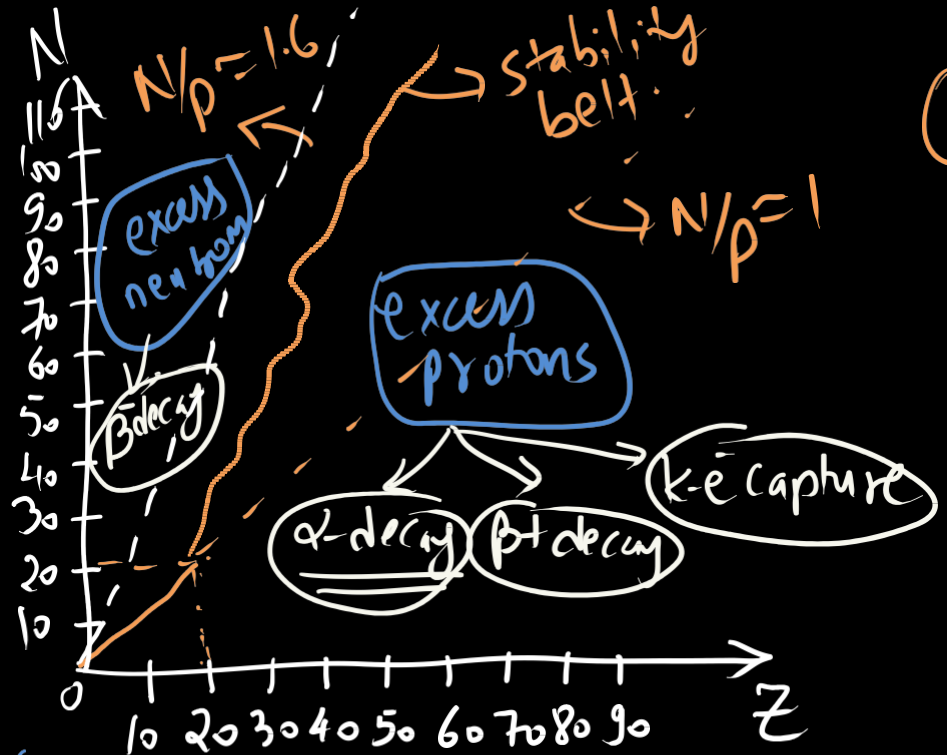
33rd Session: Modern Physics III
Mass Energy Equivalence

- Recap
- 2nd classification of nuclei
  - Nuclear reactions
  - Binding energy & mass defect
  - Stability Criteria
  - Stability curve



(1) For $Z < 20$

Stable nuclei have $n/p \simeq 1$

$^{4}_{2}He$ $^{12}_{6}C$ $^{14}_{7}N$ $^{16}_{8}O$ $^{23}_{11}Na$ $^{24}_{12}Mg$ $^{40}_{20}Ca$

$p \to 2$ $p \to 6$ $p \to 7$ $p \to 8$ $p \to 11$ $p \to 12$ $p \to 20$

$n \to 2$ $n \to 6$ $n \to 7$ $n \to 8$ $n \to 12$ $n \to 12$ $n \to 20$

$12/11 = 1.09$

$^{1}_{1}H$ $^{3}_{2}He$ $^{9}_{4}Be$ $^{7}_{3}Li$

$p \to 1$ $p \to 2$ $p \to 4$ $p \to 3$

$n \to 0$ $n \to 1$ $n \to 5$ $n \to 4$

0.5 $n/p = 5/4 = 1.25$ $n/p = 4/3 = 1.33$

(2) for $Z > 20$.

Stable nuclei have $1 < n/p < 1.618$

$^{56}_{26}Fe$ $p \to 26$ $n \to 30$

$^{108}_{47}Ag$ $p \to 47$ $n \to 61$

last stable nucleus $\to$ $^{209}_{83}Bi$

(3) An unstable nucleus disintegrates to become stable by changing its (n/p) ratio.

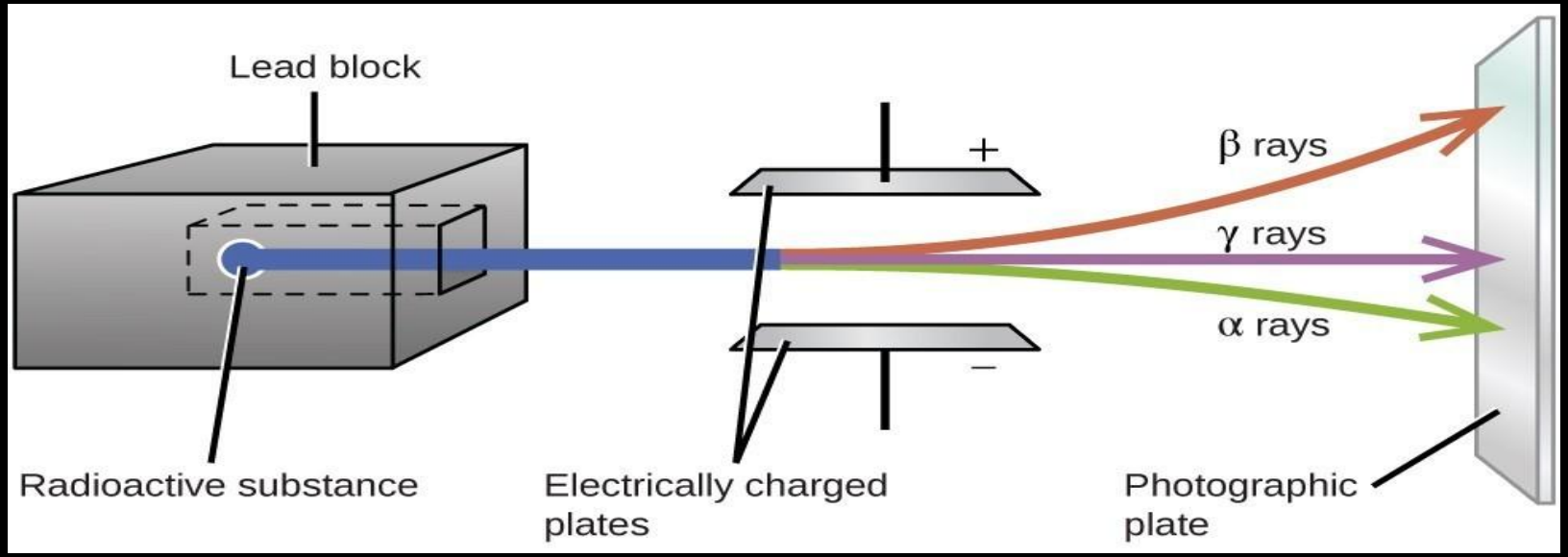
2nd Classification of Nuclei

- Stable Nuclei & Unstable (Radioactive) Nuclei

- Concepts/Phenomena:
  - ✓ Radioactivity
  - ✓ Mass Energy Equivalence

- Two Important curves
  - n v/s p (Chart of Nuclides)
  - B.E. per nucleon v/s Atomic Mass number (A)

Rutherford's Experiment on Radioactivity



Modern Physics - III - Nuclear Physics
(Stability of Nuclei)

Write nuclear reactions

(iv) β^+ decay of $^{11}_{6}C \rightarrow {}^{11}_{5}Y + {}^{0}_{+1}\beta$ (excess protons)

$^{11}_{6}C$: p = 6, n = 5 ; $^{11}_{5}Y$: p = 5, n = 6

$$^{1}_{1}p \rightarrow {}^{1}_{0}n + {}^{0}_{+1}\beta \quad (\text{positron}) \quad (\text{anti particle of } e^-)$$

(v). β^+ decay of $^{97}_{43}Tc$ (excess protons)

$$^{97}_{43}Tc \rightarrow {}^{97}_{42}Y + {}^{0}_{+1}\beta$$

(vi) Electron Capture of $^{120}_{54}Xe$ — excess protons

$$^{120}_{54}Xe \rightarrow {}^{120}_{53}Y$$

$^{120}_{54}Xe$: p → 54, n → 66 ; $^{120}_{53}Y$: p = 53, n → 67

$$^{1}_{1}p \rightarrow {}^{1}_{0}n + {}^{0}_{+1}\beta$$

(iii) β^- decay of $^{32}_{15}P$

$$^{32}_{15}P \rightarrow {}^{32}_{16}X + {}^{0}_{-1}\beta$$

$^{32}_{15}P$: p = 15, n = 17 ; $^{32}_{16}X$: p = 16, n = 16

$$^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}\beta$$

(ii) $^{242}_{94}Pu \rightarrow {}^{238}_{92}Y + {}^{4}_{2}\alpha$

$^{242}_{94}Pu$: p = 94, n = 148 ; $^{238}_{92}Y$: p = 92, n = 146 ; $^{4}_{2}\alpha$: p = 2, n = 2

Modern Physics - III - Nuclear Physics
(Stability of Nuclei)

Q. $^{238}_{92}U \xrightarrow{n\alpha,\ n'\beta} {}^{206}_{82}Pb$. Find n & n'.

$n = 8$ ✓
$n' = 6$

$8\ {}^{4}_{2}He$

↳ $p \to 16$ protons.

$p \to 92$

$p \to 82 + 16$ protons.

$-1 \times N_\beta = 92 - (82 + 16)$

$\boxed{N_\beta = 6}$