RADIOACTIVITY AND NUCLEAR PHYSICS pdf

1: Radioactivity, Nuclear Physics - from A-level Physics Tutor

Nuclear Radioactivity. 1. Suppose the range for \(\displaystyle MeVÎ±\) ray is known to be mm in a certain material. Does this mean that every \(\displaystyle MeVÎ±\) a ray that strikes this material travels mm, or does the range have an average value with some statistical fluctuations in the distances traveled?

The application of x-rays and radioactive materials is far reaching in medicine and industry. Radioactive material is used in everything from nuclear reactors to isotope infused saline solutions. These technologies allow us to utilize great amounts of energy and observe biological systems in ways which were unthinkable less than a century ago. Introduction What is the definition of radioactive? If you look up the meaning in the dictionary the convoluted answer that you will receive is: This definition begs the questions: What are ionizing radiation or particles? What exactly is meant by emission? Can you see or feel these particles? What makes something radioactive? Received the first Noble Prize in physics for his discovery of x-rays in On November 8, , at the University of Wurzburg, Roentgen was working in the lab when he noticed a strange fluorescence coming from a nearby table. Upon further observation he found that it originated from a partially evacuated Hittof-Crookes tube, covered in opaque black paper which he was using to study cathode rays. He concluded that the fluorescence, which penetrated the opaque black paper, must have been caused by rays. Antoine Henri Becquerel Contributions: Received the Noble Prize in physics for being the first to discover radioactivity as a phenomenon separate from that of x-rays and document the differences between the two. With the intention of further advancing the study of x-rays, Becquerel intended to place the concealed photographic paper in the sunlight and observe what transpired. Unfortunately, he had to delay his experiment because the skies over Paris were overcast. He placed the wrapped plates into a dark desk drawer. Instead, the salts left very distinct outlines in the photographic paper suggesting that the salts, regardless of lacking an energy source, continually fluoresced. What Becquerel had discovered was radioactivity. Pierre and Marie were award the Noble Prize in Physics in for their work on radioactivity. Marie Curie became the first woman to be awarded the nobel prize and the first person to obtain two nobel prizes when she won the prize for the discovery of Polonium and Radium in Though it was Henri Becquerel that discovered radioactivity, it was Marie Curie who coined the term. Using a device invented by her husband and his brother, that measured extremely low electrical currents, Curie was able to note that uranium electrified the air around it. Further investigation showed that the activity of uranium compounds depended upon the amount of uranium present and that radioactivity was not a result of the interactions between molecules, but rather came from the atom itself. Using Pitchblende and chalcolite Curie found that Thorium was radioactive as well. She later discovered two new radioactive elements: Radium and Polonium which took her several years since these elements are difficult to extract and extremely rare. Unfortunately, the Curies died young. Pierre Curie was killed in a street accident and Marie died of aplastic anemia, almost certainly a result of radiation exposure. Ernest Rutherford Contributions: Ernest Rutherford is considered the father of nuclear physics. With his gold foil experiment he was able to unlock the mysteries of the atomic structure. He received the noble prize in chemistry in In at the University of Manchester, Rutherford was bombarding a piece of gold foil with Alpha particles. Rutherford noted that although most of the particles went straight through the foil, one in every eight thousand was deflected back. He concluded that though an atom consists of mostly empty space, most of its mass is concentrated in a very small positively charged region known as the nucleus, while electrons buzz around on the outside. Rutherford was also able to observe that radioactive elements underwent a process of decay over time which varied from element to element. In , Rutherford used alpha particles to transmutate one element Oxygen into another element Nitrogen. Papers at the timed called it "splitting the atom. We now have the essentials to utilize radioactive elements. Roentgen gave us x-rays, Becquerel discovered radioactivity, the Curies were able to discover which elements were radioactive, and Rutherford brought about transmutation and the "splitting of the atom. Time showed the damaging effects of radiation exposure and the incredible destruction that could be harnessed from these elements. Applications Radioactive isotopes are presently used in many aspects of human life today. Here are a few examples of how radioactive isotopes are utilized today. At Home Most people have radioactive material in their very own homes, or at least we would hope so. Because in most every smoke detector unit today there is a very small amount of Americium How does it work? Well Americium is present in the detector in oxide form and it emits alpha particles and very low energy gamma rays. When smoke enters the chamber it absorbs the alpha particles disrupting the rate of ionization in the chamber, thereby turning off the electrical current, which sets off the alarm. For more information go to: These plants, though clean burning, produce a great deal of toxic nuclear waste which is difficult to eliminate. With the rise in gas prices many countries around the world considered increasing their use nuclear energy. The problem with nuclear energy is that although it is "clean" in the sense that only water vapor is emitted into the atmosphere, it has its share of problems. It must be kept constantly regulated, and is extremely hard to dispose of. In the past, poor regulation of nuclear power has caused major problems, such as the Chernobyl incident in Even when regulated properly, the waste can cause contamination which lasts for many years and destroys natural resources. For more information and a specific example go to: Large scale gamma irradiation is also used for killing parasites found in wool, wood and other widely distributed products. Small scale irradiates are also used for blood transfusions and other medical sterilization procedures. Gamma Ray Analysis Gamma Rays can be used to determine the ash content of coal. By bombarding stable elements with radioactive rays one can cause a fluorescence, the energy of fluorescent x-rays can help identify if any elements are represented in a material. The intensity of the rays can indicate the quantity of that material. This process is commonly used in element processing plants. Medicine Radioisotopes are used as tracers in medical research. Radioactive elements are also used in clearing angioplasty obstructions and eliminating cancer. War To date the only country to utilize nuclear weapons and actually use them is the United States. These weapons were a part of a top secret project known today as the Manhattan project. Though those within the blast zone were instantly killed, the effects of these weapons would be felt for many years to come. Many more people died in the months following the bombing due to radiation poisoning, and years later, birth defects would prove the effects of radioactive bombardment upon DNA. A good resource on the industrial and medical uses of radioactive isotopes: Also note that there is a break between and on the table, which are suspected radioactive elements that have yet to be discovered.

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2: Atomic and Nuclear Physics

The discovery and study of nuclear radioactivity quickly revealed evidence of revolutionary new physics. In addition, uses for nuclear radiation also emerged quicklyâ€"for example, people such as Ernest Rutherford used it to determine the size of the nucleus and devices were painted with radon-doped paint to make them glow in the dark (see).

A physics student caught breaking conservation laws is imprisoned. She leans against the cell wall hoping to tunnel out quantum mechanically. Explain why her chances are negligible. This is so in any classical situation. That is, does it travel each point along an imaginary line from inside to out? Radiation Detection and Detectors The energy of Suppose a particle of ionizing radiation deposits 0. What maximum number of ion pairs can it create? A particle of ionizing radiation creates ion pairs in the gas inside a Geiger tube as it passes through. What minimum energy was deposited, if The small answer is consistent with the fact that the energy is large on a quantum mechanical scale but small on a macroscopic scale. Suppose a particle of ionizing radiation deposits 1. Each ion pair requires What is the current? What is the current if this last effect multiplies the number of ion pairs by ? This mass at nuclear density would make a cube 1. Find the length of a side of a cube having a mass of 1. Note that the radius of the largest nucleus is still much smaller than the size of an atom. Verify that this amount of mass converted to energy yields The detail observable using a probe is limited by its wavelength. Note that a photon having this energy is difficult to produce and interacts poorly with the nucleus, limiting the practicability of this probe. What is the ratio of the velocity of a 5. A favorite isotope in physics labs, since it has a short half-life and decays to a stable nuclide. Poses special problems because its daughter is a radioactive noble gas. The parent nuclide is a major waste product of reactors and has chemistry similar to potassium and sodium, resulting in its concentration in your cells if ingested. When an electron and positron annihilate, both their masses are destroyed, creating two equal energy photons to preserve momentum. To do this, identify the values of each before and after the annihilation. To do this, identify the values of each before and after the decay. To do this, identify the values of each before and after the capture.

3: Lise Meitner - Wikipedia

Introduction to Radioactivity and Nuclear Physics There is an ongoing quest to find substructures of matter. At one time, it was thought that atoms would be the ultimate substructure, but just when the.

The effects of radiation on genes, including the effect of cancer risk, were recognized much later. In , Hermann Joseph Muller published research showing genetic effects and, in , was awarded the Nobel Prize in Physiology or Medicine for his findings. The committee met in , and After World War II , the increased range and quantity of radioactive substances being handled as a result of military and civil nuclear programmes led to large groups of occupational workers and the public being potentially exposed to harmful levels of ionising radiation. Units of radioactivity[edit] Graphic showing relationships between radioactivity and detected ionizing radiation The International System of Units SI unit of radioactive activity is the becquerel Bq , named in honor of the scientist Henri Becquerel. One Bq is defined as one transformation or decay or disintegration per second. An older unit of radioactivity is the curie , Ci, which was originally defined as "the quantity or mass of radium emanation in equilibrium with one gram of radium element ". For radiological protection purposes, although the United States Nuclear Regulatory Commission permits the use of the unit curie alongside SI units, [17] the European Union European units of measurement directives required that its use for "public health Types of decay[edit] Alpha particles may be completely stopped by a sheet of paper, beta particles by aluminium shielding. Gamma rays can only be reduced by much more substantial mass, such as a very thick layer of lead. Nuclear drip line , Gamma decay , Internal conversion , Electron capture , Alpha decay , Nuclear fission , Neutron emission , and Cluster emission Early researchers found that an electric or magnetic field could split radioactive emissions into three types of beams. The rays were given the names alpha , beta , and gamma , in increasing order of their ability to penetrate matter. Alpha decay is observed only in heavier elements of atomic number 52 tellurium and greater, with the exception of beryllium-8 which decays to two alpha particles. The other two types of decay are produced by all of the elements. Lead, atomic number 82, is the heaviest element to have any isotopes stable to the limit of measurement to radioactive decay. Radioactive decay is seen in all isotopes of all elements of atomic number 83 bismuth or greater. Bismuth, however, is only very slightly radioactive, with a half-life greater than the age of the universe; radioisotopes with extremely long half-lives are considered effectively stable for practical purposes. Types of radioactive decay related to N and Z numbers In analysing the nature of the decay products, it was obvious from the direction of the electromagnetic forces applied to the radiations by external magnetic and electric fields that alpha particles carried a positive charge, beta particles carried a negative charge, and gamma rays were neutral. From the magnitude of deflection, it was clear that alpha particles were much more massive than beta particles. Passing alpha particles through a very thin glass window and trapping them in a discharge tube allowed researchers to study the emission spectrum of the captured particles, and ultimately proved that alpha particles are helium nuclei. Other experiments showed beta radiation, resulting from decay and cathode rays , were high-speed electrons. Likewise, gamma radiation and X-rays were found to be high-energy electromagnetic radiation. The relationship between the types of decays also began to be examined: For example, gamma decay was almost always found to be associated with other types of decay, and occurred at about the same time, or afterwards. Gamma decay as a separate phenomenon, with its own half-life now termed isomeric transition , was found in natural radioactivity to be a result of the gamma decay of excited metastable nuclear isomers , which were in turn created from other types of decay. Although alpha, beta, and gamma radiations were most commonly found, other types of emission were eventually discovered. Shortly after the discovery of the positron in cosmic ray products, it was realized that the same process that operates in classical beta decay can also produce positrons positron emission , along with neutrinos classical beta decay produces antineutrinos. In a more common analogous process, called electron capture , some proton-rich nuclides were found to capture their own atomic electrons instead of emitting positrons, and subsequently these nuclides emit only a neutrino and a gamma ray from the excited nucleus and often also Auger electrons and characteristic X-rays , as a result of the re-ordering of electrons to fill the place of the missing captured electron. These types of decay involve the nuclear capture of electrons or emission of electrons or positrons, and thus acts to move a nucleus toward the ratio of neutrons to protons that has the least energy for a given total number of nucleons. This consequently produces a more stable lower energy nucleus. A theoretical process of positron capture , analogous to electron capture, is possible in antimatter atoms, but has not been observed, as complex antimatter atoms beyond antihelium are not experimentally available. Shortly after the discovery of the neutron in , Enrico Fermi realized that certain rare beta-decay reactions immediately yield neutrons as a decay particle neutron emission. Isolated proton emission was eventually observed in some elements. It was also found that some heavy elements may undergo spontaneous fission into products that vary in composition. In a phenomenon called cluster decay , specific combinations of neutrons and protons other than alpha particles helium nuclei were found to be spontaneously emitted from atoms. Other types of radioactive decay were found to emit previously-seen particles, but via different mechanisms. An example is internal conversion , which results in an initial electron emission, and then often further characteristic X-rays and Auger electrons emissions, although the internal conversion process involves neither beta nor gamma decay. A neutrino is not emitted, and none of the electron s and photon s emitted originate in the nucleus, even though the energy to emit all of them does originate there. Internal conversion decay, like isomeric transition gamma decay and neutron emission, involves the release of energy by an excited nuclide, without the transmutation of one element into another. Rare events that involve a combination of two beta-decay type events happening simultaneously are known see below. Any decay process that does not violate the conservation of energy or momentum laws and perhaps other particle conservation laws is permitted to happen, although not all have been detected. An interesting example discussed in a final section, is bound state beta decay of rhenium In this process, beta electron-decay of the parent nuclide is not accompanied by beta electron emission, because the beta particle has been captured into the K-shell of the emitting atom. An antineutrino is emitted, as in all negative beta decays. Radionuclides can undergo a number of different reactions. These are summarized in the following table. A nucleus with mass number A and atomic number Z is represented as A, Z. The column "Daughter nucleus" indicates the difference between the new nucleus and the original nucleus. If energy circumstances are favorable, a given radionuclide may undergo many competing types of decay, with some atoms decaying by one route, and others decaying by another. An example is copper , which has 29 protons, and 35 neutrons, which decays with a half-life of about This isotope has one unpaired proton and one unpaired neutron, so either the proton or the neutron can decay to the opposite particle. The excited energy states resulting from these decays which fail to end in a ground energy state, also produce later internal conversion and gamma decay in almost 0. More common in heavy nuclides is competition between alpha and beta decay. The daughter nuclides will then normally decay through beta or alpha, respectively, to end up in the same place.

4: Radioactivity and nuclear fission - Physics Stack Exchange

To understand the basic nuclear structure. To understand the forces that hold the nucleus together and under what circumstances it might break apart. To understand the concept of nuclear binding energy and calculate the binding energy for different nuclei.

Early years[edit] Meitner in She was born Elise Meitner on 7 November into a Jewish upper-middle-class family in Vienna , 2nd district Leopoldstadt , the third of eight children. Her father Philipp Meitner [13] was one of the first Jewish lawyers in Austria. She was particularly drawn to math and science, and first studied colors of an oil slick, thin films, and reflected light. Women were not allowed to attend public institutions of higher education in Vienna around , but Meitner was able to achieve a private education in physics in part because of her supportive parents, and she completed in with an "externe Matura " examination at the Akademisches Gymnasium. Because she was unsure if she wanted to study mathematics or physics, she attended multiple lectures in both areas of study, "taking more notes than the registered students". While studying a beam of alpha particles , she found that scattering increased with the atomic mass of the metal atoms, in her experiments with collimators and metal foil, which led Ernest Rutherford later on to the nuclear atom, and which had been her forte, submitting her report of same to the Physikalische Zeitschrift on 29 June During the first years she worked together with chemist Otto Hahn and together with him discovered several new isotopes. In she presented two papers on beta radiation. She also, together with Otto Hahn, discovered and developed a physical separation method known as radioactive recoil, in which a daughter nucleus is forcefully ejected from its matrix as it recoils at the moment of decay. It was not until , at 35 years old and following an offer to go to Prague as associate professor, that she got a permanent position at KWI. In the first part of World War I , she served as a nurse handling X-ray equipment. She returned to Berlin and her research in , but not without inner struggle. She felt in a way ashamed of wanting to continue her research efforts when thinking about the pain and suffering of the victims of war and their medical and emotional needs. This program eventually led to the unexpected discovery of nuclear fission of heavy nuclei in December , half a year after she had left Berlin. As Chadwick and others were attempting to prove the existence of the neutron , Meitner sent polonium to Chadwick for his experiments. Chadwick eventually required and received more polonium for his experiments from a hospital in Baltimore , but he would remain grateful to Meitner. After the discovery of the neutron in the early s, the scientific community speculated that it might be possible to create elements heavier than uranium atomic number 92 in the laboratory. At the time, all concerned believed that this was abstract research for the probable honour of a Nobel prize. None suspected that this research would culminate in nuclear weapons. When Adolf Hitler came to power in , Meitner was still acting as head of the physics department of the Kaiser Wilhelm Institute for Chemistry. Most of them emigrated from Germany. Her response was to say nothing and bury herself in her work. After the Anschluss in March , her situation became difficult. She was forced to travel under cover to the Dutch border, where Coster persuaded German immigration officers that she had permission to travel to the Netherlands. She reached safety, though without her possessions. Before she left, Otto Hahn had given her a diamond ring he had inherited from his mother: Here she established a working relationship with Niels Bohr , who travelled regularly between Copenhagen and Stockholm. She continued to correspond with Hahn and other German scientists. Later they continued to exchange a series of letters. In December Hahn and his assistant Fritz Strassmann performed the difficult experiments which isolated the evidence for nuclear fission at their laboratory in Berlin-Dahlem. The possibility that uranium nuclei might break up under neutron bombardment had been suggested years before, notably by Ida Noddack in However, by employing the existing "liquid-drop" model of the nucleus, [31] Meitner and Frisch, exclusively informed by Hahn in advance, were therefore the first to articulate a theory of how the nucleus of an atom could be split into smaller parts: She and Frisch had discovered the reason that no stable elements beyond uranium in atomic number existed naturally; the electrical repulsion of so many protons overcame the strong nuclear force. Nuclear fission experimental setup, reconstructed at the Deutsches Museum , Munich A letter from Bohr had sparked the above inspiration in December But Meitner and Frisch later confirmed that chemistry had been solely responsible for the discovery, although Hahn, as a chemist, was reluctant to explain the fission process in correct physical terms. In a later appreciation Lise Meitner wrote: It seems to me that what makes the science behind this discovery so remarkable is that it was achieved by purely chemical means. The Americans learned to do it later. But at that time, Hahn and Strassmann were really the only ones who could do it. And that was because they were such good chemists. Somehow they really succeeded in using chemistry to demonstrate and prove a physical process. Fritz Strassmann responded in the same interview with this clarification: I have to make a slight correction. Chemistry merely isolated the individual substances, it did not precisely identify them. This is where his achievement lies. Hahn and Strassmann had sent the manuscript of their first paper to Naturwissenschaften in December , reporting they had detected and identified the element barium after bombarding uranium with neutrons ; [34] simultaneously, Hahn had communicated their results exclusively to Meitner in several letters, and did not inform the physicists in his own institute. Roosevelt a letter of caution. In Frisch and Rudolf Peierls produced the Frischâ€"Peierls memorandum , which first set out how an atomic explosion could be generated, and this ultimately led to the establishment in of the Manhattan Project. Meitner refused an offer to work on the project at Los Alamos , declaring "I will have nothing to do with a bomb! In , a personal position was created for her at the University College of Stockholm with the salary of a professor and funding from the Council for Atomic Research. On 15 November , the Royal Swedish Academy of Sciences announced that Hahn had been awarded the Nobel Prize in Chemistry for "his discovery of the fission of heavy atomic nuclei. There is really no doubt about it. But I believe that Otto Robert Frisch and I contributed something not insignificant to the clarification of the process of uranium fissionâ€"how it originates and that it produces so much energy and that was something very remote to Hahn. He would have deserved it even if he had not made this discovery. But everyone recognized that the splitting of the atomic nucleus merited a Nobel Prize. Both he and Meitner had been nominated for both the chemistry and the physics prizes several times even before the discovery of nuclear fission. Referring to the leading German nuclear physicist Werner Heisenberg , she said: And you tried to offer only a passive resistance. Certainly, to buy off your conscience you helped here and there a persecuted person, but millions of innocent human beings were allowed to be murdered without any kind of protest being uttered Also Hahn wrote in his memoirs, which were published shortly after his death in , that he and Meitner had remained lifelong close friends. She became a Swedish citizen in She retired in and moved to the UK where most of her relatives were, although she continued working part-time and giving lectures. A strenuous trip to the United States in led to Meitner having a heart attack , from which she spent several months recovering. Her physical and mental condition weakened by atherosclerosis , she was unable to travel to the US to receive the Enrico Fermi prize. President Johnson sent Glenn Seaborg , the discoverer of plutonium, to present it to her. The presentation was made in the home of Max Perutz in Cambridge. After breaking her hip in a fall and suffering several small strokes in , Meitner made a partial recovery, but eventually was weakened to the point where she moved into a Cambridge nursing home. She died in her sleep on 27 October at the age of July or his wife Edith, as her family believed it would be too much for someone so frail. James parish church, close to her younger brother Walter, who had died in Her nephew Frisch composed the inscription on her headstone. She lectured at Princeton , Harvard and other US universities, and was awarded a number of honorary doctorates. She was nominated by Otto Hahn for both honours. Meitner was elected a foreign member of the Royal Swedish Academy of Sciences in , and had her status changed to that of a Swedish member in In she received the Award of the City of Vienna for science. She was the first female member of the scientific class of the Austrian Academy of Sciences. In , element was named meitnerium in her honour. Curium was named after both Marie and Pierre Curie. Additional naming honours are the Hahnâ€"Meitner-Institut in Berlin, craters on the Moon and on Venus , and the main-belt asteroid Meitner. In , the European Physical Society established the biannual "Lise Meitner Prize" for excellent research in nuclear science.

5: Radioactive decay - Wikipedia

RADIOACTIVITY AND NUCLEAR PHYSICS pdf

In this chapter, the fundamentals of nuclear radioactivity and the nucleus are explored. The following two chapters explore the more important applications of nuclear physics in the field of medicine.

6: Radioactivity and Nuclear Physics (Exercises) - Physics LibreTexts

Explain nuclear radiation. Explain the types of radiationâ€"alpha emission, beta emission, and gamma emission. Explain the ionization of radiation in an atom. Define the range of radiation. The discovery and study of nuclear radioactivity quickly revealed evidence of revolutionary new physics. In.

7: Discovery of Radioactivity - Chemistry LibreTexts

Resources Text Resources. Australian Nuclear Science and Technology Organisation , A Nuclear Source: A Resource Kit for Teachers, ANSTO, Sydney, NSW. Caro, McDonell & Spicer , Modern Physics, 3rd edn, Edward Arnold, London.

8: Half-life and activity, Radioactivity and nuclear physics, By OpenStax | www.enganchecubano.com

Nuclear and particle physics, such as radioactivity, nuclear reactions, and fundamental particles Relativity, such as time dilation, length contraction, and mass-energy equivalence A Framework for K Science Education: Practices, Crosscutting Concepts, and Core Ideas ().

9: Introduction to Radioactivity and Nuclear Physics â€“ College Physics chapters

Radioactive decay rates are normally stated in terms of their half-lives, and the half-life of a given nuclear species is related to its radiation www.enganchecubano.com different types of radioactivity lead to different decay paths which transmute the nuclei into other chemical elements.

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