

The Lanthanides: Lanthanum through Ytterbium

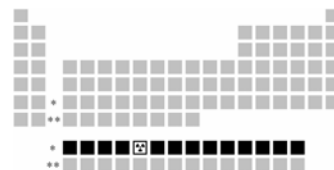


Table L.2 Ground electronic configurations of the lanthanides

Element	Symbol	Atomic number	Electronic Configuration
Lanthanum	La	57	[Xe] 4f ⁰ 5d ¹ 6s ²
Cerium	Ce	58	[Xe] 4f ¹ 5d ¹ 6s ²
Praseodymium	Pr	59	[Xe] 4f ³ 6s ²
Neodymium	Nd	60	[Xe] 4f ⁴ 6s ²
Promethium	Pm	61	[Xe] 4f ⁵ 6s ²
Samarium	Sm	62	[Xe] 4f ⁶ 6s ²
Europium	Eu	63	[Xe] 4f ⁷ 6s ²
Gadolinium	Gd	64	[Xe] 4f ⁷ 5d ¹ 6s ²
Terbium	Tb	65	[Xe] 4f ⁹ 6s ²
Dysprosium	Dy	66	[Xe] 4f ¹⁰ 6s ²
Holmium	Ho	67	[Xe] 4f ¹¹ 6s ²
Erbium	Er	68	[Xe] 4f ¹² 6s ²
Thulium	Tm	69	[Xe] 4f ¹³ 6s ²
Ytterbium	Yb	70	[Xe] 4f ¹⁴ 6s ²
Lutetium	Lu	71	[Xe] 4f ¹⁴ 5d ¹ 6s ²

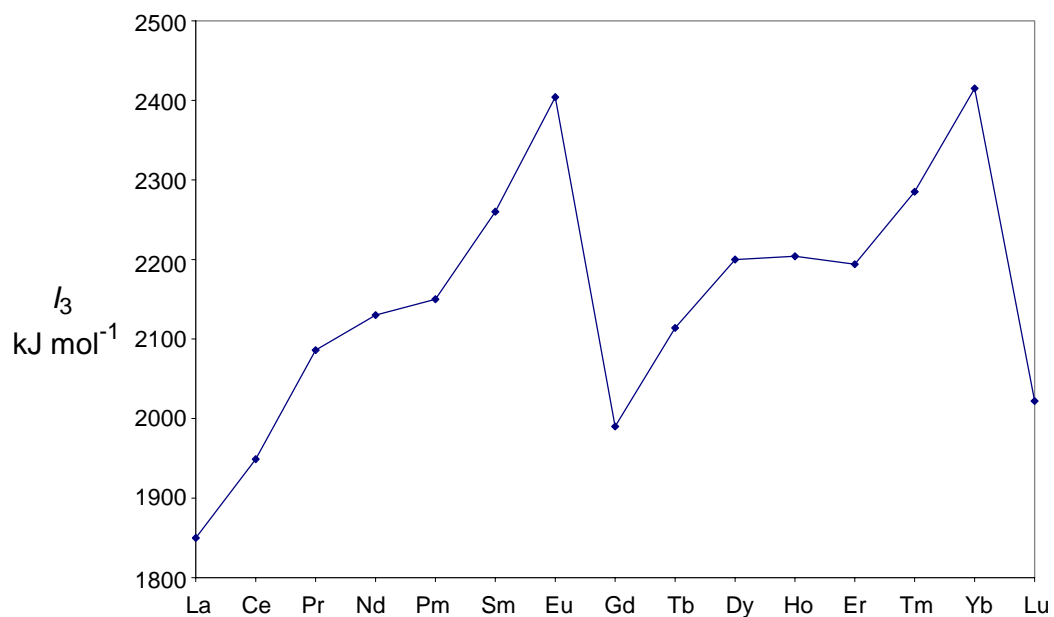


Figure L.1 The variation of the third ionization energy (I_3) of the lanthanides

Table L.3. Number of pairs of parallel spins for the f^n configurations.

Configuration	m	δm^*	Configuration	m	δm^*	
f^1		0	0	f^8	21	0
f^2		1	1	f^9	22	1
f^3		3	2	f^{10}	24	2
f^4		6	3	f^{11}	27	3
f^5		10	4	f^{12}	31	4
f^6		15	5	f^{13}	36	5
f^7		21	6	f^{14}	42	6

* δm refers to the number of pairs of parallel spins lost for the process $f^n \rightarrow f^{n-1}$

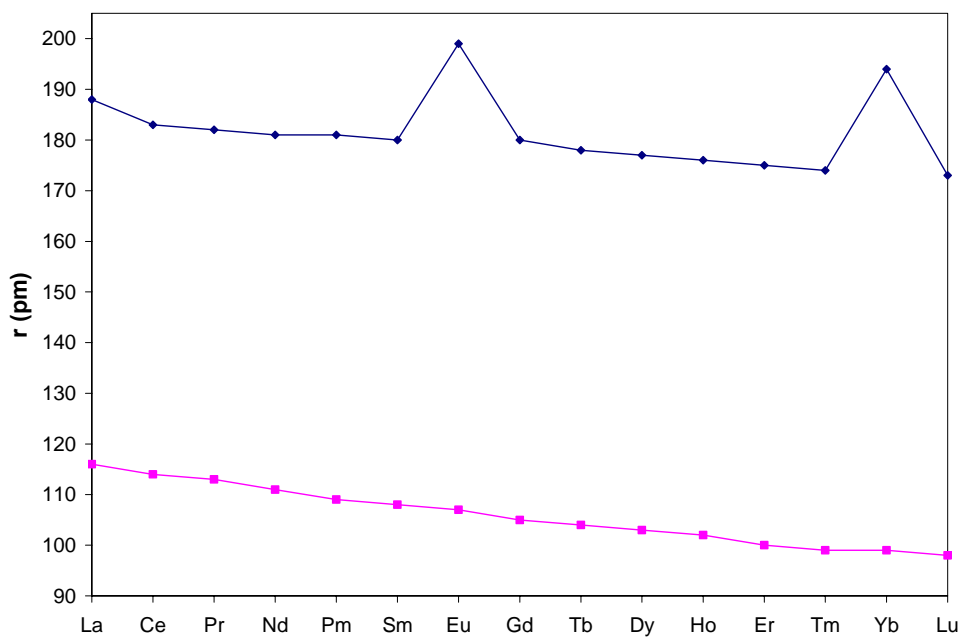


Figure L.2 Variation of metal radius and +3 ionic radius for the lanthanide elements

Table L.4. Summary of the properties of Ln^{III} ions.

Ln ³⁺	4f ⁿ	ground level	color	g [J(J+1)] ^{1/2}	Observed
La	0		colorless		0
Ce	1		colorless		2.3-2.5
Pr	2		green		3.4-3.6
Nd	3	⁴ I _{9/2}	lilac	3.62	3.5-3.6
Pm	4		pink		-
Sm	5		yellow		1.4-1.7
Eu	6		pale pink		3.3-3.5
Gd	7		colorless		7.9-8.0
Tb	8		pale pink		9.5-9.8
Dy	9		yellow		10.4-10.6
Ho	10		yellow		10.4-10.7
Er	11		rose-pink		9.4-9.6
Tm	12		pale green		7.1-7.5
Yb	13	² F _{7/2}	colorless	4.54	4.3-4.9
Lu	14	¹ S ₀	colorless	0	0

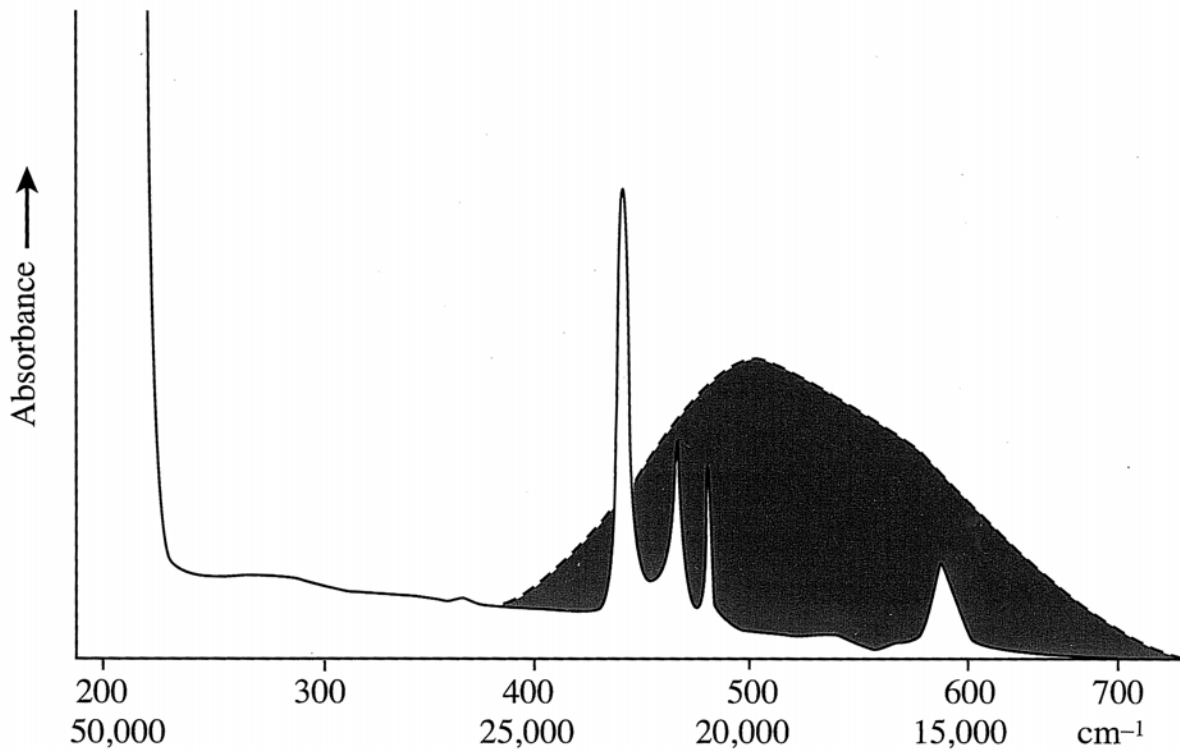


Figure L.3 The electronic spectrum of Pr³⁺ (solid line) and Ti³⁺ (broken line). Like d-d transitions, f-f transitions are Laporte-forbidden and give weak absorptions.

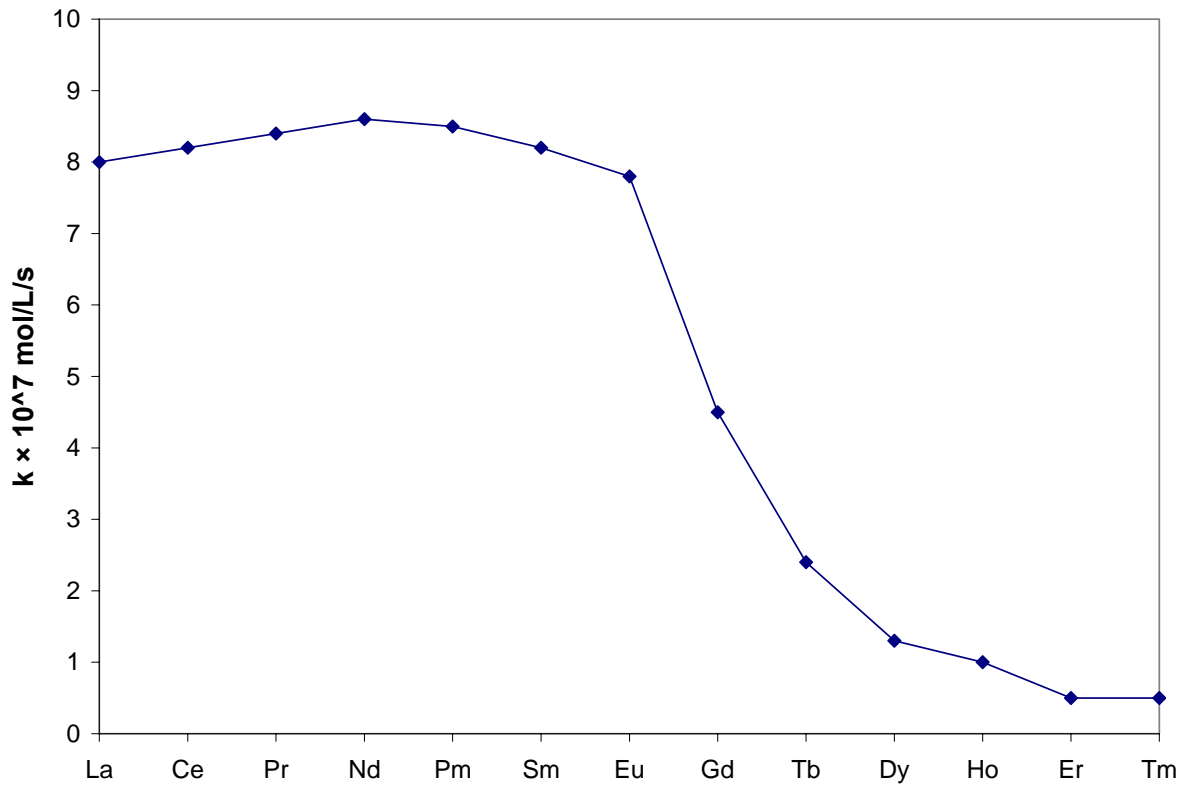


Figure L.4 Rate constants for the formation of 1:1 Ln^{3+} /oxalate complexes at 25°C.

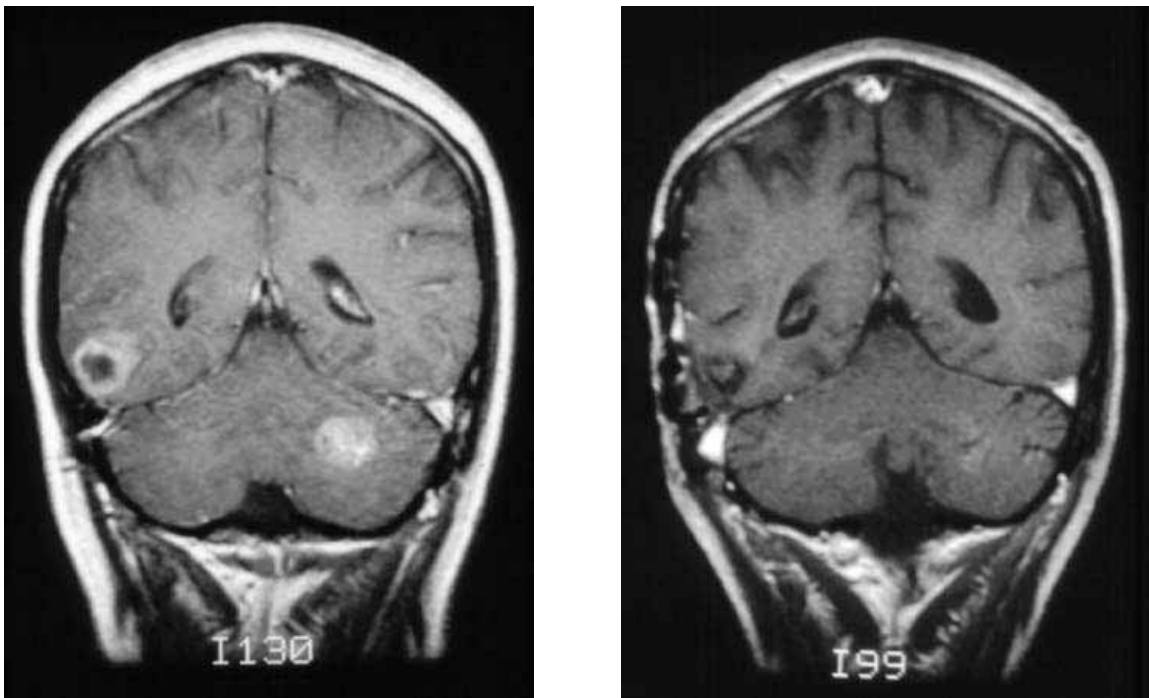


Figure L.5. MRI scans with Gd enhancement before and after surgery and radiotherapy. The follow-up study shows only minimal enhancement in the left cerebellar region, consistent with almost complete disappearance of the tumor mass.

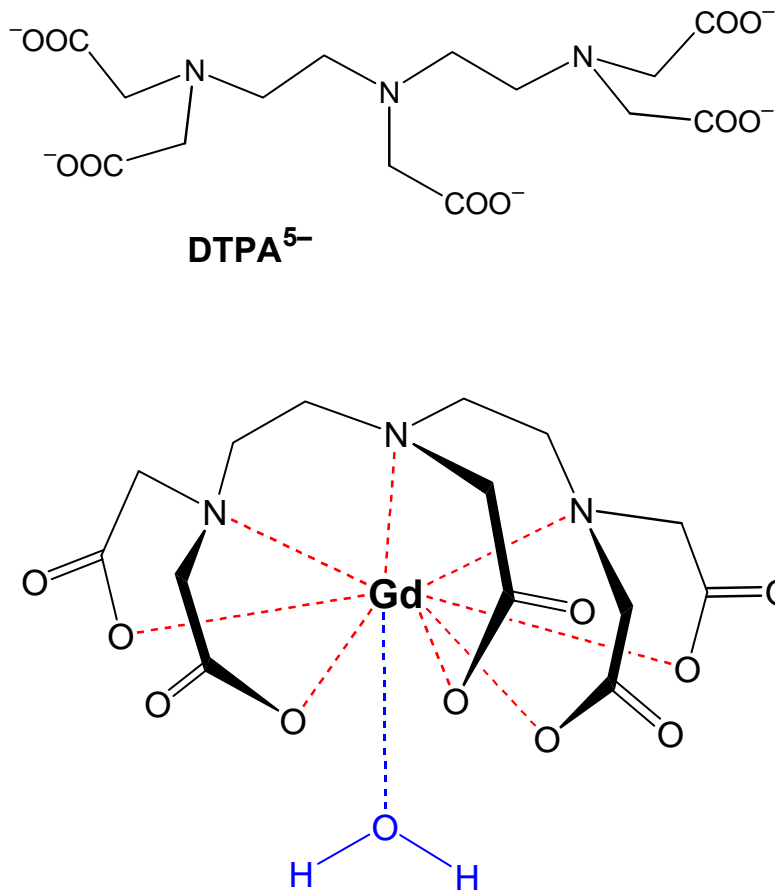


Figure L.6. The free DTPA⁵⁻ ligand, and its gadolinium complex. Note the additional coordination site available for water to bind to.

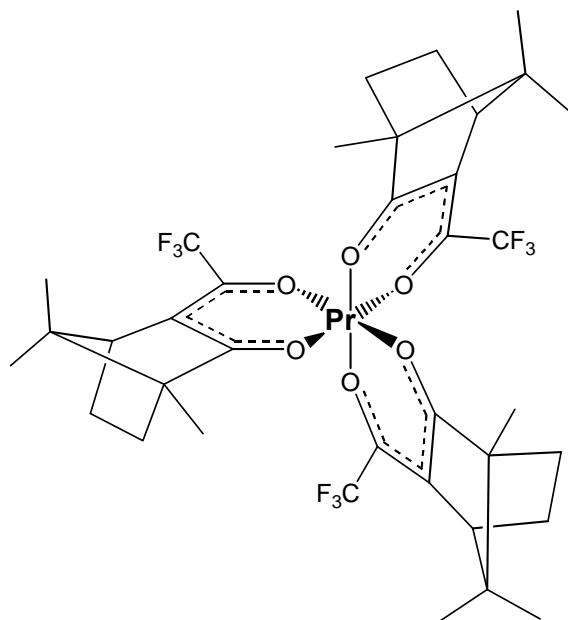


Figure L.7. Chiral praseodymium complex with three β -diketonate ligands. Eu³⁺ and Pr³⁺ complexes are often used because their electronic relaxation times are very short, reducing line-broadening for the nucleus under study (usually ¹H).