= Ununtrium =

Ununtrium (symbol Uut) is a temporary name for the chemical element with atomic number 113 . It is a synthetic element (an element that can be created in a laboratory but is not found in nature) and is extremely radioactive ; its most stable known isotope , ununtrium @-@ 286 , has a half @-@ life of 20 seconds . It is also known as eka @-@ thallium or simply element 113 . Ununtrium was first reported to have been created in 2003 by the Joint Institute for Nuclear Research in Dubna , Russia , and in 2004 by a team of Japanese scientists at RIKEN . In December 2015 , the International Union of Pure and Applied Chemistry (IUPAC) and the International Union of Pure and Applied Physics (IUPAP) recognized the element and assigned the priority of the discovery to RIKEN . In June 2016 , the IUPAC published a declaration proposing the name nihonium / n??ho?ni?m / , symbol Nh . The name is set to be formally accepted in (or after) November 2016 . The name comes from one of the pronunciations of the Japanese word for Japan (?? , nihon) .

In the periodic table , it is a p @-@ block transactinide element . It is a member of the 7th period and is placed in the boron group , although it has not been confirmed to behave as the heavier homologue to thallium in the boron group . Ununtrium is calculated to have some similar properties to its lighter homologues , boron , aluminium , gallium , indium , and thallium , although it should also show several major differences from them . Unlike all the other p @-@ block elements , it is predicted to show some transition metal character .

= = History = =

= = = Dubna ? Livermore collaboration = = =

The first report of ununtrium was in August 2003 , when it was identified as an alpha decay product of element 115 , ununpentium . These results were published on February 1 , 2004 , by a team composed of Russian scientists at Dubna (Joint Institute for Nuclear Research) , and American scientists at the Lawrence Livermore National Laboratory :

243
95Am + 48
20Ca ? 288
115Uup + 3 1
0n ? 284
113Uut + ?
243
95Am + 48
20Ca ? 287
115Uup + 4 1
0n ? 283
113Uut + ?

The Dubna ? Livermore collaboration has strengthened their claim for the discovery of ununtrium by conducting chemical experiments on 268Db , the final decay product of 288Uup . This was valuable as none of the nuclides in this decay chain were previously known , so that their claim was not supported by any previously obtained experimental data (as none existed) , and chemical experimentation would strengthen the case for their claim . In June 2004 and again in December 2005 , this dubnium isotope was successfully identified by extracting the final decay products , measuring spontaneous fission (SF) activities and using chemical identification techniques to confirm that they behave like a group 5 element (as dubnium is known to be in group 5 of the periodic table) . Both the half @-@ life and decay mode were confirmed for the proposed 268Db which lends support to the assignment of the parent and daughter nuclei to ununpentium and ununtrium respectively . Further experiments at Dubna in 2005 have fully confirmed the decay data for ununpentium and ununtrium , but in 2011 , the IUPAC / IUPAP Joint Working Party (JWP) did

not recognize the two elements as having been discovered because current theory could not distinguish between group 4 and group 5 elements by their chemical properties with sufficient confidence , and the identification of the daughter dubnium isotope was the most important factor in confirming the discovery of ununpentium and ununtrium . Furthermore , the decay properties of all the nuclei in the decay chain of ununpentium had not been previously characterized before the Dubna experiments , a situation which the JWP generally considers " troublesome , but not necessarily exclusive " .

= = = RIKEN = = =

On July 23 , 2004 , a team of Japanese scientists at RIKEN bombarded a target of bismuth @-@ 209 with accelerated nuclei of zinc @-@ 70 and detected a single atom of the isotope ununtrium @-@ 278 . They published their results on September 28 , 2004 :

209
83Bi + 70
30Zn ? 278
113Uut + 1
0n

Previously , in 2000 , a team led by P. A. Wilk identified the decay product 266Bh as decaying with identical properties to what the Japanese team had observed , thus lending support for their claim . However , they also observed the daughter of 266Bh , 262Db , undergo alpha decay instead of spontaneous fission (the Japanese team observed the latter decay mode) .

The RIKEN team produced a further atom on April 2 , 2005 , although the decay data were slightly different from the first chain , perhaps due to either the formation of a metastable state or an alpha particle escaping from the detector before depositing its full energy . Due to these inconsistencies in the decay data , the small number of ununtrium atoms produced , and the lack of unambiguous anchors to known isotopes , the JWP did not accept this as a conclusive discovery of ununtrium in 2011 .

Most recently , production and identification of another 278Uut nucleus occurred at RIKEN on August 12 , 2012 . In this case , a series of six alpha decays was observed , leading down to an isotope of mendelevium :

278
113Uut ? 274
111Rg + ? ? 270
109Mt + ? ? 266
107Bh + ? ? 262
105Db + ? ? 258
103Lr + ? ? 254
101Md + ?

This decay chain differed from the previous observations at RIKEN mainly in the decay mode of dubnium , which was previously observed to undergo spontaneous fission , but in this case instead alpha decayed ; the alpha decay of 262Db to 258Lr is well @-@ known . The scientists on this team calculated the probability of accidental coincidence to be 10 ? 28 , or totally negligible . The resulting 254Md atom than underwent beta plus decay to 254Fm , which itself finally alpha decayed to the long @-@ lived 250Cf , which has a half @-@ life of around thirteen years .

= = Naming = =

In March 2016 , Kosuke Morita , the leader of the RIKEN team , proposed the name " nihonium " to IUPAC , after its place of discovery and referencing Japanese chemist Masataka Ogawa 's 1908 discovery of rhenium , which he named " nipponium " . IUPAC is expected to formally decide on the name by the end of 2016 after a period of public comments .

Until the proposed name is confirmed , ununtrium remains the lightest element that has not yet

received an official name . Using Mendeleev 's nomenclature for unnamed and undiscovered elements , ununtrium should be known as eka @-@ thallium . In 1979 IUPAC published recommendations according to which the element was to be called ununtrium (with the corresponding symbol of Uut) , a systematic element name as a placeholder , until the discovery of the element is confirmed and a name is decided on . Although widely used in the chemical community on all levels , from chemistry classrooms to advanced textbooks , the recommendations were mostly ignored among scientists in the field , who call it " element 113 " , with the symbol of (113) or even simply 113 .

Claims to the discovery of ununtrium have been put forward by both the Dubna and RIKEN teams . In 2011 , the IUPAC evaluated the 2004 RIKEN experiments and 2004 and 2007 Dubna experiments , and concluded that they did not meet the criteria for discovery .

On August 12 , 2012 , researchers at the RIKEN Nishina Center for Accelerator @-@ Based Science in Japan , claimed to have synthesised element 113 by colliding zinc nuclei (with 30 protons each) into a thin layer of bismuth (which contains 83 protons) . In December 2015 , IUPAC recognized the element and assigned the priority of the discovery to RIKEN . For the first time in history a team of Asian physicists will name a new element .

The following names were speculated before the June 2016 announcement of the proposed name " nihonium " :

On 8 June 2016 , IUPAC disclosed the name of ununtrium as nihonium . Prior to the formal approval by the IUPAC Council , a five @-@ month public review is now set , expiring 8 November 2016 .

= = Isotopes = =

Ununtrium has no stable or naturally @-@ occurring isotopes . Several radioactive isotopes have been synthesized in the laboratory , either by fusing two atoms or by observing the decay of heavier elements . Six different isotopes of ununtrium have been reported with atomic masses 278 and 282 ? 286 ; they all decay through alpha decay .

= = = Stability and half @-@ lives = = =

All ununtrium isotopes are extremely unstable and radioactive ; however , the heavier ununtrium isotopes are more stable than the lighter . The most stable known ununtrium isotope , 286Uut , is also the heaviest known ununtrium isotope ; it has a half @-@ life of 20 seconds . The isotope 285Uut has been reported to also have a half @-@ life of over a second . The isotopes 284Uut and 283Uut have half @-@ lives of 0 @.@ 48 and 0 @.@ 10 seconds respectively . The remaining two isotopes have half @-@ lives between 0 @.@ 1 and 100 milliseconds : 282Uut has a half @-@ life of 70 milliseconds , and 278Uut , the lightest known ununtrium isotope , is also the shortest @-@ lived known ununtrium isotope , with a half @-@ life of just 0 @.@ 24 milliseconds . It is predicted that even heavier undiscovered ununtrium isotopes could be much more stable : for example , 287Uut is predicted to have a half @-@ life of around 20 minutes , close to two orders of magnitude more than that of 286Uut .

Theoretical estimates of alpha decay half @-@ lives of isotopes of ununtrium are in good agreement with the experimental data . The undiscovered isotope 293Uut has been predicted to be the most stable towards beta decay ; however , no known ununtrium isotope has been observed to undergo beta decay .

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 the exception of dubnium @-@ 268 . Nevertheless , because of reasons not very well understood yet , there is a slight 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 , explains why superheavy elements last longer than predicted .

= = Predicted properties = =

Ununtrium is the first member of the 7p series of elements and the heaviest boron group element on the periodic table , below boron , aluminium , gallium , indium , and thallium . It is predicted to show many differences from its lighter homologues : a largely contributing effect is the spin ? orbit (SO) interaction . It is especially strong for the superheavy elements , because their electrons move much faster than in lighter atoms , at velocities comparable to the speed of light . In relation to ununtrium atoms , it lowers the 7s and the 7p electron energy levels (stabilizing the corresponding electrons) , but two of the 7p electron energy levels are stabilized more than the other four . The stabilization of the 7s electrons is called the inert pair effect , and the effect " tearing " the 7p subshell into the more stabilized and the less stabilized parts is called the subshell splitting . Computation chemists see the split as a change of the second (azimuthal) quantum number l from 1 to 1 / 2 and 3 / 2 for the more stabilized and less stabilized parts of the 7p subshell , respectively . For many theoretical purposes , the valence electron configuration may be represented to reflect the 7p subshell split as 7s27p1 / 21 . These effects stabilize lower oxidation states : the first ionization energy of ununtrium is expected to be 7 @.@ 306 eV , the highest among the boron group elements . Hence , the most stable oxidation state of ununtrium is predicted to be the + 1 state , and ununtrium is expected to be less reactive than thallium . Differences for other electron levels also exist . For example , the 6d electron levels (also split in halves , with four being 6d3 / 2 and six being 6d5 / 2) are both raised , so that they are close in energy to the 7s ones . Thus , the 6d electron levels , being destabilized , should still be able to participate in chemical reactions in ununtrium (as well as in the next 7p element , flerovium) , thus making it behave in some ways like transition metals and allow higher oxidation states . Ununtrium should hence also be able to show stable + 2 , + 3 and + 5 oxidation states . However , the + 3 state should still be less stable than the + 1 state , following periodic trends . Ununtrium should be the most electronegative among all the boron group elements : for example , in the compound UutUus , the negative charge is expected to be on the ununtrium atom rather than the ununseptium atom , the opposite of what would be expected from simple periodicity . The electron affinity of ununtrium is calculated to be around 0 @.@ 68 eV ; in comparison , that of thallium is 0 @.@ 4 eV . The high electron affinity and electronegativity of ununtrium are due to it being only one electron short of the closed @-@ shell valence electron configuration of flerovium (7s27p1 / 22) : this would make the ? 1 oxidation state of ununtrium more stable than that of its lighter congener thallium .

The simplest possible ununtrium compound is the monohydride , UutH . The bonding is provided by the 7p1 / 2 electron of ununtrium and the 1s electron of hydrogen . However , the SO interaction causes the binding energy of ununtrium monohydride to be reduced by about 1 eV and the ununtrium ? hydrogen bond length to decrease as the bonding 7p1 / 2 orbital is relativistically contracted . The analogous monofluoride (UutF) should also exist . Ununtrium should also be able to form the trihydride (UutH3) , trifluoride (UutF3) , and trichloride (UutCl3) , with ununtrium in the + 3 oxidation state . Because the 6d electrons are involved in bonding instead of the 7s ones , these molecules are predicted to be T @-@ shaped and not trigonal planar . Although the polyfluoride anion UutF ?

6 should be stable , the corresponding neutral fluoride UutF5 should be unstable , spontaneously decomposing into the trifluoride and elemental fluorine . Ununtrium (I) is predicted to be more similar to silver (I) than thallium (I) : the Uut + ion is expected to more willingly bind anions , so that UutCl should be quite soluble in an excess of hydrochloric acid or in ammonia while TlCl is not . Additionally , in contrast to the strongly basic TlOH , ununtrium (I) should instead form Uut2O , which would be weakly water @-@ soluble and readily ammonia @-@ soluble .

Ununtrium is expected to be much denser than thallium , having a predicted density of about 16 to 18 g / cm3 , due to the relativistic stabilization and contraction of its 7s and 7p1 / 2 orbitals . This is because calculations estimate it to have an atomic radius of about 170 pm , the same as that of thallium , even though periodic trends would predict it to have an atomic radius larger than that of thallium due to it being one period further down in the periodic table . The melting and boiling points

of ununtrium are not definitely known , but have been calculated to be 430 ° C and 1100 ° C respectively , exceeding the values for gallium , indium , and thallium , following periodic trends .

= = Experimental chemistry = =

Unambiguous determination of the chemical characteristics of ununtrium has yet to have been established . The isotopes 284Uut , 285Uut , and 286Uut have half @-@ lives long enough for chemical investigation . It is theoretically predicted that ununtrium should have an enthalpy of sublimation around 150 kJ / mol and an enthalpy of adsorption on a gold surface around ? 159 kJ / mol . From 2010 to 2012 , some preliminary chemical experiments were performed to determine the volatility of ununtrium . The reaction used was 243Am (48Ca , 3n) 288Uup ; the isotope 288Uup has a short half @-@ life and would quickly decay to the longer @-@ lived 284Uut , which would be chemically investigated . Teflon capillaries at 70 ° C connecting the recoil chamber , where the ununtrium atoms were synthesized , and the gold @-@ covered detectors : the ununtrium atoms would be carried along the capillaries by a carrier gas . While about ten to twenty atoms of 284Uut were produced , none of these atoms were registered by the gold @-@ covered detectors , suggesting either that ununtrium was similar in volatility to the noble gases or , more plausibly , that pure ununtrium was not very volatile and thus could not efficiently pass through the Teflon capillaries at 70 ° C. Formation of the hydroxide UutOH would ease the transport , as UutOH is expected to be more volatile than elemental ununtrium , and this reaction could be facilitated by adding more water vapor into the carrier gas . However , it seems likely that this formation is not kinetically favored , so that one would need to use the longer @-@ lived isotope 286Uut in future experiments .