Rutherford-the father of nuclear physics

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"Rutherford, Simple Genius"
by David Wilson, MIT Press Cambridge, Massachusetts. Details are given below

Rutherford was born on August 30, 1871, in a remote country area near the city of Nelson in southern New Zealand. His father was a Scottish immigrant who at the age of five had emigrated with Rutherford's grandfather. Rutherford's father owned a flax farm in New Zealand and has been described as a sort of "bush engineer' a hardworking and inventive man who used to spend most of his time away from home in connection with work. Rutherford's mother an English immigrant to whom he was deeply attached, was a very hardworking school teac-

Comment [A1]: Para 1 of the article published by Dr. Mujahid Kamran

The above paragraph is verbatim/paraphrased from the following paragraphs of the book.

Many of the settlers were Scottish, especially those who went to the South Island of New Zealand, and perhaps it was their in-

It was into this isolated, sober, almost crime-free society that Ernest Rutherford was born. Among his few known ancestors

Yet this Ernest Rutherford, born on August 30th, 1871, in a remote country area thirteen miles south of the pioneering town of Nelson in the South Island of New Zealand, the fourth child in a family of twelve, became, quite simply, the greatest experimental scientist of his age, "the father of nuclear energy". The ashes of

Both Rutherford's parents came to New Zealand as children with their parents in the early waves of organised settlers. His grandfather, George Rutherford, a wheelwright from Dundee who worked for a Perth firm of coachbuilders, came to the Nelson colony in 1843. He had been specifically recruited by Captain

His father is a more shadowy figure, at least in personal terms. He was plainly honest and upright, a pioneering "bush engineer", hardworking and inventive, able to turn his hand to most tasks of practical necessity in a new country, and perfectly capable of adapting existing machinery to the new tasks of a strange environ-

logging, milling and flax cultivation. But he was often away from the family home for most of the working week, or even for longer spells, and the roles of disciplinarian and family treasurer both fell

There is no doubt that his mother was the dominating influence of Rutherford's early life. She set the tone of the home, and indeed it was reported just before she died at the age of ninety-two in 1935 that she "still ruled" the house. Since she was a schoolmistress it is hardly surprising that she valued learning and that the home was

Comment [A2]: This is from the pages 13,14,17,24, and 23 of the David's book

her. Rutherford was the fourth of her twelve children. The family was not very well off fincially and Rutherford's higher education was supported entirely by scholarships.

Comment [A3]: This is page 1, col. 3 and Para 1 of the article of Dr. Mujahid Kamran. This is taken from the paragraph given below.

Nelson in the South Island of New Zealand, the fourth child in a family of twelve, became, quite simply, the greatest experimental

In social and economic terms the childhood of Ernest Rutherford occurred in a period of ever-increasing depression, the worst depression New Zealand has ever known. Nelson, the province in

Comment [A4]: Page 14, 24 of the book

Rutherford is known to have distinguished himself in academic activities at school,

college and university. On account of his school performance, he was regarded as a kind of local pride. In Nov-

Comment [A5]: Para 2 & 1, Col. 3&4 of Dr. Mujahid Kamran's article which is copied from the text given below of the book

population, and the opportunity for further education came almost / solely through the offer of scholarships, few in number, to Nelson

He won his scholarship with the previously unattained to 580 marks out of a possible 600, including a maximum of 200 n

The scholarships to Nelson College carried free tuition and

results. It is characteristic of the man he was to become that he called important people "big pots" for many years – throughout his life his admirers noted a "boyish enthusiasm" – while the few who

Comment [A6]: Page 31, 32 of the book

ember 1893, he finished university, obtaining the only first class in mathematics and physics in the university. A comparison with other con-

Comment [A7]: Para 2, col. 3 of MK article. This is paraphrased from the following text of book

ive, though it must be remembered this was a provincial colonial college with only eighty pupils. He won prizes in every one of his three years there, prizes in English, French, history and Latin as well as in his strongest subject, maths, the most valuable being the Stafford and Simmons scholarships, each worth £100, which made a considerable difference at a time when the family fortunes over

languages "a very careful scholar". No hint of genius or brilliance or imagination; that sort of note only comes in the report on maths: "Very quick, a very promising mathematician". The cricketing W. J. Ford recorded of him "Top in every class and his conduct

scholarship, pointed out that another boy (C. E. Broad) was "slightly superior" in Greek. The mathematical scholarship, however, he awarded to Frederick Neve: "In Trigonometry and Arithmetic he was somewhat surpassed by Rutherford but this was more than counterbalanced by the other subjects." The same C. E. Broad also outclassed Rutherford the following year when the headmaster himself did the examining and gave Broad the

tions in experimental science and maths. In 1893 he was awarded his B.A. degree and won a senior scholarship in maths. In 1894 he achieved his M.A. with the rare distinction of a "double first" – First Class Honours in Physical Sciences and Mathematics.

Comment [A8]: Above text is from 33,40 of the book

university years, however, reveals that he was by no means the best among them. Some did better than him at various stages, so that there was no real hint of the shape of things to come. Unlike many other scientists of his stature, he was not considered a young prodigy.

Comment [A9]: Para 1, col. 1 of Dr. Mujahid Kamran's article is taken from the source given below poraries at Nelson, for plainly they were not completely outclassed by him, as we have been led to believe. They were mostly honour-

Rutherford was, then, the best scholar but by no means outstanding in a small collection of worthy, but not particularly

The young man took the next step in his career by winning his university scholarship to Canterbury College at Christchurch.

Comment [A10]: Page 38 of the book

In 1894, Rutherford applied for the award of a scholarship for higher studies (known as the Royal Commission for the Exhibition of 1851 Scholarship) on the basis of the above-mentioned research. He was placed second on the list, the first one being a chemistry graduate named Maclaurin. For personal reasons Maclaurin was unable to take up the scholarship and so it came to Rutherford. Thus was opened to him the way to the heights of achievement, fame and power.

It is very interesting to note that MK wrote in this paragraph that Rutherford applied for scholarship on the basis of above mentioned research but there is no such thing he wrote in this article. How ever, this "above mentioned research" is given in the book where he took this stuff. Proof with given the text from book is below.

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The radio work was not only the most dramatic of his experiments, it was also a major part of his claim for the 1851 Exhibition Scholarship which was to be his passport to Europe and the centre of the scientific stage. This scholarship was derived from a fund, administered by Commissioners, from the profits of the International Exhibition of 1851 in London. It was remarkably easy to

candidate, and in late 1894 Rutherford decided to apply. He failed. The award went instead to the chemist, J. C. Maclaurin of Auckland, who had obtained a First Class Honours in chemistry in 1892, had been working a year longer than Rutherford at research,

Zealand, and to Rutherford, they were informed that J. C. Maclaurin had withdrawn his candidature for family reasons. In fact he had decided to get married and to stay in New Zealand – for the scholarship was only worth £150 a year and even in 1895 it was

Comment [A12]: Page 59, 60 &61 of the book

But who could have known them? It is said that Rutherford was at home digging potatoes when his mother told him that the letter intimating the award of the scholarship had arrived. Rutherford threw the shovel away and exclaimed, "This is the last potato I will ever dig". And he, it appears, kept his words.

Comment [A13]: Para 2, col. 5 of Dr. Mujahid Kamran's article is verbatim copy of the text from book page no.62 as shown below

It is not known when Rutherford received the news – except in so far as he was in the garden at Pungarehu digging potatoes at the time when his mother brought out the telegram. He flung down his spade and declared, "That's the last potato I'll dig." And it seems that he lived up to his word, for he never went in for gardening,

Comment [A14]: Test from Page 162 of the book

Rutherford elected to go to Cambridge and in Cambridge he chose to work at Trinity College. This choice appears to have been made partly becaus of the presence of J.J. Thomson who, in 1897, was to make a monumental discovery – that of the electron. At that time (1894-95) his fame rested on his work in electromagnetic theory and in 1893 he had written a treatise on *Recent Researches in Electricity and Magnetism*. Rutherford was familiar with this work, but what also surprises one is the fact that the book appears to have arrived in New Zealand by 1894. In autumn, 1895, Rutherford

Comment [A15]: Col. 5, Para 3 of Dr. Mujahid Kamran's article is copied from page 63, 64 of the book

Although he did go to Cambridge University, to Trinity College, to the Cavendish Laboratory, which makes such a satisfactory

Whether the Professor did study the youngster's paper we do not know. If it was Rutherford's first paper that was sent he would have found that his book, *Recent Researches in Electricity and Magnetism*, published in 1893, had provided some of the inspiration. But he would also have found "the experimental method pursued here is entirely different from Professor J. J. Thomson's, but the final results obtained are the same. The results are also quantitative

Comment [A16]: This is the text from page 63, 64 of the book

arrived in Cambridge.

During his first year at Cambridge, Rutherford continued to work on the transmission and reception of electromagnetic waves. He gradually extended the range of his transmission to about half a mile across houses and streets and, as Feather has put it, "held the record for the time for long-distance transmission". Further progress to utilise this on a Commercial scale by extending the range of transmission required a lot of money and so he seems to have dropped the project. Later, Marconi, with much greater resources at his disposal, succeeded in sending and receiving signals across very long distances.

Comment [A17]: Page 2, column #1, Para #1 of Dr. Mujahid Kamran article is taken from the following text of the book, pages 58, 87, 88

Ernest Rutherford's detector of electromagnetic (radio) waves which he brought with him from New Zealand, plainly fitted perfectly into the Cavendish tradition and scheme of things.

This he wrote in 1910, and J.J. Thomson frequently claimed that Rutherford had held the world record for distance of transmission and reception of radio-waves during his first few months' work at the Cavendish.

This was the device and the experiment Rutherford's contemporaries most clearly remembered; it was his demonstration of the detection of radio-waves many years ahead of Marconi and the other pioneers of "wireless" that stuck most clearly in their minds

Comment [A18]: The text from page 58, 87-88 of the book

with his detector already in existence. This impression grows even

sense was slow in coming. Plainly Rutherford, and J.J. too, saw it first as a detector of a scientific phenomenon predicted by Clerk Maxwell. The first public demonstration was at a meeting of the

But in that letter of January 15th, 1896, the young man confided, "My next experiment will be, I think, from the tower of the Cavendish to St John's tower nearly half a mile away." We do not know whether this was performed successfully, for the next epi-

In November 1895 and February 1896, two of the most famous discoveries in the history of physics were made. In November 1895, X-rays were discovered by Rontgen in Germany; and in February 1896, Becquerel in France discovered the phenomenon of radioactivity. X-rays aroused so much interest that for almost a year Becquerel's discovery lay in the background. During 1896 and part of 1897, Rutherford, too, worked on X-rays under Thomson. Thomson had found that when X-rays were passed through a substance it acquired the property of allowing electricity to pass through it. Thomson and Rutherford together then discovered that the passage of electric current through a previously exposed substance destroyed the property of conductivity it acquired through exposure to X-rays. However, sometime in 1897, Rutherford appears to have begun working on radioactivity and this was to lead him to a Nobel Prize in a little over ten years. Radioactivity became his field, his sport, his hunting ground.

Comment [A19]: Para #2, Coulmn#1, page 2 of Dr. Mujahid Kamran article is paraphrased from the text given next page and scientific mind alike by the discovery of the penetrating X-rays by Röntgen in 1895. Almost every physical laboratory in the world started some work on them." J. J. Thomson was certainly one of

also used for medical emergencies, but the main interest in the laboratory was in the power of X-rays to make a gas at normal pressure into a conductor of electricity. What was a major development in scientific knowledge, the revelation of something entirely new in nature, was immediately turned into a tool by the Cavendish. J.J. was soon able to confirm Röntgen's statement that X-rays turned a gas into a conductor, and furthermore he obtained strong evidence that both positive and negative "ions" were formed to enable this to happen, and this in turn strengthened the belief that cathode rays were streams of negatively charged particles.

It was to pursue this line of research that "J. J. Thomson was joined by Rutherford who had just completed his experiments

of the process in the gas that made it act as a conductor under the influence of the rays.

The fact that Rutherford had entered this field by the middle of 1897 is again emphasised by his citations of Becquerel's papers – he

significant feature of the paper is the discovery and naming of alpha- and beta-rays as two distinct types of radiation, the alpha-radiation very easily absorbed and the beta-radiation much more penetrating. The paper however begins with a clear statement of the advantages of Rutherford's electrical method of measurement:

Present at the meeting was Henri Becquerel, one of France's most distinguished scientists; he was Professor of Physics at the Museum

meeting of the Académie at which X-rays were reported, Becquerel seems to have drawn an association between the production of the rays and the fact that the glass of the discharge tube fluoresced. He set out to find if he could produce X-rays by purely optical means using the then mysterious techniques of fluorescence and phosphorescence.

The story of his discovery of the radiation from uranium is well known; he was trying to see whether various salts known to possess

Comment [A20]: Page 107, 110, 111, 124 and 125 of the book

Radioactivity refers to continuous emission, from certain substances, of invisible rays. While studying the effects of rays from radioactive substances on the conductivity of materials, Rutherford noticed that these were very similar to the effects produced by X-rays. But there were some subtle differences. It is a testimony to Rutherford's intelligence and clear-headedness that he did not consider the two kinds of rays identical. Instead, he concluded, and this was a major discovery, that radioactive emissions were complex and contained two distinct types of radiations or rays. He named these alpha and beta rays. This terminology soon became a textbook thing and is still used. The basis of this distinction, at that time, was the range through which these rays could penetrate. Alpha rays could only penetrate a short distance, whereas beta rays could penetrate through much larger distances in matter.

Comment [A21]: Pag22 2, Col. 2, Para 1 of MK is taken from the page 126 of the book as shown below

Rutherford showed that the radiation from uranium, though complex, consists of two entirely different types – and he achieved this with a convincing simplicity. He simply covered his uranium with thin foils of aluminium, gradually increasing the number of foils. For the first three layers of foil the radiation escaping from the

"These experiments show that the uranium radiation is complex and that there are present at least two distinct types of radiation – one that is very readily absorbed, which will be termed for convenience the alpha-radiation, and the other of more penetrative character which will be termed the beta-radiation."

world. It is an extraordinary tribute to Rutherford's imagination, and his sheer power of measuring things previously unmeasured, that he was able to distinguish between them in his very first investigation of the subject.

Comment [A22]: Page 126 of the book

It so happened that in 1898 Rutherford applied for a post of Professor at the McGill University in Montreal, Canada. He was less than 27 at that time. J.J. Thomson gave him a glowing recommendation. Rutherford himself had also acquired some reputation in scientific circles by that time. He was selected for the post and in September 1898 arrived at McGill. Thus at the age of 27 Rutherford became a professor. By the time he had two important contributions to his credit — his detection of electromagnetic waves and his discovery that radioactive emanations from uranium contained two different kinds of rays. The elucidation of their

Comment [A23]: Page 2, Col. 2, Para 2 of the article is copied from pages 169 and 130 of the book

Whether J.J. exerted himself over Rutherford's Fellowship is not known but he certainly wrote him a glowing testimonial: "I have never had a student with more enthusiasm or ability for original research than Mr Rutherford, and I am sure that if elected he would establish a distinguished school of physics at Montreal . . . I should consider any institution fortunate that secured the services of Mr Rutherford." In his own letter of application the

At the age of twenty-seven, in 1898, Ernest Rutherford became a Professor – the Second MacDonald Professor of Physics at the University of McGill in Montreal, Canada. His salary was to be

search. He had found his field, the radiations from uranium and thorium, the subject which we now call radioactivity, and he rushed into it, scarcely pausing for a week or two over such matters as professorships. In 1898 and 1899 there was really only one

thing that interested him – his research. He was involved in one of his most profound, almost manic bursts of work, and, though he did not know it at the time, he was about to revolutionise physics and chemistry, about to cause "one of the biggest revolutions in scientific thought", according to the chemist Lord Fleck.

Comment [A24]: Page 169 and 130 from book

B fore Rutherford left for Can-da the Curies had announced the discovery of two new chemical elements – one of these was named polonium and the other radium. Both were radioactive. These discoveries had a great impact on Rutherford. When he arrived in Canada, he set to work on studies of radioactivity and also verified for himself the results of the Curie couple. During 20 months of hectic work Rutherford made a new discovery. He found that thorium compounds under certain conditions possessed the property of producing temporary radioactivity in all solid substances in their neighbourhood. He also found that the intensity of the excited radiation was not constant but gradually diminished. These

Comment [A25]: Page 2, Col. 3, Para 1 of MK article is paraphrased from the page 142 of the book.

Rendues carried reports by the Curies and Becquerel that they too had found "excited radioactivity" caused by radium and polonium. Rutherford points out that the Curies' radioactive bodies are between ten and fifty thousand times as active as his own uranium sources, and the phenomenon seems to be similar to that produced by his thorium. And then he criticises his rivals – "but there are not

Comment [A26]: Page 142 of book

The same year he left for New Zealand for a holiday, a family reunion, and above all to get married to a college friend of his name Mary Newton.

Comment [A27]: Page 2, Col. 3 Para 1 line 32-36 of MK article is taken from the following paragraph of the book

says quite clearly that it was received on June 15th, 1900 – and by that time Rutherford was finally in New Zealand to marry Mary Newton. The paper is important for several reasons. It is Ruther-

Comment [A28]: Page 131 of the book

By that time Rutherford had most probably become aware of his innate powers. The drive to lead had always been strong in him. That was the reason he chose to work in Canada rather than New Zealand although the salary in his own country would have been higher. "In Montreal the physical laboratory is the best of its kind in the world", he had written to his mother explaining his decision. However, he felt that to be in the forefront, he should be closer

Comment [A29]: Page 2, Col. 3 Para 3 of MK article

One of the chief reasons for his wanting the post at McGill was that the research facilities in the university's new MacDonald Physics Building (always referred to locally as MPB) were possibly the best in the world. And one of the chief reasons for accepting the

he was, Rutherford learnt the hard lesson of the sheer distance of Canada from the centres of scientific activity in Europe where researchers could get their results printed, and claim priority of discovery, within a few days of submitting their work.

Comment [A30]: The above paragraph of the Dr. Mujahid Kamran's article is taken from Page 130, 142 of the book

to Europe where he could communicate physics more quickly and discuss it more often and more easily. In 1902 he wrote to his mother, "I have to keep going as there are always people on my track. I have to publish my present work as rapidly as possible in order to keep in the race. The best sprinters in this road are Becquerel and Curies in Paris,..." Rutherford knew that he had attained the same class as Becquerel and Curies and that he could lead them if he were in Europe. He applied for a professorship in Edinburgh but was not selected.

Comment [A31]: Page 2, Col. 4 Para 1 of the article is copied from page 147 of the book and it is shown on next page had already established himself and the MacDonald Laboratory as one of the very small number of world centres of radioactivity research, but he felt cut off, too far from the focus of intellectual activity, hampered by the slowness of a publication system which had to cross and recross three thousand miles of ocean. He plainly felt what he wrote to his mother a year later in one of his best known letters: "I have to keep going as there are always people on my track. I have to publish my present work as rapidly as possible in order to keep in the race. The best sprinters in this road of investigation are Becquerel and the Curies in Paris who have done a great deal of very important work in the subject of radioactive bodies during the last few years."

So in March 1901, with the birth of his first child due any day, he wrote to J.J. about the possibility of getting the post of Professor of Physics at Edinburgh University, just vacated by P. G. Tait. On March 26th he wrote again:

ful in this case." (Rutherford took Thomson's advice to apply for the job as a gesture, but the electors followed J.J.'s predictions, and he did not get the post.) But the basic problem was acknowledged: "I quite appreciate the isolation of scientific workers in the

Comment [A32]: Page 147of the book

His failure to get a position at Edinburgh was perhaps fortunate. For, in 1900 a chemist named Soddy arrived at McGill and decided to work with Rutherford. They found that certain anomalies in the radioactive behaviour of thorium could be explained if one assumed that "the major part of radioactivity of thorium is due to a non-thorium type of matter, thorium-X, possessing distinct chemical properties which is temporarily radioactive". It was thorium-X which gave rise to the temporary excited radioactivity noted earlier by Rutherford. After a good deal of effort they found that a new inert gas was also present among the products. This gas they isolated and named randon since thorium-X was found to be a short-lived form of radium. Now the situation was that one had the property of radioactivity and of producing new kinds of matter. Thorium was a solid and randon a gas. How were these connected? In Rutherford

Comment [A33]: Page 3, Col.4, Para 2 of Mujahid Kamran's article is paraphrased from the text of the book given in next page.

probably neither of them accepted the other's point of view for years, yet for eighteen months they joined in one of the most successful and significant scientific collaborations ever known.

Frederick Soddy was a brilliant young chemist, at this time twenty-three years old and six years Rutherford's junior. But it was

October 12th, 1901 was the day that the great Rutherford–Soddy partnership started work. The work is described as "Comparison of emanations from thorium oxide and thorium oxide heated",

excited by the radioactivity of the thorium. It seemed then that emanation must be a totally inert gas which would not react with anything or combine with anything, just like the recently discovered argon types of gas. Rutherford and Soddy became convinced of this – they have since been proved right and the emanation is now called thoron and is classed with radon and actinon, the emanations of radium and actinium, in the family of inert gases.

But at the time the implications of the discovery were, literally, frightening. Thorium was an element, normally a solid. Emanation was a gas, an argon type of gas, probably a new element. One element was turning into another. This was heresy. This was transmutation, the alchemist's dream. Soddy recalled how he was "standing there transfixed as though stunned by the colossal import of the thing" and how he blurted out, "Rutherford, this is transmutation: the thorium is disintegrating and transmuting itself into an argon gas." This was what was frightening; professional

some compounds more than in others). Soddy tried his methods of separating thorium from its compounds yet again, but the results were still confusing. And then they tested the "left-overs", the precipitates from which all the thorium had been removed. And they found that there was emanating power in these, though there was no thorium. Further, these thorium-free precipitates had the ordinary radioactivity of thorium. So there had been an "impurity" in the original thorium all along, it seemed, and they had discovered a thorium-X similar to uranium-X. However there was no suggestion as to what sort of material thorium-X might turn out to be, and there was no mention of transmutation in the first Rutherford–Soddy paper which was sent off just before Christmas 1901 and was printed in the *Transactions of the Chemical Society* in 1902.

Comment [A34]: Page 148,152 and 153 of the book

and Soddy had realised tha
thorium atoms were disinte
grating and giving off atoms o
new elements in the proces
(thorium gave thorium-)
which then gave rise to randon)

Comment [A35]: Page 3, Col. 1, Para 1 of the article is paraphrased from the following paragraph of the book

...value. Then when they came back in January there was
...shock – the deposits of thorium from which Soddy had
...ing to strip off the active thorium-X were if anything even
...ive than when they had left them, while the deposits
...ing the active thorium-X had almost completely lost their
The facts were getting even more uncomfortable, even
...transmutation. It looked very much as if thorium natur-
...duced its own radioactivity and produced something
...X), which was an entirely different chemical and was
...ve in its own right. This thorium-X then seemed to
...the gas emanation, which was radioactive, and the emana-
...it produced yet another chemical, probably a solid, which
...ted as "excited activity" and which was also radioactive.
...these different chemicals lost their activity with time,
...original thorium)

Comment [A36]: Page 154 of the book

This realisation, upon publi
cation, created a great stir in
scientific circles. This was in
July 1902. The disintegration
theory spread Rutherford's
name far and wide. Scientific
circles discussed this theory
and assessed its significance. As
one contemporary put it
"Here is a fact, if fact it be, of
prodigious importance. . .
Assuming the truth of this
strange string of laboratory
facts, we appear to be face to
face with a phenomenon quite
new in the history of the
world". From the scientific
point of view this revolu-
tionary idea had a conserva-
tive side. Rutherford had
pointed out that "the idea of
a chemical atom, in certain
cases spontaneously breaking
up with the evolution of
energy, is not of itself con-
trary to anything that is
known".

Comment [A37]: Page 3, Col. 1, Para 1 of Mujahid' Kamran's article is copied from text of the book as given in next page charged. These results confirmed a suspicion that had been steadily growing in the minds of both Rutherford and Soddy and provided concrete evidence for the final form of their "Theory of Radioactive Disintegration". They abandoned the idea that radioactivity was the dissipation of energy obtained by the daughter-product as it transmuted from the parent. Because the graphs of the change of

of the great new theory with all the supporting evidence. Rutherford and Soddy in the spring and early summer of 1902 completely rewrote the two papers they had sent to Sir William Crookes and

pounds appeared by heating. But still there was no change in the production of thorium-X. The two men were forced to conclude that the production of thorium-X was the result of a "sub-atomic chemical change".

wrath of scientific gods, "The idea of the chemical atom in certain cases spontaneously breaking up with evolution of energy is not of itself contrary to anything that is known of the properties of atoms,

However, it was in 1902 that Rutherford' and Soddy's results really began to flow into the literature of science. J.J. seems to have accepted their revolution with little difficulty. In May 1902 he acknowledged receipt of the latest papers on radioactivity, saying, "It seems to me that your explanation clears up a great deal of obscurity." 1903 was the peak year in this matter – the year in which the full disintegration theory was published. It was also the year in which Rutherford was elected Fellow of the Royal Society; and at the same time it was the year in which he first returned to

of friends asking for their presence and support. This lobbying turned out to be unnecessary, however. Larmor had welcomed the news that he was coming to England by writing to him, "You may be the lion of the season for the newspapers have become radio-active. I see that you are again monopolising the *Phil. Mag.*" Sir

Comment [A38]: Page 161,162,156,158,194 and 195 o book

After the publication of the disintegration theory, Rutherford made another outstanding contribution. This concerned the establishment of the nature of the alpha radiation. It was generally thought that these were electrically neutral waves somewhat similar to X-rays. Rutherford and Soddy were able to demonstrate, using a method similar to that used by J.J. Thomson for discovering the electron, that on the contrary these radiations were corpuscular in character and that the particles composing them carried positive electric charge.

They further established that these alpha particles were similar to helium atoms except that they seemed to have two electrons less. This was done by measuring the charge to mass ratio of the particles without measuring the mass and charge separately. Rutherford was also able to determine that alpha particles came out of disintegration atoms with

Comment [A39]: Page 3, Col. 2, Para 1 of Dr. Mujahid Kamran's article is taken from page 161 & 206 of the book

Then he applied the same sort of mathematics as J.J. had done with the cathode rays and he came up with some surprising results. The alpha-rays were streams of definite material particles and they were the size of whole atoms – certainly as big as hydrogen atoms and carrying either the same charge as the hydrogen atom or even twice as much. And finally, what surprised Rutherford most, although it was not relevant to the immediate investigation and was not pursued until later was that the alpha-particles were positively charged. These results confirmed a suspicion that had been steadily growing in the minds of both Rutherford and Soddy and provided concrete evidence for the final form of their "Theory of Radioactive Disintegration". They abandoned the idea that radioactivity was the dissipation of energy obtained by the daughter-product as it transmuted from the parent. Because the graphs of the change of radioactivity were so typical of those processes in which the rate of change is proportional to the amount of the changing substance that is present, they came to realise that the process of emitting

alpha-particle. Rutherford believed the alpha-particle was a helium atom, indeed he "knew" it was a helium atom as he wrote to Boltwood privately, but he could not prove this unambiguously and publicly, and he was not to achieve this goal until he was well settled into the next period of his life, the Manchester period. He returned to the type of experiment in the deflection of alpha-particles by electric and magnetic fields that he had used in clinching the disintegration theory. He tried to get better values for e/m, the ratio between the electrical charge and the mass of the alpha-particle. His results left three alternatives. The alpha could either be a molecule of hydrogen, that is two atoms of hydrogen linked together; or it could be one half of a helium atom carrying a single unit of charge; or it could be a helium molecule (one helium atom) carrying twice the charge of the hydrogen atom. This was the

Comment [A40]: Page 161, 208 0f the book

Rutherford, in collaboration with Prof. Barnes, was also able to interpret and clarify a surprising result obtained by Curie and a collaboration. They had found that radium atoms were continuously generating heat. This discovery at that time surprising, was shown by Rutherford to result from the energy lost by alpha particles in colliding with atoms of the surrounding medium. Rutherfofd and Barnes went on to show, by estimating the heat so generated, that atoms must be enormous reservoirs of energy. This was a very significant result. Rutherford even at McGill had surpassed Curies in interpreting results. His genius was now an established fact.

Comment [A41]: Page 3, Col.2 &3, Para 1,2 of the Mujahid Kamran's article is copied from the page 132 of the book

Several of Rutherford's biographers have implied that it was only when he worked with H. T. Barnes on the heating effects of radium in 1904 that he tapped this source of expertise, but it is clear from a careful reading of this paper, and the true dating of the work involved, as well as from photographs of apparatus preserved at

never allowed to escape. He concentrated on the alpha-rays that were emitted and showed that, although they were so very easily absorbed, and could be cut off by covering his radioactive sample with nothing more than sheets of thin paper, nevertheless they had

Nevertheless the work done here, overshadowed as it must be by the simultaneous start of the great series of investigations which led to the discovery of the laws and nature of radioactive disintegration, was absolutely essential as the quantitative basis of so much

quantitative parameters of the work he was going to do. He showed what order of magnitude the energies and velocities of the radioactive phenomena must have. Perhaps this was most important to his own mental picture of the world he was examining – it

Comment [A42]: Page 132 of the book

Rutherford left McGill in 1907. By that time he had made contributions of the highest order, some of them of historic significance. He was then 36 and was an established star on the horizon of physics

Comment [A43]: Page 3, Col. 3, Para 2 of article is taken from page 223 of the book

Rutherford simply hurled himself into life and science in England. He arrived in Manchester on May 24th, 1907. Within three weeks

Comment [A44]: Page 223 of the book

Rutherford's professorship at Manchester had been carefully arranged and much behind-the-scenes work was done. Arthur Schuster, himself a great physicist, deliberately relinquished his chair at the

Comment [A45]: Page 3, Col. 3, Para 3 of Dr. Mujahid Kamran's article is copied from page 217 of the book

he was necessary. The incumbent Professor of Physics at Manchester decided that he wanted Rutherford as his successor; he approached Rutherford personally and negotiated with him; he offered his own early retirement if, and only if, Rutherford could succeed him; when he had secured the university's formal agreement to his plan, he proceeded to give major financial aid to his successor by paying the salary of a new reader out of his own pocket. This cavalier benefactor was Sir Arthur Schuster, who was not only wealthy, but talented and cultured. He had learned his research techniques at the Cavendish at about the same time as J.J.

Comment [A46]: Text from the page 217 of the book