More on Radioactivity 12/11/2022

Friday, 11 November 2022 18:30

Session 1:

GCSE…

What is nuclear fission?
When a nucleus splits into two.

What is nuclear fusion?
When two nucleons fuse together.

What is an isotope?
Atoms with the same atomic number but differing mass numbers.

Give an example of nuclear fusion.
A hydrogen bomb.

$$2{}_{1}^{1}\boldsymbol{H} + 2{}_{0}^{1}\boldsymbol{n} \rightarrow {}_{\boldsymbol{2}}^{\boldsymbol{4}}\boldsymbol{He}$$

Beyond GCSE…

Key Vocabulary:

- Ion: **Atoms with the same atomic number, mass number and neutron number but differing electron numbers (charge).**

- Isotopes: **Atoms with the same atomic number but differing mass numbers.**

- Isotones: **Atoms with the same neutron number but differing atomic numbers.**

- Isomers: **Atoms with the same atomic number, mass number and neutron number but differing amounts of energy.**

- Isobars: **Atoms with the same mass number but differing atomic and neutron numbers.**

- Nuclide: **An atom with defined atomic and neutron numbers that exists within a defined energy state.**

- Nucleus (plural nuclei): **The dense central part of an atom consisting of protons and neutrons.**

- Nucleon: **A particle inside of a nucleus (either a proton or neutron).**

- Radionuclide: **A nuclide that emits radiation.**

Nuclear fission:
Nuclear fission can refer either to induced or spontaneous fission (SF). SF occurs naturally if the atomic nucleus is larger than and including Cm-250. In induced fission, a fissile radionuclide is bombarded with neutrons until it splits.

Nuclear Fission Equations:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow \left[^{236}_{92}U\right] \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\,^{1}_{0}n$$

$$^{239}_{94}Pu + ^{1}_{0}n \rightarrow \left[^{240}_{94}Pu\right] \rightarrow ^{134}_{54}Xe + ^{103}_{40}Zr + 3\,^{1}_{0}n$$

$$^{233}_{92}U + ^{1}_{0}n \rightarrow \left[^{234}_{92}U\right] \rightarrow ^{137}_{54}Xe + ^{94}_{38}Sr + 3\,^{1}_{0}n$$

These are all examples of induced fission.

Two important people for our next session:

- **Yuri Oganession**
- **Glenn Seaborg**

Session 2:

What is beta-minus (β^-) decay?
A neutron transmutes to become a proton, electron and electron antineutrino.

β^+: Proton transmutes to become a neutron, positron and an electron neutrino.

What is nuclear transmutation?
When an atoms atomic number changes.

What does primordial mean?
Something that exists naturally, formed in stars billions of years ago.

What section of an atom produces radioactivity?
The nucleus.

Element creation:
Elements can be created synthetically in laboratories, all elements after (but not including) plutonium are synthetic. The synthetic elements are produced due to induced radioactive decay chains that are meticulously prepared and may take months to occur.

Neptunium creation:
$$^{235}_{92}U + ^{1}_{0}n \rightarrow \left[^{236m}_{92}U\right] \rightarrow ^{236}_{92}U + ^{0}_{0}\gamma$$

$$^{236}_{92}U + ^{1}_{0}n \rightarrow \left[^{237}_{92}U\right] \rightarrow ^{237}_{93}Np + ^{0}_{-1}\beta$$

Plutonium creation:

$$^{238}_{92}U + ^{1}_{0}n \rightarrow \left[^{239}_{92}U\right] \rightarrow \left[^{239}_{93}Np + ^{0}_{-1}\beta\right] \rightarrow ^{239}_{94}Pu + ^{0}_{-1}\beta$$

$$^{238}_{92}U + ^{2}_{1}D \rightarrow \left[^{238}_{93}Np + 2^{1}_{0}n\right] \rightarrow ^{238}_{94}Pu + ^{0}_{-1}\beta$$

$^{2}_{1}D$**: Deuteron**

Americium creation:

$$^{239}_{94}Pu + ^{1}_{0}n \rightarrow \left[^{240}_{94}Pu\right] + ^{1}_{0}n \rightarrow \left[^{241}_{94}Pu\right] \rightarrow ^{241}_{95}Am + ^{0}_{-1}\beta$$

Curium creation:

$$^{241}_{95}Am + ^{1}_{0}n \rightarrow \left[^{242}_{95}Am\right] \rightarrow ^{242}_{96}Cm + ^{0}_{-1}\beta$$

$$^{239}_{94}Pu + ^{4}_{2}\alpha \rightarrow ^{242}_{96}Cm + ^{1}_{0}n$$

Element detection:

When heavier elements were synthesised, they were found to exist for only a very short amount of time. To detect these short-lived radionuclides their decay products (e.g. radiation and smaller nuclides) are detected using a Geiger-Muller tube and using predictions of these decay products, scientists are able to show that the element produced matches their predictions.

A final note:

Nuclear fission was discovered by Otto Hahn and Fritz Strassmann and physicists Lise Meitner and Otto Robert Frisch. A little fact that may be useful for general knowledge quizzes.