

# Nuclear Chemistry

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1. Write, using proper symbolism, the symbols for

Nitrogen-13       ${}^{13}_7\text{N}$

Tritium             ${}^3_1\text{H}$

Boron-10          ${}^{10}_5\text{B}$

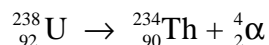
The isotope of lead containing 125 neutrons       ${}^{207}_{82}\text{Pb}$

2. What is an alpha particle? A helium nucleus:  ${}^4_2\text{He}$

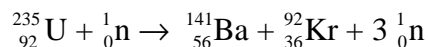
...  $\beta$ -particle? A nuclear electron:  ${}^0_{-1}\text{e}$

... neutrino?      An infinitesimally small particle that can travel enormous distances without encountering or colliding with other matter.

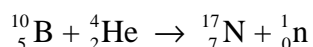
3. Write the equation for the spontaneous disintegration of  ${}^{238}_{92}\text{U}$  during which an  $\alpha$ -particle is produced.



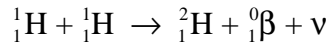
4. Write the equation for the slow neutron initiated fission reaction of  ${}^{235}_{92}\text{U}$  to produce barium-141 and krypton-92.



5. Write the equation for the fusion boron-10 with an  $\alpha$ -particle. The by-product of this reaction is a single neutron.



6. a. When two protons combine in a fusion reaction, a deuteron, positron, and neutrino are formed. The mass of the proton is 1.0078 u, the mass of the deuteron is 2.0141 u, and the mass of the positron is  $4.49 \times 10^{-4}$  u. Assuming the mass of the neutrino is negligible, how much energy (in J) is produced this nuclear fusion reaction? ( $1 \text{ u} = 1.6606 \times 10^{-27} \text{ kg}$ )



$$\text{total mass of protium} = 2 \times (1.0078 \text{ u}) = 2.0156 \text{ u}$$

$$\text{total mass of products} = 2.0141 \text{ u} + 4.49 \times 10^{-4} \text{ u} = 2.01455 \text{ u}$$

$$\text{mass defect} = 2.0156 \text{ u} - 2.01455 \text{ u} = 0.001051 \text{ u}$$

$$\text{mass defect (kg)} = 0.001051 \text{ u} \times 1.6606 \times 10^{-27} \frac{\text{kg}}{\text{u}} = 1.7453 \times 10^{-30} \text{ kg}$$

$$\text{Energy produced} = E = mc^2$$

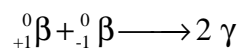
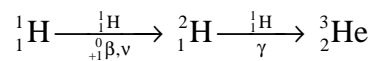
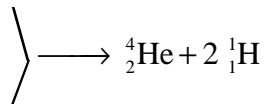
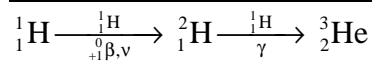
$$E = 1.7453 \times 10^{-30} \text{ kg} \times (3.00 \times 10^8 \text{ m/s})^2 = 1.571 \times 10^{-13} \text{ J}$$

- b. How much energy is produced when  $3 \times 10^{23}$  atom pairs (1.0 g) combine?

$$E = 1.571 \times 10^{-13} \text{ J} \times (3 \times 10^{23} \text{ atom pairs}) = 4.7 \times 10^{10} \text{ J}(!)$$

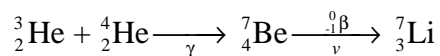
7. What is the name of the primary nuclear reaction thought to be powering the Sun? Write the reaction.

### PROTON-PROTON CHAIN REACTION (Branch I)

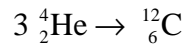


8. What is another nuclear reaction thought to be going on in the Sun? Write the reaction.

### PROTON-PROTON CHAIN REACTION (Branch II)



9. When the hydrogen in a solar mass star is depleted to the point that core hydrogen fusion can no longer be sustained, the triple-alpha process starts. Write the equation for the triple-alpha reaction.



10. In larger stars, the CNO cycle may be the primary “power-plant” reaction. Write the complete equation for the CNO cycle.

