① Summary - nuclear reactions

nuclear reactions are induced by energetic particles (projectiles)

→ two types : - fission
- fusion

Typical reaction : $a + X \rightarrow Y + b$

a: projectile, X: target, Y: heavy, b: light

other notation
$X(a, b)Y$
↓
(a, b) classification

classification : ① scattering
② knockout reaction
③ transfer reaction

based on mechanism:
- direct reaction
- compound reaction
- resonance reactions

Fission :

→ A general ~~(type)~~ method is to bombard heavy particles with neutrons

→ Fission is the result between the competition of the Coulomb force (Z^2) and the strong force (A)

→ neutron induced fission (n, n) → produces more n → chain reaction → controled / uncontroled

How does it happen?

- Heavy elements sit high in the potential well and the fission products can escape the well if supplied by energy that is larger than the activation energy → fission → energy release
  - → the energy gets mostly carried away by the fission products
  - → fission is more likely is the released E is higher
  - → spontanious fission is possible too, but it is very rare

Characteristics:

- → fission products are not uniquely determined but follow a distribution
- → distribution is symmetric between the heavy and the light product
- → for low energy fission we usually get a heavy and a light product
- → number of emitted n also follows a distribution
  - ↳ average number of emitted n : ν
  - → prompt neutrons (energetic neutrons)
  - → delayed neutrons (β delayed neutron emission)
    - ↳ from fission products

- → fission products tend to be radioactive → decays
- → thermal neutrons (slow ones)

Energy: if $^{235}U + n \to {}^{236}U^{*} \to$ fission

↳ excited

$$E_{ex} = [m(^{236}U^{*}) - m(^{235}U)]c^2$$

$$m(^{236*}U^{*}) = m(^{235}U) + m_n$$ ⇒ E_{ex} needs to be larger than the activation E for fission

- → difference in excitation energies for different isotopes → different n number
- → neutron capture by an odd N nuclei → larger cross section →
  - → easier to induce fission

Energy release:

- → most of the energy gets carried by the fission products (due to Coulomb repulsion)
  - ↓ about 80% of the energy
  - → carried energy depends on the inverse of the mass ratios
- → some by the n

other E release:
- prompt γ rays
- β decay
- γ decay

of fragments