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APPENDIX I

Safe Handling of Optical Materials

When using any optical material—solid, liquid, or gas—it is always advisable to consult the Material Safety Data Sheet (MSDS). These informative documents prepared by the manufacturer or importer of a hazardous substance describe the physical and chemical properties of the product, are helpful in understanding potential health and physical hazards, and describe how to respond effectively to exposure situations. They include information such as hazardous ingredients, physical data of the material, fire and explosion hazard data, health hazard data, reactivity data, spill or leak procedures, special protection information, and emergency and first aid procedures.

Hazards associated with optical materials depend on how the material is used. This is particularly important in the case of liquids where properties such as viscosity, toxicity, and system compatibility may need to be considered. Within the refractive index range of 1.45 to 1.55 there are so many possible liquids that one can easily choose one with low toxicity. Outside this range of indices the choices of liquid are fewer, thus some degree of toxicity may be unavoidable and the use of ventilation, fume hoods, protective gloves, eye protection, and other protective devices may be mandatory. When working with optical liquids, it is always a good idea to wear appropriate gloves and eye protection and to work where ventilation is sufficient.

The following tables present information about the suitability of various common glove materials for handling liquids and about the flammability of selected liquids.

Resistance to Liquids of Common Glove Materials

Liquid	Natural rubber	Neoprene	Nitrile	Vinyl
acetic acid, $C_2H_4O_2$	excellent	excellent	excellent	excellent
acetone, C_3H_6O	good	good	good	fair
benzene,[a] C_6H_6	poor	fair	good	fair
carbon disulfide, CS_2	poor	poor	good	fair
carbon tetrachloride,[a] CCl_4	poor	fair	good	fair
cyclohexane, C_6H_{12}	fair	excellent	—	poor
diethyl ether, CH_2Cl_2	fair	good	excellent	poor
dimethylsulfoxide,[b] C_2H_6OS	—	—	—	—
ethylene glycol, $C_2H_6O_2$	good	good	excellent	excellent
glycerine (glycerol), $C_3H_8O_3$	good	good	excellent	excellent
hexane, C_6H_{14}	poor	excellent	—	poor
toluene, C_7H_8	poor	fair	good	fair

a Aromatic and halogenated hydrocarbons will attack all types of natural and synthetic glove materials.

b No data are available on the resistance to methylsulfoxide of natural rubber, neoprene, nitrile rubber, or vinyl materials; the manufacturer recommends the use of butyl rubber gloves.

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Flammability of Selected Liquids

Properties listed in the table below:

Boiling point: at a pressure of 101.325 kPa.

Flash point: minimum temperature at which the vapor pressure of the liquid is sufficient to form an ignitable mixture with air near the surface of the liquid.

Ignition temperature (also called autoignition temperature): minimum temperature required for self-sustained combustion in the absence of an external ignition source.

Both the flash point and the ignition temperature are not intrinsic properties but depend on the test conditions. Observed values may differ by several degrees and large uncertainties should be assumed.

Flammability

Liquid	Boiling point (°C)	Flash point (°C)	Ignition temperature (°C)
acetic acid, $C_2H_4O_2$	117.9	39	463
acetone, C_3H_6O	56	-20	465
benzene, C_6H_6	80.0	-11	498
carbon disulfide, CS_2	46	-30	90
cyclohexane, C_6H_{12}	80.7	-20	245
1,2-dichloroethane, $C_2H_4Cl_2$	83.5	13	413
dicloromethane, CH_2Cl_2	40	—	556
diethyl ether, $C_4H_{10}O$	34.5	-45	180
dimethylsulfoxide, C_2H_6OS	189	95	215
1,4-dioxane, $C_4H_8O_2$	101.5	12	180
ethanol, C_2H_6O	78.2	13	363
ethylene glycol, $C_2H_6O_2$	197.3	111	398
glycerine (glycerol), $C_3H_8O_3$	290	199	370
heptane, C_7H_{16}	98.5	—	204
hexane, C_6H_{14}	68.7	-22	225
methanol, CH_4O	64.6	11	464
methylcyclohexane, C_7H_{14}	100.9		250
nitrobenzene, $C_6H_5NO_2$	210.8	88	482
toluene, C_7H_8	110.6	4	480

Data for the above tables are from the *CRC Handbook of Chemistry and Physics*, 82nd ed., Lide, D. R., Ed. (CRC Press, Boca Raton, FL, 2001), p. 16–13 and 16–16. This reference contains extensive data on the flammability of many additional chemical substances.

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References:

The internet site *www.MSDS-Search.com* provides links to all major online MSDS databases.

Other references to the handling and disposition of hazardous materials include:

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Fire Protection Guide to Hazardous Materials, 10th edition, National Fire Protection Association, Quincy, MA (1991).

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APPENDIX II

Abbreviations, Acronyms, Initialisms, and Mineralogical or Common Names of Optical Materials

α-quartz	silicon dioxide (crystal)	SiO_2
αβ-YAG	alphabet YAG	$Y_3Al_5O_{12}:Ho^{3+},Er^{3+},Tm^{3+}$
AANP	2-adamantylamino-5-nitropyridine	
AB5	ammonium pentaborate	$NH_4B_5O_8•4H_2O$
ABS	acrylonitrile, butadiene, styrene terpolymer	$[CH_2CH(CN)]_x$-$[CH_2CHCHCH_2]_y$-$[CH_2CH(C_6H_5)]_z$
acrylic	polymethyl methacrylate	$[CH_2C(CH_3)(COOCH_3)]_n$
ADA	ammonium dihydrogen arsenate	$NH_4H_2AsO_4$
AD*A[a]	deuterated ammonium dihydrogen arsenate	$NH_4(H,D)_2AsO_4$
ADC	allyl diglycol carbonate	$O(CH_2CH_2OCOOCH_2CHCH_2)_2$
ADP	ammonium dihydrogen phosphate	$NH_4H_2PO_4$
AD*P	deuterated ammonium dihydrogen phosphate	$NH_4(H,D)_2PO_4$
AGS	silver gallium silicate	$AgGaS_2$
AGSe	silver gallium sellenide	$AgGaSe_2$
AHC	alkali halide crystal	
alexandrite	Cr-doped chrysoberyl	$BeAl_2O_4:Cr$
ALON	aluminum oxynitride	$5AlN\text{-}9Al_2O_3$
altaite	lead selenide	PbSe
alumina	aluminum oxide	Al_2O_3
AMTIR	amorphous GeAsSe (glass)	GeAsSe
AN	acrylonitrile	$[CH_2CH(CN)]_n$
anatase	titanium dioxide	TiO_2
andalusite	aluminum silicate	Al_2SiO_5
anglesite	lead sulfate	$PbSO_4$
AODCST	alkyl-oxydicyanostyrene	
apatite	calcium phosphate plus fluorine or chlorine	$Ca_5(PO_4)_3(F,OH,Cl)$
APDA	8-(4'-acetylphenyl)-1,4-dioxa-8-azaspiro[4,5]decane	
APO	amorphous polyolefin	$[CH_2CRR']_n$
aragonite	calcium carbonate	$CaCO_3$
ASN	strontium magnesium aluminate	$SrMgAl_{11}O_{19}$
ATCC	allythiourea cadmium chloride	
AZF	alumino-zirco-fluoride (glass)	variable compositions
β"-alumina	beta double-prime alumina	$Na_{1+x}Mg_xAl_{11-x}O_{17}$
BANANAS	barium sodium niobate	$Ba_2NaNb_5O_{15}$

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barite	barium sulfate	$BaSO_4$
BBB	beta barium borate	β-BaB_2O_4
BBcP	2,5-bis(benzylidene) cycloheptanone	
BBO	barium metaborate	BaB_2O_4
BCBF	barium calcium fluoroborate	$BaCaBO_3F$
BCT	barium calcium titanate	$Ba_{0.77}Ca_{0.23}TiO_3$
BEL	lanthanum beryllate	$La_2Be_2O_5$
berlinite	aluminum phosphate	$AlPO_4$
beryl	beryllium aluminum silicate	$Be_3Al_2(SiO_3)_6$
BFAP	barium fluoroapatite	$Ba_5(PO_4)_3F$
BGO	bismuth germanate	$Bi_{12}GeO_{20}$
BGO	bismuth germanium oxide	$Bi_4Ge_3O_{12}$
BIBO	bismuth metaborate	BiB_3O_6
BIG	bismuth substituted iron garnet	$Bi_{3x}Y_{3(1-x)}Fe_5O_{12}$
BIGGSe	barium-indium-gallium-germanium selenide glass	variable compositions
BluB	barium lanthanium borate	$Ba_3La(BO_3)_3$
BMAG	barium magnesium germinate	$Ba_2MgGe_2O_7$
BNB	m-bromonitrobenzene	$Br(C_6H_4NO_2)$
BOV	barium vanadate	$Ba_5(VO_4)_3$
bromellite	beryllium oxide	BeO
bromyrite	silver bromide	AgBr
brookite	titanium dioxide	TiO_2
BSG	borosilicate glass	variable compositions
BSKNN	barium strontium potassium sodium niobate	$Ba_{2-x}Sr_xK_{1-y}Na_yNb_5O_{15}$
BSO	bismuth silicate	$Bi_{12}SiO_{20}$
BST	barium strontium titanate	$Ba_{1-x}Sr_xTiO_3$
BSTN	barium strontium titanium niobate	$Ba_4Sr_2Ti_2Nb_8O_{30}$
BT	barium titanate	$BaTiO_3$
BTO	bismuth titanate	$Bi_{12}TiO_{20}$
BYF	barium yttrium fluoride	BaY_2F_8
BZMA	benzyl methacrylate	$[CH_2C(CH_3)(COOCH_2C_6H_5)]_n$
CAAP	calcium fluoroarsenite	$Ca_{5(}AsO_4)_3F$
CAB	cellulose acetate butyrate	$(C_6H_7O_2)(C_2H_3O_2)_x(C_4H_7O_2)_{y-}(OH)_z$
CaGB	calcium gadolinium borate	$Ca_3Gd_2(BO_3)_4$
calcite	calcium carbonate	$CaCO_3$

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Abbreviations, Acronyms, Initialisms, and Mineralogical or Common Names of Optical Materials—*continued*

CALO	cerium aluminate	$CeAlO_3$
calomel	mercurous chloride	HgCl
CAMGAR	calcium magnesium garnet	$CaY_2Mg_2Ge_3O_{12}$
CAS	calcium aluminum silicate	$Ca_2Al_2SiO_7$
cassiterite	tin oxide	SnO_2
CAT	cadmium triallyd thiource	
CAZGAR	calcium zinc garnet	$CaZn_2Y_2Ge_3O_{12}$
CBN	cubic boron nitride	BN
CBO	cesium triborate	CsB_3O_5
CBS	carbon black suspension	C + liquid
CDA	cesium dihydrogen arsenate	CsH_2AsO_4
CD*A	deuterated cesium dihydrogen arsenate	$Cs(H,D)_2AsO_4$
cerargyrite	silver chloride	AgCl
cerussite	lead carbonate	$PbCO_3$
CGA	cadmium germanium arsenate	$CdGeAs_2$
CGS	calcium gallium silicate	$Ca_2Ga_2SiO_7$
ChG	chalcogendie glass	variable compositions
chrysoberyl	beryllium aluminate	$BeAl_2O_4$
cinnabar	mercury sulfide	HgS
CIS	copper indium diselenide	$CuInSe_2$
CIGS	copper indium gallium diselenide	$CuIn_{1-x}Ga_xSe_2$
CLBO	cesium lithium triborate	$CsLi(BO_3)_3O$
CMP-M	2-cyano-3-(2-methyl phenyl)-propenoic acid methyl ester	
CMT	cadmium mercury telluride	$Cd_{1-x}Hg_xTe$
CNGG	calcium niobate gallium garnet	$Ca_3(NbLiGa)_5O_{12}$
COANP	2-cyclo-octylamino-5-nitropyridine	
colquiriite	lithium calcium aluminum fluoride	$LiCaAlF_6$
corundum	aluminum oxide, alumina	Al_2O_3
cotunnite	lead chloride	$PbCl_2$
CPAP	calcium fluoroapatite	$Ca_5(PO_4)_3F$
CPF	calcium fluoroapatite	$Ca_5(PO_4)_3F$
CR 39	allyl diglycol carbonate	$[O(CH_2CH_2OCOOCH_2CHCH_2)_2]_n$
cristobalite	silica (allotropic form)	SiO_2
cryolite	sodium fluoroaluminate	Na_3AlF_6
CS-FAP	calcium-strontium fluoroapatite	$(Ca,Sr)_5(PO_4)_3F$
CTA	cesium titanyl arsenate	$CsTiOAsO_4$

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Abbreviations, Acronyms, Initialisms, and Mineralogical or Common Names of Optical Materials—*continued*

CTH:YAG	chromium-thulium-holmium doped YAG	$Y_3Al_5O_{12}$:Cr,Tm,Ho
CTP	cesium titano phosphnate	$CsTiOPO_4$
cunyite	calcium germanate	Ca_2GeO_4
CVAP	calcium fluorovandate	$Ca_{5(}VO_4)_3F$
CWO	cadmium tungstate	$CdWO_4$
CYB	calcium yttrium borate	$Ca_3Y_2(BO_3)_4$
CYS	calcium yttrium silicate oxyapatite	$CaY_4(SiO_4)_3O$
CZ	cubic zirconia	ZrO_2
CZT	cadnium zinc telluride	(Cd,Zn)Te
DAN	4-(*N,N*-dimethylamino)-3-nitroacetanilide	
DANS	4-di-methylamino-4'-nitrostilbene	
DAST	dimethylamino-*N*-methyl-4-stilbazolium-tosylate	
DBNMNA	2,6-dibromo-*N*-methyl-4-nitroailne	
DCANP	2-docosylamino-5-nitropyridine	
D-CDA	deuterated cesium dihydrogen arsenate	$Cs(H,D)_2AsO_4$
DCM	4-dicyanomethylene-2-methyl-6-dimethylamino-4'-nitrostyrene	
DCMNA	2-docosyl-2-methyl-4-nitroaniline	
DEANS`	4-di-ethylamino-4'-nitrostilbene	
DEANST	4-(*N,N*-diethylamino)-*b*-nitrostyrene	
diamond	carbon	C
diopside	calcium magnesium silicate	$CaMgSi_2O_6$
D-KB5	deuterated potassium pentaborate	$KB_5O_8•4D_2O$
D-KDA	deuterated potassium dihydrogen arsenate	$K(H,D)_2AsO_4$
D-KDP	deuterated potassium dihydrogen phosphate	$K(H,D)_2PO_4$
D-LAP	deuterated L-arginine phosphate	$[C_6H_{7+x}D_{8-x}N_4O_2]^+•H_2PO_4.H_2O$
DMC	7-dimethylamino-4-methylcoumarin	$C_{14}H_{17}NO_2$
DMNP	3,5-dimethyl-1-(4 nitrophenylpyrzole	
DMSM	trans-4'-dimethylamino-*N*-methyl-4-stilbazolium methyl sulfate	
dolomite	calcium magnesium carbonate	$CaMg(CO_3)_2$
D-RDA	deuterated rubidium dihydrogen arsenate	$Rb(H,D)_2AsO_4$
DTGS	deuterated triglycine sulfate	$[N(H,D)_2CH_2COOH)_3•H_2SO_4$
ECOB	erbium calcium oxyborate	$ErCa_4(BO_3)_3O$
EDDT	ethylene diamine dextrotartrate	$C_6H_{14}N_2O_6$
elpasolite	potassium sodium aluminum fluoride	K_2NaAlF_6

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Abbreviations, Acronyms, Initialisms, and Mineralogical or Common Names of Optical Materials—*continued*

emerald	Cr-doped beryl	$Be_3Al_2Si_6O_{18}$:Cr
eulytite	bismuth silicate	$Bi_4Si_3O_{12}$
EVA	ethylene-vinyl acetate	$[CH_2CH_2]_x$-$[CH_2CH(OCOCH_3)]_v$
EYAB	erbium yttrium aluminum borate	$YAl_3(BO_3)_4$:Er
FAG	fluoroaluminate glass	variable compositions
FAP	calcium fluoroapatite	$Ca_5(PO_4)_3F$
FEP	perfluorinated ethylene propylene	
fluorapatite	calcium phosphate fluoride	$Ca_5(PO_4)_3(F,Cl,OH)$
fluorite	calcium fluoride	CaF_2
forsterite	magnesium silicate	Mg_2SiO_4
fused quartz	silicon dioxide (amorphous)[(b)]	SiO_2
fused silica	silicon dioxide (amorphous)	SiO_2
GAB	gadolinium aluminate borate	$GdAl_3(BO_3)_4$
gahnite	zinc aluminate	$ZnAl_2O_4$
galena	lead sulfide	PbS
garnet	complex family of mineral compositions	$A_3B_2C_3O_{12}$
GASH	quanidinium aluminate sulfate hexahydrate	$(CN_3H_6)Al(SO_4)_2 \cdot 6H_2O$
g-C	graphite	C
gelenite	calcium aluminium silicate	$Ca_2Al_2SiO_7$
GFG	gallium fluoride garnet	$Na_3Ga_2Li_3F_{12}$
GGG	gadolinium gallium garnet	$Gd_3Ga_5O_{12}$
GIGG	gadolinium indium gallium garnet	$Gd_3In_2Ga_3O_{12}$
GLF	gadolinium lithium tetrafluoride	$GdLiF_4$
GLS	generating luminescence stekla (Russian)	laser glass
GLS	gallium lanthanum sulfide (glass)	$\sim 70GaS–30La_2O_3$
GOS	gadolinium oxysulfide	Gd_2O_2S
greenockite	cadmium sulfide	CdS
grossularite	calcium aluminum silicate garnet	$Ca_3Al_2Si_3O_{12}$
GSAG	gadolinium scandium aluminum garnet	$Gd_3Sc_2Al_3O_{12}$
GSGG	gadolinium scandium gallium garnet	$Gd_3(Sc,Ga)_2Ga_3O_{12}$
GSO	gadolinium orthosilicate	Gd_2SiO_5
GVO	gadolimium vanadate	$GdVO_4$
GYAG	gadolimium-yttrium luminum garnet	$(Gd,Y)_3Al_5O_{12}$
halite	sodium chloride	NaCl
HAP	high-average-power (laser) glass	variable compositions
hematite	ferric oxide	Fe_2O_3
HMF	heavy metal fluoride (glass)	variable compositions

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HMO	heavy metal oxde (glass)	variable compositions
HPP glass	high-peak-power (laser) glass	variable compositions
hydroxy-apatite	calcium phosphate hydroxide	$Ca_5(PO_4)_3OH$
ilmenite	iron titanate	$FeTiO_3$
iodyrite	silver iodide	β-AgI
Irtran 1	magnesium fluoride (polycrystalline)	MgF_2
Irtran 2	zinc sulfide (polycrystalline)	ZnS
Irtran 3	calcium fluoride (polyscrystalline)	CaF_2
Irtran 4	zinc selenide (polycrystalline)	ZnSe
Irtran 5	magnesium oxide (polycrystalline)	MgO
Irtran 6	cadmium tellurite (polycrystalline)	CdTe
ITO	indium tin oxide	$\sim 0.9In_2O_3–0.1SnO_2$
KABO	potassium aluminum borate	$K_2Al_2B_2O_7$
KAP	potassium acid phthalate	$C_8H_5O_4K$
KB5	potassium pentaborate	$KB_5O_8•4H_2O$
KBBF	potassium beryllium borate fluoride	$KBeBO_3F_2$
KCND	potassium cerium nitrate dihydrate	$K_2Ce(NO_3)_5.H_2O$
KDA	potassium dihydrogen arsenate	KH_2AsO_4
KD*A[a]	deuterated potassium dihydrogen arsenate	$K(H,D)_2AsO_4$
KDP	potassium dihydrogen phosphate	KH_2PO_4
KD*P[a]	deuterated potassium dihydrogen phosphate	$K(H,D)_2PO_4$
KGW	potassium gadolinium tungstate	$KGd(WO_4)_2$
KLGF	potassium lithium gadolinium fluoride	$KLiGdF_5$
KLN	potassium lithium nitrate	$K_3Li_2\text{-}xNb_{5+x}O_{15+2x}$
KLND	potassium lanthanum nitrate dihydrate	$K_2La(NO_3)_5.2H_2O$
KLTN	potassium lithium tantalate niobate	$K_{1-y}Li_yTa_{1-x}Nb_xO_3$
KLYF	potassium lithium yttrium fluoride	$KLiYF_4$
KN	potassium niobate	$KNbO_3$
KNB	potassium niobium borate	$KNbB_2O_6$
KNLF	potassium neodymium lithium fluoride	$K_5NdLi_2F_{10}$
KNSBN	potassium sodium strontium barium niobate	$(K_xNa_{1-x})_{0.4}(Sr_yBa_{1-y})_{0.8}Nb_2O_6$
KRS-5	thallium bromoiodide	$Tl(Br_{1-x},I_x)$
KRS-6	thallium chlorobromide	$Tl(Cl_{1-x},Br_x)$
KRTA	potassium-rubidium titanyl arsenate	$(K,Rb)TiOAsO_4$
KSAG	lutetium scadium aluminum garnet	$Lu_3Cs_2Al_5O_{12}$
KTA	potassium titanyl arsenate	$KTiOAsO_4$

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KTN	potassium tantalate niobate	$KTa_{1-x}Nb_xO_3$
KTP	potassium titanyl phosphate	$KTiOPO_4$
KTP-GTR	potassium titanyl phosphate-greytrack resistant	$KTiOPO_4$
kyanite	aluminum silicate	Al_2SiO_5
KYF	potassium yttrium fluoride	KYF_4
LABO	lanthanum metaborate	LaB_3O_6
LAP	L-arginine phosphate	$[C_6H_{15}N_4O_2]^+ \cdot H_2PO_4^- \cdot H_2O$
LB	Langmuir–Blodgett (film)	various compositions
LBG	lanthanium boron germanium oxide	$LaBGeO_5$
LBO	lithium triborate	LiB_3O_5
LC	liquid crystal	various compositions
Lexan	polycarbonate plastic	$[OCOOC_6H_4C(CH_3)_2C_6H_4]_n$
LFM	lithium formate monohydrate	$LiHCO_2 \cdot H_2O$
LGO	lithium germanate	Li_2GeO_5
LGS	lanthanum gallium silicate	$La_3Ga_5SiO_{14}$
LI	lithium iodate	$LiIO_3$
LiBAF	lithium barium aluminum fluoride	$LiBaAlF_6$
LiCAF	lithium calcium aluminum fluoride	$LiCaAlF_6$
LiChrom	lithium strontium chromium fluoride	$LiSrCrF_6$
LiSAF	lithium strontium aluminum fluoride	$LiSrAlF_6$
LiSGaF	lithium strontium gallium fluoride	$LiSrGaF_6$
litharge	lead oxide	PbO
LLF	Lutetium lithium fluoride	$LuLiF_4$
LLGG	lanthanum lutetium gallium garnet	$(La,Lu)_3(Lu,Ga)_2Ga_3O_{12}$
LMA	lanthanum magnesium hexaluminate	$LaMgAl_{11}O_{19}$
LN	lithium niobate	$LiNbO_3$
LNA	lanthanum neodymium hexaluminate	$LaMgAl_{11}O_{19}$:Nd
LNP	lithium neodymium tetraphosphate	$LiNdP_4O_{12}$
LNPP	lanthum neodymium pentaphosphate	$La_{1-x}Nd_xP_5O_{14}$
LOP	lutetium orthophosphate	$LuPO_4$
LSB	lanthanium scandium borate	$LaSc_3(BO_3)_4$
LSO	lutetium silicon oxide (orthosilicate)	Lu_2SiO_5
LT	lithium tantalate	$LiTaO_3$
LuAG	lutetium aluminum garnet	$Lu_3Al_5O_{12}$
Lucalox	alumina (polycrystalline)	Al_2O_3
magnesite	magnesium carbonate	$MgCO_3$

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magnetite	iron oxide	Fe_3O_4
MAP	methyl-(2,4-dinitrophenyl)-aminopropanoate	$C_{10}H_{12}N_3O_6$
massicot	lead oxide	PbO
MBANP	2-(a-methyl benzylamino)-5-nitropyridine	
MBBF	alkali metal beryllium borate fluoride	$(Na,K)BeBO_3F_2$
MCT	mercury cadmium telluride	HgCdTe
MEH-PPV	poly(2-methoxy-5-(2'-ethyl-hexyloxy)-1,4-phenylene vinylene	
Mg:LN	MgO-doped lithium niobate	$Mg:LiNbO_3$
Mg:SLN	MgO-doped stoichiometric lithium niobate	$Mg:LiNbO_3$
mica	potassium aluminosilicate	$KAl_3Si_3O_{10}.(OH)_2$
MMA	methylmethacrylate	$CH_2C(CH_3)(COOCH_3)$
MMONS	3-methyl-4-methoxy-4'-nitrostilbene	
MNA	2 methyl-4-nitro-aniline	$CH_3NH_2NO_2C_6H_4$
MND	4-methoxy-4'-nitro-diphenyl-diacetylene-	
MNMA	2-methyl-4-nitro-*N*-methylaniline	
MNT	4-methyl-4'-nitrolan	
monazite	rare earth phosphate	$(rare\ earth)PO_4$
MPMMA	modified polymethylmethacrylate	
MSO	magnesium silicate	Mg_2SiO_4
MTTNPH	5-methylthio-thiophenecarboxaldehyde-4-nitrophenyl-hydrazone	
mullite	aluminum silicate	$Al_6Si_2O_{13}$
NAB	neodymium aluminum borate	$NdAl_3(BO_3)_4$
nantokite	copper chloride	CuCl
NAS	methyl methacrylate styrene copolymer	$[CH_2C(CH_3)(COOCH_3)]_x$-$[CH_2CH(C_6H_5)]_y$
NBD-Cl	7-chloro-4'-nitrobenzo-2-oxa-1,3-diazole	
NdPP	neodymium pentaphosphate	NdP_5O_{14}
NGAB	neodymium gadolinium aluminum borate	$Nd_xGd_{1-x}Al_3(BO_3)_4$
NMBA	4-nitro-4'-methyl-benzylidene aniline	
NPP	*N*-4-nitrophenyl-(L,S)-prolinol	
NPP	neodymium pentaphosphate	NdP_5O_{14}
NPPA	*N*-(4-nitro-2-pyridinyl)-phenylalaninol	
NYAB	neodymium yttrium aluminum borate	$Nd_xY_{1-x}Al_3(BO_3)_4$
olivine	magnesium iron silicate	$(Mg,Fe)_2SiO_4$
ORMOSIL	organic modified silicate	SiO_2

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orpiment	arsenic trisulfide	As_2S_3
PAMS	poly(alpha-methylstyrene)	
paratelluride	tellurium oxide	TeO_2
PBDG	poly(g-benzl-D-glutamate)	
PBLG	poly(g-benzl-L-glutamate)	
PBN	lead barium niobate	$Pb_{1-x}Ba_xNb_2O_6$
PBSP	photonic band-gap structure	variable compositions
PBT	polybenzothiazole	$[C_6H_3NSC]_n$
PBZT	poly(p-phenylene benzo bis thiozole)	
PCS	plastic clad silica	
PDA	polydiacetylene	$[C(R)CCC(R)]_n$
PDBT	poly(3,4-dibutoxythiophene	
PDHG	poly(di-*n*-hexylgermane)	
PDHS	poly(di-*n*-hexylsilane)	
PDLC	polymer dispersed liquid crystal	variable compositions
periclase	magnesium oxide	MgO
perovskite	calcium titanate	$CaTiO_3$
PET	pentaery-thritol	$[OCH_2CH_2OOCC_6H_4CO]_n$
PGO	lean germanium oxide	$Pb_5Ge_3O_{11}$
plattnerite	lead oxide	PbO
PLZT	lead lanthanum zirconium titanate	$PbLa(Zr,Ti)O_3$
PMMA	polymethylmethacrylate	
PMPS	poly(methyl phenyl silane)	
PNP	2-(*N*-prolinol)-5-nitropyridine	
POF	plastic optical fiber	variable compositions
poly-4BCMU	polydiacetylene poly-[5,7-dodecadiyn-2,12-diol-bis(*n*-butoxycarbonyl-methyl-urethane]	
POM	3-methyl-4-nitropyridine-1-oxide	NO_2• $CH_3NOC_5H_4$
POMT	poly(3-octyloxy,4-methyl thiophene)	
PSC	porous silicon carbide	SiC
powellite	calcium molybdate	$CaMoO_4$
PPKTP	periodically poled potassium titanyl phosphate	$KTiOPO_4$
PPLN	periodically poled lithium niobate	$LiNbO_3$
PPLT	periodically poled lithium tantalate	$LiTaO_3$
PPNA	poly-*p*-nitroaniline	
PPRTA	periodically poled rubidium titanyl arsenate	$RbTiOAsO_4$
PPV	poly(*p*-phenylene vinylene)	

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Abbreviations, Acronyms, Initialisms, and Mineralogical or Common Names of Optical Materials—*continued*

proustite	silver arsenic sulfide	Ag_3AsS_3
PrPP	praseodymium pentaphosphate	PrP_5O_{14}
PS	polystyrene	$[CH_2CH(C_6H_5)]_n$
PSG	porous silica glass	SiO_2
PSZ	partially stabilized zirconia	ZrO_2: (Mg,Ca,Y)
PT	polythiophene	
PTB	lead tetraborate	PbB_4O_7
PTG	poly(3-hexylthiophene	
PTOPT	poly-[3-(4-octylphenyl)]-2,2'-bithiophene	
PTS	poly-bis-(*p*-toluene sulfonate)-2,4-hexazine -1,6-diole	
PTV	poly(2,5-thienyl vinylene)	
PU	polyurethane	$[OCONHRNHCOOR']_n$
pucherite	bismuth vanadate	$BiVO_4$
PV	polyvinylxylene	$[CH_2CH(CH_2C_6H_4CH_3)]_n$
PVA	polyvinyl alcohol	
PVF_2	polyvinylidene fluoride	
PVP	polyvinyl-pyrrolidimone	
pyrite	iron sulfide	FeS_2
PZT	lead zirconium titanate	$Pb(Zr,Ti)O_3$
QC	quantum crystallite (quantum dot)	
quartz	silicon dioxide (crystal)	SiO_2
RAP	rubidium acid phthalate	$C_8H_5O_4Rb$
RB5	rubidium pentaborate	$RbB_5O_8 \cdot 4H_2O$
RbAP	rubidim acid phthalate	$CO_2HC_6H_4CO_2Rb$
RDA	rubidium dihydrogen arsenate	RbH_2ASO_4
RD*A	deuterated rubidium dihydrogen arsenate	$Rb(H,D)_2AsO_4$
RDP	rubidium dihydrogen phosphate	RbH_2PO_4
RD*P	deuterated rubidium dihydrogen phosphate	$Rb(H,D)_2PO_4$
RGB	rubidium gadolinium bromide	$RbGd_2Br_7$
rochelle salt	sodium potassium tartrate	$NaKC_4H_4O_6 \cdot 4H_2O$
rocksalt	sodium chloride	NaCl
RTA	rubidium titanyl arsenate	$RbTiOAsO_4$
RTP	rubidium titanyl phosphate	$RbTiOPO_4$
ruby	Cr-doped corundum (sapphire)	Al_2O_3:Cr
rutile	titanium dioxide	TiO_2
SAN	styrene acrylonitrile copolymer	$[CH_2CH(C_6H_5)]_x$-$[CH_2CH(CN)]_v$

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Abbreviations, Acronyms, Initialisms, and Mineralogical or Common Names of Optical Materials—*continued*

sapphire	aluminum oxide	Al_2O_3
sapphire	aluminum oxide (gemstone)	Al_2O_3:Ti,Fe
SBA	sodium-β" alumina	$Na_{1+x}Mg_xAl_{11-x}O_{17}$
SBBO	strontium beryllium borate	$Sr_2Be_2B_2O_7$
SBN	strontium barium niobate	$Sr_{1-x}Ba_xNb_2O_6$
SCAB	scandium aluminum beryllate	$ScAlBeO_4$
scheelite	calcium tungstate	$CaWO_4$
SDG	semiconductor-doped glass	variable compositions
sellaite	magnesium fluoride	MGF_2
S–FAP	strontium fluoroapatite	$Sr_5(PO_4)_3F$
SGGM	strontium gadolinium gallium melilite	$SrGdGaO_7$
silica	silicon dioxide	SiO_2
SIMOX	separation by implanation of oxygen (silicon-on-insulator material)	
SLG	strontium lanthanum gallate	$SrLaGa_3O_7$
SMA	polystyrene co-maleic anhydride	$[CH_2CH(C_6H_5)CH(COOCO)CH]_n$
SMMA	polystyrene co-methyl methacrylate	$[CH_2C(CH_3)(COOCH_3)]_x$-$[CH_2CH(C_6H_5)]_y$
SNA	strontium aluminate	$SrAl_{12}O_{19}$
SOAP	calcium silico-oxyapatite	$CaY_4(SiO_4)_3O$
SOI	silicon-on-insulator (material)	
SOS	silicon (Si) epitaxial film on sapphire substrate	Si/Al_2O_3
SPAP	strontium fluoroapatite	$Sr_5(PO_4)_3F$
SPF	strontium fluoroapatite	$Sr_5(PO_4)_3F$
spodumene	lithium aluminum silicate	$LiAlSi_2O_6$
sphalerite	zinc sulfide (cubic)	ZnS
STRAP	strontium fluoroapatite	$Sr_5(PO_4)_3F$
sphalerite	zinc sulfide	ZnS
spinel	magnesium aluminate	$MgAl_2O_4$
spodumene	lithium aluminum silicate	$LiAlSi_2O_6$
SrYBO	strontium yttrium borate	$Sr_3Y(BO_3)_3$
styrene	polystyrene	
STZO	strontium titanate zironate	$\sim 0.8SrTiO_3–0.2ZrO_2$
S-VAP	strontium vanadium fluoroapatite	$Sr_5(VO_4)_3F$
sylvite	potassium chloride	KCl
SYS	strontium yttrium silicate oxyapatite	$SrY_4(SiO_4)_3O$
T-12	barium fluoride-calcium fluoride	BaF_2-CaF_2

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TAS	thallium arsenic selenide	Tl_3AsSe_3
TBPc	tetrakis (tert-butyl) phthalocyanine	
TCDMA	tricyclodecyl co-methacrylate	$[CH_2C(CH_3)(COOC_{10}H_{15})]_n$
TCO	transparent conductive oxide	e.g., ITO
TCNQ	7,7,8,8-tetracyanoquinodimethane	
TEOS	tetraethyl orthosilicate	$(C_2H_5O)_4Si$
TeX	tellurium halide glass	variable composition
TGG	terbium gallium garnet	$Tb_3Ga_5O_{12}$
TGS	triglycine sulfate	$(NH_2CH_2COOH)_3 \cdot H_2SO_4$
TGSe	triglycine selenate	
THAM-P	tris-hydroxylmethylaminomethane-phosphate	
THAM-S	tris-hydroxylmethylaminomethane-sulfate	
TiOPc	titanyl pthalocyanine	
Ti:S	Ti-doped corundum/alumina	Al_2O_3:Ti
Ti sapphire	Ti-doped corundum/alumina	Al_2O_3:Ti
TlAP	thallium acid phthalate	$C_8H_5O_4Tl$
TMOS	tetramethyloxysilane	$Si(OCH_3)_4$
TOC	transparent optical ceramic	various compositions
topaz	aluminum silicate fluoride hydroxide	$Al_2SiO_4(F,OH)_2$
tourmaline	sodiun aluminum borosilicate	$Na_3Al_6Si_6O_{18}(BO_3)_2(OH,F)_4$
TPX	methyl pentene polymer	
tridymite	silicon dioxide	SiO_2
TSCCC	thiosemicarbazide cadmium chloride monohydrate	
tysonite	lanthanum trifluoride	LaF_3
urea	urea crystal	CH_4N_2O
VAC	vinyl acetate	$[CH_2CH(OCOCH_3)]_n$
VB	vinyl benzoate	
villiaumite	sodium fluoride	NaF
VOPc	vanadyl phthalocyanine	
VPAC	vinyl phenyl acetate	$[CH_2CH(OCOC_6H_5)]_n$
VTE LN	vapor-transport-equilibrated lithium niobate	$LiNbO_3$
weberite	sodium magnesium aluminum fluoride	$NaMgAlF_7$
willemite	zinc silicate	$ZnSiO_4$
wollastonite	calcium silicate	$CaSiO_3$
wulfenite	lead molybdate	$PbMoO_4$
wurtzite	zinc sulfide (hexagonal)	ZnS

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Abbreviations, Acronyms, Initialisms, and Mineralogical or Common Names of Optical Materials—*continued*

xenotime	yttrium phosphate	YPO_4
YAB	yttrium aluminum borate	$YAl_3(BO_3)_4$
YAG	yttrium aluminum garnet[c]	$Y_3Al_5O_{12}$
YAlG	yttrium aluminum garnet	$Y_3Al_5O_{12}$
valliaumite	sodium fluoride	NaF
yablonovite	photonic bandgap crystal	variant of the diamond structure
YAlO	yttrium orthoaluminate	$YAlO_3$
YAP	yttrium aluminum perovskite	$YAlO_3$
YAM	yttrium aluminum monoclinic	$Y_4Al_2O_9$
YBF	yttrium barium fluoride	Y_2BaF_8
YGG	yttrium gallium garnet	$Y_3Ga_5O_{12}$
YGO	yttrium gadolinium oxide	$(Y,Gd)_2O_3$
YGOB	yttrium gadolinium borate	$CaY_4(BO_3)_3O$
YIG	yttrium iron garnet	$Y_3Fe_5O_{12}$
YIGG	yttrium indium gallium gadolinium garnet	$Y_3(In,Ga)_2Gd_3O_{12}$
YLF	yttrium lithium fluoride	$YLiF_4$ ($LiYF_4$)
YOP	yttrium orthophosphate	YPO_4
YOS	yttrium orthosilicate	Y_2SiO_5
YSAG	yttrium scandium aluminum garnet	$Y_3Sc_2Al_3O_{12}$
YSB	yttrium scandium borate	$YSc_3(BO_3)_4$
YSGG	yttrium scandium gallium garnet	$Y_3Sc_2Ga_3O_{12}$
YSO	yttrium silicon oxide (orthosilicate)	Y_2SiO_5
YSZ	yttria stabilized zirconia	ZrO_2:Y_2O_3
yttralox	yttrium oxide (polycrystalline)	Y_2O_3
Zerodur	glass ceramic	SiO_2–Al_2O_3+ . . .
zinc blende	zinc sulfide (cubic)	ZnS
zincite	zinc oxide	ZnO
ZTS	zinc tris(thiourea) sulfate	$Zn[CS(NH_2)_2]_3SO_4$
zircon	zirconium silicate	$ZrSiO_4$
zirconia	zirconium dioxide	ZrO_2

(a) When crystals are grown in heavy water (D_2O) solution, hydrogen is replaced in part or totally by deuterium. Such crystals are designated by a prefix d- or D-, or by an asterisk, e.g., d-CDA and CD*A.

(b) Produced from natural quartz.

(c) Nd-doped YAG lasers are frequently simply called YAG lasers.

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APPENDIX III

Abbreviations for Methods of Preparing Optical Materials and Thin Films

ACR	—	accelerated crucible rotation (flux growth)
ACRT	—	accelerated crucible rotation technique
ALE	—	atomic layer epitaxy
ALL MBE	—	atomic layer-by-layer molecular beam epitaxy
APCVD	—	accelerated plasma chemical vapor deposition
APD	—	accelerated plasma deposition
APE	—	annealed proton exchange
ARE	—	activated reactive evaporation
BARE	—	biased activated reactive evaporation
BE	—	bond and etch (waveguide structure)
Br	—	Bridgman (growth)
CAIBE	—	chemically-assisted ion beam epitaxy
CAMBE	—	chemically-assisted molecular beam epitaxy
CBE	—	chemical beam epitaxy
CLD	—	chemical liquid deposition
CVD	—	chemical vapor deposition
CVT	—	chemical vapor transport
Cz	—	Czochralski (growth)
DIBD	—	dual ion beam deposition
DIBS	—	dual ion beam sputtering
DMILC	—	double-metal-induced lateral crystallization
DWB	—	direct wafer bonding (waveguide structure)
ED	—	electrodeposition
EDFF	—	edge-defined film-fed (growth)
EFG	—	edge-defined film-fed growth
FHD	—	flame hydrolysis deposition
FIB	—	focused ion beam (sputtering)
FICZ	—	flat interface Czochralski (growth)
FZ	—	float zone
GD	—	glow discharge
GILD	—	gas immersion laser doping
GS-MBE	—	gas-source molecular beam epitaxy
HBr	—	horizontal Bridgman (growth)
HCD	—	hollow cathode discharge deposition
HEM	—	heat exchange method
HGF	—	horizontal gradient freeze
HIP	—	hot isostatic pressing
HPBr	—	high-pressure Bridgman (growth)
HPVB	—	high-pressure vertical Bridgman

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Abbreviations for Methods of Preparing Optical Materials and Thin Films—*continued*

HTS	—	high temperature solution
HTSG	—	high temperature solution growth
HVPE		hydride vapor-phase epitaxy
IAD	—	ion assisted deposition
IAD	—	ion beam assisted deposition
IBD	—	ion beam deposition
IBE	—	ion beam etching
IBED	—	ion beam enhanced deposition
IBS	—	ion beam sputtering
ICB	—	ion cluster beam
ICBD	—	ionized cluster beam deposition
ISZ-THM	—	increasing solution zone travelling heater method
IVD	—	inside vapor deposition
IVDO	—	inside vapor deposition oxidation
JVD	—	jet vapor deposition
LAD	—	laser aerosol deposition
LAD	—	laser-assisted deposition
LB	—	Langmuir-Blodgett (film technique)
LBD	—	Langmuir-Blodgett deposition
LCVD	—	laser-induced chemical vapor deposition
LEC	—	liquid-encapsulated Czochralski (growth)
LECVD	—	liquid-encapsulated chemical vapor deposition
LEVGF	—	liquid-encapsulated vertical gradient freeze
LHPG	—	laser heated pedestal growth
LPCVD	—	liquid-phase chemical vapor deposition
LPCVD	—	low-pressure chemical vapor deposition
LPE	—	liquid phase epitaxy
LP-MOVPE	—	low-pressure metal-organic vapor-phase epitaxy
LTE	—	local thermal equilibrium
LTGCz	—	low-thermal gradient Czochralski (growth)
LT-MBE	—	low-temperature molecular beam epitaxy
LVRIP	—	low-voltage reactive ion plating
MBD	—	molecular beam deposition
MBE	—	molecular beam epitaxy
MCVD	—	modified chemical vapor deposition
MIC	—	metal-induced crystallization
MILC	—	metal-induced lateral crystallization
MOCVD	—	metal-organic chemical vapor deposition
MOMBE	—	metal-organic molecular beam epitaxy
MOVD	—	modified vapor deposition
MOVPE	—	metal-organic vapor-phase epitaxy

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Abbreviations for Methods of Preparing Optical Materials and Thin Films—*continued*

MPD	—	microwave plasma deposition
NSP	—	neutral solution processing
OMCVD	—	organometallic chemical vapor deposition
OMMBE	—	organometallic molecular beam epitaxy
OMVPE	—	organometallic vapor-phase epitaxy
OVD	—	outside vapor deposition
OVPO	—	outside vapor phase
PCVD	—	plasma chemical vapor deposition
PACVD	—	plasma-assisted chemical vapor deposition
PAE	—	plasma assisted epitaxy
PCVD	—	plasma chemical vapor deposition
PE	—	plasma etching
PECVD	—	plasma-enhanced chemical vapor deposition
PIBD	—	primary ion beam deposition
PICVD	—	plasma ionization chemical vapor deposition
PLD	—	physical liquid deposition
PLD	—	pulsed laser deposition
PVD	—	physical vapor deposition
PVT	—	physical vapor transport
RAP	—	reactive atmosphere processing
RE	—	reactive evaporation
RIBE	—	reactive ion beam etching
RICBD	—	reactive ionized cluster beam deposition
RIE	—	reactive ion etching
RS	—	reactive sputtering
SAM	—	self-assembled monolayer
SIBD	—	secondary ion beam deposition
SOL GEL	—	solution gelation (processing)
SPCVD	—	surface-plasma chemical vapor deposition
SPE	—	solid phase epitaxy
SPVT	—	seeded physical vapor transport
SSE	—	solid-state epitaxy
SSMOCVD	—	solid source metal-organic chemical vapor deposition
SSVG	—	self-selected vapor growth
St	—	Stockbarger (growth)
TGZM	—	temperature-gradient zone melting
THM	—	travelling heater method
TNFC	—	top nucleated floating crstal (growth)
TSFZ	—	travelling solvent float zone
TSM	—	travelling solvent method
TSSG	—	top-seeded solution growth

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Abbreviations for Methods of Preparing Optical Materials and Thin Films—*continued*

UHV-CVD	—	ultra-high-vacuum chemical vapor deposition
VAD	—	vapor-phase axial deposition
VBr	—	vertical Bridgman (growth)
VD	—	vacuum deposition
VGD	—	vapor gel deposition
VGF	—	vertical gradient freeze
VLPC	—	very-low-pressure chemical
VD	—	vapor deposition
VLS	—	vapor-liquid-solid
VMS	—	vapor melt solid
VPE	—	vapor-phase epitaxy
VPG	—	vapor-phase growth
VPO	—	vapor-phase oxidation
VT	—	vapor transport
VTE	—	vapor transport equilibrated
ZM	—	zone rnelted
ZMR	—	zone melting recrystallization

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APPENDIX IV

Fundamental Physical Constants

Quantity	Symbol	Value
speed of light in vacuum	c	299 792 458 m/s
permeability of vacuum, $4\pi \times 10^{-7}$	μ_0	$1.256\ 637\ 061\ 4 \times 10^{-6}$ N/A^2
permittivity of vacuum, $1/\mu_0 c^2$	ε_0	$8.854\ 187\ 817 \times 10^{-12}$ F/m
Planck constant	h	$6.626\ 075\ 5 \times 10^{-34}$ J s
elementary charge	e	$1.602\ 177\ 33 \times 10^{-19}$ C
magnetic flux quantum, $h/2e$	Φ_0	$2.067\ 834\ 61 \times 10^{-15}$ Wb
electron mass	m_e	$9.109\ 389\ 7 \times 10^{-31}$ kg
proton mass	m_p	$1.672\ 623\ 1 \times 10^{-27}$ kg
fine structure constant, $\mu_0 c e^2/2h$	α	$7.297\ 353\ 08 \times 10^{-3}$
inverse fine-structure constant	$1/\alpha$	137.035 989 5
Rydberg constant, $m_e c\alpha^2/2h$	R_y, R_∞	10 973 731.534 m^{-1}
Bohr radius, $\alpha/4\pi R_\infty$	a_0	$0.529\ 177\ 249 \times 10^{-10}$ m
Hartree energy, $e^2/4\pi\varepsilon_0 a_0 = 2R_\infty hc$	E_h	$4.359\ 748\ 2 \times 10^{-18}$ J
in eV, E_h/e		27.211 396 1 eV
Compton wavelength, $h/m_e c$	λ_C	$2.426\ 310\ 58 \times 10^{-12}$ m
classical electron radius, $\alpha^2 a_0$	r_e	$2.817\ 940\ 92 \times 10^{-15}$ m
Bohr magneton, $eh/4\pi m_e$	μ_B	$9.274\ 015\ 4 \times 10^{-24}$ J/T
nuclear magneton, $eh/4\pi m_p$	μ_N	$5.050\ 786\ 6 \times 10^{-27}$ J/T
electron magnetic moment	μ_e	$9.284\ 770\ 1 \times 10^{-24}$ J/T
magnetic moment anomaly, $\mu_e/\mu_B - 1$	a_e	$1.159\ 653\ 193 \times 10^{-3}$
electron g factor, $2(1 + a_e)$	g_e	2.002 319 304 386
proton gyromagnetic ratio	γ_p	$2.675\ 221\ 28 \times 10^{8}$ s^{-1}T^{-1}
Avogadro constant	N_A	$6.022\ 136\ 7 \times 10^{23}$ mol^{-1}
Boltzmann constant, R/N_A	k	$1.380\ 658 \times 10^{-23}$ J/K
Faraday constant, $N_A e$	F	96 485.309 C/mol
molar gas constant	R	8.314 510 J/mol K
Stefan-Boltzmann constant	s	$5.670\ 51 \times 10^{-8}$ W/m^2 K^4

References:

Cohen, E. R., and Taylor, B. N., The 1986 adjustment of the fundamental physical constants, *Rev. Mod. Phys.* 59, 1121 (1987).

Taylor, B. N., and Cohen, E. R., Recommended values of the fundamental physical constants: a status report, *J. Res. Natl. Inst. Stand. Technol.* 95, 497 (1990).

For updated values see NIST Web site: physics.nist.gov/constants.

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APPENDIX V

Units and Conversion Factors

Energy E(eV)

Multiply E(eV) by 1.6022×10^{-19} to convert to E(J)
Multiply E(eV) by 8065.5 to convert to E(cm^{-1})

Photon energy (eV) = $1.2398/\lambda_{vacuum}(\mu m)$

Linear absorption coefficient α (cm^{-1}) = $(4\pi n \times 10^4/\lambda)k$, where n is the index of refraction of the material, the wavelength λ is in microns (μm), and k is the complex index of refraction.

Two-photon absorption coefficient β (m/W)

β (m/W) = $(N/E)\sigma^2$, where N is the number density of molecules per cm^3, E is the photon energy (J), σ^2 is the two-photon absorption cross section (cm^4 s/molecule).
Multiply β (m/W) by 10^{-9} to convert to the CGS system (cal/cm s/erg)

Nonlinear index of refraction γ (m^2/W)

Multiply γ (m^2/W) by $2.386 \times 10^6 n$ to convert to the esu system, where n is the index of refraction of the material.
n_2[cm^3/erg] = $238.7n\ \gamma$[cm^2/W]

Linear electrooptic coefficient r (m/V)

Multiply r (m/V) by 2.9979×10^4 to convert to the CGS system (cm/statvolt)

Kerr constant B (10^{-16}m V^2)

Multiply B (10^{-16}m V^2) by 8.988×10^6 to convert to the CGS system ($cm/statvolt^2$)

Verdet constant V (rad/T m)

Multiply V (rad/T m) by 3.438×10^{-3} to convert to the CGS system (min/Oe cm)

Temperature T(K)

Temperature T(˚C) = T(K) – 273.15

Specific heat capacity c_p (J/kg K)

Multiply c_p (J/kg K) by 2.388×10^{-4} to convert to the CGS system (cal/g K)

Thermal conductivity κ (W/m K)

Multiply κ (W/m K) by 2.388×10^{-3} to convert to the CGS system (cal/cm s K)

Hardness (Knoop or Vickers)

1 kgf/mm^2 = 9.8066 N/mm^2

Pressure, mechanical stress (Pa)

1 Pa = 1 N/m^2 = 1 kg/m s^2
10^5 Pa = 1 bar
1 psi = 6.9 x 10^3 Pa

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