Energy

↳ Ability to do work

$\Delta E = \Delta KE + \Delta PE$

Associated w/ bonding

Attractive forces

+/−

↓ PE

Stabilizing

Repulsive forces

+/+

↑ PE

Destabalizing

"nucleons"

protons + neutrons

Nucleus

↳ Held together by "strong force"

neutrons/neutrons attracts ← lowers energy, ↑stable

neutrons/protons attract

proton/proton repel

BAND OF STABILITY → ratio of protons/neutrons.

↑ protons → ↑ neutron ratio bc more protons = more repulsion so we need more neutrons

↑ protons ← less + less stable nuclei → will decay → repulsion will dominate (past 83)

Nuclear equations

Parent nuclide

Daughter nuclide

$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + \underline{^{4}_{2}He}$

Radioactive Decay

changes mass

radioactive particle + energy produced (exothermic process)

Decay → increases net attraction in nucleus (more stable)

Proton

↑q ↑q ↓q

$\underbrace{\frac{2}{3} \quad \frac{2}{3} \quad -\frac{1}{3}}_{\text{charge}}$ → +1 charge

Neutrons

↓q ↓q ↑q ← "quark"

$-\frac{1}{3} \quad -\frac{1}{3} \quad \frac{2}{3}$ → 0 charge

Neutrons are heavier
↓ quarks are heavier

Alpha Decay → $2n^0$, $2p^+$ split off

parent nucleus → Alpha Particle
parent nucleus → Daughter Nucleus

ex. $^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + ^{4}_{2}\alpha$

$2n^0$
$2p^+$

α or He

$^{A}_{Z}X$ Atomic mass = $\#p^+ + \#n^0$
$Z = \#p^+$

(ENERGY IS A PRODUCT)

Beta Decay ← usually more common w/ lighter nuclei
→ Add a proton
→ change the quark of a neutron

neutron → proton
↑↓↓ → ↑↑↓

shifts into an up quark
(DECAY)

ex. $^{3}_{1}H \rightarrow ^{3}_{2}He + ^{0}_{-1}e$

β particle
(−)
negligible mass

Positron Emission → Proton shifts into neutron

Need to let go of a positive

ex. $^{22}_{11}Na \rightarrow ^{22}_{10}Ne + ^{0}_{1}e$

β^+ (+)

Avogadro's Number

Microscopic — Atomic Mass Unit — Macroscopic

kg/atom — AMU — g/mol

$6.022 \cdot 10^{23}$ atom

ex 12 g/mol = 12 amu

Macroscopic 1 g/mol = 1 amu

Microscopic 1 amu = $1.66 \cdot 10^{-27}$ kg/atom

1 amu → 1 hydrogen → 1 g/mol

→ $1.66 \cdot 10^{-27}$ kg

90 → 82

6

4

α Decay - $^{236}_{92}U \to ^{234}_{90}Th + ^{4}_{2}$

β Decay - $^{5}_{2}He \to ^{4}_{3}Li + ^{0}_{-1}\beta^{-}$

Positron Decay - $^{22}_{11}Na \to ^{23}_{10}Ne \to ^{0}_{1}\beta^{+}$

$^{232}Th \to ^{208}_{82}Pb$

$^{232}_{90}Th \xrightarrow{\alpha} ^{228}_{88}Ra \xrightarrow{\beta} ^{228}_{87}Ac \xrightarrow{\alpha} ^{224}_{87} \xrightarrow{\beta} 88 \xrightarrow{a} 86 \xrightarrow{\beta} 82 \xrightarrow{a} 85 \xrightarrow{\beta} 86 \xrightarrow{a} 84$

+1 -2 +1 -2 +1 -2

β → 85
+1

a → 83
-2

β u → 84

a -2 → 82

Gain Stability → exothermic

Nuclear rxs **DON'T** conserve mass $E=mc^2$

you **ALWAYS** lose mass

m = mass lost in a nuclear process

$c = 2.998 \times 10^8$ m/s

Fe-56 Binding energy → energy released when p^+/n^0 to form nucleus
when atoms are formed

Free proton / free neutron - unstable/no stabalizing attraction

Calculate the mass defect in Fe-56 if the mass of an Fe-56 nucleus is 55.921 amu. The mass of a proton is 1.00728 amu and the mass of a neutron is 1.008665 amu.

measured mass

$$\text{Fe-56} - 26p^+/30n^0 = 26(1.00728\,\text{amu}) + 30(1.008665\,\text{amu})$$

$$= 56.44923\,\text{amu}$$

greater value than actual

$$\Delta m = 55.921\,\text{amu} - 56.44923\,\text{amu}$$

mass defect $= -0.528$ amu

Represents mass converted to energy

$$E = (-0.528\,\text{amu})\left(\frac{1.66 \times 10^{-27}\,\text{kg/atom}}{1\,\text{amu}}\right)\left(\frac{6.022 \times 10^{23}\,\text{atoms}}{\text{mol}}\right)\left(2.998 \times 10^8\,\tfrac{\text{m}}{\text{s}}\right)^2$$

Look for J/mol, kg/mol

$E = -4.746 \times 10^{13}$ J/mol ← - bc it is released

Nuclear rxns + energy released

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{56}Ba + ^{93}_{36}Kr + 3\,^{1}_{0}n + E$$

mass of products   mass of reactants

$$\Delta m = (235.86769\text{ amu}) - (236.05258\text{ amu})$$

$$= \boxed{-0.18489\text{ amu}} \rightarrow E = mc^2$$

$$E = (-0.18489\text{ amu})\left(\frac{1.66\cdot10^{-2}\,\frac{kg}{atom}}{1\text{ amu}}\right)\left(\frac{6.022\times10^{23}\text{ atoms}}{mol}\right)(c)^2$$

$$= \boxed{-1.66\cdot10^{13}\text{ J/mol}}$$

$$J = \frac{kg\,m^2}{s^2}$$

ν = frequency → waves/second (Hz)