Radiochemistry #5 (Q & A) 2017.5.31

Questions & Answers

(1) Calculate the speed (relative to the speed of light) of an alpha ray with a kinetic energy of 5 MeV. Do not use SI units such as kilogram for calculation, but use the mass unit MeV/c^2. 運動エネルギー 5 MeV のα線の速度を光速と比較した値として計算せよ。キログラムなどの国際単位系 (SI) は使わず、質量の単位には MeV/c^2 を使って計算すること。

A. 5 MeV = (4000 MeV/c^2) v^2 / 2 ∴ v/c = 0.05

(2) Calculate the speed (relative to the speed of light) of a beta ray with a kinetic energy of 1 MeV. The result calculated with the same formula used for (1) above is not acceptable as it is. Not acceptable in what sense? 運動エネルギー 1 MeV のβ線の速度を光速と比較した値として計算せよ。(1) と同様の計算をすると、困った結果が得られると思うが、何が困ったことになるか。

A. 1 MeV = (0.5 MeV/c^2) v^2 / 2 ∴ v/c = 2

The velocity of the beta ray is calculated to be larger than the speed of light, which is not possible. Correct calculation should not use the Newtonian formula but use the relativistic formula given in the slide copy. The correct answer is v/c = 0.94

(3) The mass stopping power does not depend very much on the material through which charged particles penetrate. Calculate the thickness of paper (with a density of 0.8 g/cm^3) needed to stop alpha rays with 5 MeV energy. Note that the range of 5-MeV alpha rays in the standard air is 3.6 cm. 質量阻止能は荷電粒子が通過する物質の種類にあまりよらない。エネルギー 5 MeV のα線を止めるのに必要な紙（密度は 0.8 g/cm^3 とする）の厚さを求めよ。ただし、5 MeV のα線の標準空気中での飛程は 3.6 cm である。

A. The mass stopping power does not depend very much on the material.

Density of the air : 28.8 g / 22.4 L = 1.29×10^{-3} g/cm^3

Density ratio between paper and air = 0.8 / (1.29×10^{-3}) = 620

3.6 cm / 620 = 58 μm Roughly 60 μm.