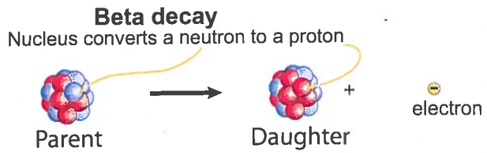
Beta Decay

Beta decay

Beta decay happens when an unstable nucleus emmits an electron. We know that the nucleus does not have any electrons in it. So where does the emitted electron during beta decay come from? It turns out that the electron is formed when a neutron in the nucleus changes into a proton and an electron. The radiation released during beta decay is called **beta radiation**.

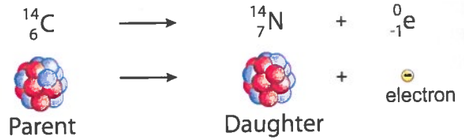
Beta particle is an electron

Since the charge of the nucleus increases by +1 as the neutron changes to a proton, the formation of the electron, which has a charge of -1, maintains the overall charge of the nucleus. The electron released during beta decay is called beta particle.



Beta symbol ${}^{0}_{-1}e$

The beta (β) particle is an electron. For consistency with the genral nuclide symbol and in order to help us with the balance of mass and atomic numbers the β particle is written with the symbol ${}^{0}_{-1}e$.



$${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

Radium ${}^{228}_{88}Ra$ could also decay by β-decay according to: $${}^{226}_{88}Ra \rightarrow {}^{228}_{89}Ac + {}^{0}_{-1}e$$

Solved problem

Write the complete nuclear equation for the β decay of Radium isotope ${}^{228}_{88}Ra$

Given: *The parent nuclide and the type of reaction*

Relationships: *We need to find the type of the daughter nucleus X, the atomic number Z and the mass number A.* ${}^{228}_{88}Ra \rightarrow {}^{A}_{Z}X + {}^{0}_{-1}e$

Solve: *First: Balance the atomic number and the mass number.*

- *By balancing the mass number we obtain A = 228*
- *By balancing the atomic number we obtain 88 = Z-1 or Z = 89*

Second: Look at the periodic table to determine the identity of the unkown daughter element.

- *The atomic number is 89 and the daughter nuclide is actinium, Ac.*

Answer: *The complete β decay equation is* ${}^{228}_{88}Ra \rightarrow {}^{228}_{89}Ac + {}^{0}_{-1}e$

Chemistry terms

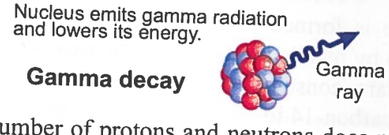
beta decay - when an unstable nucleus releases an electron.

beta radiation - the radiation resulting from beta decay.

Gamma Decay, Positron Emission

Gamma decay

Radioactive decay may also happen with the emission of electromagnetic radiation. **Gamma decay**, abreviated γ-decay, happens when an excited nucleus goes to a lower energy state by emitting high energy electromagnetic radiation. The wavelength of this radiation is about 10^{-12} m. In some cases the emission of γ radiation, also called γ-rays and denoted by ${}^{0}_{0}\gamma$, follows some other radioactive decay such as β-decay or α-decay.



Protons	Stay the same
Neutrons	Stay the same
Atomic number	Stays the same
Mass number	Stays the same

γ-ray energy

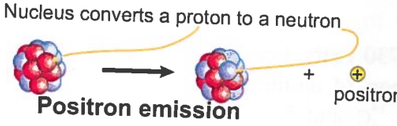
The number of protons and neutrons does not change during γ-decay. Gamma radiation has high enough energy (greater than 10^{-13} joules per disintegration) to break apart other atoms making them dangerous to living organisms. The best way to stop γ-rays is by using a thick shielding material made of lead or concrete.

Positron

Positron, denoted with the symbol ${}^{0}_{+1}e$ in nuclear equations, is a nuclear particle that has the same mass as the electron, but it has a positive charge.

Positron emission

Nuclear decay by **positron emission** happens when an unstable nucleus emits a positron. In doing so it converts a proton into a neutron.



Protons	Decrease by 1
Neutrons	Increase by 1
Atomic number	Decreases by 1
Mass number	Stays the same

Solved problem

Determine the type of decay for the reactions:

1) ${}^{234}_{90}Th \rightarrow {}^{234}_{90}Th + {}^{A1}_{Z1}X1$. 2) ${}^{95}_{43}Tc \rightarrow {}^{95}_{42}Mo + {}^{A2}_{Z2}X2$

Given: *We are given the mass and atomic numbers of the parent and daughter nuclides. Balance the equations to find unknowns X1 and X2.*

Solve: *Balance the atomic numbers to find Z and mass numbers to find A*

- *For reaction 1: 234 = 234 + A1, A1=0. And 90 = 90 + Z1, Z1=0*
- *For reaction 2: 95 = 95 + A2, A2=0. And 43 = 42 + Z2, Z2=+1*

Answer: *For reaction 1:* ${}^{A1}_{Z1}X1 = {}^{0}_{0}X1$ *which denotes γ-decay.* ${}^{A1}_{Z1}X1 = {}^{0}_{0}\gamma$

For reaction 2: ${}^{A2}_{Z2}X2 = {}^{0}_{+1}X2$ *denotes positron decay.* ${}^{A2}_{Z2}X2 = {}^{0}_{+1}e$.

Chemistry terms

gamma decay - when a nucleus decays releasing electromagnetic energy.

positron - a particle that has the same mass as the electron and positive charge.

positron emission - when a nucleus decays by releasing a positron.