NEW ENERGY TIMES ANALYSIS

University of Manchester "Centenary of Transmutation" One-Day Meeting
Saturday, June 8, 2019
Campbell Discussion Analysis — by Steven B. Krivit

[Link to News Story and Video Clips]
[Link to Partial Meeting Transcript]

This analysis contains a summary and, in some cases, direct quotes from the discussion that took place after John Campbell's presentation at the "Centenary of Transmutation" meeting.

Discussion #1
This is an excerpt from a comment by an audience member who spoke about Rutherford's statements about the recoil energy of the swift nitrogen nucleus:

> Now, he's not actually saying that the anomalous nitrogen is oxygen, but it appears to me that he has identified pretty accurately that the energy of the recoil atom is the same as oxygen —

Campbell responded but did not address the audience member's question about a recoil atom. Campbell said that Rutherford "never claimed it was oxygen." For this reason, Campbell did not appear to understand the person's question. In the context of the audience member's question, Rutherford indeed was talking about oxygen. I will explain the context in the moment. The audience member was not satisfied and continued to argue with Campbell that something Rutherford said in his papers indicated oxygen as a product of the reaction. The audience member agreed with Campbell that Rutherford never explicitly claimed oxygen as a product but persisted in speculating an alternative conclusion that Rutherford might have been considering:

> No, he never claimed that, but in that section in Part IV, it's almost as if he's putting out an alternative to the disintegration. He's saying that the recoil atom, the swift nitrogen, has the energy of oxygen.

The answer to the audience member's question is most clearly understood by looking at the first of Rutherford four papers in this series. In these experiments, Rutherford used a variety of gases to be examined in the containing vessel; air, hydrogen, nitrogen — and oxygen. Initially, Rutherford was examining the kinetics of alpha bombardment in the presence of each of these gases. The energetic alpha particle, on impact with each gas in the vessel, set the nuclei of hydrogen, nitrogen, and oxygen, respectively, into motion. Rutherford identified these faster atoms as swift hydrogen, nitrogen or oxygen atoms, respectively. Here are some excerpts from his papers that illustrate the concept:

> On the nucleus theory of atomic structure, it is to be anticipated that the nuclei of light atoms should be set in swift motion by intimate collisions with alpha particles. From consideration of impact, it can be simply shown that as a result of a head-on collision, and atom of hydrogen should acquire a velocity 1.6 times that of the alpha particle before impact. (Rutherford, Collisions, p. 537, ¶ 1)

> In a previous paper (III) we have seen that the number of swift atoms of nitrogen or oxygen produced per unit path by collision with alpha particles is about the same as the corresponding number of H atoms in hydrogen. (Rutherford, Collisions IV, p. 584, ¶ 4)

> We have drawn attention in Paper III to the rather surprising observation that the range of the nitrogen atoms in air is about the same as the oxygen atoms. (Rutherford, Collisions IV, p. 586, ¶ 1)

In his Collisions papers, whenever Rutherford speaks about a "recoil atom," he is talking about atoms in each of the examined gases that are set into swift motion by collisions with alpha particles. He is never speaking about a residual atom that would result from a transmutation.

When Rutherford mentions oxygen in his papers, he is mentioning it only in the context — using chemistry terms — of a reactant, not as a product. Using physics terminology, he mentions oxygen as only a target, not a residual atom.

> In the first place, we have seen that the passage of alpha particles through nitrogen and oxygen gives rise to numerous bright scintillations which have a range of about 9 cm. in air. These scintillations have about the range to be expected if they are due to swift N or O atoms ... (Rutherford, Collisions IV, p. 581, ¶ 3)

Above, Rutherford is talking about the number of swift (accelerated) atoms of nitrogen or oxygen, when such atoms are impacted by the energetic alpha particle. Rutherford is talking only about kinetics of the reactants that he knows are in the system: either nitrogen or oxygen. He is comparing only the quantity and range of swift nitrogen atoms when the vessel is filled with nitrogen gas, and swift oxygen atoms when the vessel is filled with oxygen gas. It wouldn't be for another six years before Rutherford understood, thanks to Blackett's experiments, that oxygen is produced in experiments where the vessel is filled with nitrogen gas.

Discussion #2

Next, an audience member initiated a discussion about Rutherford's interpretation of the fate of the impinging alpha particle during his 1917-1917 experiments. When Rutherford published his papers in 1919, his interpretation about the alpha particle was wrong. However, Campbell accurately stated to the audience member what Rutherford had written.

"He said [that] the surprising thing is that the alpha particle stayed whole, it wasn't broken up," Campbell said.

Rutherford stated this most clearly in this paragraph:

> Taking into account the intense forces brought into play in such collisions, it would not be surprising if the helium nucleus were to break up. No evidence of such a disintegration, however, has been observed, indicating that the helium nucleus must be a very stable structure. (Collisions I, p. 561, ¶ 2)

The same audience member asked Campbell whether Rutherford "either wrote or decided that the alpha particle was actually being incorporated into the nitrogen." Campbell gave a long, rambling response but did not answer the question. The answer is, no, Rutherford did not discuss the alpha particle being incorporated into the nitrogen until two months after Blackett's paper published:

> Since the proof that protons can be expelled from the nuclei of many light elements, the fate of the bombarding alpha particle after the disintegration has been a matter of conjecture. To throw light on this question, Blackett has recently photographed the tracks of more than 400,000 alpha particles in nitrogen. ... In these photographs, the fine track of the proton was clearly visible, and also that of the recoiling nucleus, but in no case was there any sign of a third branch due to the escaping alpha particle. He concluded that the alpha particle was captured in a collision which led to the ejection of a proton. ... These experiments suggest ... that the alpha particle is captured by the nucleus. If no electron is expelled, the resulting nucleus should have a mass 14 + 4 - 1 = 17, and a nuclear charge 7 + 2 - 1 = 8 — that is, it should be an isotope of oxygen. It thus appears that the nucleus may increase rather than diminish in mass as the result of collisions in which the proton is expelled. (Rutherford, Ernest (1925) "Studies of Atomic Nuclei," in Proceedings of the Royal Institution Library of Science," **9**, 75, ¶ 4)

The audience member asked Campbell about oxygen as the transmutation product of nitrogen (The sentence below represents our best-effort transcription from the video.):

> Did [Rutherford] ever consider, at any time prior to Blackett's experiment, that oxygen could be [a product of the] reaction? Did he wait until Blackett's experiment before he came up with this idea?

Campbell answered mostly accurately and explained that it was Blackett who identified oxygen as the transmutation product.

"No, [Rutherford] never made any claim that oxygen was being produced. All he'd done was produce hydrogen," Campbell said.

In fact, Rutherford claimed that he had produced the subatomic particle proton, not the element hydrogen. The term proton did not exist in 1919, but Rutherford's statement above about the production of "corresponding number of H atoms in hydrogen" makes clear that he understood the distinction between a particle and an atom.

Discussion #3

The next audience member asked Campbell about the residual nuclei that resulted from the transmutation of nitrogen:

> The obvious thing — what he says in this paper, which I just happen to have it in front of me — is that the hydrogen atom which is liberated formed a constituent part of the nitrogen nucleus. So you could say he imagined the alpha particle chipped a proton. But that, of course, would have made carbon. Did he ever speculate that he made carbon?

Campbell responded to the audience member, "Not that I'm aware of."

The person who asked this question understood that Rutherford believed that the alpha particle remained intact and separate from the target nitrogen nucleus after bombardment. This person therefore recognized that Rutherford would have expected that the mass of the nitrogen target would have decreased with the emission of a proton. In fact, Rutherford did speculate in his Bakerian lecture on June 3, 1920, that he made carbon:

> The expulsion of a mass 3 carrying two charges from nitrogen, probably quite independent of the release of the H atom, lowers the nuclear charge by 2 and the mass by 3. The residual atom should thus be an isotope of boron of nuclear charge 5 and mass 11. If an electron escapes as well, there remains an isotope of carbon of mass 11.

Discussion #4
An audience member discussed a quote from Rutherford in which he stated his research was far more important than the war.

Discussion #5
This person appears to be the same audience member who initiated Discussion #1. The audience member again stated his perception about Rutherford that "it's almost as if he's putting out an alternative to the disintegration idea."

The audience member asserted that the concept of disintegration continued over into Blackett's 1925 paper. Campbell disagreed and said no, it was all over by 1920. Campbell then started talking about neutrons.

Discussion #6
This audience member began speaking about the fact that the alpha particle was integrated into the nitrogen nucleus and that the result was Oxygen-17. Campbell interrupted with his concurrence and said, "Yes."

The audience member continued with his question and asked whether it would have been possible to detect the specific isotope of oxygen by using a magnetic field detector. Campbell explained that the flux of the nuclei in these experiments was far too low for magnetic detection field detection.

Discussion #7
The final set of discussions was about accelerators.