Fission of ^{235}U

Neither ^{235}U *nor* ^{238}U fission *spontaneously*.

Extra energy is necessary to surmount the Coulomb barrier.

Neutron-induced fission

Although ^{235}U does not fission spontaneously, if a neutron, even a slow (thermal) neutron, interacts with it, fission does take place.

This is what happens in neutron-induced fission.

The first step is that a neutron interacts with a ^{235}U nucleus to produce the compound nucleus $^{236}U^*$

In the case of a *thermal neutron* the excitation energy of the $^{236}U^*$ is just the binding energy of the last neutron (+ ~0.025eV which is negligible)

Neutron-induced fission

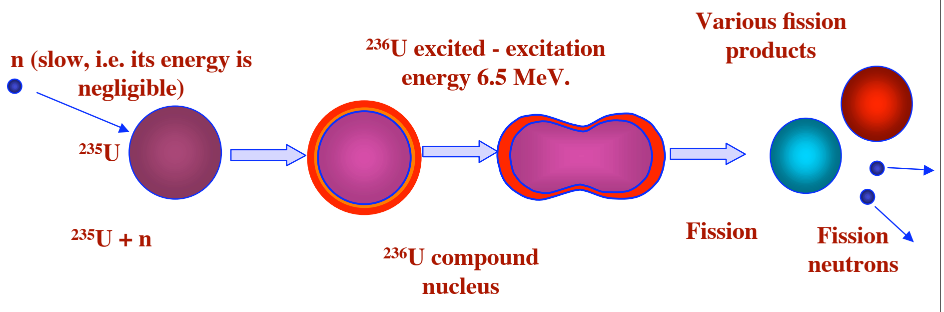
Exercise 28.

1. If the binding energy of the last neutron in ^{236}U is 6.55 MeV, what is the *excitation energy* of the compound nucleus after it absorbs a thermal (slow) neutron (the average thermal energy is 0.025 eV).
2. What is its excitation energy after it absorbs a fast neutron, say with an energy of 2 MeV?

Neutron-induced fission

Fission in ^{235}U with a slow neutron.

$^{235}U + n \rightarrow$ fission



The 6.5 MeV binding energy of the neutron in ^{236}U excites the compound nucleus - it distorts - first scission and finally fission occurs.

Neutron-induced fission

There are three naturally occurring isotopes of the element uranium.
The two that are important as reactor fuels are ^{235}U and ^{238}U.

The natural abundance of ^{238}U is 99.28%
The natural abundance of ^{235}U is 0.72%

We have seen above that ^{235}U fissions with slow neutrons.
What happens in the case of ^{238}U?

If a neutron interacts with ^{238}U we would get the compound nucleus ^{239}U*

It turns out that the binding energy of the last neutron in ^{239}U is only 4.8062 MeV (Compared with 6.5452 MeV in the case of ^{236}U).

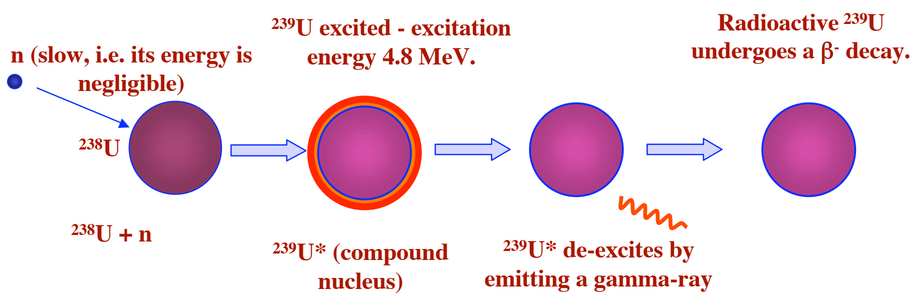
Comment on this

This is not enough for the compound nucleus to overcome the fission barrier.

Neutron-induced fission

Reaction of ^{238}U with a *slow* neutron.

^{238}U + n - fission does *not* occur with a *slow* neutron.

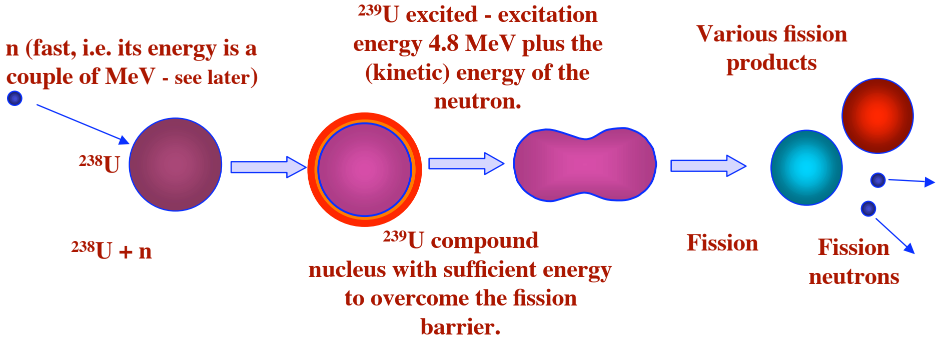


The 4.8 MeV binding energy of the neutron in ^{239}U is not sufficient to overcome the fission barrier - we get radiative capture: ^{238}U(n,γ)^{239}U.

Neutron-induced fission

Reaction of ^{238}U with a *fast* neutron.

^{238}U + n - fission *does* occur when the neutron is *fast*.



The 4.8 MeV binding energy of the neutron in ^{239}U together with the energy (kinetic energy) of the incoming fast neutron excites the compound nucleus - it distorts - scission and finally fission occurs.

The Liquid Drop Model and Fission

Exercise 29

Fission and the Coulomb barrier

1 Discuss why ^{235}U fissions with thermal neutrons, while ^{238}U will only fission if the neutrons are fast (with energies of several MeV).

Do not take more than a page to do this.