

= Ununoctium =

Ununoctium (symbol Uuo) is the temporary name of a transactinide chemical element . It was first synthesized in 2002 by a joint team of Russian and American scientists at the Joint Institute for Nuclear Research (JINR) in Dubna , Russia . With the atomic number 118 in the periodic table , the synthetic element is also known as element 118 , or eka @-@ radon . In December 2015 , it was recognized as one of four new elements by the Joint Working Party of international scientific bodies IUPAC and IUPAP . In June 2016 , the IUPAC suggested the element to be named oganesson / ${}_{118}^{294}\text{Og}$ (element symbol : Og) , a name expected to be formally accepted by the end of 2016 . The proposal is in line with the tradition of honoring a scientist and recognizes nuclear physicist Yuri Oganessian , who has played a leading role in the discovery of the heaviest elements in the periodic table .

Ununoctium has the highest atomic number and highest atomic mass of all known elements . The radioactive ununoctium atom is very unstable , and since 2005 , only three or possibly four atoms of the isotope ${}^{294}\text{Uuo}$ have been detected . Although this allowed very little experimental characterization of its properties and possible compounds , theoretical calculations have resulted in many predictions , including some surprising ones . For example , although ununoctium is a member of group 18 ? the first synthetic one to be so ? it may possibly not be a noble gas , unlike all the other elements of that group . It was formerly thought to be a gas under normal conditions but is now predicted to be a solid due to relativistic effects . On the periodic table of the elements it is a p @-@ block element and the last one of the 7th period .

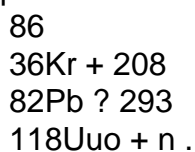
= = History = =

The Danish physicist Niels Bohr was the first to seriously consider the possibility of an element with atomic number as high as 118 , noting in 1922 that such an element would take its place in the periodic table below radon as the heaviest of the noble gases . Following this , Aristid von Grosse wrote an article in 1965 predicting the likely properties of element 118 . These were remarkably early predictions , given that it was not yet known how to produce elements artificially in 1922 , and that the existence of the island of stability had not yet been theorized in 1965 . It took eighty years from Bohr 's initial prediction before ununoctium was first successfully synthesised , although its chemical properties have not yet been investigated to see if it really does behave as the heavier congener of radon .

= = = Unsuccessful synthesis attempts = = =

In late 1998 , Polish physicist Robert Smola?czuk published calculations on the fusion of atomic nuclei towards the synthesis of superheavy atoms , including ununoctium . His calculations suggested that it might be possible to make ununoctium by fusing lead with krypton under carefully controlled conditions .

In 1999 , researchers at Lawrence Berkeley National Laboratory made use of these predictions and announced the discovery of livermorium and ununoctium , in a paper published in Physical Review Letters , and very soon after the results were reported in Science . The researchers reported to have performed the reaction



The following year , they published a retraction after researchers at other laboratories were unable to duplicate the results and the Berkeley lab could not duplicate them either . In June 2002 , the director of the lab announced that the original claim of the discovery of these two elements had been based on data fabricated by principal author Victor Ninov .

== Discovery reports ==

The first decay of atoms of ununoctium was observed in 2002 at the Joint Institute for Nuclear Research (JINR) in Dubna , Russia , by a joint team of Russian and American scientists . Headed by Russian nuclear physicist Yuri Oganessian , the team included American scientists of the Lawrence Livermore National Laboratory , California . On 9 October 2006 , the researchers announced that they had indirectly detected a total of three (possibly four) nuclei of ununoctium @-@ 294 (one or two in 2002 and two more in 2005) produced via collisions of californium @-@ 249 atoms and calcium @-@ 48 ions .

249

$98\text{Cf} + 48$

$20\text{Ca} \rightarrow 294$

$118\text{Uuo} + 3\text{n}$.

In 2011 , IUPAC evaluated the 2006 results of the Dubna @-@ Livermore collaboration and concluded : " The three events reported for the $Z = 118$ isotope have very good internal redundancy but with no anchor to known nuclei do not satisfy the criteria for discovery " .

Because of the very small fusion reaction probability (the fusion cross section is $\sim 0.3 - 0.6$ pb or $(3 - 6) \times 10^{-41} \text{ m}^2$) the experiment took four months and involved a beam dose of 4×10^{19} calcium ions that had to be shot at the californium target to produce the first recorded event believed to be the synthesis of ununoctium . Nevertheless , researchers are highly confident that the results are not a false positive , since the chance that the detections were random events was estimated to be less than one part in 100000 .

In the experiments , the alpha @-@ decay of three atoms of ununoctium was observed . A fourth decay by direct spontaneous fission was also proposed . A half @-@ life of 0.89 ms was calculated : 294Uuo decays into 290Lv by alpha decay . Since there were only three nuclei , the half @-@ life derived from observed lifetimes has a large uncertainty : $0.89 + 1.07$

$- 0.31 \text{ ms}$.

294

$118\text{Uuo} \rightarrow 290$

$116\text{Lv} + 4$

2He

The identification of the 294Uuo nuclei was verified by separately creating the putative daughter nucleus 290Lv directly by means of a bombardment of 245Cm with 48Ca ions ,

245

$96\text{Cm} + 48$

$20\text{Ca} \rightarrow 290$

$116\text{Lv} + 3\text{n}$,

and checking that the 290Lv decay matched the decay chain of the 294Uuo nuclei . The daughter nucleus 290Lv is very unstable , decaying with a lifetime of 14 milliseconds into 286Fl , which may experience either spontaneous fission or alpha decay into 282Cn , which will undergo spontaneous fission .

In a quantum @-@ tunneling model , the alpha decay half @-@ life of 294Uuo was predicted to be $0.66 + 0.23$

$- 0.18 \text{ ms}$ with the experimental Q @-@ value published in 2004 . Calculation with theoretical Q @-@ values from the macroscopic @-@ microscopic model of Muntian ? Hofman ? Patyk ? Sobiczewski gives somewhat lower but comparable results .

== Confirmation ==

In December 2015 , the Joint Working Party of international scientific bodies International Union of Pure and Applied Chemistry (IUPAC) and International Union of Pure and Applied Physics (IUPAP) recognized the element 's discovery and assigned the priority of the discovery to the Dubna @-@ Livermore collaboration .

== Naming ==

Using Mendeleev's nomenclature for unnamed and undiscovered elements, ununoctium is sometimes known as eka @-@ radon (until the 1960s as eka @-@ emanation, emanation being the old name for radon). In 1979, IUPAC assigned the systematic placeholder name ununoctium to the undiscovered element, with the corresponding symbol of Uuo, and recommended it to be used until after confirmed discovery of the element. Although widely used in the chemical community on all levels, from chemistry classrooms to advanced textbooks, the recommendations are mostly ignored among scientists in the field, who call it " element 118 ", with the symbol of (118) or even simply 118.

Before the retraction in 2002, the researchers from Berkeley had intended to name the element ghorsium (Gh), after Albert Ghiorso (a leading member of the research team).

The Russian discoverers reported their synthesis in 2006. According to IUPAC recommendations, the discoverer (s) of a new element has the right to suggest a name. In 2007, the head of the Russian institute stated the team were considering two names for the new element: flyorium, in honor of Georgy Flyorov, the founder of the research laboratory in Dubna; and moskovium, in recognition of the Moscow Oblast where Dubna is located. He also stated that although the element was discovered as an American collaboration, who provided the californium target, the element should rightly be named in honor of Russia since the Flerov Laboratory of Nuclear Reactions at JINR was the only facility in the world which could achieve this result. These names were later proposed for element 114 (flerovium) and element 116 (moscovium). However, the final name proposed for element 116 was instead livermorium.

Traditionally, the names of all noble gases end in " -on ", with the exception of helium, which was not known to be a noble gas when discovered. The IUPAC guidelines valid at the moment of the discovery approval however required all new elements be named with the ending " -ium ". While the provisional name ununoctium followed this convention, a new IUPAC recommendation published in 2016 recommends using the " -on " ending for new group 18 elements, no matter whether they turn out to be a noble gas or not.

In June 2016 IUPAC announced that it plans to give the element the name oganesson (symbol : Og), in honour of the Russian nuclear physicist Yuri Oganessian.

== Characteristics ==

== Nuclear stability and isotopes ==

The stability of nuclei decreases greatly with the increase in atomic number after plutonium, the heaviest primordial element, so that all isotopes with an atomic number above 101 decay radioactively with a half @-@ life under a day, with an exception of dubnium @-@ 268. No elements with atomic numbers above 82 (after lead) have stable isotopes. Nevertheless, because of reasons not very well understood yet, there is a slightly increased nuclear stability around atomic numbers 110 ? 114, which leads to the appearance of what is known in nuclear physics as the " island of stability ". This concept, proposed by University of California professor Glenn Seaborg, hypothesizes why superheavy elements last longer than predicted. Ununoctium is radioactive and has a half @-@ life that appears to be less than a millisecond. Nonetheless, this is still longer than some predicted values, thus giving further support to the idea of this " island of stability ".

Calculations using a quantum @-@ tunneling model predict the existence of several neutron @-@ rich isotopes of ununoctium with alpha @-@ decay half @-@ lives close to 1 ms.

Theoretical calculations done on the synthetic pathways for, and the half @-@ life of, other isotopes have shown that some could be slightly more stable than the synthesized isotope ^{294}Uuo , most likely ^{293}Uuo , ^{295}Uuo , ^{296}Uuo , ^{297}Uuo , ^{298}Uuo , ^{300}Uuo and ^{302}Uuo . Of these, ^{297}Uuo might provide the best chances for obtaining longer @-@ lived nuclei, and thus might

become the focus of future work with this element . Some isotopes with many more neutrons , such as some located around 313Uuo could also provide longer @-@ lived nuclei .

= = = Calculated atomic and physical properties = = =

Ununoctium is a member of group 18 , the zero @-@ valence elements . The members of this group are usually inert to most common chemical reactions (for example , combustion) because the outer valence shell is completely filled with eight electrons . This produces a stable , minimum energy configuration in which the outer electrons are tightly bound . It is thought that similarly , ununoctium has a closed outer valence shell in which its valence electrons are arranged in a $7s^2 7p^6$ configuration .

Consequently , some expect ununoctium to have similar physical and chemical properties to other members of its group , most closely resembling the noble gas above it in the periodic table , radon . Following the periodic trend , ununoctium would be expected to be slightly more reactive than radon . However , theoretical calculations have shown that it could be quite reactive , so that it probably cannot be considered a noble gas . In addition to being far more reactive than radon , ununoctium may be even more reactive than elements flerovium and copernicium . The reason for the apparent enhancement of the chemical activity of ununoctium relative to radon is an energetic destabilization and a radial expansion of the last occupied $7p$ @-@ subshell . More precisely , considerable spin ? orbit interactions between the $7p$ electrons and the inert $7s^2$ electrons effectively lead to a second valence shell closing at flerovium , and a significant decrease in stabilization of the closed shell of element 118 . It has also been calculated that ununoctium , unlike other noble gases , binds an electron with release of energy ? or in other words , it exhibits positive electron affinity , due to the relativistically stabilized $8s$ energy level .

Ununoctium is expected to have by far the broadest polarizability of all elements before it in the periodic table , almost double that of radon . By extrapolating from the other noble gases , it is expected that ununoctium has a boiling point between 320 and 380 K. This is very different from the previously estimated values of 263 K or 247 K. Even given the large uncertainties of the calculations , it seems highly unlikely that ununoctium would be a gas under standard conditions , and as the liquid range of the other gases is very narrow , between 2 and 9 kelvins , this element should be solid at standard conditions . If ununoctium forms a gas under standard conditions nevertheless , it would be one of the densest gaseous substances at standard conditions (even if it is monatomic like the other noble gases) .

Because of its tremendous polarizability , ununoctium is expected to have an anomalously low ionization energy (similar to that of lead which is 70 % of that of radon and significantly smaller than that of flerovium) and a standard state condensed phase .

= = = Predicted compounds = = =

No compounds of ununoctium have been synthesized yet , but calculations on theoretical compounds have been performed since 1964 . It is expected that if the ionization energy of the element is high enough , it will be difficult to oxidize and therefore , the most common oxidation state will be 0 (as for other noble gases) ; nevertheless , this appears not to be the case .

Calculations on the diatomic molecule Uuo

2 showed a bonding interaction roughly equivalent to that calculated for Hg

2 , and a dissociation energy of 6 kJ / mol , roughly 4 times of that of Rn

2 . But most strikingly , it was calculated to have a bond length shorter than in Rn

2 by 0 @.@ 16 Å , which would be indicative of a significant bonding interaction . On the other hand , the compound $UuoH^+$ exhibits a dissociation energy (in other words proton affinity of Uuo) that is smaller than that of RnH^+ .

The bonding between ununoctium and hydrogen in $UuoH$ is predicted to be very limp and can be regarded as a pure van der Waals interaction rather than a true chemical bond . On the other hand , with highly electronegative elements , ununoctium seems to form more stable compounds than for

example copernicium or flerovium . The stable oxidation states + 2 and + 4 have been predicted to exist in the fluorides UuoF_2 and UuoF_4

2 and UuoF_4

4 . The + 6 state would be less stable due to the strong binding of the $7p_{1/2}$ subshell . This is a result of the same spin-orbit interactions that make ununoctium unusually reactive . For example , it was shown that the reaction of ununoctium with F_2

2 to form the compound UuoF_4

2 would release an energy of 106 kcal / mol of which about 46 kcal / mol come from these interactions . For comparison , the spin-orbit interaction for the similar molecule RnF_4

2 is about 10 kcal / mol out of a formation energy of 49 kcal / mol . The same interaction stabilizes the tetrahedral T_d configuration for UuoF_4

4 , as distinct from the square planar D_{4h} one of XeF_4

4 , which RnF_4

4 is also expected to have . The $\text{Uuo}-\text{F}$ bond will most probably be ionic rather than covalent , rendering the UuoF_n compounds non-volatile . UuoF_2 is predicted to be partially ionic due to ununoctium 's high electropositivity . Unlike the other noble gases (except possibly xenon) , ununoctium was predicted to be sufficiently electropositive to form a $\text{Uuo}-\text{Cl}$ bond with chlorine .