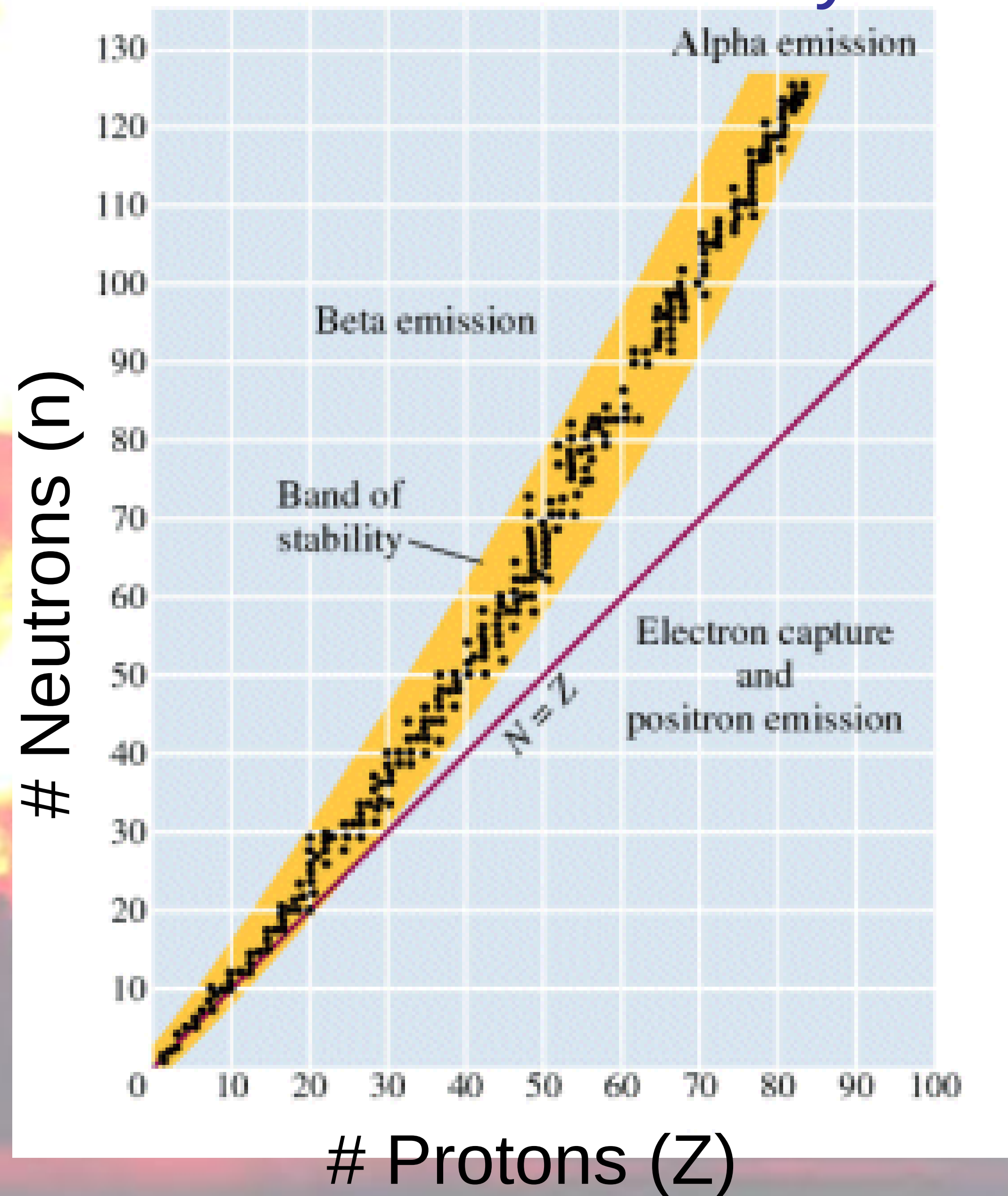
Review Notes 25.3



Nuclear Stability

- Depends on the neutron to proton ratio.

Band of Stability



Too many neutrons?

Neutron

Proton

Beta Decay

Example:

$^{14}_{6}\mathrm{C} \rightarrow$

In C-14 the ratio of neutrons to protons is 1.3 : 1.

Radioactive Half-Life ($t_{1/2}$):

Time for **half** of the radioactive nuclei in a given sample to undergo **decay**.

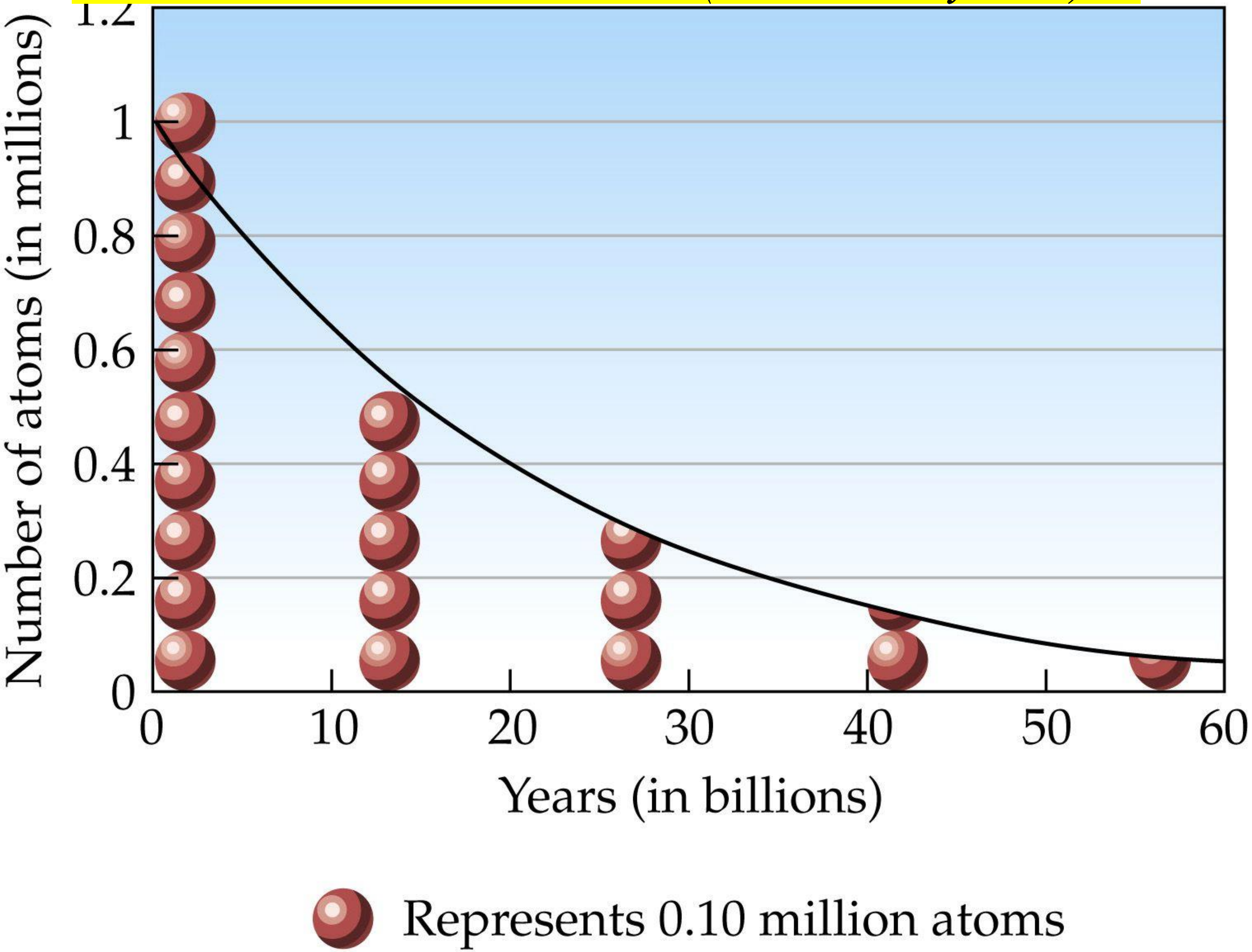
Isotope	*Half-Life*	*Radiation*
Carbon-14		β, γ
Radon-222		α
Uranium-235		α, γ
Uranium-238		α

Radioactive Half-Life

- After one half life there is HALF of original sample left.

- After two half-lives:
  - there will be **1/2** of the **1/2 =** of the original sample.

Half-life of Th-232 *(14 billion years)*



FUSION AND FISSION

FUSION

In nuclear fusion, two nuclei with low mass numbers fuse to produce a single nucleus.

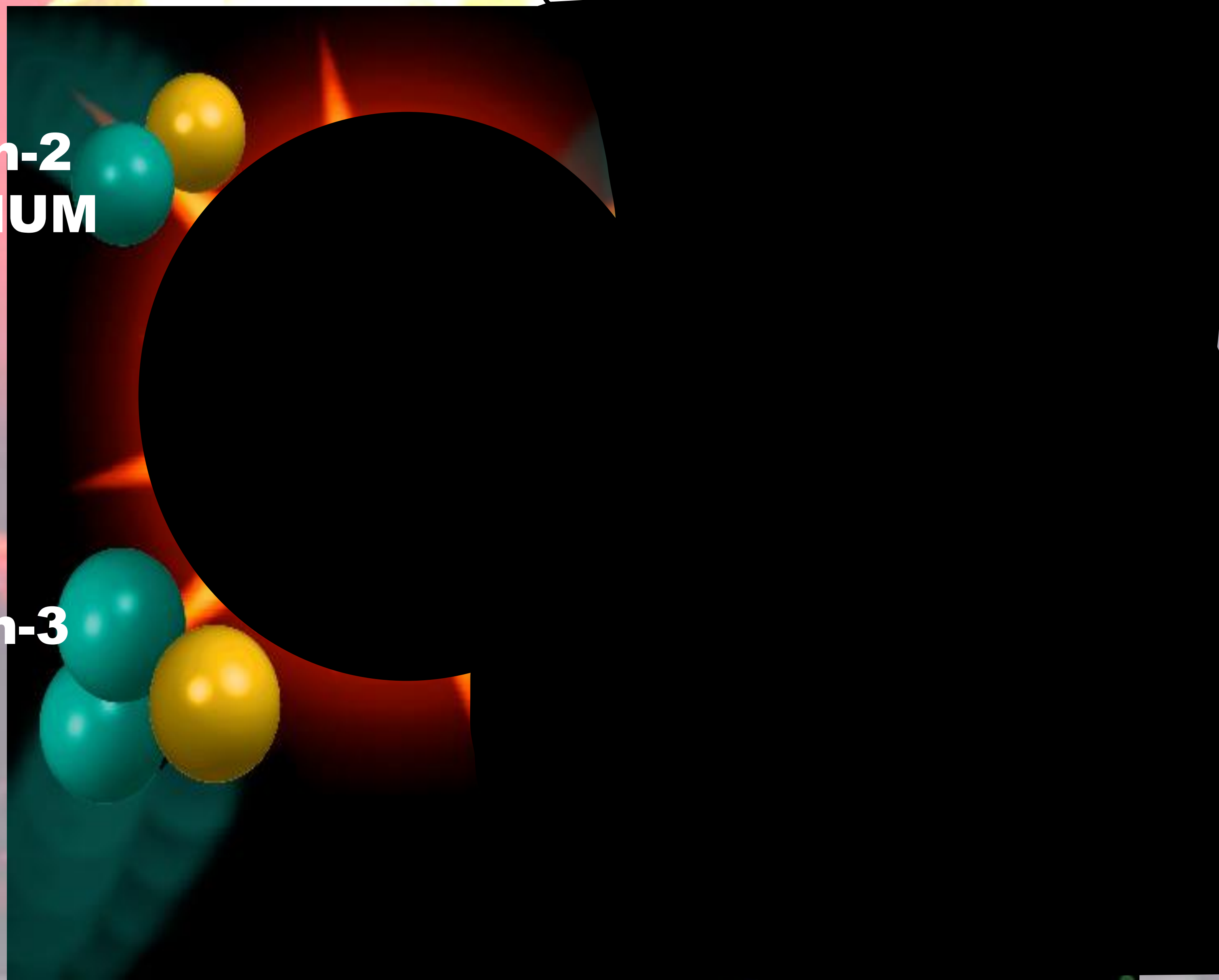
$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + \text{Energy}$$

FUSION

Hydrogen-2
DEUTERIUM

+

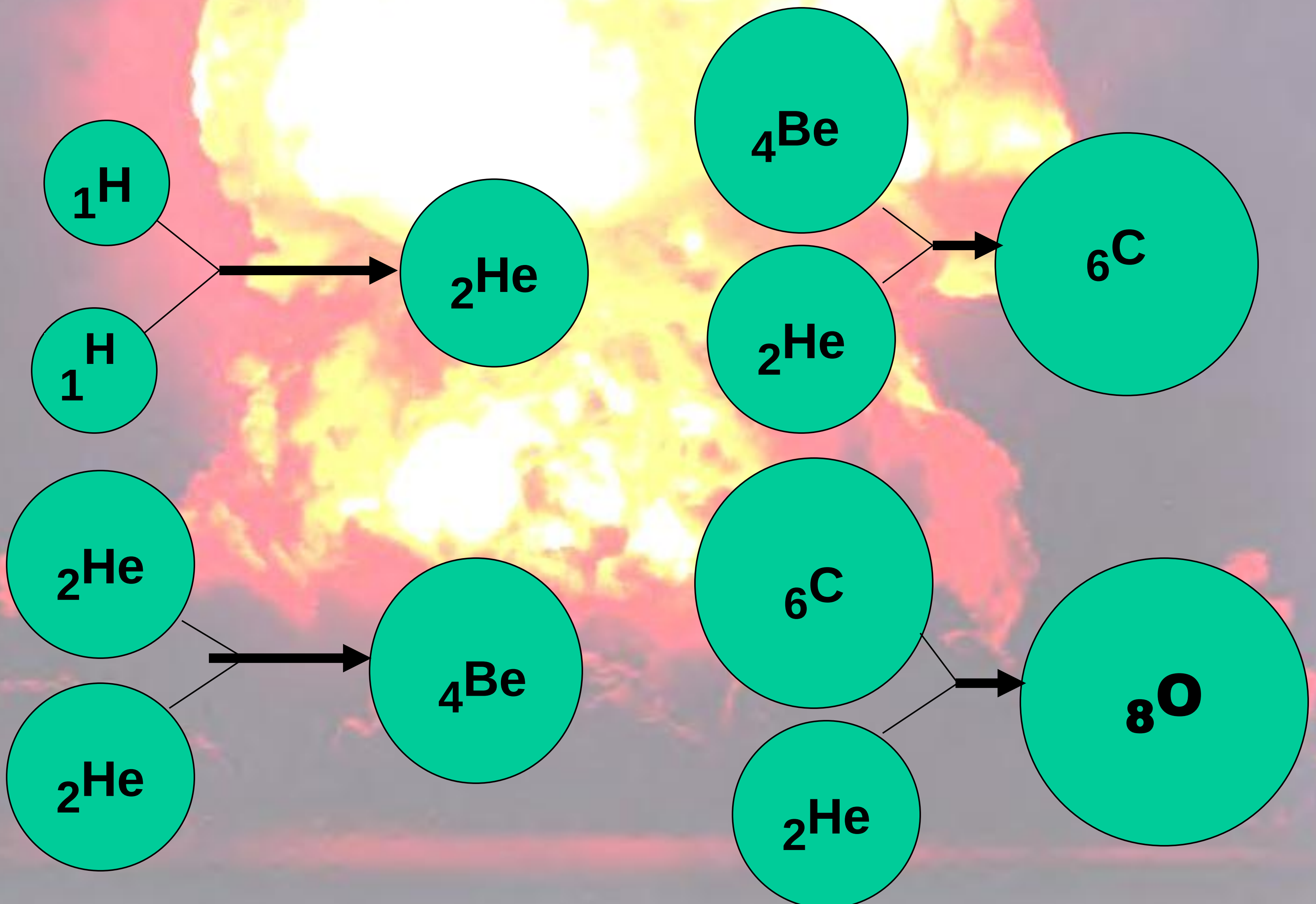
Hydrogen-3
TRITIUM



THE SUN

Every second, the sun converts 500 million metric tons of hydrogen to helium through nuclear fusion.

Complete the Fusion Reaction

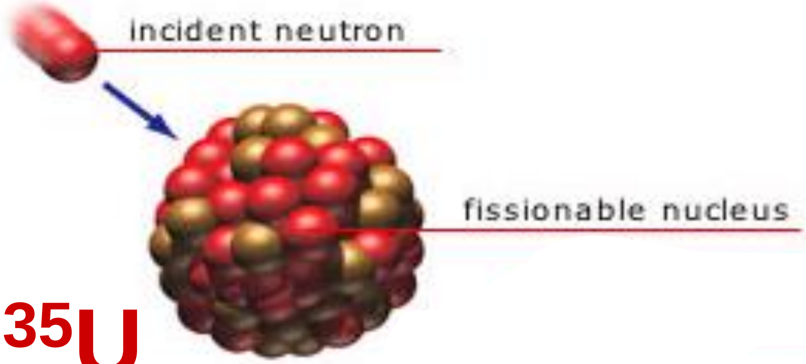


NUCLEAR FISSION

When nuclei, with a high mass number, are bombarded with neutrons, their nuclei splits into 2 parts which are roughly equal in size.

During nuclear fission, neutrons are released.

Nuclear Fission



^{235}U

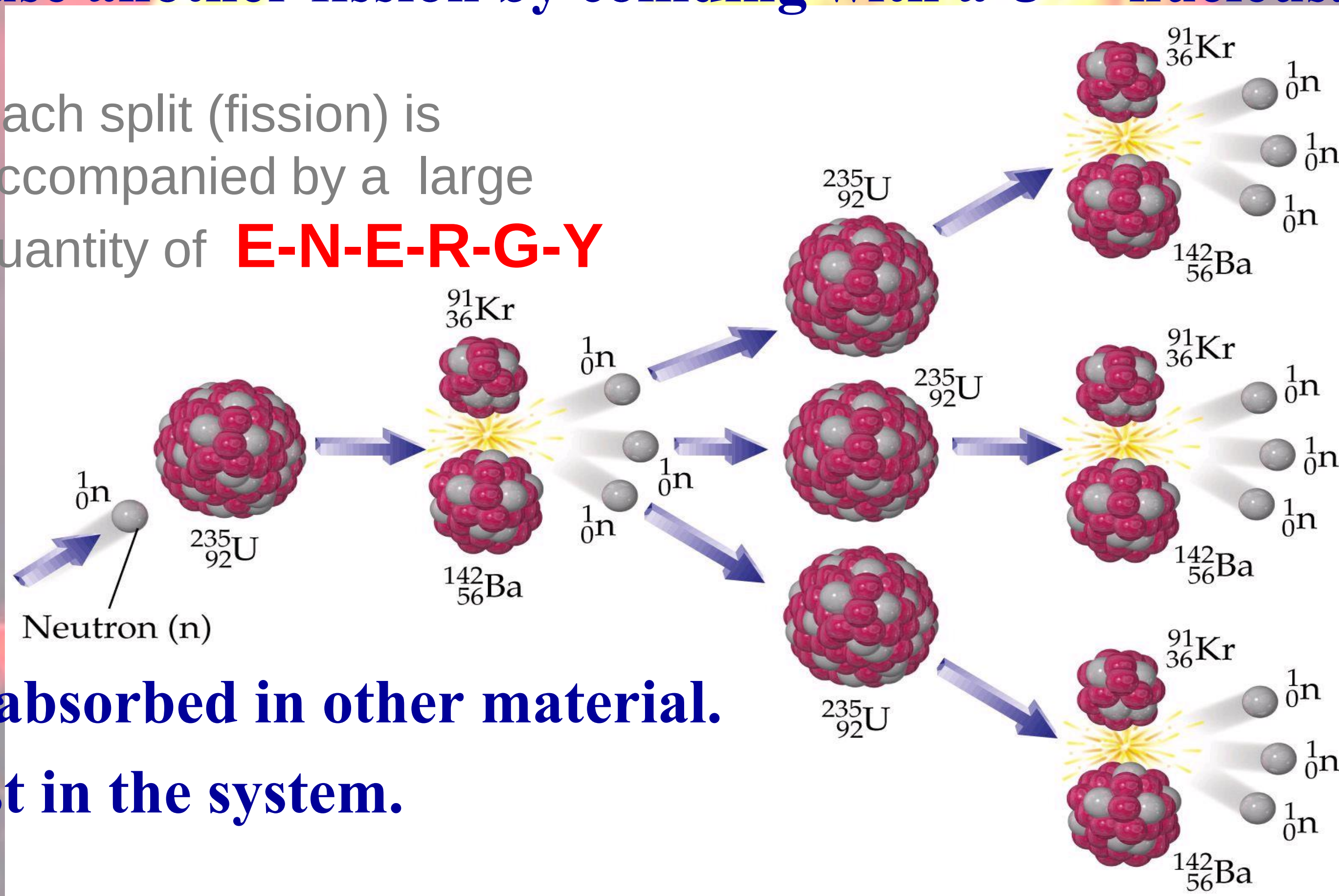
Fission is Exothermic

= **ENERGY**

Neutrons may:

1 - Cause another fission by colliding with a U^{235} nucleus.

Each split (fission) is accompanied by a large quantity of **E-N-E-R-G-Y**



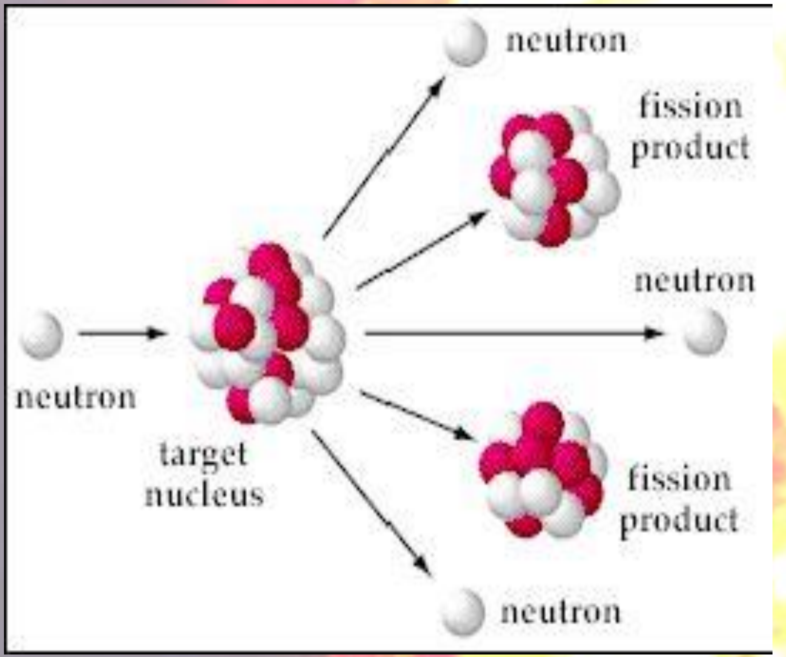
2 - Be absorbed in other material.

3 - Lost in the system.

If sufficient neutrons are present, we may achieve a **chain reaction**.

Mousetrap Fission

Review

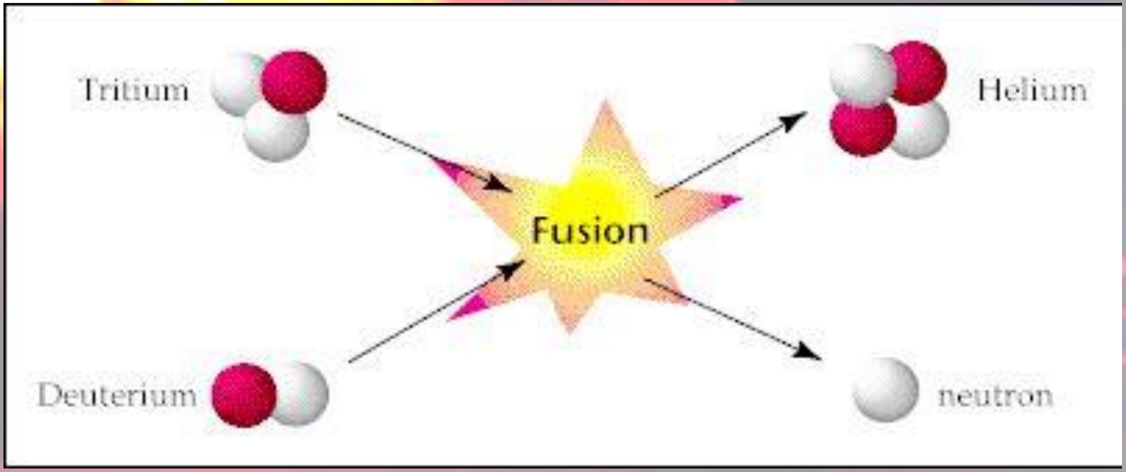


Nuclear fission:

A large _**nucleus**_ splits into several small ___**nuclei**__when impacted by a__**neutron**_, and energy is __**released**__.

Occurs in **nuclear reactors**_.

Nuclear fusion:



Several _**small**_ nuclei _**fuse**_ together and **release** energy.

Occurs in _**the sun**___.