6b. Refractive Index of Special Crystals and Certain Glasses

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Refractive indices for the following materials are given in this section:

Ammonium dihydrogen phosphate (ADP) and Potassium dihydrogen phosphate (KDP)
Barium fluoride
Barium titanate
Cadmium fluoride
Cadmium iodide
Cadmium selenide
Cadmium sulfide
Calcite
Calcium fluoride
Cesium bromide
Cesium iodide
Crystal quartz
Cuprous chloride
Diamond
Fused silica
Germanium
Irtrans 1 to 6
Lanthanum fluoride
Lead bromide
Lead chloride
Lead fluoride
Lead selenide
Lead sulfide
Lead telluride
Lithium fluoride
Magnesium fluoride
Magnesium oxide
Muscovite mica
Potassium bromide
Potassium chloride
Potassium iodide
Rubidium bromide
Rubidium chloride
Rubidium iodide
Ruby
Sapphire
Selenium
Silicon
Silver chloride
Sodium chloride
Sodium fluoride
Sodium nitrate
Spinel
Strontium titanate
T-12
Tellurium
Thallium bromide
Thallium chloride
Thallium bromide-chloride (KRS-6)
Thallium bromide-iodide (KRS-5)
Titanium dioxide
Zinc sulfide
Group III–Group V compounds:
- Gallium antimonide
- Gallium arsenide
- Gallium phosphide
- Indium antimonide
- Indium arsenide
- Indium phosphide

Nonoxide chalcogenic glasses:
- Arsenic-modified selenium glass
- Arsenic triselenide glass
- Arsenic trisulfide glass
- A telluride glass
- Texas Instruments Glass No. 1173

Special glasses:
- Cer-Vit
- Corning Vycor

Refractive index, or index of refraction, can be defined in a number of ways. The complex refractive index, often written as $n + ik$, is defined and described in Sec. 6g. The real part of the refractive index of a substance can be defined as the ratio of the velocity of light in vacuo to the phase velocity of the light in the substance. Usually this quantity is called the absolute refractive index. Often the relative index—the ratio of the absolute refractive index of one substance to the absolute refractive index of another—is the more useful quantity. The refractive index relative to air is expecially useful, since most optical systems have air for both the initial and the final

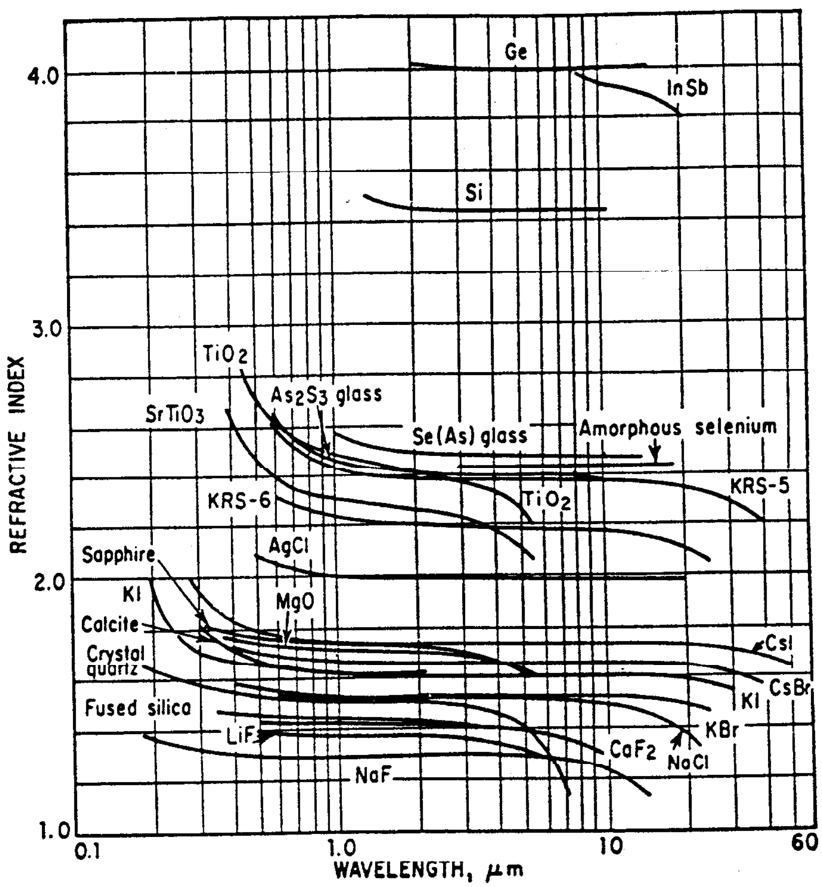

Fig. 6b-1. Refractive index vs. wavelength for several optical materials.

media and since the refractive index of air does not vary appreciably from that of a vacuum (see Table 6e-5). Unless stated otherwise, the refractive-index data in this section are values relative to air for the experimental conditions described. The absolute refractive index can be obtained from these data by multiplying by the appropriate values of the absolute refractive index of air.

The index of refraction varies throughout the entire electromagnetic spectrum in a manner described by theory. Between two absorption bands, the region of primary interest for most materials, the index decreases with increasing wavelength. Near the first absorption band the decrease is rapid; then the decrease becomes quite slow until an inflection point is reached; the decrease of index with wavelength then becomes more rapid again as the second absorption band is approached. This behavior can be seen in Fig. 6b-1. The figure also suggests the large range of values of refractive index covered by optical materials. Some of the more recently available semiconductors, silicon, germanium, and tellurium, have very large refractive indices—about 3.4, 4, and 6, respectively. In Fig. 6b-2 the slopes of many of the curves shown in Fig. 6b-1 are plotted, following the usual practice of plotting $-dn/d\lambda$ rather than $dn/d\lambda$. Regions of smallest dispersion ($d^2n/d\lambda^2 = 0$) and values of $|dn/d\lambda|$ in various spectral regions can be obtained directly from this figure.

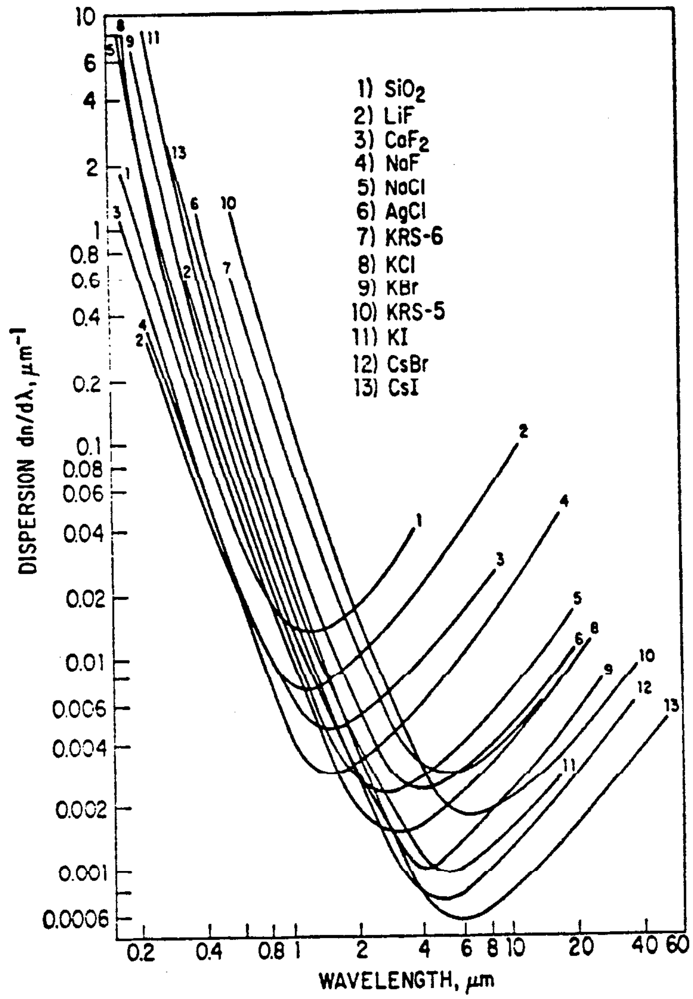

FIG 6b-2. Dispersion vs. wavelength for several optical materials. [*From A. Smakula, Opt. Acta* **9**, 205 (1962).]

The method usually employed for the precise measurement of refractive index is that of minimum deviation. A prism is made from the material; it is mounted on a prism table, and the prism angle is measured; then the angles of minimum deviation are determined for a series of spectral lines. For some measurements, a monochromator is used to obtain light of the desired wavelength, but where possible, spectral lines provide radiation of a more accurately known wavelength. Thus, precise measurements are usually reported as values of refractive index for a number of irregularly spaced wavelengths of light. However, intermediate values may often be desired by the optical designer. Thus, interpolation techniques, some based on physical principles and others which are strictly mathematical or graphical, have been developed. The equations so derived, relating refractive index to wavelength, are called dispersion formulas. The formulas reported in the literature are included here. They not only provide the interpolation mechanism described above, but they can be used to evaluate the experimental data. The formulas also contribute to a better understanding of the properties of the material they describe.

For some applications the change of refractive index with temperature (dn/dT), the so-called temperature coefficient, is an important consideration. The relative temperature coefficient, $(1/n)(dn/dT)$, is also used. The available data for these properties of each material are included. A complete description includes telling how the temperature coefficient changes for each wavelength, as illustrated for several materials in Fig. 6b-3, and also how it varies with temperature. The variations of the temperature coefficient with both wavelength and temperature are presented when available, but it is usually sufficient to indicate a single value for a given wavelength or temperature region. The second-order effects d^2n/dT^2 and

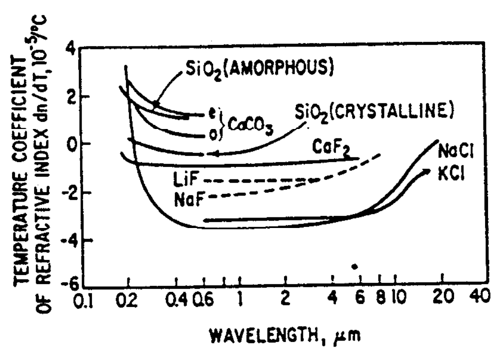

FIG. 6b-3. The temperature coefficient of refractive index of several materials. [*Adapted from A. Smakula, Opt. Acta* **9**, 205 (1962).]

$d^2n/d\lambda\, dT$ have not been reported. They will occasionally be found in the references for some of the older, more throughly measured materials, such as rock salt.

If at all possible, the reference describing the original work has been cited; for some materials additional references to compendia and collections of data are given.

A number of conventions have been assumed for this section. Unless stated otherwise, wavelengths—even those in dispersion formulas—are given in micrometers (μm), and temperatures T are in kelvins (K), employing the new Système International set of units. Many sets of data were recorded using degrees Celsius (°C), and no attempt has been made to convert them to kelvins. The index data listed in the tables are generally the measured rather than computed values. Where the data are computed, the table is immediately followed by a dispersion formula. *Note:* For some materials where the data were measured, a dispersion equation is given as a supplement, but these instances are clearly indicated. If the temperature at which measurements were made is not reported, it can be assumed to be room temperature, or about 20°C. The refractivity $(n - 1)$ of several materials is reported rather than the refractive index n. For anisotropic media, both the refractive index for the ordinary ray (n_o) and the refractive index for the extraordinary ray (n_e) are usually given. Finally, a table entitled Miscellaneous Refractive-index Data has been included; it covers those materials for which only a very few data are available.

Comments on any important physical or chemical characteristics of the materials are presented in Sec. 6c.

The individual materials are treated in the same order as listed at the beginning of this section, with the exception of those included in Table 6b-64, Miscellaneous Refractive-index Data.

(The literature search extended back to January, 1959. It was restricted primarily to "optical" journals, i.e., *Journal of the Optical Society of America*, *Applied Optics*, *Optics & Spectroscopy*, *Optica Acta*, and *Infrared Physics*. It is realized that optical data on semiconductor materials are to be found also through the literature of solid-state physics.)

Ammonium Dihydrogen Phosphate (ADP) and Potassium Dihydrogen Phosphate (KDP)

TABLE 6b-1. REFRACTIVE INDICES OF ADP AND KDP IN AIR AT 24.8°C

ADP			KDP		
λ, 10^{-4} μm	n_o	n_e	λ, 10^{-4} μm	n_o	n_e
2138.560	1.62598	1.56738	2138.560	1.60177	1.54615
2288.018	1.60785	1.55138	2288.018	1.58546	
2536.519	1.58688	1.53289	2446.905	1.57228	
2967.278	1.56462	1.51339	2464.068	1.57105	
3021.499	1.56270	1.51163	2536.519	1.56631	1.51586
3125.663	1.55917	1.50853	2800.869	1.55263	1.50416
3131.545	1.55897	1.50832	2980.628	1.54618	1.49824
3341.478	1.55300	1.50313	3021.499	1.54433	1.49708
3650.146	1.54615	1.49720	3035.781	....	1.49667
3654.833	1.54608	1.49712	3125.663	1.54117	1.49434
3662.878	1.54592	1.49698	3131.545	1.54098	1.49419
3906.410	1.54174	....	3341.478	....	1.48954
4046.561	1.53969	1.49159	3650.146	1.52932	1.48432
4077.811	1.53925	1.49123	3654.833	1.52923	1.48423
4358.350	1.53578	1.48831	3662.878	1.52909	1.48409
4916.036	....	1.48390	3906.410	....	1.48089
5460.740	1.52662	1.48079	4046.561	1.52341	1.47927
5769.590	1.52478	1.47939	4077.811	1.52301	1.47898
5790.654	1.52466	1.47930	4358.350	1.51990	1.47640
6328.160	1.52195	1.47727	4916.036	....	1.47254
10 139.75	1.50835	1.46895	5460.740	1.51152	1.46982
11 287.04	1.50446	1.46704	5769.580	1.50987	
11 522.76	1.50364	1.46666	5790.654	1.50977	1.46856
			6328.160	1.50737	1.46685
			10 139.75	1.49535	1.46041
			11 287.04	1.49205	1.45917
			11 522.76	1.49135	1.45893
			13 570.70	1.48455	
			15 231.00	....	1.45521
			15 295.25	....	1.45512

The accuracy of the data is believed to be ±0.00003 or better. The index values for ADP are adapted from F. Zernike, Jr., *J. Opt. Soc. Am.* **54**, 1215 (1964), and **55**, 210E (1965). The indexes for KDP are from **54**, 1215 (1964). Zernike also reports several absolute index values. Index values of ADP and KDP for 0.4860, 0.5890, and 0.6560 μm are given in the "International Critical Tables," vol. VII, pp. 19, 27, McGraw-Hill Book Company, New York, 1930. In addition, Zernike lists many computed index values in air, using the following dispersion equation:

$$n^2 = \frac{A + B\nu^2}{1 - \nu^2/C} + \frac{D}{E - \nu^2}$$

where $\nu = 1/\lambda$ in cm^{-1}.

TABLE 6b-2. CONSTANTS OF THE DISPERSION EQUATION FOR ADP

	Extraordinary ray	Ordinary ray
A	2.163510	2.302842
B	9.616676×10^{-11}	$1.1125165 \times 10^{-10}$
C	7.698751×10^{9}	7.5450861×10^{9}
D	1.479974×10^{6}	3.775616×10^{6}
E	2.500000×10^{5}	2.500000×10^{5}

From F. Zernike, Jr.: *J. Opt. Soc. Am.* **55**, 210E (1965).

TABLE 6b-3. CONSTANTS OF THE DISPERSION EQUATION FOR KDP

	Extraordinary ray	Ordinary ray
A	2.132668	2.259276
B	8.637494×10^{-11}	1.008956×10^{-10}
C	8.142631×10^{9}	7.726408×10^{9}
D	8.069981×10^{5}	3.251305×10^{6}
E	2.500000×10^{5}	2.500000×10^{5}

From F. Zernike, Jr., *J. Opt. Soc. Am.* **54**, 1215 (1964).

Temperature dependences of n_o and n_e for ADP and KDP are given by R. A. Phillips: *J. Opt. Soc. Am.* **56**, 629 (1966); M. Yamazaki and T. Ogawa, *ibid.*, 1407; and by V. N. Vishnevskii and I. V. Stefanski: *Opt. Spectr. U.S.S.R.* **20**, 195 (1966).

Barium Fluoride

TABLE 6b-4. REFRACTIVE INDEX OF BARIUM FLUORIDE AT 25°C

λ, μm	n	λ, μm	n	λ, μm	n
0.2652	1.51217	0.589262	1.47443	2.5766	1.46262
0.28035	1.50668	0.643847	1.47302	2.6738	1.46234
0.28936	1.50390	0.656279	1.47274	3.2434	1.46018
0.296728	1.50186	0.706519	1.47177	3.422	1.45940
0.30215	1.50044	0.85211	1.46984	5.138	1.45012
0.3130	1.49782	0.89435	1.46942	5.3034	1.44904
0.32546	1.49521	1.01398	1.46847	5.343	1.44878
0.334148	1.49363	1.12866	1.46779	5.549	1.44732
0.340365	1.49257	1.36728	1.46673	6.238	1.44216
0.34662	1.49158	1.52952	1.46613	6.6331	1.43899
0.361051	1.48939	1.681	1.46561	6.8559	1.43694
0.366328	1.48869	1.7012	1.46554	7.0442	1.43529
0.404656	1.48438	1.97009	1.46472	7.268	1.43314
0.435835	1.48173	2.1526	1.46410	9.724	1.40514
0.486133	1.47855	2.32542	1.46356	10.346	1.39636
0.546074	1.47586				

Adapted from I. H. Malitson: *J. Opt. Soc. Am.* **54**, 628 (1964).

Malitson also reports several computed index values, using the following dispersion equation:

$$n^2 - 1 = \frac{0.643356\lambda^2}{\lambda^2 - (0.057789)^2} + \frac{0.506762\lambda^2}{\lambda^2 - (0.10968)^2} + \frac{3.8261\lambda^2}{\lambda^2 - (46.3864)^2}$$

TABLE 6b-5. TEMPERATURE COEFFICIENT OF REFRACTIVE INDEX

λ, μm	Refractive index			dn/dT, (10^{-6}/°C)
	15°C	35°C	55°C	
0.4046563	1.484054	1.483753	1.483452	−15.05
0.4358342	1.481416	1.481116	1.480816	−15.00
0.4861327	1.478234	1.477930	1.477628	−15.15
0.5460740	1.475559	1.475255	1.474951	−15.20
0.589262*	1.474124	1.473820	1.473515	−15.22
0.6562793	1.472439	1.472135	1.471830	−15.23
0.6678149	1.472196	1.471892	1.471586	−15.25
0.7065188	1.471474	1.471167	1.470863	−15.28
0.767858*	1.470538	1.470230	1.469920	−15.45

* Intensity weighed mean of doublet.
Adapted from I. H. Malitson, *loc. cit.*

The low-temperature dependence of refractive index is given by T. W. Houston, L. F. Johnson, P. Kisliuk, and D. J. Walsh: *J. Opt. Soc. Am.* **53**, 1286 (1963).

Cadmium Sulfide

TABLE 6b-6. REFRACTIVE INDEX OF CADMIUM SULFIDE

λ, μm	n_e	n_o
0.5120	2.751	
0.5130	2.743	
0.5140	2.737	
0.5150	2.726	2.743
0.5160	2.720	2.735
0.5170	2.714	2.727
0.5180	2.706	2.718
0.5190	2.702	2.709
0.5200	2.698	2.702
0.5210	2.694	2.700
0.5220	2.689	2.694
0.5230	2.685	2.687
0.5240	2.680	2.681
0.5250	2.675	2.674
0.5275	2.665	2.661
0.5300	2.654	2.649
0.5325	2.644	2.638
0.5350	2.637	2.628
0.5375	2.628	2.617
0.5400	2.622	2.609
0.5425	2.612	2.602
0.5450	2.606	2.594
0.5475	2.600	2.587
0.5500	2.593	2.580
0.5750	2.545	2.528
0.6000	2.511	2.493
0.6250	2.484	2.467
0.6500	2.463	2.446
0.6750	2.446	2.427
0.7000	2.432	2.414
0.7500	2.409	2.390
0.8000	2.392	2.374
0.8500	2.378	2.361
0.9000	2.368	2.350
0.9500	2.359	2.341
1.0000	2.352	2.334
1.0500	2.346	2.328
1.1000	2.340	2.324
1.1500	2.336	2.320
1.2000	2.332	2.316
1.2500	2.329	2.312
1.3000	2.326	2.309
1.3500	2.323	2.306
1.4000	2.321	2.304

From T. M. Bieniewski and S. J. Czyzak: *J. Opt. Soc. Am.* **53**, 496 (1963).

For computational purposes, dispersion equations are given by S. J. Czyzak, W. M. Baker, R. C. Crane, and J. B. Howe: *J. Opt. Soc. Am.* **47**, 240–243 (1957):

Ordinary ray:

$$n_o^2 = 5.235 + \frac{1.819 \times 10^7}{\lambda^2 - 1.651 \times 10^7}$$

Extraordinary ray:

$$n_e^2 = 5.239 + \frac{2.076 \times 10^7}{\lambda^2 - 1.651 \times 10^7}$$

Calcite

TABLE 6b-7. REFRACTIVE INDEX OF CALCITE

λ, μm	n_o	n_e	λ, μm	n_o	n_e	λ, μm	n_o	n_e
0.198	....	1.57796	0.410	1.68014	1.49640	1.229	1.63926	1.47870
0.200	1.90284	1.57649	0.434	1.67552	1.49430	1.273	1.63849	
0.204	1.88242	1.57081	0.441	1.67423	1.49373	1.307	1.63789	1.47831
0.208	1.86733	1.56640	0.508	1.66527	1.48956	1.320	1.63767	
0.211	1.85692	1.56327	0.533	1.66277	1.48841	1.369	1.63681	
0.214	1.84558	1.55976	0.560	1.66046	1.48736	1.396	1.63637	1.47789
0.219	1.83075	1.55496	0.589	1.65835	1.48640	1.422	1.63590	
0.226	1.81309	1.54921	0.643	1.65504	1.48490	1.479	1.63490	
0.231	1.80233	1.54541	0.656	1.65437	1.48459	1.497	1.63457	1.47744
0.242	1.78111	1.53782	0.670	1.65367	1.48426	1.541	1.63381	
0.257	1.76038	1.53005	0.706	1.65207	1.48353	1.609	1.63261	
0.263	1.75343	1.52736	0.768	1.64974	1.48259	1.615	....	1.47695
0.267	1.74864	1.52547	0.795	1.64886	1.48216	1.682	1.63127	
0.274	1.74139	1.52261	0.801	1.64869	1.48216	1.749	....	1.47638
0.291	1.72774	1.51705	0.833	1.64772	1.48176	1.761	1.62974	
0.303	1.71959	1.51365	0.867	1.64676	1.48137	1.849	1.62800	
0.312	1.71425	1.51140	0.905	1.64578	1.48098	1.909	....	1.47573
0.330	1.70515	1.50746	0.946	1.64480	1.48060	1.946	1.62602	
0.340	1.70078	1.50562	0.991	1.64380	1.48022	2.053	1.62372	
0.346	1.69833	1.50450	1.042	1.64276	1.47985	2.100	....	1.47492
0.361	1.69316	1.50224	1.097	1.64167	1.47948	2.172	1.62099	
0.394	1.68374	1.49810	1.159	1.64051	1.47910	3.324	....	1.47392

From F. F. Martens, *Ann. Physik* **6**, 603 (1901), for 0.198 to 0.768 μm; W. Gifford, *Proc. Roy. Soc.* (*London*) **70**, 329 (1902), for 0.226, 0.303, 0.330, 0.361, 0.706, and 0.795 μm; A. Carvallo, *Compt. Rend.* **126**, 950 (1898), and *J. Phys. Radium*, ser. 3, **9**, 465 (1900), for 0.346, and 0.801 to 2.172 μm; A. Smakula, *Office Tech. Serv.* (*OTS*) *Rept.* 111053, 1952, for 3.324 μm.

The data fit together to within a few parts in the fifth decimal. Data for the ordinary ray at about 0.21 μm appear a little out of line.

TABLE 6b-8. TEMPERATURE COEFFICIENTS OF REFRACTIVE INDEX

λ, μm	dn_o/dT (10^{-5}/°C)	dn_e/dT (10^{-5}/°C)
0.211	2.150	
0.231	1.397	2.198
0.298	0.604	1.641
0.361	0.360	1.449
0.441	0.325	1.318
0.467	0.319	
0.480	0.305	1.287
0.508	0.287	1.234
0.589	0.240	1.213
0.643	0.208	1.185

From F. J. Micheli, *Ann. Physik* **4**, 7, 772 (1902).

Calcium Fluoride

TABLE 6b-9. REFRACTIVE INDEX OF CALCIUM FLUORIDE AT 24°C, AND TEMPERATURE COEFFICIENT OF INDEX FOR MEAN TEMPERATURE OF 19°C

λ, μm	Computed index	Measured difference		dn/dT (10^{-6}/°C)
		Synthetic	Natural	
0.228803	1.47635	−2	+1	−6.2
0.24827	1.46793	+3	+5	−7.0
0.2537	1.46602	+9	+12	−7.5
0.26520	1.46233	−1	0	−8.1
0.28035	1.45828	−1	+1	−8.4
0.296728	1.45467	−2	0	−8.8
0.334148	1.44852	−1	+2	−9.2
0.34662	1.44694	−3	0	−9.4
0.365015	1.44400	−4	0	−9.6
0.4046563	1.44151	−3	+1	−9.8
0.4358342	1.43949	−3	0	−10.0
0.4861327	1.43703	−4	0	−10.2
0.546074	1.43494	−3	+1	−10.4
0.589262	1.43381	−2	+2	−10.4
0.643847	1.43268	−2	+3	−10.4
0.6562793	1.43246	−2	+1	−10.4
0.6678149	1.43226	−1	+1	−10.5
0.7065188	1.43167	−2	+2	−10.5
0.767858	1.43088	−2	+2	−10.6
0.85212	1.43002	−1	+4	−10.6
0.8944	1.42966	0	+1	−10.6
1.01398	1.42879	−2	0	−10.5
1.3622	1.42691	+1	+8	−10.0
1.39506	1.42675	+1	+6	−9.9
1.52952	1.42612	+4	+4	−9.6
1.7012	1.42531	+2	+4	−9.4
1.81307	1.42478	0	+9	−9.1
1.97009	1.42401	+3	+3	−8.9
2.1526	1.42306	−1	+1	−8.7
2.32542	1.42212	+3	+4	−8.5
2.4374	1.42147	0	+2	−8.5
3.3026	1.41561	0	+3	−8.2
3.422	1.41467	+2	+2	−8.1
3.5070	1.41398	−1	+2	−8.0
3.7067	1.41229	+2	+2	−7.8
4.258	1.40713	+4	+4	−7.5
5.01882	1.39873	+1	+5	−7.3
5.3034	1.39520	+3	+3	−7.2
6.0140	1.38539	+5	+5	−7.0
6.238	1.38200	−6	0	−7.0
6.63306	1.37565	0	+1	−6.9
6.8559	1.37186	−8	+2	−6.7
7.268	1.36443	+2	+7	−6.5
7.4644	1.36070	+5	+6	−6.4
8.662	1.33500	−4	+3	−6.0
9.724	1.30756	+1	+5	−5.6

The third and fourth columns give the difference between the computed and measured values of refractive index for synthetic calcium fluoride and natural calcium fluoride (fluorite).

Dispersion equation:

$$n^2 - 1 = \sum_j \frac{A_j\lambda^2}{\lambda^2 - \lambda_j^2}$$

TABLE 6b-10. CONSTANTS OF THE DISPERSION EQUATION AT 24°C

$\lambda_1 =$ 0.050263605	$\lambda_1^2 =$ 0.002526430	$A_1 =$ 0.5675888
$\lambda_2 =$ 0.1003909	$\lambda_2^2 =$ 0.01007833	$A_2 =$ 0.4710914
$\lambda_3 =$ 34.649040	$\lambda_3^2 =$ 1200.5560	$A_3 =$ 3.8484723

Adapted from I. H. Malitson, *Appl. Opt.* **2**, 1103 (1963).

Cesium Bromide

TABLE 6b-11. REFRACTIVITY OF CESIUM BROMIDE AT 27°C

λ, μm	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	......	......	......	......	73,519	70,896	69,583	68,825	68,345	68,022
1	67,793	67,624	67,496	67,397	67,318	67,254	67,201	67,157	67,120	67,088
2	67,061	67,036	67,015	66,996	66,979	66,963	66,948	66,935	66,923	66,911
3	66,901	66,890	66,881	66,871	66,862	66,853	66,845	66,837	66,829	66,821
4	66,813	66,805	66,798	66,790	66,782	66,775	66,767	66,760	66,752	66,745
5	66,737	66,730	66,722	66,715	66,707	66,699	66,691	66,683	66,675	66,667
6	66,659	66,651	66,643	66,634	66,626	66,617	66,609	66,600	66,591	66,582
7	66,573	66,564	66,555	66,545	66,536	66,526	66,517	66,507	66,497	66,487
8	66,477	66,467	66,457	66,446	66,436	66,425	66,414	66,403	66,392	66,381
9	66,370	66,359	66,347	66,335	66,324	66,312	66,300	66,288	66,276	66,263
10	66,251	66,238	66,226	66,213	66,200	66,187	66,174	66,160	66,147	66,134
11	66,120	66,106	66,092	66,078	66,064	66,050	66,035	66,021	66,006	65,991
12	65,976	65,961	65,946	65,931	65,915	65,900	65,884	65,868	65,852	65,836
13	65,820	65,804	65,787	65,770	65,754	65,737	65,720	65,703	65,685	65,668
14	65,651	65,633	65,615	65,597	65,579	65,561	65,543	65,524	65,505	65,487
15	65,468	65,449	65,430	65,411	65,391	65,372	65,352	65,332	65,312	65,292
16	65,272	65,251	65,231	65,210	65,190	65,169	65,148	65,126	65,105	65,084
17	65,062	65,040	65,018	64,996	64,974	64,952	64,929	64,907	64,884	64,861
18	64,838	64,815	64,792	64,768	64,745	64,721	64,697	64,673	64,649	64,625
19	64,600	64,576	64,551	64,526	64,501	64,476	64,450	64,425	64,399	64,374
20	64,348	64,322	64,295	64,269	64,243	64,216	64,189	64,162	64,135	64,108
21	64,080	64,053	64,025	63,997	63,969	63,941	63,913	63,884	63,856	63,827
22	63,798	63,769	63,739	63,710	63,681	63,651	63,621	63,591	63,561	63,530
23	63,500	63,469	63,438	63,407	63,376	63,345	63,313	63,282	63,250	63,218
24	63,186	63,154	63,121	63,089	63,056	63,023	62,990	62,957	62,923	62,890
25	62,856	62,822	62,788	62,754	62,719	62,685	62,650	62,615	62,580	62,545
26	62,509	62,474	62,438	62,402	62,366	62,330	62,293	62,256	62,220	62,183
27	62,146	62,108	62,071	62,033	61,995	61,957	61,919	61,881	61,842	61,803
28	61,764	61,725	61,686	61,646	61,607	61,567	61,527	61,487	61,446	61,406
29	61,365	61,324	61,283	61,242	61,200	61,158	61,116	61,074	61,032	60,990
30	60,947	60,904	60,861	60,818	60,775	60,731	60,687	60,643	60,599	60,555
31	60,510	60,465	60,420	60,375	60,330	60,284	60,238	60,192	60,146	60,100
32	60,053	60,007	59,960	59,912	59,865	59,817	59,770	59,722	59,673	59,625
33	59,576	59,527	59,478	59,429	59,380	59,330	59,280	59,230	59,179	59,129
34	59,078	59,027	58,976	58,924	58,873	58,821	58,769	58,717	58,664	58,611
35	58,558	58,505	58,452	58,398	58,344	58,290	58,236	58,181	58,126	58,071
36	58,016	57,960	57,905	57,849	57,792	57,736	57,679	57,622	57,565	57,508
37	57,450	57,392	57,334	57,276	57,217	57,158	57,099	57,040	56,980	56,920
38	56,860	56,800	56,739	56,678	56,617	56,556	56,494	56,432	56,370	56,308
39	56,245	56,182	56,119							

From W. S. Rodney and R. J. Spindler, *J. Res. NBS* **51**, 123–126 (1953).

Dispersion equation:

$$n^2 = 5.640752 - 0.000003338\lambda^2 + \frac{0.0018612}{\lambda^2} + \frac{41{,}110.49}{\lambda^2 - 14{,}390.4} + \frac{0.0290764}{\lambda^2 - 0.024964}$$

The average temperature coefficient of refractive index for two samples of different origin is given by Rodney and Spindler as 7.9×10^{-5} per °C.

Cesium Iodide

Table 6b-12. Refractivity of Cesium Iodide at 24°C

λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n
0.280	103 939	0.840	76 352	1.80	74 702	10.8	73 852	16.4	73 267	22.0	72 435	27.6	71 334	33.2	69 941	38.8	68 227	44.4	66 151
0.300	97 872	0.860	76 252	1.84	74 683	11.0	73 835	16.6	73 242	22.2	72 400	27.8	71 289	33.4	69 886	39.0	68 159	44.6	66 070
0.320	93 700	0.880	76 159	1.88	74 664	11.2	73 818	16.8	73 216	22.4	72 365	28.0	71 244	33.6	69 830	39.2	68 091	44.8	65 988
0.340	90 649	0.900	76 074	1.92	74 647	11.4	73 800	17.0	73 190	22.6	72 330	28.2	71 199	33.8	69 774	39.4	68 023	45.0	65 905
0.360	88 324	0.920	75 993	1.96	74 631	11.6	73 783	17.2	73 164	22.8	72 294	28.4	71 153	34.0	69 717	39.6	67 954	45.2	65 822
0.380	86 497	0.940	75 918	2.00	74 616	11.8	73 765	17.4	73 137	23.0	72 258	28.6	71 107	34.2	69 660	39.8	67 884	45.4	65 739
0.400	85 027	0.960	75 848	2.20	74 551	12.0	73 746	17.6	73 111	23.2	72 222	28.8	71 061	34.4	69 602	40.0	67 814	45.6	65 655
0.420	83 823	0.980	75 782	2.40	74 500	12.2	73 728	17.8	73 083	23.4	72 185	29.0	71 014	34.6	69 544	40.2	67 744	45.8	65 570
0.440	82 820	1.00	74 721	2.60	74 460	12.4	73 709	18.0	73 056	23.6	72 148	29.2	70 967	34.8	69 486	40.4	67 673	46.0	65 485
0.460	81 975	1.04	75 608	2.80	74 427	12.6	73 690	18.2	73 028	23.8	72 111	29.4	70 919	35.0	69 427	40.6	67 601	46.2	65 399
0.480	81 255	1.08	75 508	3.00	74 400	12.8	73 670	18.4	72 999	24.0	72 073	29.6	70 871	35.2	69 368	40.8	67 530	46.4	65 313
0.500	80 635	1.12	75 419	3.50	74 346	13.0	73 650	18.6	72 971	24.2	72 035	29.8	70 823	35.4	69 308	41.0	67 457	46.6	65 226
0.520	80 097	1.16	75 339	4.00	74 305	13.2	73 630	18.8	72 942	24.4	71 997	30.0	70 774	35.6	69 248	41.2	67 384	46.8	65 138
0.540	79 626	1.20	75 268	4.50	74 270	13.4	73 610	19.0	72 913	24.6	71 958	30.2	70 725	35.8	69 188	41.4	67 311	47.0	65 051
0.560	79 213	1.24	75 203	5.00	74 239	13.6	73 589	19.2	72 883	24.8	71 919	30.4	70 676	36.0	69 127	41.6	67 237	47.2	64 962
0.580	78 846	1.28	75 144	5.50	74 210	13.8	73 568	19.4	72 853	25.0	71 880	30.6	70 626	36.2	69 065	41.8	67 163	47.4	64 873
0.600	78 520	1.32	75 091	6.00	74 181	14.0	73 547	19.6	72 823	25.2	71 840	30.8	70 576	36.4	69 004	42.0	67 088	47.6	64 783
0.620	78 229	1.36	75 042	6.50	74 152	14.2	73 525	19.8	72 793	25.4	71 800	31.0	70 525	36.6	68 941	42.2	67 013	47.8	64 693
0.640	77 967	1.40	74 997	7.00	74 122	14.4	73 504	20.0	72 762	25.6	71 759	31.2	70 474	36.8	68 879	42.4	66 937	48.0	64 602
0.660	77 731	1.44	74 956	7.50	74 091	14.6	73 481	20.2	72 731	25.8	71 718	31.4	70 422	37.0	68 815	42.6	66 861	48.2	64 511
0.680	77 517	1.48	74 919	8.00	74 059	14.8	73 459	20.4	72 699	26.0	71 677	31.6	70 371	37.2	68 752	42.8	66 784	48.4	64 419
0.700	77 323	1.52	74 884	8.50	74 026	15.0	73 436	20.6	72 667	26.2	71 635	31.8	70 318	37.4	68 688	43.0	66 707	48.6	64 326
0.720	77 146	1.56	74 852	9.00	73 991	15.2	72 413	20.8	72 635	26.4	71 593	32.0	70 266	37.6	68 623	43.2	66 629	48.8	64 233
0.740	76 985	1.60	74 822	9.50	73 954	15.4	73 389	21.0	72 602	26.6	71 551	32.2	70 213	37.8	68 558	43.4	66 551	49.0	64 139
0.760	76 836	1.64	74 795	10.0	73 916	15.6	73 366	21.2	72 570	26.8	71 508	32.4	70 159	38.0	68 493	43.6	66 472	49.2	64 045
0.780	76 700	1.68	74 769	10.2	73 901	15.8	73 342	21.4	72 536	27.0	71 465	32.6	70 105	38.2	68 427	43.8	66 392	49.4	63 950
0.800	76 575	1.72	74 745	10.4	73 885	16.0	73 317	21.6	72 503	27.2	71 422	32.8	70 051	38.4	68 361	44.0	66 312	49.6	63 855
0.820	76 459	1.76	74 723	10.6	73 868	16.2	73 292	21.8	72 469	27.4	71 378	33.0	69 996	38.6	68 294	44.2	66 232	49.8	63 759
																		50.0	63 662

Dispersion equation:

$$n^2 - 1 = \sum_i \frac{K_i \lambda^2}{\lambda^2 - \lambda_i^2}$$

TABLE 6b-13. CONSTANTS OF THE DISPERSION EQUATION

i	λ_i^2	K_i
1	0.00052701	0.34617251
2	0.02149156	1.0080886
3	0.032761	0.28551800
4	0.044944	0.39743178
5	25,921.0	3.3605359

From W. S. Rodney, *J. Opt. Soc. Am.* **45**, 987 (1955).

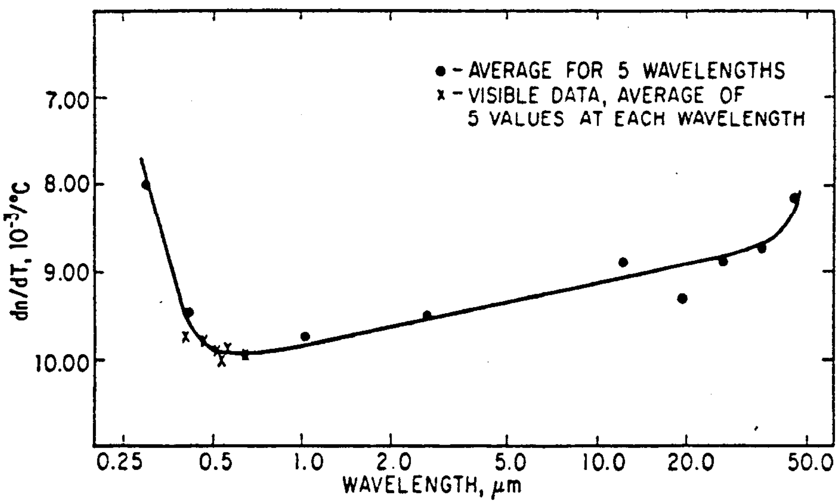

FIG. 6b-4. The temperature coefficient of refractive index of cesium iodide. [*From W. S. Rodney, J. Opt. Soc. Am.* **45**, 987 (1955).]

The data for the region 0.185 to 0.76 μm were taken at 23°C by F. F. Martens, *Ann. Physik* **6**, 603 (1901). Similar values are given by J. W. Gifford, *Proc. Phys. Soc.* (*London*) **70**, 329 (1902), and by H. Trommsdorff, *Z. Physik* **2**, 576 (1901). R. B. Sosman, "The Properties of Silica," Chemical Catalog Company, Inc., New York, 1927, gives a collation of the above data. The data for the wavelength region from 0.8325 to 2.30 μm (at 20°C) are taken from A. Carvallo, *Compt. Rend.* **126**, 728 (1898). For the region from 2.60 to 7.0 μm (at 18°C), the data are taken from H. Rubens, *Wied. Ann.* **54**, 488 (1895). The values fit together well (to a few parts in the fifth decimal place). They are, however, questionable at the extreme ends of the range (0.185, 5.00, 6.45, and 7.0 μm).

Crystal Quartz

TABLE 6b-14. REFRACTIVE INDEX OF CRYSTAL QUARTZ

λ, μm	n_o	n_e	λ, μm	n_o	n_e
0.185	1.65751	1.68988	1.5414	1.52781	1.53630
0.198	1.65087	1.66394	1.6815	1.52583	1.53422
0.231	1.61395	1.62555	1.7614	1.52468	1.53301
0.340	1.56747	1.57737	1.9457	1.52184	1.53004
0.394	1.55846	1.56805	2.0531	1.52005	1.52823
0.434	1.55396	1.56339	2.30	1.51561	
0.508	1.54822	1.55746	2.60	1.50986	
0.5893	1.54424	1.55335	3.00	1.49953	
0.768	1.53903	1.54794	3.50	1.48451	
0.8325	1.53773	1.54661	4.00	1.46617	
0.9914	1.53514	1.54392	4.20	1.4569	
1.1592	1.53283	1.54152	5.00	1.417	
1.3070	1.53090	1.53951	6.45	1.274	
1.3958	1.52977	1.53832	7.0	1.167	
1.4792	1.52865	1.53716			

TABLE 6b-15. TEMPERATURE COEFFICIENTS OF REFRACTIVE INDEX

λ, μm	dn_o/dT (10^{-5}/°C)	dn_e/dT (10^{-5}/°C)	λ, μm	dn_o/dT (10^{-5}/°C)	dn_e/dT (10^{-5}/°C)
0.202	+0.321	+0.267	0.298	−0.311	−0.415
0.206	0.253	0.198	0.313	−0.348	−0.450
0.210	0.193	0.143	0.325	−0.352	−0.469
0.214	0.124	0.083	0.340	−0.393	−0.501
0.219	0.074	0.027	0.361	−0.418	−0.521
0.224	0.017	−0.048	0.441	−0.475	−0.593
0.226	−0.008	−0.075	0.467	−0.485	−0.601
0.228	−0.027	−0.093	0.480	−0.499	−0.610
0.231	−0.052	−0.112	0.508	−0.514	−0.616
0.257	−0.186	−0.265	0.589	−0.539	−0.642
0.274	−0.235	−0.323	0.643	−0.549	−0.653
0.288	−0.279	−0.385			

From F. J. Micheli, *Ann. Physik* **4**, 7 (1902).

Diamond

TABLE 6b-16. REFRACTIVE INDEX OF DIAMOND

λ, μm	n	λ, μm	n
0.480	2.4368	0.589	2.4175
0.486	2.4354	0.644	2.4114
0.546	2.4235	0.656	2.4104

From von S. Rösch, *Opt. Acta* **12**, 253 (1965).

Table 6b-17. Refractive Index at 20°C for Three Specimens of Fused Silica

λ, μm	Computed index	Measured difference			
		C-D-G.E.*	Corning	Dynasil	General Electric
0.213856	1.534307	−27	−29	−42	−31
0.214438	1.533722	− 2	−11	−21	−22
0.226747	1.522750	+70	+71	+68	+73
0.230209	1.520081	−21	−28	−31	−23
0.237833	1.514729	+ 1	+13	+23	+19
0.239938	1.513367	+ 3	+ 6	+ 2	+ 9
0.248272	1.508398	+ 2	+ 6	− 1	+ 7
0.265204	1.500029	−29	−32	−25	−13
0.269885	1.498047	+ 3	+ 7	− 4	+11
0.275278	1.495913	− 3	+ 2	+ 8	+12
0.280347	1.494039	+ 1	− 4	− 9	−11
0.289360	1.490990	+20	+18	+22	+20
0.296728	1.488734	−14	− 7	−12	− 4
0.302150	1.487194	− 4	− 9	− 2	+ 4
0.330259	1.480539	− 9	+ 1	+10	+ 3
0.334148	1.479763	− 3	− 8	− 1	+ 9
0.340365	1.478584	+ 6	+ 9	+ 2	− 8
0.346620	1.477468	+ 2	−17	−12	−14
0.361051	1.475129	+ 1	+ 3	− 9	− 8
0.365015	1.474539	−19	−11	−15	−21
0.404656	1.469618	+ 2	+ 1	− 1	+ 2
0.435835	1.466693	− 3	+ 5	+ 1	+ 3
0.467816	1.464292	+ 8	+ 5	+ 3	+ 6
0.486133	1.463126	+ 4	+ 6	+ 5	+ 7
0.508582	1.461863	+ 7	+ 4	+ 1	+ 5
0.546074	1.460078	+ 2	+ 4	+ 1	− 5
0.576959	1.458846	+ 4	+ 5	+ 3	+ 4
0.579065	1.458769	+ 1	+ 6	+ 6	+ 6
0.587561	1.458464	+ 6	+ 3	− 2	+ 1
0.589262	1.458404	− 4	+ 6	+ 3	+ 7
0.643847	1.456704	+ 6	+ 9	+ 4	+ 7
0.656272	1.456367	+ 3	+ 7	+ 5	+ 7
0.667815	1.456067	+ 3	+ 8	+ 6	+ 3
0.706510	1.455145	+ 5	+10	+12	+ 7
0.852111	1.452465	+ 5	+ 8	+ 3	+ 5
0.894350	1.451835	+ 5	+11	+ 5	+10
1.01398	1.450242	+ 8	+ 6	+ 3	+ 6
1.08297	1.449405	− 5	+ 8	+ 1	+ 9
1.12866	1.448869	+ 1	+ 7	+ 8	+ 9
1.3622	1.446212	−12	− 6	−14	−12
1.39506	1.445836	+ 4	− 1	+ 4	− 3
1.4695	1.444975	− 5	+ 3	+ 9	+10
1.52952	1.444268	+ 2	+ 8	+ 6	0
1.6606	1.442670	−20	−14	−19	−11
1.681	1.442414	+ 6	− 2	−10	+ 8
1.6932	1.442260	0	+ 7	− 6	+ 1
1.70913	1.442057	+ 3	0	+ 3	− 1
1.81307	1.440699	+21	− 7	− 7	+ 6
1.97009	1.438519	+ 1	+ 6	+12	+12
2.0581	1.437224	− 4	− 3	− 9	−11
2.1526	1.435769	−29	−22	−25	−24
2.32542	1.432928	−18	−10	− 3	− 6
2.4374	1.430954	−24	−23	−21	−14
3.2439	1.413118	+32	+21	+29	+25
3.2668	1.412505	+25	+20	+30	+25
3.3026	1.411535	+25	+32	+30	+28
3.422	1.408180	+20	+40	+42	+37
3.5070	1.405676	−16	−26	−20	−10
3.5564	1.404174	−24	−27	−29	−18
3.7067	1.399389	−19	−22	−14	− 9
Average of absolute values of measured differences		10.5	11.9	12.2	11.7

* Difference for arithmetical mean table of values compiled from experimental data of Corning (C), Dynasil (D), and General Electric (G.E.).

Adapted from I. H. Malitson, *J. Opt. Soc. Am.* **55**, 1205 (1965).

Dispersion equation:

$$n^2 - 1 = \frac{0.6961663\lambda^2}{\lambda^2 - (0.0684043)^2} + \frac{0.4079426\lambda^2}{\lambda^2 - (0.1162414)^2} + \frac{0.8974794\lambda^2}{\lambda^2 - (9.896161)^2}$$

The companies that submitted material for interspecimen comparison are Corning Glass Works, Dynasil Corporation of America, and the General Electric Company. They identify their brands as Corning code 7940 fused silica, Dynasil high-purity synthetic fused silica, and General Electric type 151. Each company submitted material from four different production runs. All specimens are considered to be of comparable optical quality, produced according to the highest standards of purity and uniformity.

TABLE 6b-18. TEMPERATURE COEFFICIENT OF REFRACTIVE INDEX

λ, μm	n, 26°C	n, 471°C	dn/dT (10^{-6}/°C)	n, 828°C	dn/dT (10^{-6}/°C)
0.23021	1.52034	1.52908	+19.6	1.53584	+19.3
0.23783	1.51496	1.52332	+18.8	1.52985	+18.6
0.2407	1.51361	1.52201	+18.9	1.52832	+18.3
0.2465	1.50970	1.51774	+18.1	1.52391	+17.7
0.24827	1.50865	1.51665	+18.0	1.52289	+17.8
0.26520	1.50023	1.50763	+16.6	1.51351	+16.5
0.27528	1.49615	1.50327	+16.0	1.50899	+16.0
0.28035	1.49425	1.50143	+16.2	1.50691	+15.8
0.28936	1.49121	1.49818	+15.7	1.50358	+15.4
0.29673	1.48892	1.49584	+15.6	1.50112	+15.2
0.30215	1.48738	1.49407	+15.1	1.49942	+15.0
0.3130	1.48462	1.49126	+14.9	1.49641	+14.7
0.33415	1.48000	1.48633	+14.2	1.49135	+14.1
0.36502	1.47469	1.48089	+14.0	1.48563	+13.6
0.40466	1.46978	1.47575	+13.4	1.48033	+13.2
0.43584	1.46685	1.47248	+12.7	1.47716	+12.9
0.54607	1.46028	1.46575	+12.3	1.47004	+12.2
0.5780	1.45899	1.46429	+11.9	1.46870	+12.1
1.01398	1.45039	1.45562	+11.8	1.45960	+11.5
1.12866	1.44903	1.45426	+11.8	1.45820	+11.4
1.254*	1.44772	1.45283	+11.5	1.45700	+11.6
1.36728	1.44635	1.45140	+11.4	1.45549	+11.4
1.470*	1.44524	1.45031	+11.4	1.45440	+11.4
1.52952	1.44444	1.44961	+11.6	1.45352	+11.3
1.660*	1.44307	1.44799	+11.1	1.45174	+10.8
1.701	1.44230	1.44733	+11.3	1.45140	+11.3
1.981*	1.43863	1.44361	+11.2	1.44734	+10.9
2.262*	1.43430	1.43933	+11.3	1.44306	+10.9
2.553*	1.42949	1.43450	+11.3	1.43854	+11.3
3.00*	1.41995	1.42495	+11.2	1.42877	+11.0
3.245*	1.41353	1.41893	+12.2	1.42243	+11.1
3.37*	1.40990	1.41501	+11.5	1.41915	+11.5

* Wavelength determination by narrow-bandwidth interference filters.
From J. H. Wray and J. T. Neu, *J. Opt. Soc. Am.* **59**, 774 (1969).

These values of *dn/dT* are for Corning No. 7940, ultraviolet grade.

Germanium

TABLE 6b-19. REFRACTIVE INDEX OF GERMANIUM AT 27°C

λ, μm	Single-crystal n	Polycrystal n
2.0581	4.1016	4.1018
2.1526	4.0919	4.0919
2.3126	4.0786	4.0785
2.4374	4.0708	4.0709
2.577	4.0609	4.0608
2.7144	4.0552	4.0554
2.998	4.0452	4.0452
3.3033	4.0369	4.0372
3.4188	4.0334	4.0339
4.258	4.0216	4.0217
4.866	4.0170	4.0167
6.238	4.0094	4.0095
8.66	4.0043	4.0043
9.72	4.0034	4.0033
11.04	4.0026	4.0025
12.20	4.0023	4.0020
13.02	4.0021	4.0018

Adapted from C. D. Salzberg and J. J. Villa, *J. Opt. Soc. Am.* **48**, 579 (1958).

Resistivity is about 50 ohm-cm.

TABLE 6b-20. TEMPERATURE COEFFICIENT OF REFRACTIVE INDEX AT 24.5°C AND RELATIVE TEMPERATURE COEFFICIENT

λ, μm	dn/dT (10^{-4}/°C)	$(1/n)(dn/dT)$ (10^{-4}/°C)
1.934	5.919	1.432
2.174	5.285	1.287
2.246	5.251	1.280
2.401	5.037	1.231

From D. H. Rank, H. E. Bennett, and D. C. Cronemeyer, *J. Opt. Soc. Am.* **44**, 13 (1954).

For computational purposes, a dispersion equation for the wavelength region 0.5 to 6.0 μm is given by M. Herzberger and C. D. Salzberg, *J. Opt. Soc. Am.* **52**, 420 (1962):

$$n = A + BL + CL^2 + D\lambda^2 + E\lambda^4$$

where $L = \dfrac{1}{\lambda^2 - 0.028}$

$A = 3.99931$
$B = 0.391707$
$C = +0.163492$
$D = -0.0000060$
$E = +0.000000053$

Irtrans 1 to 6

TABLE 6b-21. REFRACTIVE INDEX OF IRTRANS 1 to 6

λ, μm	Irtran 1	Irtran 2	Irtran 3	Irtran 4	Irtran 5	Irtran 6	λ, μm	Irtran 1	Irtran 2	Irtran 3	Irtran 4	Irtran 5	Irtran 6
1.0000	1.3778	2.2907	1.4289	2.485	1.7227	2.838	7.0000	1.2934	2.2304	1.3693	2.423	1.5452	2.679
1.2500	1.3763	2.2777	1.4275	2.466	1.7188	2.773	7.2500	1.2865	2.2282	1.3648	2.422	1.5307	2.678
1.5000	1.3749	2.2706	1.4263	2.456	1.7156	2.742	7.5000	1.2792	2.2260	1.3600	2.421	1.5154	2.678
1.7500	1.3735	2.2662	1.4251	2.450	1.7123	2.725	7.7500	1.2715	2.2237	1.3550	2.419	1.4993	2.677
2.0000	1.3720	2.2631	1.4239	2.447	1.7089	2.714	8.0000	1.2634	2.2213	1.3498	2.418	1.4824	2.677
2.2500	1.3702	2.2608	1.4226	2.444	1.7052	2.707	8.2500	1.2549	2.2188	1.3445	2.417	1.4646	2.676
2.5000	1.3683	2.2589	1.4211	2.442	1.7012	2.702	8.5000	1.2460	2.2162	1.3388	2.416	1.4460	2.675
2.7500	1.3663	2.2573	1.4196	2.441	1.6968	2.698	8.7500	1.2367	2.2135	1.3330	2.415	1.4265	2.675
3.0000	1.3640	2.2558	1.4179	2.440	1.6920	2.695	9.0000	1.2269	2.2107	1.3269	2.413	1.4060	2.674
3.2500	1.3614	2.2544	1.4161	2.438	1.6868	2.693	9.2500	......	2.2078	1.3206	2.411	......	2.674
3.5000	1.3587	2.2531	1.4141	2.437	1.6811	2.691	9.5000	......	2.2048	1.3141	2.410	......	2.673
3.7500	1.3558	2.2518	1.4120	2.436	1.6750	2.689	9.7500	......	2.2018	1.3073	2.409	......	2.672
4.0000	1.3526	2.2504	1.4097	2.435	1.6684	2.688	10.0000	......	2.1986	1.3002	2.407	......	2.672
4.2500	1.3492	2.2491	1.4072	2.434	1.6612	2.687	11.0000	......	2.1846	1.2694	2.401	......	2.669
4.5000	1.3455	2.2477	1.4047	2.433	1.6536	2.686	12.0000	......	2.1688	......	2.394	......	2.666
4.7500	1.3416	2.2462	1.4019	2.433	1.6455	2.685	13.0000	......	2.1508	......	2.386	......	2.663
5.0000	1.3374	2.2447	1.3990	2.432	1.6368	2.684	14.0000	......	......	......	2.378	......	2.660
5.2500	1.3329	2.2432	1.3959	2.431	1.6275	2.683	15.0000	......	......	......	2.370	......	2.657
5.5000	1.3282	2.2416	1.3926	2.430	1.6177	2.683	16.0000	......	......	......	2.361	......	2.655
5.7500	1.3232	2.2399	1.3892	2.429	1.6072	2.682	17.0000	......	......	......	2.352		
6.0000	1.3179	2.2381	1.3856	2.428	1.5962	2.681	18.0000	......	......	......	2.343		
6.2500	1.3122	2.2363	1.3818	2.426	1.5845	2.681	19.0000	......	......	......	2.333		
6.5000	1.3063	2.2344	1.3778	2.425	1.5721	2.680	20.0000	......	......	......	2.323		
6.7500	1.3000	2.2324	1.3737	2.424	1.5590	2.680							

From *Kodak Pamphlet* U-71, 1968.

Index of refraction values were experimentally determined at selected wavelengths between 1 and 10 μm. Coefficients of an interpolation formula were established and reduced by least-square methods, and the values computed. All values beyond 10 μm are extrapolated.

Other references give a dispersion equation:

$$n = A + BL + CL^2 + D\lambda^2 + E\lambda^4$$
$$L = \frac{1}{\lambda^2 - 0.028}$$

TABLE 6b-22. CONSTANTS FOR THE DISPERSION EQUATION

Material	Wavelength range, μm		A	$B \times 10^2$	$C \times 10^4$	$D \times 10^5$	$E \times 10^8$
	From	To					
Irtran 1......	1.0	6.7	1.37770	0.1348	+2.16	−150.41	−441
Irtran 2......	1.0	13.5	2.25698	3.2586	+6.79	−52.72	−60.4
Irtran 4......	8.0	14.0	2.43508	5.156757	+24.90192	−27.24521	−9.85413
Irtran 6......	8.0	14.0	2.68238	11.80200	+327.680	−12.0298	+21.773

Constants for Irtrans 1 and 2 are adapted from M. Herzberger and C. D. Salzberg, *J. Opt. Soc. Am.* **52,** 420 (1962). Constants for Irtrans 4 and 6 are from A. I. Funai, *Lockheed Missiles & Space Co. Rept.* LMSC/6-78-68-34, pp. 7–8, 1968.

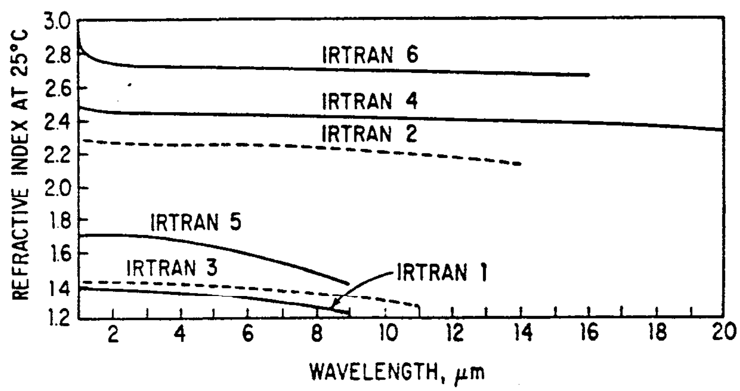

FIG. 6b-5. Refractive index vs. wavelength for Irtrans 1 to 6. *(From Kodak Pamphlet* U-71, 1968.)

The temperature coefficient of refractive index dn/dT of Irtran 4, from 198 to 295 K, has essentially a constant value of 4.8×10^{-5} per K from 3 to 13 μm [adapted from A. R. Hilton and C. E. Jones, *Appl. Opt.* **6,** 1513 (1967)].

Lanthanum Fluoride

TABLE 6b-23. REFRACTIVE INDEX OF LANTHANUM FLUORIDE

λ, μm	n_e (observed)	n_e (computed)	n_o (observed)	n_o (computed)
0.25365	1.64866	1.64866	1.65587	1.65587
0.31315	1.61803	1.61694		1.63639
0.36633	1.61803	1.61694		1.62520
0.40465	1.61184	1.61216	1.61797	1.61733
0.43583	1.60950	1.60916	1.61664	1.61546
0.54607	1.60223	1.60223	1.60597	1.60597

Adapted from M. P. Wirick, *Appl. Opt.* **5**, 1966 (1966).

Dispersion equations:

$$n_e = 1.58330 + \frac{77.850}{\lambda - 1346.5} \qquad n_o = 1.57376 + \frac{153.137}{\lambda - 686.2}$$

A mean value between n_e and n_o of about 1.58 between 0.8 and 2.0 μm is reported by J. B. Mooney, *Infrared Phys.* **6**, 153 (1966).

Lead Fluoride

TABLE 6b-24. REFRACTIVE INDEX OF LEAD FLUORIDE

λ, μm	n	λ, μm	n
0.3088	1.915	0.5711	1.771
0.3188	1.887	0.6259	1.764
0.3338	1.882	0.6930	1.758
0.3462	1.854	0.7775	1.753
0.3645	1.849	0.8861	1.748
0.3810	1.826	1.031	1.744
0.4045	1.824	1.237	1.743
0.4266	1.804	1.545	1.742
0.4565	1.801	12	1.62
0.4876	1.787	15	1.52
0.5277	1.785	18	1.40

The index values from 0.3088 to 1.545 μm are for a 0.8869-μm film of lead fluoride on fused quartz, and were adapted from J. M. Bennett, E. J. Ashley, and H. E. Bennett, *Appl. Opt.* **4**, 961 (1965). The last three values are adapted from B. Welber, *Appl. Opt.* **6**, 925 (1967).

Lithium Fluoride

TABLE 6b-25. REFRACTIVE INDEX OF LITHIUM FLUORIDE

λ, μm	n	λ, μm	n	λ, μm	n
0.1935	1.4450	0.366	1.40121	4.50	1.33875
0.1990	1.4413	0.391	1.39937	5.00	1.32661
0.2026	1.4390	0.4861	1.39480	5.50	1.31287
0.2063	1.4367	0.50	1.39430	6.00	1.29745
0.2100	1.4346	0.80	1.38896	6.91	1.260
0.2144	1.4319	1.00	1.38711	7.53	1.239
0.2194	1.4300	1.50	1.38320	8.05	1.215
0.2265	1.4268	2.00	1.37875	8.60	1.190
0.231	1.4244	2.50	1.37327	9.18	1.155
0.254	1.41792	3.00	1.36660	9.79	1.109
0.280	1.41188	3.50	1.35868		
0.302	1.40818	4.00	1.34942		

Data at a temperature of 20°C for wavelengths 0.193 to 0.231 μm are taken from Z. Gyulai, *Z. Physik* **46**, 84 (1927); at 20°C for 0.254 to 0.486 μm are taken from H. Harting, *Sitzber. Deut. Akad. Wiss. Berlin* **IV**, 1–25 (1948); at 23.6°C for 0.50 to 6.0 μm from L. W. Tilton and E. K. Plyler, *J. Res. NBS* **47**, 25 (1951); at 18°C for 6.91 to 9.79 μm from H. W. Hohls, *Ann. Physik* **29**, 433 (1937). The data for the four spectral regions reported here fit together to within a few parts in the fourth decimal place.

For computational purposes, a dispersion equation for the wavelength range 0.5 to 6.0 μm is given by M. Herzberger and C. D. Salzberg, *J. Opt. Soc. Am.* **52**, 420 (1962):

$$n = A + BL + CL^2 + D\lambda^2 + E\lambda^4$$

where $L = \dfrac{1}{\lambda^2 - 0.028}$

$A = 1.38761$
$B = 0.001796$
$C = -0.000041$
$D = -0.0023045$
$E = -0.00000557$

Magnesium Fluoride

TABLE 6b-26. REFRACTIVE INDEX OF MAGNESIUM FLUORIDE AT 21°C

λ (10^{-4} μm)	n_o	n_e	λ (10^{-4} μm)	n_o	n_e
1,780 ± 2	1.43075	1.45365	5,015.68	1.37972	1.39163
1,849.68	1.43424	1.44797	5,085.82	1.37953	1.39142
2,536.5	1.40208	1.41483	5,460.74	1.37859	1.39043
2,893.59	1.39485	1.4073	5,875.62	1.37774	1.38954
4,046.56	1.38359	1.39566	5,893.7	1.37770	1.38950
4,340.465	1.38215	1.39415	6,234.37	1.37713	1.38889
4,358.35	1.38207	1.39407	6,438.47	1.37681	1.38858
4,471.48	1.38160	1.39357	6,562.79	1.37662	1.38838
4,678.16	1.38082	1.39275	6,678.15	1.37647	1.38822
4,799.92	1.38039	1.39231	6,907.16	1.37618	1.38790
4,921.93	1.37001	1.39192	7,065.25	1.37599	1.38771

The index values from 0.1780 to 0.289359 μm are from D. L. Steinmetz, W. G. Phillips, M. Wirick, and F. F. Forbes, *Appl. Opt.* **6**, 1001 (1967). The values from 0.404656 to 0.706525 are those of A. Duncanson and R. W. H. Stevenson, *Proc. Phys. Soc.* (*London*) **72**, 1001 (1958). The birefringence of magnesium fluoride in the vacuum ultraviolet is discussed by V. Chandrasekharan and H. Damany, *Appl. Opt.* **7**, 939 (1968), and **8**, 671 (1969), and many values are listed.

For computational purposes Duncanson and Stevenson also give two dispersion equations:

$$n_o = 1.36957 + \frac{35.821}{\lambda - 1492.5}$$

$$n_e = 1.38100 + \frac{37.415}{\lambda - 1494.7}$$

TABLE 6b-27. TEMPERATURE COEFFICIENT OF REFRACTIVE INDEX

λ, μm	dn_o/dT (10^{-5}/°C)	dn_e/dT (10^{-5}/°C)
0.4047	+0.23	+0.17
0.7065	+0.19	+0.10

From A. Duncanson and R. W. H. Stevenson, *loc. cit.*

Magnesium Oxide

TABLE 6b-28. REFRACTIVE INDEX OF MAGNESIUM OXIDE AT 23.3°C

λ, μm	n	λ, μm	n
0.36117	1.77318	1.97009	1.70885
0.365015	1.77186	2.24929	1.70470
1.01398	1.72259	2.32542	1.70350
1.12866	1.72059	3.3033	1.68526
1.36728	1.71715	3.5078	1.68055
1.52952	1.71496	4.258	1.66039
1.6932	1.71281	5.138	1.63138
1.7092	1.71258	5.35	1.62404
1.81307	1.71108		

Dispersion equation:

$$n^2 = 2.956362 - 0.01062387\lambda^2 - 0.0000204968\lambda^4 - \frac{0.02195770}{\lambda^2 - 0.01428322}$$

From R. E. Stephens and I. H. Malitson, *J. Res. NBS* **49**, 249 (1952). The earlier measurements of J. Strong and R. T. Brice, *J. Opt. Soc. Am.* **25**, 207 (1935), are discussed therein. A systematic difference in values of n appears to exist, the data of Strong and Brice being about 37×10^{-5} higher.

TABLE 6b-29. TEMPERATURE COEFFICIENT OF REFRACTIVE INDEX

λ, μm	dn/dT (10^{-6}/°C)				
	20°C	25°C	30°C	35°C	40°C
7.679	13.6	13.7	13.8	13.9	14.0
7.065	14.1	14.2	14.3	14.4	14.5
6.678	14.4	14.5	14.6	14.7	14.8
6.563	14.5	14.6	14.7	14.8	14.9
5.893	15.3	15.4	15.5	15.6	15.7
5.461	15.9	16.0	16.1	16.2	16.3
4.861	16.9	17.0	17.1	17.2	17.3
4.358	18.0	18.1	18.2	18.3	18.4
4.047	18.9	19.0	19.1	19.2	19.3

From R. E. Stephens and I. H. Malitson, *loc. cit.*

Muscovite Mica

TABLE 6b-30. REFRACTIVE INDICES OF MUSCOVITE MICA

t = 5.24 μm thick				t = 20.82 μm thick			
λ_F, μm	λ_S, μm	n_F	n_S	λ_F, μm	λ_S, μm	n_F	n_S
0.6665	0.6675	1.590	1.592	0.6960	0.6985	1.598	1.594
0.6188	0.6210	1.594	1.600	0.6316	0.6336	1.593	1.598
0.5573	0.5590	1.595	1.600	0.5539	0.5555	1.596	1.601
0.5082	0.5090	1.600	1.603	0.4935	0.4950	1.600	1.605
0.4538	0.4555	1.602	1.608	0.4600	0.4615	1.062	1.607
0.4320	0.4330	1.608	1.611	0.4310	0.4326	1.604	1.610
t = 13.91 μm thick				t = 48.68 μm thick			
λ_F, μm	λ_S, μm	n_F	n_S	λ_F, μm	λ_S, μm	n_F	n_S
0.6910	0.6930	1.590	1.594	0.6914	0.6935	1.591	1.596
0.5995	0.6010	1.595	1.599	0.6110	0.6125	1.594	1.598
0.5293	0.5308	1.598	1.603	0.5470	0.5487	1.596	1.601
0.4740	0.4754	1.602	1.606	0.4958	0.4971	1.599	1.603
0.4300	0.4308	1.607	1.611	0.4667	0.4680	1.601	1.606
				0.4408	0.4425	1.603	1.609

Adapted from M. A. Jeppeson and A. M. Taylor, *J. Opt. Soc. Am.* **56**, 451 (1966).

The values for the fast and slow rays are for four different thicknesses t.

Potassium Bromide

TABLE 6b-31. REFRACTIVE INDEX OF POTASSIUM BROMIDE AT 22°C

λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n
0.404656	1.589752	1.01398	1.54408	6.238	1.53288	17.40	1.50390
0.435835	1.581479	1.12866	1.54258	6.692	1.53225	18.16	1.50076
0.486133	1.571791	1.36728	1.54061	8.662	1.52903	19.01	1.49703
0.508582	1.568475	1.7012	1.53901	9.724	1.52695	19.91	1.49288
0.546074	1.563928	2.44	1.53733	11.035	1.52404	21.18	1.48655
0.587562	1.559965	2.73	1.53693	11.862	1.52200	21.83	1.48311
0.643847	1.555858	3.419	1.53612	14.29	1.51505	23.86	1.47140
0.706520	1.552447	4.258	1.53523	14.98	1.51280	25.14	1.46324

From R. E. Stephens, E. K. Plyler, W. S. Rodney, and R. J. Spindler, *J. Opt. Soc. Am.* **43**, 111–112 (1953).

Dispersion equation:

$$n^2 = 2.361323 - 0.000311497\lambda^2 - 0.000000058613\lambda^4 + \frac{0.007676}{\lambda^2} + \frac{0.0156569}{\lambda^2 - 0.0324}$$

The average value of the temperature coefficient of refractive index is given as 4.0×10^{-5} per °C.

Potassium Chloride

TABLE 6b-32. REFRACTIVE INDEX OF POTASSIUM CHLORIDE

λ, μm	n	λ, μm	n	λ, μm	n
0.185409	1.82710	0.410185	1.50907	5.3039	1.470013
0.186220	1.81853	0.434066	1.50503	5.8932	1.468804
0.197760	1.73120	0.441587	1.50390	8.2505	1.462726
0.198990	1.72438	0.467832	1.50044	8.8398	1.460858
0.200090	1.71870	0.486149	1.49841	10.0184	1.45672
0.204470	1.69817	0.508606	1.49620	11.786	1.44919
0.208216	1.68308	0.53383	1.49410	12.965	1.44346
0.211078	1.67281	0.54610	1.49319	14.144	1.43722
0.21445	1.66188	0.56070	1.49218	15.912	1.42617
0.21946	1.64745	0.58931	1.49044	17.680	1.41403
0.22400	1.63612	0.58932	1.490443	18.2	1.409
0.23129	1.62043	0.62784	1.48847	18.8	1.401
0.242810	1.60047	0.64388	1.48777	19.7	1.398
0.250833	1.58979	0.656304	1.48727	20.4	1.389
0.257317	1.58125	0.67082	1.48669	21.1	1.379
0.263200	1.57483	0.76824	1.48377	22.2	1.374
0.267610	1.57044	0.78576	1.483282	23.1	1.363
0.274871	1.56386	0.88398	1.481422	24.1	1.352
0.281640	1.55836	0.98220	1.480084	24.9	1.336
0.291368	1.55140	1.1786	1.478311	25.7	1.317
0.308227	1.54136	1.7680	1.475890	26.7	1.300
0.312280	1.53926	2.3573	1.474751	27.2	1.275
0.340358	1.52726	2.9466	1.473834	28.2	1.254
0.358702	1.52115	3.5359	1.473049	28.8	1.226
0.394415	1.51219	4.7146	1.471122		

Dispersion equations (for the ultraviolet and visible, respectively):

$$n^2 = a^2 + \frac{M_1}{\lambda^2 - \lambda_1^2} + \frac{M_2}{\lambda^2 - \lambda_2^2} - k\lambda^2 - h\lambda^4$$

$$n^2 = b^2 + \frac{M_1}{\lambda^2 - \lambda_1^2} + \frac{M_2}{\lambda^2 - \lambda_2^2} - \frac{M_3}{\lambda_3^2 - \lambda^2}$$

$a^2 = 2.174967$	$k = 0.000513495$
$M_1 = 0.008344206$	$h = 0.06167587$
$\lambda_1^2 = 0.0119082$	$b^2 = 3.866619$
$M_2 = 0.00698382$	$M_3 = 5{,}569.715$
$\lambda_2^2 = 0.0255550$	$\lambda_3^2 = 3{,}292.47$

Refractive-index data for the wavelength ranges indicated are from the following sources: (1) 0.185409 to 0.76824 μm at 18°C, F. F. Martens, *Ann. Physik* **6,** 619 (1901); (2) 18.2 to 28.8 μm, H. W. Hohls, *Ann. Physik* **29,** 433 (1937); (3) 0.58932 to 17.680 μm at 15°C, F. Paschen, *Ann. Physik* **26,** 120 (1908). Note that the data of Paschen and of Martens overlap in a small region, and both sets are presented. There is less spread between Hohls's data and Paschen's data than there is among Paschen's data in the region where they join. The fit in this region is good (~0.0005). Paschen also presents two dispersion curves which fit the data of Martens to about five parts in the fifth decimal.

Temperature coefficient of refractive index:

$$n = 1.490443 - (T - 15)0.000034$$

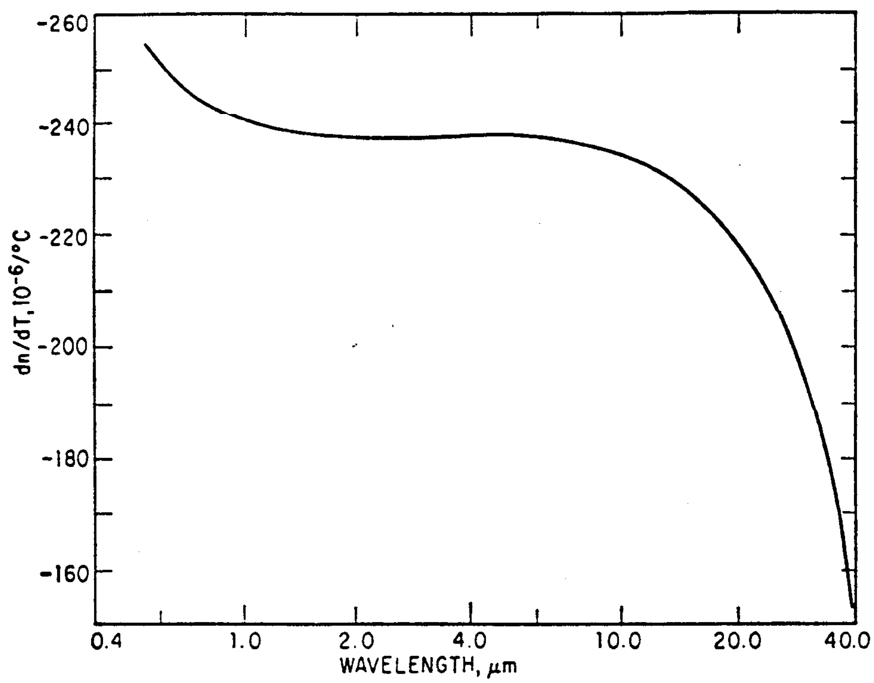

Fig. 6b-6. Average temperature coefficient of refractive index dn/dT of potassium chloride near room temperature. [*From F. Paschen, Ann. Physik* **26**, 120 (1908).]

Potassium Iodide

Table 6b-33. Refractive Index of Potassium Iodide

λ, μm	n	λ, μm	n	λ, μm	n
0.248	2.0548	0.656	1.65809	10.02	1.6201
0.254	2.0105	0.707	1.6537	11.79	1.6172
0.265	1.9424	0.728	1.6520	12.97	1.6150
0.270	1.9221	0.768	1.6494	14.14	1.6127
0.280	1.8837	0.811	1.6471	15.91	1.6085
0.289	1.85746	0.842	1.6456	18.10	1.6030
0.297	1.83967	0.912	1.6427	19	1.5997
0.302	1.82769	1.014	1.6396	20	1.5964
0.313	1.80707	1.083	1.6381	21	1.5930
0.334	1.77664	1.18	1.6366	22	1.5895
0.366	1.74410	1.77	1.6313	23	1.5858
0.391	1.72671	2.36	1.6295	24	1.5819
0.405	1.71843	3.54	1.6275	25	1.5775
0.436	1.70350	4.13	1.6268	26	1.5729
0.486	1.68664	5.89	1.6252	27	1.5681
0.546	1.67310	7.66	1.6235	28	1.5629
0.588	1.66654	8.84	1.6218	29	1.5571
0.589	1.66643				

The values for the wavelengths 0.248 through 1.083 μm are from H. Harting, *Sitzber. Deut. Akad. Wiss. Berlin* IV, 1 (1948); for 1.18 through 29 μm the values are from K. Korth, *Z. Physik* **84,** 677 (1933). The temperature coefficient of refractive index for 0.546 μm in the temperature region 38 to 90°C is -5.0×10^{-5} per °C.

Ruby

TABLE 6b-34. REFRACTIVE INDEX OF RUBY AT 22°C

λ, μm	n_0	n_e
0.4358	1.78115	1.77276
0.5461	1.77071	1.76258
0.5876	1.76822	1.76010
0.6678	1.76445	1.75641
0.7065	1.76302	1.75501

From M. J. Dodge, I. H. Malitson, and A. I. Mahan, *Appl. Opt.* **8,** 1703 (1969).

Several refractive-index values at high temperatures are given by T. W. Houston, L. F. Johnson, P. Kisliuk, and D. J. Walsh, *J. Opt. Soc. Am.* **53,** 1286 (1963).

Sapphire

TABLE 6b-35. REFRACTIVE INDEX OF SAPPHIRE FOR THE ORDINARY RAY AT 24°C

λ, μm	n_0	λ, μm	n_0	λ, μm	n_0	λ, μm	n_0
0.26520	1.83360	0.435834	1.78120	1.52952	1.74660	3.3026	1.70231
0.28035	1.82427	0.546071	1.77078	1.6932	1.74368	3.3303	1.70140
0.28936	1.81949	0.576960	1.76884	1.70913	1.74340	3.422	1.69818
0.29673	1.81595	0.579066	1.76871	1.81307	1.74144	3.5070	1.69504
0.30215	1.81351	0.64385	1.76547	1.9701	1.73833	3.7067	1.68746
0.3130	1.80906	0.706519	1.76303	2.1526	1.73444	4.2553	1.66371
0.33415	1.80184	0.85212	1.75885	2.24929	1.73231	4.954	1.62665
0.34662	1.79815	0.89440	1.75796	2.32542	1.73057	5.1456	1.61514
0.361051	1.79450	1.01398	1.75547	2.4374	1.72783	5.349	1.60202
0.365015	1.79358	1.12866	1.75339	3.2439	1.70437	5.419	1.59735
0.39064	1.78826	1.36728	1.74936	3.2668	1.70356	5.577	1.58638
0.404656	1.78582	1.39506	1.74888				

Adapted from I. H. Malitson, *J. Opt. Soc. Am.* **52,** 1377 (1962).

The refractive index n_e for the extraordinary ray at 1.014 μm was also measured by Malitson and determined to be 1.74794. The birefringence of sapphire in the vacuum ultraviolet is discussed by V. Chandrasekharan and H. Damany, *Appl. Opt.* **7,** 939 (1968), and **8,** 671 (1969); and many values are listed.

Temperature coefficients of index dn/dT were determined from differences between indices measured at 19°C and those at 24°C. The results indicate that the coefficient is positive and decreases from about 20×10^{-6} per °C at the short wavelengths to about 10×10^{-6} per °C near 4μm. An average value of 13×10^{-6} per °C for the visible region was determined from additional measurements made at 17, 24, and 31°C. (From I. H. Malitson, *loc. cit.*)

For computational purposes, Malitson gives a dispersion equation for the wavelength region 0.270 to 5.60 μm:

$$n^2 - 1 = \frac{A_1\lambda^2}{\lambda^2 - \lambda_1^2} + \frac{A_2\lambda^2}{\lambda^2 - \lambda_2^2} + \frac{A_3\lambda^2}{\lambda^2 - \lambda_3^2}$$

TABLE 6b-36. CONSTANTS OF THE DISPERSION EQUATION AT 24°C

$\lambda_1 = 0.06144821$	$\lambda_1^2 = 0.00377588$	$A_1 = 1.023798$
$\lambda_2 = 0.1106997$	$\lambda_2^2 = 0.0122544$	$A_2 = 1.058264$
$\lambda_3 = 17.92656$	$\lambda_3^2 = 321.3616$	$A_3 = 5.280792$

Selenium

TABLE 6b-37. REFRACTIVE INDEX OF SELENIUM AT 23°C (±2°C)

λ, μm	n_o	n_e
1.06	2.790 ± 0.008	3.608 ± 0.008
1.15	2.737 ± 0.008	3.573 ± 0.008
3.39	2.65 ± 0.01	3.46 ± 0.01
10.6	2.64 ± 0.01	3.41 ± 0.01

These values are for single-crystal selenium [from L. Gampel and F. M. Johnson, *J. Opt. Soc. Am.* **59**, 72 (1969)]. For the region 9 to 23 μm, the index values are 2.78 ± 0.02 for the ordinary and 3.58 ± 0.02 for the extraordinary ray with no appreciable variation [from R. S. Caldwell and H. Y. Fan, *Phys. Rev.* **114**, 664 (1959)]. For amorphous selenium in the region 2.5 to 15 μm, index values of 2.46 to 2.38 are referenced by Caldwell and Fan.

Silicon

TABLE 6b-38. REFRACTIVE INDEX OF SILICON AT 26°C

λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n
1.3570	3.4975	2.1526	3.4476	4.00	3.4255	7.50	3.4186
1.3673	3.4962	2.3254	3.4430	4.258	3.4242	8.00	3.4184
1.3951	3.4929	2.4373	3.4408	4.50	3.4236	8.50	3.4182
1.5295	3.4795	2.7144	3.4358	5.00	3.4223	10.00	3.4179
1.6606	3.4696	3.00	3.4320	5.50	3.4213	10.50	3.4178
1.7092	3.4664	3.3033	3.4297	6.00	3.4202	11.04	3.4176
1.8131	3.4608	3.4188	3.4286	6.50	3.4195		
1.9701	3.4537	3.50	3.4284	7.00	3.4189		

From C. D. Salzberg and J. J. Villa, *J. Opt. Soc. Am.* **47**, 244 (1957).

The purity of the silicon sample is not specified. These data are about five parts in the third decimal place lower than those reported by H. B. Briggs, *Phys. Rev.* **77**, 287 (1950). The refractive index of adequately pure (30 ohm-cm) cast polycrystal silicon should have refractive-index values very near those of single crystals.

The relative temperature coefficient of refractive index is $(1/n)\, dn/dT = (3.9 \pm 0.4) \times 10^{-5}$ per °C in a temperature range from 77 to 400 K [from M. Cardona, W. Paul, and H. Brooks, *J. Phys. Chem. Solids* **8**, 204 (1959)].

For computational purposes, a dispersion equation for the wavelength region 1.3 to 11.0 μm is given by M. Herzberger and C. D. Salzberg, *J. Opt. Soc. Am.* **52**, 420 (1962):

$$n = 3.41696 + 0.138497L + 0.013924L^2 - 0.0000209\lambda^2 + 0.000000148\lambda^4$$

where $L = 1/(\lambda^2 - 0.028)$.

Silver Chloride

TABLE 6b-39. REFRACTIVE INDEX OF SILVER CHLORIDE AT 23.9°C

λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n
0.5	2.09648	2.3	2.00465	4.5	1.99866	13.5	1.96133
0.6	2.06385	2.4	2.00424	5.0	1.99745	14.0	1.95807
0.7	2.04590	2.5	2.00386	5.5	1.99618	14.5	1.95467
0.8	2.03485	2.6	2.00351	6.0	1.99483	15.0	1.95113
0.9	2.02752	2.7	2.00318	6.5	1.99339	15.5	1.94743
1.0	2.02239	2.8	2.00287	7.0	1.99185	16.0	1.94358
1.1	2.01865	2.9	2.00258	7.5	1.99021	16.5	1.93958
1.2	2.01582	3.0	2.00230	8.0	1.99847	17.0	1.93542
1.3	2.01363	3.1	2.00203	8.5	1.98661	17.5	1.93109
1.4	2.01189	3.2	2.00177	9.0	1.98464	18.0	1.92660
1.5	2.01047	3.3	2.00151	9.5	1.98255	18.5	1.92194
1.6	2.00931	3.4	2.00126	10.0	1.98034	19.0	1.91710
1.7	2.00833	3.5	2.00102	10.5	1.97801	19.5	1.91208
1.8	2.00750	3.6	2.00078	11.0	1.97556	20.0	1.90688
1.9	2.00678	3.7	2.00054	11.5	1.97297	20.5	1.90149
2.0	2.00615	3.8	2.00030	12.0	1.97026		
2.1	2.00559	3.9	2.00007	12.5	1.96742		
2.2	2.00510	4.0	1.99983	13.0	1.96444		

From L. W. Tilton, E. K. Plyler, and R. E. Stephens, *J. Opt. Soc. Am.* **40**, 540 (1950).

Dispersion equation:

$$n^2 = 4.00804 - 0.00085111\lambda^2 - 0.00000019762\lambda^4 + \frac{0.079086}{\lambda^2 - 0.04584}$$

The temperature coefficient of refractive index is given as approximately 6.1×10^{-5} per °C at 0.61 μm.

Sodium Chloride

TABLE 6b-40. REFRACTIVE INDEX OF SODIUM CHLORIDE

λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n
0.19	1.85343	1.1786	1.53031	4.0	1.52190	12.50	1.47568
0.20	1.79073	1.2016	1.53014	4.1230	1.52156	12.9650	1.47160
0.22	1.71591	1.2604	1.52971	4.7120	1.51979	13.0	1.47141
0.24	1.67197	1.3126	1.52937	5.0	1.51899	14.0	1.46189
0.26	1.64294	1.4	1.52888	5.0092	1.51883	14.1436	1.46044
0.28	1.62239	1.4874	1.52845	5.3009	1.51790	14.7330	1.45427
0.30	1.60714	1.5552	1.52815	5.8932	1.51593	15.0	1.45145
0.35	1.58232	1.6	1.52798	6.0	1.51548	15.3223	1.44743
0.40	1.56769	1.6368	1.52781	6.4825	1.51347	15.9116	1.44090
0.50	1.55175	1.6848	1.52764	6.80	1.51200	16.0	1.44001
0.589	1.54427	1.7670	1.52736	7.0	1.51136	17.0	1.42753
0.6400	1.54141	1.8	1.52728	7.0718	1.51093	17.93	1.4149
0.6874	1.53930	2.0	1.52670	7.22	1.51020	18.0	1.41393
0.70	1.53881	2.0736	1.52649	7.59	1.50850	19.0	1.39914
0.7604	1.53682	2.1824	1.52621	7.6611	1.50822	20.0	1.38307
0.7858	1.53607	2.2464	1.52606	7.9558	1.50665	20.57	1.3735
0.80	1.53575	2.3	1.52594	8.0	1.50655	21.0	1.36563
0.8835	1.53395	2.3560	1.52579	8.04	1.5064	21.3	1.352
0.90	1.53366	2.6	1.52525	8.8398	1.50192	22.3	1.3403
0.9033	1.53361	2.6505	1.52512	9.0	1.50105	22.8	1.318
0.9724	1.53253	2.9466	1.52466	9.00	1.50100	23.6	1.299
1.0	1.53216	3.0	1.52434	9.50	1.49980	24.2	1.278
1.0084	1.53206	3.2736	1.52371	10.0	1.49482	25.0	1.254
1.0540	1.53153	3.5	1.52317	10.0184	1.49462	25.8	1.229
1.0810	1.53123	3.5359	1.52312	11.0	1.48783	26.6	1.203
1.1058	1.53098	3.6288	1.52286	11.7864	1.48171	27.3	1.175
1.1420	1.53063	3.8192	1.52238	12.0	1.48004		

Refractive-index data for rock salt are from the following sources for the indicated wavelengths: the data for wavelengths given with two-figure accuracy (0.19, 0.50, . . .) or three-figure accuracy (10.0, 11.0, . . .) are reported for 20°C by F. Kohlrausch, "Praktische Physik," vol. II, p. 528, B. G. Teubner, Leipzig, 1943; the data reported to four figures (1.299) in index at 18°C (even though they are three figures in wavelength) are from H. W. Hohls, *Ann. Physik* **29**, 433 (1937); other data at 20°C are from W. W. Coblentz, *J. Opt. Soc. Am.* **4**, 443 (1914). Still more data have been published by Langley, Martens, Paschen, Rubens, Trowbridge, Nichols, and others, but all have apparently measured natural crystals of undetermined purity; the data all agree to the fifth decimal place.

TABLE 6b-41. TEMPERATURE COEFFICIENT OF REFRACTIVE INDEX AT ABOUT 60°C

λ, μm	dn/dT (10^{-5}/°C)	λ, μm	dn/dT (10^{-5}/°C)
0.202	3.134	0.589	−3.622
0.206	2.229	0.643	−3.636
0.210	1.570	0.656	−3.652
0.214	0.861	1.1	−3.642
0.219	0.235	1.6	−3.557
0.224	−0.187	2.7	−3.427
0.226	−0.382	3.96	−3.286
0.229	−0.598	4.96	−3.172
0.231	−0.757	6.4	−3.149
0.257	−1.979	8.85	−2.405
0.274	−2.396	10.02	−2.2
0.288	−2.602	11.79	−1.6
0.298	−2.727	12.97	−1.4
0.313	−2.862	14.14	−1.2
0.325	−2.987	14.73	−1.0
0.340	−3.068	15.32	−0.8
0.361	−3.194	15.91	−0.7
0.441	−3.425	17.93	−0.5
0.467	−3.454	20.57	0
0.480	−3.468	22.3	0
0.508	−3.517		

From F. J. Micheli, *Ann. Physik* **4,** 7 (1902) for the region 0.202 through 0.643 μm; from E. Liebreich, *Verhandl. Deut. Physik. Ges.* **13,** 709 (1911) for the region 0.656 through 15.91 μm; and from H. Rubens and E. F. Nichols, *Weid. Ann.* **60,** 454 (1897) for the region 17.93 to 22.3 μm.

Sodium Fluoride

TABLE 6b-42. REFRACTIVE INDEX OF SODIUM FLUORIDE

λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n
0.186	1.3936	0.486	1.32818	3.9	1.309	9.4	1.251
0.193	1.3854	0.546	1.32640	4.1	1.308	9.8	1.241
0.199	1.3805	0.588	1.32552	4.5	1.305	10.3	1.233
0.203	1.3772	0.589	1.32549	4.7	1.303	10.8	1.222
0.206	1.3745	0.656	1.32436	4.9	1.302	11.3	1.209
0.210	1.3718	0.707	1.32372	5.1	1.301	11.7	1.193
0.214	1.3691	0.720	1.32349	5.3	1.299	12.5	1.180
0.219	1.3665	0.768	1.32307	5.5	1.297	13.2	1.163
0.227	1.3630	0.811	1.32272	5.7	1.295	13.8	1.142
0.231	1.3606	0.842	1.32247	5.9	1.294	14.3	1.118
0.237	1.3586	0.912	1.32198	6.1	1.292	15.1	1.093
0.240	1.35793	1.014	1.32150	6.3	1.290	15.9	1.065
0.248	1.35500	1.083	1.32125	6.5	1.288	16.7	1.034
0.254	1.35325	1.27	1.320	6.7	1.286	17.3	1.000
0.265	1.34999	1.48	1.319	6.9	1.284	18.1	0.963
0.270	1.34881	1.67	1.318	7.1	1.281	18.6	0.924
0.280	1.34645	1.83	1.318	7.3	1.279	19.3	0.881
0.289	1.34462	2.0	1.317	7.5	1.277	19.7	0.838
0.297	1.34328	2.2	1.317	7.7	1.274	20.0	0.82
0.302	1.34232	2.4	1.316	7.9	1.272	20.5	0.75
0.313	1.34062	2.6	1.315	8.1	1.269	21.0	0.70
0.334	1.33795	2.8	1.314	8.3	1.266	21.5	0.65
0.366	1.33482	3.1	1.313	8.5	1.263	22.0	0.55
0.391	1.33290	3.3	1.312	8.7	1.261	22.5	0.45
0.405	1.33194	3.5	1.311	8.9	1.258	23.0	0.33
0.436	1.33025	3.7	1.309	9.1	1.252	23.5	0.25
						24.0	0.24

From Alexander Smakula, *U.S. Dept. Comm. Office Tech. Serv. Doc.* 111,052, pp. 88–89, October, 1952, who references these values.

The data fit together well (within a few parts in the fifth decimal place).

TABLE 6b-43. TEMPERATURE COEFFICIENT OF REFRACTIVE INDEX

λ, μm	dn/dT (10^{-5} per °C)	T, °C
0.546	−1.6	18–80
3.5	−1.6	18–80
8.5	−0.7	18–80

From H. W. Hohls, *Ann. Physik* **29**, 433 (1937).

Sodium Nitrate

TABLE 6b-44. REFRACTIVE INDEX OF SODIUM NITRATE

λ, μm	n_o	n_e	λ, μm	n_o	n_e
0.434	1.6126	1.340	0.578	1.5860	1.336
0.436	1.6121	1.340	0.589	1.5840	1.336
0.486	1.5998	1.338	0.656	1.5791	1.334
0.501	1.5968	1.337	0.668	1.5783	1.334
0.546	1.5899	1.336			

From *International Critical Tables*, vol. VII, p. 26, McGraw-Hill Book Company, New York, 1930.

Spinel

TABLE 6b-45. REFRACTIVE INDEX OF SPINEL

λ, μm	n
0.4861	1.736
0.5893	1.727
0.6563	1.724

From Linde Air Products Company Technical Data Sheets.

Strontium Titanate

TABLE 6b-46. REFRACTIVE INDEX OF STRONTIUM TITANATE

λ, μm	n	λ, μm	n
0.404657	2.6481	1.52952	2.2848
0.435834	2.5680	1.7012	2.2783
0.486132	2.4897	1.81307	2.2744
0.546074	2.4346	1.871	2.2710
0.576960	2.4149	1.918	2.2704
0.579066	2.4137	2.1526	2.2624
0.587562	2.4090	2.3126	2.2564
0.589262	2.4081	2.4374	2.2525
0.643847	2.3837	2.5628	2.2466
0.656279	2.3790	2.6707	2.2438
0.667815	2.3750	2.7248	2.2404
0.706519	2.3634	3.2434	2.2211
0.767858	2.3488	3.3026	2.2181
0.85212	2.3337	3.4226	2.2124
0.89440	2.3276	3.5070	2.2088
1.01398	2.3147	3.5564	2.2063
1.12866	2.3055	3.7067	2.1990
1.3622	2.2921	4.2553	2.1680
1.39506	2.2906	5.138	2.1119
1.517	2.2859	5.3034	2.1004

From I. H. Malitson, National Bureau of Standards, private communication, 1960.

Tellurium

TABLE 6b-47. REFRACTIVE INDEX OF TELLURIUM

λ, μm	n_o	n_e	λ, μm	n_o	n_e
4.0	4.929	6.372	9.0	4.802	6.253
5.0	4.864	6.316	10.0	4.796	6.246
6.0	4.838	6.286	12.0	4.789	6.237
7.0	4.821	6.270	14.0	4.785	6.230
8.0	4.809	6.257			

The data are for single-crystal tellurium [from R. S. Caldwell and H. Y. Fan, *Phys. Rev.* **114**, 664 (1959)]. The data of P. A. Hartig and J. J. Loferski, *J. Opt. Soc. Am.* **44**, 17 (1954), may be compared: The latter are probably in error, owing to an averaging effect of the two indices. (Hartig's data are lower for the high index and higher for the low index.) The 8-μm value reported here (the datum of Caldwell) is probably about 0.002 too low.

Thallium Bromide

TABLE 6b-48. REFRACTIVE INDEX OF THALLIUM BROMIDE

λ, μm	n	λ, μm	n
0.438	2.652	0.750	2.350
0.546	2.452	9.98	2.338
0.578	2.424	13.95	2.321
0.589	2.418	19.76	2.321
0.650	2.384	24.39	2.321

The indices in the visible region are from Tom F. W. Barth, *Am. Mineralogist* **14**, 358 (1929). The indices in the infrared region were measured at 45°C by D. E. McCarthy, *Appl. Opt.* **4**, 878 (1965).

Thallium Chloride

TABLE 6b-49. REFRACTIVE INDEX OF THALLIUM CHLORIDE

λ, μm	n	λ, μm	n
0.436	2.400	0.750	2.198
0.546	2.270	10.0	2.193
0.578	2.253	12.47	2.191
0.589	2.247	18.35	2.182
0.650	2.223		

The indices in the visible region are from Tom F. W. Barth, *Am. Mineralogist* **14**, 358 (1929). The indices in the infrared region were measured at 45°C by D. E. McCarthy, *Appl. Opt.* **4**, 878 (1965).

Thallium Bromide-Chloride (KRS-6)

TABLE 6b-50. REFRACTIVE INDEX OF THALLIUM BROMIDE-CHLORIDE

λ, μm	n	λ, μm	n	λ, μm	n
Na-D	2.3367	2.0	2.2059	11.0	2.1723
0.6	2.3294	2.2	2.2039	12.0	2.1674
0.7	2.2982	2.4	2.2024	13.0	2.1620
0.8	2.2660	2.6	2.2011	14.0	2.1563
0.9	2.2510	2.8	2.2001	15.0	2.1504
1.0	2.2404	3.0	2.1990	16.0	2.1442
1.1	2.2321	3.5	2.1972	17.0	2.1377
1.2	2.2255	4.0	2.1956	18.0	2.1309
1.3	2.2212	4.5	2.1942	19.0	2.1236
1.4	2.2176	5.0	2.1928	20.0	2.1154
1.5	2.2148	6.0	2.1900	21.0	2.1067
1.6	2.2124	7.0	2.1870	22.0	2.0976
1.7	2.2103	8.0	2.1839	23.0	2.0869
1.8	2.2086	9.0	2.1805	24.0	2.0752
1.9	2.2071	10.0	2.1767		

From G. Hettner and G. Leisegang, *Optik* **3**, 305 (1948).

The composition of the KRS-6 used was 44 percent thallium bromide and 56 percent thallium chloride.

Thallium Bromide-Iodide (KRS-5)

TABLE 6b-51. REFRACTIVE INDEX OF THALLIUM BROMIDE-IODIDE AT 25°C

λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n	λ, μm	n
0.540	2.68059	1.46	2.40938	5.80	2.37832	15.0	2.35812	22.1	2.33161	26.7	2.30844	31.3	2.28011	35.9	2.24609
0.560	2.64959	1.48	2.40854	6.00	2.37797	15.2	2.35751	22.2	2.33116	26.8	2.30789	31.4	2.27943	36.0	2.24528
0.580	2.62390	1.50	2.40774	6.20	2.37763	15.4	2.35690	22.3	2.33070	26.9	2.30732	31.5	2.27875	36.1	2.24447
0.600	2.60221	1.52	2.40697	6.40	2.37729	15.6	2.35629	22.4	2.33025	27.0	2.30676	31.6	2.27807	36.2	2.24366
0.620	2.58261	1.54	2.40623	6.60	2.37695	15.8	2.35566	22.5	2.32979	27.1	2.30619	31.7	2.27738	36.3	2.24284
0.640	2.56748	1.56	2.40552	6.80	2.37661	16.0	2.35502	22.6	2.32933	27.2	2.30562	31.8	2.27669	36.4	2.24202
0.660	2.55337	1.58	2.40484	7.00	2.37627	16.2	2.35438	22.7	2.32887	27.3	2.30505	31.9	2.27600	36.5	2.24120
0.680	2.54092	1.60	2.40419	7.20	2.37592	16.4	2.35373	22.8	2.32840	27.4	2.30448	32.0	2.27531	36.6	2.24038
0.700	2.52986	1.62	2.40355	7.40	2.37558	16.6	2.35307	22.9	2.32793	27.5	2.30390	32.1	2.27461	36.7	2.23955
0.720	2.51998	1.64	2.40295	7.60	2.37523	16.8	2.35240	23.0	2.32746	27.6	2.30332	32.2	2.27391	36.8	2.23872
0.740	2.51110	1.66	2.40236	7.80	2.37488	17.0	2.35173	23.1	2.32699	27.7	2.30274	32.3	2.27321	36.9	2.23788
0.760	2.50309	1.68	2.40180	8.00	2.37452	17.2	2.35104	23.2	2.32652	27.8	2.30216	32.4	2.27251	37.0	2.23705
0.780	2.49583	1.70	2.40125	8.20	2.37416	17.4	2.35035	23.3	1.32604	27.9	2.30157	32.5	2.27180	37.1	2.23621
0.800	2.48922	1.72	2.40073	8.40	2.37380	17.6	2.34965	23.4	2.32556	28.0	2.30098	32.6	2.27109	37.2	2.23536
0.820	2.48318	1.74	2.40022	8.60	2.37343	17.8	2.34894	23.5	2.32508	28.1	2.30039	32.7	2.27038	37.3	2.23452
0.840	2.47766	1.76	2.39974	8.80	2.37305	18.0	2.34822	23.6	2.32460	28.2	2.29979	32.8	2.26966	37.4	2.23367
0.860	2.47258	1.78	2.39926	9.00	2.37267	18.2	2.34750	23.7	2.32411	28.3	2.29920	32.9	2.26895	37.5	2.23281
0.880	2.46790	1.80	2.39881	9.20	2.37229	18.4	2.34676	23.8	2.32362	28.4	2.29860	33.0	2.26823	37.6	2.23196
0.900	2.46358	1.82	2.39837	9.40	2.37190	18.6	2.34602	23.9	2.32313	28.5	2.29800	33.1	2.26750	37.7	2.23110
0.920	2.45958	1.84	2.39794	9.60	2.37150	18.8	2.34527	24.0	2.32264	28.6	2.29739	33.2	2.26678	37.8	2.23024
0.940	2.45587	1.86	2.39753	9.80	2.37110	19.0	2.34451	24.1	2.32215	28.7	2.29679	33.3	2.26605	37.9	2.22937
0.960	2.45242	1.88	2.39713	10.0	2.37069	19.2	2.34374	24.2	2.32165	28.8	2.29618	33.4	2.26532	38.0	2.22850
0.980	2.44920	1.90	2.39674	10.2	2.37027	19.4	2.34296	24.3	2.32115	28.9	2.29556	33.5	2.26458	38.1	2.22763
1.00	2.44620	1.92	2.39637	10.4	2.36985	19.6	2.34217	24.4	2.32065	29.0	2.29495	33.6	2.26384	38.2	2.22676
1.02	2.44339	1.94	2.39600	10.6	2.36942	19.8	2.34138	24.5	2.32014	29.1	2.29433	33.7	2.26310	38.3	2.22588
1.04	2.44076	1.96	2.39565	10.8	2.36898	20.0	2.34058	24.6	2.31964	29.2	2.29371	33.8	2.26236	38.4	2.22500
1.06	2.43830	1.98	2.39531	11.0	2.36854	20.1	2.34017	24.7	2.31913	29.3	2.29309	33.9	2.26161	38.5	2.22412
1.08	2.43598	2.00	2.39498	11.2	2.36809	20.2	2.33976	24.8	2.31861	29.4	2.29247	34.0	2.26087	38.6	2.22323
1.10	2.43380	2.20	2.39214	11.4	2.36763	20.3	2.33935	24.9	2.31810	29.5	2.29184	34.1	2.26011	38.7	2.22234
1.12	2.43175	2.40	2.38997	11.6	2.36717	20.4	2.33894	25.0	2.31758	29.6	2.29121	34.2	2.25936	38.8	2.22145
1.14	2.42981	2.60	2.38826	11.8	2.36669	20.5	2.33853	25.1	2.31707	29.7	2.29058	34.3	2.25860	38.9	2.22055
1.16	2.42798	2.80	2.38688	12.0	2.36622	20.6	2.33811	25.2	2.31655	29.8	2.28994	34.4	2.25784	39.0	2.21965
1.18	2.42625	3.00	2.38574	12.2	2.36573	20.7	2.33770	25.3	2.31602	29.9	2.28931	34.5	2.25708	39.1	2.21875
1.20	2.42462	3.20	2.38478	12.4	2.36523	20.8	2.33727	25.4	2.31550	30.0	2.28867	34.6	2.25631	39.2	2.21784
1.22	2.42307	3.40	2.38396	12.6	2.36473	20.9	2.33685	25.5	2.31497	30.1	2.28802	34.7	2.25554	39.3	2.21693
1.24	2.42159	3.60	2.38325	12.8	2.36422	21.0	2.33643	25.6	2.31444	30.2	2.28738	34.8	2.25477	39.4	2.21602
1.26	2.42020	3.80	2.38261	13.0	2.36371	21.1	2.33600	25.7	2.31391	30.3	2.28673	34.9	2.25400	39.5	2.21510
1.28	2.41887	4.00	2.38204	13.2	2.36318	21.2	2.33557	25.8	2.31337	30.4	2.28608	35.0	2.25322	39.6	2.21418
1.30	2.41760	4.20	2.38153	13.4	2.36265	21.3	2.33514	25.9	2.31283	30.5	2.28543	35.1	2.25244	39.7	2.21326
1.32	2.41640	4.40	2.38105	13.6	2.36211	21.4	2.33471	26.0	2.31229	30.6	2.28477	35.2	2.25166	39.8	2.21233
1.34	2.41525	4.60	2.38061	13.8	2.36157	21.5	2.33427	26.1	2.31175	30.7	2.28411	35.3	2.25087	39.9	2.21140
1.36	2.41416	4.80	2.38019	14.0	2.36101	21.6	2.33383	26.2	2.31121	30.8	2.28345	35.4	2.25008	40.0	2.21047
1.38	2.41312	5.00	2.37979	14.2	2.36045	21.7	2.33339	26.3	2.31066	30.9	2.28279	35.5	2.24929		
1.40	2.41212	5.20	2.37940	14.4	2.35988	21.8	2.33295	26.4	2.31011	31.0	2.28212	35.6	2.24849		
1.42	2.41117	5.40	2.37903	14.6	2.35930	21.9	2.33251	26.5	2.30956	31.1	2.28145	35.7	2.24769		
1.44	2.41025	5.60	2.37867	14.8	2.35871	22.0	2.33206	26.6	2.30900	31.2	2.28078	35.8	2.24689		

Dispersion equation:

$$n^2 - 1 = \sum_i \frac{K_i \lambda^2}{\lambda^2 - \lambda_i^2}$$

TABLE 6b-52. CONSTANTS OF THE DISPERSION EQUATION AT 25°C

i	λ_i^2	K_i
1	0.0225	1.8293958
2	0.0625	1.6675593
3	0.1225	1.1210424
4	0.2025	0.04513360
5	27,089.737	12.380234

From W. S. Rodney and I. H. Malitson, *J. Opt. Soc. Am.* **46**, 956 (1956).

Data are also given in the reference for temperatures of 19 and 31°C. A comparison of these data, taken with the 45.7 to 54.3 mole percent mixed crystal, is made with the older data taken with 42 to 58 crystal material by L. W. Tilton, E. K. Plyler, and R. E. Stephens, *J. Res. NBS* **43**, 81 (1949). The 45.7 to 54.3 composition, which has the lowest freezing temperature of the binary system, should give the best optical homogeneity.

TABLE 6b-53. TEMPERATURE COEFFICIENT OF REFRACTIVE INDEX

λ, μm	dn/dT (10^{-6}/K)	λ, μm	dn/dT (10^{-6}/K)
0.577	−254	14	−228
1.1	−240	16	−225
2	−238	20	−217
4	−237	25	−207
6	−237	30	−195
8	−236	35	−175
10	−235	40	−152
12	−232		

From A. I. Funai, *Lockheed Missiles & Space Co. Rept.* LMSC/6-78-68-34, p. 46, (1968) who references Rodney and Malitson.

The composition of KRS-5 in Table 6b-52 was 45.7 percent thallium bromide and 54.3 percent thallium iodide.

Titanium Dioxide

TABLE 6b-54. REFRACTIVE INDEX OF RUTILE

λ, μm	n_o	n_e	λ, μm	n_o
0.4358	2.853	3.216	2.0000	2.399
0.4916	2.725	3.051	2.5000	2.387
0.4960	2.718	3.042	3.0000	2.380
0.5461	2.652	2.958	3.5000	2.367
0.5770	2.623	2.921	4.0000	2.350
0.5791	2.621	2.919	4.5000	2.322
0.6907	2.555	2.836	5.0000	2.290
0.7082	2.548	2.826	5.5000	2.200
1.0140	2.484	2.747		
1.5296	2.454	2.710		

Dispersion equation—ordinary ray:

$$n_o^2 = 5.913 + \frac{2.441 \times 10^7}{\lambda^2 - 0.803 \times 10^7}$$

Dispersion equation—extraordinary ray:

$$n_e^2 = 7.197 + \frac{3.322 \times 10^7}{\lambda^2 - 0.843 \times 10^7}$$

For wavelengths between 0.4358 and 1.5296 μm, the calculated refractive-index data from J. R. DeVore, *J. Opt. Soc. Am.* **41**, 418 (1951), are given. The dispersion equations are also due to DeVore; note that wavelength must be specified in angstroms in these equations. The other data are the observed values of W. F. Parsons, private communication. It should be noted that the data of Parsons and of DeVore do not fit together smoothly, probably indicating that there are differences from sample to sample. Data for dn/dT are listed by Alexander Smakula, *U.S. Dept. Comm. Office Tech. Serv. Doc.* 111,052, October, 1952; the original data of Z. Schroeder, *Z. Krist.* **67**, 509 (1928), are quoted herein.

The refractive index of the anastase form of titanium dioxide is discussed by T. N. Krylova and G. O. Bagdyk'yants, *Opt. Spectr. U.S.S.R.* **9**, 339 (1960), and several other references are listed.

Zinc Sulfide

TABLE 6b-55. REFRACTIVE INDICES OF HEXAGONAL ZINC SULFIDE

λ, μm	n_e	n_o	λ, μm	n_e	n_o
0.3600	2.709	2.705	0.5000	2.425	2.421
0.3750	2.640	2.637	0.5250	2.407	2.402
0.4000	2.564	2.560	0.5500	2.392	2.386
0.4100	2.544	2.539	0.5750	2.378	2.375
0.4200	2.525	2.522	0.6000	2.368	2.363
0.4250	2.514	2.511	0.6250	2.358	2.354
0.4300	2.505	2.502	0.6500	2.350	2.346
0.4400	2.488	2.486	0.6750	2.343	2.339
0.4500	2.477	2.473	0.7000	2.337	2.332
0.4600	2.463	2.459	0.8000	2.328	2.324
0.4700	2.453	2.448	0.9000	2.315	2.310
0.4750	2.449	2.445	1.0000	2.303	2.301
0.4800	2.443	2.438	1.2000	2.294	2.290
0.4900	2.433	2.428	1.4000	2.288	2.285

From T. M. Bieniewski and S. J. Czyzak, *J. Opt. Soc. Am.* **53**, 496 (1963).

TABLE 6b-56. REFRACTIVE INDEX OF CUBIC ZINC SULFIDE

λ, μm	n	λ, μm	n
0.4400	2.488	0.6000	2.359
0.4600	2.458	0.6500	2.346
0.4800	2.435	0.7000	2.334
0.5000	2.414	0.9000	2.306
0.5250	2.395	1.0500	2.293
0.5500	2.384	1.2000	2.282
0.5750	2.375	1.4000	2.280

These values are for synthetic cubic zinc sulfide [from S. J. Czyzak, W. M. Baker, R. C. Crane, and J. B. Howe, *J. Opt. Soc. Am.* **47**, 240 (1957)]. Refractive-index values in the wavelength region 0.365 to 1.53 μm for natural cubic zinc sulfide are give by J. R. DeVore, *J. Opt. Soc. Am.* **41**, 416 (1951).

For computational purposes, Czyzak, Baker, Crane, and Howe and give a dispersion equation:

$$n^2 = 5.131 + \frac{1.275 \times 10^7}{\lambda^2 - 0.732 \times 10^7}$$

The hexagonal form of zinc sulfide is called wurtzite, and the cubic form is called sphalerite. Natural-crystal zinc sulfide occurs in the cubic form only and is called sphalerite or zincblende. Note that the birefringence of hexagonal zinc sulfide is very small but fairly constant. Cubic zinc sulfide evidences electro-optic properties.

Group III—Group V Compounds

Gallium Antimonide

TABLE 6b-57. REFRACTIVE INDEX OF GALLIUM ANTIMONIDE

λ, μm	n_D	n_R
1.8	3.820	3.61
1.9	3.802	3.59
2.0	3.789	3.57
2.1	3.780	3.55
2.2	3.764	3.54
2.3	3.758	3.53
2.4	3.755	3.52
2.5	3.749	3.49

From D. F. Edwards and G. S. Haynes, *J. Opt. Soc. Am.* **59**, 414 (1959).

These values are for *p*-type single-crystal gallium antimonide which has a purity corresponding to 7.5×10^{16} carriers/cm^3 measured at room temperature. The refractive index n_D was calculated from the relation for the angle of minimum deviation, with an estimated error of 0.3 percent. The refractive index n_R was deduced from reflectivity measurements, with an error of less than 2 percent. The discrepancy between the values of n_D and n_R is not explained.

Gallium Arsenide

TABLE 6b-58. REFRACTIVE INDEX OF GALLIUM ARSENIDE

λ, μm	n	λ, μm	n
0.78 ± 0.01	3.34 ± 0.04	14.5 ± 0.05	2.82 ± 0.04
8.0 ± 0.05	3.34 ± 0.04	15.0 ± 0.05	2.73 ± 0.04
10.0 ± 0.05	3.135 ± 0.04	17.0 ± 0.05	2.59 ± 0.04
11.0 ± 0.05	3.045 ± 0.04	19.0 ± 0.05	2.41 ± 0.04
13.0 ± 0.05	2.97 ± 0.04	21.9 ± 0.1	2.12 ± 0.04
13.7 ± 0.05	2.895 ± 0.04		

The experimental data seem to be somewhat more scattered than the reported experimental errors indicate. The data are from L. C. Barcus, *Phys. Rev.* **111**, 167 (1958), and L. C. Barcus, Lowell Institute of Technology, private communication. The index is approximately 3.34 from about 2 to 7 μm.

Indium Antimonide

TABLE 6b-59. REFRACTIVE INDEX OF INDIUM ANTIMONIDE

λ, μm	n	λ, μm	n
7.87	4.00	15.13	3.88
8.00	3.99	15.79	3.87
9.01	3.96	16.96	3.86
10.06	3.95	17.85	3.85
11.01	3.93	18.85	3.84
12.06	3.92	19.98	3.82
12.98	3.91	21.15	3.81
13.90	3.90	22.20	3.80

From R. G. Breckenridge, *Phys. Rev.* **96**, 571 (1954).

These values are for a sample of indium antimonide which has a purity corresponding to 2.0×10^{16} carriers/cm^3; measured at room temperature. These data are in agreement with values reported by T. S. Moss, *Proc. Phys. Soc.* (*London*), ser. B, **70**, 776 (1954). The temperature dependence of index of refraction for three different temperatures is given by R. F. Potter, *Appl. Opt.* **5**, 35 (1966).

Nonoxide Chalcogenic Glasses

Arsenic-modified Selenium Glass

TABLE 6b-60. REFRACTIVE INDEX OF ARSENIC-MODIFIED SELENIUM GLASS AT 27°C

λ, μm	n, prism A	n, prism B	λ, μm	n, prism A	n, prism B
1.0140	2.5774	2.5783	7.00	2.4778	2.4787
1.1286	2.5554	2.5565	7.50	......	2.4784
1.3622	2.5285	2.5294	8.10	2.4772	2.4778
1.5295	2.5173	2.5183	8.50	......	2.4775
1.7012	2.5089	2.5100	9.10	2.4765	2.4771
2.1526	2.4950	2.4973	9.50	......	2.4768
3.00	2.4861	2.4882	10.00	2.4756	2.4767
3.4188	2.4841	2.4858	10.50	......	2.4759
4.00	2.4825	2.4835	11.00	2.4752	2.4758
4.50	......	2.4822	11.50	......	2.4753
5.00	2.4803	2.4811	12.00	......	2.4749
5.50	......	2.4804	13.00	......	2.4760[*sic*]
6.00	2.4789	2.4798	13.50	......	2.4748
6.50	......	2.4792	14.00	......	2.4743

From C. D. Salzberg and J. J. Villa, *J. Opt. Soc. Am.* **47**, 244 (1957).

Arsenic Trisulfide Glass

TABLE 6b-61. REFRACTIVE INDEX OF ARSENIC TRISULFIDE GLASS AT 25°C

λ, μm	n	λ, μm	n	λ, μm	n
0.560	2.68689	1.800	2.43009	7.000	2.39899
0.580	2.65934	2.000	2.42615	7.200	2.39806
0.600	2.63646	2.200	2.42318	7.400	2.39709
0.620	2.61708	2.400	2.42086	7.600	2.39610
0.640	2.60043	2.600	2.41898	7.800	2.39508
0.660	2.58594	2.800	2.41742	8.000	2.39403
0.680	2.57323	3.000	2.41608	8.200	2.39294
0.700	2.56198	3.200	2.41491	8.400	2.39183
0.720	2.55195	3.400	2.41386	8.600	2.39068
0.740	2.54297	3.600	2.41290	8.800	2.38949
0.760	2.53488	3.800	2.41200	9.000	2.38827
0.780	2.52756	4.000	2.41116	9.200	2.38700
0.800	2.52090	4.200	2.41035	9.400	2.38570
0.820	2.51483	4.400	2.40956	9.600	2.38436
0.840	2.50928	4.600	2.40878	9.800	2.38298
0.860	2.50418	4.800	2.40802	10.000	2.38155
0.880	2.49949	5.000	2.40725	10.200	2.38007
0.900	2.49515	5.200	2.40649	10.400	2.37855
0.920	2.49114	5.400	2.40571	10.600	2.37698
0.940	2.48742	5.600	2.40493	10.800	2.37536
0.960	2.48396	5.800	2.40414	11.000	2.37369
0.980	2.48074	6.000	2.40333	11.200	2.37196
1.000	2.47773	6.200	2.40250	11.400	2.37018
1.200	2.45612	6.400	2.40166	11.600	2.36833
1.400	2.44357	6.600	2.40079	11.800	2.36643
1.600	2.43556	6.800	2.39991	12.000	2.36446

Dispersion equation: $$n^2 - 1 = \sum_{i=1}^{i=5} \frac{K_i \lambda^2}{\lambda^2 - \lambda_i^2}$$

TABLE 6b-62. CONSTANTS FOR THE DISPERSION EQUATION FOR 25°C

i	λ_i^2	K_i
1	0.0225	1.8983678
2	0.0625	1.9222979
3	0.1225	0.8765134
4	0.2025	0.1188704
5	750	0.9569903

From I. H. Malitson, W. S. Rodney, and T. A. King, *J. Opt. Soc. Am.* **48**, 633 (1958).

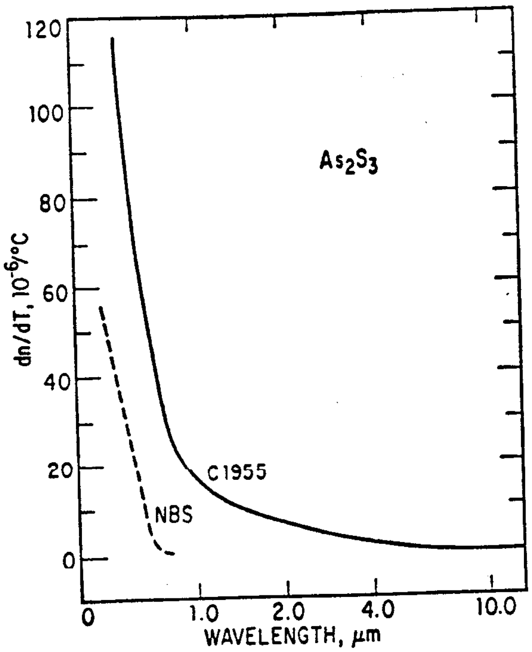

FIG. 6b-7. The temperature coefficient of refractive index dn/dT for two types of arsenic trisulfide glass. [*From I. H. Malitson, W. S. Rodney, and T. A. King, J. Opt. Soc. Am.* **48**, 633 (1958).]

It should be noted that arsenic and sulfur form an entire glass system, with varying properties. Therefore, one should expect different values of transmission, refractive index, and so forth, for samples from different batches.

Special Glasses

Corning Vycor

TABLE 6b-63. REFRACTIVE INDEX VS. TEMPERATURE FOR CORNING NO. 7913 (VYCOR), OPTICAL GRADE

λ, μm	n, 28°C	n, 526°C	dn/dT (10^{-6}/°C)	n, 826°C	dn/dT (10^{-6}/°C)
0.26520	1.49988	1.50799	+16.3	1.51438	+18.2
0.28936	1.49074	1.49831	+15.2	1.50418	+16.8
0.29673	1.48851	1.49587	+14.8	1.50164	+16.5
0.30215	1.48694	1.49423	+14.6	1.49990	+16.2
0.3130	1.48416	1.49121	+14.2	1.49679	+15.8
0.33415	1.47949	1.48622	+13.5	1.49158	+15.2
0.36502	1.47415	1.48065	+13.1	1.48570	+14.5
0.40466	1.46925	1.47547	+12.5	1.48027	+13.8
0.43584	1.46628	1.47234	+12.2	1.47708	+13.5
0.54607	1.45960	1.46544	+11.7	1.46992	+12.9
0.5780	1.45831	1.46407	+11.6	1.46849	+12.8
1.01398	1.44968	1.45526	+11.2	1.45924	+12.0
1.12866	1.44831	1.45373	+10.9	1.45779	+11.9
1.254*	1.44677	1.45222	+10.9	1.45627	+11.9
1.36728	1.44554	1.45095	+10.9	1.45504	+11.9
1.470*	1.44422	1.44965	+10.9	1.45370	+11.9
1.52952	1.44356	1.44896	+10.8	1.45306	+11.9
1.660*	1.44206	1.44750	+11.0	1.45157	+11.9
1.701	1.44137	1.44677	+10.8	1.45088	+11.9
1.981*	1.43750	1.44291	+10.9	1.44702	+11.9
2.262*	1.43298	1.43839	+10.9	1.44258	+12.0
2.553*	1.42825	1.43373	+11.0	1.43824	+12.5

* Wavelength determination by narrow-bandwidth interference filters.
From J. H. Wray and J. T. Neu, *J. Opt. Soc. Am.* **59**, 774 (1969).

TABLE 6b-64. MISCELLANEOUS REFRACTIVE-INDEX DATA

Material	Wavelength Region, μm	Refractive index	Reference
Barium titanate	Visible and infrared	2.40	
Cadmium fluoride	2	1.63	1
	5.5	1.53	1
	11	1.45	1
Cadmium iodide	0.6	2.7	2
Cadmium selenide	1-8	2.45	3
	>8	2.42	3
Cuprous chloride	0.4-20.5	1.93	4
Lead bromide	"White light"	2.53	5
Lead chloride	"Yellow light"	2.2	6
Lead selenide	1-3.5	3.5-4.6	7
	5	4.6	8
Lead sulfide	3.0	4.10 ± 0.06	7
	6.0	4.19 ± 0.06	9
	$dn/dT = 6 \times 10^{-4}$ per °C in the temperature range 20-300°C		9
Lead telluride	1-3.5	4.1-5.3	7
	3.9-20	5.10	10
Rubidium bromide	1-8	1.53	11
Rubidium chloride	1-8	1.48	11
Rubidium iodide	1-8	1.62	11
T-12	"Near infrared"	1.41	12
Gallium phosphide	<1	3.5	13
	1-8	3.2-2.9	13
	>8	2.8	13
Indium arsenide	4-15	3-3.5	14
Indium phosphide	2-15	3-3.5	14
Arsenic triselenide glass	4	2.796	15
	2-16	2.812-2.768	15
Telluride glass (Ge-As-Te)	5	3.5	16
Texas Instruments Glass No. 1173	3.3	2.63	16
	5	2.62	17
	$dn/dT = 79 \times 10^{-6}$ per °C in the region 3-13 μm		17
Cer-Vit material C-101	0.589 at 25°C	1.540	18

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