

= Lutetium =

Lutetium is a chemical element with symbol Lu and atomic number 71 . It is a silvery white metal , which resists corrosion in dry , but not in moist air . It is considered the first element of the 6th @-@ period transition metals and the last element in the lanthanide series , and is traditionally counted among the rare earths .

Lutetium was independently discovered in 1907 by French scientist Georges Urbain , Austrian mineralogist Baron Carl Auer von Welsbach , and American chemist Charles James . All of these men found lutetium as an impurity in the mineral ytterbia , which was previously thought to consist entirely of ytterbium . The dispute on the priority of the discovery occurred shortly after , with Urbain and Welsbach accusing each other of publishing results influenced by the published research of the other ; the naming honor went to Urbain , as he had published his results earlier . He chose the name lutecium for the new element , but in 1949 the spelling of element 71 was changed to lutetium . In 1909 , the priority was finally granted to Urbain and his names were adopted as official ones ; however , the name cassiopeium (or later cassiopium) for element 71 proposed by Welsbach was used by many German scientists until the 1950s .

Lutetium is not a particularly abundant element , though significantly more common than silver in the earth 's crust ; it has few specific uses . Lutetium @-@ 176 is a relatively abundant (2 @. @ 5 %) radioactive isotope with a half @-@ life of about 38 billion years , and so used to determine the age of meteorites . Lutetium usually occurs in association with the element yttrium and is sometimes used in metal alloys and as a catalyst in various chemical reactions . 177Lu @-@ DOTA @-@ TATE is used for radionuclide therapy (see Nuclear medicine) on neuroendocrine tumours . Lutetium has the highest Brinell hardness of any lanthanide , at 890 ? 1300 MPa .

= = Characteristics = =

= = = Physical properties = = =

A lutetium atom has 71 electrons , arranged in the configuration [Xe] 4f145d16s2 . When entering a chemical reaction , the atom loses its two outermost electrons and the single 5d @-@ electron ; this is unusual since reactions of the other lanthanides invariably involve f @-@ shell electrons . The lutetium atom is the smallest among the lanthanide atoms , due to the lanthanide contraction , and as a result lutetium has the highest density , melting point , and hardness of the lanthanides . Some of these properties can be explained by its position in the d @-@ block , which gives the metal properties of some heavier transition metals . Occasionally , lutetium is classified as a transition metal on this basis , although the IUPAC classifies it as a lanthanide .

= = = Chemical properties and compounds = = =

Lutetium 's compounds always contain the element in the oxidation state + 3 . Aqueous solutions of most lutetium salts are colorless and form white crystalline solids upon drying , with the common exception of the iodide . The soluble salts , such as nitrate , sulfate and acetate form hydrates upon crystallization . The oxide , hydroxide , fluoride , carbonate , phosphate and oxalate are insoluble in water .

Lutetium metal is slightly unstable in air at standard conditions , but it burns readily at 150 ° C to form lutetium oxide . The resulting compound is known to absorb water and carbon dioxide , and may be used to remove vapors of these compounds from closed atmospheres . Similar observations are made during reaction between lutetium and water (slow when cold and fast when hot) ; lutetium hydroxide is formed in the reaction . Lutetium metal is known to react with the four lightest halogens to form trihalides ; all of them (except the fluoride) are soluble in water .

Lutetium dissolves readily in weak acids and dilute sulfuric acid to form solutions containing the colorless lutetium ions , which are coordinated by between seven and nine water molecules , the

average being [Lu (H₂O) 8 @. @ 2] 3 + .
 $2 \text{ Lu} + 3 \text{ H}_2\text{SO}_4 \rightarrow 2 \text{ Lu}_2\text{O}_3 + 3 \text{ SO}_2 + 4 \text{ H}_2\text{O}$

== Isotopes ==

Lutetium occurs on the Earth in form of two isotopes : lutetium @-@ 175 and lutetium @-@ 176 . Out of these two , only the former is stable , making the element monoisotopic . The latter one , lutetium @-@ 176 , decays via beta decay with a half @-@ life of 3 @. @ 78 × 10¹⁰ years ; it makes up about 2 @. @ 5 % of natural lutetium . To date , 32 synthetic radioisotopes of the element have been characterized , ranging in mass from 149 @. @ 973 (lutetium @-@ 150) to 183 @. @ 961 (lutetium @-@ 184) ; the most stable such isotopes are lutetium @-@ 174 with a half @-@ life of 3 @. @ 31 years , and lutetium @-@ 173 with a half @-@ life of 1 @. @ 37 years . All of the remaining radioactive isotopes have half @-@ lives that are less than 9 days , and the majority of these have half @-@ lives that are less than half an hour . Isotopes lighter than the stable lutetium @-@ 175 decay via electron capture (to produce isotopes of ytterbium) , with some alpha and positron emission ; the heavier isotopes decay primarily via beta decay , producing hafnium isotopes .

The element also has 42 nuclear isomers , with masses of 150 , 151 , 153 ? 162 , 166 ? 180 (not every mass number corresponds to only one isomer) . The most stable of them are lutetium @-@ 177m , with half @-@ life of 160 @. @ 4 days and lutetium @-@ 174m , with half @-@ life of 142 days ; this is longer than half @-@ lives of the ground states of all radioactive lutetium isotopes , except only for lutetium @-@ 173 , 174 , and 176 .

== History ==

Lutetium , derived from the Latin Lutetia (Paris) , was independently discovered in 1907 by French scientist Georges Urbain , Austrian mineralogist Baron Carl Auer von Welsbach , and American chemist Charles James . They found it as an impurity in ytterbia , which was thought by Swiss chemist Jean Charles Galissard de Marignac to consist entirely of ytterbium . The scientists proposed different names for the elements : Urbain chose neoytterbium and lutecium , whereas Welsbach chose aldebaranium and cassiopeium (after Aldebaran and Cassiopeia) . Both of these articles accused the other man of publishing results based on those of the author .

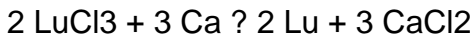
The International Commission on Atomic Weights , which was then responsible for the attribution of new element names , settled the dispute in 1909 by granting priority to Urbain and adopting his names as official ones , based on the fact that the separation of lutetium from Marignac 's ytterbium was first described by Urbain ; after Urbain 's names were recognized , neoytterbium was reverted to ytterbium . Until the 1950s , some German @-@ speaking chemists called lutetium by Welsbach 's name , cassiopeium ; in 1949 , the spelling of element 71 was changed to lutetium . However , Welsbach 's 1907 samples of lutetium had been pure , while Urbain 's 1907 samples only contained traces of lutetium . This later misled Urbain into thinking that he had discovered element 72 , which he named celtium , which was actually very pure lutetium . Charles James , who stayed out of the priority argument , worked on a much larger scale and possessed the largest supply of lutetium at the time . Pure lutetium metal was first produced in 1953 .

== Occurrence and production ==

Found with almost all other rare @-@ earth metals but never by itself , lutetium is very difficult to separate from other elements . The principal commercially viable ore of lutetium is the rare earth phosphate mineral monazite : (Ce , La , etc .) PO₄ which contains 0 @. @ 0001 % of the element . The abundance of lutetium in the Earth crust is only about 0 @. @ 5 mg / kg . The main mining areas are China , United States , Brazil , India , Sri Lanka and Australia . The world production of lutetium (in the form of oxide) is about 10 tonnes per year . Pure lutetium metal is very difficult to prepare . It is one of the rarest and most expensive of the rare earth metals with the price about US \$ 10 @, @

000 per kilogram , or about one @-@ fourth that of gold .

Crushed minerals are treated with hot concentrated sulfuric acid to produce water @-@ soluble sulfates of rare earths . Thorium precipitates out of solution as hydroxide and is removed . After that the solution is treated with ammonium oxalate to convert rare earths into their insoluble oxalates . The oxalates are converted to oxides by annealing . The oxides are dissolved in nitric acid that excludes one of the main components , cerium , whose oxide is insoluble in HNO_3 . Several rare earth metals , including lutetium , are separated as a double salt with ammonium nitrate by crystallization . Lutetium is separated by ion exchange . In this process , rare @-@ earth ions are sorbed onto suitable ion @-@ exchange resin by exchange with hydrogen , ammonium or cupric ions present in the resin . Lutetium salts are then selectively washed out by suitable complexing agent . Lutetium metal is then obtained by reduction of anhydrous LuCl_3 or LuF_3 by either an alkali metal or alkaline earth metal .



= = Applications = =

Because of the rarity and high price , lutetium has very few commercial uses . However , stable lutetium can be used as catalysts in petroleum cracking in refineries and can also be used in alkylation , hydrogenation , and polymerization applications .

Lutetium aluminium garnet ($\text{Al}_5\text{Lu}_3\text{O}_{12}$) has been proposed for use as a lens material in high refractive index immersion lithography . Additionally , a tiny amount of lutetium is added as a dopant to gadolinium gallium garnet (GGG) , which is used in magnetic bubble memory devices . Cerium @-@ doped lutetium oxyorthosilicate (LSO) is currently the preferred compound for detectors in positron emission tomography (PET) . Lutetium is used as a phosphor in LED light bulbs .

Aside from stable lutetium , its radioactive isotopes have several specific uses . The suitable half @-@ life and decay mode made lutetium @-@ 176 used as a pure beta emitter , using lutetium which has been exposed to neutron activation , and in lutetium ? hafnium dating to date meteorites . The synthetic isotope lutetium @-@ 177 bound to octreotate (a somatostatin analogue) , is used experimentally in targeted radionuclide therapy for neuroendocrine tumors . Indeed , lutetium @-@ 177 is seeing increasing use as a radionuclide , in neuroendocrine tumor therapy and bone pain palliation .

Lutetium tantalate (LuTaO_4) is the densest known stable white material (density 9 @-@ 81 g / cm^3) and therefore is an ideal host for X @-@ ray phosphors . The only denser white material is thorium dioxide , with density of 10 g / cm^3 , but the thorium it contains is radioactive .

= = Precautions = =

Like other rare @-@ earth metals , lutetium is regarded as having a low degree of toxicity , but its compounds should be handled with care nonetheless : for example , lutetium fluoride inhalation is dangerous and the compound irritates skin . Lutetium nitrate may be dangerous as it may explode and burn once heated . Lutetium oxide powder is toxic as well if inhaled or ingested .

Similarly to other group 3 elements and lanthanides , lutetium has no known biological role , but it is found even in humans , concentrating in bones , and to a lesser extent in the liver and kidneys . Lutetium salts are known to occur together with other lanthanide salts in nature ; the element is the least abundant in the human body of all lanthanides . Human diets have not been monitored for lutetium content , so it is not known how much the average human takes in , but estimations show the amount is only about several micrograms per year , all coming from tiny amounts taken by plants . Soluble lutetium salts are mildly toxic , but insoluble ones are not .