

"In thermonuclear weapons, radiation from a fission explosive can be contained and used to transfer energy to compress and ignite a physically separate component containing thermonuclear fuel."

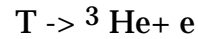
The 3 basic concepts of thermonuclear devices, U.S. DOE, Sept 1980, Duane Sewell, Assistant Secretary of Energy for Defense, Official Declassification Act.

FUSION PRINCIPLES Under solar conditions (high temps of about 100 millions degrees C, 1 million megabars pressure), H atoms fuse into He. Three isotopes of H exist:

- ^1H (P) protium
- ^2H (D) deuterium
- ^3H (T) tritium.

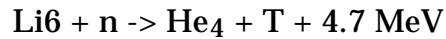
Protium reacts too slowly even in the sun so deuterium and tritium are used. Under solar conditions, the H atoms gain enough kinetic energy to overcome the electrostatic repulsion of their positive charges. The electrons which are normally found surrounding H nuclei have already been ionized. You have a plasma of positive nuclei.

^4He is formed in a H-H reaction, releasing energy. Sources of D and T . Heavy water (D_2O) is present at 1 part in 6700 in normal tap water. You can separate the heavy water, and then obtain deuterium gas. D_2 gas is obtained via electrolysis. Tritium is radioactive, and is obtained via bombardment of ^6Li with thermal (slow) neutrons. It beta decays like:

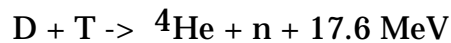


T fuses with D at a temperature an order of mag lower than for D-D fusion, hence its usefulness in a weapon. Lithium The lightest of metals, only 1/2 as dense as water. Found combined with other elements in igneous rocks and mineral spring water. ^7Li is separated electrolytically from $^7\text{LiCl}$. Has several isotopes: ^5Li to ^9Li . ^6Li and ^7Li are used in weapons, and are naturally occurring. ^5Li , ^8Li , and ^9Li are man-made radioisotopes. ^6Li is present as 7.5% of all naturally occurring Li. Separation methods include electrolysis, distillation, chemical exchange, or EM methods. Li bonds with H to form the solid ^6LiD . Back to the Story Since the mass of the resultant He is less than the mass of the separate H, the excess energy is converted into radiation and kinetic energy of neutrons. One cubic metre of gaseous deuterium, when fused into helium, yields the equivalent of about 10 megatons of TNT. Deuterium and tritium are gases at room temperature, so their storage in a weapon would be cumbersome. Instead, a substance called lithium deuteride (^6LiD or ^7LiD) is used. This material has the property of being a whitish, slightly-blue powdery light salt-solid (which is extremely hygroscopic) at room temperature. It is made by heating metal lithium in a vessel, into which deuterium gas is injected. It is then pressed and shaped into a ceramic. When a neutron is absorbed by a LiD molecule, the

molecule breaks up into a He, ³H, and a deuterium. The D can then react with the T in fusion. This releases enormous amounts of energy, much greater than you would get in a fission reaction. The end products include a free n, and a He. (thermal kinetic energy of neutrons).

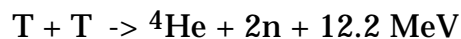
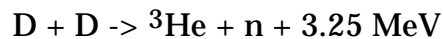
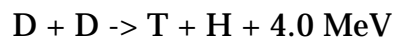
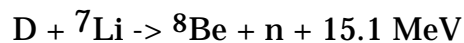
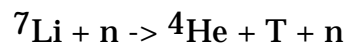
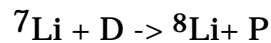
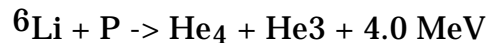
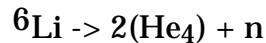


then



These reactions occur in under 1/10-6 secs.

Additional reactions are:

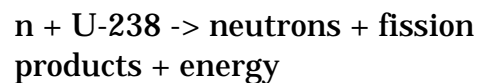


Beryllium is useful in the core of a fission mass since you can use it to increase the neutron flux:



In addition, the energy of the slow neutrons is high enough to split some additional U-235 (which was part of the reaction that started the fusion reaction). Fast neutrons only transmute U-238 into Np-239 (which then beta decays into Pu-239) reducing the number of neutrons available to other reactions.

Schematically: U-235 fission releases fast neutrons and heat



For a thermonuclear reaction, you have to compress the ⁶LiD solid to 15-30 times it's original uncompressed density at RTP (15lbs/foot³). Compression is needed to: (1) increase fusion *probability*. You pack the molecules closer together. In the process, you pave the way to overcoming the electrostatic repulsion of the H atoms in the ⁶LiD. (2) increase fusion *rate*, since you get quicker reactions when the reactants are packed closely together than far apart. The *time* for a reaction is inversely proportional to fuel density. Denser fuels mean shorter reaction times, and hence more chance of a larger number of reactions. The *rate* of reaction, on the other hand, is proportional to the square of the fuel density. Increase the density by a factor of 30, and your rate increases by

a factor of 900. Compression is a form of inertial confinement fusion (ICF). You are in effect counteracting the explosive forces released in the fusion, by giving the reactants an inwardly directed momentum. So the whole mass of fuel stays together. It's collapsing in on itself; at the same time it wants to tear itself apart