

Lanthanum

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Lanthanum is a soft, ductile, silvery-white metallic chemical element with symbol **La** and atomic number 57. It tarnishes rapidly when exposed to air and is soft enough to be cut with a knife. It is the eponym of the lanthanide series, a group of 15 similar elements between lanthanum and lutetium in the periodic table, of which lanthanum is the first and the prototype. It is also sometimes considered the first element of the 6th-period transition metals and is traditionally counted among the rare earth elements. The usual oxidation state is +3. Lanthanum has no biological role and is not very toxic.

Lanthanum usually occurs together with cerium and the other rare earth elements. Lanthanum was first found by the Swedish chemist Carl Gustav Mosander in 1839 as an impurity in cerium nitrate – hence the name *lanthanum*, from the Ancient Greek *λανθάνειν* (*lanthanein*), meaning "to lie hidden". Although it is classified as a rare earth element, lanthanum is the 28th most abundant element in the Earth's crust, almost three times as abundant as lead. In minerals such as monazite and bastnäsite, lanthanum composes about a quarter of the lanthanide content.^[3] It is extracted from those minerals by a process of such complexity that pure lanthanum metal was not isolated until 1923.

Lanthanum compounds have numerous applications as catalysts, additives in glass, carbon arc lamps for studio lights and projectors, ignition elements in lighters and torches, electron cathodes, scintillators, GTAW electrodes, and other things. Lanthanum carbonate is used as a phosphate binder cases of renal failure.

Characteristics

Physical

Lanthanum is the first element and prototype of the lanthanide series.^[a] In the periodic table, it appears to the right of the alkaline earth metal barium and to the left of the lanthanide cerium. Lanthanum is often considered to be a group 3 element, along with its lighter congeners scandium and yttrium and its heavier

Lanthanum, ⁵⁷La



General properties

Name, symbol	lanthanum, La
Appearance	silvery white

Lanthanum in the periodic table

Atomic number (Z)	57
Group, block	group n/a, f-block
Period	period 6
Element category	☐ lanthanide, sometimes considered a transition metal
Standard atomic weight (\pm) (A_r)	138.90547(7) ^[1]
Electron configuration	[Xe] 5d ¹ 6s ²
per shell	2, 8, 18, 18, 9, 2

Physical properties

congener, the radioactive actinium,^[5] although this classification is sometimes disputed. Similarly to scandium, yttrium, and actinium, the 57 electrons of a lanthanum atom are arranged in the configuration $[\text{Xe}]5d^16s^2$, with three valence electrons outside the noble gas core. In chemical reactions, lanthanum almost always gives up these three valence electrons from the 5d and 6s subshells to form the +3 oxidation state, achieving the stable configuration of the preceding noble gas xenon.^[6] Some lanthanum(II) compounds are also known, but they are much less stable.^[7]

Among the lanthanides, lanthanum is exceptional as it does not have any 4f electrons; indeed, the sudden contraction and lowering of energy of the 4f orbital that is important for the chemistry of the lanthanides only begins to happen at cerium. Thus it is only very weakly paramagnetic, unlike the strongly paramagnetic later lanthanides (with the exceptions of the last two, ytterbium and lutetium, where the 4f shell is completely full).^[8] Furthermore, since the melting points of the trivalent lanthanides are related to the extent of hybridisation of the 6s, 5d, and 4f electrons, lanthanum has the second-lowest (after cerium) melting point among all the lanthanides: 920 °C.^[9] The lanthanides become harder as the series is traversed: as expected, lanthanum is a soft metal. Lanthanum has a relatively high resistivity of 615 nΩm at room temperature; in comparison, the value for the good conductor aluminium is only 26.50 nΩm.^{[10][11]} Lanthanum is the least volatile of the lanthanides.^[12] Like most of the lanthanides, lanthanum has a hexagonal crystal structure at room temperature. At 310 °C, lanthanum changes to a face-centered cubic structure, and at 865 °C, it changes to a body-centered cubic structure.^[11]

Chemical

As expected from periodic trends, lanthanum has the largest atomic radius of the lanthanides and the stable group 3 elements. Hence, it is the most reactive among them, tarnishing slowly in air and burning readily to form lanthanum(III) oxide, La_2O_3 , which is almost as basic as calcium oxide.^[13] A centimeter-sized sample of lanthanum will corrode completely in a year as its oxide spalls off like iron rust, instead of forming a protective oxide coating like aluminium and lanthanum's lighter

Phase	solid
Melting point	1193 K (920 °C, 1688 °F)
Boiling point	3737 K (3464 °C, 6267 °F)
Density near r.t.	6.162 g/cm ³
when liquid, at m.p.	5.94 g/cm ³
Heat of fusion	6.20 kJ/mol
Heat of vaporization	400 kJ/mol
Molar heat capacity	27.11 J/(mol·K)

Vapor pressure (extrapolated)

P (Pa)	1	10	100	1 k	10 k	100 k
at T (K)	2005	2208	2458	2772	3178	3726

Atomic properties

Oxidation states	3 , 2, 1 (a strongly basic oxide)
Electronegativity	Pauling scale: 1.10
Ionization energies	1st: 538.1 kJ/mol 2nd: 1067 kJ/mol 3rd: 1850.3 kJ/mol
Atomic radius	empirical: 187 pm
Covalent radius	207±8 pm

Miscellanea

Crystal structure	double hexagonal close-packed (dhcp)
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Speed of sound thin rod	2475 m/s (at 20 °C)
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Thermal	α, poly: 12.1 μm/(m·K)
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congeners scandium and yttrium.^[14] Lanthanum reacts with the halogens at room temperature to form the trihalides, and upon warming will form binary compounds with the nonmetals nitrogen, carbon, sulfur, phosphorus, boron, selenium, silicon and arsenic.^{[6][7]} Lanthanum reacts slowly with water to form lanthanum(III) hydroxide, La(OH)₃.^[15] In dilute sulfuric acid, lanthanum readily forms the aquated tripositive ion [La(H₂O)₉]³⁺: this is colorless in aqueous solution since La³⁺ has no f electrons.^[15] Lanthanum is the strongest and hardest base among the lanthanides and group 3 elements, which is again expected from its being the largest of them.^[16]

Isotopes

Naturally occurring lanthanum is made up of two isotopes, the stable ¹³⁹La and the primordial long-lived radioisotope ¹³⁸La. ¹³⁹La is by far the most abundant, making up 99.910% of natural lanthanum: it is produced in the s-process (slow neutron capture, which occurs in low- to medium-mass stars) and the r-process (rapid neutron capture, which occurs in core-collapse supernovae).^[17] The very rare isotope ¹³⁸La is one of the few primordial odd-odd nuclei, with a long half-life of 1.05×10¹¹ years: it is one of the proton-rich p-nuclei which cannot be produced in the s- or r-processes. ¹³⁸La, along with the even rarer ^{180m}Ta, is produced in the ν-process, where neutrinos interact with stable nuclei.^[18] All other lanthanum isotopes are synthetic: with the exception of ¹³⁷La with a half-life of about 60,000 years, all of them have half-lives less than a day, and most have half-lives less than a minute. The isotopes ¹³⁹La and ¹⁴⁰La occur as fission products of uranium.^[17]

Position in the periodic table

Traditionally, from the 1940s, lanthanum has been placed under scandium and yttrium in group 3 of the periodic table, as its differentiating electron from the previous element goes into a d-orbital. This results in a consistent set of electron configurations in group 3 (Sc: [Ar]3d¹4s²; Y: [Kr]4d¹5s²; La: [Xe]5d¹6s²). However, this position has sometimes been disputed, on the grounds that yttrium and to a lesser extent scandium are closer in their chemical properties to lutetium than lanthanum. Indeed, early

expansion	(at r.t.)
Thermal conductivity	13.4 W/(m·K)
Electrical resistivity	α, poly: 615 nΩ·m (at r.t.)
Magnetic ordering	paramagnetic ^[2]
Young's modulus	α form: 36.6 GPa
Shear modulus	α form: 14.3 GPa
Bulk modulus	α form: 27.9 GPa
Poisson ratio	α form: 0.280
Mohs hardness	2.5
Vickers hardness	360–1750 MPa
Brinell hardness	350–400 MPa
CAS Number	7439-91-0

History

Discovery Carl Gustaf Mosander (1838)

Most stable isotopes of lanthanum

iso	NA	half-life	DM	DE (MeV)	DP
¹³⁷ La	syn	6×10 ⁴ y	ε	0.600	¹³⁷ Ba
¹³⁸ La	0.089%	1.05×10 ¹¹ y	ε	1.737	¹³⁸ Ba
			β [−]	1.044	¹³⁸ Ce
¹³⁹ La	99.911%	is stable with 82 neutrons			

techniques on separating the rare earths relied on the distinction between the early lanthanides in the cerium group (whose sodium double sulfates dissolve in water with difficulty) and the late ones (as well as yttrium) in the yttrium group (whose sodium double sulfates are very water-soluble), prompting some researchers in the 1920s and 1930s to place lutetium under yttrium instead. Since the differentiating electron between ytterbium and lutetium also goes into a d-orbital, both lutetium and lanthanum appear by this argument as equally valid candidates for being the third member of group 3.^[19]

Many of the discrepancies between lanthanum and the lighter group 3 elements can simply be explained by its larger size, as expected from periodic trends, as it precedes the lanthanide contraction that makes the early period 6 transition metals so similar to their period 5 homologs.^[20] This phenomenon, based on the poor shielding of nuclear charge by the 4f electrons that are added across the lanthanide series, results in a decrease of ionic and atomic radii across the lanthanide series, causing the early period 6 transition metals (just after the lanthanides) until about rhenium to be very similar to their period 5 homologs. This same effect makes yttrium more similar to lutetium ($[\text{Xe}]4f^{14}5d^16s^2$) than lanthanum. However, scandium still shows many differences from lutetium because it is even smaller, and in any case the similarity of yttrium is more generally to all of the late lanthanides from gadolinium onward, especially holmium which has almost the same ionic radius.^[21] Unlike all the other lanthanides, no lanthanum ions have any electrons in f-orbitals (La^+ : $[\text{Xe}]5d^2$; La^{2+} : $[\text{Xe}]5d^1$; La^{3+} : $[\text{Xe}]$),^[22] and in lanthanum metal the f-orbitals are not involved in metallic bonding. This casts some doubt on lanthanum's placement in the f-block, as would be suggested by a table placing lutetium in group 3.^[23]

The trends going down from scandium and yttrium to lanthanum tend to be more similar to those going down groups 1 and 2 in the periodic table, while those going down from scandium and yttrium to lutetium tend to be more similar to those in the early transition metals. Since Sc^{3+} , Y^{3+} , and La^{3+} still have a low enough charge for their compounds to be predominantly ionic, unlike Ti^{4+} , Zr^{4+} , and Hf^{4+} , it has been argued that lanthanum and the rest of group 3 should be considered at best atypical transition metals, as their chemistry is focused on the predominantly ionic +3 state and they have a low ability to form coordination compounds or organometallic compounds. Indeed, lanthanum is a strongly electropositive metal, comparable to calcium in electropositivity.^[20] The rare earth metals in general are more similar in reactivity to the alkaline earth metals that immediately precede them than to the transition metals proper which follow them.^[21]

Bibliography

- Wikipedia: Lanthanum

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