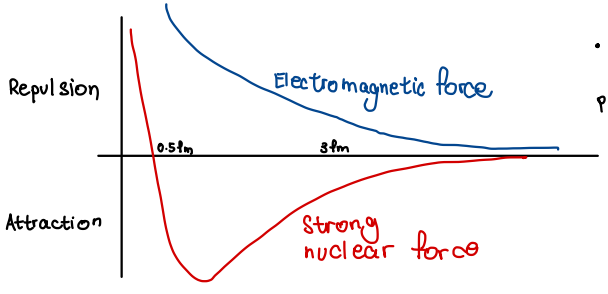
Stable and Unstable Nuclei

Forces in the nucleus:

- **Electromagnetic force** causes protons in the nucleus to repel
- **Gravitational force** causes nucleons (protons & neutrons) to attract each other
- **Strong nuclear force** to combat the electromagnetic force to hold the nucleus together.



- The nuclear force is repulsive up to 0.5fm to prevent it crushing the nucleus
- Past 0.5fm, the strong nuclear force becomes attractive

What makes the nucleus unstable?

- The range of the strong nuclear force is only a few femtometres. It struggles to hold together very large nuclei, which makes them unstable.
- Unstable nuclei will emit particles to become more stable – known as nuclear decay.

Alpha decay

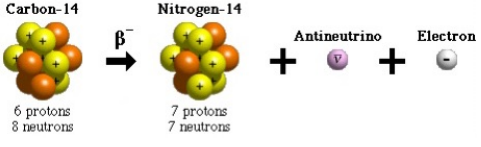
- Happens in very big atoms – as the nuclei of these atoms are too big for the strong nuclear force to keep them stable
- An alpha particle is emitted: ${}^{4}_{2}\alpha$ (contains 2 protons and 2 neutrons – helium nucleus)

$${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}\alpha$$

(element negatively charged?)

Beta-minus decay (β^-)

- Happens in isotopes that are "neutron rich"
- An electron & an antineutrino particle are emitted
- One neutron is changed into a proton
- This leaves the element positively charged (1 less electron)



$${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}W + {}^{0}_{-1}\beta + \bar{\nu}_e$$

(neutron → proton) (electron) (antineutrino)

this is needed due to lepton number conservation

Positron emission / Beta-plus decay (β^+)

- Takes place in an unstable nucleus with too many protons - "proton-rich".
- A proton changes into a neutron.
- The positron (β^+) is the antiparticle of the electron, so it carries a positive charge.

$$ {}^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}\beta + \nu_e $$

- PET scanning involves a positron-emitting isotope.

Gamma decay / radiation

- It is electromagnetic radiation emitted by an unstable nucleus.
- It is emitted by a nucleus with too much energy.
- Gamma radiation has no mass and no charge. It can pass through thick metal plates.