Nuclear Reactions

Lecture 30

PH-122

Nuclear Reactions

Nuclear reactions are of two types:

- Fission (splitting of nucleus into lighter nuclei).
- Fusion (combining of nuclei to form a heavier nucleus).

Nuclear Fission

$$^{235}U + n \rightarrow {}^{236}U.$$

$$^{235}U + n \rightarrow {}^{236}U \rightarrow {}^{140}Xe + {}^{94}Sr + 2n.$$

$$^{140}Xe \rightarrow {}^{140}Cs \rightarrow {}^{140}Ba \rightarrow {}^{140}La \rightarrow {}^{140}Ce$$

$T_{1/2}$	14 s	64 s	13 d	40 h	Stable
Z	54	55	56	57	58

$$^{94}Sr \rightarrow {}^{94}Y \rightarrow {}^{94}Zr$$

$T_{1/2}$	75 s	19 min	Stable
Z	38	39	40

Nuclear Fission

The ^{235}U absorbs a slow neutron (with little kinetic energy), becoming ^{236}U.

Energy is transferred from mass energy to energy of the oscillations caused by the absorption.

Both globs contain protons and are positively charged and thus they repel each other.

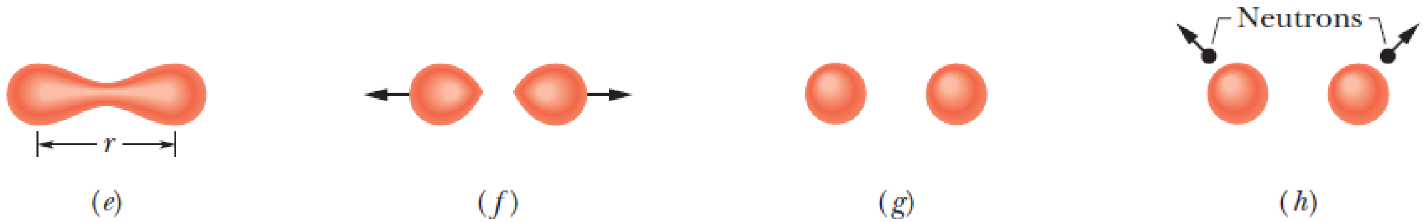
But the protons and neutrons also attract one another by the strong force that binds the nucleus.

The strong force, however, decreases very quickly with distance between the globs.

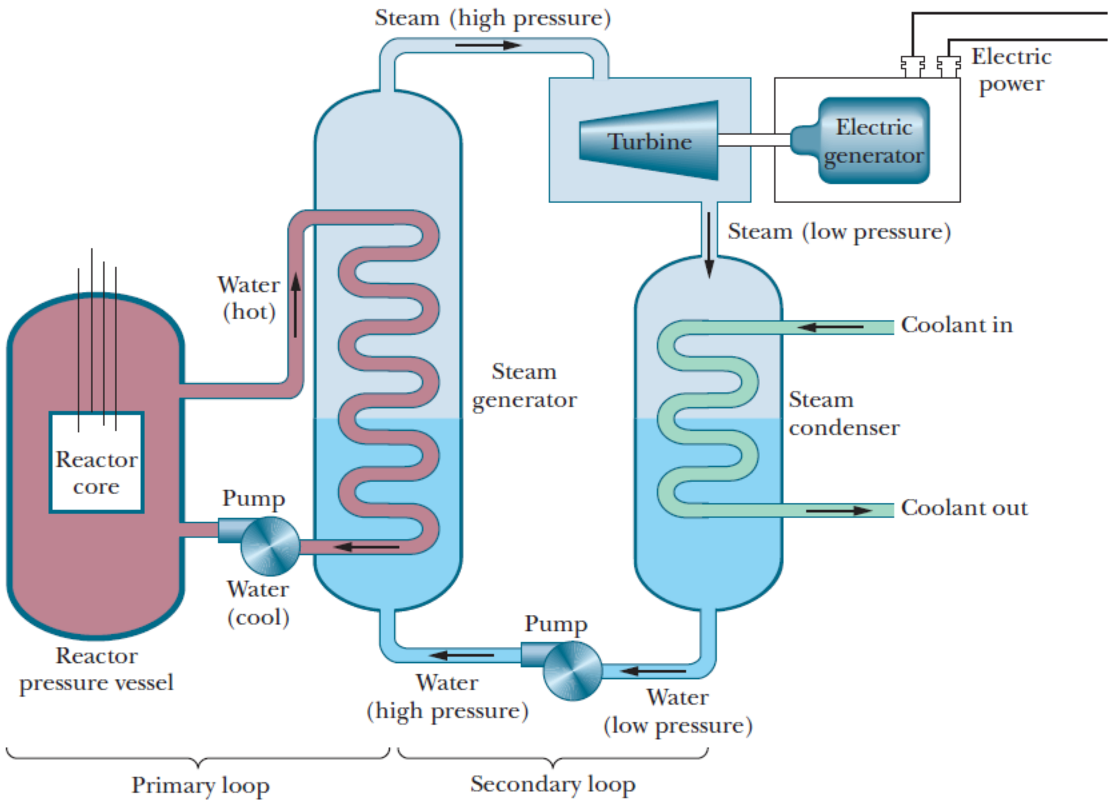
So, if the globs move apart enough, the electric repulsion rips apart the nucleus.

This fission decreases the mass energy, thus releasing energy.

The two fragments eject neutrons, further reducing mass energy.



Nuclear Reactor



Multiplication factor (k) is defined as number of neutrons per fission reaction.

k=1 (exactly critical)

K<1 (under critical)

K>1 (super critical)

Problem

- A nuclear reactor has an output of 5000 Mwatt per day. How much Uranium U^{235} is consumable to produce this power output when energy released as a result of single fission reaction is 200 MeV.

- $E = PXt = 5000X10^6X24X60X60 = 4.32X10^{14}J$
- $E_f = 200X10^6(1.6X10^{-19}) = 3.2X10^{11}J$
- No. of fission reactions = No. of atoms of U^{235}
- $N = \frac{4.32X10^{14}J}{3.2X10^{11}J} = 1.35X10^{25}$
- Mass consumable= N x mass of single U^{235} nucleus
- $m = (1.35X10^{25})$(235.0439)(1.66X10^−27)= 5.266 kg.