

# Radiation

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# 1 Radioactivity

## 1.1 Definition

Radioactivity is a set of physical-nuclear processes through which some unstable or radioactive atomic nuclei decay, in a certain period of time called decay time.

An unstable nuclei will keep emitting radiations and transmuting to other nuclei until the atom is stable.

## 1.2 Decay

The mass of a radioactive material will decrease exponentially.

$$M(t) = M_0 \cdot e^{-kt}$$

$M(t)$  is the mass (or number of particles) after a certain time  $t$ .  $M_0$  is the initial mass and  $k$  is the rate of decay.

## 1.3 Half-life

The time of half-life is given by  $t_{\frac{1}{2}} = \frac{\ln 2}{k}$ .

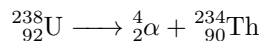
$$\begin{aligned}\frac{1}{2}M_0 &= M_0 e^{-kt} \\ \frac{1}{2} &= e^{-kt} \\ \ln\left(\frac{1}{2}\right) &= -kt \\ t &= \frac{\ln 2}{k}\end{aligned}$$

## 1.4 Types of radiations

There are three types of radiations that can be emitted by an unstable nuclei.

### 1.4.1 $\alpha$ particles

An  $\alpha$  particle is a helium nuclei. For example



### 1.4.2 $\beta$ particles

There are two types of  $\beta$  particles.  $\beta^+$  and  $\beta^-$ . A  $\beta^+$  particle is emitted when the nuclei is unstable due to having too many protons, whilst the  $\beta^-$  one is emitted when it has too many neutrons.

$$\begin{cases} \beta^+, & {}_+^0\text{e (positron)} \\ \beta^-, & {}_-^0\text{e (electron)} \end{cases}$$

### 1.4.3 $\gamma$ particles

$\gamma$  rays are photons of electromagnetic energy. They have 0 mass and 0 charge.