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Solar System Elemental Abundances from the Solar Photosphere and CI-Chondrites

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Table A1. References for CI-Chondrite Concentration Data [a]

Reference	Code	Method	Number of samples and meteorites [b]	Elements Analyzed
Ahrens et al. 1969	A69	XRF	1 Org	Al, Ca, [Fe], K, [Mg], Mn, P, [Si], Ti
Akaiwa 1966	A66	RNAA	2 Org	[In], [Se], [Te]
Arden & Cressey 1984	A84	IDMS	1 Org	Pb, Tl, U
Babechuk et al. 2010	B10	ICPMS	1 Org	Ba, [Hf], U, W La, Sm
Baedecker et al. 1973	B73	RNAA	1 Org	Au, Ge, Ir, [Ni]
Baker et al. 2010	B10	ICPMS-ID	1 Org	Pb,[Tl]
Barrat et al. 2012	B12	ICPMS-SF, ICP-AES	1 Alais, 1 Ivuna, 6 Org	Ba, Be, Co Cs*, Cu, Ga, Hf, K*,Li, Ni*, Mn, P, Pb, Rb*, Sc, Sr*, Ta, U*, V, W*, Y, Zn, Zr. All REE*. ICP-AES: [Al], [Ca], Co, Cr, [Fe], Mg, Mn, Na, P, Ni, Ti
Barrat et al. 2016	B16	ICPMS-SF	1 Alais, 1 Ivuna, 5 Org	All REE
Beer et al. 1984	B84	IDMS, TIMS	2 Org	Ba, Cs, Hf, K, Rb, [Sr]. La, Ce, Nd, Sm, Eu, Gd, Dy, Er, Yb, Lu.
Bendel 2013	B13	ICPMS-MC	1 Alais 2 Ivuna, 2 Org	Hf, Nb*, Ta, W, Zr. Nd, Sm, Lu
Bermingham et al. 2016	B16	ICPMS	2 Org	Ba
Blichert-Toft & Albarede 1997	B97	ID-MS	1 Org	[Hf], Lu
Bouvier et al. 2008	B08	ICPMS-ID-MC	1 Ivuna, 1 Org	Hf, Lu
Braukmüller et al. 2018	B18	ICPMS-SF	1 Ivuna, 2 Org	Ag, Al, As,[Ba],Ca, Cd, [Cs],Co, Cr, Cu, Ga, [Fe], [Hf], In, Ir, [K], Mg, Mn, Na, Nb, Ni, P, Pt, [Rb], Re, Rh, Sn, [Te], [Ti], Tl, U*, V, W, Zn, [Zr] All REE: La*
Braukmüller et al. 2020	B20	ICPMS-ID-Q	1 Org	Ag, Cd, Cu, Ga, In, Sn,Tl, Zn
Briggs & Mamikunian 1963	B63	Wet chem.(?)	1 Org	[Al], [Ca], [Co[, [Cr], Fe, [K], Mg, [Mn], [Na], [Ni], [P], Si, [Ti]
Burkhardt et al. 2012	B12	ICPMS	1 Org	Mo, [W]
Burnett et al. 1989	B89	PIXE	3 Ivuna, 3 Org	As*, [Cu], Fe, Ga, Ge, Mo, Ni, Pb*, Rb*, Ru*, Se, Sr*, [Y], Zn*, Zr
Case et al. 1973	C73	RNAA	2 Ivuna, 2 Org	As, Au*, Co*, Ga, [Mo], [Re],Sb*, [Se], [Te], Zn
Chou et al. 1976	C76	RNAA	4 Org	Au, Cd, Ge*, In, Ir, Ni*,Zn
Curtis & Gladney 1985	C85	PGA (NAA for Na)	1 Ivuna, 2 Org	B, Na*, S, Si
Curtis et al. 1980	C80	PGA	[Ivuna], 6 Org	[B]
Craddock & Dauphas 2010	C10	ICPMS	1 Ivuna	[Fe]
Crocket et al. 1967	C67	RNAA	1 Alais, 2 Ivuna, 3 Org	Au, Ir*, Os*, Pd*, Pt*, Ru
Dauphas & Pourmand 2011	D11	IDMS	1 Ivuna	Hf, U
Dauphas & Poumand 2015	D15	ICPMS-MC	3 Org	All REE
David et al. 2000	D00	ICPMS-ID-MC	1 Org	[Hf], [Zr]
De Laeter et al. 1974	D74	IDMS	1 Org	Sn
De Laeter & Hosie 1978	D78	IDMS	1 Org	Ba
De Laeter et al. 1998	D98	IDMS	1 Ivuna, 4 Org	Ba
Easton, Lovering 1964	E64	Flame photometry	1 Org	[K]

Table A1. References for CI-Chondrite Concentration Data [a]

Reference	Code	Method	Number of samples and meteorites [b]	Elements Analyzed
Ebihara et al. 1982	E82	RNAA	1 Alais,1 Ivuna, 4 Org	Ag, Au, Bi, Cd, Cs, Ge, In, Ir, Ni*, Os*, Pd*, Pt, Rb*, Re, Sb, Se, Sn, [Te], Tl, Zn. [Ce], [Nd], [Eu], [Tb], [Yb], [Lu]
Edwards & Urey 1956	E55	Flame photo.	2 Ivuna, 2 Org	K, [Na]
Ehmann & Chyi 1974	E74	RNAA	Ivuna, 4 Org	Hf, [Zr]
Ehmann & Gillum 1972	E72a	RNAA	1 Ivuna, 2 Org	Au, Pt
Ehmann & Rebagay 1970	E72b	INAA/RNAA	1Ivuna, 1 Org	[Zr,Hf] Do not use at all
Ehmann et al. 1970a	E70	INAA/RNAA	1 Ivuna, 2 Org	Au, Ir*
Evensen et al. 1978	E78	IDMS	1 Ivuna, 2 Or	[La], [Ce], [Nd], [Sm], [Eu], [Gd],[Dy], [Er], [Yb]
Fehr et al. 2005	F05	ICPMS	2 Org	[Sn], Te
Fehr et al. 2018	F18	ICPMS	4 Org	Te
Fischer-Gödde et al. 2010	F10	ICPMS-ID	Ivuna, 3 Org	Au, Ir, Os, Pd, Pt, Re, Rh, Ru
Fisher 1972	F72	Fission track	2 Org	[U]
Folinsbee et al. 1967	F67a	XRF	2 Revelstoke	Co,[Cu], [Fe], [K], [Ni], Ti*
Fouche & Smales 1967a	F67b,	RNAA	1 Ivuna, 1 Org	As, Au, Re, Pd, Sb
Fouche & Smales 1967b	F67c	RNAA	1 Iv Ivuna, 1 Org	Au, Ga, Ge, In
Fredriksson et al. 1997	F97	Pellet EMP	Org	[Al], [Ca], [Fe], [Mg], [Na], [Ni], [Si]
Friedrich et al. 2002	F02	ICPMS-Q	Org	As, Ba, Co, Cs, Cu, Ga,[Hf], Ir, [Li], [Nb], [Mo], Rb, Re, Mn, Pd, Pt, [Ru],Sb, Sc, Se, Sn, [Sr], Te, Ti, U, V, [W], [Y], Zn, [Zr]. All REE.
Funk 2015	F15	ICPMS-ID	1 Ivuna,2 Org	Se, Te
Ganapathy et al. 1976	G76-2	RNAA	2 Org	[Hf], [Zr]
Gooding 1979	G79	NAA	7 Org	Al, [Au], Ca*,Co*, Cr, Fe*, Ir*, Mg, Mn, Na, Ni*,Sc*, [Ta], [Ti], V, Zn [La], [Sm], [Eu],[Yb], [Lu]
Graham & Mason 1972	G72	SMSS	1 Ivuna	Nb
Greenland 1967	G67	RNAA	1 Ivuna, 1 Org	[Ag], [Cd], [Pd], [Se], [Te] ,[Zn]
Greenland & Goles 1965	G65a	RNAA	1 Ivuna, 3 Org	Cu*, [Zn]
Greenland & Lovering 1965	G65b	spectrometric	Org	Emission spectrographic: [Ba], [Cr], [Cu], [P], [Sc], [Sr], [V] Colorimetric/ spectrophotom.: Co, Fe, [Ga] Ge, [Mn], [Ni], Ti, Zn
Grossman et al. 1985	G85	NAA	1 Org	Al, As, Au, Ca, Co, Cr, Cs, [Fe], Ga, Hf, Ir, K, [Mg], Mn, Na, [Ni], Os, Ru, Sb, Se, [Te], V, Zn, [La], [Sm], [Eu], [Yb],[Lu]
Grossman & Ganapathy 1975	G75	NAA	Alais, 2 Org	Mn*, Na
Grossman & Ganapathy 1976	G76	NAA	[1 Al],1 Org	Au, Co, Cr, Fe, Ir*, Os, Sc, [La], [Dy], [Sm], [Eu],
Hamaguchi et al. 1969	H69	RNAA	3 Org	As, Sb, Sn
Hellmann et al. 2020	H20	ICPMS	1 Ivuna, 1 Org	Te
Hermann & Wichtl 1974	H74	NAA	1 Org	[As],Au, [Cs], Ir, [Mo], [Pd], Re, [Rb], Ru, Sb,[Sc],[Se],Sn, [Zn]
Hidaka & Yoneda, 2011	H11	ICPMS	1 Org	Ba, Cs
Hintenberger et al. 1973	H73	IDSSMS	1 Org	[Au], [Ir], [Pb],[Pd], [Pt],[Tl], [U], [W]
Horan et al. 2003	H03	IDMS; N-TIMS: Re, Os	2 Ivuna, 2 Org	Ir, Os, Pd, Pt, Re, Ru
Hu et al. 2023a	H23	ICPMS	1 Org	Al, [K],[Li], Na, Pb, Ti, U, V, All REE: [Lu]

Table A1. References for CI-Chondrite Concentration Data [a]

Reference	Code	Method	Number of samples and meteorites [b]	Elements Analyzed
Humayun & Clayton 1995	H95	IDMS	1 Org	[K]
Islam et al. 2012	I12	PGA	1 Alais,1 Ivuna, 2 Org	Ca, Co, [Cr], Fe, K, [Mg], Mn, Na, Ni, [Si], [Ti], [Sm], [Gd]
James & Palmer 2000	J00	ID-MS	1 Org	Li
Jarosewich 1972	J72	Flame photometry	1 Org	[Al], Ca, Co, [Cr], Fe, K, Mg, [Mn], [Na], [Ni], P, Si, Ti
Jenniskens et al. 2014	J14	ICPMS-Q	1 Org	Ba, Be, Ca, Cd, Co, Cr, Cs, Cu, Ga, [Fe], [Hf], K, Li, Mg, Mn, Na, Nb, Ni, P, Pb, Rb, Sb, Sc,[Sr], [Ta], Ti, Tl, U, [V], Y, Zn, [Zr] REE
Jochum et al. 1986	J86	ID-SSMS	1 Ivuna, 2 Org	Nb, Sc, U, Y. NAA for [Ta]
Jochum et al. 1993	J93	ID-SSMS	1 Ivuna, 1 Org	Sn
Jochum et al. 1996	J96	ID-SSMS	1 Ivuna, 2 Org	Au, Ir, Mo, Os, Pt, Re, Rh, Ru
Jochum et al. 2000	J00	ID-SSMS	2 Org	Nb, Y, Zr
Jochum & Seufert 1995	J95	ID-SSMS	1 Org	Nb, Rh, Y, Zr
Kallemeyn & Wasson 1981	K81	RNAA/INAA	2 Alais, 4 Org	Al, As, Au, Ca, Cd, Co, Cr, Fe, Ga, Ge, In, Ir, K, Mg*, Mn, Na, Ni*, Os, Ru, Sb, Sc, Se, V, Zn. [La], [Sm], [Eu], [Yb], [Lu]
Kaushal & Wetherill 1970	K70	IDMS	1 Ivuna, 3 Org	K*, Rb*, Sr*
Kiesl 1979	K79	NAA	1 Org	Al, Ca, [Cr], Fe, K, Mg, [Mn], Na, Ni, [P], Si, [Ti]
King et al. 2020	K20	ICP-OES,MS	2 Ivuna	Al, [Ba], Be, Ca, Cd, Co, Cs, Cu, [Fe], [Hf], K*, Na*, Ni, Mo, Rb, Sn, P, Sc, Sr*,Ti, [U], V, Y, Zn, Zr*, Dy
Kleine et al. 2004	K06	IXPMS	2 Org	Hf, [W]
Knab & Hintenberger 1978	K78	IDMS	1 Org	Ba, Cu, Ga, Ge, Hf, Pb, Pt, [Re], Sb, Sn, Sr, [Te], [W], Zr, Dy
Koefoed et al. 2023	K23	ICPMS	1 Alais, 1 Ivuna, 5 Org	K*
Kolesov 1974	K74	RNAA	1 Org	[subset of REE]
Krähenbühl et al. 1973	K73	RNAA	1 Alais, 3 Ivuna,4 Org	[Ag], Au, Bi, [Br], Cd*, Cs, Ge*, I, In, [Ir], Rb*, Re, [Sb], Se, [Te], Tl, U*, Zn
Krankowsky & Müller 1964	K64	ID-MS	1 Org	[Li]
Labidi et al. 2016	L16	ICPMS	2 Alais, 2 Org	Se
Laul et al. 1970a	L70a	RNAA	Ivuna,1 Org	Bi
Laul et al. 1970b	L70b	RNAA	Ivuna,1 Org	Tl
Loss et al. 1984	L84	IDMS	5 Org	Ag, Cd*, Pd, Te
Loss et al. 1989	L89	IDMS	4 Org	Sn
Loveland et al. 1969	L69	NAA	1 Alais, 2 Ivuna, 1 Org	Al
Lu et al. 2007	L07	ICPMS-ID	1 Ivuna, 4 Org	Hf*,Nb*. Mo, Sb, Sn ,Ta,*Ti, Zr*
Luck et al. 2005	L05	ICPMS-ID	1 Ivuna, 2 Org	Cu, Zn
Makishima & Nakamura 2006	M06	ICPMS-ID	2 Org	Al, Ba, Be, Bi, Ca, Co, Cs, Cu, Ga, [Fe], In, K, Li, Mn, Na, [Ni], P, Pb, Rb, Sc, Sr*, Tl, U, V, Y, Zn, All REE.
Mermelengas et al. 1979	M79	IDMS	1 Org	Pd
Mittlefehldt 2002	M02	NAA	1 Org	Al, As, Au, Ca, Co, Cr, Cs, Fe, [Hf], Ir, K, Mg, Mn, [Na], [Ni], Sb, Sc, Se, V, Zn. [La], [Eu], [Yb], [Lu]
Mittlefehldt & Wetherill 1979	M79b	IDMS	1 Ivuna, 3 Org	K, Rb, Sr*
Morgan & Lovering 1967	M64	RNAA	2 Org	Os

Table A1. References for CI-Chondrite Concentration Data [a]

Reference	Code	Method	Number of samples and meteorites [b]	Elements Analyzed
Morgan & Lovering 1967	M67	RNAA	2 Org	Os, Re
Morgan & Lovering 1968	M68	RNAA	2 Alais, 6 Ivuna, 8 Org, 2 Tonk	Th*, U*
Morgan & Walker 1988	M88	IDMS RIMS	1 Org	Os, Re
Münker et al. 2003	M03	ICPMS-ID-MC	1 Org	[Hf], [Nb], [Ta], [Zr]
Murty et al. 1983	M83	RNAA	1 Org	[Li]
Murthy & Compston 1965	M65	IDMS	1 Org	K*, Rb*,Sr*
Nakamura et al. 2022	N22	ICPMS	1 Org	Al, As, [B], Ba, [Be], [Bi], [Ca], Cd, [Cr], [Co], Cs, [Fe], Ga, Ge, Hf, Ir, K,[Li], [Mg], Mn, Na, [Nb], [Ni], Os, P, Pb, Pd, Pt, Rb, Re, Ru, Sb, Se, Sn, [Sr], Te, Th, Ti, [Tl], V, W, Y , Zn, Zr, All REE: [La]
Nakamura 1974	N74a	AES	2 Org	Ba*, K, Fe, Mg, Na, Pd, Sc, U, La,Ce, Nd, Dy, Sm, Eu, Gd, Dy, Er, Yb, Lu.
[Nichiporuk & Bingham. 1970]	N70b	AES	1 Org	[Cu], [V]
Nichiporuk & Moore 1970	N70	AAS	1 Org	[Li]
Nichiporuk & Moore 1974	N74b	AAS	1 Ivuna, 1 Org	[Fe], K, Li, Na
Nichiporuk et al. 1967	N67	XRF	1 Org	Ca,[Co], [Cr], [Fe], Mn, Ni
Nie et al. 2021	N21	ICPMS	1 Ivuna, 1 Org	K*, Rb*
Palme & Zipfel 2021	P21	INAA	2 Alais, 3 Ivuna, 9 Org, 1 Tonk	Al, As*, Au, Ca*, Co*, Cs*, Cr, Cu, Fe, Ga, Ge, Hf*, Ir, K*, Mg, Mn, Na*, Nb, Ni*, [Mo], O, Os*, [Pd], [Pt], Re*, Ru*, Sb, Sc, Se*, Si, [Ti], V, [W], Zn, [La], [Ce], [Nd], [Sm], [Eu], [Gd],[[Tb], Dy], [Ho], [Er], [Tm], [Yb], [Lu]
Pinson et al. 1953	P53	AAS/ES	1 Org	[Sc]
Pogge von Strandmann et al. 2011	P11	ICPMS	1 Org	Li*
Pourmand et al. 2012	P12	ICPMS-MC	1 Alais,3 Ivuna, 7 Org	Sc, Y, All REE
Pringle & Moynier 2017	P17	ICPMS	1 Org	Rb
Rambaldi et al. 1978	R78	RNAA	1 Org	Au, Ir, Ni, Os, Pt, Re
Rammensee & Palme 1982	R82	RNAA	2 Org	As, Au, Co, Cu, Ir, Mo, Ni, Os, Pt, Sb, W
Reed et al. 1960	R60	RNAA	2 Org	Ba, Pb*, Tl, U
Reed & Allen1966	R66	RNAA	2 Ivuna,2 Org	[Te], U
Rocholl & Jochum 1993	R93	ID-SSMS	1 Ivuna, 5 Org	Ba*,Cs, Hf*, Nb*, Rb, Pb, Sb*, [Sr], Th*, U*, Y, Zr*, La*, Ce, Pr, Nd, Sm, Eu*, Gd, Tb, Dy, Ho, Er, Yb
Rosman & De Laeter 1974	R74	IDMS	1 Org	Cd
Rosman & De Laeter 1986	R86	IDMS	1 Org	Cd
Schmitt et al. 1963	S63	INAA/RNAA	1 Ivuna, 1 Org	[Cd]
Schmitt et al. 1964	S64-1	RNAA	1 Ivuna, 1 Org	Sc*, Y. [All REE except Gd]
Schmitt et al. 1972	S72	NAA	1 Alais, 2 Ivuna, 1 Org	Al, Co*, Cr, Cu, Fe*, In, Mn, Na, Sc
Schönbächler et al. 2005	S05	ICPMS	1 Org	Ag, [Nd], Pd, Zr
Seitz et al. 2007	S07	ICPMS	1 Org	Li
Sephton et al. 2013	S13	ICPMS	1 Org	Li
Shima 1979	S79	IDMS	1 Org	Hf, Ti, Zr

Table A1. References for CI-Chondrite Concentration Data [a]

Reference	Code	Method	Number of samples and meteorites [b]	Elements Analyzed
Smales et al. 1964	S64-2	IDMS, RNAA	4 Iv	Cs, Rb
Smales et al. 1971	S71	IDMS	1 Iv	Cs, Rb
Smith et al. 1977	S77	IDMS	2 Org	Te
Takahashi et al. 1978	T78	RNAA	1 Org	Ag, Au, Cd, Cs, [Ge], In, Ir, Ni, Os, Pd, Rb, Re, [Sb], Se, [Te], Tl, U, Zn
Tanner & Ehmann 1967	T67	INAA/RNAA	1 Ivuna,1 Org	Sb
Tatsumoto et al. 1976	T76	IDMS	1 Org	Pb, Th, U
Vilcsek E. 1977	V77	AAS	1 Org	[Be]
Vogt & Ehmann 1965	V65	NAA	1 Org	Si
Vollstaedt et al. 2016	V16	ICPMS-ID	1 Org	Se
Von Michaelis et al. 1969	V69	XRF	1Org	Al, [Ca],Fe, K, Mg, Mn, P, Si, Ti
Walker et al. 2002	W02	N-TIMS	2 Ivuna, 2 Org	Os, Re
Wang et al. 2013	W13	ICPMS-HG-ID	1 Org	Se, Te
Wang et al. 2014	W15	ICPMS-SF-ID	1 Ivuna,1 Org	Ag*, [Ba], [Bi], Cd, Cu, Mo, Se, Te, Tl, W, Sm.
Wang & Jacobsen 2016	W16	ICPMS	1 Org	[K]
Wieser & de Laeter 2000	W00	IDMS	3 Org	Mo
Weller et al. 1978	W78	Various	1 Ivuna, 1 Org	[B]
Wieser, & De Laeter 2000	W00	IDMS	2 Ivuna, 3 Org	Mo
Wiik 1956. 1969	W56	Flame photometry	1 Alais, 1 Ivuna, 2 Org	[Al], Co, Cr*, [Cu],Fe, K*, Mg, [Mn], [Na], [P], Si, Ti, [V]
Wing 1964	W64	NAA	1 Org	Si, O
Wolf & Palme 2001	W02	XRF	1 Ivuna, 4 Org	Al, Ca, Cr, Fe, Mg, Mn, P, Si, Ti, V
Wolf et al. 2005	W05	ICPMS-Q	1 Org	Bi, Cd, Cs, Cu, Ga, Rb, Sb, Se, Sn, Te, Tl, Zn
Xiao & Lipschutz 1992	X92	RNAA	2 Org	Ag, Au, Bi, Cd, Co, Cs, Ga, In, Rb, Sb, Se, [Te], Zn
Yi & Masuda 1996	Y96	ICPMS-ID	2 Org	Ir, Pd, Pt, Ru
Zhai & Shaw 1994	Z94	PGA	2 Ivuna, 2 Org	B

[a] For C, N, O, and S see Table 2. For halogens, see Lodders and Fegley (2023). Data in square brackets [ ] indicate that raw data were considered but not included in final meteorite and group mean. Elements marked with a star indicate that one or more samples were excluded from multiple samples reported in a given reference. No iron measurements from ICP and no REE by INAA and RNAA are included in the group mean. [b] Org =Orgueil.

Table A2. References for Hydrogen, Carbon, Nitrogen, Sulfur in CI-Chondrites

Reference	Code	Method	Number of samples and meteorites [b]	Elements Analyzed
Alexander et al. 2012b	A12	Combustion element analyzer	1 Ivuna, 2 Org	C
Belsky & Kaplan 1970	B70	Stepped combustion, MS	1 Ivuna, 1 Org	C (same as S70)
Berzelius 1834	B834	Wet. Chem/ combustion	1 Alais	[C from carbonate & bulk], [S]
Boato 1954	B54	Stepped combustion, MS	1 Ivuna, 1 Org	C
Braukmüller et al. 2018	B18	ICPMS	1 Ivuna, 2 Org	S
Briggs & Mamikunian 1963	B63	Combustion	1 Org	H, C, S
Burgess et al. 1991	B91	Stepped combustion, MS	1 Ivuna, 2 Org*	S”
Christie 1914	C14	Wet chem., flame photom. combustion	1 Tonk	C [as carbonate] C bulk, S
Cloez 1864a	C864a	Wet. Chem./ combustion	1 Org I	C
Cloez 1864b	C864b	Wet. Chem./ combustion	1 Org	C, S
Cloez 1864c	C864c	combustion	1 Org	[C from carbonate only]
Curtis & Galdney 1985	C85	PGA	2 Ivuna, 2 Org	S
Dreibus et al. 1993	D93	Combustion element analyzer	1 Org	S
Dreibus et al. 2004	D04	Combustion element analyzer	1 Ivuna, 1 Org	C, S
Filhols & Mellies 1864	F864	Wet. Chem./combustion	1 Org	C, [S]
Folinsbee et al. 1967	F67	Combustion element analyzer	2 Revelstoke	C, S
Fredriksson et al. 1997	F97	Pellet analysis	1 Org	[C, S]
Funk 2015	F15	ICPMS	1 Org	S
Gao & Thiemens 1993		Wet. Chem., MS	2 Org	S*
Gibson et al. 1971	G71	Gas chromatography /spectrophotometic	4 Org	C, N
Grady et al 1991	G91	MS, stepwise heating	1 Alais, 1 Org	C, N
Grady et al. 2002	G02	MS, stepwise heating	1 Org	C, N
Halbout et al. 1986	H86	MS, stepwise heating	1 Org	C
Islam et al 2012	I12	PGA	2 Org	S
Jarosewich 1972	J72	Combustion	1 Org	C, S
Kaplan & Hulston 1966	K66	MS, pyrolysis	1 Org	S
Kerridge 1985	K85	MS, pyrolysis	1 Alais, 1 Iv	H, C, N
Kiesl 1979	K79	Unknown	1 Org	C, S
Lawrence Smith 1876a	L876a	Dissolution/combustion	Orgueil 50gr, [Alais 2 grams]	C
Lawrence Smith 1876b	L876b	Dissolution/combustion	Orgueil 50gr, Alais 2 grams]	C*
Mason 1962	M62	Combustion	1 Alais	C, [S]
Monge et al. 1864	M864	Wet. Chem./combustion	1 Alais 5 gr	[C from carbonate only]
Monster et al. 1965	M65-2			
Mueller et al. 1965	M65-3	Combustion	1 Org	H.C,S
Nakamura et al. 2022	N22	Combustion element analyzer	1 Org	C, S
Otting & Zaehringer 1967	O67	Combustion	1 Org	C
Pearson et al. 2005	P05	Combustion element analyzer, MS	8 Alais, 4 Org	C*
Pisani 1864	P864	Wet. Chem./ combustion	1 Orgueil	[C], S
Robert & Epstein 1982	R82-2	Combustion, stepped pyrolysis, 200-1300°C, MS	2 Org	C
Roscoe 1863	R863	Combustion	1 Alais	C
Sephton et al. 2003	S03	MS, stepwise heating	1 Org	C
Smith & Kaplan 1970	S70	MS, stepwise heating	1 Org, 1 Iv	S

Table A2. References for Hydrogen, Carbon, Nitrogen, Sulfur in CI-Chondrites

Reference	Code	Method	Number of samples and meteorites [b]	Elements Analyzed
Thenard 1806	T806	Wet. Chem.	Alais, 10 gr	C, [S]
Wang et al. 2014	W15		1 Ivuna, 1 Org	S
Wiik 1956	W56	Wet. Chem./combustion	1 Ivuna, 1 Org	C, S
Wiik 1969	W69	Wet. Chem./combustion	1 Org	C, S
Wright et al. 1985	W85	MS, stepwise heating	1 Org	C
Wright et al. 1986	W86	MS, stepwise heating	1 Alais, 1 Org	[C]

Table A3. References for Early Analyses of CI-Chondrites

Reference	Code	Method	Number of samples and meteorites [b]	Elements Analyzed
Berzelius 1834	B834	Wet. Chem	Alais	[Al], [Fe], [Mg], [Si]
Christie 1914	C14	Wet chem., flame photometry	Tonk	[Ca], [Fe], [P], [Si], [Ti]
Cloez 1864a,b	C864a,b	Wet. Chem.	Orgueil	[Ca],[Al], [Fe], [Mg], [Si]
Filhols & Mellies 1864	F864	Wet. Chem.	Orgueil	[Al], [Fe], [Mg], other?
Monge et al. 1864	M864	Wet. Chem.	Orgueil, 5 gr	[Cr],[Fe], [Si], [Mn],[Ni]-
Thenard 1806	T806	Wet. Chem.	Alais, 10 gr	
Pisani 1864	P864	Wet. Chem.	Orgueil	[Al], [Ca],[Fe], [Mg], [Si] other

Table A4. Refractory Element Concentrations from Element Ratios in Carbonaceous Chondrites, and determined by averaging selected analyses [a]

Element	Concentration from	Source	Weight Ratio	%SD	Concentration ppm	%SD
Lu	grand average	Table 4	--		**0.255**	5.7
Hf	ratio used	Lu/Hf	0.238	1	**0.107**	**5.8**
Hf	grand average				0.108	7.4
Zr	ratio used	Zr/Hf	34.1	1	**3.65**	**5.9**
Zr	grand average				3.73	8.0
Nb	ratio used	Zr/Nb	13.47	5.8	**0.271**	**8.3**
Nb	grand average				0.29	10.3
Ta	ratio used	Nb/Ta	19.4	3.9	0.0140	9.2
Ta	grand average				**0.0149**	**4.7**
Y	ratio used	Zr/Y	2.4	6.5	**1.52**	**8.8**
Y	grand average				1.51	9.2
Th	grand average	Table 4			0.0304	10.9
U	ratio used	Th/U	3.75	11	0.0810	12.3
U	grand average				**0.0810**	**9.5**
Al	grand average	Table 4			8470	5.7
Ca	ratio used	Ca/Al	1.08	2.1	**9148**	**6.1**
Ca	grand average				8970	8.9
Ir	grand average	Table 4			**0.456**	**5.9**
Os	ratio used	Os/Ir	1.06	2.8	0.483	6.6
Os	grand average				**0.491**	**2.8**
Re	ratio used	Os/Re	12.32	3.0	**0.0399**	**4.1**
Re	grand average				0.0371	9.2
Ru	ratio used	Os/Ru	0.723	5.3	**0.670**	**8.4**
Ru	grand average				0.648	10.2
Pt	ratio used	Pt/Ir	1.98	5.0	**0.904**	**7.7**
Pt	grand average				0.926	11.2
Rh	ratio used	Pt/Rh	7.24	7.5	0.126	10.8
Rh	grand average				**0.133**	**4.5**

[a] entries in bold are adopted final values, see Table 4. For element ratios, see tables A5-A12.

Table A5. Ca/Al Ratios of Carbonaceous Chondrites

Source	Number of samples	Ca/Al	%SD	Remarks
Ahrens 1970	8	1.08	1.9	CI, CM, CO, CV
Kallemeyn and Wasson 1981	45	1.07	8.5	CI, CM, CO, CV
Wolf and Palme 2001	19	1.10	4.8	one Orgueil, Axtell, Bali excluded
Jarosewich 2006	15	1.04	7.2	Murchison, Colony, Axtell excluded
Patzer et al. 2010	7	1.10	5.6	Axtell excluded
Stracke et al. 2012	39	1.10	8.8	only Allende samples
Braukmüller et al. 2018	24	1.07	8.6	Tagish Lake, EET85013 excluded
Average Ratios		**1.080**	**6.1**	
from grand average method		1.060	8.9	

Table A6. Lu/Hf Ratios of Carbonaceous Chondrites

Source	Number of samples	Lu/Hf	%SD	Remarks	Analytical Method
Beer et al. 1984	2	0.2382		2 Orgueil samples	ID
Patchett et al. 2004	7	0.2386	1.4	Karoonda & Kainsaz excluded	ID
Bouvier et al. 2008	15	0.2387	1.3	Karoonda & Ninqiang excluded	ID
Dauphas & Pourmand 2011	13	0.2382	1.0		ID
Stracke et al. 2012	39	0.2408	2.7	only Allende samples	ICP-MS
Barrat et al. 2012; Göpel et al. 2015	10	0.2346	2.9	2 Orgueil samples excluded	ICP-MS
Braukmüller et al. 2018	17	0.2478	2.7	ALH85002 excluded	ICP-MS
Average Ratios		**0.2384**	**1**	**only ID analyses**	
From grand average method		0.2355	9.3		

Samples with excessive deviations (>2σ) from average were excluded; Barrat et al. (2012) reported data on 6 Orgueil samples, Göpel et al. (2015) included additional data analyzed by Barrat.

Table A7. Zr/Hf Ratios of Carbonaceous Chondrites

Source	Number of samples	Zr/Hf	%SD	Analytical Method
Shima 1971	11	34.11	3.4	ID
Weyer et al. 2002	5	34.12	2.1	ID
Münker et al. 2003	14	34.09	1.3	ID
Lu et al. 2007	8	33.44	2.8	ICP-MS
Patzer et al. 2010	6	32.89	4.2	ICP-MS
Stracke et al. 2012	39	35.99	2.1	ICP-MS
Barrat et al.2012; Göpel et al. 2015	12	32.85	3.0	ICP-Ms
Braukmüller et al. 2018	26	33.74	1.4	ICP-MS
Münker et al. 2025	8	33.9	1.5	ID
Average, all data		33.9	2.7	
Average ID analyses		**34.1**	**1**	
Grand average method		34.1	7.5	

Table A8. Zr/Nb Ratios of Carbonaceous Chondrites (only CI- and CM-Chondrites, see text)

Source	Number of samples	Zr/Nb	%SD	Remarks
Schönbächler et al. 2003	5	14.11	10.2	Ci, CM
Münker et al. 2003	6	13.58	9.7	CI, CM
Lu et al. 2007	8	12.41	4.2	CI
Braukmüller et al. 2018	16	12.95	5.0	CI, CM
Münker et al. 2025	8	14.3	5.6	CI, CM
Average Ratios	**6**	**13.47**	**5.8**	
Grand average method		13.27	13.0	

Table A9. Nb/Ta Ratios of Carbonaceous Chondrites (only CI- and CM-Chondrites, see text)

Source	Number of samples	Nb/Ta	%SD	Remarks
Münker et al. 2003	6	20.40	3.8	only CI and CM
Lu et al. 2007	7	18.67	6.3	CI, CM
Barrat et al. 2012 Göpel et al. 2015	10	19.53	3.09	CI, CM [a]
Münker et al. 2025	6	19.00	2.1	CI
Average Ratios		**19.40**	**3.6**	
Grand average method		18.94	11.3	

[a] Barrat et al. (2012) reported data for 6 Orgueil samples, Göpel et al. (2015) included additional data analyzed by Barrat. Data for heavily weathered Arch were excluded.

Table A10. Zr/Y Ratios of Carbonaceous Chondrites

Source	Number of samples	Zr/Y	%SD	Remarks
Jochum et al. 2000	3	2.36	5.9	Orgueil, Murray, Murchison
Stracke et al. 2012	39	2.58	6.7	only Allende
Barrat et al. 2012; Göpel et al. 2015	12	2.27	8.7	
Average Ratios		**2.40**	**6.6**	
Grand average method		2.47	12.2	

[a] Barrat et al. (2012) reported data for 6 Orgueil samples, Göpel et al. (2015) included additional data analyzed by Barrat.

Table A11. Sm/Nd Ratios of Carbonaceous Chondrites

Source	Number of samples	Sm/Nd	%SD	Remarks
Beer et al. 1984	2	0.3276		Orgueil
Patchett et al. 2004	6	0.3230	2.0	
Bouvier et al. 2008	17	0.3250	0.9	
Barrat et al. 2012; Göpel et al. 2015	13	0.3280	2.9	CI, CM
Braukmüller et al. 2018	24	0.3306	2.1	CI, CM
Average Ratios		**0.3268**	**1**	
Grand average method		0.323	7.3	

Table A12. Th/U Ratios of Carbonaceous Chondrites

Source	Number of samples	Th/U	%SD	Remarks
Tatsumoto et al. 1973	3	3.8	6	CM, CV
Rocholl and Jochum 1993	29	3.08	24	
Dauphas and Pourmand 2011	12	3.74	7.7	CI, CM, CV, CO; Lance excluded
Makashima and Nakamura 2011	6	3.66	4.3	CI, CM
Stracke et al. 2012	39	4.21	12.7	Allende, one sample excluded
Barrat et al. 2012; Göpel et al. 2015	9	3.61	6.6	CI, CM
Braukmüller et al. 2018	23	4.15	9.6	Nogoya, Vigarano excluded
Average		**3.75**	**11**	
Grand average method		3.75	14	

Table A13. Proto Solar (4.567 Ga ago) Isotopic and Elemental Compositions, Mass Fractions, and Atomic Weights *

	Z	A	Isotope Fractions of Element atom%	Elemental Abundance N(Si)=1e6	Isotopic Abundance Σ Si=1e6	Elemental Mass Fractions	Isotopic Mass Fractions	Atomic Mass AMU	Mean Atomic Weight (Proto Solar) Dalton	Mean Atomic Weight (Present-Day) Dalton
H	1	1	99.99803		2.29E+10		7.061E-01	1.007825032		
H (D)	1	2	0.00197		4.51E+05		2.780E-05	2.014101778		
			100	**2.29E+10**		**0.7061**			1.007825	1.007845
He	2	3	0.0166		3.73E+05		3.443E-05	3.01602932		
He	2	4	99.9834		2.25E+09		2.752E-01	4.002603254		
			100	**2.25E+09**		**0.2752**			4.002199	4.002439
Li	3	6	7.589		4.3		7.830E-10	6.015122885		
Li	3	7	92.411		51.8		1.112E-08	7.016003428		
			100	**56.1**		**1.190E-08**			6.940047	6.940047
Be	4	9	**100**	**0.657**	0.657	**1.810E-10**	1.810E-10	9.01218291	9.012183	9.012183
B	5	10	19.83		3.6		1.099E-09	10.01293696		
B	5	11	80.17		14.5		4.885E-09	11.00930537		
			100	**18.1**		**5.984E-09**			10.81176	10.81176
C	6	12	98.965		8.99E+06		3.299E-03	12		
C	6	13	1.035		94000		3.738E-05	13.00335484		
			100	**9.08E+06**		**3.336E-03**			12.01039	12.01039
N	7	14	99.774		2.44E+06		1.044E-03	14.003074		
N	7	15	0.226		5520		2.532E-06	15.0001089		
			100	**2.44E+06**		**1.047E-03**			14.00532	14.00532
O	8	16	99.777		1.61E+07		7.883E-03	15.99491462		
O	8	17	0.035		5700		2.963E-06	16.99913176		
O	8	18	0.188		30400		1.673E-05	17.99915961		
			100	**1.62E+07**		**7.902E-03**			15.99904	15.99904
F	9	19	**100**	**1278**	1278	**7.424E-07**	7.424E-07	18.99840317	18.99840	18.99840
Ne	10	20	93.125		3.69E+06		2.257E-03	19.99244018		
Ne	10	21	0.224		8860		5.689E-06	20.99384668		
Ne	10	22	6.651		2.64E+05		1.773E-04	21.99138512		
			100	**3.96E+06**		**2.440E-03**			20.12764	20.12764
Na	11	23	**100**	**55900**	55900	**3.930E-05**	3.930E-05	22.98976928	22.98977	22.98977
Mg	12	24	78.992		8.18E+05		6.003E-04	23.9850417		
Mg	12	25	10.003		1.04E+05		7.919E-05	24.98583691		
Mg	12	26	11.005		1.14E+05		9.060E-05	25.98259295		
			100	**1.04E+06**		**7.701E-04**			24.30498	24.30498

Al	13	27	**100**	**81100**	81100	**6.692E-05**	6.692E-05	26.98153859	26.98154	26.98154
Si	14	28	92.2297		9.22E+05		7.891E-04	27.97692653		
Si	14	29	4.6832		46800		4.147E-05	28.97649467		
Si	14	30	3.0872		30900		2.833E-05	29.97377017		
			100	**1.00E+06**		**8.589E-04**			28.08538	28.08538
P	15	31	**100**	**8390**	8390	**7.948E-06**	7.948E-06	30.973762	30.97376	30.97376
S	16	32	95.04074		4.04E+05		3.947E-04	31.97207117		
S	16	33	0.74869		3180		3.207E-06	32.97145569		
S	16	34	4.19599		17800		1.849E-05	33.9678669		
S	16	36	0.01458		62		6.820E-08	35.96708076		
			100	**4.25E+05**		**4.165E-04**			32.06388	32.06388
Cl	17	35	75.7647		4030		4.310E-06	34.96885268		
Cl	17	37	24.2353		1290		1.458E-06	36.96590259		
			100	**5320**		**5.768E-06**			35.45284	35.45284
Ar	18	36	84.596		75100		8.261E-05	35.96754511		
Ar	18	38	15.380		13600		1.579E-05	37.96273234		
Ar*	18	40	0.024		21		2.567E-08	39.96238312		
			100	**88800**		**9.843E-05**			36.27538	36.27536
K	19	39	93.132		3410		4.063E-06	38.96370649		
K*	19	40	0.147		5		6.111E-09	39.96399848		
K	19	41	6.721		246		3.082E-07	40.96182526		
			100	**3660.00**		**4.378E-06**			39.09830	39.09947
Ca*	20	40	96.941		58500		7.150E-05	39.96259086		
Ca	20	42	0.647		391		5.017E-07	41.95861801		
Ca	20	43	0.135		82		1.077E-07	42.95876667		
Ca	20	44	2.086		1260		1.694E-06	43.95548173		
Ca	20	46	0.004		2		2.811E-09	45.9536926		
Ca	20	48	0.187		113		1.657E-07	47.9525343		
			100	**60400**		**7.397E-05**			40.07802	40.07802
Sc	21	45	**100**	**33.7**	3.371E+01	**4.634E-08**	4.634E-08	44.9559119	44.95591	44.95591
Ti	22	46	8.249		200		2.811E-07	45.95262889		
Ti	22	47	7.437		181		2.599E-07	46.95176293		
Ti	22	48	73.72		1790		2.625E-06	47.94794631		
Ti	22	49	5.409		131		1.961E-07	48.94786998		
Ti	22	50	5.185		126		1.925E-07	49.94479117		
			100	**2430**		**3.554E-06**			47.86688	47.86688
V	23	50	0.25		0.7		1.046E-09	49.9471585		
V	23	51	99.75		273.6		4.263E-07	50.9439595		

			100	**274**		**4.2735E-07**			50.94147	50.94147
Cr	24	50	4.345		575		8.783E-07	49.9460442		
Cr	24	52	83.790		11100		1.763E-05	51.94050751		
Cr	24	53	9.501		1260		2.040E-06	52.94064943		
Cr	24	54	2.365		313		5.163E-07	53.93888045		
			100	**13200**		**2.107E-05**			51.99612	51.99612
Mn	25	55	**100**	**9270**	9.270E+03	**1.558E-05**	1.558E-05	54.93804512	54.93804	54.93804
Fe	26	54	5.845		51100		8.430E-05	53.93961046		
Fe	26	56	91.754		8.02E+05		1.371E-03	55.93493745		
Fe	26	57	2.119		18500		3.221E-05	56.93539427		
Fe	26	58	0.282		2460		4.359E-06	57.93327558		
			100	**873500**		**1.492E-03**			55.84514	55.84514
Co	27	59	**100**	**2290**	2.260E+03	**4.073E-06**	4.073E-06	58.93319506	58.93319	58.93319
Ni	28	58	68.077		34100		6.042E-05	57.9353435		
Ni	28	60	26.223		13100		2.401E-05	59.93078635		
Ni	28	61	1.140		570		1.062E-06	60.93105603		
Ni	28	62	3.635		1820		3.447E-06	61.92834511		
Ni	28	64	0.926		463		9.052E-07	63.92796594		
			100	**50030**		**8.985E-05**			58.69335	58.69335
Cu	29	63	69.174		381		7.338E-07	62.92959751		
Cu	29	65	30.826		170		3.374E-07	64.92778945		
			100	**551**		**1.071E-06**			63.54556	63.54556
Zn	30	64	49.1704		614		1.200E-06	63.92914224		
Zn	30	66	27.7306		346		6.979E-07	65.92603345		
Zn	30	67	4.0401		50		1.032E-07	66.92712739		
Zn	30	68	18.4483		230		4.784E-07	67.9248442		
Zn	30	70	0.6106		8		1.630E-08	69.9253193		
			100	**1250**		**2.496E-06**			65.37777	65.37777
Ga	31	69	60.108		21.6		4.559E-08	68.9255735		
Ga	31	71	39.892		14.4		3.114E-08	70.9247026		
			100	**36.0**		**7.673E-08**			69.72307	69.72307
Ge	32	70	20.526		24.9		5.330E-08	69.9242474		
Ge	32	72	27.446		33.3		7.330E-08	71.9220758		
Ge	32	73	7.76		9.4		2.101E-08	72.9234589		
Ge	32	74	36.523		44.3		1.003E-07	73.92117777		
Ge	32	76	7.745		9.4		2.183E-08	75.92140273		
			100	**121**		**2.697E-07**			72.62959	72.62959
As	33	75	**100**	**6.15**	6.15	**1.410E-08**	1.410E-08	74.9215965	74.92159	74.92159

Se	34	74	0.863		0.6		1.396E-09	73.92247594		
Se	34	76	9.22		6.6		1.531E-08	75.91921372		
Se	34	77	7.594		5.4		1.278E-08	76.919914		
Se	34	78	23.685		16.9		4.037E-08	77.9173091		
Se	34	80	49.813		35.6		8.708E-08	79.9165213		
Se^	34	82	8.825		6.3		1.581E-08	81.9166994		
			100	**71.5**		**1.728E-07**			78.97168	78.97168
Br	35	79	50.686		6.29		1.518E-08	78.9183371		
Br	35	81	49.314		6.12		1.515E-08	80.9162906		
			100	**12.4**		**3.033E-08**			79.90361	79.90361
Kr	36	78	0.3652667		0.21		4.988E-10	77.92036486		
Kr	36	80	2.3440789		1.34		3.283E-09	79.91637915		
Kr	36	82	11.686258		6.70		1.678E-08	81.91348282		
Kr	36	83	11.572467		6.63		1.682E-08	82.9141271		
Kr	36	84	56.89512		32.6		8.367E-08	83.91149717		
Kr	36	86	17.13681		9.82		2.580E-08	85.91061067		
			100	**57.3**		**1.468E-07**			83.78964	83.78964
Rb	37	85	70.844		5.02		1.305E-08	84.91178974		
Rb*	37	87	29.156		2.07		5.497E-09	86.90918054		
			100	**7.09**		**1.855E-08**			85.46776	85.49415
Sr	38	84	0.558		0.13		3.440E-10	83.9134203		
Sr	38	86	9.871		2.37		6.226E-09	85.9092602		
Sr	38	87	6.898		1.66		4.402E-09	86.9088771		
Sr	38	88	82.672		19.8		5.336E-08	87.9056122		
			100	**24.0**		**6.433E-08**			87.61369	87.61750
Y	39	89	**100**	**4.49**	4.49	**1.221E-08**	1.221E-08	88.9058483	88.90584	88.90584
Zr	40	90	51.49		5.41		1.488E-08	89.9047044		
Zr	40	91	11.218		1.18		3.277E-09	90.9056458		
Zr	40	92	17.148		1.80		5.064E-09	91.9050408		
Zr	40	94	17.359		1.82		5.238E-09	93.9063152		
Zr^	40	96	2.785		0.29		8.583E-10	95.9082734		
			100	**10.5**		**2.931E-08**			91.22184	91.22184
Nb	41	93	**100**	**0.766**	0.766	**2.176E-09**	2.176E-09	92.9063781	92.90637	92.90637
Mo	42	92	14.649904		0.380		1.069E-09	91.90680811		
Mo	42	94	9.1877391		0.238		6.847E-10	93.9050856		
Mo	42	95	15.873772		0.412		1.196E-09	94.9058394		
Mo	42	96	16.67381		0.433		1.269E-09	95.90467712		
Mo	42	97	9.582996		0.249		7.370E-10	96.9060196		
Mo	42	98	24.286871		0.630		1.887E-09	97.9054058		
Mo^	42	100	9.7449085		0.253		7.727E-10	99.9074724		

			100	**2.60**		**7.615E-09**			95.94866	95.94866
Ru	44	96	5.54		0.098		2.874E-10	95.9075939		
Ru	44	98	1.87		0.033		9.892E-11	97.9052876		
Ru	44	99	12.76		0.226		6.822E-10	98.9059393		
Ru	44	100	12.60		0.223		6.805E-10	99.9042195		
Ru	44	101	17.06		0.302		9.307E-10	100.9055821		
Ru	44	102	31.55		0.558		1.738E-09	101.9043493		
Ru	44	104	18.62		0.329		1.046E-09	103.9054326		
			100	**1.77**		**5.464E-09**			101.06498	101.06498
Rh	45	103	**100**	**0.341**	0.341	**1.072E-09**	1.072E-09	102.9055043	102.90549	102.90549
Pd	46	102	1.02		0.014		4.404E-11	101.9056286		
Pd	46	104	11.14		0.154		4.904E-10	103.9040359		
Pd	46	105	22.33		0.309		9.925E-10	104.9050847		
Pd	46	106	27.33		0.379		1.226E-09	105.9034808		
Pd	46	108	26.46		0.367		1.210E-09	107.9038907		
Pd	46	110	11.72		0.162		5.458E-10	109.9051703		
			100	**1.39**		**4.509E-09**			106.41533	106.41533
Ag	47	107	51.8392		0.261		8.518E-10	106.9050965		
Ag	47	109	48.1608		0.242		8.062E-10	108.9047523		
			100	**0.503**		**1.658E-09**			107.86815	107.86815
Cd	48	106	1.249		0.020		6.450E-11	105.9064602		
Cd	48	108	0.89		0.014		4.683E-11	107.9041824		
Cd	48	110	12.485		0.199		6.691E-10	109.9030035		
Cd	48	111	12.804		0.204		6.924E-10	110.9041781		
Cd	48	112	24.117		0.385		1.316E-09	111.9027578		
Cd^	48	113	12.225		0.195		6.731E-10	112.9044026		
Cd	48	114	28.729		0.458		1.596E-09	113.9033595		
Cd^	48	116	7.501		0.120		4.239E-10	115.9047632		
			100	**1.59**		**5.482E-09**			112.41215	112.41215
In	49	113	4.281		0.008		2.643E-11	112.9040574		
In^	49	115	95.719		0.171		6.015E-10	114.9038788		
			100	**0.179**		**6.279E-10**			114.81827	114.81827
Sn	50	112	0.971		0.036		1.227E-10	111.9048218		
Sn	50	114	0.659		0.024		8.474E-11	113.9027788		
Sn	50	115	0.339		0.013		4.397E-11	114.9033424		
Sn	50	116	14.536		0.537		1.902E-09	115.9017405		
Sn	50	117	7.676		0.283		1.013E-09	116.9029516		
Sn	50	118	24.223		0.894		3.224E-09	117.9016031		
Sn	50	119	8.59		0.317		1.152E-09	118.9033076		
Sn	50	120	32.593		1.203		4.412E-09	119.9022002		
Sn	50	122	4.629		0.171		6.370E-10	121.9034391		
Sn	50	124	5.789		0.214		8.098E-10	123.9052761		

			100	**3.69**		**1.340E-08**			118.71035	118.71035
Sb	51	121	57.213		0.194		7.175E-10	120.9038157		
Sb	51	123	42.787		0.145		5.455E-10	122.904214		
			100	**0.339**		**1.263E-09**			121.75972	121.75972
Te	52	120	0.096		0.005		1.670E-11	119.9040452		
Te	52	122	2.603		0.124		4.605E-10	121.9030439		
Te^	52	123	0.908		0.043		1.619E-10	122.9042701		
Te	52	124	4.816		0.229		8.659E-10	123.9028176		
Te	52	125	7.139		0.339		1.294E-09	124.9044307		
Te	52	126	18.952		0.899		3.463E-09	125.9033117		
Te^	52	128	31.687		1.504		5.881E-09	127.9044621		
Te^	52	130	33.799		1.604		6.372E-09	129.9062228		
			100	**4.74**		**1.851E-08**			127.58559	127.58559
I	53	127	**100**	**1.59**	1.590E+00	**6.171E-09**	6.171E-09	126.9044728	126.90447	126.90447
Xe^	54	124	0.129		0.007		2.747E-11	123.905893		
Xe	54	126	0.110		0.006		2.365E-11	125.9042912		
Xe	54	128	2.220		0.124		4.862E-10	127.9035313		
Xe	54	129	27.428		1.536		6.055E-09	128.9047809		
Xe	54	130	4.349		0.244		9.677E-10	129.9035094		
Xe	54	131	21.763		1.219		4.879E-09	130.9050524		
Xe	54	132	26.360		1.476		5.955E-09	131.9041551		
Xe	54	134	9.730		0.545		2.231E-09	133.9053945		
Xe^	54	136	7.911		0.443		1.841E-09	135.9072145		
			100	**5.60**		**2.247E-08**			131.18270	131.18270
Cs	55	133	**100**	**0.367**	3.671E-01	**1.492E-09**	1.492E-09	132.905452	132.90545	132.90545
Ba^	56	130	0.1058		4.879E-03		1.938E-11	129.9063215		
Ba	56	132	0.1012		4.667E-03		1.883E-11	131.9050613		
Ba	56	134	2.417		1.115E-01		4.564E-10	133.9045084		
Ba	56	135	6.592		3.040E-01		1.254E-09	134.9056886		
Ba	56	136	7.853		3.621E-01		1.505E-09	135.904576		
Ba	56	137	11.232		5.179E-01		2.169E-09	136.9058274		
Ba	56	138	71.699		3.306E+00		1.394E-08	137.9052473		
			100	**4.61**		**1.937E-08**			137.32692	137.32692
La*	57	138	0.0916		4.294E-04		1.811E-12	137.907112		
La	57	139	99.9084		4.684E-01		1.990E-09	138.9063533		
			100	**0.469**		**1.992E-09**			138.90548	138.90545
Ce	58	136	0.186		2.208E-03		9.179E-12	135.9071295		
Ce^	58	138	0.250		2.967E-03		1.251E-11	137.905991		
Ce	58	140	88.450		1.050E+00		4.493E-09	139.9054387		
Ce^	58	142	11.114		1.320E-01		5.727E-10	141.9092442		

			100	**1.19**		**5.088E-09**			140.90766	140.90766
Pr	59	141	**100**	**0.179**	1.786E-01	**7.697E-10**	7.697E-10	140.9076525	140.90766	140.90766
Nd	60	142	27.045		0.237		1.030E-09	141.9077233		
Nd*	60	143	12.023		0.105		4.610E-10	142.9098143		
Nd^	60	144	23.729		0.208		9.162E-10	143.9100873		
Nd	60	145	8.763		0.077		3.407E-10	144.9125736		
Nd	60	146	17.130		0.150		6.706E-10	145.9131169		
Nd	60	148	5.716		0.050		2.268E-10	147.9168933		
Nd^	60	150	5.596		0.049		2.251E-10	149.9208949		
			100	**0.877**		**3.870E-09**			144.24276	144.24465
Sm	62	144	3.083		0.0084		3.695E-11	143.9120046		
Sm*	62	147	15.017		0.0000		0.000E+00	146.9148979		
Sm^	62	148	11.254		0.0422		1.907E-10	147.9148227		
Sm	62	149	13.830		0.0307		1.397E-10	148.9171847		
Sm	62	150	7.351		0.0377		1.729E-10	149.9172755		
Sm	62	152	26.735		0.0201		9.333E-11	151.9197324		
Sm	62	154	22.730		0.0729		3.433E-10	153.9222093		
			100	**0.0620**		**9.770E-10**			150.36500	150.36328
Eu^	63	151	47.81		0.0498		2.296E-10	150.9198502		
Eu	63	153	52.19		0.0543		2.540E-10	152.9212303		
			100	**0.1041**	0.1041	**4.836E-10**			151.96438	151.96438
Gd^	64	152	0.2029		0.00071		3.320E-12	151.9197922		
Gd	64	154	2.1809		0.00768		3.616E-11	153.9208693		
Gd	64	155	14.7998		0.05213		2.470E-10	154.9226276		
Gd	64	156	20.4664		0.07209		3.437E-10	155.9221287		
Gd	64	157	15.6518		0.05513		2.646E-10	156.9239647		
Gd	64	158	24.8347		0.08747		4.225E-10	157.9241101		
Gd	64	160	21.8635		0.07701		3.766E-10	159.9270585		
			100	**0.352**		**1.694E-09**			157.25205	157.25205
Tb	65	159	**100**	**0.0637**	6.370E-02	**3.096E-10**	3.096E-10	158.9253468	158.92535	158.92535
Dy	66	156	0.0539		0.0002		1.079E-12	155.9242829		
Dy	66	158	0.0946		0.0004		1.917E-12	157.9244096		
Dy	66	160	2.3288		0.0098		4.780E-11	159.9251975		
Dy	66	161	18.8887		0.0793		3.901E-10	160.9269334		
Dy	66	162	25.4791		0.1069		5.295E-10	161.9267984		
Dy	66	163	24.8954		0.1045		5.206E-10	162.9287312		
Dy	66	164	28.2596		0.1186		5.946E-10	163.9291748		
			100	**0.420**		**2.086E-09**			162.49977	162.49977
Ho	67	165	**100**	**0.0906**	0.0906	**4.570E-10**	4.570E-10	164.9303221	164.93033	164.93033

Er	68	162	0.139		0.0004		1.808E-12	161.9287799		
Er	68	164	1.601		0.004		2.108E-11	163.9292065		
Er	68	166	33.503		0.088		4.465E-10	165.9302931		
Er	68	167	22.869		0.060		3.066E-10	166.9320482		
Er	68	168	26.978		0.071		3.639E-10	167.9323702		
Er	68	170	14.91		0.039		2.035E-10	169.9354643		
			100	**0.263**		**1.343E-09**			167.25908	167.25908
Tm	69	169	**100**	**0.0410**	0.0410	**2.116E-10**	2.116E-10	168.9342133	168.93422	168.93422
Yb	70	168	0.123		0.0003		1.637E-12	167.9338869		
Yb	70	170	2.982		0.008		4.010E-11	169.9347618		
Yb	70	171	14.086		0.036		1.905E-10	170.9363258		
Yb	70	172	21.686		0.056		2.951E-10	171.9363815		
Yb	70	173	16.103		0.042		2.204E-10	172.9382108		
Yb	70	174	32.025		0.083		4.408E-10	173.9388621		
Yb	70	176	12.995		0.034		1.809E-10	175.9425717		
			100	**0.259**		**1.369E-09**			173.05447	173.05447
Lu	71	175	97.18		0.0373		1.996E-10	174.9407712		
Lu*	71	176	2.82		0.0011		5.831E-12	175.9426867		
			100	**0.0384**		**2.054E-10**			174.96681	174.96906
Hf^	72	174	0.16		0.0003		1.349E-12	173.9400462		
Hf	72	176	5.20		0.008		4.408E-11	175.9414091		
Hf	72	177	18.60		0.029		1.585E-10	176.9432224		
Hf	72	178	27.30		0.043		2.338E-10	177.9437004		
Hf	72	179	13.63		0.021		1.174E-10	178.945817		
Hf	72	180	35.11		0.055		3.041E-10	179.9465512		
			100	**0.157**		**8.591E-10**			178.48515	178.48658
Ta*	73	180	0.01201		0.000003		1.436E-14	179.9474648		
Ta	73	181	99.98799		0.0217		1.202E-10	180.9479958		
			100	**0.0217**		**1.202E-10**			180.94788	180.94788
W^	74	180	0.1198		0.0002		9.494E-13	179.9467091		
W	74	182	26.4985		0.038		2.123E-10	181.9482042		
W	74	183	14.3136		0.021		1.153E-10	182.9502223		
W	74	184	30.6422		0.044		2.482E-10	183.9509312		
W	74	186	28.4259		0.041		2.328E-10	185.9543641		
			100	**0.144**		**8.096E-10**			183.84170	183.84170
Re	75	185	35.6616		0.0211		1.191E-10	184.9529549		
Re*	75	187	64.3384		0.0380		2.172E-10	186.9557531		
			100	**0.0591**		**3.363E-10**			186.20675	186.24152
Os^	76	184	0.0198		0.0001		7.546E-13	183.9524891		
Os^	76	186	1.5973		0.011		6.143E-11	185.9538382		
Os	76	187	1.2817		0.009		4.956E-11	186.9557505		

Os	76	188	13.3269		0.090		5.181E-10	187.9558382		
Os	76	189	16.2549		0.110		6.353E-10	188.9581475		
Os	76	190	26.4368		0.179		1.039E-09	189.9584471		
Os	76	192	41.0827		0.278		1.631E-09	191.9614807		
			100	**0.676**		**3.935E-09**			190.23494	190.24822
Ir	77	191	37.272		0.232		1.358E-09	190.9605941		
Ir	77	193	62.728		0.391		2.309E-09	192.9629264		
			100	**0.624**		**3.667E-09**			192.21661	192.21661
Pt*	78	190	0.0130		0.0002		9.183E-13	189.9599321		
Pt	78	192	0.7938		0.010		5.676E-11	191.961038		
Pt	78	194	32.8078		0.400		2.371E-09	193.962679		
Pt	78	195	33.7871		0.412		2.454E-09	194.9647901		
Pt	78	196	25.2902		0.308		1.846E-09	195.9649515		
Pt	78	198	7.3083		0.089		5.390E-10	197.967891		
			100	**1.218**		**7.267E-09**			195.08395	195.08395
Au	79	197	**100**	**0.201**	0.201	**1.209E-09**	1.209E-09	196.9665687	196.96657	196.96657
Hg	80	196	0.16		0.001		3.572E-12	195.9658326		
Hg	80	198	10.04		0.039		2.337E-10	197.9667689		
Hg	80	199	16.94		0.065		3.963E-10	198.9682804		
Hg	80	200	23.14		0.089		5.440E-10	199.968326		
Hg	80	201	13.17		0.051		3.112E-10	200.9703022		
Hg	80	202	29.74		0.114		7.064E-10	201.970643		
Hg	80	204	6.82		0.026		1.635E-10	203.9734941		
			100	**0.384**		**2.359E-09**			200.59240	200.59240
Tl	81	203	29.524		0.054		3.326E-10	202.9723442		
Tl	81	205	70.476		0.128		8.017E-10	204.9744275		
			100	**0.181**		**1.134E-09**			204.38333	204.38333
Pb^	82	204	1.9968		0.066		4.101E-10	203.9730436		
Pb	82	206	18.5823		0.612		3.854E-09	205.9744653		
Pb	82	207	20.5631		0.677		4.286E-09	206.9758969		
Pb	82	208	58.8578		1.938		1.233E-08	207.976652		
			100	**3.293**		**2.088E-08**			207.31630	207.31887
Bi^	83	209	**100**	**0.142**	0.142	**9.064E-10**	9.064E-10	208.9803987	208.98040	208.98040
Th*	90	232	**100**	**0.0431**	0.0431	**3.062E-10**	3.062E-10	232.0380553	232.03806	232.03806
U*	92	234	0.0042		9.9E-07		7.093E-15	234.0409521		
U*	92	235	24.3016		0.0058		4.161E-11	235.0439299		
U*	92	238	75.6942		0.0180		1.313E-10	238.0507882		
			100	**0.0238**		**1.729E-10**			238.02891	237.31991
Sum						1.000E+00	1.000000			

* Table modified from Lodders (2020, 2021) where more references and details can be found. Abundances are for 4.567 Ga ago. Atomic Masses are from Wang et al. 2012. Elements marked with * involve long-lived radioactive nuclides with half-lives up to 10^12 years. Isotopes with half-lives above 10^12 years (marked with ^) can be considered as stable compared to the age of the solar system and some of them are of interest of studies of double-beta decay. Isotopic compositions mainly adopted from Meija et al. (2016); except for H, He, C, N, O, Ne, Ar, Kr, and Xe isotopic compositions; see Lodders 2020 for details and references.

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*references only relevant for Tables A4-A12 are marked with one preceding star, references in Table A13 with 2 stars.

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