

# *Nuclear Radiation & Radioactive Decay Equations*

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*Chemistry Honors*

# Radioactivity

- \* Unstable nucleus spontaneously emits *nuclear radiation*
- \* Any isotope emitting nuclear radiation is radioactive nuclide
- \* Resulting nucleus has been changed to new, more stable element (spontaneous transmutation).
- \* A nucleus continues emitting radiation until stable nucleus is reached.

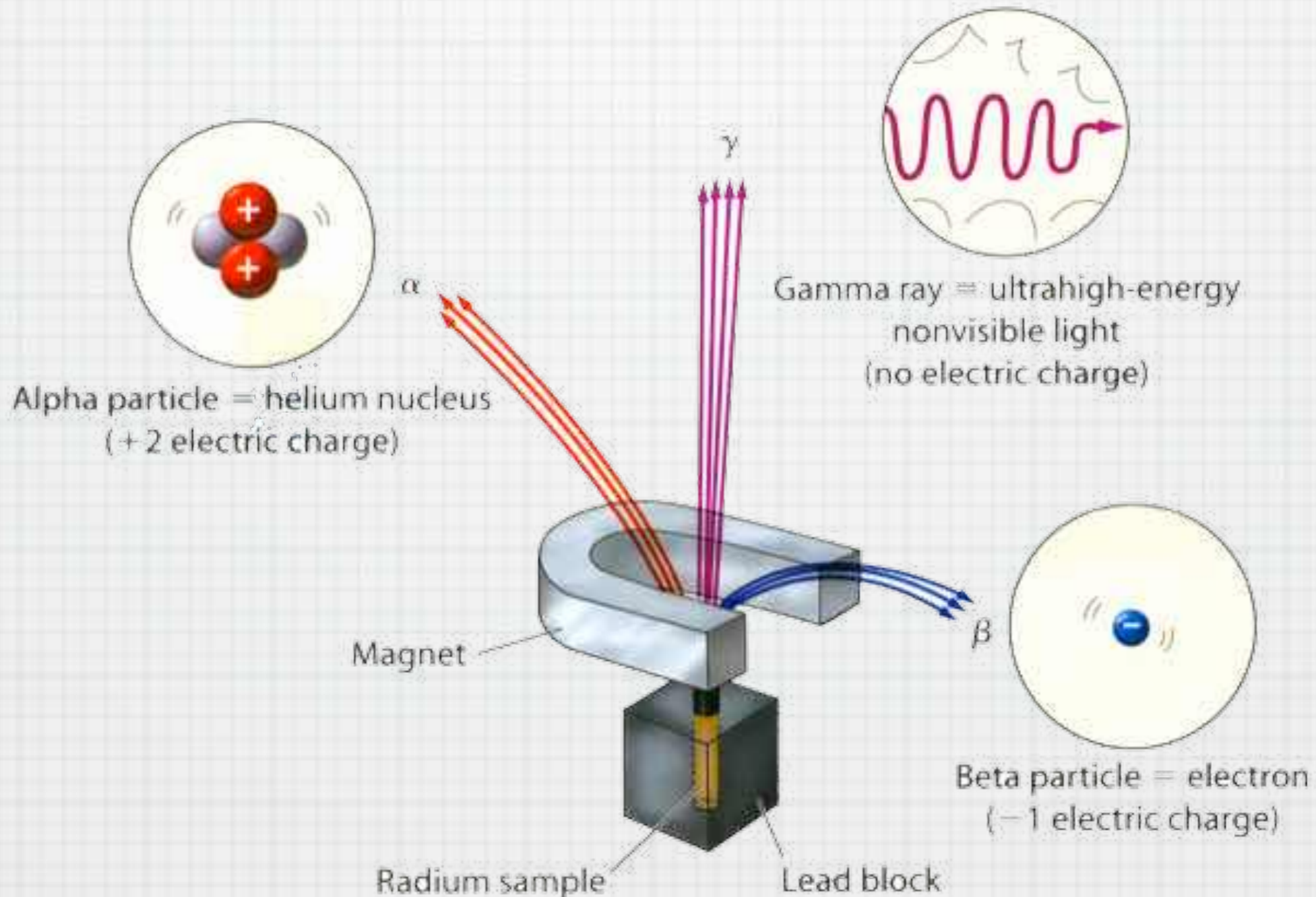
# 4 Main Types of Radiation

- \* Ernest Rutherford identified three types of nuclear radiation: Alpha, Beta & Gamma

Radiation	Composition	Symbols	Mass	Charge
Alpha particle	He-4 nucleus (2 p <sup>+</sup> & 2 n <sup>0</sup> )	$\alpha$ , ${}^4_2\alpha$ or ${}^4_2\text{He}$	4.003 amu	2+
Beta particle	High-energy electron	$\beta$ , ${}^0_{-1}\beta$ or ${}^0_{-1}\text{e}$	$\frac{1}{1823}$ amu	1-
Positron	High-energy anti- electron	$\beta^+$ , ${}^0_{+1}\beta$ or ${}^0_{+1}\text{e}$	$\frac{1}{1823}$ amu	1+
Gamma ray	High-energy EM radiation	$\gamma$ or ${}^0_0\gamma$	0	0

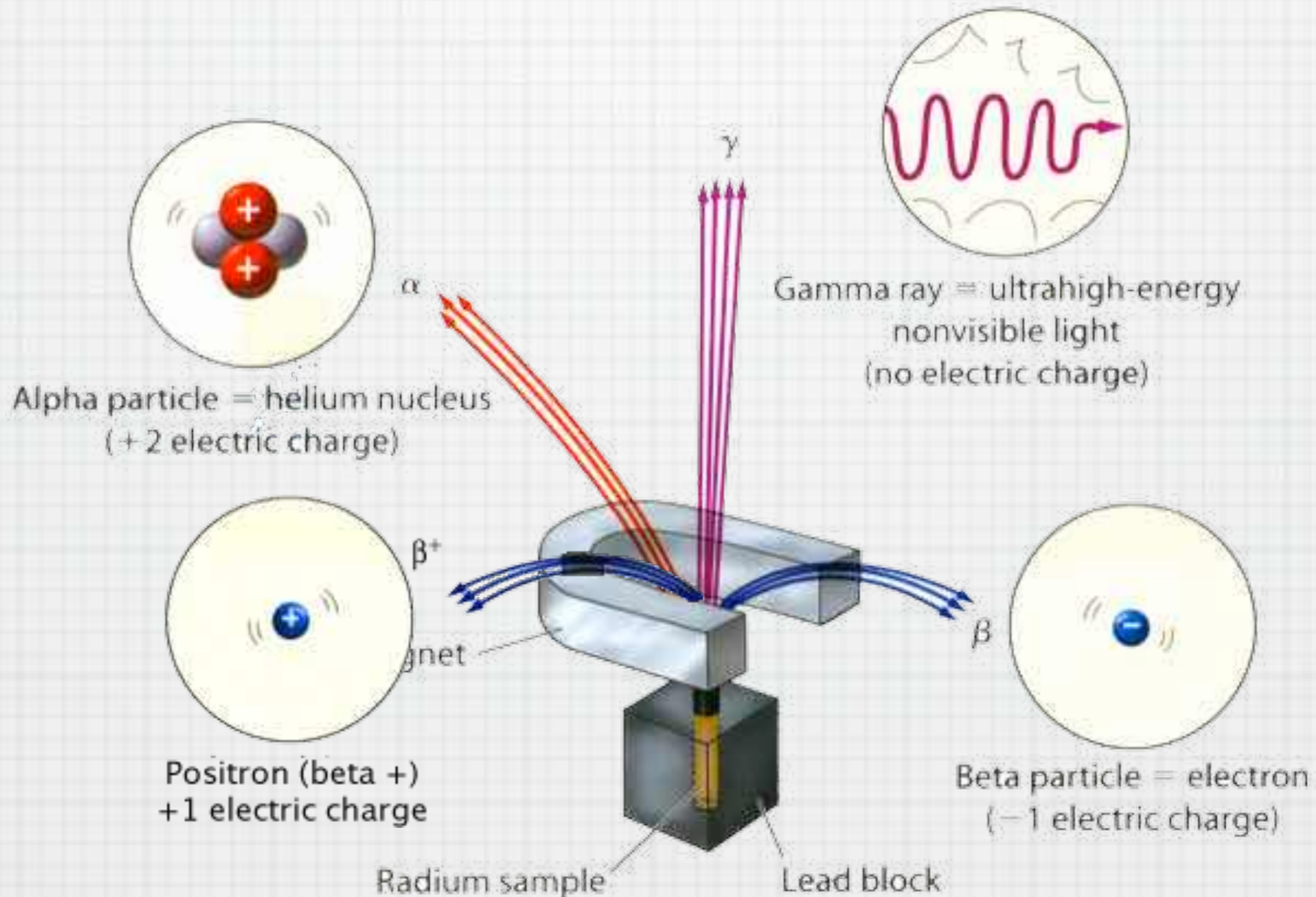
# Deflection of Radiation

- \* Alpha and Beta particles can be deflected by electrical or magnetic fields:



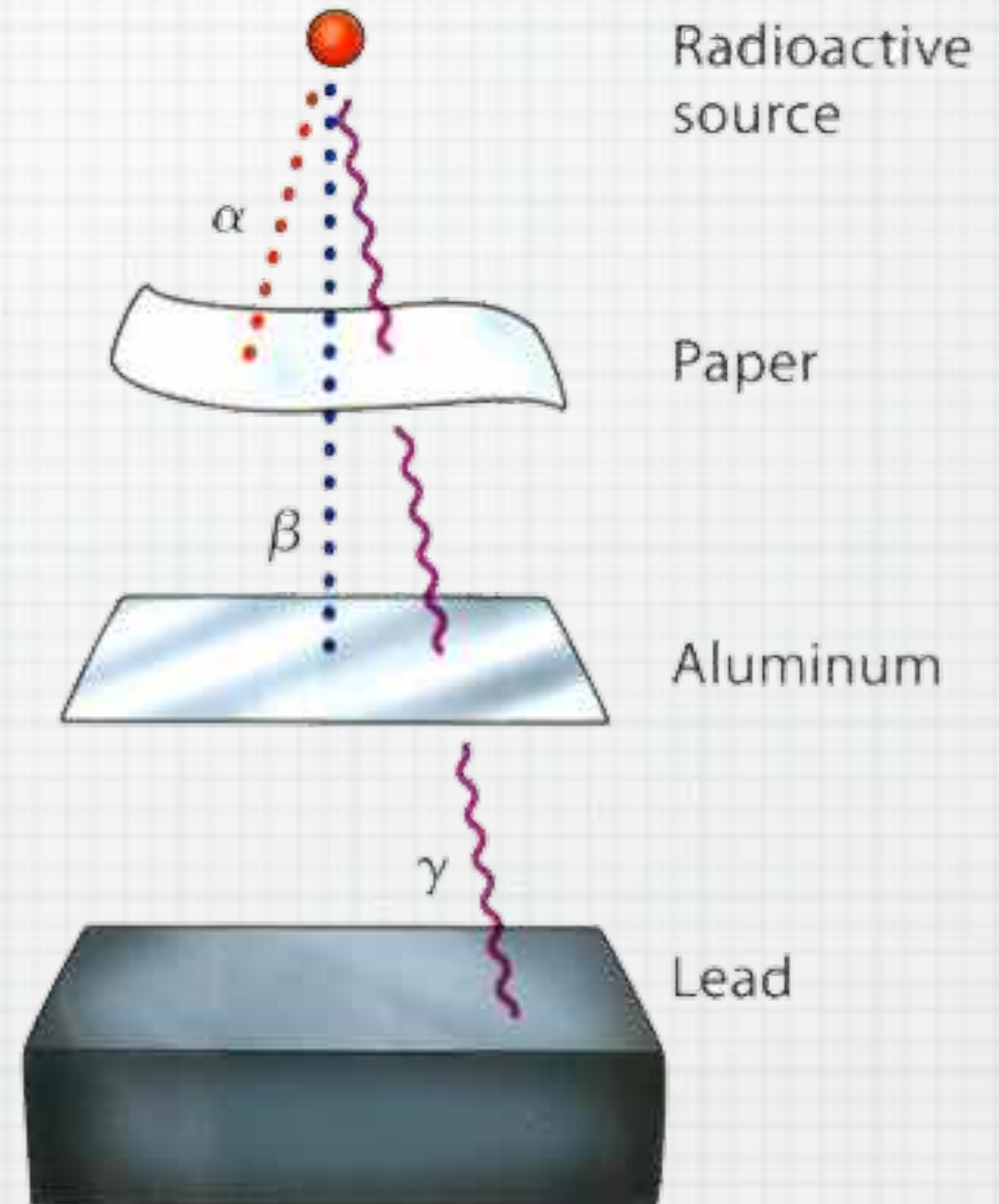
# Deflection of Radiation

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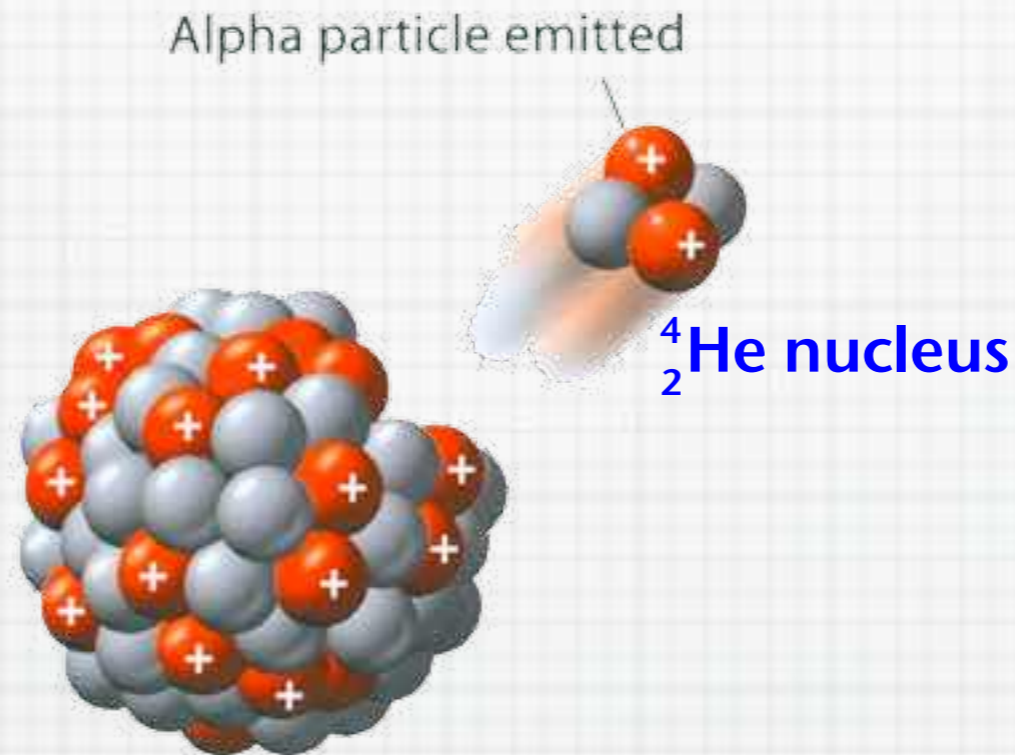


# Penetrating Power

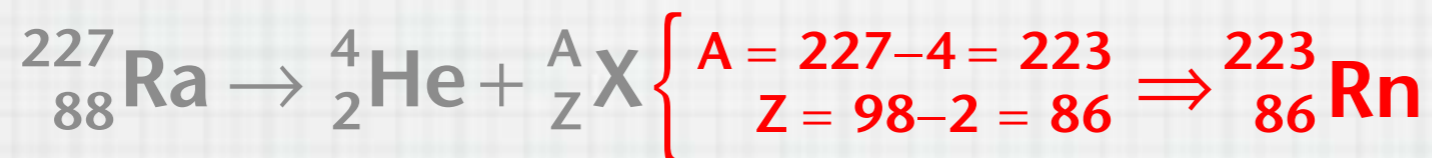
Radiation	Penetrating Strength
Alpha particle	Stopped by paper or cloth
Beta particle/ Positron	Stopped by metal sheet
Gamma ray	Not completely stopped even by thick Pb



# (a) Alpha Decay

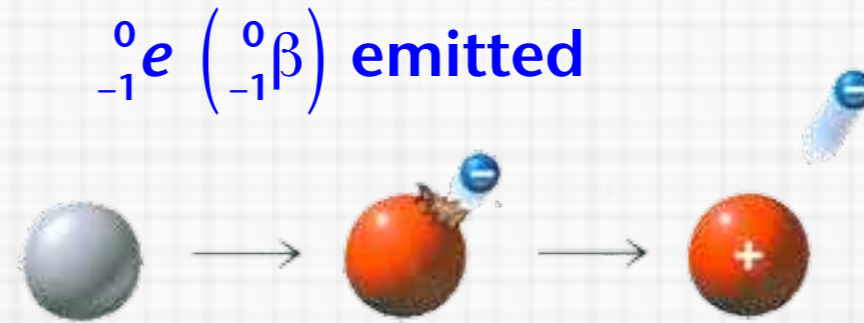


- \* Too-large nucleus emits 2  $p^+$  & 2  $n^0$ :  ${}^4_2\alpha$  or  ${}^4_2\text{He}$

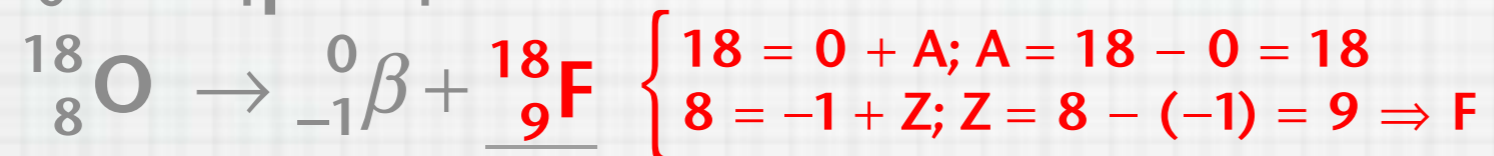


- \* Total mass # (A) and atomic # (Z) both need to balance
  - \* atomic #  $\downarrow 2$  and mass #  $\downarrow 4$
- \* New Z gives identity of unknown element

# (b) Beta Decay/Emission



- \* Unstable neutron emits high-energy electron ( ${}_{-1}^0\beta$  or  ${}_{-1}^0e$ ) and becomes a proton:

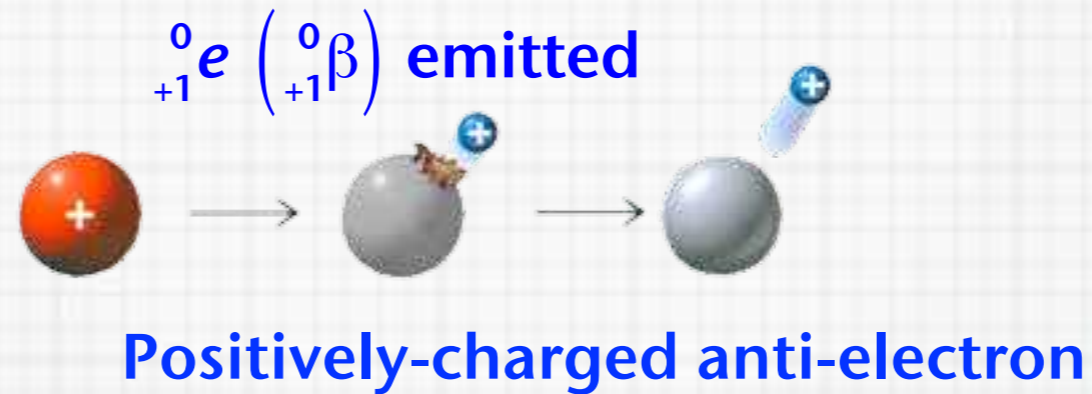


- \* atomic #  $\uparrow 1$  and mass # unchanged

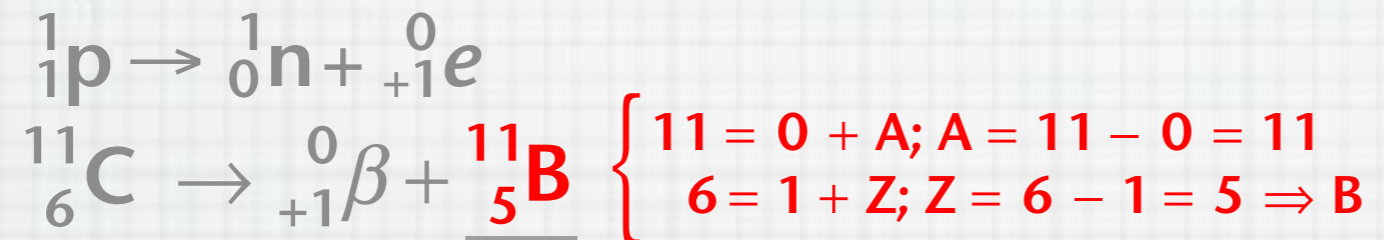
- \* Note: we ignore the antineutrino that is also emitted



# (c) Positron Emission

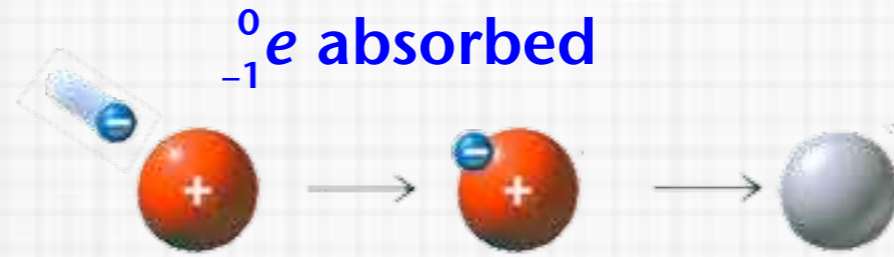


- \* Unstable proton emits positron ( ${}_{+1}^0\beta$  or  ${}_{+1}^0e$ ) and becomes neutron

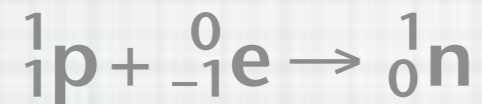


- \* atomic #  $\downarrow 1$  and mass # unchanged
- \* neutrino is ignored

# (d) Electron Capture

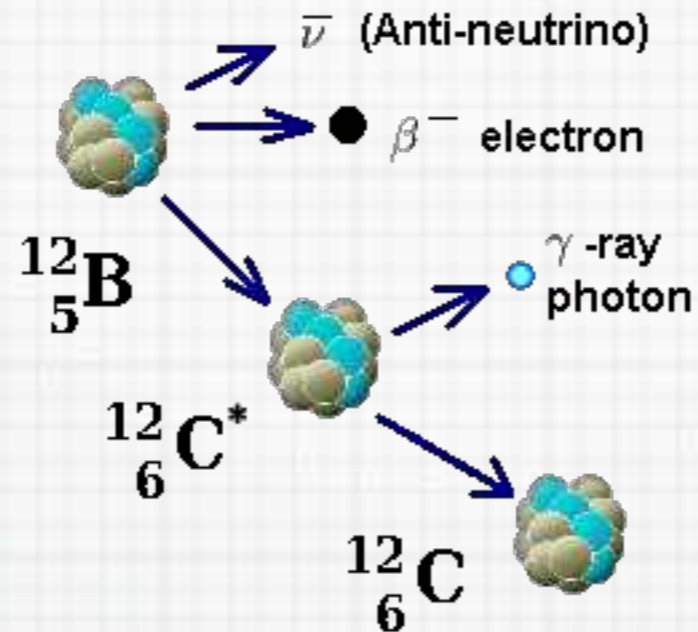


- \* Unstable electron,  ${}^0_{-1}e$  (a **reactant**), captured by proton & forms neutron:



- \* result looks the same as positron decay

# (e) Gamma Radiation



$\gamma$  Radiation emitted with other radiation

\* High energy nucleus emits energy:

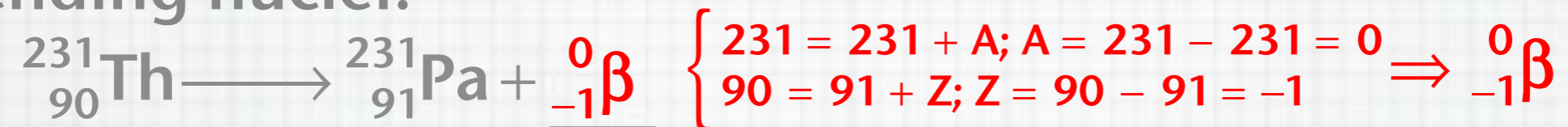


\* \*indicates excited state (excess energy)

\* no particles emitted, no change in nucleus

# Determining Decay Type

- \* Can identify decay type (particle) if given starting and ending nuclei:



- \* This is  $\beta$  decay