24.2 Nuclear Stability

The Nucleus – Emitting Beta or Positron Particles

2. Beta Emission: Nucleus emitting a $^{0}_{-1}\beta$ particle ... an electron, where does this come from ?

$$^{1}_{0}n \rightarrow {}^{0}_{-1}e + {}^{1}_{1}H \quad ... *1.$$

Neutron — Beta part. — Proton

↳ This Beta particle emitted and of course also get γ rays.

Net Result : Neutron → Proton which changes the # Neutron to # Proton ratio.

3. Positron Emission: Nucleus emitting a $^{0}_{+1}\beta$ particle, where does this come from ?

$$^{1}_{1}H \rightarrow {}^{0}_{+1}e + {}^{1}_{0}n \quad ... *1$$

Proton — Positron — Neutron

↳ Emitted and again also get γ rays.

Net Result : Proton → Neutron thereby changing the # Neutron to # Proton ratio.

*1. Memorize these ... NO ... Nucleus made up of $^{1}_{1}H$ and $^{1}_{0}n$, if you choose the wrong one, equation makes no sense. For 2., try a Proton emmiting a Beta particle !

$$^{1}_{1}H \rightarrow {}^{0}_{-1}e + {}^{1}_{2}?$$

↳ What is this ! :'(

24.2 Nuclear Stability

The Nucleus – Capturing an Electron

4. Electron Capture: Neucleus capturing an electron ... Why?

$$ {}^{1}_{1}H + {}^{0}_{-1}e \rightarrow {}^{1}_{0}n $$

PROTON ELECTRON NEUTRON

NET RESULT: PROTON → NEUTRON, again changing the # NEUTRON to # PROTON ratio.

24.2 Nuclear Stability

The Nucleus – Emitting an Alpha Particle

$^{234}_{92}U$ undergoes radioactive decay by emitting an alpha particle. As a result of this emission the #Neutron/#Proton ratio –

a) Increases ✓ b) Decreases c) Remains the same

$$^{234}_{92}U \rightarrow {}^{4}_{2}He + {}^{230}_{90}Th + \gamma \text{ rays}$$

$^{234}_{92}U$: 92 PROTONS, 142 NEUTRONS $\qquad \frac{142}{92} = 1.543$

$^{230}_{90}Th$: 90 PROTONS, 140 NEUTRONS $\qquad \frac{140}{90} = 1.556$

24.2 Nuclear Stability

The Nucleus – Emitting an Alpha Particle

BBC NEWS

Last Updated: Thursday, 30 November 2006, 21:26 GMT

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Radiation found at 12 locations

Experts probing the death of former Russian spy Alexander Litvinenko have found traces of radioactivity at 12 locations, the home secretary has said.

Mr Litvinenko died last week in a London hospital

Among them are two British Airways (BA) planes. A third one is awaiting checks.

Home Secretary John Reid told Parliament that two Russian aircraft, one of which is currently at Heathrow airport, were also of interest.

The Health Protection Agency said 24 people had been referred to a specialist clinic for tests.

BA is contacting 33,000 passengers from 221 flights. But Mr Reid stressed the public health risk was low.

Mr Litvinenko, an ex-KGB officer and a fierce critic of Russian President Vladimir Putin, died last week of radiation poisoning.

Traces of radioactive polonium-210 were discovered in his body, and more traces of the substance have been found at venues he visited in the capital on 1 November.

Earlier, an inquest into the death of Mr Litvinenko was

The inquest was held in England in 2015. Be warned, that if you do a web search, the images of how fast Litvinenko's body deteriorated in 7 days are graphic.

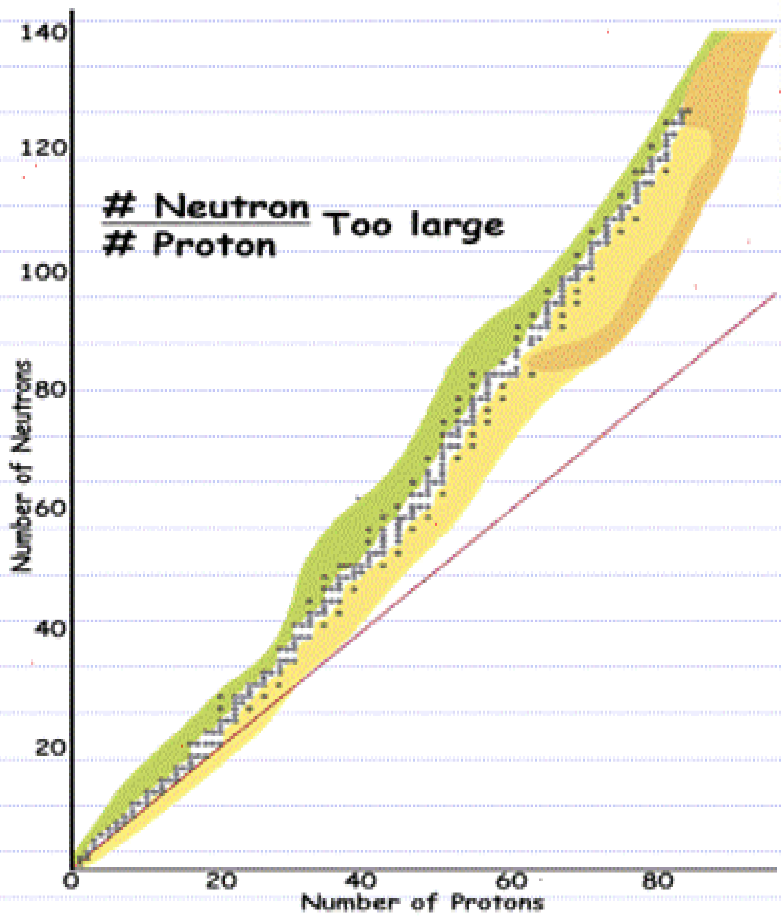
$$^{210}_{84}Po \rightarrow ^{4}_{2}He + ^{206}_{82}Pb + \gamma \text{ rays}$$

? Why was the public health risk low.

24.2 Nuclear Stability

Predicting Decay Processes

Beta Emission used to detect cracks in underground pipes. (0.5 cms its penetrating power).



$^{60}_{27}Co$ is one of many radioactive isotopes whose #Neutron/#Proton ratio is too large. Radioactive isotopes on this side of the stability have only one form of radioactive decay available to them –

a) Alpha emission
b) Positron emission
c) Electron capture
d) Beta emission.

We want the ratio to decrease, to do this the # Neutrons must go ↓ and the # Protons to go ↑.

∴ We are looking for a process that converts a neutron to a proton.

a) X : We know that this causes the ration to ↑.

b) X : Converts a proton to a neutron.

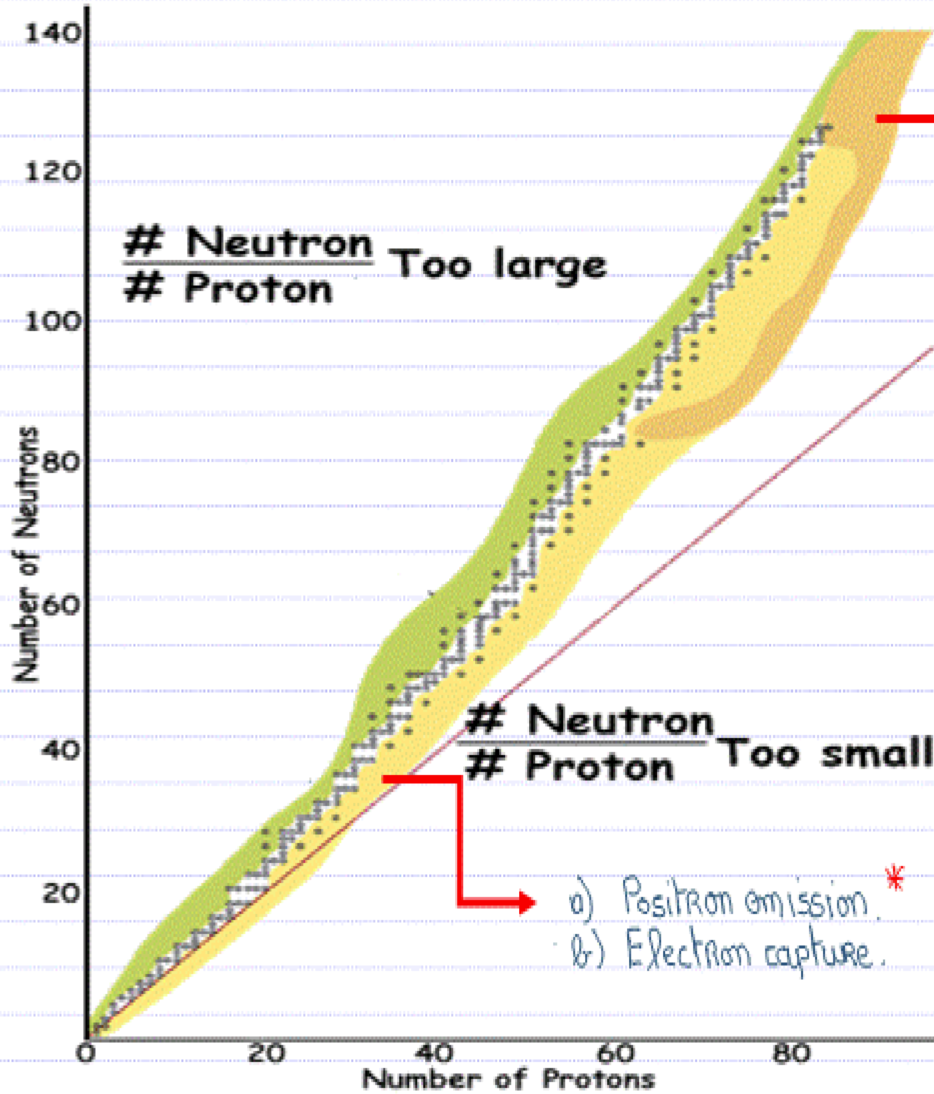
c) X : Same result as b)

d) ✓ : Only one that converts a neutron to a proton.

24.2 Nuclear Stability

Predicting Decay Processes

For the side where # Neutron to # Proton ratio is too small, the following are just predictions on what may occur at various parts.



$^{4}_{2}He$ emission

* A Note on Positron Emission.

This is used in medicine for high clarity PET scans.

PET: Positron Emission Tomography

$$^{18}_{9}F \rightarrow ^{0}_{+1}e + ^{18}_{8}O + \gamma \text{ rays.}$$

$^{18}_{9}F$ just one of the isotopes used. Will return to this in the final lecture.

24.2 Nuclear Stability

Binding Energy

*1: The mass of ^1_1H is in fact $^1_1H + ^0_{-1}e$ (it includes the mass of the electron)

What is the binding energy in kJ/mol nucleons for nitrogen-15?

Masses (g/mol): $^1_1H = 1.00783$ *1 ; $^1_0n = 1.00867$; $^{15}_7N = 15.00011$

Speed of Light = 2.998×10^8 m.s^{-1}

Determine the Mass of the Isotope built from its Particles

$$^{15}_7N = \underbrace{7(^1_1H) + 7(^0_{-1}e)} + 8(^1_0n)$$

$$7(1.00783) + 8(1.00867)$$

$$= 15.12417 \text{ g.mol}^{-1}$$

Convert the Mass Defect to Energy (in kJ.mol^{-1})

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

$$= 1.2406 \times 10^{-4} (2.998 \times 10^8)^2$$

$$= 1.1151 \times 10^{13} \text{ J.mol}^{-1}$$

$$= 1.1151 \times 10^{10} \text{ kJ.mol}^{-1}$$

Determine the Mass Defect (in Kg.mol^{-1}) Mass Defect = Δm

$$\Delta m = 15.12417 - 15.00011$$

$$= 0.12406 \text{ g.mol}^{-1}$$

$$= 1.2406 \times 10^{-4} \text{ kg.mol}^{-1}$$

Divide this Energy by the number of Nucleons

↳ # Protons + # Neutrons.

Nucleons = 7+8 = 15

$$E_B = \frac{1.1151 \times 10^{10}}{15} = 7.4337 \times 10^8 \text{ kJ.mol}^{-1}.\text{nucleon}^{-1}$$

E_B = Binding Energy.