Solving Problems In Nuclear Physics

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ABSTRACT

This article reveals the essence of solving problems in nuclear physics.

KEYWORDS

Nuclei, atom, energy, neutron, neutrino, proton, electron, mass, study, quantum, flux, velocity.

INTRODUCTION

Using a mass spectrometer, the masses of the nucleus are compared, and the difference in the masses of the helium atom in the normal and metastable states is also determined. In most cases, the mass of the nucleus is found from the Einstein equation($E = mc^2$).

The epegdiapi that the nucleus spends on splitting into free nucleons is called the epegdiapi of the nucleus bond. The relation between the atomic stem Z and the mass stem A with the nuclear mass M (Z, A) the epegdua expression is as follows:

$$E = (ZM_\rho + (A - Z)M_n - M(Z_1 A))c^2$$

M_ρ - free proton mass, M_n - mass of free netron. The mass of these two nucleons is of great importance. The mass of the proton is found with great accuracy by measuring the charge-to-mass ratio. The mass of the neutron is determined based on the reactions in which the deiron is involved. If the mass of the M_d -deuteron is equal to its binding energy

$$E_d = (M_p + M_n - M_d)c^2.$$

M_ρ - it is known from experience that, M_d / M_p the ratio value is found as a result of mass spectrometric measurements, then the M_d value is determined. For this reason E_d - the size is measured, M_n easily calculate the size. The following reaction can be used to determine the binding energy E_d. When a slow-moving neutron collides with water or paraffin (Figure 44), it is captured by protons, forming deuterium and emitting gamma radiation. This reaction is written as follows.

$$_1^1H + _0^1n \rightarrow (_1^2H) \rightarrow _1^2H + h\nu$$
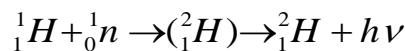
The intermediate deuterium core is in the $(_1^2H)$ state. For it to go to the ground state, it must emit an $h\nu$ gamma ray. h - Planck's constant. ν - the frequency of the gamma ray quantum.

Knowing the ν -frequency of γ -radiation, it is easy to determine its $h\nu$ -energy.

The mass of the neutron is greater than the mass of the proton. The mass of the proton versus the mass of the electron $M_p = (988,256 \pm 0,005)m_e$, $Mn = (939,550 \pm 0,005)m_e$.

The release of energy as a result of the addition of light nuclei is called a fusion reaction. In the fusion reaction, the lighter atoms join and form a heavier nucleus, and when two deuterons collide with a higher energy, one of the deuterons absorbs the proton or neutron of the other, attaching it to itself. In the first case, an isotope of helium with a mass of 3 is formed. As a result of this reaction, an energy of 3.25 MeV is released. The reaction goes as follows:

$$_1^2D + _1^2D \rightarrow _2^3He + _0^1n + 3,25 \text{ MeV}$$
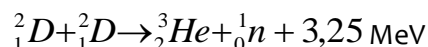
If one of the colliding deuterons attaches a neutron to the other, the result is a tritium nucleus and an energy of 4 MeV is released. The appearance of a reaction: $_1^2D + _1^2D \rightarrow _1^3T + _1^1p + 4$ MeV

For two nuclei to react, their nuclei must touch each other.
But the nuclei have a positive electric charge, so they repel each other. As a result, energy must be transferred to the nuclei to overcome the force of electrostatic repulsion. The gas in which the synthesis reaction is observed is always stored at a high temperature. Only this time of the velocity of the thermal motion of the nucleus will be enough to overcome the force of mutual repulsion of the nuclei.

For the practical use of a synthesis reaction, the energy expended in the reaction must be less than the energy produced by the reaction. Such a case is appropriate for very light nuclei, that is, the nuclei of hydrogen and helium. As we move to heavier nuclei, their positive electric charge also increases. Ultimately, it takes a lot of energy to overcome the forces of mutual repulsion.

How much energy is needed for the synthesis reaction to proceed? It has enough energy of about 20 keV.

The atomic energy at room temperature is 0.025 eV. The value of this energy increases with increasing temperature. For the energy of an atom to reach 20 keV, it must be heated to 200 million degrees. Only at this temperature is the synthesis reaction observed.

By studying the neutral, highly penetrating radiation produced by the bombardment of a beryllium target with polonium α-particles. Chadwick found that it produced recoil protons with a maximum energy of 5.7 MeV in hydrogen, and recoil ions with a maximum energy of 1.2 MeV in nitrogen. To show, applying the laws of conservation of energy and momentum, that this unknown radiation could not be a stream of gamma rays.

Decision

Considering the interaction of the gamma quantum with the nucleus, we conclude that the photoelectric effect could not have taken place, since the protons and nitrogen recoil ions had different energies. Solving the equations for the conservation of energy and momentum in the case of the Compton effect in a mass collision, we proceed

$$h\nu = E\left(\frac{1}{2} + \frac{c}{\vartheta}\right),$$

where hν is the energy of the incident quantum, E and ϑ are the energy and velocity of the recoil core; according to the recoil in hydrogen, it turns out that hν=55 MeV, and according to the recoil in nitrogen, hν=90 MeV, i.e. the answers contradict each other.

Difficulties in interpreting their experiences (see problem № 1). Chadwick eliminated it by assuming that the mentioned unknown radiation is a stream of neutrinos. Determine the mass of the neutron from these problems № 1, considering its collisions with the nuclei of hydrogen and nitrogen elastic.

Decision. The laws of conservation of energy and momentum in light collisions with hydrogen and nitrogen nuclei are expressed by the following equations:

$$\frac{m_n \vartheta_0^2}{2} = E_{\text{H}} + \frac{m_n \vartheta_1^2}{2}, \quad m_n \vartheta_0 = \sqrt{2 M_{\text{H}} E_{\text{H}}} - m_n \vartheta_1,$$

$$\frac{m_n \vartheta_0^2}{2} + E_N + \frac{m_n \vartheta_0^2}{2}, \quad m_n \vartheta_0 = \sqrt{2 M_N E_N} - m_n \vartheta_2,$$

where m_n is the mass of the neutron, M_n and M_N are the masses of the hydrogen and nitrogen nuclei, and E_n and E_N are their recoil energy, ϑ_1 and ϑ_2 are the neutron velocities after collision with the hydrogen and nitrogen nuclei.

Excluding from the equations ϑ_1, ϑ_2, and ϑ_0 we get:

$$\frac{m_n + M_{\text{H}}}{m_n + M_N} = \sqrt{\frac{M_{\text{H}} E_N}{M_N E_{\text{H}}}}.$$

Substituting the experimental values E_n and E_N, as well as M_n=1 and M_N=14, into the last ratio, we get m_n=0.81≈1.

Determine the difference in the binding energies of two mirror nuclei C_6^{13} and N_7^{13}. Calculate also the difference in the energy of the Coulomb repulsion between the protons between the protons of these nuclei. To explain why the difference in the binding energies of the two above-mentioned mirror nuclei is equal to the difference in the Coulomb repulsion energies between the protons in the nuclei. When calculating the radius of the core, take equal to R=1,5 10^{-13} A$^{1/3}$ sm.

Decision. Using the formulas for the mass, we write

$$M(C_6^{13}) = 6M(H^1) + 7m_n - \frac{\varepsilon_{\text{CB}}(C^{13})}{c^2}$$

$$M(N_7^{13}) = 7M(H^1) + 6m_n - \frac{\varepsilon_{\text{CB}}(N^{13})}{c^2}$$

Therefore,

$$M(N^{13}) - M(C^{13}) = M(H^1) - m_n + \frac{1}{c^2}[\varepsilon_{\text{CB}}(C^{13}) - \varepsilon_{\text{CB}}(N^{13})] \text{ и}$$

$$\Delta\varepsilon_{\text{CB}} = \varepsilon_{\text{CB}}(C^{13}) - \varepsilon_{\text{CB}}(N^{13}) = [M(N^{13}) - M(C^{13}) + m_n - M(H^1)]c^2 = 3.0 \; MeV$$

Based on the formula for the Coulomb repulsion energy of protons in a nucleus with charge Z_e, we can write

$$\varepsilon_{kul}(N^{13}) = \frac{3}{5}\frac{c^2}{R_N} 7 \cdot 6, \quad \varepsilon_{kul}(C^{13}) = \frac{3}{5}\frac{c^2}{R_c} 6 \cdot 5, .$$

Отсюда следует, что

$$\Delta\varepsilon_{kul} = \varepsilon_{kul}(N^{13}) - \varepsilon_{kul}(C^{13}) = \frac{36}{5}\frac{c^2}{R} = 2{,}8 \ MeV.$$

Since $R_c = R_N = 1{,}5 \cdot 10^{-2} A^{1/3} = 3{,}7 \cdot 10^{-13} \ sm.$

The fact that $\Delta\varepsilon_c \approx \Delta\varepsilon$ is explained by the approximate equality of the nuclear forces between the nucleons.

Isotope Be_4^7 as a result, the K-capture turns into Li_3^7, being in the main state. Determine the recoil energy of the latter, if the reaction energy Q is 0.87 MeV, and the rest mass of the neutrino is zero.

Decision. Let m be the mass of the lithium atom and p be the momentum of the recoil nucleus (it is also equal to the momentum of the neutron). We have $\frac{p^2}{2m} + pc = Q$. Assuming $\frac{p}{\sqrt{2m}} = x$, we have the following equation:

$$x^2 + \sqrt{2mc^2} \cdot x - Q = 0,$$

Where from

$$x = -\frac{1}{2}\sqrt{2mc^2} + \sqrt{\frac{1}{4} \cdot 2 \cdot mc^2 + Q}.$$

Given that $x^2 - E$, where E- the desired energy of the recoil core, we have $E = mc^2 \left[1 + \frac{Q}{mc^2} - \sqrt{1 + \frac{2Q}{mc^2}}\right]$ and, decomposing the root into a series, we get

$$E \approx \frac{1}{2}\frac{Q^2}{mc^2} = 58 \ MeV. \quad \text{Answer: } E \approx \frac{1}{2}\frac{Q^2}{mc^2} = 58 \ MeV$$

REFERENCES

1. Grigorov N. D., Kondratieva M. A., Rapoport I. D. Practicum on nuclear physics, vyt. 2. Cosmic rays. - M.: "Fizmatgiz", 1963.

2. Estulin I. V., Practicum on nuclear physics, vyt.1. Radioactive radiation. - M.: "Fizmatgiz", 1963.

3. Skachkov S. V., Konstantinov L. V., Strogonova R. P., Yurova L. N., Toporkova E. P. Collection of problems in nuclear physics. - M.:" Fizmatgiz", 1963.

4. Boymirov Sherzod., Ashirov Shamshiddin., Elmurotov Rustam., Davlatov Utkir., Mamatov Abduraim., Urozbokov Alijon. Principles Of Selecting Materials For Problem Based Training In The Section Electrodynamics Physics // Solid State Technology. ISSN 0038-11IX Volume: 63 Issue: 4, 2020.

5. Ashirov Shamshiddin, Mamatov Abdurayim, Boymirov Sherzod, Sattarkulov Komil & Daminov Rahim. Development of problem technology of teaching in physics // European Journal of Research and Reflection in Educational Sciences. ISSN 2056-5852 Vol.7No. 12, 2019.

6. Yusuf Makhmudov., Sherzod Boymirov. Educational and creative activity of the student and technology of its management in problem teaching of physics // European Journal of Research and Reflection in Educational Sciences. ISSN 2056-5852. Vol.8 No. 2, 2020.