Outstanding Maria and radioactivity

The end of the 19th century is coming. It's not the successful time for Poland. Due to the partitions, it's divided between Austria, Prussia and Russia. Maria Sklodowska was born in Warsaw, which is located in the area of the Russian Empire, and in which the Russian language is officially spoken. The Polish culture is being killed off, and there are no Polish schools, since their existence is prohibited. Nevertheless, Maria is the best student in the class and at the age of 15, she finishes the secondary school, being awarded with the golden medal. And what is she going to do later? The majority of the girls of her age would think about marriage, but she is dreaming about further education – she would like to become a scientist… But is it possible in the family with 5 children, where only father, Wladyslaw, physics teacher, is alive (Maria's mother died when she was 11), and with their financial problems? Possibly not, that's why two sisters – Maria and Bronislawa (called also Bronia) started to give private lessons to the children from rich families. At that time, Maria comes up with the plan, which is supposed to make the dreams of two sisters come true. She is going to be a governess in the country and she is going to send half of her salary to Bronia. Thanks to that, her sister will be able to study medicine in Paris, and when she finally becomes a physician, she will pay for Maria's travel and her studies in Paris. We have to bear in mind that at this time women were not allowed to study at the universities in Polish ethnic areas. Did the dreams of the sisters come true? Let's find it out from our story…

In March, 1890, Maria received the invitation from her sister, Bronia, who was finishing her medical studies in Paris: "Come to Paris next year"… And suddenly Maria, who always had her opinion and she was always able to make a decision, was at that time, after 7 years of waiting for her chance, hesitating: "Should I really go to Paris? If yes, what should I study there?... Am I sure it should be physics?! When I have been in Warsaw recently, I spent much time in the laboratory of the Museum of Industry and Agriculture, in which my cousin, a physicist and a chemist, Jozef Boguski, is a director. I loved conducting the scientific experiments with the use of the scientific instruments, trying to get the proper results."

Q1. If you were Maria, would you decide to study abroad? Why?
Q2. Give the proposition how would you try to get the means for the studies abroad?

It was November, 1891. Maria finally had made a decision, and she started her travel to Paris in the third class train, leaving from the Warsaw-Vienna railway station, which was located at the center of Warsaw. She took everything that might be useful to her - one could find books, pillow, bedclothes and even the foldout stool in her luggage. At the beginning, she lived with her sister and her husband, Kazimierz Dluski, also a physician, in Paris. Maria was the first woman to pass the entrance exam in physics and chemistry and she enrolled to the faculty of the exact sciences at the Sorbonne, calling herself 'Marie'. However, the flat of Bronia and Kazimierz was not a proper place for Marie to study French, maths, chemistry and physics intensely. There were always some people at home, who were laughing, speaking loudly in Polish, while Marie did not have time for relax and chitchats… That's why she rented a simple flat - at the attic in the students' area in the Latin Quarter in Paris. Very hardworking, persistent and ambitious Marie was doing her best there, working on the development of her knowledge and skills. She spent many hours in the library. She had to pay for her lessons (mainly French lessons), which was difficult, since she did not have much money. Sometimes she studied so hard, that she forgot even about eating. But she was so fascinated with science that all that did not matter for her.

Q3. Would you be so persistent to achieve the goals you once had created? If so, please specify the motivating factors.

By studying at the Sorbonne, Marie had a chance to attend the lectures of the famous scientists of that time. The result of her hard work was that as one of only few women in the history of the Sorbonne, she was given the diploma at physics *magna cum laude* in 1893, and a year later she terminated her maths studies and received another diploma.

Q4. What do you think, why Maria decided to study additionally maths? Explain your opinion.

Marie reported (she had written it down in her diary): "at the same year, which was 1894, my former physics lecturer at the Sorbonne, professor Gabriel Lippmann, invited me and proposed an annual grant of 600 francs for conducting scientific studies concerning the *magnetic characteristics of steel*, which meant working as a laboratory assistant in his workshops".

There was only one problem. Lippmann's laboratory was overcrowded, and Marie needed more space. By coincidence, at that time professor Jozef Kowalski arrived to Paris with his wife, whom Marie had known from Poland. He told her: "I know one scientist here, maybe he knows something about any laboratory to rent? I will invite him, please, visit us tomorrow for a cup of tea." And that is how Marie met a 35-year old lecturer from the School of Industrial Physics and Chemistry, Pierre Curie. It was in the laboratories of that school - where Pierre found some space for Marie to conduct her studies. Soon it turned out that these two young scientists had much in common: similar upbringing and values taught at the family home, love to nature and countryside, not many needs concerning the everyday life and an enormous passion to conduct scientific studies. Pierre Curie had already been a physicist, famous in the scientific environment in Paris. In the year 1895 Marie married Pierre.

The end of the 19th century was rich in numerous discoveries which were very important to the development of science. In 1895, Wilhelm Conrad Roentgen discovered X-rays. In 1896, Alfred Nobel died, the discoverer of dynamite and a famous industrialist. In his testimony he dedicated all his money for the prizes for the people who would create better world due to their merits in the fields of science, literature and world peace. At the same time, Antoine Henri Becquerel was the first to observe by chance a new phenomenon while conducting the research on X-rays. But, as it happens very often with science, he ignored this observation – he thought that although the film was not exposed to the sunlight, it has blackened because of the X-rays supposedly emitted by the probe with the uranium salts placed in the same drawer…

It was that seemingly uninteresting phenomenon, ignored by Becquerel, that inspired Marie to start the studies on the properties of the uranium ore, which were at the same time the subject of her doctoral thesis. She started the research on the "uranium rays", as they were called at that time. She used mainly the property that the "uranium rays" discharged the electrometer. After few weeks of observations, Marie put forward the hypothesis that there was an unknown type of radiation, other than X radiation. Marie's husband, Pierre, decided to help his wife in the research. Together with his brother, Pierre built new measuring instruments, including a very precise quartz electrometer. But they both needed space and equipment. The headmaster of the School of Industrial Physics and Chemistry, where Pierre was a lecturer, gave them the opportunity to use the "laboratory". It was, in fact, a shed in the bailey which was previously used as a dissection room. When a German chemist, Wilhelm Ostwald, visited once the Curies in their work place, he was completely shocked: "It looks like a stable and a basement for keeping potatoes; if I hadn't seen the table designed to work with the chemical instruments, I would have thought that I had been mocked…"

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Exactly in these conditions, working half of the year, Marie and Pierre demonstrated that the compounds of the elements such as uranium and thorium emit spontaneous radiation. Marie proposed to call this property of the elements "radioactivity".

Q5. Marie Curie was the first person who used the word "radioactivity". Let's imagine you are Marie Curie, and after the publication of your discovery, someone asks you to explain what the word "radioactivity" means. What can you say?

Marie noticed also that the emission of the radiation of some minerals containing uranium (pitchblende, chalcolithic or autunite) is much stronger than it should be due to the amount of the uranium inside them. She put forward a daring hypothesis: There is unknown chemical element inside these substances.

But it was not easy for Marie to prove this hypothesis. The conversation of Marie and Pierre in July 1898 in the French Academy of Sciences was quite rough:

Marie Curie: "This is a new substance that appeared from that mineral, pitchblende. It turns the air into a conductor. One can measure its activity thanks to the quartz electrometer, invented by Pierre. That's how we assisted '*our hero*' during many investigations".

Scientific opponent: "It's nothing new; uranium and thorium are also active".

Marie Curie: "Yes, they are, but when the mixture is under the influence of the acids, we have a solution as an effect. Later, when we put this solution under the influence of the hydrogen sulphide, there are still uranium and thorium left, while '*our young hero*' precipitates as a sulphide".

Scientific opponent: "And what would it prove? Lead, bismuth, copper, arsenic and antimony behave in the same way and they do precipitate!"

Marie Curie: "But if you try to dissolve them in the ammonium sulphate, this something is not subject to dissolution…"

Scientific opponent: "Oh right, I admit it's neither arsenic, nor antimony, but it could be one of the known '*heroes*' of the past: lead, copper or bismuth".

Marie Curie: "My friend, it's impossible, because lead precipitates in the sulphuric acid, while *our substance* rests in the solution. While speaking about copper, it dissolves in the ammonia."

Scientific opponent: "So what? That means that what you call the active substance is just bismuth. There is a new property added to the old, well - known bismuth – *activity*. This does not require accepting *a new substance*."

Pierre Curie: "Really? Ok then, so please tell us, what would persuade you that this substance does exist?"

Scientific opponent: "It would be enough to show me the experiment in which bismuth reacts differently than your '*hero*'."

Marie Curie: "Try to warm it up in vacuum up to 700°C. What is happening then? Bismuth stays in the most warmed up place in the pipe, while *something* in type of strange black is created in colder places. And it's more active than the original substance. If you repeat the reaction few times, *this thing* which you mislead with bismuth, turns out *to be four hundred times more active than uranium!*"

Scientific opponent: "…"

Pierre Curie: "Ah! You're silent… that's because we think that the *substance* received from the pitchblende *is an unknown metal* so far. If the existence of a new metal is proved, we propose to call it *polonium* after Marie's homeland."

Q6. If you were Marie Curie and you discovered that apart uranium there is a new radioactive element in chalcolite, what further scientific actions would you take next?

To confirm the existence of a new element definitely, Marie, who knew the chemical composition of chalcolite:

$[Cu(UO_2)2(PO_4)2{\cdot}(8–12)H_2O]$,

stated that only uranium is the radioactive component in this mineral. She put forward the proper hypothesis that this mineral has to contain some new, unknown chemical element.

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Marie received the synthetic chalcolite in her laboratory and she proved that it emits weaker radiation. It was the solid experimental evidence for the existence of a new element being a part of chalcolite, which existed in nature. As it was planned, it was named *polonium*. It happened in July 1898.

Encouraged by this success, the Curies continued their research on the radioactivity and in December of the same year they identified another new element in the same pitchblende – *radium.*

Q7. What radioactive substances do you know? How do you know them?

These discoveries were appreciated in 1903 by giving the Nobel Prize in physics to Marie and Pierre Curie together with Henri Becquerel for their discovery and the study of radioactivity. In 1911 Marie Sklodowska-Curie received another Nobel Prize in chemistry for receiving the metallic radium in the pure state.

So, the ambitious dreams of Marie being a scientist have come true… At the end, it is worth noting that the Marie Sklodowska-Curie was also a great teacher of physics and declared significant words: "You have to be persistent and believe that you are able to do something well."

Q8: Please characterize the personality traits of Marie Sklodowska-Curie that in your opinion have decided that she is called "a women – scientist of all times."

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