Section 4: Metals

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Section 4

METALS

Metals are used in optical systems as reflective optical components, optical thin films, structural elements, and mirror substrates. For these optical applications only a limited number of metals are useful. The materials and properties included in this section are therefore necessarily selective.

Depending upon the application, various physical, optical, mechanical, and thermal properties are of interest; for example, structural stiffness with low mass, thermal diffusivity to reduce thermal gradients and associated distortions, and smooth surface finish to accept of optical coatings. Thermal, elastic, electrical and magnetic properties may be anisotropic, thus crystal structure is also important.

4.1 Physical Properties of Selected Metals

Metal	Symbol	Crystal structure	Space group	Atomic weight	Density (g/cm^3)
Aluminum	Al	cubic	Fm3m	26.98	2.70
Beryllium	Be	hexagonal	$P6_3/mmc$	9.01	1.85
Chromium	Cr	cubic	Im3m	52.00	7.15
Copper	Cu	cubic	Fm3m	63.55	8.96
Germanium	Ge	cubic	Fd3m	72.61	5.32
Gold	Au	cubic	Fm3m	196.97	19.3
Iridium	Ir	cubic	Fm3m	192.22	22.5
Iron	Fe	cubic	Im3m	55.85	7.87
Magnesium	Mg	hexagonal	$P6_3/mmc$	24.30	1.74
Molybdenum	Mo	cubic	Im3m	95.94	10.2
Nickel	Ni	cubic	Fd3m	58.69	8.9
Niobium	Nb	cubic	Im3m	92.91	8.57
Osmium	Os	hexagonal	$P6_3/mmc$	190.23	22.59
Palladium	Pd	cubic	Fm3m	106.42	12.0
Platinum	Pt	cubic	Fm3m	195.08	21.5
Rhenium	Re	cubic	Fm3m	186.21	20.8
Rhodium	Rh	cubic	Fm3m	102.91	12.4
Silicon	Si	cubic	Fd3m	28.09	2.33
Silver	Ag	cubic	Fm3m	107.87	10.50
Tantalum	Ta	cubic	Im3m	180.95	16.4
Tin	Sn	tetragonal	Fd3m	118.71	7.28
Titanium	Ti	cubic	Im3m	47.88	4.5
Tungsten	W	cubic	Im3m	183.84	19.3
Zinc	Zn	hexagonal	$P6_3/mmc$	65.39	7.14
Zirconium	Zr	hexagonal	$P6_3/mmc$	91.22	6.51

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Electrical Resistivity of Pure Metals (nohm m)

Temp. (K)	10	20	80	200	300	400	600
Aluminum	0.0010	0.00755	2.45	15.87	27.33	38.7	61.3
Beryllium	0.332	0.336	0.75	12.9	376	67.6	132
Chromium	—	—	—	77	127	158	247
Copper	0.0200	0.0280	2.15	10.46	17.25	24.02	37.92
Gold	0.226	0.35	4.81	14.62	22.71	31.07	48.7
Iron	0.238	0.287	6.93	52.0	99.8	161	329
Molybdenum	0.0089	0.0261	4.82	31.3	55.2	80.2	131
Nickel	0.057	0.140	5.45	36.7	72.0	118	255
Palladium	0.0242	0.0563	1.75	6.88	10.80	14.48	21.2
Platinum	0.154	1.17	19.22	67.7	108	146	219
Silver	0.0115	0.042	2.89	10.29	16.29	22.41	35.3
Tantalum	1.02	1.46	26.2	86.6	135	182	274
Tungsten	0.00137	0.0196	6.06	31.8	54.4	78.3	130
Zinc	0.112	0.387	11.5	38.3	60.6	83.7	134.9
Zirconium	0.253	0.357	6.64	26.3	43.3	60.3	91.5

From the *CRC Handbook of Chemistry and Physics*, 82nd edition, Lide, D. R., Ed. (CRC Press, Boca Raton, FL, 2001), p. 12-45. Values of resistivity at other temperatures are given in this reference.

4.2 Optical Properties

The following tables list the index of refraction n, the extinction coefficient k, and the normal incidence reflection $R(\phi = 0)$ as a function of photon energy E expressed in electron volts (eV). The dielectric function $\varepsilon = \varepsilon_1 + i\varepsilon_2$ can be computed from the complex index of refraction $N = n + ik$ using $\varepsilon_1 = n^2 - k^2$ and $\varepsilon_2 = 2nk$.

The tables are from Weaver, J. H. and Frederikse, H. P. R., Optical properties of selected elements, in *CRC Handbook of Chemistry and Physics*, 82nd edition, Lide, D. R., Ed. (CRC Press, Boca Raton, FL, 2001), p. 12-133. The optical constants in these tables are abridged from three more extensive tabulations.[1-3] For critical applications the reader should refer to the original work. References for individual metals are listed at the end of the tables. Generally tabulated values for the optical properties are accurate to better than 10%. Data in parentheses are extrapolated or interpolated values. For most elements the spectral range covered is from the far infrared (0.010 or 0.10 eV) to the far ultraviolet (10, 30, or 300 eV). The intervals between successive energies in the tables are chosen in such a way that the major spectral features are preserved.

Tables of n, k, and $R(\phi = 0)$ are given for the following metals:

Aluminum	Iron	Palladium	Tantalum
Chromium	Magnesium	Platinum	Titanium
Copper	Molybdenum	Rhenium	Tungsten
Germanium	Nickel	Rhodium	Zinc
Gold	Niobium	Silicon	Zirconium
Iridium	Osmium	Silver	

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Aluminum[4]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.040	98.595	203.701	0.9923	4.400	0.244	3.380	0.9249
0.050	74.997	172.199	0.9915	4.600	0.223	3.222	0.9249
0.060	62.852	150.799	0.9906	4.800	0.205	3.076	0.9249
0.070	53.790	135.500	0.9899	8.000	0.072	1.663	0.9269
0.080	45.784	123.734	0.9895	8.500	0.063	1.527	0.9272
0.090	39.651	114.102	0.9892	9.000	0.056	1.402	0.9277
0.100	34.464	105.600	0.9889	9.500	0.049	1.286	0.9282
0.125	24.965	89.250	0.9884	10.000	0.044	1.178	0.9286
0.150	18.572	76.960	0.9882	10.500	0.040	1.076	0.9293
0.175	14.274	66.930	0.9879	11.000	0.036	0.979	0.9298
0.200	11.733	59.370	0.9873	11.500	0.033	0.883	0.9283
0.250	8.586	48.235	0.9858	12.000	0.033	0.791	0.9224
0.300	6.759	40.960	0.9844	12.500	0.034	0.700	0.9118
0.350	5.438	35.599	0.9834	13.000	0.038	0.609	0.8960
0.400	4.454	31.485	0.9826	13.500	0.041	0.517	0.8789
0.500	3.072	25.581	0.9817	14.000	0.048	0.417	0.8486
0.600	2.273	21.403	0.9806	14.200	0.053	0.373	0.8312
0.700	1.770	18.328	0.9794	14.400	0.058	0.327	0.8102
0.800	1.444	15.955	0.9778	14.600	0.067	0.273	0.7802
0.900	1.264	14.021	0.9749	14.800	0.086	0.211	0.7202
1.000	1.212	12.464	0.9697	15.000	0.125	0.153	0.6119
1.100	1.201	11.181	0.9630	15.200	0.178	0.108	0.4903
1.200	1.260	10.010	0.9521	15.400	0.234	0.184	0.3881
1.300	1.468	8.949	0.9318	15.600	0.280	0.073	0.3182
1.400	2.237	8.212	0.8852	15.800	0.318	0.065	0.2694
1.500	2.745	8.309	0.8678	16.000	0.351	0.060	0.2326
1.600	2.625	8.597	0.8794	16.200	0.380	0.055	0.2031
1.700	2.143	8.573	0.8972	16.400	0.407	0.050	0.1789
1.800	1.741	8.205	0.9069	16.750	0.448	0.045	0.1460
1.900	1.488	7.821	0.9116	17.000	0.474	0.042	0.1278
2.000	1.304	7.479	0.9148	17.250	0.498	0.040	0.1129
2.200	1.018	6.846	0.9200	17.500	0.520	0.038	0.1005
2.400	0.826	6.283	0.9228	17.750	0.540	0.036	0.0899
2.600	0.695	5.800	0.9238	18.000	0.558	0.035	0.0809
2.800	0.598	5.385	0.9242	18.500	0.591	0.032	0.0664
3.000	0.523	5.024	0.9241	19.000	0.620	0.030	0.0554
3.200	0.460	4.708	0.9243	19.500	0.646	0.028	0.0467
3.400	0.407	4.426	0.9245	20.000	0.668	0.027	0.0398
3.600	0.363	4.174	0.9246	20.500	0.689	0.025	0.0342
3.800	0.326	3.946	0.9247	21.000	0.707	0.024	0.0296
4.000	0.294	3.740	0.9248	21.500	0.724	0.023	0.0258
4.200	0.267	3.552	0.9248	22.000	0.739	0.022	0.0226
4.400	0.244	3.380	0.9249	22.500	0.753	0.021	0.0199
4.600	0.223	3.222	0.9249	23.000	0.766	0.021	0.0177
4.800	0.205	3.076	0.9249	23.500	0.778	0.020	0.0157
4.000	0.294	3.740	0.9248	24.000	0.789	0.019	0.0140
4.200	0.267	3.552	0.9248	24.500	0.799	0.018	0.0126

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Aluminum[4]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
25.000	0.809	0.018	0.0113	85.000	1.007	0.028	0.0002
25.500	0.817	0.017	0.0102	90.000	1.005	0.031	0.0002
26.000	0.826	0.016	0.0092	95.000	0.999	0.036	0.0003
27.000	0.840	0.015	0.0076	100.000	0.991	0.030	0.0002
28.000	0.854	0.014	0.0063	110.000	0.994	0.025	0.0002
29.000	0.865	0.014	0.0053	120.000	0.991	0.024	0.0002
30.000	0.876	0.013	0.0044	130.000	0.987	0.021	0.0001
35.000	0.915	0.010	0.0020	140.000	0.989	0.016	0.0001
40.000	0.940	0.008	0.0010	150.000	0.990	0.015	0.0001
45.000	0.957	0.007	0.0005	160.000	0.989	0.014	0.0001
50.000	0.969	0.006	0.0003	170.000	0.989	0.011	0.0001
55.000	0.979	0.005	0.0001	180.000	0.990	0.010	0.0000
60.000	0.987	0.004	0.0000	190.000	0.990	0.009	0.0000
65.000	0.995	0.004	0.0000	200.000	0.991	0.007	0.0000
70.000	1.006	0.004	0.0000	220.000	0.992	0.006	0.0000
72.500	1.025	0.004	0.0002	240.000	0.993	0.005	0.0000
75.000	1.011	0.024	0.0002	260.000	0.993	0.004	0.0000
77.500	1.008	0.025	0.0002	280.000	0.994	0.003	0.0000
80.000	1.007	0.024	0.0002	300.000	0.995	0.002	0.0000

Chromium[5]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.06	21.19	42.00	0.962	2.80	1.80	4.06	0.703
0.10	11.81	29.76	0.955	3.00	1.54	3.71	0.695
0.14	15.31	26.36	0.936	3.20	1.44	3.40	0.670
0.18	8.73	25.37	0.953	3.40	1.39	3.24	0.657
0.22	5.30	20.62	0.954	3.60	1.26	3.12	0.661
0.26	3.91	17.12	0.951	3.80	1.12	2.95	0.660
0.30	3.15	14.28	0.943	4.00	1.02	2.76	0.651
0.42	3.47	8.97	0.862	4.20	0.94	2.58	0.639
0.54	3.92	7.06	0.788	4.40	0.90	2.42	0.620
0.66	3.96	5.95	0.736	4.50	0.89	2.35	0.607
0.78	4.13	5.03	0.680	4.60	0.88	2.28	0.598
0.90	4.43	4.60	0.650	4.70	0.86	2.21	0.586
1.00	4.47	4.43	0.639	4.80	0.86	2.13	0.572
1.12	4.53	4.31	0.631	4.90	0.86	2.07	0.557
1.24	4.50	4.28	0.629	5.00	0.85	2.01	0.542
1.36	4.42	4.30	0.631	5.10	0.86	1.94	0.523
1.46	4.31	4.32	0.632	5.20	0.87	1.87	0.503
1.77	3.84	4.37	0.639	5.40	0.93	1.80	0.466
2.00	3.48	4.36	0.644	5.60	0.95	1.74	0.443
2.20	3.18	4.41	0.656	5.80	0.97	1.74	0.437
2.40	2.75	4.46	0.677	6.00	0.94	1.73	0.444
2.60	2.22	4.36	0.698	6.20	0.89	1.69	0.446

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Chromium[5]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
6.40	0.85	1.66	0.447	16.50	0.31	0.75	0.134
6.60	0.80	1.59	0.444	17.00	0.90	0.73	0.132
6.80	0.75	1.51	0.439	17.50	0.88	0.72	0.130
7.00	0.74	1.45	0.425	18.00	0.87	0.70	0.129
7.20	0.71	1.39	0.414	18.50	0.84	0.69	0.130
7.40	0.69	1.33	0.404	19.00	0.82	0.68	0.131
7.60	0.66	1.23	0.378	20.00	0.77	0.64	0.130
7.80	0.67	1.15	0.347	20.5	0.76	0.63	0.129
8.00	0.68	1.07	0.315	21.0	0.74	0.58	0.121
8.20	0.71	1.00	0.278	21.5	0.72	0.55	0.116
8.50	0.74	0.92	0.235	22.0	0.71	0.52	0.112
9.0	0.83	0.81	0.170	22.5	0.70	0.50	0.109
9.50	0.92	0.74	0.132	23.0	0.69	0.48	0.105
10.00	0.98	0.73	0.120	23.5	0.68	0.45	0.101
10.50	1.01	0.72	0.112	24.0	0.68	0.43	0.096
11.00	1.05	0.69	0.103	24.5	0.67	0.39	0.089
11.50	1.09	0.69	0.100	25.0	0.68	0.36	0.080
12.00	1.13	0.70	0.101	25.5	0.68	0.33	0.072
12.50	1.15	0.73	0.108	26.0	0.70	0.31	0.063
13.00	1.15	0.77	0.119	26.5	0.71	0.28	0.055
13.50	1.12	0.80	0.128	27.0	0.72	0.26	0.048
14.00	1.09	0.82	0.135	27.5	0.73	0.25	0.043
14.50	1.03	0.82	0.142	28.0	0.75	0.23	0.037
15.00	1.00	0.82	0.143	29.0	0.77	0.22	0.032
15.50	0.96	0.80	0.141	30.0	0.78	0.21	0.030
16.00	0.92	0.77	0.139				

Copper[6]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	29.69	71.57	0.980	3.00	1.18	2.21	0.509
0.50	1.71	17.63	0.979	3.20	1.23	2.07	0.468
1.00	0.44	8.48	0.976	3.40	1.27	1.95	0.434
1.50	0.26	5.26	0.965	3.60	1.31	1.87	0.407
1.70	0.22	4.43	0.958	3.80	1.34	1.81	0.387
1.75	0.21	4.25	0.956	4.00	1.34	1.72	0.364
1.80	0.21	4.04	0.952	4.20	1.42	1.64	0.336
1.85	0.22	3.85	0.947	4.40	1.49	1.64	0.329
1.90	0.21	3.67	0.943	4.60	1.52	1.67	0.334
2.00	0.27	3.24	0.910	4.80	1.53	1.71	0.345
2.10	0.47	2.81	0.814	5.00	1.47	1.78	0.366
2.20	0.83	2.60	0.673	5.20	1.38	1.80	0.380
2.30	1.04	2.59	0.618	5.40	1.28	1.78	0.389
2.40	1.12	2.60	0.602	5.60	1.18	1.74	0.391
2.60	1.15	2.50	0.577	5.80	1.10	1.67	0.389
2.80	1.17	2.36	0.545	6.00	1.04	1.59	0.380

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Copper[6] — *continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
6.50	0.96	1.37	0.329	38.00	0.93	0.18	0.010
7.00	0.97	1.20	0.271	39.00	0.93	0.17	0.009
7.50	1.00	1.09	0.230	40.00	0.93	0.17	0.009
8.00	1.03	1.03	0.206	41.00	0.94	0.16	0.008
8.50	1.03	0.98	0.189	42.00	0.94	0.16	0.007
9.00	1.03	0.92	0.171	43.00	0.94	0.15	0.007
9.50	1.03	0.87	0.154	44.00	0.95	0.15	0.007
10.00	1.04	0.82	0.139	45.00	0.95	0.15	0.006
11.00	1.07	0.75	0.118	46.00	0.95	0.15	0.006
12.00	1.09	0.73	0.111	47.00	0.95	0.14	0.006
13.00	1.08	0.72	0.109	48.00	0.95	0.14	0.006
14.00	1.06	0.72	0.111	49.00	0.95	0.14	0.005
14.50	1.03	0.72	0.111	50.00	0.95	0.13	0.005
15.00	1.01	0.71	0.111	51.00	0.95	0.13	0.005
15.50	0.98	0.69	0.109	52.00	0.95	0.13	0.005
16.00	0.95	0.67	0.106	53.00	0.96	0.12	0.004
17.00	0.91	0.62	0.097	54.00	0.96	0.12	0.004
18.00	0.89	0.56	0.084	55.00	0.96	0.12	0.004
19.00	0.88	0.51	0.071	56.00	0.96	0.11	0.004
20.00	0.88	0.45	0.059	57.00	0.96	0.11	0.004
21.00	0.90	0.41	0.048	58.00	0.96	0.11	0.004
22.00	0.92	0.38	0.040	59.00	0.97	0.11	0.003
23.00	0.94	0.37	0.035	60.00	0.97	0.11	0.003
24.00	0.96	0.37	0.035	61.00	0.97	0.11	0.003
25.00	0.96	0.40	0.040	62.00	0.97	0.11	0.003
26.00	0.92	0.40	0.044	63.00	0.96	0.10	0.003
27.00	0.88	0.38	0.043	64.00	0.96	0.10	0.003
28.00	0.86	0.35	0.039	65.00	0.97	0.10	0.003
29.00	0.85	0.30	0.032	66.00	0.97	0.10	0.003
30.00	0.86	0.26	0.025	67.00	0.97	0.09	0.003
31.00	0.88	0.24	0.020	68.00	0.97	0.09	0.002
32.00	0.89	0.22	0.017	69.00	0.97	0.09	0.002
33.00	0.90	0.21	0.015	70.00	0.97	0.09	0.002
34.00	0.91	0.20	0.014	75.00	0.98	0.09	0.002
35.00	0.92	0.20	0.013	80.00	0.98	0.09	0.002
36.00	0.92	0.19	0.012	85.00	0.97	0.09	0.002
37.00	0.92	0.19	0.011	90.00	0.96	0.08	0.002

Germanium[7]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.01240	(4.0065)	3.00E-03	0.361	0.01736	(4.0060)	1.50E-03	0.361
0.01364	4.0063	2.40E-03	0.361	0.01860		1.50E-03	
0.01488	(4.0060)	1.70E-03	0.361	0.01984		1.60E-03	
0.01612	(4.0060)	1.55E-03	0.361	0.02108		1.60E-03	

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Germanium[7]*—continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.02232		1.55E-03		0.08266	4.0013	9.78E-05	0.360
0.02356		1.53E-03		0.08551	4.0015	5.77E-05	0.360
0.02480		1.50E-03		0.08920		3.98E-05	
0.02604		1.25E-03		0.09460		4.59E-05	
0.02728		8.50E-04		0.09840		3.51E-05	
0.02852		6.50E-04		0.1	4.0063	3.70E-05	0.361
0.02976		7.00E-04		0.2	4.0108		0.361
0.03100	3.9827	8.50E-04	0.358	0.3	4.0246		0.362
0.03224		1.55E-03		0.4	4.0429		0.364
0.03348		2.75E-03		0.5	(4.074)		0.367
0.03472		3.55E-03		0.6	(4.104)	6.58E-07	0.370
0.03596	(3.9900)	3.05E-03	0.359	0.7	4.180	1.27E-04	0.377
0.03720		2.75E-03		0.8	4.275	5.67E-03	0.385
0.03844		2.70E-03		0.9	4.285	7.45E-02	0.386
0.03968	(3.9930)	2.90E-03	0.359	1.0	4.325	8.09E-02	0.390
0.04092		2.95E-03		1.1	4.385	0.103	0.395
0.04215		3.20E-03		1.2	4.420	0.123	0.398
0.04339		6.30E-03		1.3	4.495	0.167	0.405
0.04463		3.40E-03		1.4	4.560	0.190	0.411
0.04587	(3.9955)	2.50E-03	0.360	1.5	4.635	0.298	0.418
0.04711		2.10E-03		1.6	4.763	0.345	0.428
0.04835		2.00E-03		1.7	4.897	0.401	0.439
0.04959		8.00E-04		1.8	5.067	0.500	0.453
0.05083		1.40E-03		1.9	5.380	0.540	0.475
0.05207		1.35E-03		2.0	5.588	0.933	0.495
0.05331		1.10E-03		2.1	5.748	1.634	0.523
0.05455		8.00E-04		2.2	5.283	2.049	0.516
0.05579		6.00E-04		2.3	5.062	2.318	0.519
0.05703		9.0 E-04		2.4	4.610	2.455	0.508
0.05827		6.5 E-04		2.5	4.340	2.384	0.492
0.05951		4.6 E-04		2.6	4.180	2.309	0.480
0.06075		4.0 E-04		2.7	4.082	2.240	0.471
0.06199	3.9992	3.98E-04	0.360	2.8	4.035	2.181	0.464
0.06323		4.0 E-04		2.9	4.037	2.140	0.461
0.06447		4.3 E-04		3.0	4.082	2.145	0.463
0.06571		4.4 E-04		3.1	4.141	2.215	0.471
0.06695	(4.0000)	4.3 E-04	0.360	3.2	4.157	2.340	0.482
0.06819		3.1 E-04		3.3	4.128	2.469	0.490
0.06943		3.3 E-04		3.4	4.070	2.579	0.497
0.07067		3.8 E-04		3.5	4.020	2.667	0.502
0.07191		3.3 E-04		3.6	3.985	2.759	0.509
0.07315		2.5 E-04		3.7	3.958	2.863	0.517
0.07439		1.9 E-04		3.8	3.936	2.986	0.527
0.07514		1.58E-04		3.9	3.920	3.137	0.539
0.07749	4.0009	9.55E-05	0.360	4.0	3.905	3.336	0.556
0.07999	4.0011	1.71E-04	0.360	4.1	3.869	3.614	0.579

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Germanium[7]*—continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
4.2	3.745	4.009	0.612	6.5	1.10	2.05	0.489
4.3	3.338	4.507	0.659	7.0	1.00	1.80	0.448
4.4	2.516	4.669	0.705	7.5		1.60	
4.5	1.953	4.297	0.713	8.0	0.92	1.40	0.348
4.6	1.720	3.960	0.702	8.5	0.92	1.20	0.282
4.7	1.586	3.709	0.690	9.0	0.92	1.14	0.262
4.8	1.498	3.509	0.677	9.5		1.00	
4.9	1.435	3.342	0.664	10.0	0.93	0.86	0.167
5.0	1.394	3.197	0.650	20.0		0.237	
5.1	1.370	3.073	0.636	22.0		0.179	
5.2	1.364	2.973	0.622	24.0		0.144	
5.3	1.371	2.897	0.609	26.0		0.110	
5.4	1.383	2.854	0.600	28.0		0.0747	
5.5	1.380	2.842	0.598	30.0		0.1020	
5.6	1.360	2.846	0.602	32.0		0.0999	
5.7	1.293	2.163	0.479	34.0		0.0856	
5.8	1.209	2.873	0.632	36.0		0.0740	
5.9	1.108	2.813	0.641	38.0		0.0651	
6.0	1.30	2.34	0.517	40.0		0.0604	

Gold[8]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	8.17	82.83	0.995	2.90	1.50	1.79	0.368
0.20	2.13	41.73	0.995	3.00	1.54	1.80	0.369
0.30	0.99	27.82	0.995	3.10	1.54	1.81	0.371
0.40	0.59	20.83	0.995	3.20	1.54	1.80	0.368
0.50	0.39	16.61	0.994	3.30	1.55	1.78	0.362
0.60	0.28	13.78	0.994	3.40	1.56	1.76	0.356
0.70	0.22	11.75	0.994	3.50	1.58	1.73	0.349
0.80	0.18	10.21	0.993	3.60	1.62	1.73	0.346
0.90	0.15	9.01	0.993	3.70	1.64	1.75	0.351
1.00	0.13	8.03	0.992	3.80	1.63	1.79	0.360
1.20	0.10	6.54	0.991	3.90	1.59	1.81	0.366
1.40	0.08	5.44	0.989	4.00	1.55	1.81	0.369
1.60	0.08	4.56	0.986	4.10	1.51	1.79	0.368
1.80	0.09	3.82	0.979	4.20	1.48	1.78	0.367
2.00	0.13	3.16	0.953	4.30	1.45	1.77	0.368
2.10	0.18	2.84	0.925	4.40	1.41	1.76	0.370
2.20	0.24	2.54	0.880	4.50	1.35	1.74	0.370
2.40	0.50	1.86	0.647	4.60	1.30	1.69	0.364
2.50	0.82	1.59	0.438	4.70	1.27	1.64	0.354
2.60	1.24	1.54	0.331	4.80	1.25	1.59	0.344
2.70	1.43	1.72	0.356	4.90	1.23	1.54	0.332
2.80	1.46	1.77	0.368	5.00	1.22	1.49	0.319

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Gold[8]*—continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
5.20	1.21	1.40	0.295	10.00	1.37	0.80	0.126
5.40	1.21	1.33	0.275	10.20	1.36	0.80	0.127
5.60	1.21	1.27	0.256	10.40	1.35	0.80	0.125
5.80	1.21	1.20	0.236	10.60	1.34	0.79	0.123
6.00	1.22	1.14	0.218	10.80	1.34	0.77	0.120
6.20	1.24	1.09	0.203	11.00	1.34	0.76	0.116
6.40	1.25	1.05	0.190	11.20	1.34	0.74	0.113
6.60	1.27	1.01	0.177	11.40	1.35	0.73	0.111
6.80	1.30	0.97	0.167	11.60	1.36	0.72	0.109
7.00	1.34	0.95	0.162	11.80	1.38	0.71	0.108
7.20	1.36	0.95	0.161	12.00	1.39	0.71	0.109
7.40	1.38	0.96	0.164	12.40	1.44	0.73	0.115
7.60	1.38	0.98	0.169	12.80	1.45	0.79	0.127
7.80	1.35	0.99	0.171	13.20	1.42	0.84	0.137
8.00	1.31	0.96	0.165	13.60	1.37	0.86	0.140
8.20	1.30	0.92	0.155	14.00	1.33	0.86	0.140
8.40	1.30	0.89	0.147	14.40	1.29	0.86	0.139
8.60	1.31	0.88	0.144	14.80	1.26	0.84	0.135
8.80	1.31	0.86	0.140	15.20	1.24	0.83	0.132
9.00	1.30	0.83	0.133	15.60	1.22	0.81	0.127
9.20	1.31	0.81	0.126	16.00	1.21	0.79	0.123
9.40	1.33	0.78	0.122	16.40	1.20	0.78	0.119
9.60	1.36	0.78	0.121	16.80	1.19	0.76	0.116
9.80	1.37	0.79	0.124	17.20	1.19	0.75	0.114
5.60	1.21	1.27	0.256	17.60	1.19	0.74	0.111
5.80	1.21	1.20	0.236	18.00	1.19	0.74	0.109
6.00	1.22	1.14	0.218	18.40	1.19	0.73	0.109
6.20	1.24	1.09	0.203	18.80	1.20	0.74	0.110
6.40	1.25	1.05	0.190	19.20	1.21	0.76	0.116
6.60	1.27	1.01	0.177	19.60	1.21	0.80	0.125
6.80	1.30	0.97	0.167	20.00	1.18	0.83	0.133
7.00	1.34	0.95	0.162	20.40	1.14	0.85	0.141
7.20	1.36	0.95	0.161	20.80	1.10	0.87	0.149
7.40	1.38	0.96	0.164	21.20	1.05	0.88	0.156
7.60	1.38	0.98	0.169	21.60	1.00	0.88	0.162
7.80	1.35	0.99	0.171	22.00	0.94	0.86	0.164
8.00	1.31	0.96	0.165	22.40	0.89	0.83	0.163
8.20	1.30	0.92	0.155	22.80	0.85	0.79	0.157
8.40	1.30	0.89	0.147	23.20	0.82	0.75	0.149
8.60	1.31	0.88	0.144	23.60	0.80	0.70	0.138
8.80	1.31	0.86	0.140	24.00	0.80	0.66	0.125
9.00	1.30	0.83	0.133	24.40	0.80	0.62	0.113
9.20	1.31	0.81	0.126	24.80	0.80	0.58	0.101
9.40	1.33	0.78	0.122	25.20	0.82	0.56	0.090
9.60	1.36	0.78	0.121	25.60	0.83	0.54	0.084
9.80	1.37	0.79	0.124	26.00	0.84	0.52	0.079

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Gold[8]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
26.40	0.85	0.51	0.074	28.40	0.88	0.48	0.062
26.80	0.85	0.50	0.071	28.80	0.88	0.48	0.062
27.20	0.86	0.49	0.068	29.20	0.88	0.48	0.062
27.60	0.86	0.49	0.065	29.60	0.87	0.48	0.064
28.00	0.87	0.48	0.063	30.00	0.86	0.48	0.064

Iridium[9]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	28.49	60.62	0.975	3.40	1.53	3.05	0.610
0.15	15.32	45.15	0.973	3.60	1.52	2.81	0.573
0.20	9.69	35.34	0.972	3.80	1.61	2.69	0.541
0.25	6.86	28.84	0.969	4.00	1.64	2.68	0.535
0.30	5.16	24.25	0.967	4.20	1.58	2.71	0.549
0.35	4.11	20.79	0.964	4.40	1.45	2.68	0.561
0.40	3.42	18.06	0.960	4.60	1.31	2.60	0.567
0.45	3.05	15.82	0.954	4.80	1.18	2.49	0.570
0.50	2.98	14.06	0.944	5.00	1.10	2.35	0.559
0.60	2.79	11.58	0.925	5.20	1.04	2.22	0.543
0.70	2.93	9.78	0.895	5.40	1.00	2.09	0.522
0.80	3.14	8.61	0.862	5.60	0.98	1.98	0.499
0.90	3.19	7.88	0.840	5.80	0.96	1.86	0.474
1.00	3.15	7.31	0.822	6.00	0.95	1.78	0.454
1.10	3.04	6.84	0.808	6.20	0.94	1.68	0.427
1.20	2.96	6.41	0.791	6.40	0.94	1.59	0.401
1.30	2.85	6.07	0.779	6.60	0.94	1.50	0.375
1.40	2.72	5.74	0.767	6.80	0.95	1.42	0.345
1.50	2.65	5.39	0.750	7.00	0.97	1.34	0.318
1.60	2.68	5.08	0.728	7.20	0.99	1.27	0.290
1.70	2.69	4.92	0.716	7.40	1.02	1.20	0.262
1.80	2.64	4.81	0.710	7.60	1.03	1.14	0.241
1.90	2.57	4.68	0.704	7.80	1.08	1.06	0.208
2.00	2.50	4.57	0.699	8.00	1.13	1.03	0.191
2.10	2.40	4.48	0.697	8.20	1.18	1.00	0.179
2.20	2.29	4.38	0.695	8.40	1.22	0.98	0.171
2.30	2.18	4.26	0.692	8.60	1.26	0.96	0.164
2.40	2.07	4.14	0.689	8.80	1.29	0.95	0.160
2.50	1.98	4.00	0.682	9.00	1.33	0.94	0.157
2.60	1.91	3.86	0.673	9.20	1.36	0.95	0.159
2.70	1.85	3.73	0.665	9.40	1.39	0.95	0.161
2.80	1.81	3.61	0.655	9.60	1.42	0.97	0.163
2.90	1.77	3.51	0.646	9.80	1.44	0.99	0.169
3.00	1.73	3.43	0.640	10.00	1.45	1.01	0.175
3.20	1.62	3.26	0.629	10.20	1.45	1.04	0.182

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Iridium[9]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
10.40	1.44	1.07	0.187	19.60	1.15	1.05	0.197
10.60	1.43	1.09	0.193	20.00	1.10	1.06	0.205
10.80	1.41	1.12	0.200	20.50	1.04	1.05	0.210
11.00	1.38	1.13	0.206	21.00	0.99	1.04	0.215
11.20	1.34	1.14	0.208	21.50	0.94	1.02	0.220
11.40	1.31	1.13	0.208	22.00	0.89	1.00	0.222
11.60	1.28	1.12	0.206	22.50	0.84	0.99	0.228
11.80	1.25	1.10	0.203	23.00	0.79	0.96	0.232
12.00	1.24	1.08	0.199	23.50	0.76	0.92	0.228
12.40	1.21	1.05	0.191	24.00	0.73	0.87	0.223
12.80	1.19	1.01	0.181	24.50	0.70	0.83	0.218
13.20	1.18	0.98	0.173	25.00	0.69	0.79	0.209
13.60	1.17	0.95	0.165	25.50	0.68	0.76	0.200
14.00	1.16	0.91	0.155	26.00	0.67	0.72	0.192
14.40	1.17	0.88	0.147	26.50	0.67	0.69	0.181
14.80	1.18	0.87	0.142	27.00	0.66	0.66	0.174
15.20	1.19	0.84	0.136	27.50	0.66	0.63	0.166
15.60	1.20	0.83	0.133	28.00	0.66	0.61	0.158
16.00	1.21	0.83	0.131	28.50	0.66	0.59	0.151
16.40	1.23	0.82	0.129	29.00	0.65	0.57	0.148
16.80	1.25	0.82	0.127	29.50	0.64	0.55	0.145
17.20	1.28	0.83	0.131	30.00	0.64	0.53	0.140
17.60	1.30	0.87	0.140	32.00	0.62	0.44	0.119
18.00	1.30	0.93	0.154	34.00	0.64	0.35	0.091
18.40	1.27	0.97	0.166	36.00	0.69	0.27	0.059
18.80	1.24	1.00	0.176	38.00	0.73	0.24	0.044
19.20	1.20	1.03	0.187	40.00	0.76	0.22	0.034

Iron[10]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	6.41	33.07	0.978	1.20	3.24	4.26	0.641
0.15	6.26	22.82	0.956	1.30	3.16	4.07	0.626
0.20	3.68	18.23	0.958	1.40	3.12	3.87	0.609
0.26	4.98	13.68	0.911	1.50	3.05	3.77	0.601
0.30	4.87	12.05	0.892	1.60	3.00	3.60	0.585
0.36	4.68	10.44	0.867	1.70	2.98	3.52	0.577
0.40	4.42	9.75	0.858	1.80	2.92	3.46	0.573
0.50	4.14	8.02	0.817	1.90	2.89	3.37	0.563
0.60	3.93	6.95	0.783	2.00	2.85	3.36	0.563
0.70	3.78	6.17	0.752	2.10	2.80	3.34	0.562
0.80	3.65	5.60	0.725	2.20	2.74	3.33	0.563
0.90	3.52	5.16	0.700	2.30	2.65	3.34	0.567
1.00	3.43	4.79	0.678	2.40	2.56	3.31	0.567
1.10	3.33	4.52	0.660	2.50	2.46	3.31	0.570

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Iron[10]*—continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
2.60	2.34	3.30	0.576	9.50	0.90	1.02	0.226
2.70	2.23	3.25	0.575	9.67	0.90	1.00	0.221
2.80	2.12	3.23	0.580	9.83	0.89	0.99	0.218
2.90	2.01	3.17	0.580	10.00	0.88	0.97	0.213
3.00	1.88	3.12	0.583	10.17	0.87	0.94	0.203
3.10	1.78	3.04	0.580	10.33	0.87	0.91	0.196
3.20	1.70	2.96	0.576	10.50	0.87	0.89	0.189
3.30	1.62	2.87	0.572	10.67	0.88	0.87	0.179
3.40	1.55	2.79	0.565	10.83	0.89	0.85	0.170
3.50	1.50	2.70	0.556	11.00	0.91	0.83	0.162
3.60	1.47	2.63	0.548	11.17	0.92	0.83	0.159
3.70	1.43	2.56	0.542	11.33	0.93	0.84	0.159
3.83	1.38	2.49	0.534	11.50	0.93	0.84	0.160
4.00	1.30	2.39	0.527	11.67	0.93	0.84	0.162
4.17	1.26	2.27	0.510	11.83	0.92	0.84	0.163
4.33	1.23	2.18	0.494	12.00	0.91	0.84	0.163
4.50	1.20	2.10	0.482	12.17	0.90	0.84	0.165
4.67	1.16	2.02	0.470	12.33	0.89	0.83	0.164
4.83	1.14	1.93	0.451	12.50	0.98	0.83	0.165
5.00	1.14	1.87	0.435	12.67	0.87	0.82	0.166
5.17	1.12	1.81	0.425	12.83	0.86	0.81	0.166
5.33	1.11	1.75	0.408	13.00	0.85	0.80	0.162
5.50	1.09	1.17	0.401	13.17	0.84	0.79	0.161
5.67	1.09	1.65	0.383	13.33	0.84	0.78	0.160
5.83	1.10	1.61	0.373	13.50	0.83	0.77	0.159
6.00	1.09	1.59	0.366	13.67	0.82	0.76	0.157
6.17	1.08	1.57	0.365	13.83	0.81	0.75	0.154
6.33	1.04	1.55	0.365	14.00	0.81	0.73	0.151
6.50	1.02	1.51	0.358	14.17	0.80	0.72	0.149
6.67	1.00	1.47	0.351	14.33	0.80	0.71	0.146
6.83	0.97	1.43	0.346	14.50	0.79	0.79	0.144
7.00	0.96	1.39	0.333	14.67	0.79	0.69	0.141
7.17	0.94	1.35	0.327	14.83	0.78	0.67	0.138
7.33	0.94	1.30	0.311	15.00	0.78	0.66	0.135
7.50	0.94	1.26	0.298	15.17	0.78	0.65	0.131
7.67	0.94	1.23	0.288	15.33	0.78	0.64	0.238
7.83	0.94	1.21	0.279	15.50	0.77	0.63	0.126
8.00	0.94	1.18	0.272	15.67	0.77	0.62	0.123
8.17	0.94	1.16	0.265	15.83	0.77	0.61	0.119
8.33	0.94	1.14	0.258	16.00	0.77	0.60	0.116
8.50	0.94	1.12	0.251	16.17	0.78	0.58	0.112
8.67	0.94	1.10	0.246	16.33	0.78	0.58	0.110
8.83	0.92	1.08	0.240	16.50	0.78	0.57	0.107
9.00	0.93	1.07	0.236	16.67	0.77	0.56	0.106
9.17	0.92	1.06	0.233	16.83	0.78	0.55	0.103
9.33	0.91	1.04	0.231	17.00	0.78	0.55	0.102

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Iron[10]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
17.17	0.78	0.54	0.100	21.67	0.72	0.38	0.071
17.33	0.78	0.54	0.098	21.83	0.72	0.37	0.070
17.50	0.77	0.53	0.097	22.00	0.72	0.36	0.068
17.67	0.77	0.52	0.095	22.17	0.71	0.35	0.067
17.83	0.78	0.51	0.092	22.33	0.72	0.34	0.064
18.00	0.78	0.51	0.091	22.50	0.72	0.34	0.063
18.17	0.78	0.51	0.090	22.67	0.72	0.33	0.062
18.33	0.78	0.50	0.089	22.83	0.72	0.32	0.059
18.50	0.77	0.50	0.089	23.00	0.72	0.31	0.058
18.67	0.77	0.50	0.088	23.17	0.72	0.30	0.056
18.83	0.77	0.49	0.087	23.33	0.72	0.29	0.054
19.00	0.77	0.49	0.087	23.50	0.73	0.28	0.050
19.17	0.76	0.49	0.088	23.67	0.73	0.28	0.049
19.33	0.76	0.48	0.087	23.83	0.74	0.27	0.047
19.50	0.75	0.47	0.086	24.00	0.74	0.27	0.045
19.67	0.75	0.47	0.085	24.17	0.74	0.26	0.044
19.83	0.75	0.46	0.084	24.33	0.74	0.26	0.043
20.00	0.74	0.45	0.083	24.50	0.74	0.25	0.042
20.17	0.74	0.44	0.081	24.67	0.75	0.25	0.040
20.33	0.74	0.44	0.081	24.83	0.75	0.24	0.039
20.50	0.74	0.42	0.080	25.00	0.75	0.24	0.038
20.67	0.73	0.43	0.079	26.00	0.76	0.21	0.031
20.83	0.73	0.42	0.078	27.00	0.78	0.18	0.026
21.00	0.73	0.41	0.077	28.00	0.79	0.16	0.021
21.17	0.72	0.40	0.076	29.00	0.81	0.14	0.017
21.33	0.72	0.39	0.074	30.00	0.82	0.13	0.014
21.50	0.72	0.38	0.073				

Magnesium[11] (evaporated)

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
2.145	0.48	3.71	0.880	5.636	0.15	1.50	0.832
2.270	0.57	3.47	0.843	6.200	0.20	1.40	0.765
2.522	0.53	2.92	0.805	6.889	0.25	1.30	0.693
2.845	0.52	2.65	0.777	7.750	0.20	1.20	0.722
3.064	0.52	2.05	0.681	8.857	0.15	0.95	0.730
5.167	0.10	1.60	0.894	10.335	0.25	0.40	0.419

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Molybdenum[12]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	18.53	68.51	0.985	3.50	3.06	3.21	0.543
0.15	8.78	47.54	0.985	3.60	3.05	3.23	0.546
0.20	5.10	35.99	0.985	3.70	3.04	3.27	0.550
0.25	3.36	28.75	0.984	3.80	3.04	3.31	0.554
0.30	2.44	23.80	0.983	3.90	3.04	3.40	0.564
0.34	2.00	20.84	0.982	4.00	3.01	3.51	0.576
0.38	1.70	18.44	0.980	4.20	2.77	3.77	0.610
0.42	1.57	16.50	0.978	4.40	2.39	3.88	0.640
0.46	1.46	14.91	0.975	4.60	2.06	3.84	0.658
0.50	1.37	13.55	0.971	4.80	1.75	3.76	0.678
0.54	1.35	12.36	0.966	5.00	1.46	3.62	0.695
0.58	1.34	11.34	0.960	5.20	1.22	3.42	0.706
0.62	1.38	10.44	0.952	5.40	1.07	3.20	0.706
0.66	1.43	9.67	0.942	5.60	0.96	2.99	0.700
0.70	1.48	8.99	0.932	5.80	0.89	2.80	0.688
0.74	1.51	8.38	0.921	6.00	0.85	2.64	0.674
0.78	1.60	7.83	0.906	6.20	0.81	2.50	0.660
0.82	1.64	7.35	0.892	6.40	0.79	2.36	0.641
0.86	1.70	6.89	0.876	6.60	0.78	2.24	0.619
9.90	1.74	6.48	0.859	6.80	0.78	2.13	0.592
1.00	1.94	5.58	0.805	7.00	0.80	2.04	0.568
1.10	2.15	4.85	0.743	7.20	0.81	1.98	0.548
1.20	2.44	4.22	0.671	7.40	0.81	1.95	0.542
1.30	2.77	3.74	0.608	7.60	0.75	1.90	0.552
1.40	3.15	3.40	0.562	7.80	0.71	1.81	0.542
1.50	3.53	3.30	0.550	8.00	0.69	1.73	0.530
1.60	3.77	3.41	0.562	8.20	0.67	1.65	0.512
1.70	3.84	3.51	0.570	8.40	0.66	1.57	0.495
1.80	3.81	3.58	0.576	8.60	0.65	1.49	0.475
1.90	3.74	3.58	0.576	8.80	0.65	1.41	0.450
2.00	3.68	3.52	0.571	9.00	0.65	1.33	0.420
2.10	3.68	3.45	0.565	9.20	0.67	1.25	0.385
2.20	3.76	3.41	0.562	9.40	0.69	1.19	0.355
2.30	3.79	3.61	0.578	9.60	0.71	1.12	0.320
2.40	3.59	3.78	0.594	9.80	0.74	1.05	0.285
2.50	3.36	3.73	0.591	10.00	0.77	0.99	0.250
2.60	3.22	3.61	0.582	10.20	0.81	0.93	0.217
2.70	3.13	3.51	0.573	10.40	0.86	0.88	0.188
2.80	3.08	3.42	0.565	10.60	0.91	0.83	0.162
2.90	3.05	3.33	0.566	10.80	0.98	0.79	0.138
3.00	3.04	3.27	0.550	11.00	1.05	0.77	0.125
3.10	3.03	3.21	0.544	11.20	1.12	0.78	0.123
3.20	3.05	3.18	0.540	11.40	1.18	0.80	0.125
3.30	3.06	3.18	0.540	11.60	1.23	0.85	0.135
3.40	3.06	3.19	0.541	11.80	1.25	0.89	0.145

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Molybdenum[12]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
12.00	1.26	0.92	0.154	23.60	0.58	0.53	0.166
12.40	1.25	0.98	0.168	24.00	0.58	0.49	0.151
12.80	1.23	1.00	0.178	24.60	0.60	0.43	0.124
13.20	1.20	1.02	0.185	25.00	0.62	0.39	0.106
13.60	1.17	1.02	0.187	25.60	0.66	0.35	0.085
14.00	1.15	1.01	0.185	26.00	0.68	0.33	0.072
14.40	1.13	1.00	0.182	26.50	0.71	0.31	0.060
14.80	1.13	0.99	0.179	27.00	0.73	0.29	0.050
15.00	1.14	0.99	0.179	27.50	0.76	0.28	0.041
15.60	1.15	1.01	0.184	28.00	0.79	0.27	0.036
16.00	1.14	1.04	0.194	28.50	0.81	0.26	0.031
16.60	1.10	1.10	0.216	29.00	0.83	0.26	0.028
17.00	1.04	1.12	0.233	29.50	0.86	0.26	0.025
17.60	0.94	1.14	0.257	30.00	0.88	0.26	0.023
18.00	0.87	1.12	0.270	31.00	0.92	0.29	0.024
18.60	0.77	1.08	0.283	32.00	0.92	0.32	0.030
19.00	0.71	1.02	0.284	33.00	0.90	0.33	0.032
19.60	0.66	0.94	0.275	34.00	0.91	0.34	0.034
20.00	0.64	0.89	0.264	35.00	0.87	0.37	0.043
20.60	0.62	0.81	0.245	36.00	0.82	0.34	0.043
21.00	0.61	0.77	0.234	37.00	0.81	0.30	0.038
21.60	0.61	0.71	0.215	38.00	0.81	0.27	0.033
22.00	0.60	0.69	0.207	39.00	0.82	0.25	0.029
22.60	0.59	0.63	0.195	40.00	0.83	0.23	0.025
23.00	0.58	0.60	0.185				

Nickel[13]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	9.54	45.82	0.983	1.20	2.85	5.10	0.721
0.15	5.45	30.56	0.978	1.30	2.74	4.85	0.708
0.20	4.12	22.48	0.969	1.40	2.65	4.63	0.695
0.25	4.25	17.68	0.950	1.50	2.53	4.47	0.688
0.30	4.19	15.05	0.934	1.60	2.43	4.31	0.679
0.35	4.03	13.05	0.918	1.70	2.28	4.18	0.677
0.40	3.84	11.43	0.900	1.80	2.14	4.01	0.670
0.50	4.03	9.64	0.864	1.90	2.02	3.82	0.659
0.60	3.84	8.35	0.835	2.00	1.92	3.65	0.649
0.70	3.59	7.48	0.813	2.10	1.85	3.48	0.634
0.80	3.38	6.82	0.794	2.20	1.80	3.33	0.620
0.90	3.18	6.23	0.774	2.30	1.75	3.19	0.605
1.00	3.06	5.74	0.753	2.40	1.71	3.06	0.590
1.10	2.97	5.38	0.734	2.50	1.67	2.93	0.575

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Nickel[13]*—continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
2.60	1.65	2.81	0.557	10.40	0.95	0.80	0.145
2.70	1.64	2.71	0.542	10.60	0.97	0.76	0.129
2.80	1.63	2.61	0.525	10.80	0.99	0.75	0.123
2.90	1.62	2.52	0.509	11.00	1.01	0.73	0.115
3.00	1.61	2.44	0.495	11.25	1.04	0.72	0.111
3.10	1.61	2.36	0.480	11.50	1.05	0.71	0.109
3.20	1.61	2.30	0.467	11.75	1.07	0.71	0.108
3.30	1.61	2.23	0.454	12.00	1.07	0.71	0.108
3.40	1.62	2.17	0.441	12.25	1.07	0.71	0.107
3.50	1.63	2.11	0.428	12.50	1.08	0.71	0.106
3.60	1.64	2.07	0.416	12.75	1.08	0.71	0.106
3.70	1.66	2.02	0.405	13.00	1.08	0.71	0.105
3.80	1.69	1.99	0.397	13.25	1.08	0.71	0.105
3.90	1.72	1.98	0.393	13.50	1.07	0.70	0.105
4.00	1.73	1.98	0.392	13.75	1.07	0.70	0.105
4.20	1.74	2.01	0.396	14.00	1.07	0.71	0.106
4.40	1.71	2.06	0.409	14.25	1.06	0.70	0.106
4.60	1.63	2.09	0.421	14.50	1.05	0.70	0.106
4.80	1.53	2.11	0.435	14.75	1.04	0.70	0.107
5.00	1.40	2.10	0.449	15.00	1.03	0.70	0.107
5.20	1.27	2.04	0.454	15.25	1.02	0.69	0.106
5.40	1.16	1.94	0.449	15.50	1.01	0.69	0.105
5.60	1.09	1.83	0.435	15.75	1.00	0.68	0.104
5.80	1.04	1.73	0.417	16.00	0.99	0.67	0.103
6.20	1.00	1.54	0.371	16.50	0.98	0.66	0.101
6.40	1.01	1.46	0.345	17.00	0.96	0.64	0.098
6.60	1.01	1.40	0.325	17.50	0.94	0.63	0.096
6.80	1.02	1.35	0.308	18.00	0.92	0.61	0.092
7.00	1.03	1.30	0.291	18.50	0.91	0.58	0.087
7.20	1.03	1.27	0.282	19.00	0.90	0.56	0.082
7.40	1.03	1.24	0.273	19.50	0.90	0.54	0.077
7.60	1.02	1.22	0.265	20.00	0.89	0.51	0.071
7.80	1.01	1.18	0.256	20.50	0.89	0.49	0.066
8.00	1.01	1.15	0.248	21.00	0.90	0.47	0.061
8.20	1.00	1.13	0.242	21.50	0.91	0.46	0.057
8.40	0.99	1.11	0.235	22.00	0.91	0.45	0.055
8.60	0.98	1.08	0.228	22.50	0.91	0.44	0.053
8.80	0.97	1.05	0.220	23.00	0.92	0.44	0.051
9.00	0.97	1.01	0.211	23.50	0.91	0.44	0.052
9.20	0.96	0.99	0.203	24.00	0.90	0.43	0.051
9.40	0.95	0.96	0.194	24.50	0.90	0.43	0.051
9.60	0.95	0.93	0.185	25.00	0.89	0.42	0.050
9.80	0.95	0.89	0.175	26.00	0.88	0.39	0.046
10.00	0.95	0.87	0.166	27.00	0.87	0.37	0.042
10.20	0.95	0.83	0.155	28.00	0.87	0.35	0.040

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Nickel[13]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
29.00	0.86	0.34	0.037	65.00	0.98	0.09	0.002
30.00	0.86	0.32	0.034	68.00	0.96	0.12	0.004
35.00	0.86	0.24	0.022	70.00	0.94	0.11	0.004
40.00	0.87	0.18	0.014	75.00	0.94	0.09	0.003
45.00	0.88	0.13	0.008	80.00	0.94	0.07	0.002
50.00	0.92	0.10	0.004	90.00	0.94	0.06	0.002
60.00	0.96	0.08	0.002				

Niobium[14]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.12	15.99	53.20	0.979	3.00	2.51	2.68	0.485
0.20	7.25	34.14	0.976	3.10	2.48	2.60	0.475
0.24	5.47	28.88	0.975	3.20	2.45	2.53	0.465
0.28	4.26	24.95	0.974	3.30	2.44	2.45	0.453
0.35	3.11	20.03	0.970	3.40	2.46	2.38	0.442
0.45	2.28	15.58	0.964	3.50	2.48	2.33	0.435
0.55	1.83	12.67	0.956	3.60	2.52	2.29	0.428
0.65	1.57	10.59	0.947	3.70	2.56	2.27	0.426
0.75	1.41	9.00	0.935	3.80	2.59	2.28	0.427
0.85	1.35	7.74	0.918	3.90	2.62	2.29	0.429
0.95	1.35	6.70	0.893	4.00	2.64	2.33	0.434
1.05	1.44	5.86	0.857	4.20	2.64	2.42	0.447
1.15	1.55	5.18	0.814	4.40	2.53	2.56	0.467
1.25	1.65	4.63	0.768	4.60	2.39	2.56	0.470
1.35	1.76	4.13	0.715	4.80	2.32	2.52	0.465
1.45	1.95	3.68	0.650	5.00	2.26	2.57	0.475
1.55	2.15	3.37	0.595	5.20	2.16	2.62	0.487
1.65	2.36	3.13	0.552	5.40	2.00	2.68	0.505
1.75	2.54	2.99	0.527	5.60	1.81	2.67	0.518
1.85	2.69	2.89	0.510	5.80	1.63	2.60	0.522
1.95	2.82	2.86	0.505	6.00	1.49	2.49	0.520
2.05	2.89	2.87	0.505	6.20	1.38	2.38	0.512
2.15	2.92	2.87	0.505	6.40	1.31	2.25	0.496
2.25	2.93	2.87	0.505	6.60	1.26	2.14	0.480
2.35	2.92	2.88	0.506	6.80	1.24	2.04	0.460
2.45	2.89	2.90	0.509	7.00	1.23	1.96	0.441
2.55	2.83	2.92	0.512	7.20	1.22	1.91	0.430
2.65	2.74	2.90	0.511	7.40	1.20	1.88	0.427
2.75	2.66	2.86	0.507	7.60	1.14	1.85	0.430
2.85	2.58	2.80	0.500	7.80	1.07	1.78	0.428

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Niobium[14]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
8.00	1.02	1.69	0.412	17.80	0.75	0.87	0.217
8.20	1.00	1.60	0.390	18.00	0.74	0.85	0.209
8.40	0.99	1.51	0.365	18.60	0.73	0.77	0.185
8.60	0.99	1.43	0.340	19.00	0.72	0.72	0.170
8.70	0.99	1.39	0.328	19.60	0.72	0.66	0.150
8.80	1.00	1.36	0.315	20.00	0.72	0.62	0.137
9.00	1.01	1.29	0.290	20.60	0.71	0.55	0.119
9.20	1.04	1.22	0.265	21.00	0.72	0.50	0.100
9.40	1.07	1.18	0.245	21.60	0.75	0.43	0.075
9.60	1.10	1.13	0.227	22.00	0.78	0.40	0.063
9.80	1.13	1.09	0.209	22.60	0.82	0.35	0.045
10.00	1.18	1.05	0.194	23.00	0.85	0.33	0.038
10.20	1.23	1.04	0.187	23.60	0.88	0.30	0.029
10.40	1.27	1.04	0.185	24.00	0.91	0.29	0.025
10.60	1.30	1.06	0.190	24.60	0.94	0.28	0.022
10.80	1.32	1.08	0.195	25.00	0.96	0.27	0.020
11.00	1.32	1.10	0.200	25.60	0.99	0.26	0.018
11.20	1.31	1.12	0.204	26.00	1.00	0.26	0.017
11.40	1.30	1.13	0.207	26.60	1.03	0.25	0.016
11.60	1.28	1.13	0.209	27.00	1.04	0.25	0.015
11.80	1.27	1.13	0.210	27.60	1.06	0.25	0.015
12.00	1.25	1.12	0.209	28.00	1.08	0.24	0.015
12.40	1.24	1.10	0.204	28.60	1.11	0.24	0.016
12.80	1.24	1.09	0.200	29.00	1.13	0.25	0.017
13.20	1.24	1.09	0.201	29.60	1.16	0.26	0.020
13.60	1.23	1.12	0.208	30.00	1.18	0.28	0.023
14.00	1.20	1.13	0.216	31.00	1.18	0.31	0.026
14.40	1.16	1.15	0.225	32.00	1.20	0.34	0.031
14.80	1.11	1.16	0.234	33.00	1.21	0.38	0.038
15.00	1.08	1.16	0.238	34.00	1.20	0.42	0.044
15.60	0.99	1.14	0.247	35.20	1.17	0.47	0.051
16.00	0.92	1.11	0.250	36.00	1.15	0.50	0.056
16.60	0.85	1.04	0.245	37.50	1.07	0.53	0.064
17.00	0.80	0.99	0.240	39.50	0.95	0.50	0.063
17.20	0.79	0.96	0.236	40.50	0.92	0.47	0.059
17.40	0.77	0.93	0.230				

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Osmium (polycrystalline)[15]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	4.08	50.23	0.994	4.40	2.24	3.44	0.599
0.15	2.90	33.60	0.990	4.60	2.01	3.31	0.598
0.20	2.44	25.11	0.985	4.80	1.88	3.19	0.592
0.25	2.35	19.99	0.977	5.00	1.74	3.12	0.596
0.30	2.23	16.54	0.969	5.20	1.58	3.00	0.597
0.35	2.33	14.06	0.955	5.40	1.46	2.88	0.593
0.40	2.45	12.32	0.940	5.60	1.36	2.77	0.589
0.45	2.43	11.02	0.927	5.80	1.27	2.65	0.582
0.50	2.41	9.97	0.913	6.00	1.20	2.54	0.575
0.55	2.33	9.12	0.901	6.20	1.13	2.44	0.571
0.60	2.21	8.37	0.890	6.40	1.06	2.33	0.562
0.65	2.11	7.68	0.877	6.60	1.01	2.21	0.548
0.70	2.02	7.04	0.862	6.80	0.97	2.11	0.532
0.75	2.00	6.46	0.842	7.00	0.95	2.00	0.514
0.80	2.00	5.95	0.820	7.20	0.92	1.91	0.497
0.85	2.01	5.51	0.796	7.40	0.91	1.81	0.476
0.90	2.03	5.10	0.769	7.60	0.90	1.72	0.451
0.95	2.05	4.74	0.742	7.80	0.90	1.63	0.426
1.00	2.09	4.41	0.712	8.00	0.91	1.55	0.400
1.10	2.15	3.84	0.651	8.20	0.91	1.48	0.375
1.20	2.16	3.35	0.592	8.40	0.94	1.40	0.344
1.30	2.25	2.77	0.506	8.60	0.96	1.34	0.319
1.40	2.49	2.23	0.419	8.80	0.98	1.29	0.296
1.50	2.84	1.80	0.369	9.00	1.01	1.24	0.274
1.60	3.36	1.62	0.379	9.20	1.04	1.19	0.255
1.70	3.70	1.75	0.411	9.40	1.08	1.16	0.238
1.80	3.78	1.83	0.423	9.60	1.10	1.14	0.229
1.90	3.81	1.75	0.418	9.80	1.13	1.11	0.217
2.00	3.98	1.60	0.418	10.00	1.16	1.10	0.209
2.10	4.26	1.54	0.432	10.20	1.19	1.08	0.203
2.20	4.58	1.62	0.457	10.30	1.20	1.08	0.201
2.30	4.84	1.76	0.479	10.40	1.22	1.08	0.200
2.40	5.10	2.01	0.506	10.50	1.23	1.09	0.201
2.50	5.28	2.38	0.532	10.60	1.24	1.10	0.203
2.60	5.36	2.82	0.557	10.80	1.25	1.11	0.206
2.70	5.30	3.29	0.580	11.00	1.24	1.13	0.213
2.80	5.07	3.78	0.603	11.20	1.23	1.14	0.217
2.90	4.65	4.18	0.624	11.40	1.19	1.15	0.223
3.00	4.05	4.40	0.639	11.60	1.17	1.12	0.216
3.20	3.29	3.96	0.614	11.80	1.16	1.10	0.211
3.40	2.93	3.79	0.607	12.00	1.15	1.08	0.205
3.60	2.75	3.45	0.577	12.40	1.14	1.03	0.191
3.80	2.73	3.32	0.562	12.80	1.15	1.01	0.183
4.00	2.71	3.34	0.565	13.20	1.16	0.98	0.174
4.20	2.53	3.44	0.584	13.60	1.17	0.97	0.170

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Osmium (polycrystalline)[15] — *continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
14.00	1.17	0.96	0.169	24.00	0.73	0.84	0.209
14.40	1.16	0.94	0.165	24.40	0.72	0.82	0.207
14.80	1.16	0.91	0.156	24.80	0.70	0.80	0.205
15.20	1.17	0.89	0.148	25.20	0.69	0.77	0.202
15.60	1.20	0.86	0.140	25.60	0.67	0.75	0.199
16.00	1.25	0.87	0.140	26.00	0.66	0.72	0.195
16.40	1.28	0.90	0.147	26.40	0.65	0.69	0.189
16.80	1.28	0.94	0.157	26.80	0.63	0.66	0.183
17.20	1.27	0.97	0.167	27.20	0.65	0.62	0.165
17.60	1.26	1.01	0.178	28.00	0.64	0.59	0.156
18.00	1.23	1.04	0.189	28.40	0.64	0.57	0.148
18.40	1.19	1.08	0.200	28.80	0.65	0.55	0.140
18.80	1.14	1.10	0.210	29.20	0.65	0.53	0.134
19.20	1.10	1.10	0.219	29.60	0.65	0.51	0.128
19.60	1.05	1.11	0.227	30.00	0.65	0.49	0.121
20.00	0.96	1.10	0.239	31.00	0.65	0.45	0.111
20.40	0.93	1.09	0.240	32.00	0.66	0.41	0.095
20.80	0.89	1.05	0.240	33.00	0.68	0.37	0.079
21.20	0.86	1.02	0.237	34.00	0.70	0.34	0.068
21.60	0.83	0.99	0.235	35.00	0.72	0.31	0.057
22.00	0.80	0.96	0.230	36.00	0.74	0.29	0.048
22.40	0.78	0.93	0.226	37.00	0.77	0.27	0.040
22.80	0.77	0.90	0.220	38.00	0.79	0.26	0.035
23.20	0.75	0.88	0.217	39.00	0.81	0.26	0.031
23.60	0.75	0.86	0.211	40.00	0.84	0.26	0.026

Palladium[15]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	4.13	54.15	0.994	1.20	2.65	6.10	0.790
0.15	3.13	35.82	0.990	1.30	2.50	5.78	0.781
0.20	3.07	26.59	0.983	1.40	2.34	5.50	0.774
0.26	3.11	20.15	0.971	1.50	2.17	5.22	0.767
0.30	3.56	17.27	0.955	1.60	2.08	4.95	0.755
0.36	3.98	14.41	0.932	1.70	2.00	4.72	0.745
0.40	4.27	13.27	0.916	1.80	1.92	4.54	0.737
0.46	4.27	12.11	0.902	1.90	1.82	4.35	0.729
0.50	4.10	11.44	0.896	2.00	1.75	4.18	0.721
0.56	3.92	10.49	0.883	2.10	1.67	4.03	0.714
0.60	3.80	9.96	0.876	2.20	1.60	3.88	0.707
0.72	3.51	8.70	0.854	2.30	1.53	3.75	0.700
0.80	3.35	8.06	0.840	2.40	1.47	3.61	0.693
1.00	2.99	6.89	0.811	2.50	1.41	3.48	0.685
1.10	2.81	6.46	0.800	2.60	1.37	3.36	0.676

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Palladium[15]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
2.70	1.32	3.25	0.668	8.80	1.04	0.65	0.094
2.80	1.29	3.13	0.658	9.00	1.07	0.64	0.090
2.90	1.26	3.03	0.648	9.50	1.12	0.65	0.089
3.00	1.23	2.94	0.639	10.00	1.14	0.65	0.088
3.10	1.20	2.85	0.630	10.50	1.16	0.65	0.087
3.20	1.17	2.77	0.622	11.00	1.18	0.64	0.086
3.30	1.14	2.68	0.613	11.50	1.19	0.65	0.087
3.40	1.12	2.60	0.602	12.00	1.20	0.66	0.089
3.50	1.10	2.52	0.591	12.50	1.19	0.67	0.091
3.60	1.08	2.45	0.581	13.00	1.18	0.67	0.091
3.70	1.07	2.38	0.570	13.50	1.18	0.67	0.092
3.80	1.06	2.31	0.558	14.00	1.17	0.67	0.093
3.90	1.05	2.25	0.547	14.50	1.15	0.68	0.095
4.00	1.03	2.19	0.537	15.00	1.13	0.69	0.098
4.20	1.04	2.09	0.510	15.50	1.10	0.68	0.096
4.40	1.03	2.01	0.493	16.00	1.08	0.66	0.092
4.60	1.03	1.94	0.476	16.50	1.06	0.63	0.086
4.80	1.01	1.90	0.470	17.00	1.07	0.61	0.081
5.00	0.96	1.86	0.472	17.50	1.06	0.61	0.080
5.20	0.90	1.79	0.474	18.00	1.07	0.59	0.077
5.40	0.85	1.70	0.463	18.50	1.07	0.59	0.077
5.60	0.81	1.62	0.449	19.00	1.08	0.59	0.077
5.80	0.78	1.54	0.437	19.50	1.08	0.61	0.080
6.00	0.76	1.45	0.418	20.00	1.07	0.65	0.090
6.20	0.74	1.37	0.397	20.50	1.03	0.67	0.098
6.40	0.73	1.29	0.375	21.00	0.99	0.67	0.103
6.60	0.72	1.21	0.350	21.50	0.95	0.66	0.103
6.80	0.73	1.13	0.316	22.00	0.91	0.64	0.103
7.00	0.73	1.05	0.287	22.50	0.88	0.62	0.101
7.20	0.75	0.98	0.255	23.00	0.86	0.59	0.097
7.40	0.77	0.91	0.223	23.50	0.85	0.56	0.091
7.60	0.79	0.85	0.195	24.00	0.84	0.54	0.086
7.80	0.83	0.78	0.163	25.00	0.81	0.51	0.084
8.00	0.88	0.73	0.133	26.40	0.80	0.43	0.066
8.20	0.94	0.70	0.117	27.80	0.81	0.38	0.052
8.40	0.96	0.70	0.114	29.20	0.82	0.35	0.046
8.60	1.00	0.65	0.097				

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Platinum[16]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	13.21	44.72	0.976	4.40	1.43	2.04	0.432
0.15	8.18	31.16	0.969	4.60	1.39	1.95	0.415
0.20	5.90	23.95	0.962	4.80	1.38	1.85	0.392
0.25	4.70	19.40	0.954	5.00	1.36	1.76	0.372
0.30	3.92	16.16	0.945	5.20	1.36	1.67	0.350
0.35	3.28	13.66	0.936	5.40	1.36	1.61	0.332
0.40	2.81	11.38	0.922	5.60	1.36	1.54	0.315
0.45	3.03	9.31	0.882	5.80	1.36	1.47	0.295
0.50	3.91	7.71	0.813	6.00	1.38	1.40	0.276
0.55	4.58	7.14	0.777	6.20	1.39	1.35	0.261
0.60	5.13	6.75	0.753	6.40	1.42	1.29	0.246
0.65	5.52	6.66	0.746	6.60	1.45	1.26	0.236
0.70	5.71	6.83	0.751	6.80	1.48	1.24	0.231
0.75	5.57	7.02	0.759	7.00	1.50	1.24	0.230
0.80	5.31	7.04	0.762	7.20	1.50	1.25	0.231
0.85	5.05	6.98	0.763	7.40	1.49	1.23	0.228
0.90	4.77	6.91	0.765	7.60	1.48	1.22	0.225
0.95	4.50	6.77	0.763	7.80	1.48	1.20	0.221
1.00	4.25	6.62	0.762	8.00	1.47	1.18	0.216
1.10	3.86	6.24	0.753	8.20	1.47	1.17	0.212
1.20	3.55	5.92	0.746	8.40	1.47	1.15	0.209
1.30	3.29	5.61	0.736	8.60	1.47	1.14	0.205
1.40	3.10	5.32	0.725	8.80	1.47	1.13	0.202
1.50	2.92	5.07	0.716	9.00	1.48	1.12	0.200
1.60	2.76	4.84	0.706	9.20	1.49	1.11	0.198
1.70	2.63	4.64	0.697	9.40	1.49	1.12	0.200
1.80	2.51	4.43	0.686	9.60	1.49	1.13	0.203
1.90	2.38	4.26	0.678	9.80	1.48	1.15	0.207
2.00	2.30	4.07	0.664	10.00	1.46	1.15	0.209
2.10	2.23	3.92	0.654	10.20	1.43	1.16	0.211
2.20	2.17	3.77	0.642	10.40	1.40	1.15	0.210
2.30	2.10	3.67	0.636	10.60	1.37	1.14	0.207
2.40	2.03	3.54	0.626	10.80	1.35	1.12	0.203
2.50	1.96	3.42	0.616	11.00	1.33	1.10	0.199
2.60	1.91	3.30	0.605	11.20	1.31	1.08	0.194
2.70	1.87	3.20	0.595	11.40	1.30	1.06	0.188
2.80	1.83	3.10	0.585	11.60	1.29	1.04	0.183
2.90	1.79	3.01	0.575	11.80	1.29	1.01	0.177
3.00	1.75	2.92	0.565	12.00	1.29	1.00	0.173
3.20	1.68	2.76	0.546	12.40	1.29	0.97	0.165
3.40	1.63	2.62	0.527	12.80	1.29	0.94	0.158
3.60	1.58	2.48	0.507	13.20	1.31	0.93	0.155
3.80	1.53	2.37	0.491	13.60	1.31	0.93	0.155
4.00	1.49	2.25	0.472	14.00	1.31	0.93	0.155
4.20	1.45	2.14	0.452	14.40	1.30	0.93	0.156

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Platinum[16] — *continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
14.80	1.27	0.93	0.157	22.50	0.81	0.98	0.235
15.20	1.27	0.93	0.155	23.00	0.77	0.92	0.226
15.60	1.25	0.92	0.151	23.50	0.75	0.87	0.213
16.00	1.24	0.89	0.146	24.00	0.74	0.82	0.201
16.50	1.24	0.87	0.142	24.50	0.73	0.77	0.187
17.00	1.25	0.86	0.138	25.00	0.73	0.73	0.174
17.50	1.27	0.85	0.135	25.50	0.73	0.70	0.162
18.00	1.31	0.88	0.142	26.00	0.74	0.67	0.150
18.50	1.30	0.94	0.157	26.50	0.74	0.65	0.142
19.00	1.28	0.99	0.171	27.00	0.74	0.63	0.136
19.50	1.23	1.03	0.184	27.50	0.74	0.62	0.130
20.00	1.18	1.06	0.197	28.00	0.75	0.60	0.125
20.50	1.11	1.09	0.212	28.50	0.75	0.59	0.121
21.00	1.03	1.10	0.226	29.00	0.75	0.58	0.118
21.50	0.94	1.08	0.238	29.50	0.74	0.58	0.120
22.00	0.87	1.04	0.240	30.00	0.73	0.58	0.124

Rhenium (single crystal)[8] E || c

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	6.06	51.03	0.991	1.60	2.59	3.49	0.587
0.15	4.66	33.96	0.984	1.70	2.70	3.27	0.557
0.20	4.16	25.36	0.975	1.80	2.82	3.10	0.535
0.25	4.03	20.10	0.962	1.90	2.90	3.00	0.520
0.30	4.37	16.69	0.943	2.00	2.97	2.91	0.510
0.35	4.50	14.53	0.925	2.10	3.03	2.86	0.504
0.40	4.53	12.96	0.909	2.20	3.06	2.84	0.501
0.45	4.53	11.78	0.893	2.30	3.07	2.82	0.499
0.50	4.53	10.88	0.878	2.40	3.06	2.81	0.498
0.55	4.50	10.26	0.867	2.50	3.02	2.80	0.497
0.60	4.29	9.75	0.861	2.60	2.96	2.77	0.493
0.65	4.07	9.35	0.856	2.70	2.89	2.68	0.482
0.70	3.80	8.94	0.853	2.80	2.89	2.57	0.468
0.75	3.48	8.55	0.850	2.90	2.99	2.47	0.457
0.80	3.21	8.10	0.846	3.00	3.11	2.57	0.470
0.85	2.96	7.68	0.841	3.20	2.90	2.68	0.482
0.90	2.73	7.24	0.835	3.40	2.83	2.50	0.459
0.95	2.56	6.79	0.826	3.60	2.93	2.48	0.457
1.00	2.45	6.36	0.813	3.80	2.86	2.56	0.467
1.10	2.38	5.61	0.778	4.00	2.81	2.51	0.460
1.20	2.35	5.02	0.742	4.20	2.86	2.55	0.466
1.30	2.39	4.54	0.702	4.40	2.81	2.74	0.489
1.40	2.44	4.13	0.662	4.60	2.56	2.83	0.504
1.50	2.50	3.79	0.624	4.80	2.41	2.71	0.493

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Rhenium (single crystal)[8] E || c—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
5.00	2.39	2.68	0.488	16.40	1.19	1.27	0.259
5.20	2.34	2.75	0.500	16.80	1.14	1.29	0.269
5.40	2.20	2.81	0.515	17.00	1.12	1.30	0.275
5.60	2.02	2.84	0.530	17.40	1.07	1.30	0.286
5.80	1.83	2.80	0.538	18.00	0.99	1.30	0.300
6.00	1.65	2.71	0.541	18.40	0.93	1.29	0.311
6.20	1.54	2.59	0.532	18.80	0.87	1.28	0.321
6.40	1.45	2.50	0.526	19.20	0.81	1.25	0.330
6.80	1.32	2.31	0.508	19.60	0.77	1.21	0.332
7.00	1.26	2.23	0.500	20.00	0.73	1.18	0.333
7.20	1.20	2.15	0.493	20.40	0.70	1.14	0.332
7.40	1.16	2.06	0.480	20.80	0.67	1.11	0.332
7.60	1.12	1.99	0.470	21.20	0.64	1.08	0.334
7.80	1.08	1.89	0.454	21.60	0.61	1.04	0.335
8.00	1.05	1.80	0.435	22.00	0.58	1.01	0.340
8.20	1.05	1.71	0.411	22.40	0.55	0.97	0.341
8.40	1.05	1.62	0.386	22.80	0.53	0.93	0.338
8.60	1.06	1.55	0.360	23.20	0.51	0.89	0.334
8.80	1.09	1.48	0.336	23.60	0.50	0.85	0.329
9.00	1.11	1.43	0.317	24.00	0.48	0.80	0.319
9.20	1.13	1.39	0.301	24.40	0.48	0.76	0.207
9.40	1.16	1.34	0.281	24.80	0.47	0.72	0.296
9.60	1.18	1.32	0.274	25.20	0.47	0.68	0.282
9.80	1.20	1.29	0.264	25.60	0.47	0.65	0.270
10.00	1.23	1.26	0.252	26.00	0.47	0.61	0.255
10.20	1.25	1.25	0.246	26.40	0.48	0.57	0.240
10.40	1.28	1.25	0.242	26.80	0.48	0.54	0.225
10.60	1.29	1.25	0.242	27.20	0.49	0.51	0.208
10.80	1.30	1.26	0.244	27.60	0.50	0.48	0.193
11.00	1.30	1.27	0.247	28.00	0.51	0.45	0.176
11.20	1.29	1.28	0.249	29.00	0.54	0.39	0.145
11.40	1.28	1.28	0.252	30.00	0.57	0.33	0.114
11.60	1.26	1.28	0.252	31.00	0.62	0.29	0.086
11.80	1.24	1.26	0.249	32.00	0.66	0.26	0.065
12.00	1.23	1.24	0.244	33.00	0.68	0.24	0.054
12.40	1.22	1.21	0.237	34.00	0.72	0.21	0.041
12.80	1.21	1.18	0.230	35.00	0.76	0.20	0.031
13.20	1.22	1.16	0.222	36.00	0.79	0.20	0.025
13.60	1.22	1.13	0.215	37.00	0.82	0.19	0.021
14.00	1.24	1.12	0.209	38.00	0.85	0.20	0.018
14.40	1.27	1.11	0.204	39.00	0.89	0.21	0.016
14.80	1.29	1.15	0.213	40.00	0.88	0.26	0.022
15.20	1.29	1.19	0.225	42.00	0.88	0.26	0.022
15.60	1.26	1.22	0.236	44.00	0.89	0.29	0.026
16.00	1.23	1.25	0.248	46.00	0.85	0.32	0.035

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Rhenium (single crystal)[8] E || c —*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
48.00	0.82	0.30	0.036	54.00	0.72	0.30	0.055
50.00	0.80	0.30	0.038	56.00	0.66	0.24	0.061
52.00	0.78	0.30	0.044	58.00	0.65	0.16	0.055

Rhenium (single crystal)[8] E ⊥ c

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	4.25	42.83	0.991	2.90	3.49	2.75	0.497
0.15	3.28	28.08	0.984	3.00	3.53	2.71	0.493
0.20	3.28	20.66	0.971	3.20	3.55	2.84	0.506
0.25	3.47	16.27	0.951	3.40	3.34	2.88	0.508
0.30	3.73	13.44	0.926	3.60	3.25	2.83	0.501
0.35	3.93	11.54	0.900	3.80	3.24	2.84	0.502
0.40	3.99	10.15	0.875	4.00	3.19	2.94	0.513
0.45	4.17	9.03	0.846	4.20	3.05	3.06	0.526
0.50	4.34	8.26	0.821	4.40	2.88	3.15	0.539
0.55	4.45	7.73	0.801	4.60	2.67	3.18	0.548
0.60	4.53	7.40	0.788	4.80	2.44	3.17	0.554
0.65	4.44	7.26	0.784	5.00	2.25	3.12	0.556
0.70	4.13	7.09	0.784	5.20	2.10	3.04	0.555
0.75	3.77	6.75	0.779	5.40	1.96	2.96	0.553
0.80	3.55	6.32	0.766	5.60	1.84	2.88	0.551
0.85	3.39	5.95	0.752	5.80	1.73	2.81	0.549
0.90	3.26	5.61	0.737	6.00	1.61	2.74	0.549
0.95	3.17	5.27	0.719	6.20	1.51	2.64	0.545
1.00	3.09	4.96	0.701	6.40	1.42	2.56	0.541
1.10	3.05	4.39	0.658	6.80	1.28	2.37	0.526
1.20	3.08	3.89	0.613	7.00	1.22	2.28	0.517
1.30	3.20	3.56	0.578	7.20	1.16	2.19	0.508
1.40	3.23	3.38	0.559	7.40	1.12	2.08	0.493
1.50	3.23	3.12	0.532	7.60	1.12	1.98	0.468
1.60	3.29	2.88	0.507	7.80	1.08	1.93	0.463
1.70	3.38	2.72	0.491	8.00	1.05	1.83	0.443
1.80	3.47	2.59	0.480	8.20	1.05	1.74	0.418
1.90	3.54	2.50	0.473	8.40	1.05	1.66	0.397
2.00	3.63	2.43	0.469	8.60	1.06	1.58	0.372
2.10	3.74	2.40	0.470	8.80	1.07	1.52	0.351
2.20	3.83	2.38	0.472	9.00	1.09	1.46	0.327
2.30	3.93	2.44	0.481	9.20	1.11	1.41	0.309
2.40	4.00	2.55	0.492	9.40	1.14	1.36	0.290
2.50	4.01	2.70	0.505	9.60	1.17	1.31	0.273
2.60	3.90	2.84	0.514	9.80	1.20	1.27	0.258
2.70	3.74	2.92	0.517	10.00	1.24	1.24	0.244
2.80	3.57	2.88	0.511	10.20	1.29	1.22	0.234

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Rhenium (single crystal)[8] E ⊥ c —*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
10.40	1.33	1.23	0.233	23.20	0.53	0.89	0.322
10.60	1.36	1.25	0.238	23.60	0.52	0.85	0.317
10.80	1.38	1.28	0.245	24.00	0.50	0.82	0.314
11.00	1.37	1.31	0.253	24.40	0.49	0.79	0.309
11.20	1.36	1.33	0.259	24.40	0.49	0.79	0.309
11.40	1.33	1.34	0.264	24.80	0.48	0.75	0.303
11.60	1.31	1.34	0.266	25.20	0.47	0.72	0.295
11.80	1.28	1.33	0.266	25.60	0.47	0.68	0.286
12.00	1.26	1.32	0.264	26.00	0.46	0.64	0.276
12.40	1.23	1.29	0.257	26.40	0.46	0.61	0.263
12.80	1.22	1.26	0.251	26.80	0.46	0.57	0.249
13.20	1.20	1.23	0.245	27.20	0.47	0.53	0.231
13.60	1.19	1.20	0.236	27.60	0.48	0.50	0.216
14.00	1.20	1.16	0.225	28.00	0.49	0.47	0.198
14.40	1.22	1.13	0.214	29.00	0.51	0.41	0.164
14.80	1.27	1.12	0.207	30.00	0.55	0.34	0.129
15.20	1.31	1.17	0.218	31.00	0.59	0.29	0.097
15.60	1.31	1.23	0.234	32.00	0.64	0.26	0.072
16.00	1.28	1.28	0.251	33.00	0.67	0.24	0.060
16.40	1.24	1.33	0.270	34.00	0.70	0.22	0.047
16.80	1.17	1.37	0.288	35.00	0.74	0.20	0.036
17.00	1.14	1.38	0.297	36.00	0.77	0.19	0.029
17.40	1.06	1.39	0.314	37.00	0.80	0.19	0.023
18.00	0.95	1.38	0.334	38.00	0.84	0.19	0.018
18.40	0.88	1.36	0.346	39.00	0.88	0.21	0.016
18.80	0.82	1.33	0.355	40.00	0.87	0.25	0.023
19.20	0.76	1.29	0.360	42.00	0.87	0.25	0.023
19.60	0.72	1.25	0.363	44.00	0.88	0.28	0.026
20.00	0.67	1.21	0.369	46.00	0.84	0.31	0.035
20.40	0.64	1.15	0.364	48.00	0.82	0.30	0.036
20.80	0.61	1.10	0.357	50.00	0.80	0.30	0.039
21.20	0.60	1.06	0.349	52.00	0.77	0.30	0.044
21.60	0.58	1.02	0.342	54.00	0.71	0.29	0.055
22.00	0.57	0.98	0.336	56.00	0.66	0.23	0.061
22.40	0.56	0.95	0.328	58.00	0.64	0.16	0.055

Rhodium[9]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	18.48	69.43	0.986	0.70	3.67	11.72	0.908
0.20	8.66	37.46	0.977	0.80	3.63	10.34	0.887
0.30	5.85	25.94	0.967	0.90	3.62	9.36	0.867
0.40	4.74	19.80	0.955	1.00	3.71	8.67	0.848
0.50	4.20	16.07	0.941	1.10	3.67	8.26	0.837
0.60	3.87	13.51	0.925	1.20	3.51	7.94	0.832

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Rhodium[9]*—continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
1.30	3.26	7.63	0.829	7.80	0.68	1.20	0.363
1.40	3.01	7.31	0.827	8.00	0.69	1.12	0.329
1.50	2.78	6.97	0.823	8.20	0.71	1.04	0.288
1.60	2.60	6.64	0.818	8.40	0.74	0.97	0.252
1.70	2.42	6.33	0.813	8.60	0.78	0.89	0.212
1.80	2.30	6.02	0.805	8.80	0.83	0.83	0.179
1.90	2.20	5.76	0.798	9.00	0.88	0.77	0.148
2.00	2.12	5.51	0.789	9.20	0.95	0.73	0.125
2.10	2.05	5.30	0.780	9.40	1.01	0.71	0.110
2.20	2.00	5.11	0.772	9.60	1.07	0.69	0.102
2.30	1.94	4.94	0.765	9.80	1.12	0.69	0.098
2.40	1.90	4.78	0.756	10.00	1.17	0.69	0.098
2.50	1.88	4.65	0.748	10.60	1.26	0.73	0.106
2.60	1.85	4.55	0.743	11.00	1.29	0.76	0.113
2.70	1.80	4.49	0.742	11.60	1.32	0.80	0.124
2.90	1.63	4.36	0.748	12.00	1.32	0.82	0.127
3.00	1.53	4.29	0.753	12.60	1.32	0.82	0.129
3.10	1.41	4.20	0.760	13.00	1.32	0.83	0.131
3.20	1.30	4.09	0.764	13.60	1.32	0.85	0.134
3.30	1.20	3.97	0.767	14.00	1.32	0.86	0.138
3.40	1.11	3.84	0.769	14.60	1.30	0.89	0.144
3.50	1.04	3.71	0.768	15.00	1.28	0.90	0.147
3.60	0.99	3.58	0.764	15.60	1.25	0.90	0.147
3.70	0.95	3.45	0.759	16.00	1.24	0.89	0.147
3.80	0.91	3.34	0.753	16.50	1.23	0.88	0.145
3.90	0.88	3.23	0.747	17.00	1.22	0.88	0.144
4.00	0.86	3.12	0.739	17.50	1.22	0.87	0.143
4.20	0.83	2.94	0.722	18.00	1.23	0.88	0.145
4.40	0.80	2.76	0.706	18.50	1.25	0.92	0.155
4.60	0.78	2.60	0.684	19.00	1.24	0.98	0.172
4.80	0.79	2.46	0.659	19.50	1.18	1.05	0.193
5.00	0.79	2.34	0.635	20.00	1.10	1.09	0.213
5.20	0.79	2.23	0.613	20.50	1.00	1.09	0.230
5.40	0.80	2.14	0.591	21.00	0.91	1.05	0.234
5.60	0.80	2.06	0.573	21.50	0.86	1.00	0.228
5.80	0.79	2.00	0.561	22.00	0.83	0.95	0.219
6.00	0.76	1.93	0.556	22.50	0.81	0.92	0.214
6.20	0.73	1.85	0.544	23.00	0.79	0.90	0.213
6.40	0.70	1.77	0.534	23.50	0.75	0.87	0.214
6.60	0.68	1.69	0.518	24.00	0.73	0.84	0.210
6.80	0.67	1.60	0.498	24.50	0.70	0.81	0.208
7.00	0.66	1.52	0.476	25.00	0.69	0.77	0.202
7.20	0.66	1.43	0.452	25.50	0.67	0.74	0.195
7.40	0.66	1.35	0.423	26.00	0.66	0.70	0.188
7.60	0.67	1.27	0.394	26.50	0.65	0.66	0.176

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Rhodium[9] — *continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
27.00	0.65	0.64	0.168	33.00	0.60	0.37	0.110
27.50	0.65	0.61	0.159	34.00	0.65	0.30	0.074
28.00	0.65	0.59	0.152	35.00	0.69	0.28	0.058
29.00	0.65	0.54	0.137	36.00	0.73	0.27	0.049
30.00	0.66	0.51	0.127	37.00	0.74	0.28	0.047
31.00	0.64	0.49	0.127	38.00	0.74	0.27	0.045
32.00	0.61	0.44	0.126	39.00	0.75	0.25	0.041

Silicon (single crystal)[17]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.01240	0.65	2.90E-04	0.300	0.2170		4.05E-07	
0.01488	3.4190	2.30E-04	0.300	0.2232		3.94E-07	
0.01736	3.4192	1.90E-04	0.300	0.2294		3.26E-07	
0.01984	3.4195	1.70E-04	0.300	0.2356		2.97E-07	
0.02480	3.4197		0.300	0.2418		2.82E-07	
0.03100	3.4199		0.300	0.2480	3.4261	1.99E-07	0.300
0.04092	3.4200		0.300	0.3100	3.4294		0.301
0.04463		1.08E-04		0.3626	3.4327		0.301
0.04959	3.4201	9.15E-05	0.300	0.4568	3.4393	2.50E-09	0.302
0.05703		1.56E-04		0.6199	3.4490		0.303
0.06199	3.4204	2.86E-04	0.300	0.8093	3.4784		0.306
0.06943		3.84E-04		1.033	3.5193		0.311
0.07439		7.16E-04		1.1	(3.5341)	1.30E-05	0.312
0.08059	(3.4207)	1.52E-04	0.300	1.2		1.80E-04	
0.08679		1.02E-04		1.3		2.26E-03	
0.09299		2.59E-04		1.4		7.75E-03	
0.09919		1.77E-04		1.5	3.673	5.00E-03	0.327
0.1054		1.53E-04		1.6	3.714	8.00E-03	0.331
0.1116		2.02E-04		1.7	3.752	1.00E-02	0.335
0.1178		1.22E-04		1.8	3.796	0.013	0.340
0.1240	3.4215	6.76E-05	0.300	1.9	3.847	0.016	0.345
0.1364		5.49E-05		2.0	3.906	0.022	0.351
0.1488		2.41E-05		2.1	3.969	0.030	0.357
0.1612		2.49E-05		2.2	4.042	0.032	0.364
0.1736	(3.4230)	1.68E-05	0.300	2.3	4.123	0.048	0.372
0.1798		2.45E-05		2.4	4.215	0.060	0.380
0.1860		2.66E-06		2.5	4.320	0.073	0.390
0.1922		1.74E-06		2.6	4.442	0.090	0.400
0.1984		8.46E-07		2.7	4.583	0.130	0.412
0.2046		5.64E-07		2.8	4.753	0.163	0.426
0.2108	(3.4244)	4.17E-07	0.300	2.9	4.961	0.203	0.442

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Silicon (single crystal)[17]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
3.0	5.222	0.269	0.461	5.7	1.180	3.112	0.673
3.1	5.570	0.387	0.486	5.8	1.133	3.045	0.672
3.2	6.062	0.630	0.518	5.9	1.083	2.982	0.673
3.3	6.709	1.321	0.561	6.0	1.010	2.909	0.677
3.4	6.522	2.705	0.592	6.5	0.847	2.73	0.688
3.5	5.610	3.014	0.575	7.0	0.682	2.45	0.691
3.6	5.296	2.987	0.564	7.5	0.563	2.21	0.693
3.7	5.156	3.058	0.563	8.0	0.478	2.00	0.691
3.8	5.065	3.182	0.568	8.5	0.414	1.82	0.688
3.9	5.016	3.346	0.577	9.0	0.367	1.66	0.683
4.0	5.010	3.587	0.591	9.5	0.332	1.51	0.672
4.1	5.020	3.979	0.614	10.0	0.306	1.38	0.661
4.2	4.888	4.639	0.652	12.0	0.257	0.963	0.590
4.3	4.086	5.395	0.703	14.0	0.275	0.641	0.460
4.4	3.120	5.344	0.726	16.0	0.345	0.394	0.297
4.5	2.451	5.082	0.740	18.0	0.455	0.219	0.159
4.6	1.988	4.678	0.742	20.0	0.567	0.0835	0.079
4.7	1.764	4.278	0.728	22.14	0.675	0.0405	0.038
4.8	1.658	3.979	0.710	24.31	0.752	0.0243	0.020
4.9	1.597	3.749	0.693	26.38	0.803	0.0178	0.012
5.0	1.570	3.565	0.675	28.18	0.834	0.0152	0.008
5.1	1.571	3.429	0.658	30.24	0.860	0.0138	0.006
5.2	1.589	3.354	0.646	31.79	0.877	0.0132	0.004
5.3	1.579	3.353	0.647	34.44	0.899	0.0121	0.003
5.4	1.471	3.366	0.663	36.47	0.913	0.0113	0.002
5.5	1.340	3.302	0.673	38.75	0.925	0.0104	0.002
5.6	1.247	3.206	0.675	40.00	0.930	0.0100	0.001

Silver[6]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	9.91	90.27	0.995	3.60	0.23	1.13	0.671
0.20	2.84	45.70	0.995	3.70	0.30	0.77	0.475
0.30	1.41	30.51	0.994	3.77	0.53	0.40	0.154
0.40	0.91	22.89	0.993	3.80	0.73	0.30	0.053
0.50	0.67	18.32	0.992	3.90	1.30	0.36	0.040
1.00	0.28	9.03	0.987	4.00	1.61	0.60	0.103
1.50	0.27	5.79	0.969	4.10	1.73	0.85	0.153
2.00	0.27	4.18	0.944	4.20	1.75	1.06	0.194
2.50	0.24	3.09	0.914	4.30	1.73	1.13	0.208
3.00	0.23	2.27	0.864	4.50	1.69	1.28	0.238
3.25	0.23	1.86	0.816	4.75	1.61	1.34	0.252
3.50	0.21	1.42	0.756	5.00	1.55	1.36	0.257

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Silver[6]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
5.50	1.45	1.34	0.257	29.00	0.92	0.56	0.079
6.00	1.34	1.28	0.246	30.00	0.93	0.54	0.074
6.50	1.25	1.18	0.225	31.00	0.93	0.53	0.072
7.00	1.18	1.06	0.196	32.00	0.92	0.53	0.072
7.50	1.14	0.91	0.157	33.00	0.90	0.51	0.071
8.00	1.16	0.75	0.114	34.00	0.88	0.49	0.067
9.00	1.33	0.56	0.074	35.00	0.86	0.45	0.061
10.00	1.46	0.56	0.082	36.00	0.89	0.44	0.055
11.00	1.52	0.56	0.088	38.00	0.89	0.39	0.043
12.00	1.61	0.59	0.100	40.00	0.90	0.37	0.039
13.00	1.66	0.64	0.112	42.00	0.90	0.35	0.036
14.00	1.72	0.78	0.141	44.00	0.90	0.33	0.033
14.50	1.64	0.88	0.152	46.00	0.90	0.32	0.031
15.00	1.56	0.92	0.156	48.00	0.89	0.31	0.030
16.00	1.42	0.91	0.151	50.00	0.88	0.29	0.027
17.00	1.33	0.86	0.139	52.00	0.89	0.28	0.024
18.00	1.28	0.80	0.124	54.00	0.88	0.17	0.024
19.00	1.27	0.75	0.111	56.00	0.87	0.26	0.024
20.00	1.29	0.71	0.103	58.00	0.87	0.24	0.021
21.00	1.35	0.75	0.112	60.00	0.87	0.22	0.018
21.50	1.37	0.80	0.124	62.00	0.88	0.21	0.016
22.00	1.34	0.87	0.141	64.00	0.88	0.21	0.016
22.50	1.26	0.93	0.157	66.00	0.88	0.21	0.016
23.00	1.17	0.94	0.163	68.00	0.87	0.21	0.017
23.50	1.10	0.93	0.165	70.00	0.83	0.20	0.021
24.00	1.04	0.90	0.165	72.00	0.85	0.18	0.016
24.50	0.99	0.87	0.160	74.00	0.85	0.17	0.014
25.00	0.95	0.83	0.154	76.00	0.85	0.16	0.013
25.50	0.91	0.78	0.144	78.00	0.85	0.15	0.013
26.00	0.90	0.74	0.133	80.00	0.85	0.14	0.012
26.50	0.89	0.69	0.121	85.00	0.85	0.11	0.011
27.00	0.89	0.65	0.109	90.00	0.85	0.08	0.009
27.50	0.89	0.62	0.099	95.00	0.86	0.06	0.007
28.00	0.90	0.59	0.090	100.00	0.87	0.04	0.005

Tantalum[12]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	10.14	66.39	0.9380	0.50	1.37	14.26	0.974
0.15	9.45	46.41	0.983	0.58	1.15	12.19	0.970
0.20	5.77	35.46	0.982	0.70	0.96	9.92	0.962
0.26	3.67	27.53	0.981	0.78	0.89	8.77	0.956
0.30	2.87	23.90	0.980	0.90	0.84	7.38	0.942
0.38	2.03	18.87	0.978	1.00	0.89	6.47	0.996

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Tantalum[12] *–continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
1.10	0.93	5.75	0.899	8.60	1.14	1.45	0.317
1.20	0.98	5.14	0.872	8.80	1.17	1.41	0.301
1.30	1.00	4.62	0.842	9.00	1.19	1.40	0.294
1.40	1.04	4.15	0.805	9.20	1.21	1.38	0.289
1.50	1.09	3.73	0.762	9.40	1.21	1.38	0.287
1.60	1.15	3.33	0.707	9.60	1.21	1.38	0.285
1.70	1.24	2.95	0.640	9.80	1.21	1.37	0.285
1.80	1.35	2.60	0.560	10.00	1.20	1.37	0.286
1.90	1.57	2.24	0.460	10.20	1.19	1.37	0.286
2.00	1.83	1.99	0.388	10.40	1.18	1.37	0.287
2.10	2.10	1.84	0.354	10.60	1.16	1.36	0.288
2.20	2.36	1.81	0.351	10.80	1.15	1.36	0.289
2.30	2.56	1.86	0.365	11.00	1.13	1.35	0.290
2.40	2.68	1.92	0.378	11.20	1.11	1.35	0.292
2.50	2.75	1.98	0.388	11.40	1.09	1.34	0.293
2.60	2.80	2.02	0.395	11.60	1.07	1.33	0.294
2.70	2.84	2.08	0.405	11.80	1.05	1.32	0.295
2.80	2.85	2.14	0.412	12.00	1.02	1.31	0.296
2.90	2.84	2.20	0.420	12.20	1.00	1.29	0.295
3.00	2.81	2.24	0.425	12.40	0.98	1.28	0.294
3.20	2.73	2.31	0.432	12.60	0.96	1.26	0.292
3.40	2.61	2.33	0.435	12.80	0.94	1.24	0.289
3.60	2.49	2.30	0.430	13.00	0.93	1.22	0.286
3.80	2.40	2.22	0.418	13.60	0.91	1.16	0.272
4.00	2.36	2.14	0.406	14.00	0.90	1.15	0.272
4.20	2.35	2.06	0.392	14.60	0.85	1.15	0.285
4.40	2.39	2.01	0.384	15.00	0.80	1.13	0.293
4.60	2.45	2.00	0.384	15.60	0.72	1.08	0.301
4.80	2.53	2.06	0.394	16.00	0.68	1.04	0.304
5.00	2.58	2.20	0.416	16.60	0.63	0.97	0.301
5.20	2.52	2.44	0.450	17.00	0.60	0.92	0.296
5.40	2.31	2.61	0.480	17.60	0.60	0.92	0.296
5.60	2.06	2.67	0.501	18.00	0.55	0.79	0.274
5.80	1.83	2.63	0.510	18.60	0.53	0.71	0.254
6.00	1.63	2.56	0.515	19.00	0.53	0.65	0.236
6.20	1.48	2.45	0.512	19.60	0.53	0.57	0.207
6.40	1.37	2.33	0.504	20.00	0.54	0.52	0.185
6.60	1.29	2.22	0.492	20.60	0.55	0.44	0.152
6.80	1.23	2.11	0.478	21.00	0.57	0.39	0.127
7.00	1.18	2.01	0.462	21.60	0.64	0.34	0.089
7.20	1.15	1.91	0.445	22.00	0.64	0.32	0.081
7.40	1.13	1.82	0.425	22.60	0.69	0.27	0.058
7.60	1.12	1.75	0.406	23.00	0.73	0.24	0.043
7.80	1.11	1.68	0.390	23.60	0.80	0.26	0.033
8.00	1.11	1.61	0.370	24.00	0.80	0.26	0.034
8.20	1.12	1.55	0.350	24.60	0.82	0.25	0.029
8.40	1.13	1.50	0.332	25.00	0.83	0.25	0. 026

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Tantalum[12] *–continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
25.60	0.86	0.24	0.022	31.00	0.97	0.23	0.014
26.00	0.88	0.25	0.022	32.00	0.98	0.24	0.015
26.60	0.87	0.26	0.023	33.00	0.98	0.25	0.015
27.00	0.87	0.25	0.022	34.00	0.99	0.25	0.016
27.60	0.89	0.23	0.019	35.00	0.99	0.26	0.017
28.00	0.90	0.23	0.017	36.00	0.99	0.27	0.018
28.60	0.91	0.22	0.015	37.00	0.99	0.28	0.019
29.00	0.92	0.22	0.014	38.00	0.98	0.28	0.021
29.60	0.94	0.22	0.014	39.00	0.97	0.29	0.022
30.00	0.95	0.22	0.014	40.00	0.95	0.29	0.023

Titanium (polycrystalline)[18]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	5.03	23.38	0.965	2.30	1.86	2.56	0.495
0.15	3.00	15.72	0.954	2.40	1.81	2.47	0.483
0.20	2.12	11.34	0.939	2.50	1.78	2.39	0.471
0.25	2.05	8.10	0.890	2.60	1.75	2.34	0.462
0.30	6.39	9.94	0.833	2.70	1.71	2.29	0.456
0.35	2.74	6.21	0.792	2.80	1.68	2.25	0.451
0.40	2.49	4.68	0.708	2.90	1.63	2.21	0.447
0.45	3.35	3.25	0.545	3.00	1.59	2.17	0.444
0.50	4.43	3.22	0.555	3.10	1.55	2.15	0.442
0.60	4.71	3.77	0.597	3.20	1.50	2.12	0.442
0.70	4.38	3.89	0.603	3.30	1.44	2.09	0.442
0.80	4.04	3.82	0.596	3.40	1.37	2.06	0.443
0.90	3.80	3.65	0.582	3.50	1.30	2.01	0.443
1.00	3.62	3.52	0.570	3.60	1.24	1.96	0.441
1.10	3.47	3.40	0.560	3.70	1.17	1.90	0.436
1.20	3.35	3.30	0.550	3.80	1.11	1.83	0.430
1.30	3.28	3.25	0.546	3.85	1.08	1.78	0.423
1.40	3.17	3.28	0.549	3.90	1.06	1.73	0.413
1.50	2.98	3.32	0.557	4.00	1.04	1.62	0.389
1.60	2.74	3.30	0.559	4.20	1.05	1.45	0.333
1.70	2.54	3.23	0.557	4.40	1.13	1.33	0.284
1.80	2.36	3.11	0.550	4.60	1.17	1.29	0.265
1.90	2.22	2.99	0.540	4.80	1.21	1.23	0.244
2.00	2.11	2.88	0.530	5.00	1.24	1.21	0.236
2.10	2.01	2.77	0.520	5.20	1.27	1.20	0.228
2.20	1.92	2.67	0.509	5.40	1.17	1.16	0.228

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Titanium (polycrystalline)[18] *–continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
5.60	1.24	1.21	0.234	14.40	0.77	0.42	0.069
5.80	1.21	1.22	0.241	14.80	0.79	0.38	0.058
6.00	1.15	1.21	0.244	15.20	0.79	0.36	0.052
6.20	1.11	1.18	0.240	15.60	0.79	0.32	0.045
6.40	1.08	1.14	0.232	16.00	0.83	0.31	0.037
6.60	1.04	1.06	0.212	16.40	0.84	0.28	0.030
6.80	1.05	1.02	0.198	16.80	0.87	0.27	0.025
7.00	1.06	0.97	0.182	17.20	0.90	0.25	0.020
7.20	1.07	0.95	0.175	17.60	0.93	0.25	0.017
7.40	1.11	0.94	0.167	18.00	0.94	0.24	0.165
7.60	1.09	0.92	0.165	18.40	0.94	0.23	0.017
7.80	1.11	0.93	0.165	18.80	0.95	0.24	0.016
8.00	1.10	0.94	0.169	19.20	0.96	0.25	0.016
8.20	1.10	0.95	0.171	19.60	0.97	0.25	0.017
8.40	1.08	0.95	0.175	20.00	0.98	0.27	0.018
8.60	1.04	0.96	0.181	20.40	0.98	0.27	0.019
8.80	1.02	0.95	0.181	20.60	1.00	0.29	0.020
9.00	1.00	0.94	0.182	21.20	0.99	0.31	0.023
9.20	0.97	0.93	0.182	21.60	0.99	0.31	0.024
9.40	0.95	0.91	0.181	22.00	0.98	0.32	0.025
9.60	0.94	0.90	0.179	22.40	0.98	0.33	0.027
9.80	0.91	0.88	0.179	22.80	0.97	0.33	0.028
10.00	0.89	0.88	0.180	23.20	0.96	0.34	0.030
10.20	0.86	0.85	0.178	23.60	0.95	0.35	0.031
10.40	0.85	0.83	0.175	24.00	0.92	0.35	0.033
10.60	0.81	0.79	0.167	24.5	0.91	0.34	0.032
10.80	0.80	0.76	0.162	25.0	0.91	0.33	0.032
11.00	0.79	0.72	0.152	25.5	0.89	0.33	0.032
11.20	0.81	0.69	0.139	26.0	0.89	0.33	0.032
11.40	0.81	0.69	0.139	26.5	0.88	0.32	0.032
11.60	0.79	0.68	0.139	27.0	0.86	0.31	0.032
11.80	0.78	0.67	0.137	27.5	0.85	0.30	0.033
12.00	0.77	0.65	0.132	28.0	0.84	0.29	0.033
12.80	0.76	0.55	0.106	28.5	0.82	0.26	0.029
13.20	0.76	0.52	0.097	29.0	0.83	0.25	0.027
13.60	0.76	0.48	0.087	30.0	0.84	0.22	0.022
14.00	0.77	0.45	0.077				

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Tungsten[19]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	14.06	54.71	0.983	3.40	3.39	2.66	0.485
0.20	3.87	28.30	0.981	3.50	3.24	2.70	0.488
0.25	2.56	22.44	0.980	3.60	3.13	2.67	0.482
0.30	1.83	18.32	0.979	3.70	3.05	2.62	0.476
0.34	1.71	15.71	0.973	3.80	2.99	2.56	0.468
0.38	1.86	13.88	0.963	3.90	2.96	2.50	0.460
0.42	1.92	12.63	0.954	4.00	2.95	2.43	0.451
0.46	1.69	11.59	0.952	4.20	3.02	2.33	0.440
0.50	1.40	10.52	0.952	4.40	3.13	2.32	0.442
0.54	1.23	9.45	0.948	4.60	3.24	2.41	0.455
0.58	1.17	8.44	0.938	4.80	3.33	2.57	0.475
0.62	1.28	7.52	0.917	5.00	3.40	2.85	0.505
0.66	1.45	6.78	0.888	5.20	3.27	3.27	0.548
0.70	1.59	6.13	0.856	5.40	2.92	3.58	0.586
0.74	1.83	5.52	0.810	5.60	2.43	3.70	0.618
0.78	2.12	5.00	0.759	5.80	2.00	3.61	0.637
0.82	2.36	4.61	0.710	6.00	1.70	3.42	0.643
0.86	2.92	4.37	0.661	6.20	1.47	3.24	0.646
0.90	3.11	4.44	0.660	6.40	1.32	3.04	0.640
0.94	3.15	4.43	0.658	6.60	1.21	2.87	0.631
0.98	3.15	4.36	0.653	6.80	1.12	2.70	0.619
1.00	3.14	4.32	0.649	7.00	1.06	2.56	0.607
1.10	3.05	4.04	0.627	7.20	1.01	2.43	0.593
1.20	3.00	3.64	0.590	7.40	0.98	2.30	0.573
1.30	3.12	3.24	0.545	7.60	0.95	2.18	0.556
1.40	3.29	2.96	0.515	7.80	0.93	2.06	0.533
1.50	3.48	2.79	0.500	8.00	0.94	1.95	0.505
1.60	3.67	2.68	0.494	8.20	0.94	1.86	0.481
1.70	3.84	2.79	0.507	8.40	0.96	1.76	0.449
1.80	3.82	2.91	0.518	8.60	0.99	1.70	0.422
1.90	3.70	2.94	0.518	8.80	1.01	1.65	0.401
2.00	3.60	2.89	0.512	9.00	1.01	1.60	0.388
2.10	3.54	2.84	0.506	9.20	1.02	1.55	0.369
2.20	3.49	2.76	0.497	9.40	1.03	1.50	0.352
2.30	3.49	2.72	0.494	9.60	1.05	1.44	0.329
2.40	3.45	2.72	0.493	9.80	1.09	1.38	0.307
2.50	3.38	2.68	0.487	10.00	1.13	1.34	0.287
2.60	3.34	2.62	0.480	10.20	1.19	1.33	0.274
2.70	3.31	2.55	0.472	10.40	1.24	1.34	0.270
2.80	3.31	2.49	0.466	10.60	1.27	1.36	0.274
2.90	3.32	2.45	0.461	10.80	1.29	1.39	0.282
3.00	3.35	2.42	0.459	11.00	1.28	1.42	0.290
3.10	3.39	2.41	0.460	11.20	1.27	1.44	0.297
3.20	3.43	2.45	0.465	11.40	1.25	1.46	0.305
3.30	3.45	2.55	0.476	11.60	1.22	1.48	0.313

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Tungsten[19] *—continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
11.80	1.20	1.48	0.318	22.80	0.49	0.69	0.272
12.00	1.16	1.48	0.323	23.20	0.49	0.66	0.263
12.40	1.10	1.47	0.329	23.60	0.48	0.62	0.252
12.80	1.04	1.44	0.333	24.00	0.49	0.57	0.234
13.20	0.98	1.40	0.332	24.40	0.50	0.53	0.213
13.60	0.94	1.35	0.325	24.80	0.51	0.49	0.191
14.00	0.91	1.28	0.312	25.20	0.53	0.46	0.171
14.40	0.90	1.23	0.296	25.60	0.55	0.43	0.150
14.80	0.90	1.17	0.276	26.00	0.57	0.40	0.132
15.20	0.93	1.13	0.255	26.40	0.59	0.38	0.117
15.60	0.97	1.12	0.246	26.80	0.61	0.37	0.105
16.00	0.98	1.14	0.249	27.00	0.62	0.36	0.099
16.40	0.97	1.17	0.260	27.50	0.64	0.34	0.085
16.80	0.94	1.19	0.273	28.00	0.67	0.32	0.073
17.20	0.90	1.21	0.289	28.50	0.69	0.31	0.065
17.60	0.85	1.21	0.304	29.00	0.71	0.30	0.057
18.00	0.80	1.20	0.317	29.50	0.73	0.30	0.052
18.40	0.74	1.18	0.330	30.00	0.75	0.29	0.047
18.80	0.69	1.15	0.340	31.00	0.78	0.29	0.042
19.20	0.64	1.11	0.347	32.00	0.79	0.29	0.040
19.60	0.60	1.07	0.353	33.00	0.82	0.28	0.033
20.00	0.56	1.02	0.354	34.00	0.84	0.29	0.032
20.40	0.54	0.97	0.350	35.00	0.85	0.31	0.033
20.80	0.52	0.92	0.342	36.00	0.85	0.32	0.036
21.20	0.50	0.87	0.331	37.00	0.84	0.33	0.039
21.60	0.50	0.82	0.318	38.00	0.83	0.33	0.040
22.00	0.49	0.77	0.303	39.00	0.81	0.33	0.042
22.40	0.49	0.73	0.287	40.00	0.80	0.33	0.045

Zinc, E || c[20]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.7514	1.9241	7.5619	0.883	1.377	2.9459	3.5761	0.584
0.827	1.7921	6.9973	0.874	1.459	3.2523	4.2447	0.640
0.866	1.5571	6.7753	0.881	1.550	3.8086	4.6212	0.657
0.952	1.4824	6.2296	0.868	1.653	3.7577	4.6239	0.659
0.992	1.5762	5.8843	0.847	1.722	3.5908	4.4614	0.650
1.033	1.5407	5.3192	0.823	1.823	3.4234	4.3232	0.642
1.078	1.5853	4.9013	0.793	1.937	3.0132	3.9974	0.624
1.127	1.7768	4.5307	0.748	1.984	1.8562	3.9706	0.690
1.181	1.9808	4.2004	0.701	2.066	1.4856	4.0555	0.737
1.240	2.8821	3.4766	0.575	2.094	1.2525	3.9961	0.762
1.305	3.2039	3.0042	0.520	2.119	1.0017	3.8683	0.789

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Zinc, E || c[20]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
2.275	0.7737	3.9129	0.832	3.220	0.3069	2.5088	0.847
2.445	0.6395	3.4013	0.821	3.594	0.2737	2.1737	0.828
2.666	0.4430	3.1379	0.851	4.065	0.2510	1.8528	0.799
2.917	0.3589	2.8140	0.853	4.678	0.2354	1.6357	0.776

Zinc, E ⊥ c[20]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.751	1.4469	7.4158	0.905	1.722	3.9369	4.6356	0.657
0.827	1.4744	6.9688	0.892	1.823	3.7549	4.3042	0.635
0.866	1.3628	6.6886	0.892	1.937	3.4512	4.1942	0.631
0.952	1.3165	6.2212	0.881	1.984	3.2515	4.2980	0.644
0.992	1.3835	5.8910	0.863	2.066	2.0802	4.7231	0.738
1.033	1.2889	5.4001	0.850	2.094	1.7084	4.7923	0.774
1.078	1.3095	4.9025	0.822	2.119	1.3329	4.4751	0.791
1.127	1.6897	4.4062	0.746	2.275	0.9725	4.2879	0.825
1.181	1.9701	4.0176	0.684	2.255	0.7568	3.7627	0.824
1.240	2.8717	3.2873	0.555	2.666	0.5470	3.4277	0.845
1.305	3.3991	2.7684	0.497	2.917	0.4774	3.0476	0.834
1.377	3.1807	3.4709	0.569	3.220	0.3911	2.7463	0.835
1.459	3.5064	4.1994	0.630	3.594	0.3147	2.3041	0.821
1.550	4.1241	4.7768	0.664	4.06	0.3013	2.0077	0.789
1.653	4.0269	4.8027	0.667	4.678	0.2806	1.7997	0.770

Zirconium (polycrystalline)[20]

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
0.10	6.18	1.76	0.300	0.50	4.13	1.44	0.175
0.15	3.37	1.30	0.123	0.56	5.01	1.58	0.231
0.20	2.34	1.08	0.058	0.60	5.18	1.61	0.242
0.26	2.24	1.06	0.052	0.70	4.54	1.51	0.202
0.30	2.59	1.14	0.073	0.80	4.03	1.42	0.168
0.36	3.17	1.26	0.110	0.90	3.74	1.37	0.149
0.40	3.09	1.24	0.105	0.96	3.69	1.36	0.145
0.46	3.36	1.30	0.123	1.00	3.66	1.35	0.143

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Zirconium (polycrystalline)[20] *—continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
1.10	3.65	1.35	0.142	8.00	1.66	0.91	0.026
1.20	3.53	1.33	0.134	8.20	0.67	0.91	0.026
1.30	3.25	1.27	0.116	8.40	1.68	0.92	0.026
1.40	3.10	1.25	0.106	8.60	1.68	0.92	0.026
1.50	3.02	1.23	0.100	8.80	1.66	0.91	0.026
1.60	2.88	1.20	0.091	9.00	1.65	0.91	0.025
1.70	2.68	1.16	0.078	9.20	1.63	0.90	0.025
1.80	2.49	1.12	0.067	9.40	1.60	0.89	0.024
2.00	2.14	1.03	0.047	9.60	1.57	0.89	0.023
2.10	1.99	1.00	0.040	9.80	1.52	0.87	0.021
2.20	1.87	0.97	0.034	10.00	1.47	0.86	0.020
2.30	1.78	0.94	0.030	10.20	1.42	0.84	0.018
2.40	1.71	0.92	0.027	10.40	1.35	0.82	0.016
2.50	1.62	0.90	0.024	10.50	1.32	0.81	0.016
2.60	1.54	0.88	0.022	10.60	1.28	0.80	0.015
2.70	1.46	0.86	0.019	10.80	1.23	0.78	0.014
2.80	1.40	0.84	0.018	11.00	1.19	0.77	0.014
2.90	1.34	0.82	0.016	11.20	1.16	0.76	0.013
3.00	0.30	0.81	0.016	11.40	1.13	0.75	0.013
3.10	1.26	0.80	0.015	11.60	1.11	0.74	0.013
3.30	1.19	0.77	0.014	11.80	1.09	0.74	0.013
3.40	1.16	0.76	0.013	12.00	1.08	0.73	0.013
3.50	1.13	0.75	0.013	12.40	1.05	0.72	0.012
3.60	1.10	0.74	0.013	12.80	1.01	0.71	0.012
3.70	1.07	0.73	0.013	13.20	0.98	0.70	0.012
3.80	1.04	0.72	0.012	13.60	0.95	0.69	0.013
3.90	1.01	0.71	0.012	14.00	0.92	0.68	0.013
4.00	0.98	0.70	0.012	14.40	0.89	0.67	0.013
4.20	0.94	0.68	0.013	14.80	0.90	0.67	0.013
4.40	0.89	0.67	0.013	15.20	0.92	0.68	0.013
4.60	0.85	0.65	0.014	15.60	0.95	0.69	0.013
4.80	0.81	0.64	0.014	16.00	0.98	0.70	0.012
5.00	0.78	0.63	0.015	16.40	1.01	0.71	0.012
5.20	0.77	0.62	0.016	16.80	1.04	0.72	0.012
5.40	0.77	0.62	0.016	16.40	1.01	0.71	0.012
5.60	0.80	0.63	0.014	16.80	1.04	0.72	0.012
5.80	0.87	0.66	0.013	17.20	1.09	0.74	0.013
6.00	1.00	0.71	0.012	17.60	1.13	0.75	0.013
6.20	1.11	0.75	0.013	18.00	1.17	0.76	0.014
6.40	1.23	0.78	0.014	18.40	1.21	0.78	0.014
6.60	1.33	0.81	0.016	18.80	1.24	0.79	0.014
6.80	1.42	0.84	0.018	19.20	1.27	0.80	0.015
7.00	1.49	0.86	0.020	19.60	1.29	0.80	0.015
7.20	1.54	0.88	0.022	20.00	1.30	0.81	0.015
7.40	1.58	0.89	0.023	20.60	1.29	0.80	0.015
7.60	1.61	0.90	0.024	21.00	1.27	0.80	0.015
7.80	1.63	0.90	0.025	21.60	1.23	0.78	0.014

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Zirconium (polycrystalline)[20]—*continued*

Energy eV	n	k	R(ϕ = 0)	Energy eV	n	k	R(ϕ = 0)
22.00	1.20	0.77	0.014	26.60	0.91	0.67	0.013
22.60	1.15	0.76	0.013	27.00	0.88	0.66	0.013
23.00	1.12	0.75	0.013	27.60	0.84	0.65	0.014
23.60	1.08	0.73	0.013	28.00	0.83	0.64	0.014
24.00	1.05	0.73	0.013	28.60	0.82	0.64	0.014
24.60	1.02	0.71	0.012	29.00	0.81	0.64	0.014
25.00	1.00	0.71	0.012	29.60	0.82	0.64	0.014
25.60	0.97	0.69	0.012	30.00	0.82	0.64	0.014
26.00	0.95	0.69	0.013				

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Spectra

Spectra of n and k and of the normal incidence absorptance A and reflectance R are shown graphically in Figures 4.2.1–4.2.24 for the following metals [figures are from Lynch, D. W., Mirror and reflector materials, *Handbook of Laser Science and Technology, Vol. IV, Optical Materials, Part 2* (CRC Press, Boca Raton, FL, 1986), p. 185].

Aluminum	Gold	Nickel	Silicon
Copper	Iron	Niobium	Silver
Germanium	Molybdenum	Platinum	Tungsten

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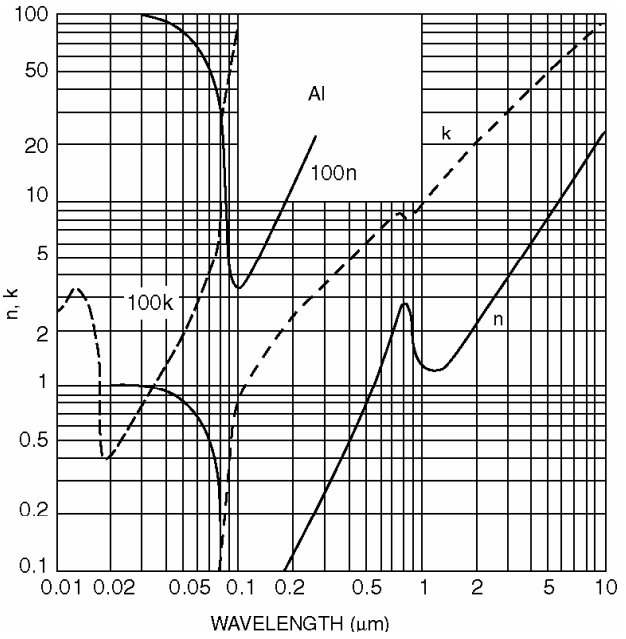

Figure 4.2.1 Real (n) and imaginary (k) part of the index of refraction for aluminum.

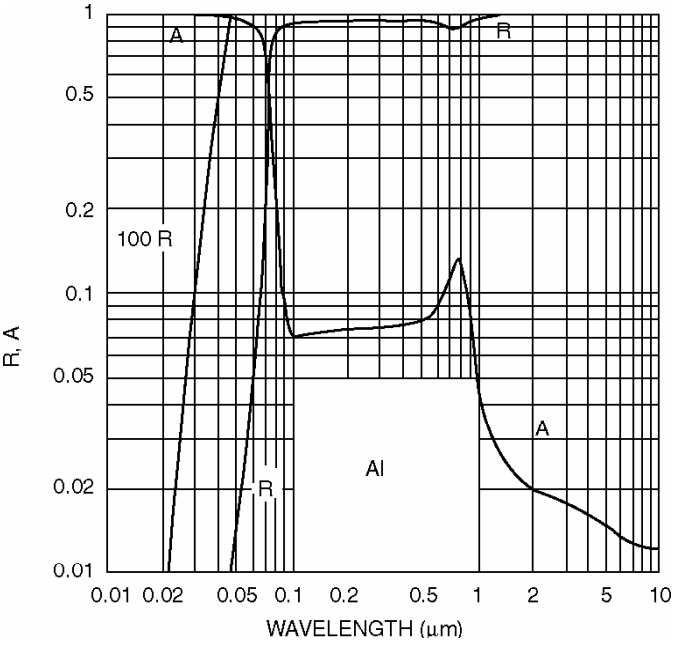

Figure 4.2.2 Reflectance and absorptance (A) for aluminum calculated for normal incidence from the data of Figure 4.2.1. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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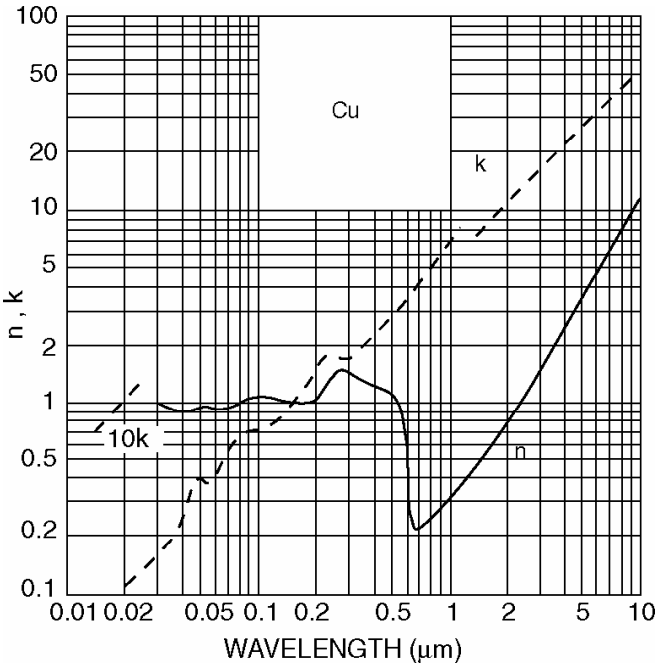

Figure 4.2.3 Real (n) and imaginary (k) part of the index of refraction for copper.

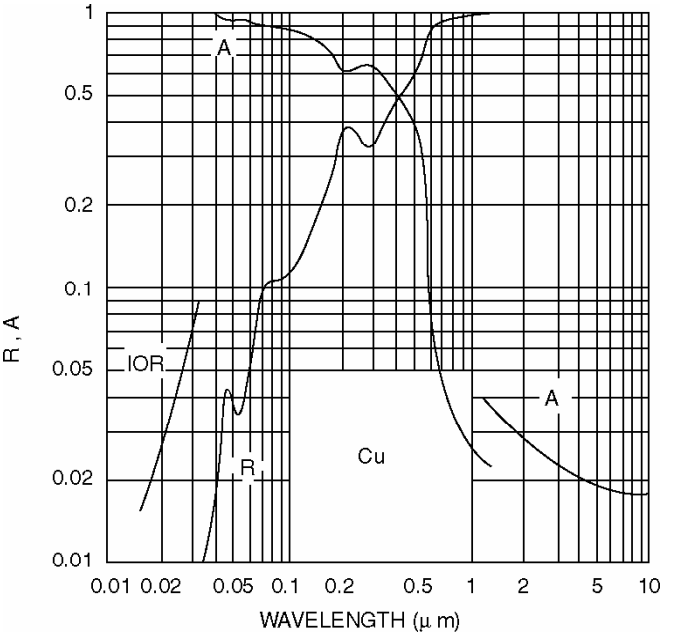

Figure 4.2.4 Reflectance and absorptance (A) for copper calculated for normal incidence from the data of Figure 4.2.3. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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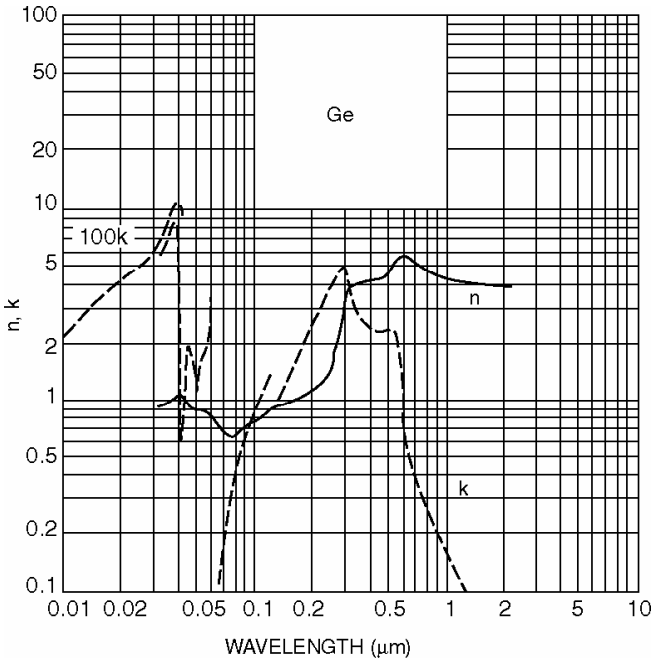

Figure 4.2.5 Real (n) and imaginary (k) part of the index of refraction for germanium.

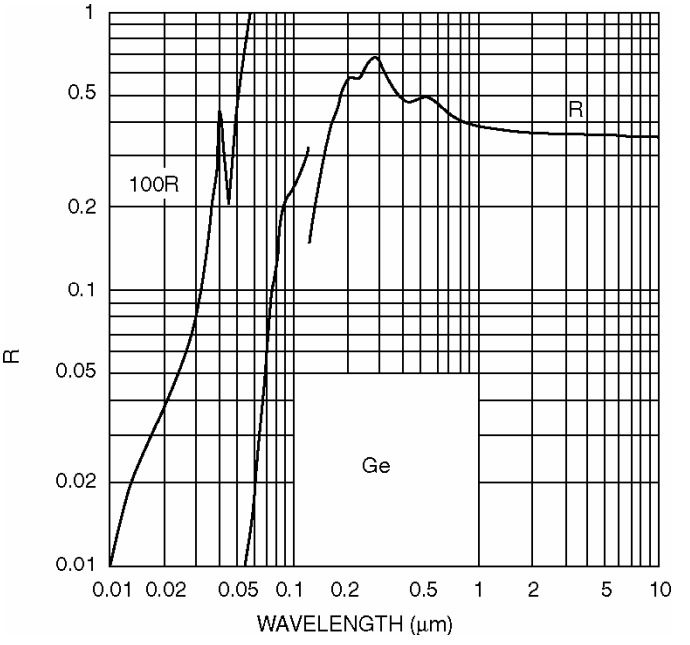

Figure 4.2.6 Reflectance (R) for germanium calculated for normal incidence from the data of Figure 4.2.4. Germanium is transparent for wavelengths >1.8 μm and no effect from a second surface has been considered in calculating R.

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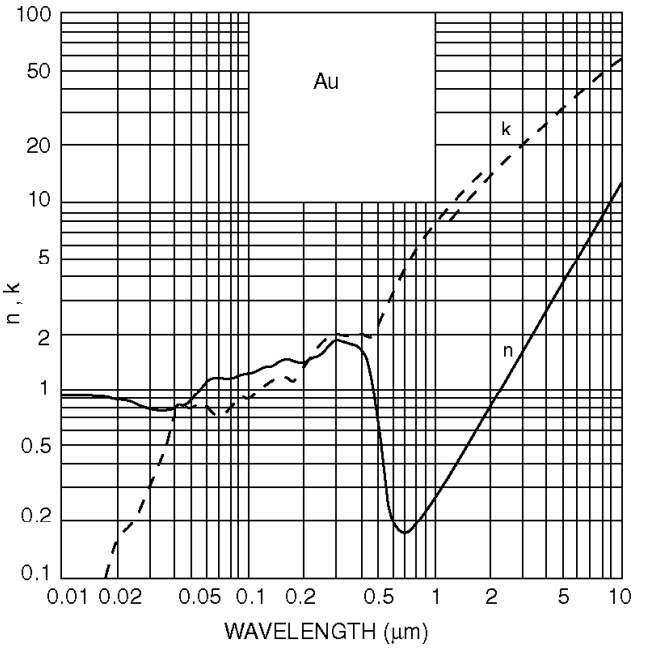

Figure 4.2.7 Real (n) and imaginary (k) part of the index of refraction for gold.

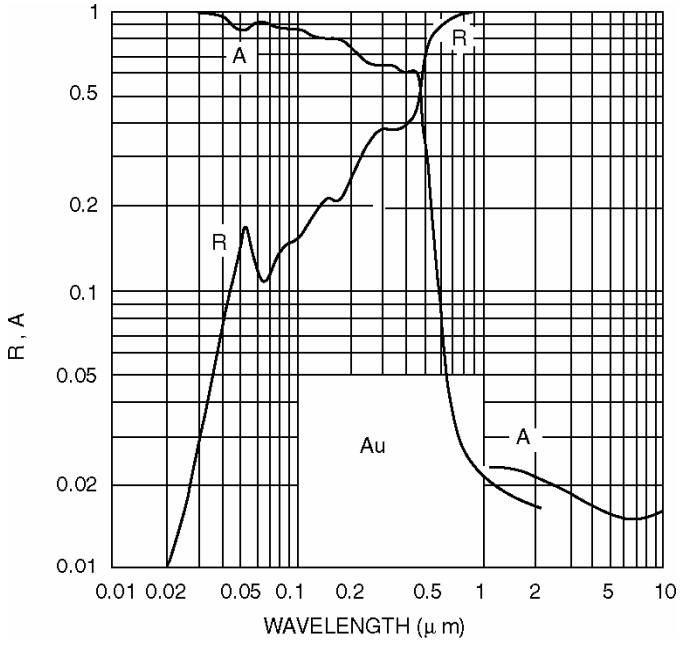

Figure 4.2.8 Reflectance and absorptance (A) for gold calculated for normal incidence from the data of Figure 4.2.7. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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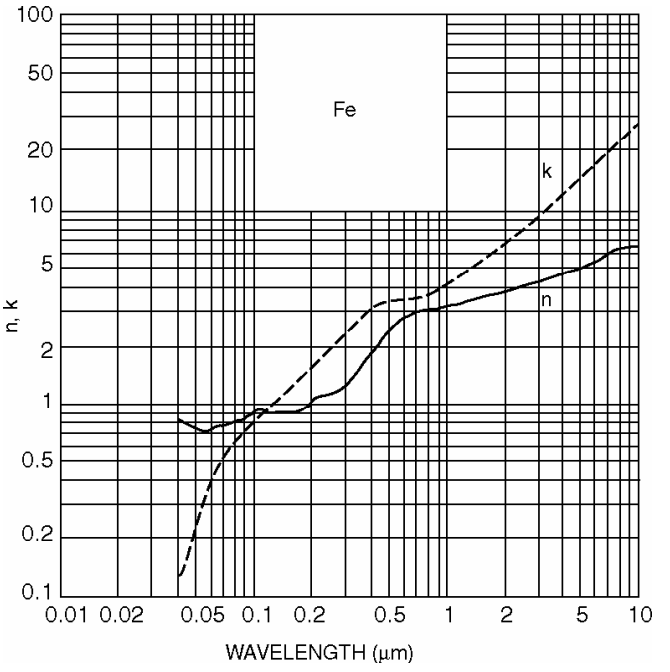

Figure 4.2.9 Real (n) and imaginary (k) part of the index of refraction for iron.

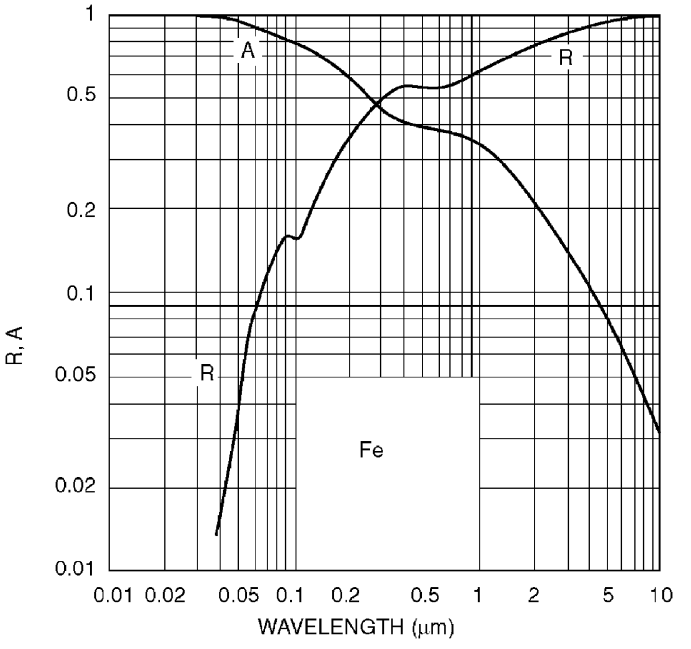

Figure 4.2.10 Reflectance and absorptance (A) for iron calculated for normal incidence from the data of Figure 4.2.9. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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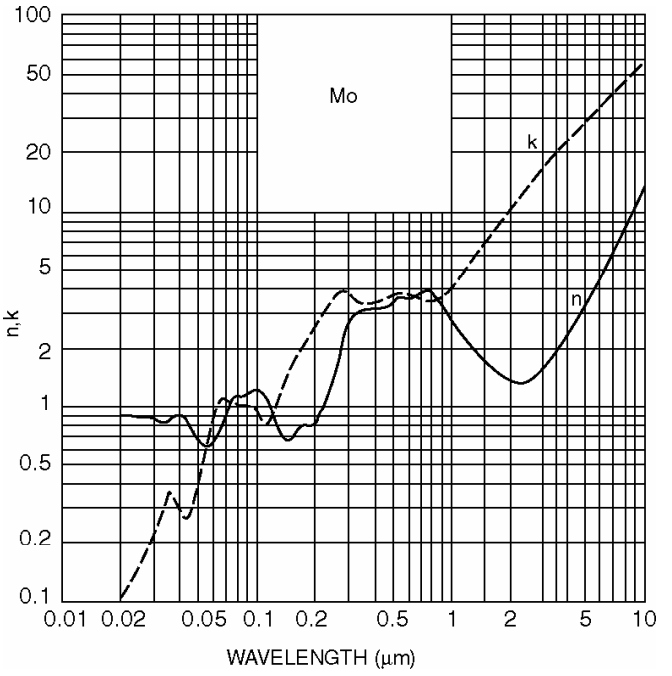

Figure 4.2.11 Real (n) and imaginary (k) part of the index of refraction for molybdenum.

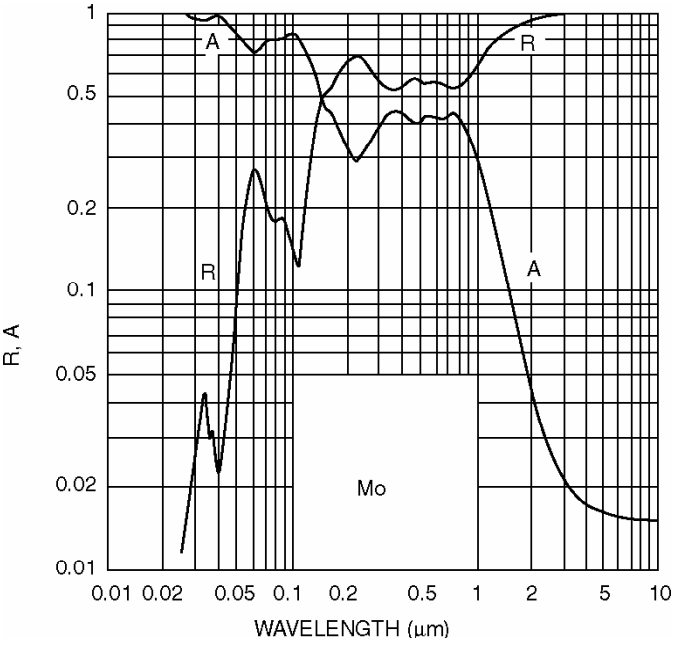

Figure 4.2.12 Reflectance and absorptance (A) for molybdenum calculated for normal incidence from the data of Figure 4.2.11. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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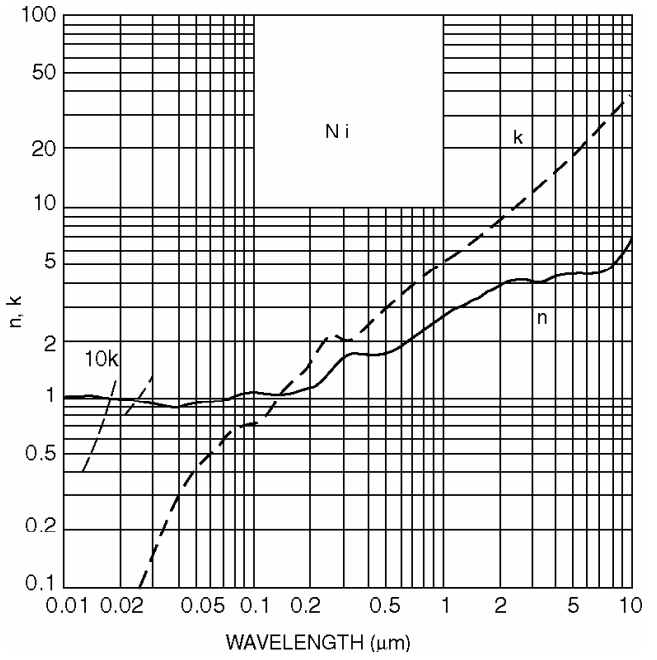

Figure 4.2.13 Real (n) and imaginary (k) part of the index of refraction for nickel.

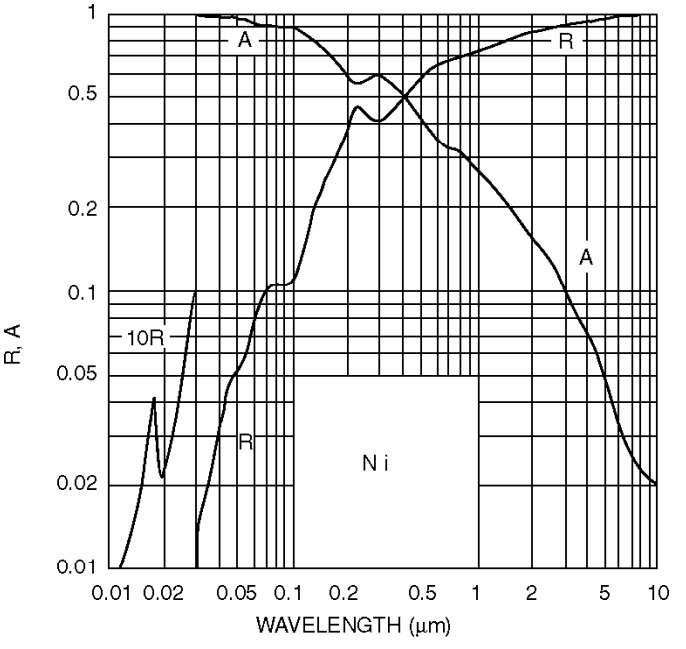

Figure 4.2.14 Reflectance and absorptance (A) for nickel calculated for normal incidence from the data of Figure 4.2.13. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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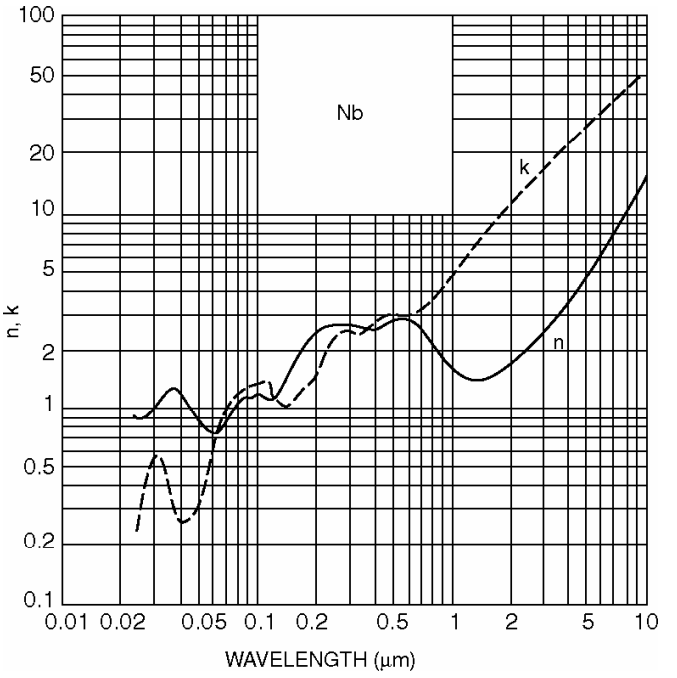

Figure 4.2.15 Real (n) and imaginary (k) part of the index of refraction for niobium.

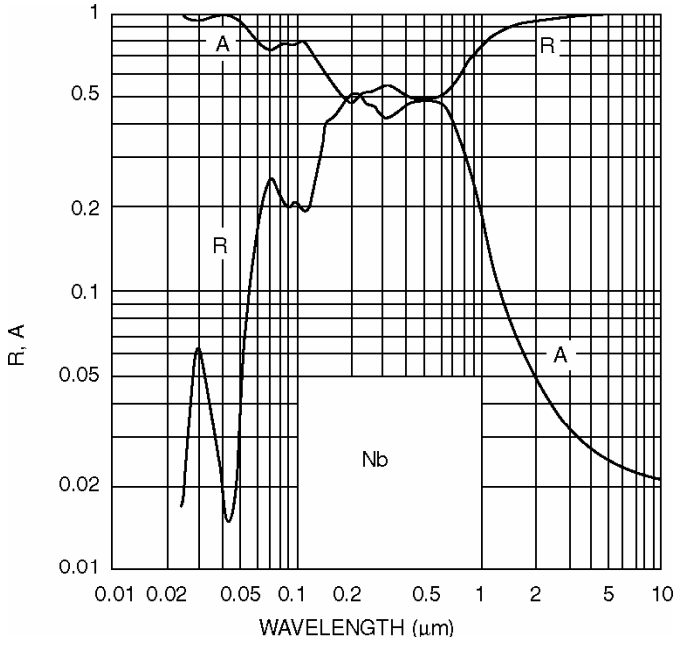

Figure 4.2.16 Reflectance and absorptance (A) for niobium calculated for normal incidence from the data of Figure 4.2.15. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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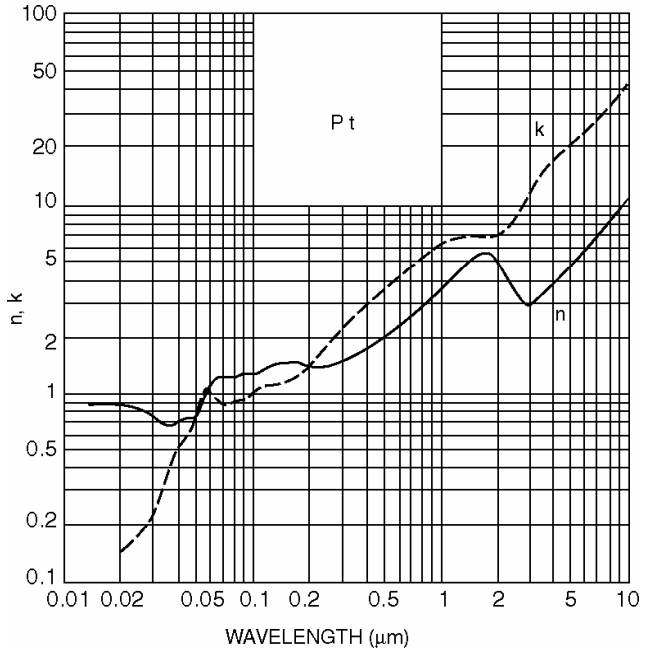

Figure 4.2.17 Real (n) and imaginary (k) part of the index of refraction for platinum.

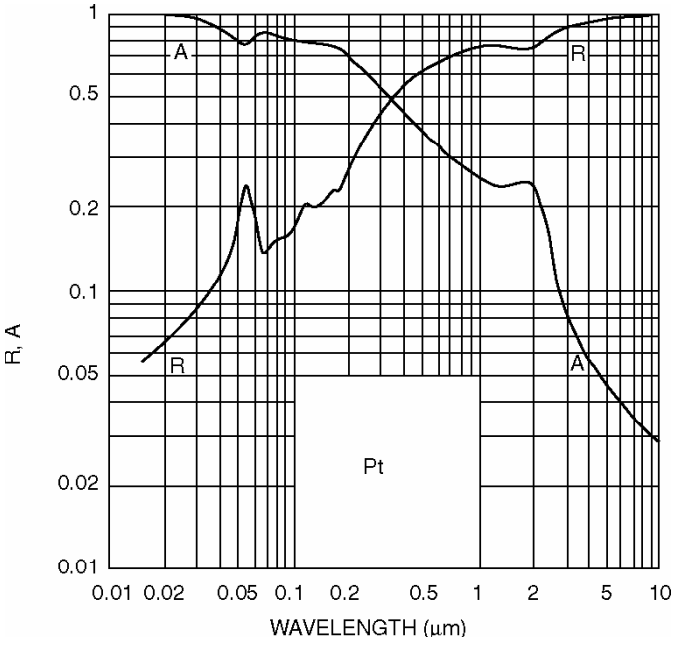

Figure 4.2.18 Reflectance and absorptance (A) for platimum calculated for normal incidence from the data of Figure 4.2.17. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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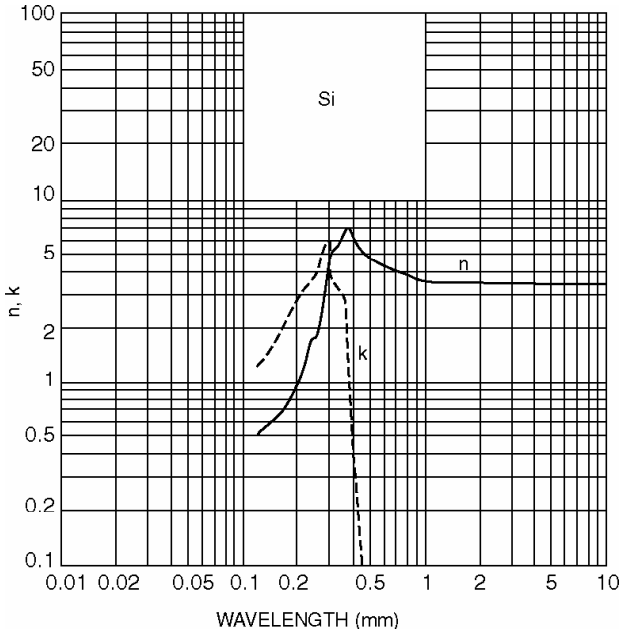

Figure 4.2.19 Real (n) and imaginary (k) part of the index of refraction for silicon.

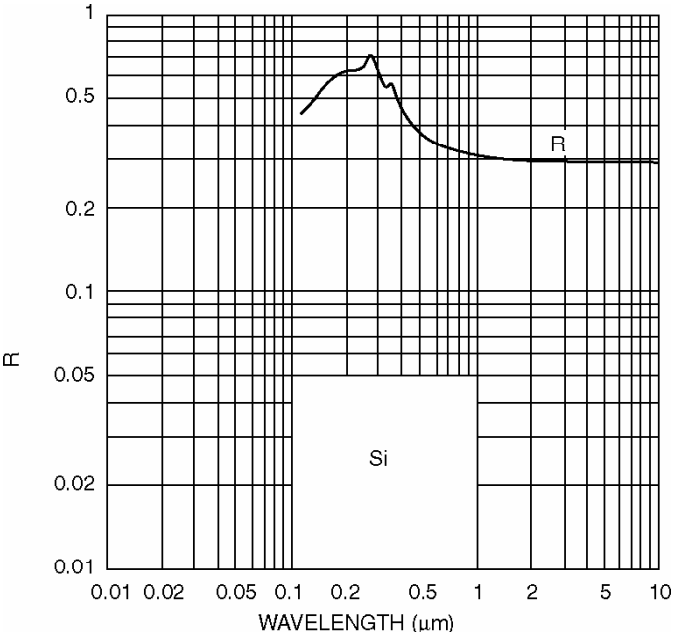

Figure 4.2.20 Reflectance and absorptance (A) for silicon calculated for normal incidence from the data of Figure 4.2.19. Silicon is transparent for wavelengths > 1.2 μm and no effect from a second surface has been considered in calculating R.

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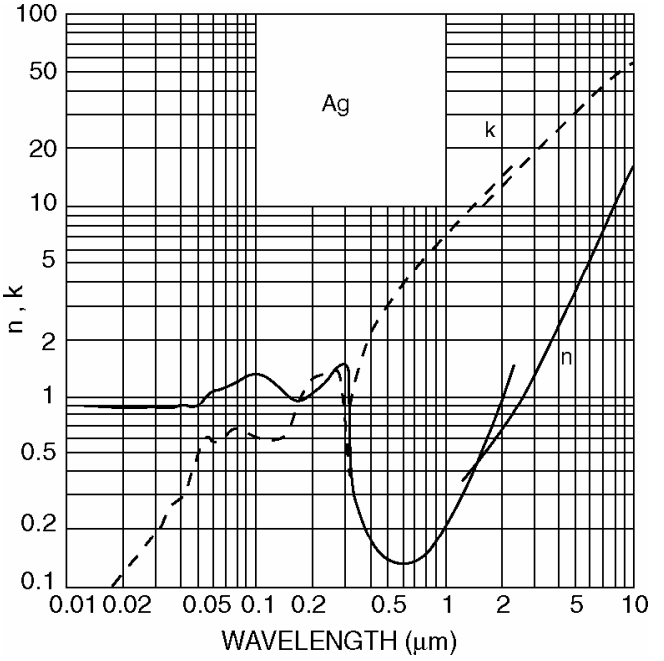

Figure 4.2.21 Real (n) and imaginary (k) part of the index of refraction for silver.

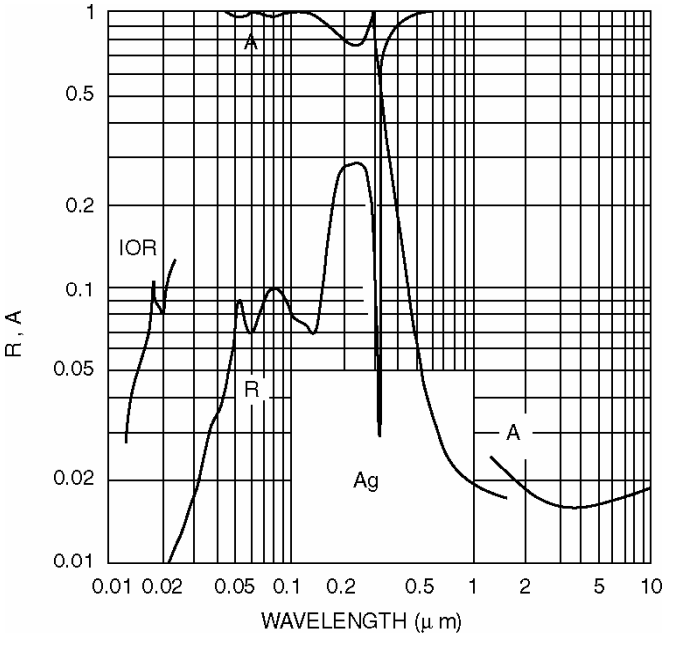

Figure 4.2.22 Reflectance and absorptance (A) for silver calculated for normal incidence from the data of Figure 4.2.21. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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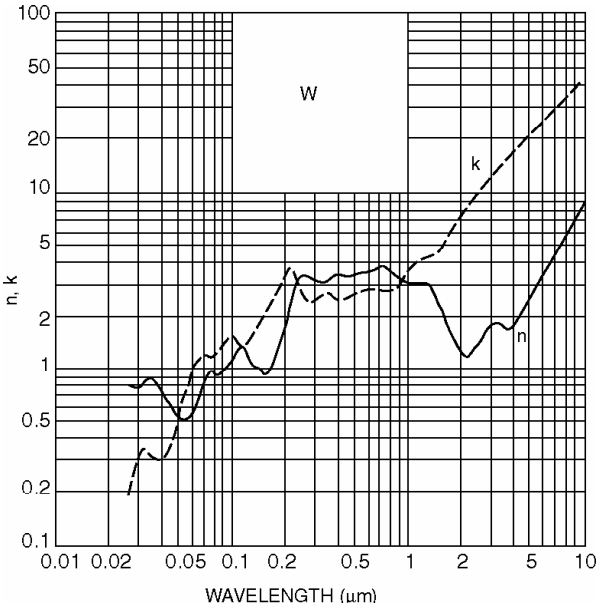

Figure 4.2.23 Real (n) and imaginary (k) part of the index of refraction for tungsten.

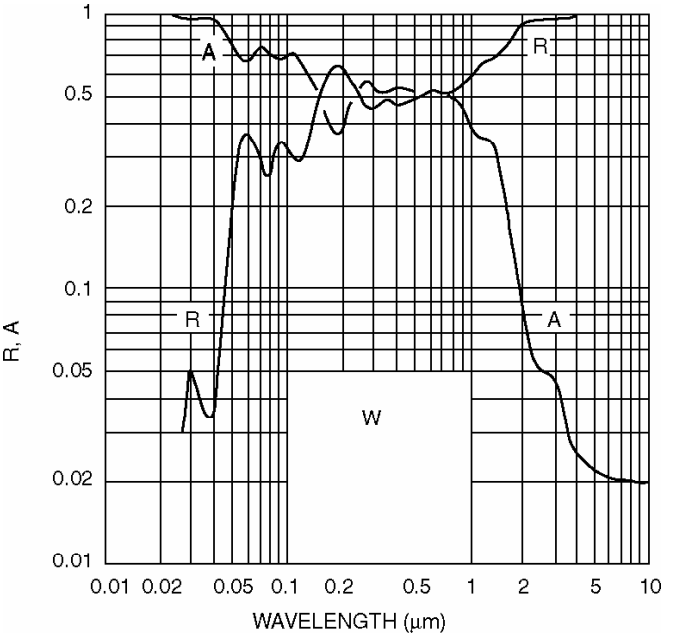

Figure 4.2.24 Reflectance and absorptance (A) for tungsten calculated for normal incidence from the data of Figure 4.2.23. Note that A = 1 – R and a semi-infinite sample is assumed, i.e., the sample is thick enough to be opaque.

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Emittance

Emittance is the ratio of radiated emitted power of a surface (W/m^2) to the emissive power of a blackbody at the same temperature. The total emittance is an integral over all wavelengths; the spectral emittance is given as a function of wavelength at constant temperature.

Normal Spectral Emittance (650 nm)

Metal	Emissivity
Beryllium	0.61
Chromium	0.34
Copper	0.10
Gold	0.14
Iron	0.35
Iron (cast)	0.37
Molybdenum	0.37
Nickel	0.36
Nickel (80) -chromium (20)	0.35
Palladium	0.33
Platinum	0.30
Silver	0.07
Steel	0.35
Tantalum	0.49
Titanium	0.63
Tungsten	0.43
Zirconium	0.32

From the *CRC Handbook of Chemistry and Physics*, 75th edition, Lide, D. R., Ed. (CRC Press, Boca Raton, FL, 1994), p. 10-296.

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Total Emittance

Metal	Temperature (˚C)	Emissivity
Aluminum		
polished	50–500	0.04–0.06
oxidized	200	0.11
	600	0.19
Chromium		
polished	50	0.1
	500–1000	0.28–0.38
Copper		
oxidized	50	0.6–0.7
	500	0.88
unoxidized	100	0.02
polished	50–100	0.02
Gold		
carefully polished	200–600	0.02–0.03
unoxidized	100	0.02
Iron, cast		
oxidized	200	0.64
	600	0.78
unoxidized	100	0.21
Molybdenum	600–1000	0.08–0.13
Nickel		
polished	200–400	0.07–0.09
unoxidized	25	0.045
	100	0.06
	500	0.12
	1000	0.19
Nickel (80)		
-chromium (20)	100	0.87
	600	0.87
Platinum		
polished	200–600	0.05–0.1
unoxidized	25	0.017
	100	0.047
	500	0.096
Silver		
polished	200–600	0.02–0.03
unoxidized	100	0.02
	500	0.035
Steel		
8%Ni, 18%Cr	500	0.35
cast, polished	750–1050	0.52–0.56
oxidized	200–600	0.8
unoxidized	100	0.08
Tantalum		
unoxidized	1500	0.21
Tungsten		
unoxidized	25	0.024
	100	0.032
	500	0.071
Zinc		
polished	200–300	0.04–0.05
unoxidized	300	0.05

From the *CRC Handbook of Chemistry and Physics*, 75th edition, Lide, D. R., Ed. (CRC Press, Boca Raton, FL, 1994), p. 10-295.

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Reflectance of Freshly Evaporated Mirror Coatings

	Normal Incidence Reflectance (%)					
λ (nm)	Aluminum	Copper	Gold	Platinum	Rhodium	Silver
220	91.5	40.4	27.5	40.5	57.8	28.0
240	91.9	39.0	31.6	46.9	63.2	29.5
260	92.2	35.5	35.6	51.5	67.7	29.2
280	92.3	33.0	37.8	54.9	70.7	25.2
300	92.3	33.6	37.7	57.6	73.4	17.6
320	92.4	36.3	37.1	60.0	75.5	8.9
340	92.5	38.5	36.1	62.0	76.9	72.9
360	92.5	41.5	36.3	63.4	78.0	88.2
380	92.5	44.5	37.8	64.9	78.1	92.8
400	92.4	47.5	38.7	66.3	77.4	95.6
450	92.2	55.2	38.7	69.1	76.0	97.1
500	91.8	60.0	47.7	71.4	76.6	97.9
550	91.5	66.9	81.7	73.4	78.2	98.3
600	91.1	93.3	91.9	75.2	79.7	98.6
650	90.5	96.6	95.5	76.4	81.1	98.8
700	89.7	97.5	97.0	77.2	82.0	98.9
750	88.6	97.9	97.4	77.9	82.6	99.1
800	86.7	98.1	98.0	78.5	83.1	99.2
850	86.7	98.3	98.2	79.5	83.4	99.2
900	89.1	98.4	98.4	80.5	83.6	99.3
950	92.4	98.4	98.5	80.6	83.9	99.3
1000	94.0	98.5	98.6	80.7	84.2	99.4
1500	97.4	98.5	99.0	81.8	87.7	99.4
2000	97.8	98.6	99.1	81.8	91.4	99.4
3000	98.0	98.6	99.3	90.6	95.0	99.4
4000	98.2	98.7	99.4	93.7	95.8	99.4
5000	98.4	98.7	99.4	94.9	96.4	99.5
6000	98.5	98.7	99.4	95.6	96.8	99.5
7000	98.6	98.7	99.4	95.9	97.0	99.5
8000	98.7	98.8	99.4	96.0	97.2	99.5
9000	98.7	98.8	99.4	96.1	97.4	99.5
10000	98.7	98.9	99.4	96.2	97.6	

Reference: Hass, G., in *Applied Optics and Optical Engineering*, vol. III, Kingslake, R., Ed., (Academic Press, New York, 1965), p. 309. See also, Palmer, J. M., *Handbook of Optics* (McGraw-Hill, New York, 1995), Chapter 25 and references cited therein.

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4.3 Mechanical Properties

Elastic Constants

Metal	Elastic stiffness constants (10^{11} N/m^2)				
Cubic crystals	C_{11}	C_{12}	C_{44}		
Aluminum	1.0675	0.6041	0.2834		
Chromium	3.398	0.586	0.990		
Copper	1.683	1.221	0.757		
Germanium	1.2835	0.4823	0.6666		
Gold	1.9244	1.6298	0.4200		
Iridium	5.80	2.42	2.56		
Iron	2.26	1.40	1.16		
Molybdenum	4.637	1.578	1.092		
Nickel	2.841	1.529	1.242		
Niobium	2.4650	1.3450	0.2873		
Palladium	2.2710	1.7604	0.7173		
Platinum	3.4670	2.5070	0.7650		
Silicon	1.6578	0.6394	0.7962		
Silver	1.2399	0.9367	0.4612		
Tantalum	2.6023	1.5446	0.8255		
Tungsten	5.2239	2.0437	1.6083		
Hexagonal crystals	C_{11}	C_{12}	C_{13}	C_{33}	C_{55}
Beryllium	2.923	0.267	0.140	3.364	1.625
Magnesium	0.5950	0.2612	0.2180	0.6155	0.1635
Zinc	1.6368	0.3640	0.5300	0.6347	0.3879
Zirconium	1.434	0.728	0.657	1.648	0.320

Reference: Frederikse, H. P. R., Elastic constants of single crystals, *Handbook of Chemistry and Physics*, 82nd edition (CRC Press, Boca Raton, FL, 1994), p. 12-37.

Elastic Moduli and Poisson's Ratio

Material	Young's modulus (GN/m^2)	Shear modulus (GN/m^2)	Bulk modulus (GN/m^2)	Poisson's ratio
Aluminum				
5086-O	71.0	26.4	—	0.33
6061-T6	68.9	25.9	—	0.33
Beryllium (I-701-H)	315.4	148.4	115.0	0.043
Copper	129.8	48.3	137.8	0.343
Germanium	79.9	29.6	—	0.32
Gold	78.5	26.0	171.0	0.42
Invar 36	144.0	26.0	99.4	0.259
Iron	211.4	57.2	169.8	0.293

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Elastic Moduli and Poisson's Ratio—*continued*

Material	Young's modulus (GN/m^2)	Shear modulus (GN/m^2)	Bulk modulus (GN/m^2)	Poisson's ratio
Molybdenum	324.8	81.6	261.2	0.293
Nickel	199.5	125.6	177.3	0.312
Platinum	170.0	76.0	276.0	0.39
Silicon	113.0	60.9	—	0.42
Silicon carbide				
CVD	461.0	39.7		0.21
reaction sintered	413.0	—	—	0.24
Silver	82.7	30.3	103.6	0.367
Stainless steel		77.0		
304	193.0	83.9	—	0.27
416	215.0	80.0	166.0	0.283
430	200	62.2	—	0.27
Tantalum	185.7	160.2	196.3	0.342
Tungsten	411		311.0	0.28

Table adapted from Palmer, J. M., *Handbook of Optics,* Vol.II (McGraw-Hill, New York, 1995), p. 35.73.

Strength Properties

Material	Yield strength (MN/m^2)	Microyield strength (MN/m^2)	Elongation (in 50 mm) %	Hardness
Aluminum				
5086-O	115	40	22	55 (Rockwell B)
6061-T6	276	160	15	95 (Rockwell B)
Beryllium (I-701-H)	276	30	4	80 (Rockwell B)
Copper	195	12	42	10 (Rockwell B)
Gold	125		30	30 (Knoop*)
Invar 36	276	37	35	70 (Rockwell B)
Molybdenum	600		47	150 (Knoop*)
Nickel	148		35	109 (Rockwell B)
Platinum	150			40 (Knoop*)
Silver	130		47	32 (Knoop*)
Stainless steel				
304	241		60	80 (Rockwell B)
416	950		12	41 (Rockwell C)
430	380		25	86 (Rockwell B)
Tantalum	220		30	120 (Knoop*)
Tungsten	780		2	350 (Knoop*)

* kg/mm^2

Table adapted from Palmer, J. M., *Handbook of Optics,* Vol.II (McGraw-Hill, New York, 1995), p. 35.74.

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4.4 Thermal Properties

Thermal Properties

Metal	Density[(a)] (g/cm^3)	Melting point (°C)	Coeff. linear expansion[(a)] (10^{-6} K^{-1})	Specific heat capacity (J/g K)	Thermal conductivity[(b)] (W/m K)
Aluminum	2.70	660.3	23.1	0.897	237
Beryllium	1.85	1287	11.3	1.825	200
Chromium	7.15	1907	4.9	0.449	93.7
Copper	8.96	1084.6	16.5	0.385	401
Gold	19.3	1064.3	14.2	0.129	317
Iridium	22.5	2446	6.4	0.131	147
Iron	7.87	1538	11.8	0.449	80.2
Magnesium	1.74	650	24.8	1.023	156
Molybdenum	10.2	2623	4.8	0.251	138
Nickel	8.9	1455	13.4	0.444	90.7
Niobium	8.57	2477	7.3	0.265	53.7
Osmium	22.59	3033	5.1	0.130	87.6
Palladium	12.0	1555	11.8	0.246	71.8
Platinum	21.5	1768.4	8.8	0.133	71.6
Rhenium	20.8	3186	6.2	0.137	47.9
Rhodium	12.4	1964	8.2	0.243	150
Silver	10.5	961.8	18.9	0.235	429
Tantalum	16.4	3017	6.3	0.140	57.5
Tin	7.28	231.9	22.0	0.228	66.6
Titanium	4.5	1668	8.6	0.523	21.9
Tungsten	19.3	3422	4.5	0.132	174
Zinc	7.14	419.5	30.2	0.388	116
Zirconium	6.52	1855	5.7	0.278	27.7

(a) 25°C, (b) 27°C. From the *CRC Handbook of Chemistry and Physics*, 82nd edition, Lide, D. R., Ed. (CRC Press, Boca Raton, FL, 2001), p. 12-219.

Temperature Dependence of Linear Thermal Expansion Coefficient (ppm/K)

Temperature (K)	100	200	293	400	500	600
Aluminum (6061)	12.2	20.9	22.5	25.0	27.5	30.1
Beryllium	1.32	7.00	11.3	13.6	15.1	16.6
Copper	10.3	15.2	16.5	17.6	18.3	18.9
Gold	11.8	13.7	14.2	14.8	15.4	15.9
Iron	506	10.1	11.8	13.4	14.4	15.1
Molybdenum	2.8	4.6	4.8	4.9	5.1	5.3
Nickel	6.6	11.3	13.4	14.5	15.3	15.9
Silicon	-0.4	1.5	2.6	3.2	3.5	3.7
Silicon carbide (α)	0.14	1.5	3.3	4	4.2	4.5
Silver	14.2	17.8	18.9	19.7	20.6	21.5
Stainless steel (304)	11.4	13.2	14.7	16.3	17.5	18.6
Stainless steel (416)	6	7.9	9.5	10.9	12.1	12.9

Adapted from Palmer, J. M., Properties of metals, in *Handbook of Optics, Vol.II* (McGraw-Hill, New York, 1995), p. 35.60.

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Temperature Dependence of Molar Heat Capacity (J/mol K)

Temp. (K)	200	250	300	350	400	500	600
Aluminum	21.33	23.08	24.25	25.11	25.78	26.84	27.89
Beryllium	9.98	13.58	16.46	18.53	19.95	21.94	23.34
Chromium	19.86	22.30	23.47	24.39	25.23	26.63	27.72
Copper	22.63	23.77	24.48	24.95	25.33	25.91	26.48
Germanium	—	—	23.25	23.85	24.31	24.96	25.45
Gold	—	—	25.41	25.37	25.51	26.06	26.65
Iron	21.95	23.94	25.15	26.28	27.39	29.70	32.05
Magnesium	22.72	24.02	24.90	25.57	26.14	27.17	28.18
Silicon	15.64	18.22	20.04	21.28	22.14	23.33	24.15
Silver			25.36	25.55	25.79	26.36	26.99
Tantalum	24.08	24.86	25.31	25.60	25.84	26.35	26.84
Titanium	22.37	24.07	25.28	26.17	26.86	27.88	28.60
Tungsten	22.49	23.69	24.30	24.65	24.92	25.36	25.79
Zinc	24.05	25.02	25.45	25.88	26.35	27.39	28.59
Zirconium	23.87	24.09	25.22	25.61	25.93	26.56	27.28

From the *CRC Handbook of Chemistry and Physics*, 82nd edition, Lide, D. R., Ed. (CRC Press, Boca Raton, FL, 2001), p. 12-218.

Temperature Dependence of Thermal Conductivity (W/m K)

Temp. (K)	4	20	80	200	300	400	600
Aluminum	15700	11700	432	237	237	240	231
Chromium	160	593	184	111	93.7	90.9	80.7
Copper	16200	10800	557	413	401	393	379
Germanium	877	1490	325	96.8	59.9	43.2	27.3
Gold	2090	1580	332	323	317	311	298
Iron	677	1540	175	94	80.2	69.5	54.7
Nickel	859	1650	210	107	90.7	80.2	65.6
Platinum	880	495	81.5	72.6	71.6	71.8	73.2
Silicon	297	4810	1340	264	148	98.9	61.9
Silver	14700	5100	471	430	429	425	412
Tin	18100	320	91.5	73.3	66.6	62.2	—
Titanium	5.75	27.5	32.6	24.5	21.9	20.4	19.4
Tungsten	5630	4050	229	185	174	159	137

From the *CRC Handbook of Chemistry and Physics*, 82nd edition, Lide, D. R., Ed. (CRC Press, Boca Raton, FL, 2001), p. 12-221.

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4.5 Mirror Substrate Materials

Tables adapted from Palmer, J. M., Properties of metals, in *Handbook of Optics*, Vol.II (McGraw-Hill, New York, 1995), p. 35.11.

Mirror Substrate Materials

Material	Density (g/cm^3)	Young's modulus (GN/m^2)	Specific stiffness (arbitrary units)
Fused silica	2.19	72	33
Beryllium (I-70)	1.85	287	155
Aluminum (6061)	2.70	68	25
Copper	8.94	117	13
Stainless steel (304)	8.00	193	24
Invar (36)	8.05	141	18
Silicon	2.33	131	56
Silicon carbide (30% Si)	2.89	330	114
Silicon carbide CVD)	3.21	465	145

Thermal Properties of Substrate Materials

Material	Coeff. linear expansion (10^6 K^{-1})	Specific heat capacity (J/g K)	Thermal conductivity (W/m K	Thermal diffusivity (10^{-6} m^2/s)
Fused silica	0.50	750	1.4	0.85
Beryllium (I-70)	11.3	1925	216	57.2
Aluminum (6061)	22.5	896	167	69
Copper	16.5	385	391	115.5
Stainless steel (304)	14.7	500	16.2	4.0
Invar (36)	1.0	515	10.4	2.6
Silicon	2.6	710	156	89.2
Silicon carbide (30% Si)	2.6	670	155	81.0
Silicon carbide CVD)	2.4	733	198	82.0

Thermal Distortion of Substrate Materials

Material	Steady state distortion coefficient[(a)] (μm/W)	Transient distortion coefficient[(b)] (s/m^2 K)
Fused silica	0.36	0.59
Beryllium (I-70)	0.05	0.20
Aluminum (6061)	0.13	0.33
Copper	0.53	0.14
Stainless steel (304)	0.91	3.68
Invar (36)	0.10	0.38
Silicon	0.02	0.03
Silicon carbide (30% Si)	0.02	0.03
Silicon carbide CVDi)	0.01	0.03

(a) Linear expansion coefficient/thermal conductivity.
(b) Linear expansion coefficient/thermal diffusivity.

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