2006 핵융합 기초 #1 (Harms, Principles of Fusion Energy)

1.3 What fraction of the original mass in D-T fusion is actually converted into energy? Compare this to the case of nuclear fission, Eq.(1.3)

1.5 Calculate the total fusion energy, in Joules, residing in a liter of water if all the deuterons were to fuse according to Eq.(1.21)

1.8 The first artificial nuclear transmutation without the use of radioactive substances was successfully carried out in the Rutherford Laboratory by Cockcroft and Walton when they bombarded Lithium (at rest) with 100 keV proton canal rays (proton accelerated by a voltage of 100kV and passing through a hole in the cathode). By scintillations in Zincblende-screen, the appearance of α-particle with a kinetic energy of 8.6MeV was determined.

(a) Formulate the law of energy conservation valid for the above experiment referring to the nuclear reaction

$$^{7}_{3}Li + ^{1}_{1}H \rightarrow 2^{2}_{4}He$$

and find therefrom the reaction energy, Q_{p7Li}, via the involved rest masses(m_p, $m_\alpha = 6.64455 \times 10^{-27} kg$, $m_{7Li} = 11.64743 \times 10^{-27} kg$).

(b) In the Cockcroft-Walton experiment, conservation of momentum was proven by cloud chamber imaging whereby it was observed that the tracks of the two α-particles diverge at an angle of 175°. What angle follows from the law of momentum conservation by calculation?

(c) A further reaction induced by the protons in natural lithium is

$$^{6}_{3}Li + ^{1}_{1}H \rightarrow ^{4}_{2}He + ^{3}_{2}He$$

Provide an argument that shows the α-particles detected in the Cockcroft-Walton experiment cannot stem from this reaction.

2.2 Determine the Coulomb barrier for the nuclear reactions d-t, d-h, and $p - ^{11}$B.

3.3 For the conditions in problem 3.2, calculate σ_s assuming a background particle density of 10^{20}m^{-3}.

3.4 Calculate the bremsstrahlung power increase if a d-t plasma were to contain to totally stripped oxygen ions at a concentration of 1% of the electron density.

3.5 Calculate the ratio of bremsstrahlung power to fusion power for a d-t plasma with $N_i=N_e=10^{20}m^{-3}$ at 2 keV and 20 keV.

3.7 A fusion reactor using two opposing accelerators is proposed, where a 30 keV tritium beam from one is aimed head on at a 30 keV deuterium beam form the other. Would this work, and can you suggest improvements? What would you estimate is the maximum energy gain possible with this system (see Ch. 8)?

7.1 Use $\langle\sigma v\rangle_{dt}$ from Appendix C for 10keV and 100keV and calculate R_{fu} for a 50:50% and 25:75% mixture of deuterium and tritium for which $N_d+N_t = N = 10^{21}m^{-3}$.

7.4 Formulate reaction rate expression for d, t and h as suggested in Table 7.2.

7.6 Fission reactors possess power densities of about $10^7 Wm^{-3}$. For this power range, determine the required particle density for d-t fusion at 10keV.