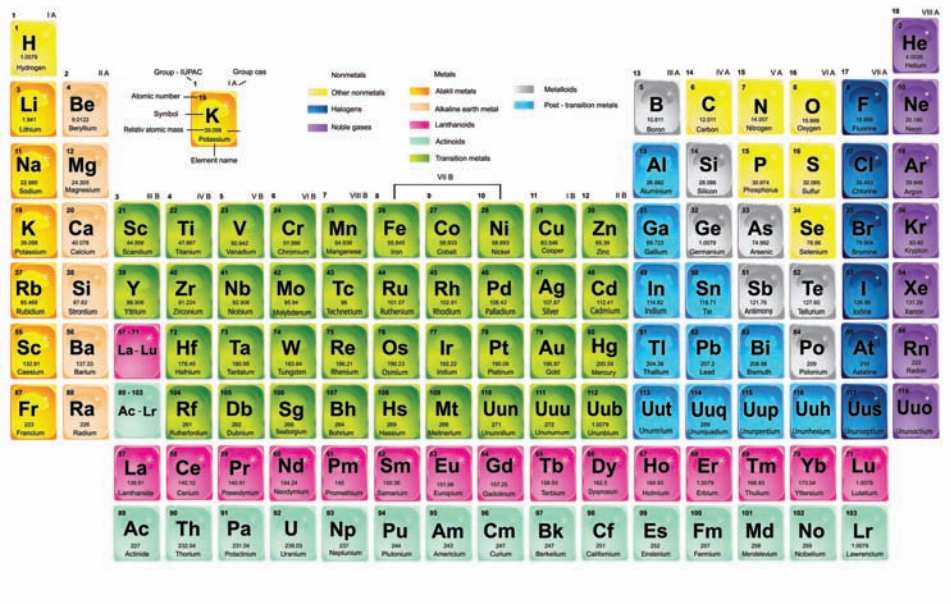
ICP Periodic Table Guide



Inorganic Ventures has over twenty-five years experience specializing in the manufacturing of inorganic certified reference materials (CRMs) and nearly a decade accredited to ISO 17025 & ISO Guide 34 by A2LA. This singular focus has enhanced the quality of our manufacturing, the depth of our technical support and the caliber of our customer service.

The pursuit of excellence in these areas has lead to the creation of the ICP Periodic Table Guide. This guide includes essential data for 70+ elements for every ICP user. Analytical data includes chemical compatibilities, preferred emission lines, as well as major interferences and detection limits for both ICP and ICP-MS. Learn more about solubility issues in different acid matrices, storage and handling tips, and the long-term stability of elements at different concentrations.

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Table of Contents

Lithium

3 6.941
1342 1.0
180.7
Li
[He]2s
0.534 1

Location: Group 1, Period 2
Atomic Weight: 6.941
Coordination Number: (6)
Chemical Form in Solution: Li^{+}(aq) (large effective radius due to hydration sphere) (coordination number in parentheses is assumed, not certain)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4, and HF aqueous matrices. Stable with all metals and inorganic anions.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Li Containing Samples (Preparation & Solution): Metal (dissolves very rapidly in water); Ores (sodium carbonate fusion in Pt^0 followed by HCl dissolution - blank levels of Li in sodium carbonate critical); Organic Matrices (sulfuric / peroxide digestion or nitric / sulfuric / perchloric acid decomposition).

Atomic Spectroscopic Information: (*italic text* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 670.784 nm	0.002/.00002 µg/mL	1	atom	**
ICP-OES 460.286 nm	0.9/.04 µg/mL	1	atom	Zr, Th
ICP-OES 323.261 nm	1.1/.05 µg/mL	1	atom	*Sb, Th, Ni*
ICP-MS 7 amu	10 ppt	n/a	M+	

*ICP-OES D.L.'s are given as radial / axial view
**2nd order radiation from R.E.s on some optical designs

Beryllium

4 9.012
2472 1.5
1287
Be
[He]2s²
1.85 2

Location: Group 2, Period 2
Atomic Weight: 9.01218
Coordination Number: 4
Chemical Form in Solution: $Be^{+}(H_2O)_4^{+2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4 and HF aqueous matrices. Stable with all metals and inorganic anions.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 5-10% HNO_3 / LDPE container.

Be Containing Samples (Preparation & Solution): Metal (is best dissolved in diluted H_2SO_4); BeO (boiling nitric, hydrochloric, or sulfuric acids or $KHSO_4$ fusion); Ores (H_2SO_4/HF digestion or carbonate fusion in Pt^0); Organic Matrices (sulfuric / peroxide digestion or nitric / sulfuric / perchloric acid decomposition, or dry ash and dissolution according to the BeO procedure above).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 313.042 nm	0.0003/.00009 µg/mL	1	ion	V, Ce, U
ICP-OES 234.861 nm	0.0003/.00016 µg/mL	1	atom	Fe, Ta, Mo
ICP-OES 313.107 nm	0.0007/.0005 µg/mL	1	ion	Ce, Th, Tm
ICP-MS 9 amu	4 ppt	n/a	M+	

*ICP-OES D.L.'s are given as radial / axial view

Boron

5 10.81
4002 2.0
2027
B
[He]2s²2p
2.34 3

Location: Group 13, Period 2
Atomic Weight: 10.811
Coordination Number: 4
Chemical Form in Solution: $B(OH)_3$ and $B(OH)_4^{-1}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Moderately soluble in HCl, HNO_3, H_2SO_4 and HF aqueous matrices and very soluble in NH_4OH. Stable with all metals and inorganic anions at low to moderate ppm levels.

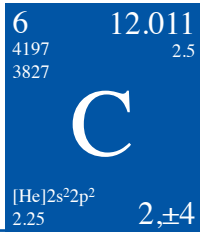
Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-1,000 ppm solutions chemically stable for years in 1% HNO_3 / LDPE container. 1000-10,000 ppm stable for years in dilute NH_4OH / LDPE container.

B Containing Samples (Preparation & Solution): Metal (crystalline form is scarcely attacked by acids or alkaline solutions; amorphous form is soluble in conc. HNO_3 or H_2SO_4); $B(OH)_3$ (water soluble); Ores (avoid acid digestions and use caustic fusions in Pt^0); Organic Matrices (dry ash mixed with Na_2CO_3 in Pt^0 at 450°C then increase heat to 1000°C to fuse; or perform a Na_2O_2 fusion in a Ni^0 crucible / Parr bomb).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 249.773 nm	0.003/.001 µg/mL	1	atom	W, Ce, Co, Th, Ta, Mn, Mo, Fe
ICP-OES 249.678 nm	0.004/.003 µg/mL	1	atom	Os, W, Co, Cr, Hf
ICP-OES 208.959 nm	0.007/.0005 µg/mL	1	atom	Mo
ICP-MS 11 amu	700 ppt	n/a	M+	

*ICP-OES D.L.'s are given as radial / axial view



Carbon

Location: Group 14, Period 2
Atomic Weight: 12.011
Coordination Number: 4
Chemical Form in Solution: (Carbon standard is made using Tartaric Acid)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Moderately soluble in HCl, HNO_3, H_2SO_4, and HF aqueous matrices and very soluble in NH_4OH. Stable with all metals and inorganic anions at low to moderate ppm levels. Do not dilute or store Carbon standards using plastic containers or similar devices.

Stability: 2-100 ppb level stability unknown. 1000-10,000 ppm level stable for years in dilute acidic media in a glass container.

C Containing Samples (Preparation & Solution): elemental amorphic or graphitic carbon (Oxidative closed vessel fusion such as a Na_2O_2 fusion in a sealed Ni^0 crucible / Parr bomb); H_2CO_3 (water soluble); Organic Compounds (water solubility is best if possible, or perform a Na_2O_2 fusion in a sealed Ni^0 crucible / Parr bomb).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 193.091 nm	0.05/.005 µg/mL	1	atom	In, Ru, Mn
ICP-OES 247.856 nm	0.2/.02 µg/mL	1	atom	Nb, V, Ti
ICP-MS 12 amu	(uncertain)	n/a	M+	

*ICP-OES D.L.'s are given as radial / axial view

Sodium

11 22.990
883 1.0
98.0
Na
[Ne]3s
0.971 1

Location: Group 1, Period 3
Atomic Weight: 22.98977
Coordination Number: (6)
Chemical Form in Solution: Na^{+}(aq) (largely ionic in nature)
(coordination number in parentheses is assumed, not certain)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4 and HF aqueous matrices. Stable with all metals and inorganic anions.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Na Containing Samples (Preparation & Solution): Metal (dissolves very rapidly in water); Ores (lithium carbonate fusion in graphite crucible followed by HCl dissolution - blank levels of Na in lithium carbonate critical); Organic Matrices (sulfuric / peroxide digestion or nitric / sulfuric / perchloric acid decomposition).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 589.595 nm	0.07/.00009 µg/mL	1	atom	**
ICP-OES 588.995 nm	0.03/.006 µg/mL	1	atom	**
ICP-OES 330.237 nm	2.0/.09 µg/mL	1	atom	*Pd, Zn*
ICP-MS 23 amu	310 ppt	n/a	M+	$^{46}Ti^{+2}$, $^{46}Ca^{+2}$

*ICP-OES D.L.'s are given as radial / axial view
**2nd order radiation from R.E.s on some optical designs

12 24.305
1090 1.2
649
Mg
[Ne]2s²
1.738 2

Magnesium

Location: Group 2, Period 3
Atomic Weight: 24.305
Coordination Number: 6
Chemical Form in Solution: $Mg(H_2O)_6^{+2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3 and H_2SO_4. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming insoluble silicates, carbonates, hydroxides, oxides, and tungstates in neutral and slightly acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-10% HNO_3 / LDPE container.

Mg Containing Samples (Preparation & Solution): Metal (best dissolved in diluted HNO_3); Oxide (readily soluble in above compatible aqueous acidic solutions); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (sulfuric / peroxide digestion or nitric / sulfuric / perchloric acid decomposition, or dry ash and dissolution in dilute HCl. Do not heat when dissolving to avoid precipitation of SiO_2).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 279.553 nm	0.0002/.00003 µg/mL	1	ion	Th
ICP-OES 280.270 nm	0.0003/.00005 µg/mL	1	ion	U, V
ICP-OES 285.213 nm	0.002/.00003 µg/mL	1	atom	U, Hf, Cr, Zr
ICP-MS 24 amu	42 ppt	n/a	M+	$^{7}Li^{17}O$, $^{48}Ti^{+2}$, $^{48}Ca^{+2}$

*ICP-OES D.L.'s are given as radial / axial view

13 26.982
2520 1.5
660.25
Al
[Ne]3s23p2
2.699 3

Aluminum

Location: Group 13, Period 3
Atomic Weight: 26.98154
Coordination Number: 6
Chemical Form in Solution: $Al(H_2O)_6^{+3}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, HF and H_2SO_4. Avoid neutral media. Soluble in strongly basic NaOH forming the $Al(OH)_4(H_2O)_2$1- species. Stable with most metals and inorganic anions. The phosphate is insoluble in water and only slightly soluble in acid.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Al Containing Samples (Preparation & Solution): Metal (is best dissolved in HCl/HNO_3); α- Al_2O_3 (Na_2CO_3 fusion in Pt^0); α- Al_2O_3 (soluble in acids such as HCl); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (sulfuric / peroxide digestion or nitric / sulfuric / perchloric acid decomposition, or dry ash and dissolution in dilute HCl.

Atomic Spectroscopic Information: (*italic text* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 394.401 nm	0.05/.006 µg/mL	1	atom	U, Ce
ICP-OES 396.152 nm	0.03/.006 µg/mL	1	atom	*Mo,* Zr, Ce
ICP-OES 167.078 nm	0.1/.009 µg/mL	1	ion	Fe
ICP-MS 27 amu	30 ppt	n/a	M+	$^{12}C^{15}N$, $^{13}C^{14}N$, $^{1}H^{12}C^{14}N$, $^{11}B^{16}O$, $^{54}Cr^{2+}$, $^{54}Fe^{2+}$

*ICP-OES D.L.'s are given as radial / axial view

14 28.086
3267 1.7
1412
Si
[Ne]3s²3p²
2.33 4

Silicon

Location: Group 14, Period 3
Atomic Weight: 28.0855
Coordination Number: 6
Chemical Form in Solution: $Si(OH)_x(F)_y^{2-}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HF, H_3PO_4, H_2SO_4, and HNO_3 as the $Si(OH)_x(F)_y^{2-}$. Avoid neutral to basic media. Unstable at ppm levels with metals that would pull F^- away (i.e. - do not mix with Alkaline or Rare Earths, or high levels of transition elements unless they are fluorinated). Stable with most inorganic anions with a tendency to hydrolyze forming silicic acid (silicic acid is soluble up to ~ 100 ppm in water) in all dilute acids except HF.

Stability: 2-100 ppb levels - stability unknown - (alone or mixed with all other metals) as the $Si(OH)_x(F)_y^{2-}$. 1-10,000 ppm single element solutions as the $Si(OH)_x(F)_y^{2-}$ chemically stable for years in 2-5% HNO_3 / trace HF in a LDPE container.

Si Containing Samples (Preparation & Solution): Metal (soluble in 1:1:1 H_2O / HF / HNO_3); Oxide - SiO_2, amorphic (dissolve by heating in 1:1:1 H_2O / HF / HNO_3); Oxide-quartz (fuse in Pt^0 with Na_2CO_3); Geological Samples (fuse in Pt^0 with Na_2CO_3 followed by HCl solution of the fuseate); Organic Matrices containing silicates and non volatile silicon compounds (dry ash at 450°C in Pt^0 and dissolve by gently warming with 1:1:1 H_2O / HF / H_2SO_4 or fuse / ash with Na_2CO_3 and dissolve fuseate with HCl / H_2O); Silicone Oils - dimethyl silicones depolymerize to form volatile monomer units when heated (measure directly in alcoholic KOH / xylene mixture where sample is treated first with the KOH at 60 - 100°C to "unzip" the Si-O-Si polymeric structure or digest with conc. H_2SO_4 / H_2O_2 followed by cooling and dissolution of the dehydrated silica with HF). Note that the direct analysis of silicone oils in an organic solvent will result in false high results due to high vapor pressure of volatile monomer units such as hexamethylcyclotrisiloxane. The KOH forms the $K_2^+Si(CH_3)_2O$=NaCl, which is not volatile at room temperature.

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 251.611 nm	0.012/.003 µg/mL	1	ion	Ta, U, Zn, Th
ICP-OES 212.412 nm	0.02/.01 µg/mL	1	ion	Hf, Os, *Mo,* Ta
ICP-OES 288.158 nm	0.03/.004 µg/mL	1	ion	*Ta,* Ce, Cr, Cd, Th
ICP-MS 28 amu	4000 - 8000 ppt	n/a	M+	$^{14}N_2$, $^{12}C^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Phosphorus

15
277
44.30
30.974
2.1
P
$[Ne]3s^2 3p^3$
1.82
±3,4,5

Location: Group 15, Period 3
Atomic Weight: 30.97376
Coordination Number: 6
Chemical Form in Solution: $OP(OH)_2(O)^{1-}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4, HF, water and NH_4OH. Stable with all metals and inorganic anions at low to moderate ppm levels under acidic conditions; precipitates with several metals occur in neutral media at higher concentrations.

Stability: 2-100 ppb levels - stability unknown - in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 0-1% HNO_3 / LDPE container.

P Containing Samples (Preparation & Solution): Metal (never found free in nature); Oxides (water soluble); Ores (naturally occurring only as the phosphate, except for a few rare minerals found in meteorites - Na_2CO_3 fusion in Pt^0); Organic Matrices (dry ash mixed with Na_2CO_3 in Pt^0 at 450°C then increase heat to 1000°C to fuse; or, perform a H_2SO_4 / H_2O_2 acid digestion).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 178.287 nm	0.03/.002 µg/mL	1	atom	I
ICP-OES 177.495 nm	0.01/.005 µg/mL	1	atom	Cu, Hf
ICP-OES 213.618 nm	0.08/.03 µg/mL	1	atom	*Cu, Mo*
ICP-MS 31 amu	6000+ ppt	n/a	M+	$^{15}N_2{}^1H$, $^{15}N^{16}O$, $^{14}N^{17}O$, $^{13}C^{18}O$, $^{12}C^{18}O^1H$, $^{62}Ni^{2+}$

*ICP-OES D.L.'s are given as radial / axial view

Sulfur

16
444.75
115.36
32.07
2.4
S
[Ne]3s²3p⁴
2.07
±2,4,6

Location: Group 16, Period 3
Atomic Weight: 32.066
Coordination Number: 6
Chemical Form in Solution: $(O)_2S(OH)_2$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_3PO_4, and HF aqueous matrices, water, and NH_4OH. Stable with all metals and inorganic anions at low to moderate ppm levels under acidic conditions, except Ba, Pb, Ca, and to a lesser extent Sr.

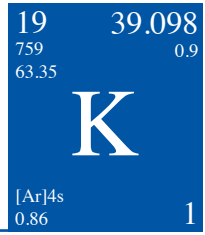
Stability: 2-100 ppb levels - stability unknown - in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in LDPE container.

S Containing Samples (Preparation & Solution): We most often get questions about the determination of S in rocks, silicates and insoluble sulfates (the finely powered sample is fused in a Pt^0 crucible with 6 times its weight of Na_2CO_3 + 0.5 grams KNO_3. The fuseate is extracted with water. Any $BaSO_4$ present in the sample is transposed by the carbonate fusion to the $BaCO_3$, which is left behind in the water-insoluble residue. If $PbSO_4$ is present, the fuseate should be boiled with a sodium carbonate saturated with CO_2 solution for 1 hour or more. The $PbSO_4$ will be transposed to the water insoluble carbonate which can be filtered off. Boiling the fuseate with a saturated carbonate solution is good insurance for samples containing Ba, Pb, Sr, and Ca. The Ba, Pb, Sr, and Ca free filtrate can be acidified and measured by ICP).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 166.669 nm	0.2/.19 µg/mL	1	atom	Si, B
ICP-OES 182.034 nm	0.3/.024 µg/mL	1	atom	
ICP-OES 143.328 nm	0.4/.035 µg/mL	1	atom	
ICP-MS 32 amu	30,000 ppt	n/a	M+	$^{16}O_2$, $^{14}N^{18}O$, $^{15}N^{17}O$, $^{14}N^{17}O^1H$, $^{15}N^{16}O^1H$

*ICP-OES D.L.'s are given as radial / axial view



Potassium

Location: Group 1, Period 4
Atomic Weight: 39.0983
Coordination Number: (6)
Chemical Form in Solution: $K^+(aq)$
(coordination number in parentheses is assumed, not certain)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4, and HF aqueous matrices. Avoid use of $HClO_4$ due to insolubility of the perchlorate. Stable with all metals and inorganic anions except ClO_4^-.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

K Containing Samples (Preparation & Solution): Metal (dissolves very rapidly in water); Ores (sodium carbonate fusion in Pt^0 followed by HCl dissolution - blank levels of K in sodium carbonate critical); Organic Matrices (sulfuric / peroxide digestion).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 766.490 nm	0.4/.001 µg/mL	1	atom	**
ICP-OES 771.531 nm	1.0/.03 µg/mL	1	atom	**
ICP-OES 404.721 nm	1.1/.05 µg/mL	1	atom	*U*, *Ce*
ICP-MS 39 amu	10 ppt	n/a	M+	$^{38}Ar^{1}H$, $^{23}Na^{16}O$, $^{78}Se^{+2}$

*ICP-OES D.L.'s are given as radial / axial view
**2nd order radiation from R.E.s on some optical designs

Calcium

20
40.08
1484
839
1.0
Ca
$[Ar]4s^2$
1.55
2

Location: Group 2, Period 4
Atomic Weight: 40.078
Coordination Number: 6
Chemical Form in Solution: $Ca(H_2O)_6^{+2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid H_2SO_4 HF, H_3PO_4 and neutral to basic media. Stable with most metals and inorganic anions forming insoluble silicate, carbonate, hydroxide, oxide, fluoride, sulfate, oxalate, chromate, arsenate, and tungstate in neutral aqueous media.

Stability: 2-100 ppb levels stable for months in 1% HNO3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-10% HNO_3 / LDPE container.

Ca Containing Samples (Preparation & Solution): Metal (best dissolved in diluted HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolution in dilute HCl. Do not heat when dissolving to avoid precipitation of SiO_2). The oxide, hydroxide, carbonate, phosphate, and fluoride of calcium are soluble in % levels of HCl or HNO_3. The sulfates (gypsum, anhydrite, etc.), certain silicates, and complex compounds require fusion with Na_2CO_3 followed by HCl / water dissolution. Note that contamination is a very real problem when analyzing for trace levels.

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 393.366 nm	0.0002/.00004 µg/mL	1	ion	U, Ce
ICP-OES 396.847 nm	0.0005/.00006 µg/mL	1	ion	Th
ICP-OES 422.673 nm	0.01/.001 µg/mL	1	atom	Ge
ICP-MS 44 amu	1200 ppt	n/a	M+	$^{16}O_2$ ^{12}C, $^{28}Si^{16}O$, $^{88}Sr^{+2}$

*ICP-OES D.L.'s are given as radial / axial view

Scandium

21 44.956
2831 1.3
1539
Sc
[Ar]3d4s²
2.99 3

Location: Group 3, Period 4
Atomic Weight: 44.95591
Coordination Number: 6
Chemical Form in Solution: $Sc(H_2O)_6^{+2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4, and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride. The fluoride is soluble in excess HF, forming ScF_6^{3-} (not recommended for standard preparations).

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 5-10% HNO_3 / LDPE container. Small atomic radius increases hydrolysis requiring higher acid levels than other Rare Earths.

Sc Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3 - aqua regia or nitric / perchloric / sulfuric acid digestions can be used - exercise caution when using perchloric acid).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 335.373 nm	0.004/.00002 µg/mL	1	ion	
ICP-OES 337.215 nm	0.004/.00002 µg/mL	1	ion	Ti, U, Ni, Rh
ICP-OES 424.683 nm	0.003/.00002 µg/mL	1	ion	Ce
ICP-MS 45 amu	2.3 ppt	n/a	M+	$^{16}O_2{}^{12}C^1H$, $^{29}Si^{16}O$, $^{90}Zr^{+2}$

*ICP-OES D.L.'s are given as radial / axial view

Titanium

22 47.867
3289 1.6
1670
Ti
[Ar]3d²4s²
4.50 3,4

Location: Group 4, Period 4
Atomic Weight: 47.867
Coordination Number: 6
Chemical Form in Solution: $Ti(F)_6^{-2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in concentrated HCl, HF, H_3PO_4, H_2SO_4, and HNO_3. Avoid neutral to basic media. Unstable at ppm levels with metals that would pull F^- away (i.e. - do not mix with Alkaline or Rare Earths or high levels of transition elements unless they are fluorinated). Stable with most inorganic anions with a tendency to hydrolyze forming the hydrated oxide in all dilute acids except HF.

Stability: 2-100 ppb levels stable (alone or mixed with all other metals) as the $Ti(F)_6^{-2}$ for months in 1% HNO_3 / LDPE container. 1-10,000 ppm single element solutions as the $Ti(F)_6^{-2}$ chemically stable for years in 2-5% HNO_3 / trace HF in an LDPE container.

Ti Containing Samples (Preparation & Solution): Metal (soluble in H_2O / HF CAUTION - *powder reacts violently*); Oxide - low temperature history *anatase or rutile* (dissolved by heating in 1:1:1 H_2O / HF / H_2SO_4); Oxide - high temperature history {~ 800°C} *brookite* (fuse in Pt^0 with $K_2S_2O_7$); Ores (fuse in Pt^0 with KF + $K_2S_2O_7$ - no KF if silica not present); Organic Matrices (dry ash at 450°C in Pt^0 and dissolve by heating with 1:1:1 H_2O / HF / H_2SO_4 or fuse ash with pyrosulfate if oxide is as plastic pigment and likely in brookite crystalline form).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 334.941 nm	0.0038/.000028 µg/mL	1	ion	Nb, Ta, Cr, U
ICP-OES 336.121 nm	0.0053/.000034 µg/mL	1	ion	W, Mo, Co
ICP-OES 323.452 nm	0.0054/.00092 µg/mL	1	ion	Ce, Ar, Ni
ICP-MS 48 amu	14 ppt	n/a	M+	$^{32}S^{16}O$, $^{34}S^{14}N$, $^{14}N^{16}O^{18}O$, $^{14}N^{17}O_2$, $^{36}Ar^{12}C$, ^{48}Ca, [$^{96}X^{=2}$ (where X = Zr, Mo, Ru)]

*ICP-OES D.L.'s are given as radial / axial view

Vanadium

23
3409
1902
50.942
1.5
V
[Ar]3d^{3}4s^2
6.11
2,3,4,5

Location: Group 5, Period 4
Atomic Weight: 50.9416
Coordination Number: 6
Chemical Form in Solution: $H_2V_{10}O_{28}^{4-}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4, HF, H_3PO_4, and strong basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

V Containing Samples (Preparation & Solution): Metal (fusion with NaOH or KOH in Ni^0 or Na_2CO3 / KNO_3); Oxides (V_2O_3 - use HCl; V_2O_4 - use HCl or HNO_3; V_2O_5 - use conc. acids); Ores (Na_2CO_3 / KNO_3 in Pt^0 *(caution - nitrates attack Pt^0)* followed by water extraction of fuseate); Organic Matrices (ash at 450°C followed by dissolving according to V_2O_5 above).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 309.311 nm	0.005/.001 µg/mL	1	ion	Mg, U, Th
ICP-OES 292.402 nm	0.006/.001 µg/mL	1	ion	Th
ICP-OES 290.882 nm	0.008/.0008 µg/mL	1	atom	Hf, Nb
ICP-MS 51 amu	4 ppt	n/a	M+	$^{34}S^{16}O^1H$, $^{35}Cl^{16}O$, $^{38}Ar^{13}C$, $^{36}Ar^{15}N$, $^{36}Ar^{14}N^1H$, $^{37}Cl^{14}N$, $^{36}S^{15}N$, $^{33}S^{18}O$, $^{34}S^{17}O$, $^{102}Ru^{+2}$, $^{102}Pd^{+2}$

*ICP-OES D.L.'s are given as radial / axial view

Chromium

24 51.996
2672 1.6
1857
Cr
[Ar]3d^{5}4s
7.19 2,3,6

Location: Group 6, Period 4
Atomic Weight: 51.9961
Coordination Number: 6
Chemical Form in Solution: $Cr(H_2O)_6^{3+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF, H_3PO_4. Avoid basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Cr Containing Samples (Preparation & Solution): Metal (soluble in HCl); Oxides / Ores (chrome ore/oxides are very difficult to dissolve. The following procedures *A - D* are commonly used:

- **A.** Fusion with $KHSO_4$ and extraction with hot KCl. The residue fused with Na_2CO_3 and $KClO_3$, 3:1
- **B.** Fusion with $NaKSO_4$ and NaF, 2:1
- **C.** Fusion with magnesia or lime and sodium or potassium carbonates, 4:1
- **D.** Fusion with Na_2O_2 or NaOH and KNO_3 or NaOH and Na_2O_2.

Nickel, iron, copper, or silver crucibles should be used for D. Platinum may be used for *A, B, and C;* Organic Matrices (ash at 450°C followed by one of the fusion methods above or sulfuric / hydrogen peroxide acid digestions *may* be applicable to non oxide containing samples).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 205.552 nm	0.006/.0008 µg/mL	1	ion	Os
ICP-OES 284.325 nm	0.008/.0007 µg/mL	1	ion	
ICP-OES 276.654 nm	0.01/.001 µg/mL	1	ion	Cu, Ta, *V*
ICP-MS 52 amu	40 ppt	n/a	M-	$^{36}S^{16}O$, $^{36}Ar^{16}O$**

*ICP-OES D.L.'s are given as radial / axial view
**The 50Cr, 53Cr, 54Cr lines suffer from many more potential interferences from sulfur, chlorine, and argon compounds of oxygen, nitrogen, and carbon.

25 54.938
2062 1.6
1244
Mn
[Ar]3d^{5}4s^2 2,3,4,6,7
7.43

Manganese

Location: Group 7, Period 4
Atomic Weight: 54.9380
Coordination Number: 6
Chemical Form in Solution: $Mn(H_2O)_6^{2+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF, and H_3PO_4. Avoid basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5 % HNO_3 / LDPE container.

Mn Containing Samples (Preparation & Solution): Metal (soluble in dilute acids); Oxides (soluble in dilute acids); Ores (dissolve with HCl. If silica is present, add HF and then fume off silica by adding H_2SO_4 and heat to SO_3 fumes - dense white fumes).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 257.610 nm	0.0014/.00002 µg/mL	1	ion	Ce, W, Re
ICP-OES 259.373 nm	0.0016/.00002 µg/mL	1	ion	U, Ta, Mo, Fe, Nb
ICP-OES 260.569 nm	0.0021/.00002 µg/mL	1	ion	Co
ICP-MS 55 amu	10 ppt	n/a	M+	$^{40}Ar^{14}N^{1}H$, $^{39}K^{16}O$, $^{37}Cl^{18}O$, $^{40}Ar^{15}N$, $^{38}Ar^{17}O$, $^{36}Ar^{18}O^{1}H$, $^{38}Ar^{16}O^{1}H$, $^{37}Cl^{17}O^{1}H$, $^{23}Na^{32}S$

*ICP-OES D.L.'s are given as radial / axial view

Iron

26
55.847
2862
1.6
1563
Fe
[Ar]3d^{6}4s^2
7.86
2,3

Location: Group 8, Period 4
Atomic Weight: 55.847
Coordination Number: 6
Chemical Form in Solution: $Fe(H_2O)_6^{3+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF, H_3PO_4. Avoid basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Fe Containing Samples (Preparation & Solution): Metal (soluble in HCl); Oxides (if the oxide has been at a high temperature then Na_2CO_3 fusion in Pt^0 followed by HCl dissolution, otherwise dissolve in dilute HCl); Ores (see Oxides above using only the fusion approach).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 238.204 nm	0.005/.001 µg/mL	1	ion	Ru, Co
ICP-OES 239.562 nm	0.005/.001 µg/mL	1	ion	Co, W, Cr
ICP-OES 259.940 nm	0.006/.001 µg/mL	1	ion	Hf, Nb
ICP-MS 56 amu	970 ppt	n/a	M+	$^{40}Ar^{15}N^1H$, $^{40}Ar^{16}O$, $^{38}Ar^{18}O$, $^{37}Cl^{18}O^1H$, $^{40}Ca^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Cobalt

27 58.933
2928 1.7
1495
Co
[Ar]3d^{7}4s^2
8.9 2,3

Location: Group 9, Period 4
Atomic Weight: 58.9332
Coordination Number: 6
Chemical Form in Solution: $Co(H_2O)_6^{2+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF and H_3PO_4. Avoid basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Co Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides (soluble in HCl); Ores (dissolve in HCl / HNO_3).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 238.892 nm	0.01/.002 µg/mL	1	ion	*Fe*, W, Ta
ICP-OES 228.616 nm	0.01/.001 µg/mL	1	ion	
ICP-OES 237.862 nm	0.01/.002 µg/mL	1	ion	W, Re, Al, Ta
ICP-MS 59 amu	2 ppt	n/a	M+	$^{42}Ca^{16}O^1H$, $^{40}Ar^{18}O^1H$, $^{36}Ar^{23}Na$, $^{43}Ca^{16}O$, $^{24}Mg^{35}Cl$

*ICP-OES D.L.'s are given as radial / axial view

Nickel

28
58.69
2914
1.8
1453
Ni
$[Ar]3d^8 4s^2$
8.9
2,3

Location: Group 10, Period 4
Atomic Weight: 58.69
Coordination Number: 6
Chemical Form in Solution: $Ni(H_2O)62^+$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF, and H_3PO_4. Avoid basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels. 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Ni Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides (soluble in HCl); Ores (dissolve in HCl / HNO_3).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 221.647 nm	0.01/.0009 µg/mL	1	ion	Si
ICP-OES 232.003 nm	0.02/.006 µg/mL	1	atom	*Cr*, Re, Os, Nb, Ag, Pt, Fe
ICP-OES 231.604 nm	0.02/.002 µg/mL	1	ion	Sb, Ta, Co
ICP-MS 60 amu	100 ppt	n/a	M+	$^{43}Ca^{16}O^{1}H$, $^{44}Ca^{16}O$, $^{23}Na^{37}Cl$

*ICP-OES D.L.'s are given as radial / axial view

Copper

29 63.546
2563 1.8
1084.6
Cu
[Ar]3d^{10}4s
8.96 1,2

Location: Group 11, Period 4
Atomic Weight: 63.546
Coordination Number: 6
Chemical Form in Solution: $Cu(H_2O)_6^{2+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF, H_3PO_4. Avoid basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Cu Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides (soluble in HCl); Ores (dissolve in HCl / HNO_3).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 324.754 nm	0.06/.001 µg/mL	1	atom	Nb, U, Th, Mo, Hf
ICP-OES 224.700 nm	0.01/.001 µg/mL	1	ion	*Pb*, Ir, Ni, W
ICP-OES 219.958 nm	0.01/.002 µg/mL	1	atom	Th, Ta, Nb, U, Hf
ICP-MS 63 amu	10 ppt	n/a	M+	$^{40}Ar^{23}Na$, $^{47}Ti^{16}O$, $^{14}N^{12}C^{37}Cl$, $^{16}O^{12}C^{35}Cl$, $^{44}Ca^{18}O^{1}H$, $^{23}Na^{40}Ca$

*ICP-OES D.L.'s are given as radial / axial view

Zinc

30
907
419.73
65.39
1.7
Zn
[Ar]3d^{10}4s^{2}
7.13
2

Location: Group 12, Period 4
Atomic Weight: 65.389
Coordination Number: 4
Chemical Form in Solution: $Zn(OH)(aq)^{1+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF and H_3PO_4. Avoid basic media that promotes formation of insoluble carbonate and hydroxide. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Zn Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides (soluble in HCl); Ores (dissolve in HCl / HNO_3); Organic based (dry ash at 450°C and dissolve ash in HCl), (sulfuric / peroxide acid digestion).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 213.856 nm	0.002/.0004 µg/mL	1	atom	Ni, Cu, V
ICP-OES 202.548 nm	0.004/.0002 µg/mL	1	ion	Nb, Cu, Co, Hf
ICP-OES 206.200 nm	0.006/.0006 µg/mL	1	ion	Sb, Ta, Bi, Os
ICP-MS 66 amu	7 ppt	n/a	M-	$^{50}Ti^{16}O$, $^{50}Cr^{16}O$, $^{50}V^{16}O$, $^{34}S^{16}O_2$, $^{32}S^{16}O^{18}O$, $^{32}S^{17}O_2$, $^{33}S^{16}O^{17}O$, $^{32}S^{34}S$, $^{33}S_2$

*ICP-OES D.L.'s are given as radial / axial view

Gallium

31 69.72
2205 1.8
29.9
Ga
[Ar]3d^{10}4s^{2}4p
5.904 3

Location: Group 13, Period 4
Atomic Weight: 69.723
Coordination Number: 6
Chemical Form in Solution: $Ga(H_2O)6^{+3}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, and H_2SO_4. Avoid neutral media. Stable with most metals and inorganic anions. The fluoride is insoluble in water but soluble in HF.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Ga Containing Samples (Preparation & Solution): Metal (is best dissolved in HCl / HNO_3); Ga_2O_3 (Na_2CO_3 fusion in Pt^0); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (sulfuric / peroxide digestion or nitric / sulfuric / perchloric acid decomposition or dry ash and dissolution in dilute HCl).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 141.444 nm	0.05/.001 µg/mL	1	ion	Hg
ICP-OES 294.364 nm	0.05/.008 µg/mL	1	atom	Ce, U, Ni
ICP-OES 417.206 nm	0.07/.005 µg/mL	1	atom	Ti, Ce
ICP-MS 69 amu	2 ppt	n/a	M+	$^{35}Cl^{16}O^{18}O$, $^{35}Cl^{17}O_2$, $^{37}Cl^{16}O_2$, $^{36}Ar^{33}S$, $^{33}S^{18}O_2$, $^{34}S^{17}O^{18}O$, $^{36}S^{16}O^{17}O$, $^{33}S^{36}S$, $^{53}Cr^{16}O$, [$^{138}X^{2+}$ (where X = Ba, La, Ce)]

*ICP-OES D.L.'s are given as radial / axial view

32 72.59
2834 2.0
937.4
Ge
$[Ar]3d^{10}4s^24p^2$
5.32 4

Germanium

Location: Group 14, Period 4
Atomic Weight: 72.59
Coordination Number: 6
Chemical Form in Solution: $Ge(OH)_x(F)_y^{2-}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HF, H_3PO_4, H_2SO_4, and HNO_3 as the $Ge(OH)_x(F)_y^{2-}$. Avoid neutral to basic media. Unstable at ppm levels with metals that would pull F^- away (i.e. - Do not mix with Alkaline or Rare Earths or high levels of transition elements unless they are fluorinated). Stable with most inorganic anions with a tendency to hydrolyze.

Stability: 2-100 ppb levels - stability unknown alone or mixed with all other metals as the $Ge(OH)_x(F)_y^{2-}$. 1-10,000 ppm single element solutions as the $Ge(OH)_x(F)_y^{2-}$ chemically stable for years in 2-5% HNO_3 / trace HF in a LDPE container.

Ge Containing Samples (Preparation & Solution): Metal (soluble in 1:1:1 H_2O / HF / HNO_3); Oxide - GeO (readily soluble in HCl or NaOH), GeO_2 (fuse in Pt^0 with Na_2CO_3 followed by HCl solution of the fuseate); Geological Samples (fuse in Pt^0 with Na_2CO_3 followed by HCl solution of the fuseate); Organic Matrices (dry ash at 450°C in Pt^0 and dissolve by gently warming with 1:1:1 H_2O / HF / H_2SO_4 or fuse ash with Na_2CO_3 and dissolve fuseate with HCl / H_2O).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 164.919 nm	0.01/.001 µg/mL	1	ion	Co, Fe, Cu
ICP-OES 219.871 nm	0.06/.009 µg/mL	1	atom	*W*, *Ir*, *Re*, Co
ICP-OES 265.117 nm	0.05/.009 µg/mL	1	atom	Ir, Re
ICP-MS 72 amu	20 ppt	n/a	M+	$^{36}Ar_2$, $^{37}Cl^{17}O^{18}O$, $^{37}Cl^{35}Cl$, $^{36}S^{18}O_2$, $^{36}S_2$, $^{36}Ar^{36}S$, $^{56}Fe^{16}O$, $^{40}Ar^{16}O_2$, $^{40}Ca^{16}O_2$, $^{40}Ar^{32}S$, $^{144}Nd^{2+}$, $^{144}Sm^{2+}$

*ICP-OES D.L.'s are given as radial / axial view

Arsenic

33 74.922
603 (subl.) 2.2
808 (28 atm)
As
$[Ar]3d^{10}4s^24p^3$
5.73 ±3,5

Location: Group 15, Period 4
Atomic Weight: 74.9216
Coordination Number: 6
Chemical Form in Solution: H_3AsO_4 and $HAsO_2$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Arsenic has no cationic chemistry. It is soluble in HCl, HNO_3,H_3PO_4, H_2SO_4 and HF aqueous matrices water and NH_4OH. It is stable with most inorganic anions (forms arsenate when boiled with chromate) but many cationic metals form the insoluble arsenates under pH neutral conditions. When fluorinated and/or under acidic conditions arsenate formation is typically not a problem at moderate to low concentrations.

Stability: 2-100 ppb levels - stable for months alone or mixed with other elements at equivalent levels - in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

As Containing Samples (Preparation & Solution): Metal (soluble in 1:1 H_2O / HNO_3); Oxides (the oxide exists in crystalline and amorphous forms where the amorphoric form is more water soluble. The oxides typically dissolve in dilute acidic solutions when boiled); Minerals (one gram of powered sample is fused in a Ni^0 crucible with 10 grams of a 1:1 mix of K_2CO_3 and KNO_3 and the melt extracted with hot water); Organic Matrices (0.2 to 0.5 grams of the sample are fused with 15 grams of a 1:1 Na_2CO_3 / Na_2O_2 mix in a Ni^0 crucible. The fuseate is extracted with water and acidified with HNO_3).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 189.042 nm	0.05/.005 µg/mL	1	atom	Cr
ICP-OES 193.696 nm	0.1/.01 µg/mL	1	atom	V, Ge
ICP-OES 228.812 nm	0.1/.01 µg/mL	1	atom	*Cd*, *Pt*, Ir, Co
ICP-MS 75 amu	30 ppt	n/a	M+	$^{40}Ar^{35}Cl$, $^{59}Co^{16}O$, $^{36}Ar^{38}Ar^{1}H$, $^{38}Ar^{37}Cl$, $^{36}Ar^{39}K$, $^{150}Nd^{2+}$, $^{150}Sm^{2+}$

*ICP-OES D.L.'s are given as radial / axial view

Selenium

34
685
221
78.96
2.5
Se
$[Ar]3d^{10}4s^24p^2$
4.79
-2,4,6

Location: Group 16, Period 4
Atomic Weight: 78.96
Coordination Number: 6
Chemical Form in Solution: H_2SeO_3

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_3PO_4, H_2SO_4 and HF aqueous matrices and water. It is stable with most inorganic anions but many cationic metals form the insoluble selenites under pH neutral conditions. When fluorinated and/or under acidic conditions precipitation is typically not a problem at moderate to low concentrations.

Stability: 2-100 ppb levels stable for months alone or mixed with other elements at equivalent levels in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Se Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides (readily soluble in water); Minerals and alloys (acid digestion with HNO_3or HNO_3 / HF); Organic Matrices (acid digestion with hot concentrated H_2SO_4 accompanied by the careful dropwise addition of H_2O_2 until clear).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 196.026 nm	0.08/0.006 µg/mL	1	atom	Fe
ICP-OES 203.985 nm	0.2/.05 µg/mL	1	atom	*Sb, Ir, Cr, Ta*
ICP-OES 206.279 nm	0.3/.16 µg/mL	1	atom	Cr, *Pt*
ICP-MS 82 amu	200 ppt	n/a	M+	$^{12}C^{35}Cl_2$

*ICP-OES D.L.'s are given as radial / axial view

Rubidium

37 85.468
688 0.9
39.64
Rb
[Kr]5s
1.532 1

Location: Group 1, Period 5
Atomic Weight: 85.4678
Coordination Number: (6)
Chemical Form in Solution: Rb(aq)
(coordination number in parentheses is assumed, not certain)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4, and HF aqueous matrices. Stable with most metals and inorganic anions. Forms insoluble $Rb_2[PtCl_6]$ (0.028g/100mL ^{20}aq).

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 0.1-1% HNO_3 / LDPE container.

Rb Containing Samples (Preparation & Solution): Metal (dissolves very rapidly in water); Ores (sodium carbonate fusion in Pt^0 followed by HCl dissolution - blank levels of Rb in sodium carbonate critical); Organic Matrices (sulfuric / peroxide digestion or nitric / sulfuric / perchloric acid decomposition).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 420.185 nm	40/10 µg/mL	1	atom	*Fe*, Zr
ICP-MS 85 amu	1.5 ppt	n/a	M+	$^{69}Ga^{16}O$, $^{170}Er+2$, $^{170}Yb^{+2}$

*ICP-OES D.L.'s are given as radial / axial view

Strontium

38
87.62
1377
1.0
768
Sr
[Kr]5s²
2.54
2

Location: Group 2, Period 5
Atomic Weight: 87.62
Coordination Number: 6
Chemical Form in Solution: $Sr(H_2O)_6^{+2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid H_2SO_4, HF and neutral to basic media. Stable with most metals and inorganic anions forming insoluble silicate, carbonate, hydroxide, oxide, fluoride, sulfate, oxalate, chromate, arsenate, and tungestate in neutral aqueous media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Sr Containing Samples (Preparation & Solution): Metal (is best dissolved in diluted HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolution in dilute HCl. Do not heat when dissolving to avoid precipitation of SiO_2).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 407.771 nm	0.0004/.00006 µg/mL	1	ion	U, Ce
ICP-OES 421.552 nm	0.0008/.00004 µg/mL	1	ion	Rb
ICP-OES 460.733 nm	0.07/.003 µg/mL	1	atom	Ce
ICP-MS 88 amu	1200 ppt	n/a	M+	$^{72}Ge^{16}O$, $^{176}Yb^{+2}$, $^{176}Lu^{+2}$, $^{176}Hf^{+2}$

*ICP-OES D.L.'s are given as radial / axial view

39 88.906
3338 1.1
1526
Y
[Kr]4d5s²
4.47 3

Yttrium

Location: Group 3, Period 5
Atomic Weight: 88.906
Coordination Number: 6
Chemical Form in Solution: $Y(OH)(H_2O)_x^{+2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4, and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

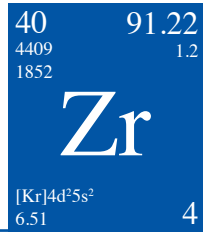
Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Y Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 360.073 nm	0.005/.000036 µg/mL	1	ion	Ce, Th
ICP-OES 371.030 nm	0.004/.00007 µg/mL	1	ion	Ce
ICP-OES 377.433 nm	0.005/.0009 µg/mL	1	ion	Ta, Th
ICP-MS 89 amu	0.8 ppt	n/a	M+	$^{73}Ge^{16}O$, $^{178}Hf^{+2}$

*ICP-OES D.L.'s are given as radial / axial view



Zirconium

Location: Group 4, Period 5
Atomic Weight: 91.224
Coordination Number: 6, 7, 8
Chemical Form in Solution: $Zr(F)_6^{-2}$
(coordination numbers 7, 8 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in concentrated HCl, HF, H_2SO_4 (very hot) and HNO_3. Avoid H_3PO_4 and neutral to basic media. Unstable at ppm levels with metals that would pull F^- away (i.e. - do not mix with Alkaline or Rare Earths or high levels of transition elements unless they are fluorinated). Stable with most inorganic anions but precipitation with phosphate, oxalate, and tartrate with a tendency to hydrolyze forming the hydrated oxide in all dilute acids except HF.

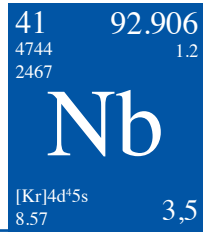
Stability: 2-100 ppb levels stable (alone or mixed with all other metals that are at comparable levels) as the $Zr(F)_6^{-2}$ + $Zr(OH)_4F_2^{-2}$ for months in 1% HNO_3 / LDPE container. 1-10,000 ppm single element solutions as the $Zr(F)_6^{-2}$ chemically stable for years in 2-5% HNO_3 / trace HF in an LDPE container.

Zr Containing Samples (Preparation & Solution): Metal (soluble in H_2O / HF / HNO_3); Oxide unlike TiO_2, the ZrO_2 is best fused in one of the following ways (Na_2O_2 in Ni^0, Na_2CO_3 in Pt^0 or Borax in Pt^0); Organic Matrices (dry ash at 450°C in Pt^0 and dissolve by fusing with Na_2CO_3 and dissolving in HF / HNO_3 / H_2O).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 343.823 nm	0.007/.0004 µg/mL	1	ion	Hf, Nb
ICP-OES 339.198 nm	0.008/.0007 µg/mL	1	ion	*Th*, Mo
ICP-OES 272.261 nm	0.018/.001 µg/mL	1	ion	*Cr*, V, Th, W
ICP-MS 90 amu	2 ppt	n/a	M+	$^{74}Ge^{16}O$, $^{74}Se^{16}O$,
				[$^{180}X^{+2}$ (where X = Hf, Ta, W)]

*ICP-OES D.L.'s are given as radial / axial view



Niobium

Location: Group 5, Period 5
Atomic Weight: 92.9064
Coordination Number: 6, 7, 8
Chemical Form in Solution: $NbOF_5^{-2}$
(coordination numbers 7, 8 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in concentrated HCl and dilute HF / HNO_3. Avoid neutral to basic media. Unstable at ppm levels with metals that would pull F^- away (i.e. - Do not mix with Alkaline or Rare Earths or high levels of transition elements unless they are fluorinated). Stable with most inorganic anions provided it is in the chemical form shown above.

Stability: 2-100 ppb levels stable (alone or mixed with all other metals that are at comparable levels) as the $NbOF_5^{-2}$ for 5 months in 1% HNO_3 / LDPE container. 1-10,000 ppm single element solutions as the $NbOF_5^{-2}$ chemically stable for years in 2-5% HNO_3 / trace HF in an LDPE container.

Nb Containing Samples (Preparation & Solution): Metal (soluble in HF / HNO_3); Oxide - very resistant to all acids including HF (fusion with $K_2S_2O_7$, KOH, or Na_2CO_3); Organic Matrices (dry ash at 450°C in Pt^0 and dissolve by fusing with Na_2CO_3 or $K_2S_2O_7$).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 309.418 nm	0.04/.002 µg/mL	1	ion	
ICP-OES 269.706 nm	0.07/.002 µg/mL	1	ion	Th, Co
ICP-OES 295.088 nm	0.08/.001 µg/mL	1	ion	Hf, U
ICP-MS 93 amu	1 ppt	n/a	M+	$^{77}Se^{16}O$, $^{76}Se^{17}O$, [$^{186}X^{+2}$ (where X = W, Os)]

*ICP-OES D.L.'s are given as radial / axial view

42 95.94
4639 1.3
2617
Mo
[Kr]4d^{5}5s 2,3,4,5,6
10.2

Molybdenum

Location: Group 6, Period 5
Atomic Weight: 95.94
Coordination Number: 6, 7, 8, 9
Chemical Form in Solution: MoO_4^{-2} (chem. form as received)
(coordination numbers 7, 8 and 9 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Mo is received in a NH_4OH matrix, giving the operator the option of using HCl or HF to stabilize acidic solutions. The MoO_4^{-2} is soluble in concentrated HCl, $MoOCl_5^{-2}$, dilute HF / HNO_3, $MoOF_5^{-2}$, and basic media MoO_4^{-2}. Stable at ppm levels with some metals, provided it is fluorinated. Do not mix with Alkaline or Rare Earths when HF is present. Stable with most inorganic anions, provided it is in the MoO_4^{-2} chemical form.

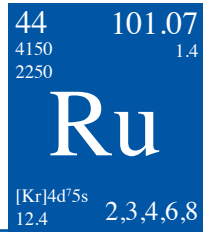
Stability: 2-100 ppb levels stable (alone or mixed with all other metals that are at comparable levels) as the $MoOF_5^{-2}$ for months in 1% HNO_3 / LDPE container. 1-10,000 ppm single element solutions as the MoO_4^{-2} chemically stable for years in 1% NH_4OH in a LDPE container.

Mo Containing Samples (Preparation & Solution): Metal (soluble in HF / HNO_3 or hot dilute HCl); Oxide (soluble in HF or NH_4OH); Organic Matrices (dry ash at 450°C in Pt^0 and dissolve oxide with HF or HCl).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 202.030 nm	0.008/.0002 µg/mL	1	ion	Os, Hf
ICP-OES 203.844 nm	0.012/.002 µg/mL	1	ion	
ICP-OES 204.598 nm	0.012/.001 µg/mL	1	ion	Ir, Ta
ICP-MS 95 amu	3 ppt	n/a	M+	$^{40}Ar^{39}K^{16}O$, $^{79}Br^{16}O$, $^{190}Os^{2+}$, $^{190}Pt^{2+}$

*ICP-OES D.L.'s are given as radial / axial view



Ruthenium

Location: Group 8, Period 5
Atomic Weight: 101.07
Coordination Number: 4, 5, 6, 8
Chemical Form in Solution: $[RuCl_6]^{2-}$
(coordination numbers 4, 5 and 8 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl. Stable with most metals and inorganic anions as the $[RuCl_6]^{2-}$ in dilute acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 10% HCl / LDPE container.

Ru Containing Samples (Preparation & Solution): Metal (fuse with KOH/KNO_3 in a Ag^0 crucible); Oxides (fuse with KOH / KNO_3 in a Ag^0 crucible); Ores (see Oxides); Alloys (see Oxides). Organics (the RuO_4 is volatile and acidic oxidizing preparations should be used with caution. The preferred approach is the KOH / KNO_3 fusion and dissolution of the fuseate in HCl).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 240.272 nm	0.03/.002 µg/mL	1	ion	Fe
ICP-MS 101 amu	3 ppt	n/a	M+	$^{40}Ar^{61}Ni$, $^{64}Ni^{37}Cl$, $^{85}Rb^{16}O$, $^{202}Hg^{2+}$

*ICP-OES D.L.'s are given as radial / axial view

45 102.906
3697 1.5
1963
Rh
[Kr]4d^{8}5s
12.4 2,3,4

Rhodium

Location: Group 9, Period 5
Atomic Weight: 102.9055
Coordination Number: 6
Chemical Form in Solution: $RhCl_6^{-3}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4 and HF aqueous matrices. May cause *AgCl* precipitation when mixed with Ag^+. Stable with all other metals.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 10% HCl/LDPE container.

Rh Containing Samples (Preparation & Solution): Metal (elevated temp. with aqua regia or HCl / Cl_2(gas)); Ores (HF / H_2SO_4 digestion followed by aqua regia digestion); Platinum scrap (aqua regia digestion).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 233.477 nm	0.04/0.004 µg/mL	1	ion	*Ni*, Sn, Mo, Nb, Ta
ICP-OES 249.077 nm	0.06/0.006 µg/mL	1	ion	Ta, Co, *Fe*, W, Cr, Os
ICP-OES 343.489 nm	0.06/0.006 µg/mL	1	atom	Mo, Th, Ce
ICP-MS 103 amu, monoisotopic	1 ppt	n/a	M+	$^{40}Ar^{63}Cu$, $^{87}Rb^{16}O$, $^{87}Sr^{16}O$, $^{206}Pb^{+2}$

*ICP-OES D.L.'s are given as radial / axial view

Palladium

46
106.42
2964
1552
1.4
Pd
[Kr]4d^{10}
12.0
2,4

Location: Group 10, Period 5
Atomic Weight: 106.42
Coordination Number: 6
Chemical Form in Solution: $Pd(H_2O)_6^{2+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF, and H_3PO_4. Avoid basic media. Stable with most metals and inorganic anions in acidic media. Avoid contact with water soluble organics such as aldehydes since Pd^{2+} is easily reduced.

Stability: 2-100 ppb levels. 2 ppb Pd is stable for 1 day in 1% HNO_3 / LDPE container. 10 ppb is stable for 3 days in 1% HNO_3 / LDPE container. 100 ppb is stable for ≥ 5 months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Pd Containing Samples (Preparation & Solution): Metal (soluble in HNO_3 or aqua regia); Oxides (soluble in HCl); Ores (dissolve in HCl / HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 340.458 nm	0.04/.003 µg/mL	1	atom	Ce, Th, Zr
ICP-OES 363.470 nm	0.05/.007 µg/mL	1	atom	
ICP-OES 229.651 nm	0.07/.004 µg/mL	1	ion	Co
ICP-MS 105 amu	2 ppt	n/a	M+	$^{40}Ar^{65}Cu$, $^{89}Y^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Silver

47 107.868
2163 1.4
961
Ag
[Kr]4d^{10}5s
10.5 1

Location: Group 11, Period 5
Atomic Weight: 107.8682
Coordination Number: 6
Chemical Form in Solution: $Ag(H_2O)_6^+$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HNO_3 and HF. Avoid basic media. Ag forms more insoluble salts than any other metal. It also is subject to photochemical reduction to the metal in HCl media although 10 µg/mL solutions in 10% HCl [$AgCl_{x\,1-x}$] are commonly used in the analytical laboratory. The most common solubility problems exist with arsenate, arsenite, bromide, chloride, iodide, carbonate, chromate, cyanide, iodate, oxalate, oxide, sulfate, sulfide, tartrate, and thiocyanate in aqueous media. The addition of nitric acid renders many of these salts soluble.

Stability: 2-100 ppb levels stable for 75+ days when mixed with equivalent levels of all other elements including the precious metals (where chloride is present) when in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Ag Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides (soluble in HNO_3); Ores (digestion with conc. HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 328.068 nm	0.007/.0007 µg/mL	1	atom	Ce, Rh, V
ICP-OES 338.289 nm	0.013/.001 µg/mL	1	atom	Ce, Cr, Th
ICP-OES 243.779 nm	0.12/.01 µg/mL	1	ion	Mn, Th, Ni, Rh
ICP-MS 107 amu	1 ppt	n/a	M+	$^{91}Zr^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Cadmium

48 112.41
767 1.5
321.18
Cd
$[Kr]4d^{10}5s^2$
8.65 2

Location: Group 12, Period 5
Atomic Weight: 112.41
Coordination Number: 4
Chemical Form in Solution: $Cd_2(OH)(aq)^{3+}$ and $Cd(OH)(aq)^{1+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, and HF. Avoid basic media forming insoluble carbonate and hydroxide. Stable with most metals and inorganic anions in acidic media. The sulfide, carbonate, oxalate, phosphate, and cyanide are insoluble in water and soluble in HCl, HNO_3, and NH_4OH. The chloride, bromide, and iodide are soluble in water. CdI_2 is one of the few iodides soluble in ethanol. All compounds of Cd are soluble in excess NaI, due to the formation of the complex ion, CdI_4^{2-}.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5 % HNO_3 / LDPE container.

Cd Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides (soluble in HCl or HNO_3); Ores (dissolve in HCl /HNO_3 then take to fumes with H_2SO_4. The silica and lead sulfate are filtered off after the addition of water); Organic based (dry ash at 450°C and dissolve ash in HCl), (sulfuric / peroxide acid digestion).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 214.438 nm	0.003/.0003 µg/mL	1	ion	Pt, Ir
ICP-OES 228.802 nm	0.003/.0003 µg/mL	1	atom	Co, Ir, *As*, Pt
ICP-OES 226.502 nm	0.003/.0003 µg/mL	1	ion	Ir
ICP-MS 111 amu	11 ppt	n/a	M+	$^{95}Mo^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Indium

49 114.82
2073 1.5
156.76
In
[Kr]4d^{10}5s^{2}5p
731 3

Location: Group 13, Period 5
Atomic Weight: 114.82
Coordination Number: 6
Chemical Form in Solution: $In(H_2O)_6^{+3}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, and H_2SO_4. Avoid neutral and basic media. Stable with most metals and inorganic anions. The oxalate, sulfide, carbonate, hydroxide, and phosphate are insoluble in water.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

In Containing Samples (Preparation & Solution): Metal (is best dissolved in HCl / HNO_3); Oxide (soluble in mineral acids); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (sulfuric / peroxide digestion or dry ash and dissolution in dilute HCl).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 158.583 nm	0.05/.002 µg/mL	1	ion	
ICP-OES 230.606 nm	0.1/.03 µg/mL	1	ion	*Ni*, *Os*
ICP-OES 325.609 nm	0.2/.05 µg/mL	1	atom	Ir, Re
ICP-MS 115 amu	1 ppt	n/a	M+	^{115}Sn, $^{99}Ru^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Tin

50 118.71
2603 1.7
232.06
Sn
[Kr]4d^{10}5s^{2}5p^{2}
7.31 2,4

Location: Group 14, Period 5
Atomic Weight: 118.710
Coordination Number: 4, 5, 6, 7, 8
Chemical Form in Solution: $Sn(OH)_xF_y^{2-}$
(coordination numbers 4, 5, 7 and 8 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and dilute HF / HNO_3. Avoid neutral to basic media. Unstable at ppm levels with metals that would pull F^- away (i.e. - do not mix with Alkaline or Rare Earths or high levels of transition elements unless they are fluorinated). Stable with most inorganic anions, provided it is in the chemical form shown above.

Stability: 2-100 ppb levels stable (alone or mixed with all other metals that are at comparable levels) as the $Sn(OH)_xF_y^{2-}$ for 1 year in 1% HNO3 / LDPE container. 1-10,000 ppm single element solutions as the $Sn(OH)_xF_y^{2-}$ are chemically stable for years in 2-5% HNO_3 / trace HF in a LDPE container.

Sn Containing Samples (Preparation & Solution): Metal (soluble in HF / HNO_3 or HCl); Oxides - SnO (soluble in HCl), SnO_2 - very resistant to all acids including HF (fusion with equal parts of Na_2CO_3 and S is soluble in water or dilute acids as the thiostannate); Alloys (treat first 0.1 g with 10 mL conc. H_2SO_4 to boiling until the alloy disintegrates and nearly all of the sulfuric acid is expelled. Then add 100 mL O_2 free water and 50 mL of conc. HCl or transfer to a plastic container and add 1 mL HF, in either case, warming gently to bring about solution); Organic Matrices (volatility and precipitation of the insoluble stannic oxide are problems -- because these preparations are prone to error, we recommend you contact our technical staff at info @inorganicventures.com or (800)669-6799 and we'll provide you with the necessary data for your specific sample type).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 189.989 nm	0.03/.003 µg/mL	1	ion	
ICP-OES 242.949 nm	0.1/.01 µg/mL	1	atom	W, Mo, Rh ,Ta, Co
ICP-MS 120 amu	5 ppt	n/a	M+	^{120}Te, $^{104}Ru^{16}O$, $^{104}Pd^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Antimony

51 121.75
1587 1.8
6317
Sb
[Kr]4d^{10}5s^{2}5p^{3}
6.69 ±3,5

Location: Group 15, Period 5
Atomic Weight: 121.75
Coordination Number: 6
Chemical Form in Solution: $Sb(O)C_4H_4O_6^{-1}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in conc. HCl, dilute or conc. HF. Stable in dilute HNO_3 as the fluoride or tartrate complex. Avoid basic media. Stable with most metals and inorganic anions in acidic media as the tartrate provided the acidity is not too high or the acid is oxidizing causing loss of the stabilizing tartrate ion. The fluoride complex of antimony is stable in strong acid but you should only mix with other metals that are fluorinated.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-2% HNO_3 / LDPE container.

Sb Containing Samples (Preparation & Solution): Metal and alloys (soluble in H_2O / HF / HNO_3 mixture); Oxides (soluble in HCl and tartaric acid or H_2O / HF / HNO_3 mixtures); Ores (fusion with Na_2CO_3 in Pt^0 followed by dissolving the fuseate in a H_2O / HF / HNO_3 mixture); Organic based (sulfuric acid / hydrogen peroxide digestion).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 206.833 nm	0.03/.003 µg/mL	1	atom	*Ta*, Cr, Ge, Hf
ICP-OES 217.581 nm	0.05/.005 µg/mL	1	atom	*Nb*, W, Re, Fe
ICP-OES 231.147 nm	0.06/.006 µg/mL	1	atom	Ni, Co, Pt
ICP-MS 121 amu	5 ppt	n/a	M+	$^{105}Pd^{16}O$, $^{89}Y^{16}O_2$

*ICP-OES D.L.'s are given as radial / axial view

Tellurium

52 127.60
988 2.0
449.65
Te
[Kr]4d^{10}5s^{2}5p^{4}
6.24 -2,4,6

Location: Group 16, Period 5
Atomic Weight: 127.60
Coordination Number: 6
Chemical Form in Solution: H_2TeO_3 (HNO_3 matrix), $TeCl_6^{2-}$ (HCl matrix)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_3PO_4, H_2SO_4 and HF aqueous matrices and water. It is stable with most inorganic anions and cations. Avoid mixing HCl matrices with elements forming insoluble chlorides such as Ag^+. When fluorinated and/or under acidic conditions precipitation is typically not a problem at moderate to low concentrations.

Stability: 2-100 ppb levels stable for months alone or mixed with other elements at equivalent levels in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Te Containing Samples (Preparation & Solution): Metal (soluble in solutions of alkali hydroxides or a 1:1:1 mixture of H_2O, H_2SO_4, HNO_3); Oxides (TeO_2 is soluble in HCl and the alkali hydroxides. $TeO_3$is soluble in hot concentrated solutions of the alkali hydroxides.); Minerals and alloys (acid digestion with HNO_3or HNO_3 / HF); Organic Matrices (Vegetable Matter - dry ash 100 g of the well-ground and mixed vegetation into a concentrated solution of 25 g of magnesium nitrate and magnesium oxide. Dry, ignite and muffle until the ash is a uniform gray color).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 170.000 nm	0.04/.004 µg/mL	1	atom	Sn
ICP-OES 214.281 nm	0.04/.004 µg/mL	1	atom	Ta, Re, V
ICP-OE 225.902 nm	0.20/.02 µg/mL	1	atom	Ir, Os W, Ga, Ru, Ta
ICP-MS 130 amu	20 ppt	n/a	M+	$^{114}Cd^{16}O$, $^{114}Sn^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Cesium

55 132.905
671 0.9
28.55
Cs
[Xe]6s
1.873 1

Location: Group 1, Period 6
Atomic Weight: 132.9054
Coordination Number: (6)
Chemical Form in Solution: Cs+(aq)
(coordination number in parentheses is assumed, not certain)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in dilute HCl, HNO_3, H_2SO_4 and HF aqueous matrices. Stable with most metals and inorganic anions. Forms insoluble $Cs_2[PtCl_6]$.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 0.1% HNO_3 / LDPE container. Will crystallize out of higher (~ 5%) levels of HNO_3 at > 1000 µg/mL.

Cs Containing Samples (Preparation & Solution): Metal (dissolves very rapidly in water); Ores (sodium carbonate fusion in Pt^0 followed by HCl dissolution - blank levels of Cs in sodium carbonate critical); Organic Matrices (sulfuric / peroxide digestion or nitric / sulfuric / perchloric acid decomposition).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 455.531 nm	100/2 µg/mL	1	atom	Cr, U, *Ce*, Ti
ICP-MS 133 amu	1.7 ppt	n/a	M+	$^{117}Sn^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Barium

56 137.33
1898 1.0
729
Ba
[Xe]6s²
3.5 2

Location: Group 2, Period 6
Atomic Weight: 137.33
Coordination Number: 6
Chemical Form in Solution: $Ba(H_2O)_6^{+2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid H_2SO_4, HF, and neutral to basic media. Stable with most metals and inorganic anions forming insoluble silicate, carbonate, hydroxide, oxide, fluoride, sulfate, oxalate, chromate, arsenate, iodate, molybdate, sulfite and tungstate in neutral aqueous media.

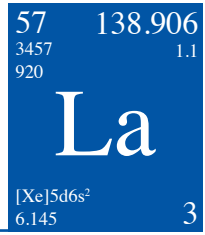
Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Ba Containing Samples (Preparation & Solution): Metal (is best dissolved in diluted HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution. If sulfate is present dissolve the fuseate using HCl / tartaric acid to prevent $BaSO_4$ precipitate); Organic Matrices (dry ash and dissolve in dilute HCl. Do not heat when dissolving to avoid precipitation of SiO_2).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 455.403 nm	0.002/.0001 µg/mL	1	ion	Zr, U
ICP-OES 233.527 nm	0.004/.0003 µg/mL	1	ion	
ICP-OES 230.424 nm	0.004/.0005 µg/mL	1	ion	Mo, Ir, Co
ICP-MS 138 amu	1 ppt	n/a	M+	$^{122}Sn^{16}O$, $^{122}Te^{16}O$

*ICP-OES D.L.'s are given as radial / axial view



Lanthanum

Location: Group 3, Period 6 (lanthanoid)
Atomic Weight: 138.9055
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $La(OH)_y(H_2O)_x^{+3-y}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid HF, H_3PO_4, H_2SO_4 and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride and sparingly soluble sulfates (La - Eu exhibit low sulfate solubility). Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5 % HNO_3 / LDPE container.

La Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 333.749 nm	0.01/.001 µg/mL	1	ion	
ICP-OES 408.672 nm	0.01/.001 µg/mL	1	ion	Th
ICP-OES 412.323 nm	0.01/.001 µg/mL	1	ion	Ce, Th
ICP-MS 139 amu	1 ppt	n/a	M+	$^{123}Sb^{16}O$, $^{123}Te^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Hafnium

72 178.49
4603 1.2
2227
Hf
[Xe]4f^{14}5d^{2}6s^{2}
13.3 4

Location: Group 4, Period 6
Atomic Weight: 178.49
Coordination Number: 6, 7, 8
Chemical Form in Solution: $Hf(F)_6^{-2}$
(coordination numbers 7 & 8 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in concentrated HCl, HF, H_2SO_4 (very hot), and HNO_3. Avoid $H_3PO_4$and neutral to basic media. Unstable at ppm levels with metals that would pull F^- away (i.e. - do not mix with Alkaline or Rare Earths or high levels of transition elements unless they are fluorinated). Stable with most inorganic anions but precipitation with phosphate, oxalate, and tartrate with a tendency to hydrolyze forming the hydrated oxide in all dilute acids except HF.

Stability: 2-100 ppb levels stable alone or mixed with all other metals that are at comparable levels as the $Hf(F)_6^{-2}$ + $Hf(OH)_4F_2^{-2}$ for months in 1% HNO_3 / LDPE container. 1-10,000 ppm single element solutions as the $Hf(F)_6^{-2}$ chemically stable for years in 2-5% HNO_3 / trace HF in an LDPE container.

Hf Containing Samples (Preparation & Solution): Metal (soluble in H_2O / HF / HNO_3); Oxide - unlike TiO_2 the HfO_2 is best fused in one of the following ways (Na_2O_2 in Ni^0, Na_2CO_3 in Pt^0 or Borax in Pt^0); Organic Matrices (dry ash at 450°C in Pt^0 and dissolve by fusing with Na_2CO_3 and dissolving in HF / HNO_3 / H_2O).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 277.336 nm	0.02/.002 µg/mL	1	ion	Nb, Cr, U
ICP-OES 273.876 nm	0.02/.002 µg/mL	1	ion	U, Mo
ICP-OES 264.141 nm	0.02/.002 µg/mL	1	ion	Ba, Th, U
ICP-MS 177 amu	4 ppt	n/a	M+	$^{161}Dy^{16}O$**

*ICP-OES D.L.'s are given as radial / axial view
**Fewer potential interferences on the 177 vs 180 mass

73 180.948
5458 1.3
3014
Ta
[Xe]4f^{14}5d^{3}6s^{2}
16.6 5

Tantalum

Location: Group 5, Period 6
Atomic Weight: 180.9479
Coordination Number: 6, 7, 8
Chemical Form in Solution: $TaOF_6^{-3}$
(coordination numbers 7 & 8 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in concentrated HCl and dilute HF / HNO_3. Avoid neutral to basic media. Unstable at ppm levels with metals that would pull F^- away (i.e. - do not mix with Alkaline or Rare Earths or high levels of transition elements unless they are fluorinated). Stable with most inorganic anions, provided it is in the chemical form shown above.

Stability: 2-100 ppb levels stable (alone or mixed with all other metals that are at comparable levels) as the $TaOF_6^{-3}$, for 2 months at the 2-10 ppb level in 1% HNO_3 / LDPE container and for 5 months at the 100 ppb level under same conditions. 1-10,000 ppm single element solutions as the $TaOF_6^{-3}$ are chemically stable for years in 2-5% HNO_3 / trace HF in an LDPE container.

Ta Containing Samples (Preparation & Solution): Metal (soluble in HF / HNO_3); Oxide - very resistant to all acids including HF (fusion with $K_2S_2O_7$, KOH, or Na_2CO_3); Organic Matrices (dry ash at 450°C in Pt^0 and dissolve by fusing with Na_2CO_3 or $K_2S_2O_7$).

Atomic Spectroscopic Information: (*italic* text indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 226.230 nm	0.03/.01 µg/mL	1	ion	Sb, Nb
ICP-OES 240.063 nm	0.03/.004 µg/mL	1	ion	*Hf*, Fe, Bi
ICP-OES 268.517 nm	0.03/.005 µg/mL	1	ion	Cr, Ru, HF, W
ICP-MS 181 amu	2 ppt	n/a	M+	$^{165}Ho^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Tungsten

74 183.85
5555 1.4
3407
W
[Xe]4f^{14}5d^{4}6s^{2}
19.3 2,3,4,5,6

Location: Group 6, Period 6
Atomic Weight: 183.85
Coordination Number: 6, 7, 8, 9
Chemical Form in Solution: WOF_5^{-2} (chem. form as received)
(coordination numbers are 7, 8 and 9 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: W is very readily hydrolyzed requiring 0.1 to 1% HF for stable acidic solutions. The $[WOF_5]^{-2}$ is soluble in % levels of HCl and HNO_3, provided it is in the $[WOF_5]^{-2}$ form. Stable at ppm levels with some metals provided it is fluorinated. Do not mix with Alkaline or Rare Earths. W is best to be mixed only with other fluorinated metals (Ti, Zr, Hf, Nb, Ta, Mo, Si, Sn, Ge). Look for yellow WO_3 precipitate if mixed with other transitions at higher levels indicating instability. The yellow WO_3 will form over a period of weeks even in trace HF, therefore HF *levels of W multi-element blends should be ~ 1%.*

Stability: 2-100 ppb levels stable (alone or mixed with all other metals that are at comparable levels) as the $[WOF_5]^{-2}$ for months in 1% HNO_3 / LDPE container. 1-10,000 ppm single element solutions as the $[WOF_5]^{-2}$ chemically stable for years in 1% HF in a LDPE container.

W Containing Samples (Preparation & Solution): Metal (soluble in HF / HNO_3); Oxide (soluble in HF or NH_4OH); Organic Matrices (dry ash at 450 0C in Pt^0 and dissolve oxide with HF).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 207.911 nm	0.03/.001 µg/mL	1	ion	Ru, In
ICP-OES 224.875 nm	0.05/.005 µg/mL	1	ion	Co, Rh, Ag
ICP-OES 209.475 nm	0.05/.008 µg/mL	1	ion	Mo
ICP-MS 182 amu	5 ppt	n/a	M+	$^{166}Er^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Rhenium

75 186.207
5596 1.5
3180
Re
$[Xe]4f^{14}5d^{5}6s^{2}$
21.0 -1,2,4,6,7

Location: Group 8, Period 6
Atomic Weight: 186.207
Coordination Number: 4, 6, 7, 8, 9
Chemical Form in Solution: ReO_4^{1-}
(coordination numbers 4, 7, 8 and 9 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, HF, and H_3PO_4. Stable with most metals and inorganic anions in acidic media. Mixing higher levels of ReO_4^{1-} with Ag^+, Hg_2^{2+}, K^+, NH_4^+, Cs^+, Rb^+, or Tl^+ will give the corresponding salt (solubilities are 1-12 g/L).

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 1-5% HNO_3 / LDPE container.

Re Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides / Ores (fuse in Pt^0 with Na_2CO_3). Organic Matrix (all modes of acid attack invite the danger of loss of some volatile perrhenic acid. The use of a reflux condenser should be considered when a wet acid digestion is used such as nitric / perchloric or sulfuric / peroxide digestions. The preferred approach is to ash the sample in Pt^0 mixed with Na_2CO_3 starting the ash at 450°C and then increasing the temperature, if necessary, to 900°C to effect a fusion of accompanying alumino-silicates, etc.).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 221.426 nm	0.006/.0006 µg/mL	1	ion	Fe, Os, Mo, Ta
ICP-OES 227.525 nm	0.006/.0006 µg/mL	1	ion	Ru, Co, Ca
ICP-MS 187 amu	2 ppt	n/a	M+	$^{171}Yb^{16}O$, ^{187}Os

*ICP-OES D.L.'s are given as radial / axial view

Osmium

76 190.2
5012 1.5
3027
Os
$[Xe]4f^{14}5d^{6}6s^{2}$
22.6 2,3,4,6,8

Location: Group 8, Period 6
Atomic Weight: 190.2
Coordination Number: 4, 5, 6, 8
Chemical Form in Solution: $OsCl_6^{2-}$
(coordination numbers 4, 5 and 8 are observed less frequently)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl. Stable with most metals and inorganic anions as the $[OsCl_6]^{2-}$ in dilute HCl media. DO NOT EXPOSE TO NITRIC ACID - FORMATION OF THE VERY VOLATILE AND TOXIC OsO_4 WILL RESULT. Any oxidizing condition must be avoided.

Stability: 2-100 ppb levels are *NOT* stable in 1% HNO_3 / LDPE container. The stability of HCl solutions at ppb levels has not been determined by our laboratory. 1-10,000 ppm solutions are presumed chemically stable for years in 10% HCl / LDPE container, stability studies have not been performed.

Os Containing Samples (Preparation & Solution): Oxides (fuse with KOH / KNO_3 in a Ag^0 crucible and dissolve in water being sure to avoid addition of any acid); Ores (see Oxides); Organics (the OsO_4 is volatile and acidic oxidizing preparations should be used with caution. The preferred approach is the KOH / KNO_3 fusion and dissolution of the fuseate in water. Our laboratory has used APDC to help stabilize Os solutions, but more work is required to validate its effectiveness).

NOTE: The presence of the OsO_4 will give false high results due to its enhanced nebulization efficiency (volatility). *Only dilutions in HCl should be made. The use of nitric acid should be strictly avoided.* Preparations from caustic nitrate fusions should be diluted in water.

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 225.585 nm	0.0004 µg/mL	1	ion	Fe, Ta, Ge, Ir, Cr
ICP-MS 192 amu	1 ppt	n/a	M+	$^{176}Yb^{16}O$, $^{176}Lu^{16}O$, $^{176}Hf^{16}O$, ^{192}Pt

*ICP-OES D.L.'s are given as radial / axial view

Iridium

77 192.22
4428 1.6
2443
Ir
[Xe]4f^{14}5d^{7}6s^{2}
22.4 2,3,4,6

Location: Group 9, Period 6
Atomic Weight: 192.22
Coordination Number: 6
Chemical Form in Solution: $IrCl_6^{-2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, H_2SO_4, and HF aqueous matrices. May cause AgCl precipitation when mixed with Ag^+. Stable with all other metals.

Stability: 2-100 ppb levels. 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 10% HCl / LDPE container.

Ir Containing Samples (Preparation & Solution): Metal (elevated temperature with aqua regia or HCl / Cl_2 {gas}); Ores (HF / H_2SO_4 digestion followed by aqua regia digestion); Platinum scrap (aqua regia digestion).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 224.268 nm	0.03 µg/mL	1	ion	*Cu*, Nb, Hf
ICP-OES 212.681 nm	0.03 µg/mL	1	ion	Ta, Yb, Au, V
ICP-OES 205.222 nm	0.06 µg/mL	1	atom	Fe
ICP-MS 191 amu	2 ppt	n/a	M+	$^{175}Lu^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Platinum

78 195.08
3827 1.4
1772
Pt
[Xe]4f^{14}5d^{6}6s^{2}
22.6 2,3,4,6,8

Location: Group 10, Period 6
Atomic Weight: 195.08
Coordination Number: 6
Chemical Form in Solution: $Pt(Cl)_6^{2-}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl and HNO_3, as the chloride complex. Avoid basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-10 ppb Pt is stable for 2 months in 1% HNO_3 / LDPE container. 100 ppb is stable for 5 months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 10 % HCl / LDPE container.

Pt Containing Samples (Preparation & Solution): Metal (aqua regia); Oxides (soluble in HCl); Ores (dissolve in HCl / HNO_3).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 214.423 nm	0.03/.003 µg/mL	1	ion	W, As, Ir, *Cd*
ICP-OES 203.646 nm	0.06/.006 µg/mL	1	ion	Co, Hf
ICP-MS 195 amu	5 ppt	n/a	M+	$^{179}Hf^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Gold

79 196.967
2857 1.4
1064.58
Au
[Xe]4f^{145}d^{10}6s
18.9 1,3

Location: Group 11, Period 6
Atomic Weight: 196.9665
Coordination Number: 6
Chemical Form in Solution: $Au(Cl)_6^{3-}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, and HNO_3, as the chloride complex. Avoid basic media. Stable with most metals and inorganic anions in acidic media.

Stability: 2-100 ppb levels. 2-10 ppb Au is stable for ≤ 1 day maximum in 1% HNO_3 / LDPE container. 100 ppb is stable for ≤ 2 days maximum in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 10% HCl / LDPE container.

Au Containing Samples (Preparation & Solution): Metal (aqua regia); Oxides (soluble in HCl); Ores (dissolve in HCl / HNO_3).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 242.795 nm	0.02/.003 µg/mL	1	atom	*Mn*, *Os*, Th, Ta, Pt Co, F
ICP-OES 267.595 nm	0.03/.003 µg/mL	1	atom	*Nb*, *Ta*, *U*, Cr, Th, Rh, Ru
ICP-OES 208.209 nm	0.04/.01 µg/mL	1	ion	Ir, Re
ICP-MS 197 amu	5 ppt	n/a	M+	$^{181}Ta^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Mercury

80 200.59
357 1.5
-38.72
Hg
[Xe]4f^{145}d^{10}6s^2
13.5 1,2

Location: Group 12, Period 6
Atomic Weight: 200.59
Coordination Number: 4
Chemical Form in Solution: $Hg(OH)(aq)^{1+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HNO_3. Avoid basic media forming insoluble carbonate. The sulfide, basic carbonate, oxalate, phosphate, arsenite, arsenate, and iodide are insoluble in water.

Stability: 2-100 ppb levels - stable in 10% HNO_3 packaged in borosilicate glass; *NOT* stable in 1% HNO_3 / LDPE container. 1-100 ppm levels stable in 7% HNO_3 packaged in borosilicate glass. 1000-10,000 ppm solutions are chemically stable for years in 5-10% HNO_3 / LDPE container.

Hg Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); HgO (soluble in HNO_3); Ores and Organic based (our documentation has more references to the preparation of Hg containing samples than any other element -- because these preparations are prone to error, we recommend you contact our technical staff at info@inorganicventures.com or (800)669-6799 and we'll provide you with the necessary data for your specific sample type).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 184.950 nm	0.03/.005 µg/mL	1	atom	
ICP-OES 194.227 nm	0.03/.005 µg/mL	1	ion	V
ICP-OES 253.652 nm	0.1 /.03 µg/mL	1	atom	Ta, *Co*, Th ,Rh , Fe, U
ICP-MS 202 amu	9 ppt	n/a	M+	$^{186}W^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Thallium

81 204.383
1473 1.4
304
Tl
[Xe]4f^{145}d^{10}6s^{2}6p
11.85 1,3

Location: Group 13, Period 6
Atomic Weight: 204.383
Coordination Number: 6
Chemical Form in Solution: $Tl(H_2O)_6^{1+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HNO_3, and H_2SO_4. Stable with most metals and inorganic anions. The sulfite, thiocyanate, and oxalate are moderately soluble; the phosphate and arsenite are slightly soluble and the sulfide is insoluble.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Tl Containing Samples (Preparation & Solution): Metal (is best dissolved in HNO_3 which forms chiefly the Tl^{1+} ion); Oxide (the thallous oxide is readily soluble in water. The thallic oxide requires high levels of acid); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (sulfuric / peroxide digestion or dry ash and dissolution in HCl).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 190.864 nm	0.04/.004 µg/mL	1	ion	V, Ti
ICP-OES 276.787 nm	0.1/.01 µg/mL	1	atom	Ta, V, Fe, Cr
ICP-OES 351.924 nm	0.2/.02 µg/mL	1	atom	Th, Ce, Zr
ICP-MS 205 amu	2 ppt	n/a	M+	$^{189}Os^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Lead

82
207.2
1750
1.6
327.6
Pb
$[Xe]4f^{14}5d^{10}6s^{2}6p^{2}$
13.5
2,4

Location: Group 14, Period 6
Atomic Weight: 207.2
Coordination Number: 6
Chemical Form in Solution: $Pb(H_2O)_6^{+2}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, HF, and HNO_3. Avoid H_2SO_4. Stable with most metals and inorganic anions forming insoluble carbonate, borate, sulfate, sulfite, sulfide, phosphate, oxalate, chromate, tannate, iodate, and cyanide in neutral aqueous media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Pb Containing Samples (Preparation & Solution): Metal (best dissolved in 1:1 H_2O / HNO_3); Oxides (the many different Pb oxides are soluble in HNO_3, with the exception of PbO_2 which is soluble in HCl or HF); Ores and Alloys (best attacked using 1:1 H_2O / HNO_3); Organic Matrices (dry ash and dissolve in dilute HCl. Do not heat when dissolving to avoid precipitation of SiO_2).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 168.215 nm	0.03/.003 µg/mL	1	ion	Co
ICP-OES 220.353 nm	0.04/.006 µg/mL	1	ion	Bi, Nb
ICP-OES 217.000 nm	0.09/.03 µg/mL	1	atom	W, Ir, Hf, Sb, Th
ICP-MS 208 amu	5 ppt	n/a	M+	$^{192}Pt^{16}O$, $^{192}Os^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Bismuth

83 208.980
1564 1.4
271.52
Bi
$[Xe]4f^{145}d^{10}6s^26p^3$
9.75 3,5

Location: Group 15, Period 6
Atomic Weight: 208.9804
Coordination Number: 6
Chemical Form in Solution: $Bi(O)(H_2O)_x^{1+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Stable in HCl, HNO_3, H_2SO_4, and HF. Avoid basic media forming insoluble hydroxide. Stable with most metals and inorganic anions in acidic media. Many salts that are insoluble in water are soluble in HCl, HNO_3 and HF. The major problem with Bi^{3+} is its tendency to hydrolyze at higher concentrations or in dilute acid. Nitric acid solutions should be 5% to hold the Bi in solution in the 100 to 10000 µg/mL concentration range.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 5 - 7% HNO_3 / LDPE container.

Bi Containing Samples (Preparation & Solution): Metal (soluble in HNO_3); Oxides (soluble in HNO_3); Alloys (dissolve in conc. 4:1 HCl / HNO_3 - heating may be required.); Organic based (dry ash at 450°C and dissolve ash in HNO_3 or acid digestion with conc. hot sulfuric acid adding hydrogen peroxide *carefully dropwise* until clear).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 223.061 nm	0.04/.005 µg/mL	1	atom	Th, Ir, Ti Cu
ICP-OES 306.772 nm	0.08/.01 µg/mL	1	atom	*Th*, U, Zr, Hf, Fe
ICP-OES 222.825 nm	0.1/.02 µg/mL	1	atom	*Cr*, *Hf*, Ce, Os
ICP-MS 209 amu	2 ppt	n/a	M+	$^{193}Ir^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Cerium

58 140.12
3426 1.1
798
Ce
[Xe]4f²6s²
6.66 3,4

Location: Period 6 (lanthanoid)
Atomic Weight: 140.12
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Ce(OH)_y(H_2O)_x^{+4-y}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid HF, H_3PO_4, H_2SO_4 and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride and sparingly soluble sulfates (La - Eu exhibit low sulfate solubility). Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Ce Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 413.765 nm	0.05/.0058 µg/mL	1	ion	Ce**
ICP-OES 418.660 nm	0.05/.003 µg/mL	1	ion	Zr
ICP-OES 453.975 nm	0.06/.0063 µg/mL	1	ion	
ICP-MS 140 amu	1 ppt	n/a	M+	$^{124}Sn^{16}O$, $^{124}Te^{16}O$

*ICP-OES D.L.'s are given as radial / axial view
**413.747 line may effect Bkg. Corr.

59 140.908
3512 1.1
931
Pr
[Xe]4f³6s² 3,4
6.77

Praseodymium

Location: Period 6 (lanthanoid)
Atomic Weight: 140.9077
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Pr(OH)_y(H_2O)_x^{+3-y}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid HF, H_3PO_4, H_2SO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride and sparingly soluble sulfates (La - Eu exhibit low sulfate solubility). Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Pr Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 414.311 nm	0.04/.004 µg/mL	1	ion	Ce
ICP-OES 417.939 nm	0.04/.004 µg/mL	1	ion	Cr, Ce
ICP-OES 422.535 nm	0.04/.004 µg/mL	1	ion	V, U
ICP-MS 141 amu	0.3 ppt	n/a	M+	$^{125}Te^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Neodymium

60 144.24
3068 1.1
1016
Nd
[Xe]4f⁴6s²
7.00 3

Location: Period 6 (lanthanoid)
Atomic Weight: 144.24
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Nd(OH)_y(H_2O)_x^{+3-y}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid HF, H_3PO_4, H_2SO_4 and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride and sparingly soluble sulfates (La - Eu exhibit low sulfate solubility). Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Nd Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 401.225 nm	0.05/.002 µg/mL	1	ion	Ti, Cr
ICP-OES 430.358 nm	0.075/.0014 µg/mL	1	ion	
ICP-OES 406.109 nm	0.1/.002 µg/mL	1	ion	Ce
ICP-MS 146 amu	2 ppt	n/a	M+	$^{130}Te^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Samarium

62 150.36
1791 1.1
1072
Sm
[Xe]4f⁶6s²
7.52 2,3

Location: Period 6 (lanthanoid)
Atomic Weight: 150.36
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Sm(OH)_y(H_2O)_x^{+3-y}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, and HNO_3. Avoid HF, H_3PO_4, H_2SO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride and sparingly soluble sulfates (La - Eu exhibit low sulfate solubility). Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Sm Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 359.260 nm	0.05/.002 µg/mL	1	ion	W, Th
ICP-OES 442.434 nm	0.075/.0014 µg/mL	1	ion	Ce, Ca
ICP-OES 428.079 nm	0.1/.002 µg/mL	1	ion	Ce, Cr
ICP-MS 152 amu	2 ppt	n/a	M+	$^{136}Ce^{16}O$, $^{136}Ba^{16}O$, ^{152}Gd

*ICP-OES D.L.'s are given as radial / axial view

Europium

63 151.96
1597 1.0
817
Eu
[Xe]4f⁷6s²
5.24 2,3

Location: Period 6 (lanthanoid)
Atomic Weight: 151.96
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Eu(OH)_y(H_2O)_x^{+3-y}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid HF, H_3PO_4, H_2SO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride and sparingly soluble sulfates (La - Eu exhibit low sulfate solubility). Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Eu Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 381.967 nm	0.003/.0003 µg/mL	1	ion	Cr, V
ICP-OES 412.970 nm	0.004/.0004 µg/mL	1	ion	Nb
ICP-OES 420.505 nm	0.004/.0004 µg/mL	1	ion	Ce, V
ICP-MS 153 amu	1 ppt	n/a	M+	$^{137}Ba^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

64 157.25
3266 1.1
1312
Gd
[Xe]4f^{7}5d6s^2
7.92 3

Gadolinium

Location: Period 6 (lanthanoid)
Atomic Weight: 157.25
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Gd(OH)_x(H_2O)_y^{+3-x}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4, and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Gd Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 342.247 nm	0.014/.001 µg/mL	1	ion	Th, U
ICP-OES 336.223 nm	0.02/.0002 µg/mL	1	ion	Th, Ca
ICP-OES 335.047 nm	0.02/.002 µg/mL	1	ion	Ce, Ca
ICP-MS 158 amu	2 ppt	n/a	M+	$^{142}Ce^{16}O$, $^{142}Nd^{16}O$, ^{158}Dy

*ICP-OES D.L.'s are given as radial / axial view

Terbium

65 158.925
3223 1.1
1357
Tb
[Xe]4f⁹6s
8.23 3,4

Location: Period 6 (lanthanoid)
Atomic Weight: 158.925
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Tb(OH)_x(H_2O)_y^{+3-x}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4, and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Tb Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 350.917 nm	0.02/.002 µg/mL	1	ion	V, Th, Ce, Zr
ICP-OES 367.635 nm	0.06/.006 µg/mL	1	ion	Ta, Ce, Co, U
ICP-MS 159 amu	1 ppt	n/a	M+	$^{143}Nd^{16}O$, $^{127}I^{16}O_2$

*ICP-OES D.L.'s are given as radial / axial view

66 162.50
2562 1.1
1409
Dy
[Xe]4f^{10}6s^{2}
8.55 3

Dysprosium

Location: Period 6 (lanthanoid)
Atomic Weight: 162.50
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Dy(OH)_x(H_2O)_y^{+3-x}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4 and HNO_3. Avoid HF, H_3PO_4 and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Dy Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O/ HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 340.780 nm	0.007/.0007 µg/mL	1	ion	Hf, Th, U, Zr
ICP-OES 353.170 nm	0.013/.001 µg/mL	1	ion	Ce, Th
ICP-MS 163 amu	3 ppt	n/a	M+	$^{147}Sm^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

67 164.930
2695 1.1
1470
Ho
[Xe]4f^{11}6s^{2}
8.80 3

Holmium

Location: Period 6 (lanthanoid)
Atomic Weight: 164.930
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Ho(OH)_x(H_2O)_y^{+3-x}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4, and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Ho Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 345.600 nm	0.006/.0001 µg/mL	1	ion	U, Ti
ICP-OES 339.898 nm	0.02/.002 µg/mL	1	ion	Ce, Re
ICP-MS 165 amu	1 ppt	n/a	M+	$^{149}Sm^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

68 167.26
2863 1.1
1522
Er
[Xe]4f^{12}6s^{2}
9.07 3

Erbium

Location: Period 6 (lanthanoid)
Atomic Weight: 167.26
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Er(OH)_x(H_2O)_y^{+3-x}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4, and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Er Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O/ HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 337.271 nm	0.01/.001 µg/mL	1	ion	Th, Ti
ICP-OES 349.910 nm	0.02/.002 µg/mL	1	ion	Ru, Th, U
ICP-MS 166 amu	1 ppt	n/a	M+	$^{150}Sm^{16}O$, $^{150}Nd^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Thulium

69 168.934
1947 1.1
1545
Tm
[Xe]4f^{13}6s^{2}
9.32 2,3

Location: Period 6 (lanthanoid)
Atomic Weight: 168.9342
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Tm(OH)_x(H2O)_y^{+3-x}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4 and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Tm Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 313.126 nm	0.005/.003 µg/mL	1	ion	U, Th, Be
ICP-OES 346.220 nm	0.008/.006 µg/mL	1	ion	Rh, U
ICP-MS 169 amu	1 ppt	n/a	M+	$^{153}Eu^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Ytterbium

70 173.04
1194 1.1
824
Yb
[Xe]4f^{14}6s^{2}
6.97 2,3

Location: Period 6 (lanthanoid)
Atomic Weight: 173.04
Coordination Number: 6 to 9, 10 for some compounds
Chemical Form in Solution: $Yb(OH)_x(H_2O)_y^{+3-x}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4, and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Yb Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 328.937 nm	0.002/.0003 µg/mL	1	ion	U, Ce, V
ICP-OES 369.419 nm	0.003/.0006 µg/mL	1	ion	Fe
ICP-MS 174 amu	2 ppt	n/a	M+	$^{158}Gd^{16}O$, $^{158}Dy^{16}O$, ^{174}Hf

*ICP-OES D.L.'s are given as radial / axial view

71 174.967
3395
1663
Lu
[Xe]4f^{14}5d6s^{2}
9.84 1

Lutetium

Location: Group 13, Period 5
Atomic Weight: 174.967
Coordination Number: 6
Chemical Form in Solution: $Lu(OH)_x(H_2O)_y^{+3-x}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl, H_2SO_4, and HNO_3. Avoid HF, H_3PO_4, and neutral to basic media. Stable with most metals and inorganic anions forming an insoluble carbonate, oxide, oxalate, and fluoride. Avoid mixing with elements / solutions containing moderate amounts of fluoride.

Stability: 2-100 ppb levels stable for months in 1% HNO3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO3 / LDPE container.

Lu Containing Samples (Preparation & Solution): Metal (soluble in acids); Oxide (dissolved by heating in H_2O / HNO_3); Ores (carbonate fusion in Pt^0 followed by HCl dissolution); Organic Matrices (dry ash and dissolve in 1:1 H_2O / HCl or HNO_3).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 261.542 nm	0.001/.0003 µg/mL	1	ion	Th, Mo, V, W
ICP-OES 291.139 nm	0.006/.0006 µg/mL	1	ion	Cr, U
ICP-MS 175 amu	1 ppt	n/a	M+	$^{159}Tb^{16}O$

*ICP-OES D.L.'s are given as radial / axial view

Thorium

90 232.038
4788 1.1
1755
Th
[Rn]6d²7s²
11.7 4

Location: Period 7 (actinoid)
Atomic Weight: 232.0381
Coordination Number: 8
Chemical Form in Solution: $Th(OH)^{3+}$ and $Th(OH)_2^{2+}$

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid H_3PO_4, H_2SO_4, and HF, although solubilities may not be a problem depending upon pH and matrix (i.e. - ThF_4 is soluble in acids). Avoid neutral to basic media. Th^{4+} is stable with most metals and inorganic anions forming an insoluble carbonate, oxide, fluoride, oxalate, sulfate, and phosphate in neutral to slightly acidic media.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

Th Containing Samples (Preparation & Solution): Metal (soluble in aqua regia); Oxide (the heated oxide is not soluble in acids except hot conc. H_2SO_4); Ores (Na_2O_2 fusion at 480 ± 20°C for 7 minutes, cool, and treat sintered mass with 50 mL cold water and let stand until disintegrated. The mass is transferred to a beaker and acidified with HCl, with 25 mL excess HCl added. Any residue is collected on a Whatman No. 42 filter, dried and ignited to 1000°C in Pt^0 crucible and ash treated with H_2SO_4 / HF and fumed. If residue remains, then treat it by peroxide fusion as described above).

Atomic Spectroscopic Information: (*italic* indicates severe at ~ concs.)

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 283.730 nm	0.07/.007 µg/mL	1	ion	U, Zr
ICP-OES 283.231 nm	0.07/.007 µg/mL	1	ion	U, Mo, Ti, Fe, Cr
ICP-OES 274.716 nm	0.08/.008 µg/mL	1	ion	Ti, Ta, *Fe*, V
ICP-MS 232 amu	1 ppt	n/a	M+	

*ICP-OES D.L.'s are given as radial / axial view

Uranium

92 238.029
4134 1.2
1132
U
[Rn]5f³6d7s²
19.0 3,4,5,6

Location: Period 7 (actinoid)
Atomic Weight: 238.0289
Coordination Number: 8
Chemical Form in Solution: UO_2^{2+} (uranyl)

Storage & Handling: Keep tightly sealed when not in use. Store and use at 20 ± 4°C. Do not pipet from container. Do not return portions removed for pipetting to container.

Chemical Compatibility: Soluble in HCl and HNO_3. Avoid H_3PO_4. H_2SO_4 and HF matrices should not be a problem depending upon [U]. Although the UO_2^{2+} ion is distinctly basic, any U^{+4} will ppt. in basic media. UO_2^{2+}salts are generally soluble in water and UO_2^{2+} is stable with most metals and inorganic anions. The uranyl phosphate is insoluble in water. UF_4 and UF_6 are water soluble.

Stability: 2-100 ppb levels stable for months in 1% HNO_3 / LDPE container. 1-10,000 ppm solutions chemically stable for years in 2-5% HNO_3 / LDPE container.

U Containing Samples (Preparation & Solution): Metal (dissolves rapidly in HCl and HNO_3); Oxide (soluble in HNO_3); Ores (digest for 1-2 hours with 1 gram of ore to 30 mL 1:1 HNO_3. Silica insolubles are removed by filtration after bringing the sample to fumes with conc. H_2SO_4).

Atomic Spectroscopic Information:

Technique / Line	Estimated D.L.*	Order	Type	Interferences
ICP-OES 385.958 nm	0.3/.01 µg/mL	1	ion	Th, Fe
ICP-OES 367.007 nm	0.3/.02 µg/mL	1	ion	Th, Ce
ICP-OES 263.553 nm	0.3/.01 µg/mL	1	ion	Ce, Ir, Th, Rh, W, Zr, Ta, Ti, V, Hf, Fe, Re, Ru
ICP-MS 238 amu	2 ppt	n/a	M+	$^{206}Pb^{16}O_2$

*ICP-OES D.L.'s are given as radial / axial view

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Paul R. Gains, PhD

Dr. Paul R. Gaines has four decades of spectroscopic experience. After earning his PhD in chemistry at Iowa State University Dr. Gaines worked in the laboratories of Exxon Research and Engineering and Union Carbide.

Today, Dr. Gaines is the Senior Technical Advisor and CEO of Inorganic Ventures, as well as, an accomplished web author of many popular guides and papers for fellow spectroscopists.

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