Explain nuclear fission on the basis of liquid drop model. Why is U^{235} fissible to slow neutrons but not U^{238}?

The Liquid drop model of the nucleus was proposed by Niels Bohr. According to this model, the nuclei behave like an electrically charged incompressible liquid drop of constant density but varying mass.

Also according to this model;

(i) The nucleus is spherical in shape in stable state just like a liquid drop.

(ii) The volume is proportional to mass number A and density of nucleus is constant.

(iii) The nucleus attract only from nearest nucleus just like molecules of liquid drop.

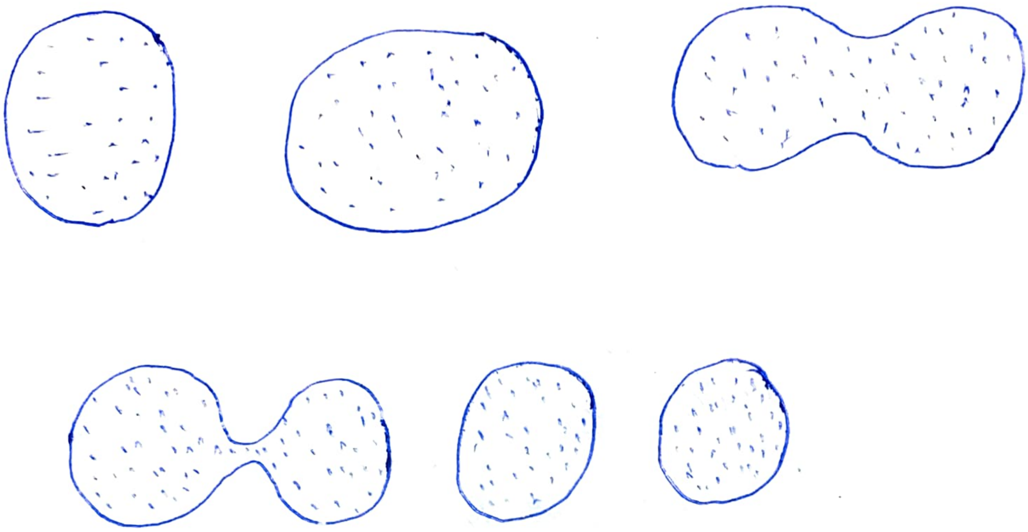
(iv) The nuclear forces are short range forces and have tendency to saturate.

Nuclear Fission on the basis of Liquid drop model:-

Bohr and Whealer explained nuclear fission on the basis of liquid drop model. According to them the nucleus is like an oil drop. The charge of proton is uniformely distributed all over the nucleus.

When a oil drop is pushed a disturbance is created. If this impact is slow, the drop agains comes to spherical shape due to surface tenssion. But if the impact is strong, the size of the drop changes. It elongates and finally breaks up.

Similarly when a slow neutron strike U^{235} nucleus a compound nucleus is formed. The disturbance are created and the nucleus is distorted. If the excitation energy is sufficient, the distortion goes on increasing and crosses a critical position, the various steps are shown in the figure.



The nucleus does not come to the original shape. All these conditions take place in a very short time 10^{-12} sec.

For a fission to occur, the energy must be greater than a critical energy.

The condition for fission is;

$$\frac{Z^2}{A} = 45$$

where, Z = Proton number

A = Mass number.

If $\frac{Z^2}{A} > 45$; spontaneous fission will take place.

If $\frac{Z^2}{A} < 45$; some energy must be supplied for fission to take place.

Now from question: U^{235} undergoes fission when bombarded by thermal neutrons ($v = 2200$ m/s) whereas U^{238} does not. U^{238} will undergoes fission when bombarded by fast neutrons ($E_n > 1$ MeV). Slow neutron fission occurs quite often in nuclei containing odd number of neutrons eg. U^{235}. This can be interpreted as due to a large excitation produced in the compound nucleus because of the energy released in the pairing of neutrons when the incident neutron is absorbed.

	Mass (Mu)
U^{235}	235.11392
$+ \, {}^1n_0$	1.00893
$U^{235} + n$	236.12285
$- \, U^{236}$	236.11559
Difference of energy -	0.00726 Mu.

$\simeq 0.00726 \times c^2$ where, $c = 3\times10^8$ m/s.

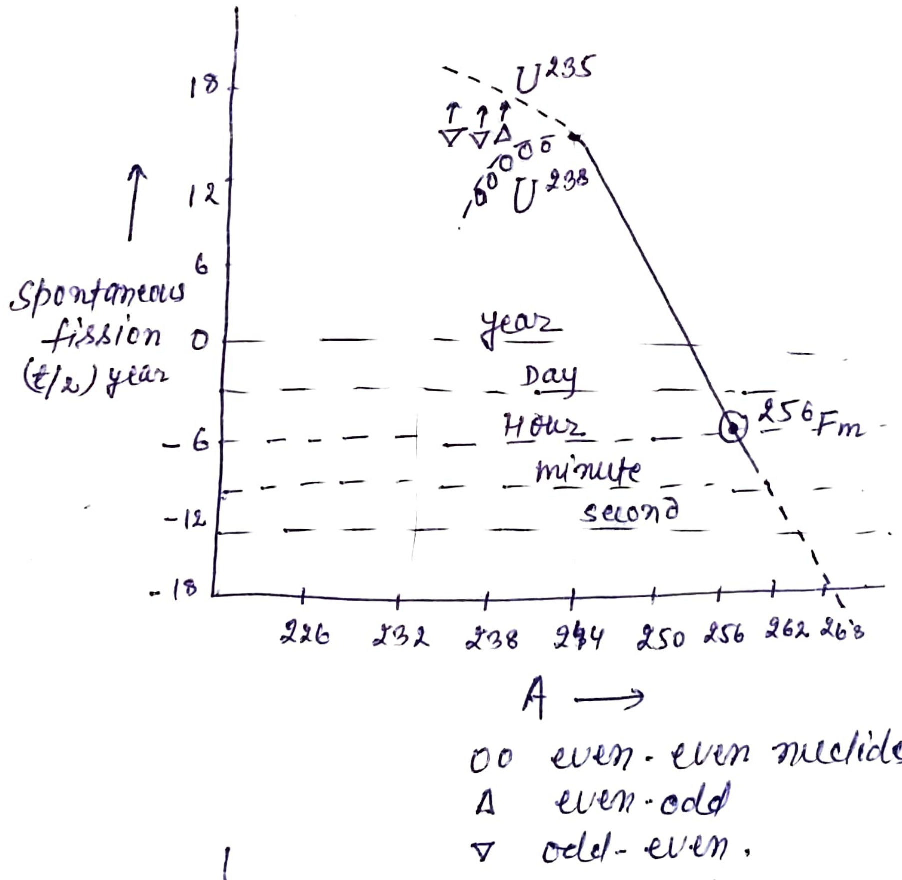
$\simeq 6.8$ MeV The excitation energy of the U^{236} compound nucleus.

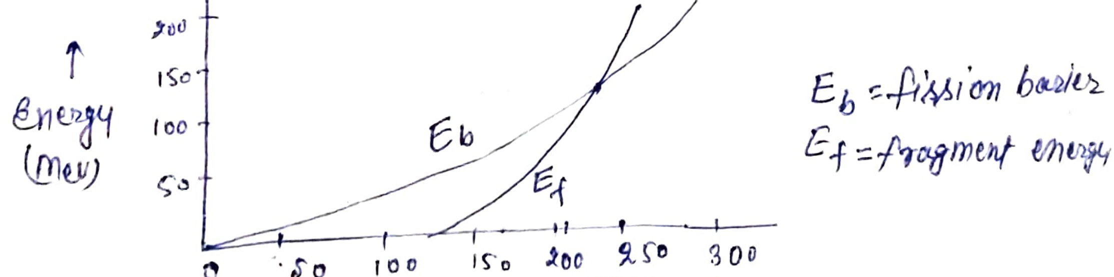
This is just equal to the required activation energy 6.8 MeV.

$$U^{238} + {}^1n_0 \longrightarrow U^{239*}$$

Here excitation energy is 5.3 MeV. Whereas the activation energy is 7.3 MeV.

Hence thermal neutron can not cause fission in case of U^{238}.





Therefore, U^{235} is fissible to slow neutrons but not U^{238}.