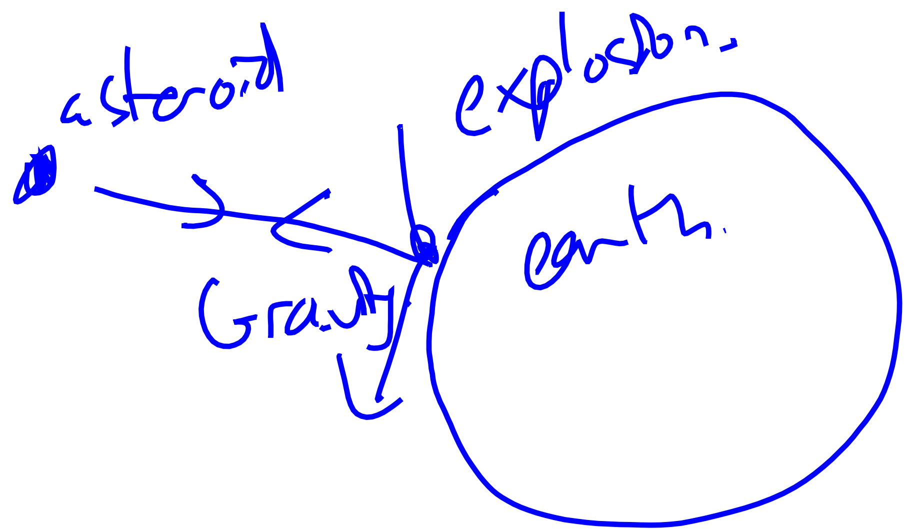
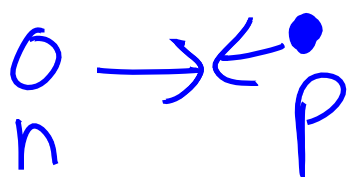
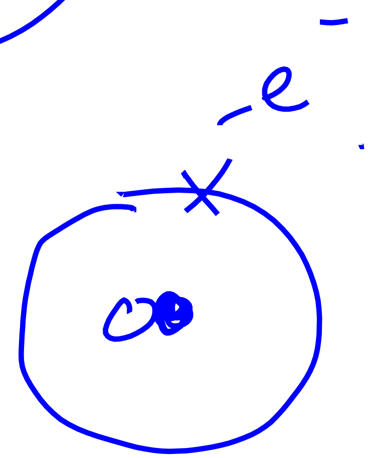
Lecture 10

Binding energy.







deuteron.

deuterium

Heavy water.

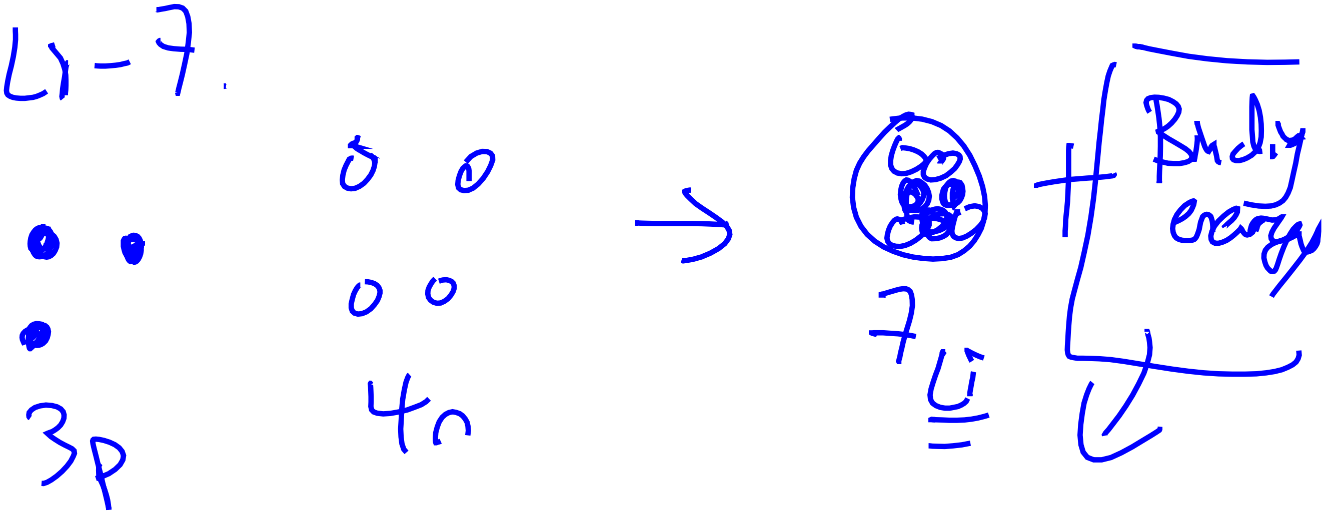
D_2O

neutron capture.

mass defect ≠ mass excess

but they are both used to calc binding energy

Li-7.



What is binding energy useful for?

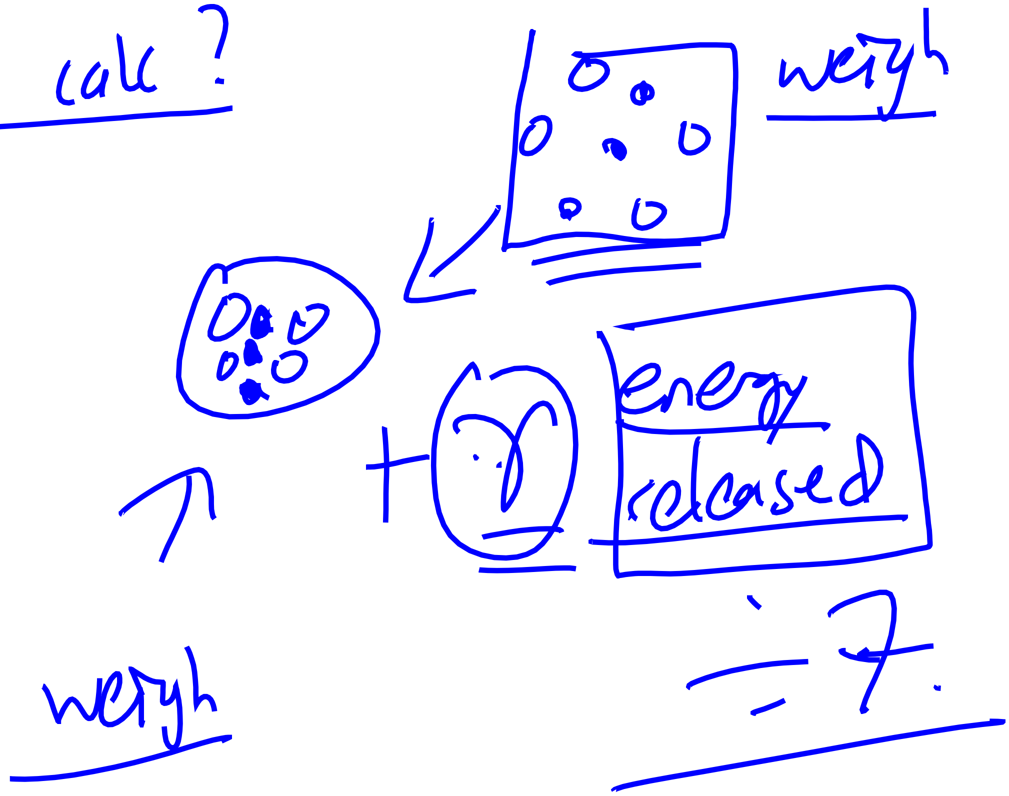
Conceptually speaking BE / nucleon is useful to describe how tightly a nucleus is bound.

Binding energy / nucleon

How to calc?

eg.

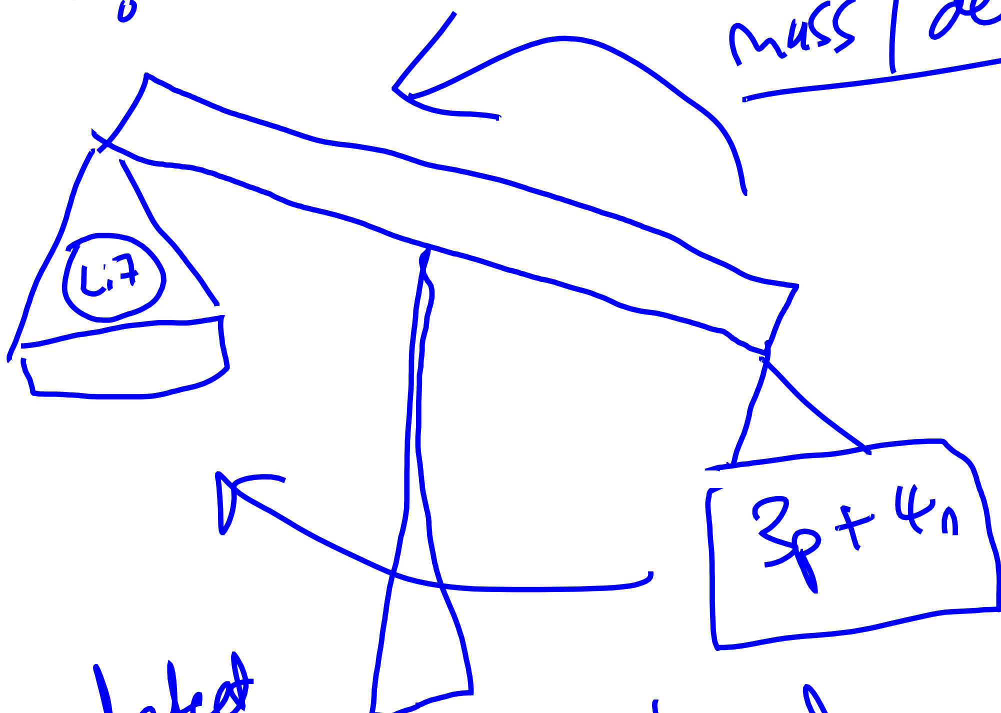
Li-7



How to measure Binding Energy? (BE)

$\underline{\underline{E}} = m_0 c^2$

rxn, mass defect



defect relative to protons & neutrons.

potential confusion.

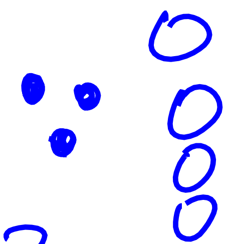
mass defect

vs mass excess.

mass defect.

Li-7

mass compare w/



3p + 4n

mass excess

mass comparison w/

$\boxed{\frac{1}{12} \text{ mass of } {}^{12}C}$

a.m.u. × no. of nucleons

practical way of calc mass excess. for Li-7 mass Li-7 — 7.0

10b Calculating Binding energy practically.

→ wallet cards.

1 MeV = 1.602×10^{-13} J

Li-7

Δ (MeV)

= 14.907 MeV.

- Calc $\underline{\underline{B.E}}$ of Li-7.

energy released when combining individual neutrons & protons into the nucleus.

- mass excess = mass of particle − no. of nucleons × $\frac{1}{12}\,{}^{12}C$

Δ (MeV) of ${}^{7}Li$ = 14.907 MeV.

BE of ^7Li

$= \text{mass of Li-7} - \text{mass of } 3p - \text{mass of } 4n.$

substituting mass excess

Δ (MeV)

$= \left(\text{mass of Li-7} - 7 \times \frac{1}{12}\,{}^{12}C\right)$

$-3\left(\text{mass of p.} - \frac{1}{12}\,{}^{12}C\right)$

$\frac{1 \text{ Dalton}}{1 \text{ amu.}}$

$-4\left(\text{mass of n} - \frac{1}{12}\,{}^{12}C\right)$

$= -7 \times \frac{1}{12}\,{}^{12}C + 3 \times \frac{1}{12}\,{}^{12}C + 4 \times \frac{1}{12}\,{}^{12}C$

$+ BE$ of ^7Li

$$= \Delta(\text{MeV})\ ^7Li$$

$$- 3\,\Delta(\text{MeV})\ p$$

$$- 4\,\Delta(\text{MeV})\ n$$

$$= 14.907 \text{ MeV}$$

$$- 3 \times 7.289 \text{ MeV}$$

$$- 4 \times 8.071 \text{ MeV}$$

$$= \cancel{-39.2 \text{ MeV}} \quad -39.244 \text{ MeV}$$

note: BE is +ve because

you must supply energy to break apart the nucleus.

^7Li: BE = 39.244 MeV

$$BE/\text{nucleon} = \frac{39.244}{7} = 5.606 \text{ MeV.}$$

Lecture 11 - Q values

Δ mass excess is a measure of how tightly a nucleus is bound w.r.t ^{12}C.

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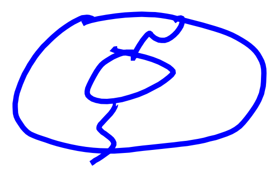
we bother about Binding energy, mass excess & mass defect, because we are interested in how much energy is released in fusion/fission processes.

<u>Q-value</u> is energy released in nuclear reaction.

$$\boxed{Q + \cancel{W} = \Delta U}$$

1st law of Thermodynamics



fusion process.

$$\underline{{}^2H + {}^3H} \to \underline{{}^4He} + \underline{{}^1_0n}$$

$$\boxed{{}^1H + {}^1H \to \quad + \cancel{e^+ + e^-} \to 2\gamma}$$

Δ

^2H	13.136
^3H	14.950
^4He	2.425
^1_0n	8.071

Q-value is +ve for <u>exothermic</u> (gives heat to outside)

Reactants

$13.136 + 14.950$

Products

$2.425 + 8.071$

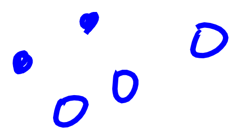
Q-value

$$= (13.136 + 14.950) - (2.425 + 8.071) = \underline{\underline{17.59}}\ \text{MeV}$$

lighter.

BE =

BE(He)



tighter bound nuclei = lighter

$$\left[\left(\text{mass of reactants}\right) - \left(\text{mass of products}\right)\right]$$

$$\Delta m \times c^2 = E$$

Q-value.