Nuclear Radiation

Natural Radioactivity

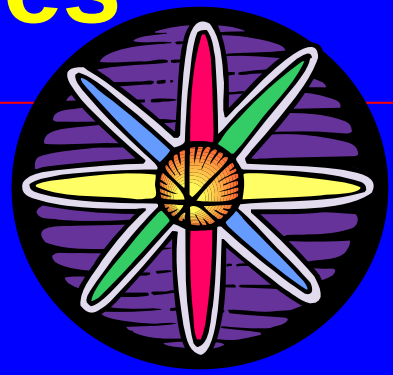
Nuclear Equations

Producing Radioactive Isotopes

Half-Life

Nuclear Fission and Fusion

Subatomic Particles



- Protons- plus charge
- Neutrons- neutral

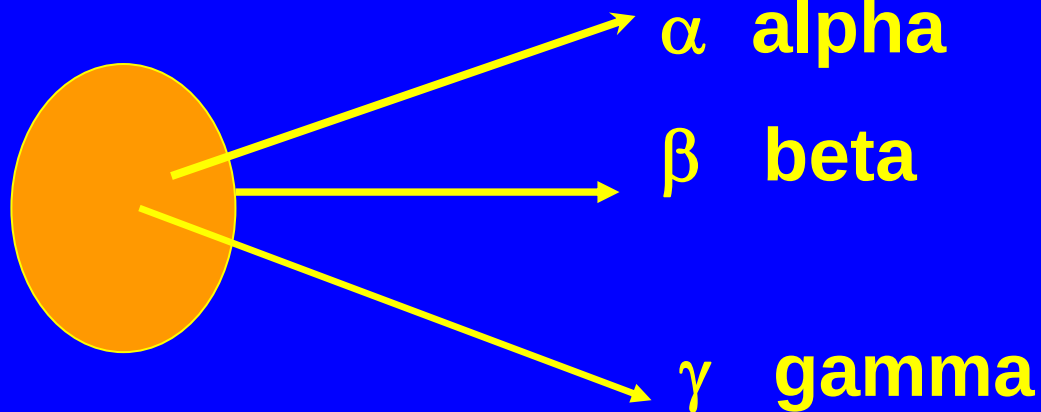
In the nucleus

- Electrons - negative charge

Outside the nucleus

Radiation

- Radiation comes from the nucleus of an atom.
- Unstable nucleus emits a particle or energy



Alpha Particle

Same as a helium nucleus (He)

$$^{4}_{2}He \quad \text{or} \quad \alpha$$

Two protons

Two neutrons

Beta Particle β

An electron emitted from the nucleus

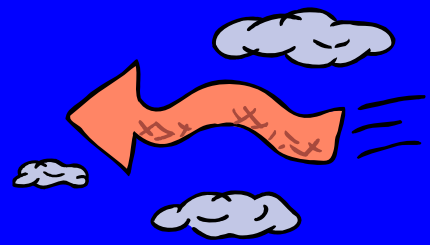
$$^{0}_{-1}e \quad \text{or} \quad \beta$$

A neutron in the nucleus breaks down

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

Gamma γ Radiation

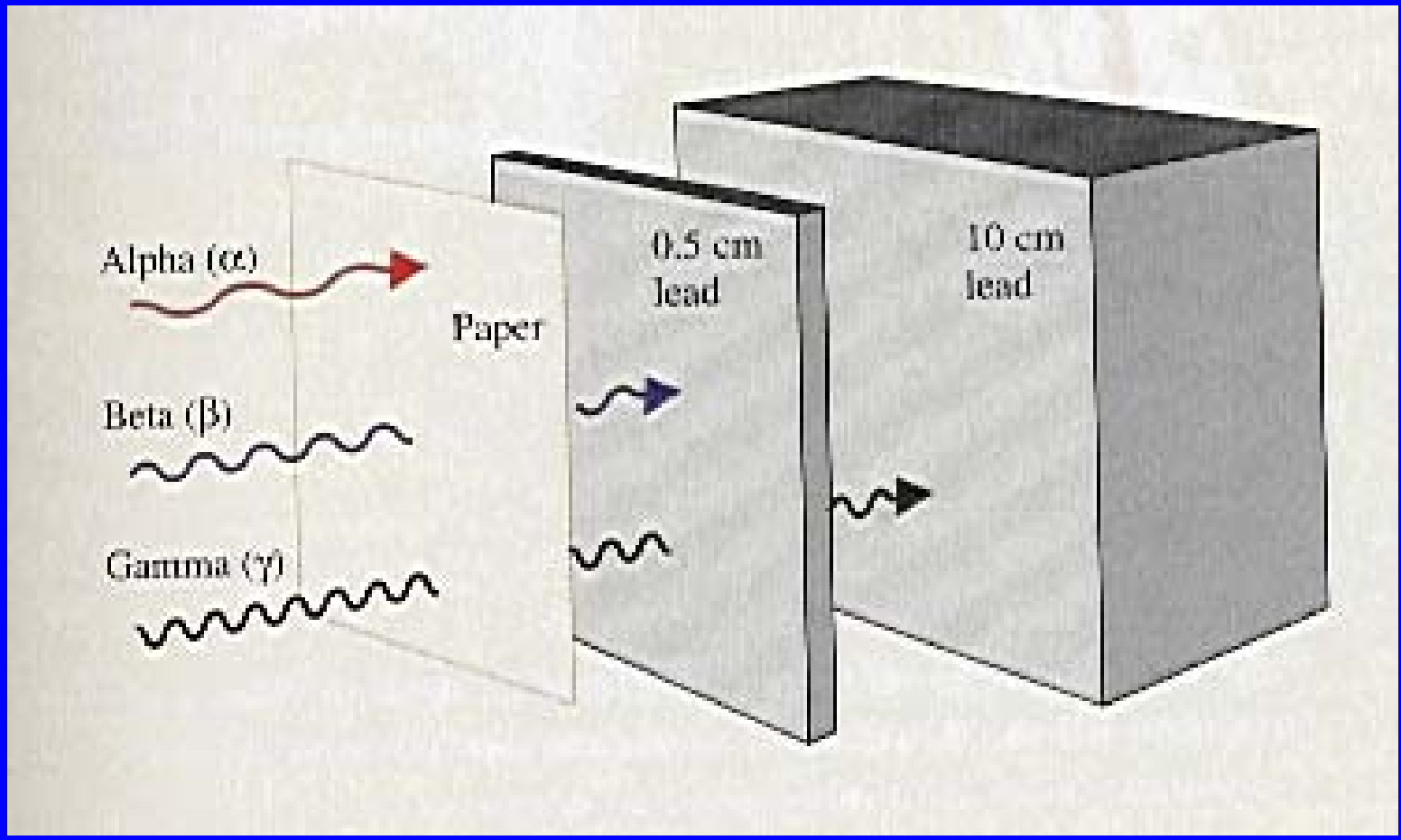
- Pure radiation
- Like an X-ray but comes from the nucleus



Radiation Protection

- Shielding
  - alpha – paper, clothing
  - beta – lab coat, gloves
  - gamma- lead, thick concrete
- Limit time exposed
- Keep distance from source

Radiation Protection



Balancing Nuclear Equations

In the reactants and products

Atomic numbers must balance

and

Mass numbers must balance

Alpha decay

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

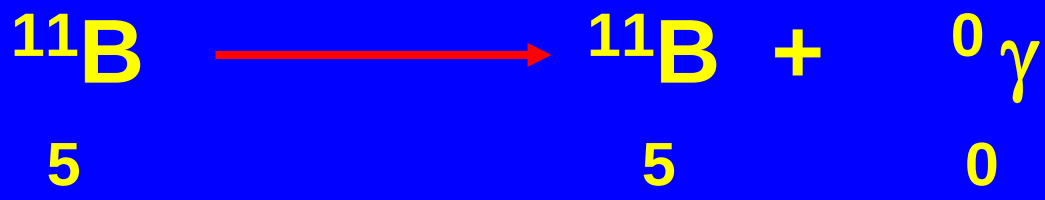
Beta decay

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

beta particle

Gamma radiation

No change in atomic or mass number



boron atom in a high-energy state

Learning Check NR1

Write the nuclear equation for the beta emitter Co-60.

Solution NR1

Write the nuclear equation for the Beta emitter Co-60.

$$^{60}_{27}\mathrm{Co} \longrightarrow {}^{60}_{28}\mathrm{Ni} + {}^{0}_{-1}\mathrm{e}$$

Producing Radioactive Isotopes

Bombardment of atoms produces radioisotopes

$$^{59}_{27}\mathrm{Co} + {}^{1}_{0}\mathrm{n} \longrightarrow {}^{56}_{25}\mathrm{Mn} + {}^{4}_{2}\mathrm{He}$$

= 60 *= 60*

= 27 *= 27*

cobalt atom **neutron** **manganese radioisotope** **alpha particle**

Learning Check NR2

What radioactive isotope is produced in the following bombardment of boron?

$$^{10}_{5}B + {}^{4}_{2}He \longrightarrow {}^{?} + {}^{1}_{0}n$$

Solution NR2

What radioactive isotope is produced in the following bombardment of boron?

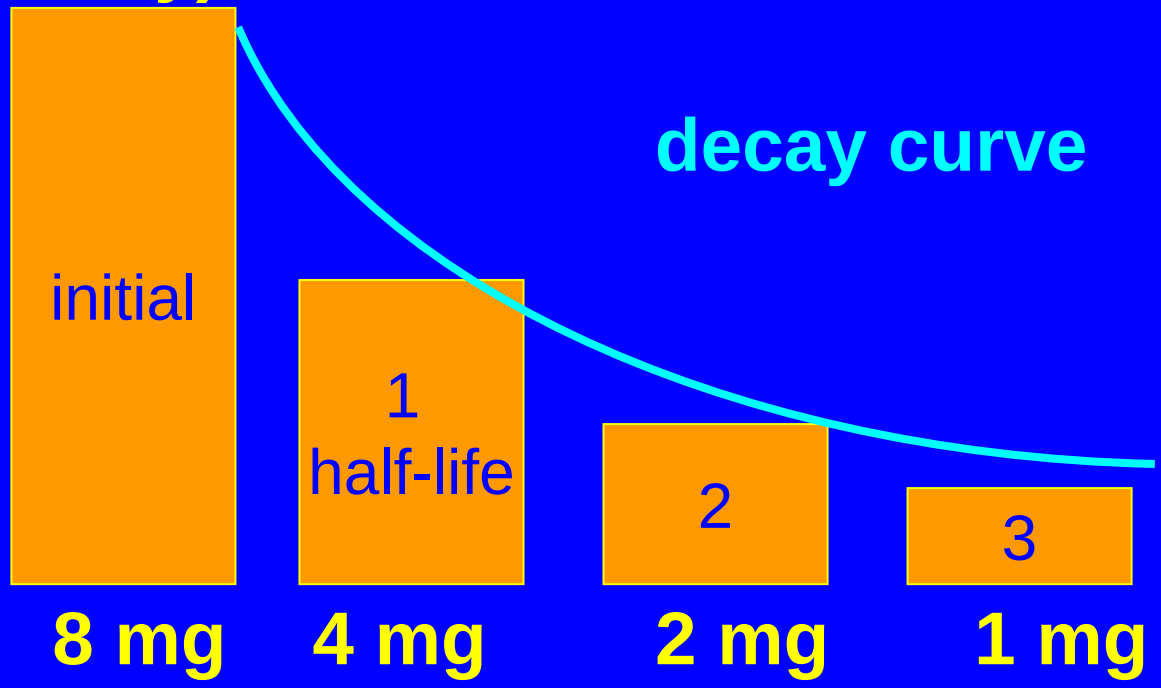
$$^{10}_{5}B + ^{4}_{2}He \longrightarrow ^{13}_{7}N + ^{1}_{0}n$$

nitrogen

radioisotope

Half-Life of a Radioisotope

The time for the radiation level to fall (decay) to one-half its initial value



Examples of Half-Life

Isotope	Half life
C-15	2.4 sec
Ra-224	3.6 days
Ra-223	12 days
I-125	60 days
C-14	5700 years
U-235	710 000 000 years

Learning Check NR3

The half life of I-123 is 13 hr. How much of a 64 mg sample of I-123 is left after 26 hours?

Solution NR3

$t_{1/2}$ = 13 hrs

26 hours = 2 x $t_{1/2}$

Amount initial = 64mg

Amount remaining = 64 mg x ½ x ½

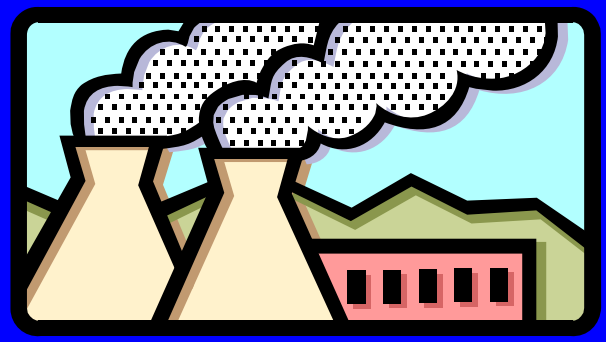
= 16 mg

Nuclear Fission

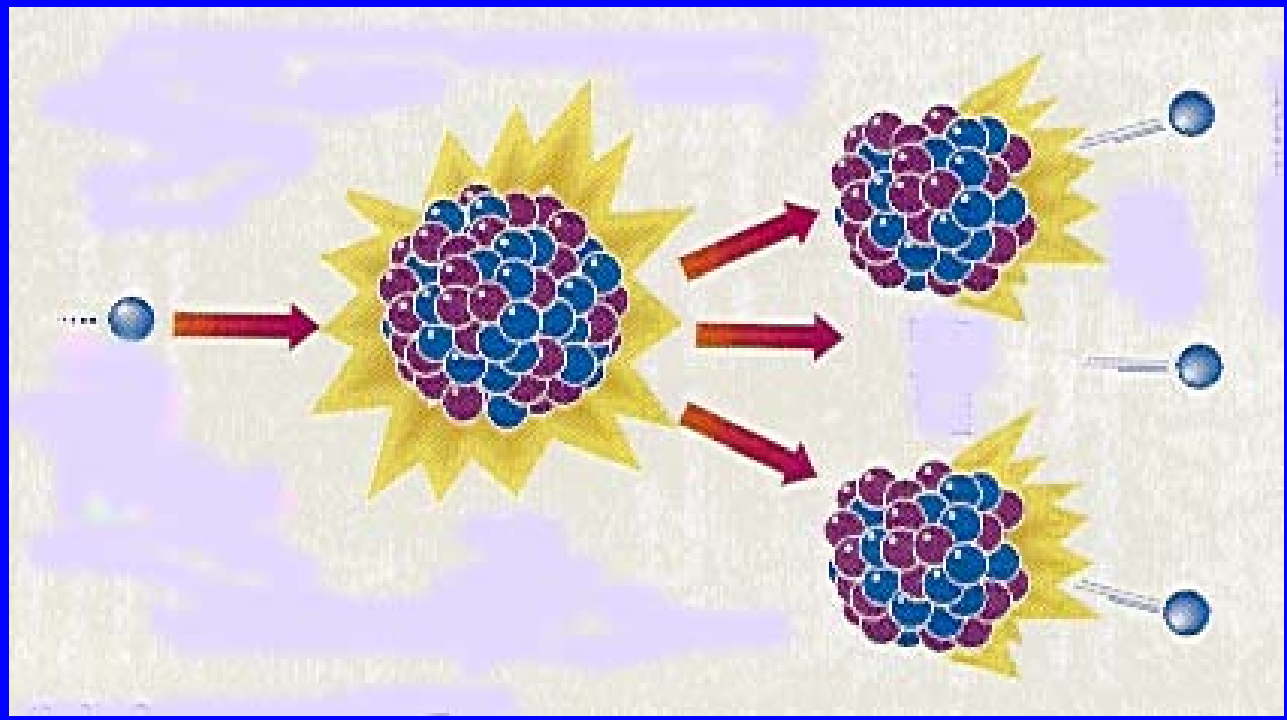
Fission

large nuclei break up

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



Fission

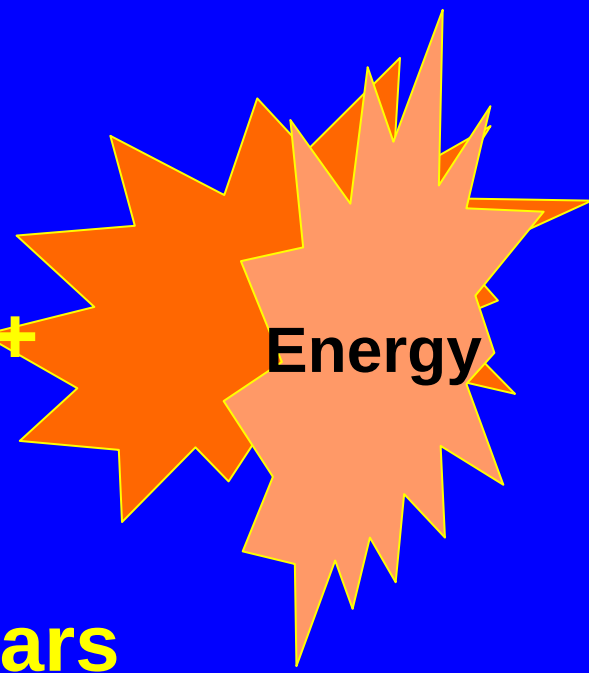


Nuclear Fusion

Fusion

small nuclei combine

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



Occurs in the sun and other stars

Learning Check NR4

Indicate if each of the following are

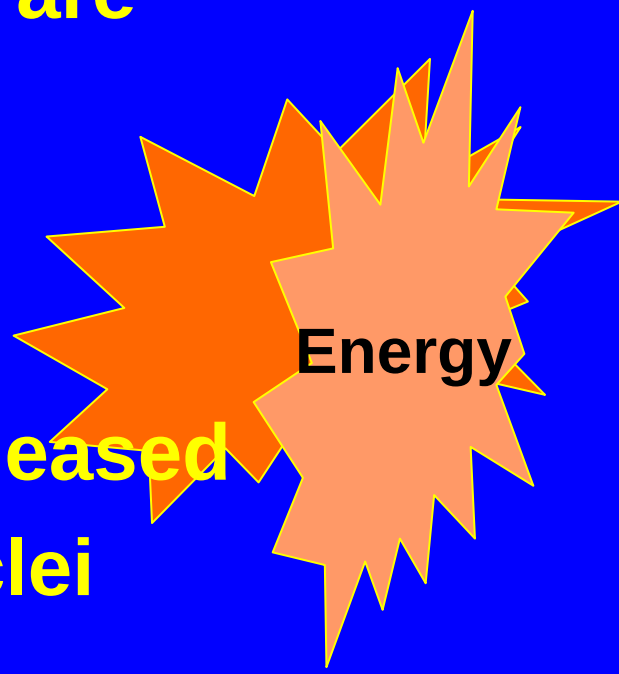
(1) Fission (2) fusion

A. Nucleus splits

B. Large amounts of energy released

C. Small nuclei form larger nuclei

D. Hydrogen nuclei react



Solution NR4

Indicate if each of the following are

(1) Fission (2) fusion

A. 1 Nucleus splits

B. 1 + 2 Large amounts of energy released

C. 2 Small nuclei form larger nuclei

D. 2 Hydrogen nuclei react