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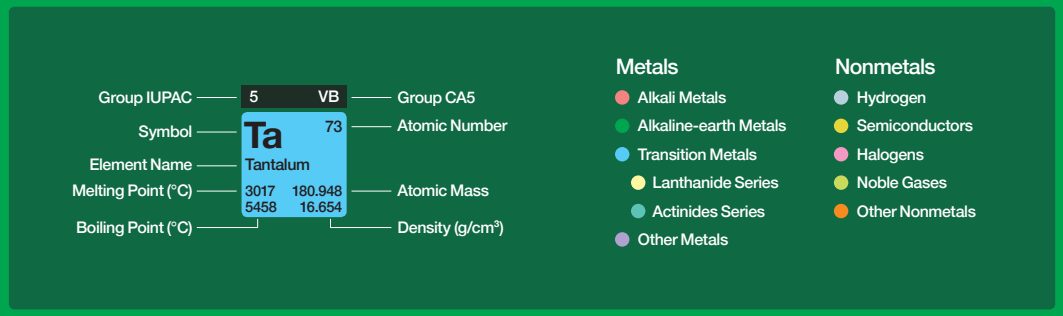

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
H 1 Hydrogen -259.34 1.008 -252.87 0.0899																	**He** 2 Helium -272.2 4.003 -268.93 0.1785
Li 3 Lithium 180.5 6.941 1342 0.53	**Be** 4 Beryllium 1287 9.012 2471 1.8477											**B** 5 Boron 2075 10.81 4000 2.34	**C** 6 Carbon 3500 12.011 3800 2.62	**N** 7 Nitrogen -210 14.007 -195.79 1.2506	**O** 8 Oxygen -218.79 15.999 -182.95 1.429	**F** 9 Fluorine -219.67 18.998 -188.12 1.696	**Ne** 10 Neon -258.59 20.179 -246.08 0.901
Na 11 Sodium 97.8 22.99 883 0.971	**Mg** 12 Magnesium 650 24.305 1090 1.738											**Al** 13 Aluminum 660.32 26.982 2519 2.702	**Si** 14 Silicon 1414 28.086 3265 2.329	**P** 15 Phosphorus 44.15 30.974 280.5 1.82	**S** 16 Sulfur 119.6 32.06 444.6 2.07	**Cl** 17 Chlorine -101.5 35.453 -34.4 3.214	**Ar** 18 Argon -189.35 39.948 -185.85 1.784
K 19 Potassium 63.5 39.098 759 0.862	**Ca** 20 Calcium 842 40.08 1484 1.55	**Sc** 21 Scandium 1541 44.956 2836 2.989	**Ti** 22 Titanium 1660.0 47.867 3287.0 4.54	**V** 23 Vanadium 1910 50.941 3407 5.8	**Cr** 24 Chromium 1907 51.996 2671 7.19	**Mn** 25 Manganese 1246 54.938 2061 7.43	**Fe** 26 Iron 1538 55.847 2861 7.86	**Co** 27 Cobalt 1495.0 58.9332 2927 8.9	**Ni** 28 Nickel 1455 58.7 2913 8.902	**Cu** 29 Copper 1084.6 63.546 2562 8.96	**Zn** 30 Zinc 419.5 65.38 907 7.133	**Ga** 31 Gallium 29.76 69.72 2204 5.907	**Ge** 32 Germanium 938.25 72.59 2833 5.323	**As** 33 Arsenic 817 74.922 603 5.72	**Se** 34 Selenium 220.5 78.96 685 4.79	**Br** 35 Bromine -7.2 79.904 58.8 3.119	**Kr** 36 Krypton -157.38 83.8 -153.22 3.74
Rb 37 Rubidium 39.3 85.468 688 1.532	**Sr** 38 Strontium 777 87.62 1382 2.54	**Y** 39 Yttrium 1522 88.906 3345 4.469	**Zr** 40 Zirconium 1855 91.22 4409 6.49	**Nb** 41 Niobium 2477 92.906 4744 8.57	**Mo** 42 Molybdenum 2623 95.94 4639 10.22	**Tc** 43 Technetium 2157 97 4265 11.5	**Ru** 44 Ruthenium 2334 101.07 4150 12.2	**Rh** 45 Rhodium 1964 102.905 3695 12.41	**Pd** 46 Palladium 1554.9 106.4 2693 12.02	**Ag** 47 Silver 961.78 107.868 2162 10.5	**Cd** 48 Cadmium 321.07 112.4 767 8.65	**In** 49 Indium 156.6 114.82 2072 7.31	**Sn** 50 Tin 231.93 118.69 2602 7.31	**Sb** 51 Antimony 630.63 121.75 1587 6.684	**Te** 52 Tellurium 449.5 127.6 988 6.24	**I** 53 Iodine 113.7 126.904 184.4 4.93	**Xe** 54 Xenon -111.79 131.3 -108.12 5.8971
Cs 55 Cesium 28.5 132.905 671 1.873	**Ba** 56 Barium 727 137.34 1897 3.51	**La** 57 Lanthanum 918 138.905 1897 6.7	**Hf** 72 Hafnium 2233 178.49 4603 13.2	**Ta** 73 Tantalum 3017 180.948 5458 16.654	**W** 74 Tungsten 3422 183.5 5555 19.3	**Re** 75 Rhenium 3186 186.207 5596 21.02	**Os** 76 Osmium 3033 190.2 5012 22.4	**Ir** 77 Iridium 2446 192.22 4428 22.5	**Pt** 78 Platinum 1768.4 195.09 3825 21.45	**Au** 79 Gold 1064.18 196.967 2856 19.32	**Hg** 80 Mercury -38.83 200.59 356.73 13.456	**Tl** 81 Thallium 304 204.37 1473 11.85	**Pb** 82 Lead 327.46 207.2 1749 11.34	**Bi** 83 Bismuth 271.4 208.98 1564 9.8	**Po** 84 Polonium 254 209 962 9.4	**At** 85 Astatine 302 210 340 –	**Rn** 86 Radon -71.0 222 -61.7 9.73
Fr 87 Francium 27 223.0 677 –	**Ra** 88 Radium 700 226.025 1140 5.0	**Ac** 89 Actinium 1051 227.0 3159 10.07	**Rf** 104 Rutherfordium – 261 – –	**Db** 105 Dubnium – 262 – –	**Sg** 106 Seaborgium – 263 – –	**Bh** 107 Bohrium – 262 – –	**Hs** 108 Hassium – 265 – –	**Mt** 109 Meitnerium – 265 – –	**Uun** 110 Ununnilium – 269 – –	**Uuu** 111 Unununium – 272 – –	**Uub** 112 Ununbium – 277 – –						

Ce 58 Cerium 798 140.12 3443 6.773	**Pr** 59 Praseodymium 931 140.908 3520 6.77	**Nd** 60 Neodymium 1021 144.24 3074 7.007	**Pm** 61 Promethium 1042 145.0 -3000 6.475	**Sm** 62 Samarium 1074 150.4 1794 7.54	**Eu** 63 Europium 822 151.96 1529 5.259	**Gd** 64 Gadolinium 1313 157.25 3273 7.895	**Tb** 65 Terbium 1356 158.925 3230 8.27	**Dy** 66 Dysprosium 1413 162.5 2567 8.536	**Ho** 67 Holmium 1474 164.93 2700 8.54	**Er** 68 Erbium 1529 167.26 2868 8.795	**Tm** 69 Thulium 1545 168.934 1950 9.321	**Yb** 70 Ytterbium 819 173.04 1196 6.98	**Lu** 71 Lutetium 1663 174.97 3402 9.85
Th 90 Thorium 1750 232.038 4788 11.72	**Pa** 91 Protactinium 1572 231.036 -4000 15.4	**U** 92 Uranium 1135 238.029 4131 18.95	**Np** 93 Neptunium 644 237.048 3900 20.45	**Pu** 94 Plutonium 640 244.0 3228 19.84	**Am** 95 Americium 1176 243 2011 13.6	**Cm** 96 Curium 1345 247 3100 13.511	**Bk** 97 Berkelium 1050 247 – –	**Cf** 98 Californium 860 251 – –	**Es** 99 Einsteinium 860 252 – –	**Fm** 100 Fermium 1527 257 – –	**Md** 101 Mendelevium 827 258 – –	**No** 102 Nobelium 827 259 – –	**Lr** 103 Lawrencium 1627 262 – –

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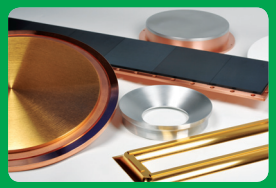
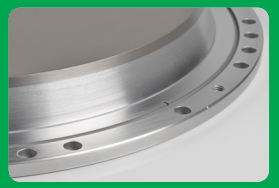
Element	Symbol	Melting Point °C	Density (bulk, g/cm3)	Z-ratio	Temperature °C at Vapor Pressure (Torr) 10^8	10^6	10^4	Evaporation Method	Crucible Key	Boat	Remarks
Aluminum	Al	660	2.7	1.08	677	821	1010	e-beam (excellent), Thermal	TiB2-BN, ZrB2, BN	TiB2, W	Alloys and wets. Fill boat 2/3.
Aluminum Oxide (Alumina)	Al203	2045	3.97	0.336	–	–	1550	e-beam (excellent)	–	W	Sapphire excellent in e-beam, forms smooth, hard films. n=1.66
Chromium	Cr	1907	7.19	0.305	837	977	1157	e-beam (good), Thermal	VC	W, Cr rod or strip	Films very adherent. High rates possible.
					Sublimes						
Copper	Cu	1085	8.96	0.437	727	857	1017	e-beam (excellent)	Al2O3, Mo, Ta	W, Mo	Films do not adhere well. Use intermediate layer, e.g. Cr. Evaporates from any source material.
								Thermal			
Germanium	Ge	938	5.32	0.516	812	957	1167	e-beam (excellent)	–	W, C, Ta	Excellent films from EB sources. Use .040 W. n=4.01
Gold	Au	1064	19.32	0.381	807	947	1132	e-beam (excellent), Thermal	BN, Al2O3, VC	W, Mo, Al203	May not adhere well.
Indium	In	157	7.31	0.841	487	597	742	e-beam (excellent)	G, Al203	W, Mo	Wets W and Cu. Use Mo liner in gun.
									Mo liner		
Iron	Fe	1538	7.86	0.349	858	998	1180	e-beam (excellent)	BeO, Al203	W	Attacks W. Use gentle preheat to outgas. Films hard, smooth.
Nickel	Ni	1455	8.91	0.331	927	1072	1262	e-beam (excellent), Thermal	Al203, BeO, VC	W	Alloys with refractory metals. Forms smooth adherent films.
Palladium	Pd	1555	12.02	–	842	992	1192	e-beam (excellent)	Al203, BeO	W	Alloys with refractory metals; rapid evaporation suggested. Spits in EB.
Platinum	Pt	1768	21.45	0.245	1292	1492	1747	e-beam (excellent), Thermal	CG, ThO2	W	Alloys with metals; poor adhesion; films soft.
Silicon	Si	1414	2.33	0.712	992	1147	1337	e-beam (fair)	BeO, Ta, VC	W, Ta	Alloys with W; use heavy W boat. SiO produced above 4x10-6 Torr. EB best. n=3.42 App. Opt. 15, 2348 (1976)
Silicon Dioxide	SiO2	1610-1710	2.2-2.7	1	–	–	~1025	e-beam (excellent)	Al203	–	Quartz excellent in EB. n=1.47
					Influenced by composition						
Silver	Ag	962	10.49	0.529	847	958	1105	e-beam (excellent), Thermal	Al203, Mo	Mo, Ta	Evaporates well from any source.
Tantalum	Ta	3017	16.6	–	1960	2240	2590	e-beam (excellent)	–	–	Forms good films.
Tantalum Pentoxide	Ta205	1800	8.74	–	1550	1780	1920	e-beam (good)	VC	W, Ta	Slight decomposition; evaporate in 10-3 Torr of O2. n=2.0 @ 1.5µ App. Opt. 19, 1737 (1980)
Tin	Sn	232	7.75	0.724	682	807	997	e-beam (excellent), Thermal	Al203, Ta	Mo	Wets Mo; use Ta liner in EB guns.
Titanium	Ti	1660	4.5	0.628	1067	1235	1453	e-beam (excellent), Thermal	TiC	W	Alloys with refractory metals. Evolves gas on first heating.
Yttrium	Y	1522	4.48	–	830	973	1157	e-beam (excellent)	Al203	W, Ta	High Ta solubility.
Zinc	Zn	419	7.14	0.514	127	177	250	e-beam (excellent), Thermal	Al203, Quartz	Mo, W, Ta	Evaporates well under wide range of conditions.







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