MODULE -V

ENERGY SOURCES & STORAGE DEVICES

5.1 Nuclear Energy Sources

5.1.1 Nuclear Energy

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5.1 NUCLEAR ENERGY SOURCES

5.1.1 Nuclear Energy

Nuclear energy is a form of energy released from the nucleus, the core of atoms, made up of protons and neutrons.

This source of energy can be produced in two ways

- fission – when nuclei of atoms split into several parts
- fusion – when nuclei fuse together.
- The large amount of energy released during the fission and fusion reaction is known as nuclear energy

5.1.2 Nuclear Fission

The process of splitting of heavier nucleus in to 2 or smaller nuclei with the release of large amount of Energy is called Nuclear fission.

Eg.

$$_{92}U^{235} + {}_{o}n^{1} \longrightarrow [\ _{92}U^{236}\ ] \xrightarrow{\text{fission}} {}_{56}Ba^{141} + {}_{36}Kr^{92} + {}_{30}n^{1} + E$$

[Uranium Nucleus] [Neutron] unstable

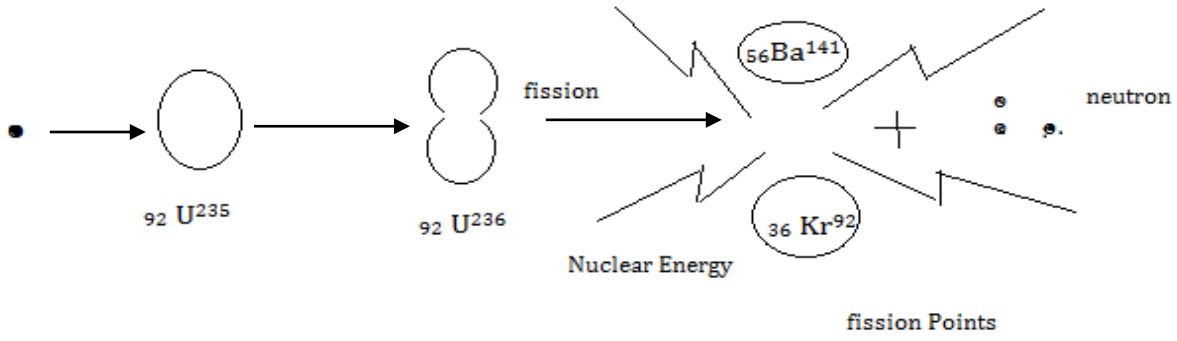

Fig:1-Nuclear fission

Source: physical chemistry by Arun paul

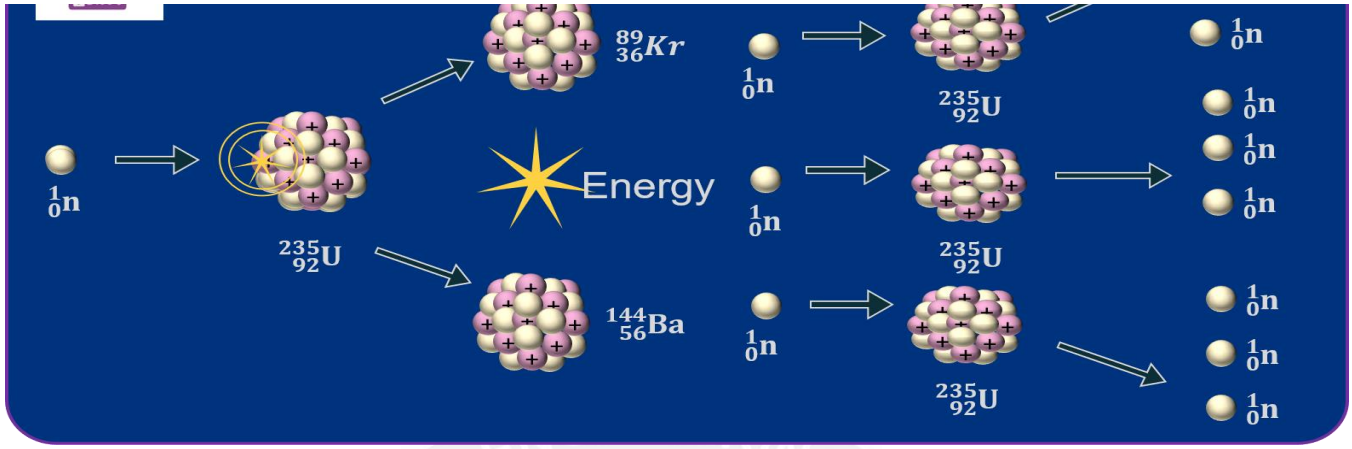

Fig:2-Nuclear fission

Source: physical chemistry by Arun paul

Energy released during nuclear fission reaction

❖ In fission reaction the sum of the masses of the products is less than the reactants total mass.

❖ This loss in mass is converted into energy by Einstein's equation.

$E=mc^2$

Where

E= energy

M= loss in mass

C= velocity of light

Calculation of energy released during the fission of $_{92}U^{235}$

The fission reaction is

$$\underbrace{{}_{92}U^{235} + {}_{o}n^{1}}_{\text{Reactants}} \longrightarrow \underbrace{{}_{56}Ba^{141} + {}_{36}Kr^{92}}_{\text{Products}} + {}_{30}n^{1} + \text{Energy}$$

Total Mass of Reactants	**Total Mass of Products**
$_{92}U^{235}$= 235.120 $_{O}n^{1}$=1.009	$_{56}B^{141}$=140.910 $_{36}Kr^{92}$=91.910 $_{3}on^{1}$=3.027 (3x1.009)
Total mass of reactants = 236.129 amu	

	Total mass of products = 235.847 amu

Loss in mass (mass defect) = Total mass of reactants – Total mass of products

= 236.129-

235.847

0.282 amu

Energy released:

Loss in mass = 0.282 amu

1 amu = 931 MeV

0.282 amu = 0.282 x 931 MeV

= 262.524 MeV

Energy Released = 262.524 MeV

Characteristics of Nuclear fission.

1) Heavier nucleus splits into 2 or more smaller nuclear.
2) Two or more neutrons are released.
3) Large amount of energy is released.
4) All the fission products are radioactive, giving –off β and γ radiations.
5) The fission reactions are self-propagating.
6) Nuclear fission reactions can be controlled by absorbing the extra neutrons.
7) The number of neutrons released from a single fission is called the multiplication factor. If it is less than 1, there is no chain reaction.

5.1.3 Nuclear fusion

The process in which 2 or smaller nuclear combine to give one heavier nuclear is known as nuclear fusion.

Eg.

$$_1H^2 + {}_1H^2 \longrightarrow {}_2He^4 + \text{Energy}$$

Hydrogen nucleus Helium nucleus

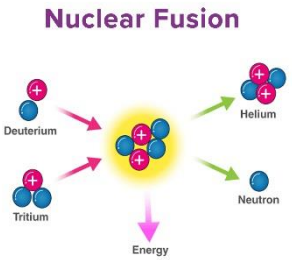

Fig:3-Nuclear fussion

Sources : Online sources

Nuclear fusion reaction takes place at very high temperature.

Difference between Nuclear fission and Nuclear fusion

Sl.No	Nuclear Fission	Nuclear Fusion
1	Splitting of heavy nuclear into small nuclear	Small Nuclear combine to from heavy nucleus
2	Emits neutrons	Emits positron
3	Occurs at ordinary temperature	Occurs at very high temperature (> 10^6k)
4	Can be controlled	Cannot be controlled
5	It is a chain process	It is not a chain process

6	Fission products are radioactive.	Fusion products are not radioactive
7	Energy released is less when compared to nuclear fusion reactions	Very high amount of energy is released

5.1.4 Nuclear Chain reactions:

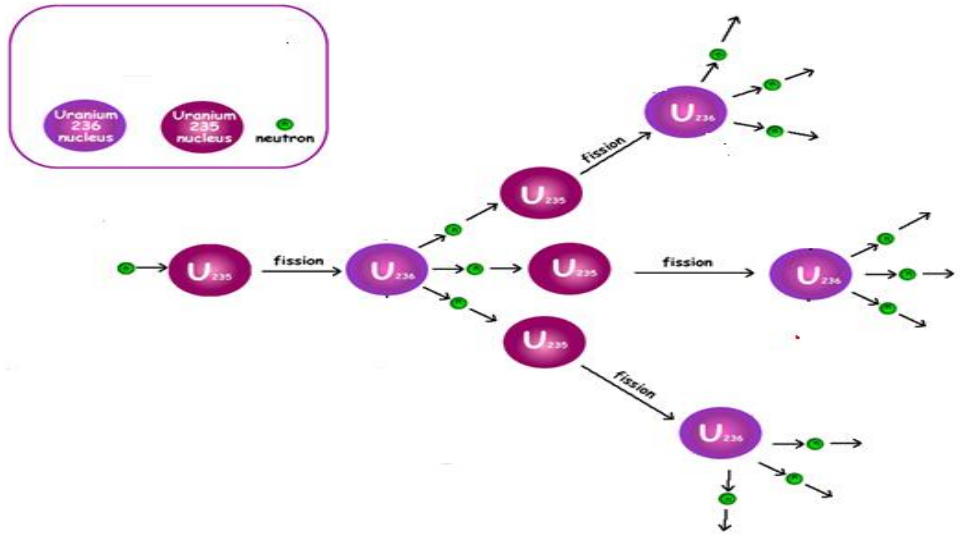

Fig:4-Nuclear Chain reaction

Source: physical chemistry by Arun paul

$$_{92}U^{235} + {}_{o}n^{1} \longrightarrow {}_{56}Ba^{140} + {}_{36}Kr^{93} + 3{}_{0}n^{1} + \text{Energy}$$

Critical Mass is the minimum mass of fissionable material required to sustain a chain reaction

Sub- Critical mass is a mass less than its critical mass

Super critical mass is a mass greater than its critical mass.

Controlled chain reaction – The chain reaction can be controlled by absorbing a desired number of neutrons so that only one neutron remains available to carry out further fission such a reaction is known as a controlled chain reaction.

Uses of Nuclear energy

1. To generate electricity
2. Used in medicine like treatment of diseases like cancer
3. In improvement of agriculture and industry
4. Scientific and research
5. Consumer products
6. Industrial applications
7. Space