

Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Third year)

Subject: Chemistry

Course Code: CHC 108

Course Title: Physical Chemistry

Unit: 02 Sec A

Module Name: Neutron Emission in fission.

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Notes

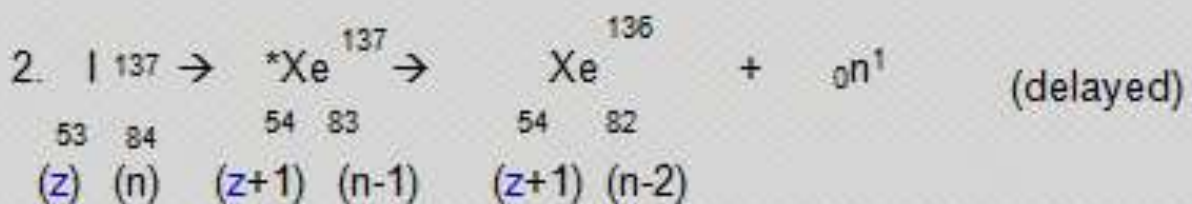
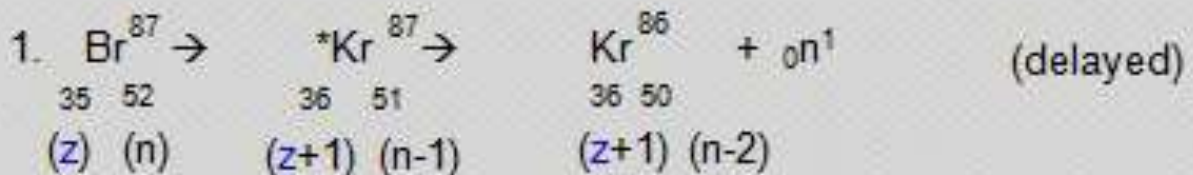
Neutron Emission in fission

Introduction

- The high neutron to proton ratio leads to instability in the fissioning nucleus. The nucleus captures neutrons, forming compound nucleus, the neutron to proton ratio is further increased. The compound nucleus undergoes rupture giving rise to two fission fragments along with a few number of neutrons.
- The emission of neutrons in fission was experimentally demonstrated by Von Halban and others. By comparing the neutron density around a neutron source ($\text{Ra} + \text{Be}$, or $\text{Pu}^{238} + \text{Be}$, or $\text{Am}^{241} + \text{Be}$) . Placed in a vessel filled with a solution of Uranyl nitrate with that when filled with an ammonium nitrate solution of same density.
- The **average neutron density** is greater when uranium was present.
- Indicating that more neutron density is greater when uranium was present. More neutrons were formed, when fission took place, than were used up. The number of neutrons emitted increases with the energy of the projectile neutrons causing fission. The number of neutrons released is taken as an average value, ν , which is not an integer and always greater than two.

- From the values of thermal cross sections , it is evident that not all the neutrons initially captured cause fission,
- But some captures result in the emission of γ - rays i.e. radiative capture competes with fission.
- The number of neutrons released per neutron absorbed in a fission of a nuclide and is given by $\eta = \nu / 1 + \alpha$
- α , the ratio of the radiative capture cross section to the fission cross section. i.e $\alpha = \sigma_r / \sigma_f$.
- **Prompt neutrons and Delayed neutrons.**
- Not all the fission neutrons are released at one instant.
- Over 99% of the neutrons produced in fission are emitted when an extremely short interval of time of the order of 10^{-14} sec of the fission process. These are **prompt neutrons**.
- The rest of the fission neutrons, constituting less than 1% of the total , are **delayed neutrons**, which are emitted for sometime after the actual fission process.
- Sufficient number of neutrons should be provided by the reaction to have self-sustain nuclear chain reaction.
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Mechanism for the emission of Delayed neutrons



The fission fragment with 'z' proton and 'n' neutron.

- The fission fragments with z proton and n neutron undergoes β -decay giving rise to daughter product with (z+1) proton and (n-1) neutron.
- The β -decay energy of the fission fragment is greater than Binding energy of the last neutrons in the daughter product.
- In the β -decay the daughter product nuclei may be left either in the ground state or one of the many excited states.
- If the excitation energy of one of the excited states of product nuclei (z+1) proton and (n-1) neutron is in excess of binding energy of last neutron de-excitation takes place.
- De-excitation takes place with emission of neutron resulting in production nuclei (z+1) proton and (n-2) neutron.
- The emission of this neutron will be delayed and corresponds to the half-life of β -decay.