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MSI Viking is your single-source comprehensive provider of precision metrology systems, services, and custom engineered solutions. We represent more than 100 of the world's leaders in precision measuring instruments, gaging, and process automation.
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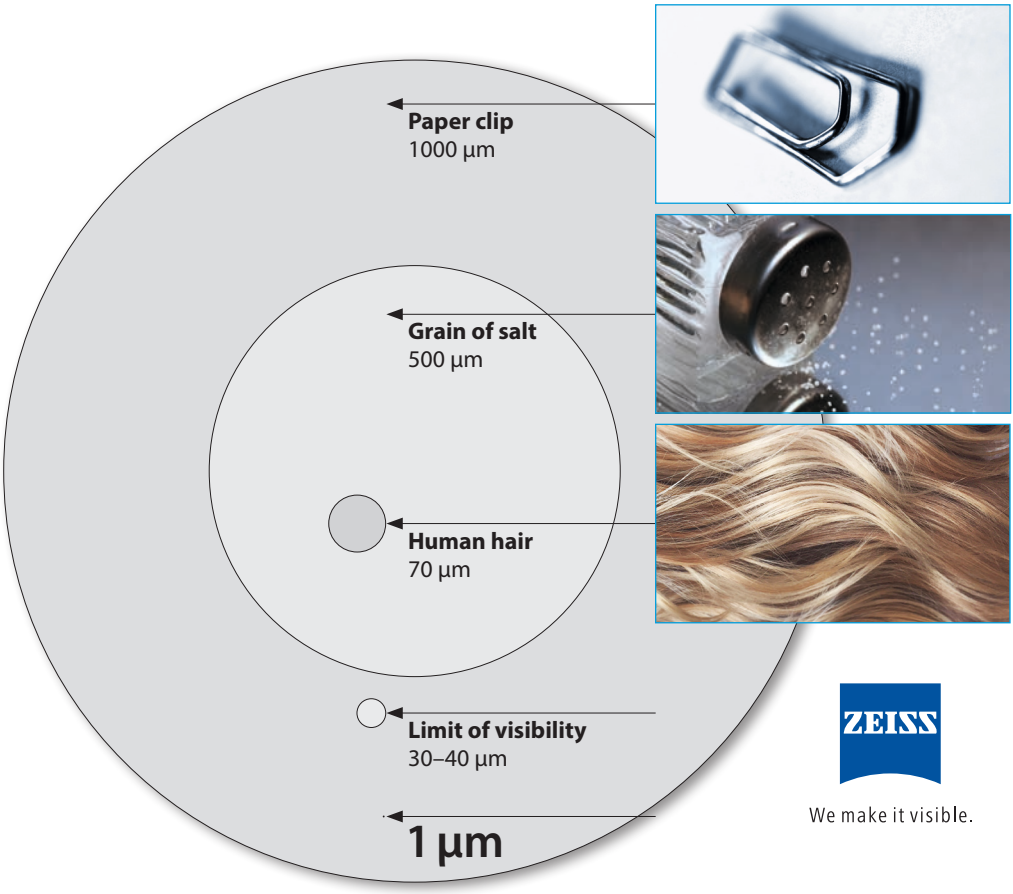
How Big is a Micron? (µm)

1 µm = 1 Millionth of 1 Meter
1 µm = 40 Millionths of 1 Inch



ZEISS

We make it visible.

Chart artwork compliments of Zeiss

Standard Reference Chart

Standard English Terminology in Terms of an Inch
1.0 = One Inch
0.5 = One half of an Inch
0.100 = One Hundredth of an inch
0.001 = One thousandth of an inch
0.0001 = One ten thousandth of an inch or "a tenth"
0.00001 = Ten Millionths of an Inch
0.000001 = One Millionth of an Inch

Metric Terminology in Terms of a Millimeter
1.0 = One Millimeter
0.1 = 100 Microns
0.01 = 10 Microns
0.001 = 1 Micron

Common Conversion Factors
1" = 25.4mm
1mm = .03937"

METRIC to INCH CONVERSION TABLE

Metric	Inch	Metric	Inch	Metric	Inch	Metric	Inch
0.01	0.00039	0.51	0.02008	1	0.03937	51	2.00787
0.02	0.00079	0.52	0.02047	2	0.07874	52	2.04724
0.03	0.00118	0.53	0.02087	3	0.11811	53	2.08661
0.04	0.00157	0.54	0.02126	4	0.15748	54	2.12598
0.05	0.00197	0.55	0.02165	5	0.19685	55	2.16535
0.06	0.00236	0.56	0.02205	6	0.23622	56	2.20472
0.07	0.00276	0.57	0.02244	7	0.27559	57	2.24409
0.08	0.00315	0.58	0.02283	8	0.31496	58	2.28346
0.09	0.00354	0.59	0.02323	9	0.35433	59	2.32283
0.10	0.00394	0.6	0.02362	10	0.3937	60	2.3622
0.11	0.00433	0.61	0.02402	11	0.43307	61	2.40157
0.12	0.00472	0.62	0.02441	12	0.47244	62	2.44094
0.13	0.00512	0.63	0.0248	13	0.51181	63	2.48031
0.14	0.00551	0.64	0.0252	14	0.55118	64	2.51968
0.15	0.00591	0.65	0.02559	15	0.59055	65	2.55905
0.16	0.0063	0.66	0.02598	16	0.62992	66	2.59842
0.17	0.00669	0.67	0.02638	17	0.66929	67	2.63779
0.18	0.00709	0.68	0.02677	18	0.70866	68	2.67716
0.19	0.00748	0.69	0.02717	19	0.74803	69	2.71653
0.20	0.00787	0.7	0.02756	20	0.7874	70	2.7559
0.21	0.00827	0.71	0.02795	21	0.82677	71	2.79527
0.22	0.00866	0.72	0.02835	22	0.86614	72	2.83464
0.23	0.00906	0.73	0.02874	23	0.90551	73	2.87401
0.24	0.00945	0.74	0.02913	24	0.94488	74	2.91338
0.25	0.00984	0.75	0.02953	25	0.98425	75	2.95275
0.26	0.01024	0.76	0.02992	26	1.02362	76	2.99212
0.27	0.01063	0.77	0.03032	27	1.06299	77	3.03149
0.28	0.01102	0.78	0.03071	28	1.10236	78	3.07086
0.29	0.01142	0.79	0.0311	29	1.14173	79	3.11023
0.30	0.01181	0.8	0.0315	30	1.1811	80	3.1496
0.31	0.0122	0.81	0.03189	31	1.22047	81	3.18897
0.32	0.0126	0.82	0.03228	32	1.25984	82	3.22834
0.33	0.01299	0.83	0.03268	33	1.29921	83	3.26771
0.34	0.01339	0.84	0.03307	34	1.33858	84	3.30708
0.35	0.01378	0.85	0.03346	35	1.37795	85	3.34645
0.36	0.01417	0.86	0.03386	36	1.41732	86	3.38582
0.37	0.01457	0.87	0.03425	37	1.45669	87	3.42519
0.38	0.01496	0.88	0.03465	38	1.49606	88	3.46456
0.39	0.01535	0.89	0.03504	39	1.53543	89	3.50393
0.40	0.01575	0.90	0.03543	40	1.5748	90	3.5433
0.41	0.01614	0.91	0.03583	41	1.61417	91	3.58267
0.42	0.01654	0.92	0.03622	42	1.65354	92	3.62201
0.43	0.01693	0.93	0.03661	43	1.69291	93	3.66141
0.44	0.01732	0.94	0.03701	44	1.73228	94	3.70078
0.45	0.01772	0.95	0.0374	45	1.77165	95	3.74015
0.46	0.01811	0.96	0.0378	46	1.81102	96	3.77952
0.47	0.0185	0.97	0.03819	47	1.85039	97	3.81889
0.48	0.0189	0.98	0.03858	48	1.88976	98	3.85826
0.49	0.01929	0.99	0.03898	49	1.92913	99	3.89763
0.5	0.01969	1.00	0.03937	50	1.9685	100	3.937

Gagemaker's Tolerance Chart [ANSI/AMSE B89.1.5]* INCH

Diameter Range Above-Including	XXX	XX	X	Y	Z	ZZ
.010"-.825"	.000010"	.000020"	.000040"	.000070"	.0001"	.0002"
.825"-1.510"	.000015"	.000030"	.000060"	.000090"	.00012"	.00024"
1.510"-2.510"	.000020"	.000040"	.000080"	.00012"	.00016"	.00032"
2.510"-4.510"	.000025"	.000050"	.0001"	.00015"	.0002"	.0004"
4.510"-6.510"	.000033"	.000065"	.00013"	.00019"	.00025"	.0005"
6.510"-9.010"	.000040"	.000080"	.00016"	.00024"	.00032"	.00064"
9.010"-12.010"	.000050"	.0001"	.0002"	.0003"	.0004"	.0008"

Gagemaker's Tolerance Chart [ANSI/AMSE B89.1.5]* METRIC

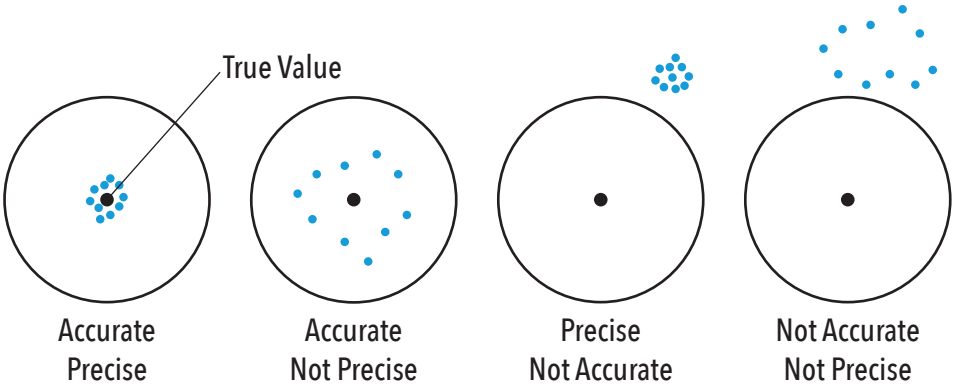
Diameter Range Above-Including	XXX	XX	X	Y	Z	ZZ
.254mm-20.96mm	.00025mm	.00051mm	.00102mm	.00178mm	.00254mm	.00508mm
20.96mm-38.35mm	.00038mm	.00076mm	.00152mm	.00229mm	.00305mm	.00610mm
38.35mm-63.75mm	.00051mm	.00102mm	.00203mm	.00305mm	.00406mm	.00813mm
63.75mm-114.55mm	.00064mm	.00127mm	.00254mm	.00381mm	.00508mm	.01016mm
114.55mm-165.35mm	.00084mm	.00165mm	.00330mm	.00483mm	.00635mm	.01270mm
165.35mm-228.85mm	.00102mm	.00203mm	.00406mm	.00610mm	.00813mm	.01626mm
228.85mm-305.05mm	.00127mm	.00254mm	.00508mm	.00762mm	.01016mm	.02032mm

*Reference Only

Measurement System Characterization

Location (Average Measurement Value vs. Actual Value)	
Stability	The ability of a measurement system to produce the same values over time when measuring the same sample.
Accuracy	A measure of the distance between the average value of the measurement of a part and the True, certified, or assigned value of a part. Also referred to as bias.
Linearity	The consistency of accuracy (bias) over the range of measurement; a slope of one (unity) between measured and true value is perfect.
Variation (Spread of Measurement Values - Precision)	
Repeatability	The consistency of a single appraiser to measure the same part multiple times with the same measurement system; it is related to the standard deviation of the measured values.
Reproducibility	Assesses whether different appraisers can measure the same part/sample with the same measurement device and get the same value.
Resolution	The ability of a measurement system to discriminate between measurement values. The consistency of different appraisers in measuring the same part with the same measurement system; it is related to standard deviation of the distribution of appraiser averages.

The diagram below illustrates the difference between the terms "Accuracy" and "Precision". Efforts to improve measurement system quality are aimed at improving both accuracy and precision.



Requirements

Following are general requirements of all capable measurement systems:

· Statistical stability over time.

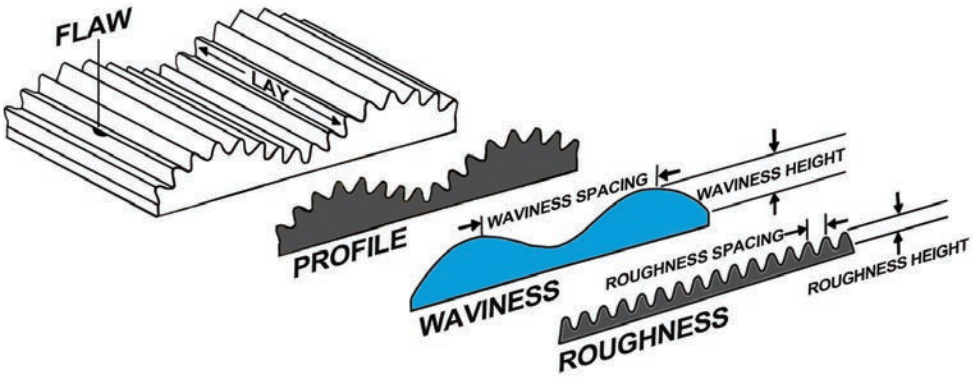
· Variability small compared to the process variability.

· Variability small compared to the specification limits (tolerance).

· The resolution, or discrimination of the measurement device must be small relative to the smaller of either the specification tolerance or the process spread (variation). As a rule of thumb, the measurement system should have resolution of at least 1/10th the smaller of either the specification tolerance or the process spread. If the resolution is not fine enough, process variability will not be recognized by the measurement system, thus blunting its effectiveness.

Definitions courtesy of Raytheon

Basic Surface Finish



PROFILE	
Pt	Sum of Height of the largest profile peak height and largest profile valley in a evaluation length
Pa	Profile average arithmetic average of absolute values of the roughness profile ordinates
Pv	Depth of the lowest profile valley of the Profile curve in one sampling length
Pp	Height of the highest profile peak of the Profile curve in one sampling length
PSm*	Mean Width Of Profile Elements arithmetic mean value of the widths of profile elements of the Profile
WAVINESS	
Wt	Sum of Height of the largest Waviness profile peak height and largest Waviness valley in the evaluation length
Wp	Largest waviness profile peak in a sampling length
Wa	Waviness Average arithmetic average of absolute values of the waviness profile ordinates
Wsm	Mean Width Of Waviness Profile Elements arithmetic mean value of widths of waviness profile elements and waviness profile
Wq*	Root mean square average of the waviness profile ordinates
ROUGHNESS	
Ra	Roughness average arithmetic average of absolute values of the roughness profile ordinates
Rz	Single Roughness Depth vertical distance between the highest peak and deepest valley within a sampling length
Rmax	Maximum Roughness Depth largest single roughness depth within evaluation length
Rsm	Mean width of profile elements arithmetic mean value of widths of profile elements and roughness profile
Rq (RMS)*	Root mean square average of the roughness profile ordinates

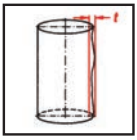
Torque Measurement					
IN-OZ	G-CM	IN-LB	FT-LB	KG-M	N-M
48	3456	3	0.25	0.03458	0.339
192	13830	12	1	0.1383	1.356
800	57600	50	4.167	0.5763	5.65
1600	115200	100	8.334	1.1526	11.3
3200	230400	200	16.668	2.3052	22.6

Torque Conversion Multipliers						
	IN-OZ	G-CM	IN-LB	FT-LB	KG-M	N-M
in-oz	1	72.01	0.0625	0.005208	0.0007203	0.007063
g-cm	0.01389	1	0.000868	0.00007233	0.00001	0.00009808
in-lb	16	1152	1	0.08333	0.01153	0.113
ft-lb	192	3456	12	1	0.1383	1.356
kg-m	1388	99960	86.77	7.231	1	9.805
n-m	141.6	10200	8.85	0.7375	0.102	1

Force Measurement				
OZF	GF	LBF	KGF	N
16	453.6	1	0.4536	4.448
80	2268	5	2.268	22.24
160	4536	10	4.536	44.48
400	11340	25	11.34	111.2
800	22680	50	22.68	222.4
1600	45360	100	45.36	444.8
3200	90720	200	90.72	889.6
8000	226800	500	226.8	2224
16000	453600	1000	453.6	4448

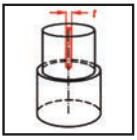
Force Conversion Multipliers					
	OZF	GF	LBF	KGF	N
OZF	1	28.35	0.0625	0.02835	0.278
GF	0.03527	1	0.002205	0.001	0.009806
LBF	16	453.6	1	0.4536	4.448
KGF	35.27	1000	2.205	1	9.806
N	3.597	102	0.2248	0.102	1

Form Parameter Tolerances



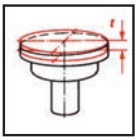
Straightness, ISO 1101

The tolerance zone is limited in the measuring plane by two parallel straight lines a distance *t* apart.



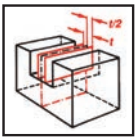
Concentricity/Coaxiality, ISO 1101

The tolerance zone is limited by a cylinder of diameter *t*, the axis of which coincides with the datum axis.



Flatness, ISO 1101

The tolerance zone is limited by two parallel planes a distance *t* apart.

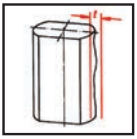


Symmetry, ISO 1101

The tolerance zone is limited by two parallel planes a distance *t* apart and symmetrically disposed to the median plane with respect to the datum axis or datum plane.

Roundness, ISO 1101

The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance *t* apart.

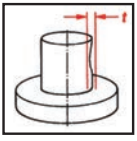


Parallelism, ISO 1101

The tolerance zone is limited in the measuring plane by two straight lines a distance *t* apart and parallel to the datum.

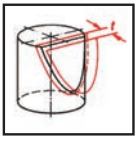
Cylindricity, ISO 1101

The tolerance zone is limited by two coaxial cylinders a distance *t* apart.



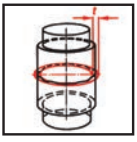
Perpendicularity, ISO 1101

The tolerance zone is limited in the measuring plane by two parallel, straight lines a distance *t* apart and perpendicular to the datum.



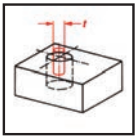
Angularity, ISO 1101

The tolerance zone is limited by two parallel planes a distance *t* apart and inclined at the specified angle to the surface.



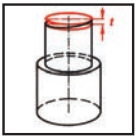
Radial run-out, ISO 1101

The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance *t* apart, the common center of which lies on the datum axis.



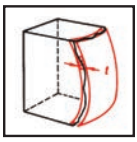
Position, ISO 1101

If the tolerance value is preceded by the sign, the tolerance zone is limited by a cylinder of diameter *t*, the axis of which is theoretically in the exact position of the toleranced line.



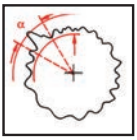
Total run-out, ISO 1101

The tolerance zone is limited by two parallel planes a distance *t* apart and perpendicular to the datum axis.



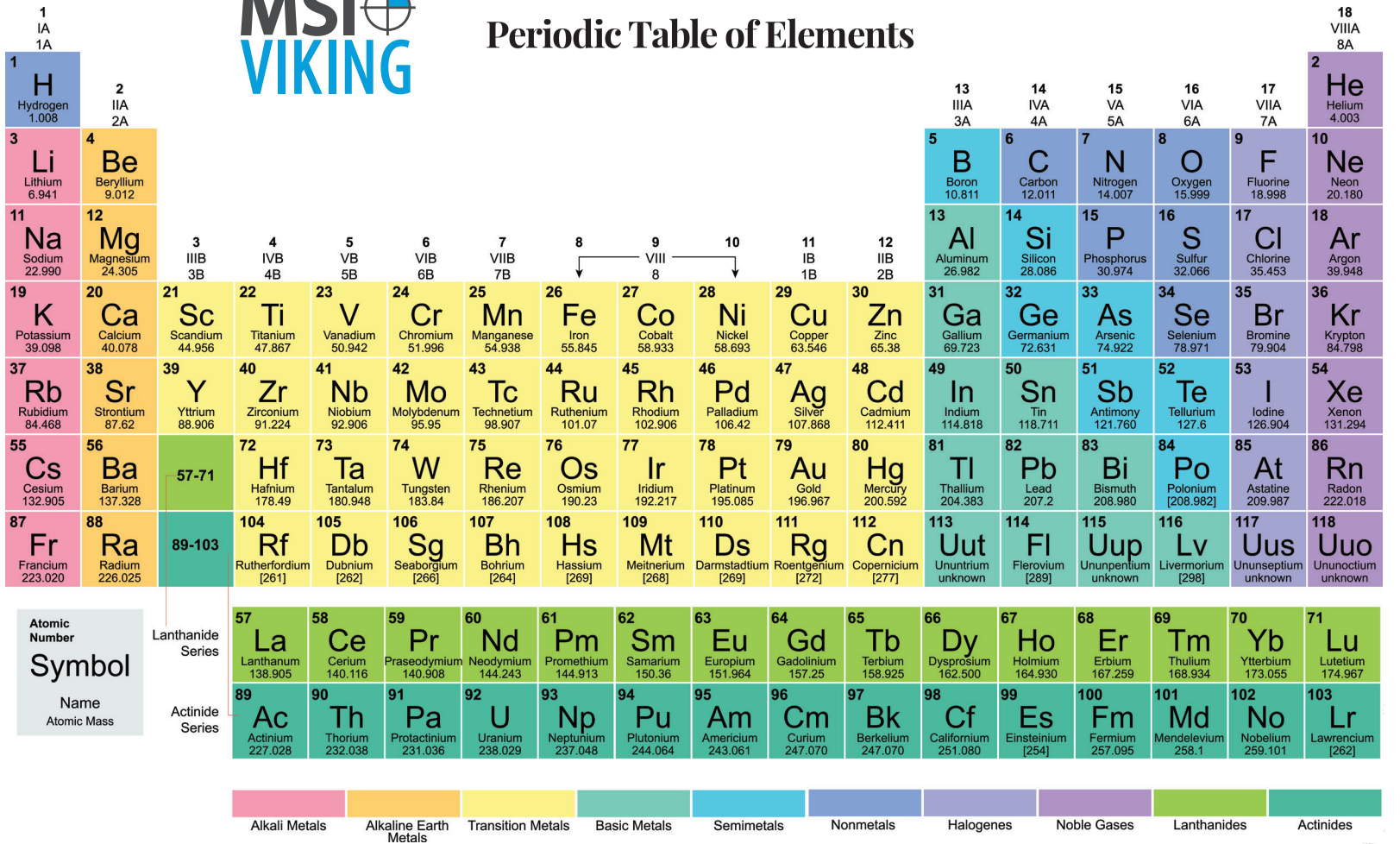
Profile any surface, ISO 1101

The tolerance zone is limited by two surfaces enveloping spheres of diameter *t*, the centres of which are situated on a surface having the true geometrical form.



Angular sector roundness, ISO 1101

The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance apart. The measured circumference shall be contained in any angular sector *t* starting from the profile centre within the tolerance zone.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Periodic Table of Elements
1 IA 1A
2 IIA 2A
3 IIIB 3B
4 IVB 4B
5 VB 5B
6 VIB 6B
7 VIIB 7B
8
9 VIII 8
10
11 IB 1B
12 IIB 2B
13 IIIA 3A
14 IVA 4A
15 VA 5A
16 VIA 6A
17 VIIA 7A
18 VIIIA 8A
1 H Hydrogen 1.008
2 He Helium 4.003
3 Li Lithium 6.941
4 Be Beryllium 9.012
5 B Boron 10.811
6 C Carbon 12.011
7 N Nitrogen 14.007
8 O Oxygen 15.999
9 F Fluorine 18.998
10 Ne Neon 20.180
11 Na Sodium 22.990
12 Mg Magnesium 24.305
13 Al Aluminum 26.982
14 Si Silicon 28.086
15 P Phosphorus 30.974
16 S Sulfur 32.066
17 Cl Chlorine 35.453
18 Ar Argon 39.948
19 K Potassium 39.098
20 Ca Calcium 40.078
21 Sc Scandium 44.956
22 Ti Titanium 47.867
23 V Vanadium 50.942
24 Cr Chromium 51.996
25 Mn Manganese 54.938
26 Fe Iron 55.845
27 Co Cobalt 58.933
28 Ni Nickel 58.693
29 Cu Copper 63.546
30 Zn Zinc 65.38
31 Ga Gallium 69.723
32 Ge Germanium 72.631
33 As Arsenic 74.922
34 Se Selenium 78.971
35 Br Bromine 79.904
36 Kr Krypton 84.798
37 Rb Rubidium 84.468
38 Sr Strontium 87.62
39 Y Yttrium 88.906
40 Zr Zirconium 91.224
41 Nb Niobium 92.906
42 Mo Molybdenum 95.95
43 Tc Technetium 98.907
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.906
46 Pd Palladium 106.42
47 Ag Silver 107.868
48 Cd Cadmium 112.411
49 In Indium 114.818
50 Sn Tin 118.711
51 Sb Antimony 121.760
52 Te Tellurium 127.6
53 I Iodine 126.904
54 Xe Xenon 131.294
55 Cs Cesium 132.905
56 Ba Barium 137.328
57-71
72 Hf Hafnium 178.49
73 Ta Tantalum 180.948
74 W Tungsten 183.84
75 Re Rhenium 186.207
76 Os Osmium 190.23
77 Ir Iridium 192.217
78 Pt Platinum 195.085
79 Au Gold 196.967
80 Hg Mercury 200.592
81 Tl Thallium 204.383
82 Pb Lead 207.2
83 Bi Bismuth 208.980
84 Po Polonium [208.982]
85 At Astatine 209.987
86 Rn Radon 222.018
87 Fr Francium 223.020
88 Ra Radium 226.025
89-103
104 Rf Rutherfordium [261]
105 Db Dubnium [262]
106 Sg Seaborgium [266]
107 Bh Bohrium [264]
108 Hs Hassium [269]
109 Mt Meitnerium [268]
110 Ds Darmstadtium [269]
111 Rg Roentgenium [272]
112 Cn Copernicium [277]
113 Uut Ununtrium unknown
114 Fl Flerovium [289]
115 Uup Ununpentium unknown
116 Lv Livermorium [298]
117 Uus Ununseptium unknown
118 Uuo Ununoctium unknown
Atomic Number
Symbol
Name
Atomic Mass
Lanthanide Series
Actinide Series
57 La Lanthanum 138.905
58 Ce Cerium 140.116
59 Pr Praseodymium 140.908
60 Nd Neodymium 144.243
61 Pm Promethium 144.913
62 Sm Samarium 150.36
63 Eu Europium 151.964
64 Gd Gadolinium 157.25
65 Tb Terbium 158.925
66 Dy Dysprosium 162.500
67 Ho Holmium 164.930
68 Er Erbium 167.259
69 Tm Thulium 168.934
70 Yb Ytterbium 173.055
71 Lu Lutetium 174.967
89 Ac Actinium 227.028
90 Th Thorium 232.038
91 Pa Protactinium 231.036
92 U Uranium 238.029
93 Np Neptunium 237.048
94 Pu Plutonium 244.064
95 Am Americium 243.061
96 Cm Curium 247.070
97 Bk Berkelium 247.070
98 Cf Californium 251.080
99 Es Einsteinium [254]
100 Fm Fermium 257.095
101 Md Mendelevium 258.1
102 No Nobelium 259.101
103 Lr Lawrencium [262]
Alkali Metals
Alkaline Earth Metals
Transition Metals
Basic Metals
Semimetals
Nonmetals
Halogens
Noble Gases
Lanthanides
Actinides

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