AEDC-TR-79-50

Infrared Optical Properties of Bipropellant Cryocontaminants

J. A. Roux, B. E. Wood,
and A. M. Smith
ARO, Inc.

August 1979

Interim Report for Period October 1, 1977 – March 15, 1979

ARNOLD ENGINEERING DEVELOPMENT CENTER
ARNOLD AIR FORCE STATION, TENNESSEE
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

APPROVAL STATEMENT

This report has been reviewed and approved.

KENNETH H. LENERS, Captain, USAF
Research Division
Directorate of Test Engineering

Approved for publication:

FOR THE COMMANDER

MARION L. LASTER
Director of Test Engineering
Deputy for Operations

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AEDC-TR-79-50	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) INFRARED OPTICAL PROPERTIES OF BIPROPELLANT CRYOCONTAMINANTS		5. TYPE OF REPORT & PERIOD COVERED Interim Report - October 1, 1977 - March 15, 1979
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. A. Roux, B. E. Wood, and A. M. Smith, ARO, Inc., a Sverdrup Corporation Company		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Arnold Engineering Development Center/DOTR Air Force Systems Command Arnold Air Force Station, Tennessee 37389		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Program Element 65807F
11. CONTROLLING OFFICE NAME AND ADDRESS Arnold Engineering Development Center/OIS Air Force Systems Command Arnold Air Force Station, Tennessee 37389		12. REPORT DATE August 1979
		13. NUMBER OF PAGES 121
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available in DDC

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

bipropellants	contamination	hydrazine
optical properties	constants	methane
infrared spectra	optical phenomena	tetroxides
cryopumping	liquid propellants	nitrogen compounds

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The infrared spectral transmittance of cryofilms formed by MMH, N_2O_4, and N_2H_4 propellants was measured. These films were cryopumped on 20 and 77°K germanium substrates and ranged in thickness from 0.25 to 9 μm; the deposition pressure for the films was approximately 1×10^{-7} torr. Transmission spectra were obtained for the 500 to 3700 wavenumber range using a Fourier transform spectrometer. Values of the complex index of refraction ($\bar{n} = n - ik$) for the cryodeposits were derived from the experimental data using an analytical model and

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

20. ABSTRACT (Continued)

a nonlinear least-squares method. The analytical model treats the germanium as a thick, noninterfering film and the deposit as a thin film. Results from the least-squares method are also compared with a Kramers-Kronig determination of the real part of the index of refraction. The optical properties (n,k) of such cryofilms are essential for predicting the degradation of cryocooled optical surfaces contaminated by liquid propellant exhaust plumes.

PREFACE

The research reported herein was performed by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC). Work and analysis for this research was done by personnel of ARO, Inc. (a Sverdrup Corporation Company), operating contractor of AEDC, AFSC, Arnold Air Force Station, Tennessee. The work covered the period from October 1, 1977 to March 15, 1979 and was done under ARO Project Numbers V32S-R1A, V32K-13A, and P32K-13A. Dr. H. E. Scott was the Air Force project manager. The manuscript was submitted for publication on May 21, 1979.

CONTENTS

ILLUSTRATIONS

TABLES

Table	Page

1.0 INTRODUCTION

Contamination from the exhaust plume of small thrusters used for attitude control maneuvers can pose severe problems for long-life satellite systems. Engine exhaust products can contaminate sensitive optical surfaces located upstream of the nozzle exit plane (referred to as the backflow region). Sensor systems, which require cryogenic cooling to achieve maximum sensitivity, are particularly susceptible to cryopumping engine exhaust products that reach the backflow region. The contaminants reaching the backflow region are thought to originate from the engine nozzle boundary layer. Gases in the boundary layer travel at low velocities and are therefore able to expand through very large angles and flow upstream of the nozzle exit plane.

To identify better the possible contaminants from bipropellant (MMH/N_2O_4) and monopropellant (N_2H_4) engines, the infrared (IR) spectra of monomethyl hydrazine (MMH), nitrogen tetroxide (N_2O_4), and hydrazine (N_2H_4) propellants were measured. The normal transmission spectra were measured using 20 and 77°K germanium as a substrate material. Germanium was chosen as a substrate because it has an absorption edge at 1.5 μm, a flat transmission of 47 percent between 2 and 10 μm, and lattice absorption bands between 10 and 20 μm. It is one of the most commonly employed substrates for cryocooled optical components because of its higher thermal conductivity as compared to pure dielectrics, the Irtrans®, or polycrystals, for example.

Complete experimental details have been given in Ref. 1; thus only a basic outline of the chamber and apparatus is presented here. The absolute transmission of thin solid films of MMH, N_2O_4, and N_2H_4, ranging in thickness up to 9 μm, is presented. Finally, a theoretical model of window plus film transmission is derived and is subsequently employed with the experimental results to determine the complex refractive index ($\bar{n} = n - ik$) of each of the above-mentioned propellants. The subtractive Kramers-Kronig treatment for calculation of the film refractive index has also been employed, and results are compared to those of the least-squares determination.

2.0 INSTRUMENTATION

A schematic drawing of the experimental apparatus, showing the IR interferometer (Digilab Model FTS-14), the high-vacuum chamber containing the cryocooled window, and the IR source location is given in Fig. 1. The chamber is an all-stainless-steel cell equipped with a liquid-nitrogen (LN_2)-cooled liner. A water-vapor-free vacuum of 10^{-8} torr can be routinely obtained. The substrate holder can be actively cooled with either liquid nitrogen (LN_2) (77°K) or gaseous helium (GHe) (20°K). Three platinum resistors located on the window holder gave temperature readouts accurate to 0.5°K.

The germanium window was mounted for cryogenic cooling as shown in Fig. 2. To ensure that the germanium window did not act as an optical stop in any manner, a stop was located in the "back-of-window" gas baffle. This stop was 1.50 in. in diameter, and the clear aperture of the germanium was 2.0 in. in diameter.

The spectral resolution of the interferometer system could be selected between 16 and 0.5 cm^{-1}, but 4-cm^{-1} resolution was found to be sufficient for all work reported herein. The wavelength accuracy of the interferometer is near 0.02 cm^{-1}, since the interferogram sampling interval is governed by an auxiliary helium-neon (He-Ne) laser interferometer. Transmission data were recorded in the 500 to 3700-cm^{-1} wavenumber region. Transmission measurements were performed by rotating the germanium out of the beam and recording a reference power spectrum. Up to 16 interferograms were generally co-added before execution of the Fourier transform, improving the signal-to-noise ratio. Next the window was rotated into the beam and the process repeated. The reference file was then divided into the sample file and plotted by a digital incremental plotter, producing the final data record on a linear ordinate scale of 0- to 100-percent transmission.

Controlled contamination of the cryocooled germanium window was accomplished with the gas induction system shown schematically in Fig. 3. A toroidal-shaped header with thirty-six 1/16-in.-diam orifices spaced 10 deg apart directed the gas toward the germanium window. The upstream pressure was determined from the vapor pressure of the liquid, and the gas flow rate was regulated by the variable leak valve. The chamber pressure would rise from 1×10^{-8} up to 4×10^{-8} or from 1×10^{-7} up to 1×10^{-6} torr during deposition at 20 and 77°K, respectively, indicating good cryopumping by the liner and substrate. Gas was prevented from condensing on the back of the germanium window by a gas baffle positioned close to the back-of-window holder. This baffle also held the optical stop mentioned earlier. The gas induction system, although quite simple, worked well in that the deposition rate could be easily controlled and the final thin-film thickness was very uniform across the 2-in.-diam exposed window area. Film uniformity and absolute thickness are two important parameters since the ultimate objective of the experiment was to determine the complex refractive index of the thin film, a quantity derived by comparison of experimental transmission versus thickness data with a theoretical model. Any error in absolute film thickness is directly introduced into the film complex refractive index results. A dual-laser-beam technique (Ref. 2) was employed to measure the film thickness and also the film refractive index at 0.6328 μm. Basically, two He-Ne laser beams are specularly reflected off the germanium window for two different and accurately measured incidence angles. As the gas is condensed two interference patterns of different periods are monitored in the reflected laser light. If the ratio of interference pattern periods is termed β then the refractive index of the film (n) is given by

$$n = \frac{\left[\sin^2\theta_b - \beta^2 \sin^2\theta_a\right]^{1/2}}{\left[1 - \beta^2\right]^{1/2}}$$

where θ_a and θ_b (typically 18 and 68 deg) are the two laser-beam incidence angles. Once m_a has been established the thickness, d_1, of the film is readily calculated from $m_a\lambda = 2nd_1 [1 - (\sin^2\theta_a/n^2)]^{1/2}$, where m is the order of the interference maxima for incidence angle θ_a. The dual-laser-beam thickness monitor yielded thin-film refractive index values accurate to within two percent. A quartz cyrstal microbalance (QCM) was used in conjunction with the dual-laser-beam technique to determine the density of each contaminant. The QCM operates on the principle of the crystal vibration frequency changing linearly with a change in mass deposited on the crystal. The QCM was located adjacent to and just above the germanium window (see Fig. 2) so that the mass deposition rate would be the same as on the germanium window. The surface density in gm/cm^2 was determined from the QCM and the film thickness determined from the interference patterns. From these two values the film density was calculated.

3.0 PROCEDURE

The chamber was initially pumped down to approximately 1×10^{-7} torr using the diffusion pump and the LN_2 liners. Chamber pressures in the low 10^{-8}-torr range were obtained when the germanium window, holder, and transfer lines were cooled to approximately 20°K with the Collins cryostat (2-kw capacity).

Samples of MMH, N_2O_4, and N_2H_4 liquid were obtained from the fuel drums. A laboratory chemical analysis was done on each sample to determine the purity level. The remainder of the sample was transferred to an evacuated cylinder that was then attached to the chamber gas bleed-in system. Absorbed gases and sample impurities were removed from the cylinder and sample using a mechanical pump to pump directly on the sample. The vapor pressure exerted by the sample of propellant supplied the forepressure for the metering valve that was adjusted to give the desired deposition rate.

Deposition of the gas on the cold germanium window was monitored using the two HeNe laser beams with the two-angle interference technique. Generally, transmission measurements were made upon reaching an interference maxima in the lower angle (18-deg) beam, at which point the gas flow was shut off. Upon completion of the transmission measurements, the gas flow was again started and deposition occurred until a film thickness corresponding to the next interference maxima was reached, etc. In some instances in which very strong absorption bands were observed, transmission measurements were alternately made for each interference minima and maxima. This was done since determination of the optical properties (n and k) required the use of as many thicknesses as possible to increase accuracy.

After completion of a series of transmission measurements for all the thicknesses, the cryogenic flow rate to the germanium substrate was turned off and the substrate and deposited film allowed to warm up. Transmission measurements were made at intervals during warmup. The time required for the interferometer to scan the sample (16 scans) was 2 to 3 minutes with a similar time required for the reference beam. With the time required for obtaining the Fourier transform and the plotting of the data, this resulted in a time interval of about 10 minutes between measurements. The temperature given on each warmup data plot is the temperature at the end of the sample interferometer scan.

The main intent was to obtain transmission measurements for as many thicknesses as possible during an experiment on each propellant. The number of thicknesses actually obtained depended considerably on the particular gas. For "well-behaved" deposits, 16 to 25 thicknesses (interference maxima or minima) were obtained, whereas in some cases only 2 to 3 thicknesses were possible. The so-called fracture or shattering effect was the primary cause of the problem. In other cases the deposit was more highly scattered, which caused the interference patterns to be washed out at thinner film thickness.

4.0 RESULTS - EXPERIMENTAL

4.1 MMH ON 20°K GERMANIUM

Transmission spectra of MMH were obtained for several thicknesses varying from 0.233 μm (one interference fringe) to 3.27 μm (14 interference fringes). At the He-Ne wavelength (0.6328 μm) the refractive index was measured and found to be 1.40 $\pm$ 0.02; in conjunction with the thickness measurement, a QCM measured the mass per unit area giving a density of 0.82 gm/cm^3 for the MMH deposit at 20°K. This yields a Lorentz-Lorenz value $\{[(n^2 - 1)/(n^2 + 2)] \cdot 1/\varrho\}$ of 0.294 cm^3/gm at 0.6328 μm.

Transmission data obtained for the 0.47-, 1.17-, and 3.27-μm-thick deposits are shown in Fig. 4. These thicknesses correspond to interference maxima of 2, 5, and 14, respectively. (The dashed curve is for the bare 20°K germanium transmission.) The absorption bands are listed in Table 1 (the 77°K data are also listed and will be discussed later), and the vibrational assignments of Durig, Harris, and Wertz (Ref. 3) are listed for comparison; their assignments were obtained for liquid MMH, whereas the spectra in the present case were for thin solid films of MMH. The MMH spectra show two wavenumber areas of considerable absorption — the region from 800 to 1700 cm^{-1} and the region from 2700 to 3400 cm^{-1}. No noticeable absorption is noted between these two regions. The broad dip in transmission centered between 1900 and 2300 cm^{-1} (Fig. 4c) is actually an interference minimum and is a part of the channel spectra. As shown in Fig. 4c, some of the transmission curve lies at values higher than the initial germanium base surface transmission. This is the result of the thin MMH film acting as an antireflection coating that increases the transmission over that of the bare germanium.

Comparing the spectral locations of the absorption bands listed in Table 1 with those from Durig et al. (Ref. 3) reveals a few differences. In Fig. 4c a relatively strong band can be observed at 3164 cm^{-1}, whereas no such band was observed by Durig et al.; this may be due to the bands being sharper in the solid phase. Similarly, a weak band at 3032 cm^{-1} was not observed by Durig et al., nor was the splitting of the ν_4 and ν_5 bands located at 2964 and 2934 cm^{-1}, respectively. The other band locations were nearer to the values obtained for the liquid phase.

After the data in Fig. 4 were obtained, the 20°K GHe flow to the germanium substrate was stopped and the MMH-germanium surface system was allowed to warm up slowly. Spectral transmission measurements were made at intermediate temperatures before the MMH film sublimated. Essentially no change occurred in the transmission for temperatures up to 145°K. Between 145 and 160°K a phase change occurred in the MMH, as is evident from a comparison of Figs. 4c and 5. The overall transmission was reduced considerably. The phase change from an amorphous solid to a crystalline structure caused a large increase in the scattered radiation (Fig. 5), thereby reducing the transmission of radiation through the MMH-germanium composite. Visually at this time the MMH film appeared translucent or milky. The absorption bands also are much less prominent than previously recorded, with some of the weaker bands being undetectable. The ν_{18} band located at 836 cm^{-1} before the phase change split into two bands located at 845 and 860 cm^{-1}. The relatively broad band located at 1004 cm^{-1} before the phase change is very sharp and shifted to 985 cm^{-1} afterward, which makes it agree with the location of the ν_{16} band of Durig et al. (Ref. 3). Considerable variations were seen in the shape and location of the other bands. The two doublet bands near 1104 and 1206 cm^{-1} before the phase change appeared as a single band after the phase change. The bands in the 2700 to 3400-cm^{-1} range showed little resemblance to those before the phase change, as shown in Figs. 4 and 5, and thus a comparison of band locations before and after warmup is difficult. In general, the shape of the bands was much sharper after the warmup. This was especially true in the 700 to 1700-cm^{-1} region. After the phase change, the temperature of the germanium substrate was allowed to increase further until the MMH had completely evaporated, which occurred between 175 and 180°K. The chamber pressure at this time was approximately 5 x 10^{-6} torr.

4.2 MMH ON 77°K GERMANIUM

Thin films of MMH were also deposited on LN_2-cooled germanium, and transmission spectra were obtained as before at each interference maxima. The refractive index at 77°K and $\lambda = 0.6328\ \mu m$ was 1.47 ± 0.02, the density was 0.98 gm/cm^3, and the Lorentz-Lorenz constant 0.284 cm^3/gm. For the transmission measurements, film thicknesses up to 40 interference maxima thick (8.84 μm) were deposited and the spectra recorded. Figure 6 shows the spectra obtained for thicknesses of 0.44, 2.21, and 8.84 μm, which are representative of the results obtained. The band locations and assignments (see Table 1) are essentially the same as given previously for the 20°K spectra. Essentially all of the bands observed at 77°K are within 10 cm^{-1} of the corresponding bands observed at 20°K.

For the films formed at 77°K no problems with fracturing occurred. Figure 7 shows the spectra obtained after the film was allowed to warm up to 161°K. A crystalline phase change occurred between 150 and 160°K as previously noted, but the transmission values (see Fig. 7) are considerably higher than that observed in the previous warmup data for the 20°K case (see Fig. 5). This is evidently caused by smaller size particles or crystals being formed when no fracture occurs before the amorphous-crystalline phase change. The fracture evidently increases the particle size, which, in turn, reduces the transmission by increasing the amount of energy scattered out of the radiation path.

There was not much change in the spectra before and after warmup. However, one significant change was the emergence of a strong, sharp absorption band at 3340 cm^{-1} not present before warmup. Evidence of its presence is found in the 20°K warmup curve (Fig. 5) as a weak band observed at approximately 3340 cm^{-1}. This band appeared prominently during the 77°K warmup in Fig. 7 and is either the ν_1 or ν_2 fundamental. The splitting of the ν_{18} band at approximately 840 cm^{-1} into bands located at 835 and 860 cm^{-1} (see Fig. 7) was also observed in the 20°K warmup curve and is the result of the amorphous deposit transforming to the crystalline phase since the splitting of the band was not observed for liquid MMH (Ref. 3). All other band locations were very close for the 20 and 77°K condensed films. Several weak bands appear in the 1700 to 2660-cm^{-1} range after warmup (see Fig. 7); these were not observed in either the 20 or 77°K data before warmup. These weak bands are combinations or lattice bands whose assignments are unknown at present.

4.3 N_2O_4 ON 20°K GERMANIUM

Shown in Fig. 8 is the IR transmission spectrum of a 1.45-μm-thick (6 interference maxima) N_2O_4 film deposited on the 20°K germanium window. In contrast to the MMH, the N_2O_4 exhibits strong absorption only at the lower wavenumbers (700 to 2300 cm^{-1}). The refractive index at 0.6328 μm and the density were measured and found to be 1.53 ± 0.02 and 1.81 gm/cm^3, respectively, at 20°K. This yields a Lorentz-Lorenz value of 0.171 cm^3/gm. During deposition the N_2O_4 films fractured or changed phase abruptly when a film thickness of 1 to 3 μm was reached. This behavior was characterized by a sudden change (within five seconds) from a clear transparent film to a highly diffuse scattering film, with the result that the thin-film laser interference patterns could no longer be observed. Infrared channel spectra were washed out at this time also.

The identifiable N_2O_4 bands are listed in Table 2. These data were compared with 77°K N_2O_4 measurements of Wiener and Nixon (Ref. 4) and the N_2O_4 gas phase measurements of Bibart and Ewing (Ref. 5); band assignments follow those of Wiener and Nixon (Ref. 4) unless indicated otherwise. The major vibration bands are the ν_{12} band located at 750 cm^{-1}, the ν_{11} band at 1260 cm^{-1}, the ν_5 band at 1720 cm^{-1}, and the ν_9 band located at 1742 cm^{-1}. The remaining N_2O_4 bands are either weaker fundamentals or combination bands.

To help identify the bands listed in Table 2 it was necessary to consider the transmission of the N_2O_4 film after the substrate had been allowed to warm up from 20 to 153°K (see Fig. 9). Transmission measurements were made at intermediate temperatures, but they are not presented. Upon warmup to 153°K the ν_{12} band located at 750 cm^{-1} in Fig. 8 splits into two bands located at 745 and 765 cm^{-1} in Fig. 9. The splitting had not occurred at 138°K. When N_2O_4 is deposited at 77°K, this band exists as a doublet (Ref. 6) as observed in AEDC data taken at 77°K (shown later) and also found by Wiener and Nixon (Ref. 4). The three weak bands observed in Fig. 8 at 785, 820, and 850 cm^{-1} became much sharper after warmup (Fig. 9) and are more easily distinguished. There was a broad absorption band between 940 and 1060 cm^{-1} before warmup. After warmup to 153°K only a narrow band still remains at 1050 cm^{-1}; this band finally disappeared between 200 and 207°K. The sharp band located at 1050 cm^{-1} is attributed to some form of nitrate (Ref. 7) (NO_3) that remained on the surface after most of the other film had sublimed.

The broad band initially between 940 and 1060 cm^{-1} is assigned (Ref. 8) to N_2O_3 since a large part of the band disappeared at an intermediate temperature of 80 to 90°K (not shown) at a chamber pressure of 10^{-6} torr. No vapor pressure curves are available for N_2O_3, but it is known that N_2O_3 vapor pressure is higher than that for N_2O_4. Other gases that sublimate in this temperature region are NO at 60 to 70°K and N_2O at 80 to 90°K; however, neither of these gases exhibits absorption in the 940 to 1060-cm^{-1} region. (N_2O_4 and NO_2 sublimate at approximately 160°K for a chamber pressure of 10^{-6} torr.)

The two strong, sharp bands in Fig. 8 located at 1260 and 1305 cm^{-1} are the ν_{11} and ν_{11} + R N_2O_4 bands, where R represents a torsional lattice mode. (The ν_{11} + R band was not observed for N_2O_4 deposited at 77°K in the AEDC studies.) Both of these bands are still present after warmup to 153°K (Fig. 9). The ν_{11} + R band of N_2O_4 at 1305 cm^{-1} (20°K) is also masking a nitrate band. Hence, the 1305-cm^{-1} band in Table 2 is listed as an N_2O_4 and ν_3 nitrate band.

The band at 1450 cm^{-1} in Fig. 8 before warmup shifts to 1385 cm^{-1} after warmup (Fig. 9). This is the N_2O_4-2 ν_7 band and is evidently highly temperature-dependent. In Fig. 8 a sharp band is located at 1618 cm^{-1} with a side lobe at 1595 cm^{-1}. In the warmup data between 20 and 90°K these bands became quite distinct, and the 1618-cm^{-1} band disappeared upon warmup to 90°K. For this reason the 1618-cm^{-1} band was identified as the ν_2 band (Ref. 8) of N_2O_3. The band at 1595 cm^{-1} was identified as the NO_2-ν_3 band.

In the region of 1700 cm^{-1} (Fig. 8) there are three distinct bands located at 1720, 1742, and 1765 cm^{-1} assigned to be the ν_5, ν_9, and ν_9 + R N_2O_4 bands, respectively (Ref. 4). Upon warmup to 153°K the band at 1720 cm^{-1} has disappeared, as shown in Fig. 9. The 1880-cm^{-1} band is the $N_2O_4 \nu_4 + \nu_5$ combination band and shifted to 1860 cm^{-1} upon warmup to 153°K.

The 1980-cm^{-1} broad band in Fig. 8 disappeared upon warmup to about 90°K and does not appear in Fig. 9. Since it disappears at the same temperature as the 940-to-1060 and the 1618-cm^{-1} bands, it also is assigned to N_2O_3 even though this band is located some 50 cm^{-1} from that observed for gaseous N_2O_3 by Bibart and Ewing (Ref. 8).

The band labeled 2135 cm^{-1} in Fig. 8 was strongly temperature-dependent, shifting some 85 cm^{-1} to its location of 2220 cm^{-1} in Fig. 9 at 153°K. Further temperature increases to 180°K caused the band to further shift to 2260 cm^{-1}. At this temperature the N_2O_4 and NO_2 had already sublimated, leaving only a deep blue film on the substrate. This band is most likely a nitrate combination band, possibly $\nu_2 + \nu_3$, which could result from the ν_2 and ν_3 bands recorded by Kato and Rolfe (Ref. 7). Further indications that the film remaining at this temperature was a nitrate were the relatively strong absorption bands at approximately 1340 cm^{-1} and a weaker one at 1050 cm^{-1}, corresponding to NO_3 fundamentals ν_3 and ν_1, respectively (Refs. 7, 9, 10, and 11). The film had completely sublimated upon reaching a temperature of 207°K.

Two sharp bands located at 2235 and 2345 cm^{-1} were also found. These two bands were eliminated when the warmup temperature reached 90°K (not shown). The 2235-cm^{-1} band is attributed to the strongest N_2O fundamental ν_3; the 2345-cm^{-1} band is assigned to be the strongest CO_2 fundamental ν_3. Only trace amounts of N_2O and CO_2 are required for these bands to show up. Other weak bands marked in Fig. 8 between 2900 and 3200 cm^{-1} are attributed to N_2O_4 and are the $\nu_5 + \nu_{11}$ band at 2970 cm^{-1}, the $2\nu_7 + \nu_9$ band at 3115 cm^{-1}, and the $2\nu_7 + \nu_9 + R$ band at 3155 cm^{-1}. These bands appear very weak in Figs. 8 and 9, but they are more prominent when N_2O_4 is deposited on a 77°K surface.

Finally, it should be mentioned that the ν_7 fundamental band, which is located at 685 cm^{-1} in the gas phase, was not observed in the solid films studied here. This band is considerably weaker in the solid phase (Ref. 4).

4.4 N_2O_4 ON 77°K GERMANIUM

Thin films of N_2O_4 were also condensed at 77°K. For $\lambda = 0.6328\ \mu m$ the refractive index was determined to be 1.55 ± 0.02 and the density was 2.01 gm/cm^3. These values yield a Lorentz-Lorenz value of 0.159 cm^3/gm, which shows only fair agreement with the value of 0.171 cm^3/gm obtained for the 20°K measurements. No fracture problems were encountered for the N_2O_4 deposited at this higher temperature. During warmup the N_2O_4 started evaporating at approximately 150°K and a chamber pressure of about 1 x 10^{-6} torr.

The infrared transmission spectra for the thin films condensed at 77°K are shown in Fig. 10 for thickness of 0.42, 1.25, and 4.18 μm. For the smallest thickness, 0.42 μm, only the bands at 1740 and 1760 cm^{-1} are very intense. The bands at 1255 cm^{-1} and the double band at 740 and 760 cm^{-1} show up strongly at the two larger thicknesses. The latter band existed as a single band located at 750 cm^{-1} when deposited at 20°K, but the splitting was observed later when the films were warmed up. The 1255-cm^{-1}-ν_{11} band showed up as a singlet until a warmup temperature of between 147 and 155°K (see Fig. 11a) was reached, at which point the 1305-cm^{-1} (ν_{11} + R) band also became quite strong. This latter band was observed at 20°K before warmup, which is in contrast to the trend observed previously. The general trend is for a film condensed at the lower temperature to be of the amorphous form and to exhibit less spectral structure than the crystalline deposits formed at a higher temperature.

From the spectra for the 4.18-μm-thick film (Fig. 11a), a weak band is observed at 1460 cm^{-1} ($2\nu_7 + R$) and a sharp band at 1620 cm^{-1}. A very sharp narrow band is observed at 1700 cm^{-1} (ν_5) and the strong double band located at 1740 (ν_9) and 1760 cm^{-1} ($\nu_9 + R$). The remainder of the bands are relatively weak and are located at 1840, 2240, 2340, 2580, 2620, 2965 ($\nu_5 + \nu_{11}$), 2985, 3100 ($2\nu_7 + \nu_9$), and 3140 ($\nu_7 + \nu_9 + R$) cm^{-1}. The 2340-cm^{-1} band is believed to be the ν_3 CO_2 band, and the 2240-cm^{-1} band is due to N_2O impurities that are absorbed in the liquid N_2O_4. Some of the weak bands, such as the 2580- and 2620-cm^{-1} bands observed at 77°K and not observed at 20°K, may be due to the much larger film thickness deposited at 77°K.

No significant differences in the warmup spectra were observed from those in the warmup spectra of the films formed at 20°K other than the previously mentioned band at 1305 cm^{-1}. After warmup to 155°K (Fig. 11a) some of the N_2O_4 was already sublimating. Figures 11b and c are spectra obtained after the N_2O_4 had come off but a very thin film remained on the substrate. At 174°K (Fig. 11b) a double band was observed in the region from 1300 to 1400 cm^{-1} and a weaker band at 2220 cm^{-1}. Further warmup to 183°K (Fig. 11c) completely eliminated the 2220-cm^{-1} band, but a single band at approximately 1370 cm^{-1} remained. At this temperature a brilliant, dark blue film was observed on the germanium window and holder. This film had sublimated when the germanium temperature reached 197 to 207°K for a chamber pressure of 1 x 10^{-7} torr. This film is probably some type of nitrate impurity in the N_2O_4.

4.5 N_2H_4 ON 77°K GERMANIUM

The other fuel studied was hydrazine (anhydrous). A sample was collected from a fuel drum of N_2H_4, and a chemical analysis showed the composition (by weight) to be 99.2-percent N_2H_4, 0.6-percent H_2O, and 0.2-percent amines.

Deposition was first attempted for the germanium window cryogenically cooled to 20°K. However, only a few (2 to 6) interference maxima were obtained before dying out because of a fracture-type phenomenon. This phenomenon sometimes occurred as a sudden fracture with the immediate cessation of the interfererence pattern or was a rapid deterioration of the interference pattern quality. The spectra of these deposits before fracturing, however, were not unlike those obtained for the 77°K measurements; therefore, they are not presented here. With the germanium window at 77°K, hydrazine films up to 32 interference maxima thick were obtained before fracture occurred. The refractive index at 0.6328 μm was found to be 1.50 ± 0.02 and the density 1.17 gm/cm_3 at 77°K. These values yield a Lorentz-Lorenz constant of 0.253 cm^3/gm at this wavelength. At a chamber pressure of 3 x 10^{-6} torr, the hydrazine films evaporated between 180 and 190°K.

The transmission spectra of hydrazine formed at 77°K germanium for thicknesses of 0.22, 2.16, and 4.74 μm are shown in Figs. 12a through c. Locations of the major absorption bands are at 890, 1060, 1305, 1345, 1620, 2955, 3180, and 3340 cm^{-1} and are listed in Table 3. Some of these bands agree with previously published data (Refs. 12 through 14) obtained on solid hydrazine, such as the 3340-, 3180-, and the 890-cm^{-1} bands. The relatively weak band at 2955 cm^{-1} shown in Fig. 12c was also observed in Ref. 12, but was not identified.

The two relatively weak bands at 1305 and 1345 cm^{-1} were observed in Ref. 12, but the relative intensities were reversed. In Fig. 12c the band located at 1305 cm^{-1} is stronger than that at 1356 cm^{-1}, whereas the relative intensities of the two bands were reversed in the data of Ref. 12. The two simple bands observed in Fig. 12c at 1060 and 1620 cm^{-1} both appear as doublet bands for solid hydrazine in Ref. 12. The data of Ref. 12 were also obtained for the N_2H_4 condensed at LN_2 temperatures but in a gas cell. Although not stated in Ref. 12, the deposits are believed to have been condensed at a relatively high pressure and formed in the crystalline phase. The N_2H_4 deposits formed in this study were condensed at a chamber pressure of approximately 1 x 10^{-7} torr and were of the amorphous form. As such, the spectra may be representative of a supercooled liquid as contrasted to a crystalline solid.

Warmup studies of N_2H_4 condensed at 20°K and subsequently warmed up until it had evaporated showed that the amorphous film changed phase and crystallized at some temperature between 95 and 127°K (see Fig. 13). At 95°K the spectrum was essentially the same as in Fig. 12c, but after warmup to 127°K the deposit had already changed phase at some intermediate temperature, and the band location in the spectra of Fig. 13 agrees with the data of Ref. 12. The single bands at 1060 and 1620 cm^{-1} became double bands with locations at 1075 and 1130 cm^{-1} and 1595 and 1650 cm^{-1}, respectively. Also the relative intensities of the two bands at 1305 and 1345 cm^{-1} reversed, with the 1345-cm^{-1} band now being the more intense, which also agrees with the spectra presented in Ref. 12.

Noticeably missing in Fig. 12c is the torsional ν_7 band that was observed in Ref. 12 for the solid crystalline phase but is not present in the liquid or gaseous phases. After warmup and phase change (Fig. 13) a strong band at 630 cm^{-1} was observed that corresponds to the previously missing ν_7 band in Fig. 12c and shown in Ref. 12. This also indicates that the amorphous solid phase is more characteristic of a supercooled liquid than the crystalline solid form.

The fracture phenomenon behaved differently spectrally in a couple of cases. In one instance the spectra obtained after fracture showed no indication of the band at 635 cm^{-1} nor the splitting of the 1060- and 1620-cm^{-1} bands. In another experiment, where fracture occurred after a 6.89-μm-thick N_2H_4 film was continuously deposited at 77°K (see Fig. 14), the first spectra obtained immediately after fracture showed both the presence of the 635-cm^{-1} band and the splitting of the 1060- and 1620-cm^{-1} bands. Therefore, whether or not the fracture is directly associated with a crystalline phase change is somewhat uncertain. The two cases where shattering (or fracture) occurred for films condensed at 20°K showed no spectral evidence of a phase change. The film condensed at 77°K before shattering (or fracture) did spectrally show the crystalline change, but this film was also considerably thicker when it fractured than was that at 20°K. The fracture phenomenon occurs while the film is being deposited, e.g., while the film is growing in thickness. The phase change occurs after a certain film thickness is reached and the film temperature then is allowed to increase. The deposit whose transmission is shown in Figs. 12a through c reached a thickness of 22 interference maxima (4.63 μm). During deposition of the 23rd maxima the film ruptured into many hairlike fibers that curled up from the center of the germanium window back to the outer edge (out of the IR beam). A spectral scan of the germanium window after this occurred showed that all of the film was removed.

5.0 OPTICAL PROPERTIES DETERMINATION

To account for the influence of these fuel constituents as contaminants it is necessary to know the solid condensed-phase optical properties. These properties are needed to compute the reflectance change of a surface or to compute the transmission change of an optical component. Knowing these properties can help correct for the effects of condensed constituents on an actual surface. The optical properties desired are the refractive index, n, and the absorption index, k.

To determine the complex refractive index ($\bar{n}$ = n - ik) of the thin solid film from the transmission versus thickness data for wavenumbers between 700 and 3700 cm^{-1}, an analytical model of film plus substrate normal transmission was developed (Refs. 15 and 16). It was assumed that the germanium window acted as a thick film, and thus there was no phase coherence between multiple internal reflected rays. Moreover, the real part of the germanium complex index, n_g, is known and given by Ref. 17:

$$n_g = A + BL + CL^2 + D\lambda^2 + E\lambda^4 \quad (1)$$

where

$$L = (\lambda^2 - 0.028)^{-1}$$

$$A = 3.99931$$

$$B = 0.391707$$

$$C = 0.163492$$

$$D = -0.000006$$

$$E = 0.000000053$$

The geometry describing the transmission is shown in Fig. 15. For convenience the different layers have been subscripted 0, 1, 2, and 3, where subscripts 0 and 3 are vacuum and 1 and 2 are the thin condensed film and the thick germanium substrate, respectively. The model employed to fit the experimental results is for normal incidence only. As shown in Fig. 15, E_0^+ is the amplitude of the incidence radiation that undergoes an infinite number of multiple reflections after passing into the thin film. Following multiple reflections the total amplitude of reflected and transmitted radiation is given by B1 and E_2^+, respectively. E_2^+ internally reflects from the back of the germanium window, becomes A1 and C1, and again undergoes thin-film multiple reflection in medium 1. This results in the rays B2 and A2, and so on. Analytically the relationships between the amplitudes of the various waves are the following:

$$E_2^+ = t_{012}E_0^+$$

$$A2 = A1\, r_{210}$$

$$A4 = A3\, r_{210} \quad (2)$$

$$A6 = A5\, r_{210}$$

$$\vdots \qquad \vdots$$

with

$$
\begin{aligned}
A1 &= E_2^- r_2 \\
A3 &= A2\, r_2 \\
A5 &= A4\, r_2 \\
&\vdots
\end{aligned}
\tag{3}
$$

with

$$
\begin{aligned}
C1 &= t_2 E_2^+ \\
C2 &= t_2\, A2 \\
C3 &= t_2\, A4 \\
&\vdots
\end{aligned}
\tag{4}
$$

and with

$$
\begin{aligned}
B1 &= E_0^+ r_{012} \\
B2 &= A1\, t_{210} \\
B3 &= A3\, t_{210} \\
B4 &= A5\, t_{210} \\
&\vdots
\end{aligned}
\tag{5}
$$

where t_2 designates the amplitude transmission of light traveling from medium 2 to medium 3, r_2 designates the amplitude reflection of light incident upon medium 3 from medium 2, r_{012} designates the amplitude reflection of light that is incident from medium 0 and is reflected back into medium 0 after undergoing thin-film interference in medium 1, r_{210} designates the amplitude reflection of light that is incident from medium 2 and is reflected back into medium 2 after undergoing thin-film interference in medium 1, t_{012} designates the amplitude transmission of light incident from medium 0 and transmitted into medium 2 after undergoing thin-film interference in medium 1, and t_{210} designates the amplitude transmission of light incident from medium 2 and transmitted into medium 0 after undergoing thin-film interference in medium 1.

The power transmitted through the thin-film, thick-film combination is given by

$$
\xi = n_3 |C1|^2 + n_3 |C2|^2 + \ldots\ldots \tag{6}
$$

where $n_3 = n_0$ since medium 3 and medium 0 are both considered as vacuum and with the constant $c/4\pi$ (c being the speed of light in vacuum) being omitted for convenience since this constant will be lost when dividing to determine the overall transmittance.

Substituting Eq. (4) into Eq. (6) yields the transmitted power as

$$\xi = n_o |t_2|^2 \left[|E_2^+|^2 + |A2|^2 + |A4|^2 + |A6|^2 + \cdots \right] \quad (7)$$

Next, combining Eqs. (2) and (3) yields

$$\left. \begin{aligned} |A2|^2 &= R_2 R_{210} |E_2^+|^2 \\ |A4|^2 &= R_2^2 R_{210}^2 |E_2^+|^2 \\ |A6|^2 &= R_2^3 R_{210}^3 |E_2^+|^2 \end{aligned} \right\} \quad (8)$$

where

$$R_2 = |r_2|^2 \quad (9)$$

$$R_{210} = |r_{210}|^2 \quad (10)$$

$$T_2 = |t_2|^2 \quad (11)$$

Inserting Eq. (11) into Eq. (7) results in the transmitted power being given by

$$\xi = n_o T_2 |E_2^-|^2 [1 + R_2 R_{210} - R_2^2 R_{210}^2 + R_2^3 R_{210}^3 + \cdots] \quad (12)$$

where the infinite sum coverges to the closed-form expression,

$$\xi = \frac{n_o T_2 |E_2^+|^2}{1 - R_2 R_{210}} \quad (13)$$

The transmittance is defined as the transmitted power divided by the incident power. The incident power is given by

$$\xi_o = n_o |E_o^-|^2 \quad (14)$$

and the expression for the overall transmittance is obtained by ratioing Eq. (13) to Eq. (14), i.e.,

$$T = \frac{\xi}{\xi_o} = \frac{T_2 |E_2^+|^2}{[1 - R_2 R_{210}] |E_o^-|^2} \quad (15)$$

But from Eq. (2)

$$\frac{|E_2^+|^2}{|E_o^+|^2} = |t_{012}|^2 = T_{012} \tag{16}$$

and the final result for the overall normal transmittance is given by

$$T = \frac{T_2 T_{012}}{[1 - R_2 R_{210}]} \tag{17}$$

The result in Eq. (17) is valid only when the substrate is a nonabsorbing medium. If the substrate is also absorbing, i.e., the imaginary part of the complex refractive index of the substrate is nonzero, then Eq. (17) becomes

$$T = \frac{T_2 T_{012}\, e^{-\alpha_g D}}{1 - R_2 R_{210}\, e^{-2\alpha_g D}} \tag{18}$$

where

D = the thickness of the substrate (germanium)

$\alpha_g = \left(4\pi k_g\right)/\lambda$ is the absorption coefficient of the substrate (germanium)

k_g = imaginary component of complex refractive index of the substrate (germanium)

λ = wavelength in vacuum

Having developed Eq. (18), which is the normal transmittance of a thin film deposited upon a thick partially transmitting film, it is now necessary to define the expressions T_2, T_{012}, R_2, and R_{210} in terms of the optical constants of the thin film, the substrate, and wavelength. The derivation of these quantities is straightforward, although tedious, and is outlined in detail in Ref. 16. For completeness, the expressions required to evaluate Eq. (18) are listed below (Fresnel coefficient for normal incidence):

$$R_2 = |r_2|^2 = \left|\left(\frac{\bar{n}_2 - n_o}{\bar{n}_2 + n_o}\right)\right|^2 \tag{19}$$

$$T_2 = |t_2|^2 = \left|\frac{2\bar{n}_2}{(n_o + \bar{n}_2)}\right|^2 \tag{20}$$

The expressions for T_{012} and R_{210} are somewhat more complicated to evaluate and will be considered separately from R_2 and T_2. The expressions for T_{012} and R_{210} based on the work of Ref. 16 are given by

$$T_{012} = \frac{|t_a|^2 |t_b|^2 \, e^{-2b}}{[1 + |r_a|^2 |r_b|^2 \, e^{-4b} + 2e^{-2b}\{Re(r_a r_b) \cos 2a - Im(r_a r_b) \sin 2a\}]} \tag{21}$$

and

$$R_{210} = \frac{[|r_a|^2 + |r_b|^2 \, e^{-4b} + 2e^{-2b}\{Re(r_b r_a^*) \cos 2a + Im(r_b r_a^*) \sin 2a\}]}{[1 + |r_a|^2 |r_b|^2 \, e^{-4b} - 2e^{-2b}\{Re(r_a r_b) \cos 2a + Im(r_a r_b) \sin 2a\}]} \tag{22}$$

where

$$r_a = \frac{\bar{n}_2 - \bar{n}_1}{\bar{n}_2 + \bar{n}_1} \tag{23}$$

$$r_b = \frac{\bar{n}_1 - n_o}{\bar{n}_1 + n_o} \tag{24}$$

$$t_a = \frac{2\bar{n}_1}{\bar{n}_1 + \bar{n}_2} \tag{25}$$

$$t_b = \frac{2n_o}{n_o - \bar{n}_1} \tag{26}$$

$$\bar{n}_1 = n_1 - ik_1 = n - ik = \bar{n} \tag{27}$$

$$\bar{n}_2 = n_g - ik_g \tag{28}$$

$$a = \frac{2\pi d_1 n_1}{\lambda} \tag{29}$$

$$b = \frac{2\pi d_1 k_1}{\lambda} \tag{30}$$

$$d_1 = \text{cryodeposit thickness} \tag{31}$$

and * denotes the complex conjugate. The optical constants of the cryopumped constituents were determined by using this analytical transmission model in conjunction with a nonlinear least-squares convergence routine. Also the subtractive Kramers-Kronig relation (which is based on solid-state physics) between n and k was used in conjunction with (for 20 and 80°K N_2O_4) and in comparison with (for 20 and 80°K MMH, also for 80°K N_2H_4) the nonlinear least-squares determination of n. The subtractive Kramers-Kronig relation is given by

$$n(\nu) = n(\nu_m) + \frac{2}{\pi} P \int_0^{\infty} \left[\frac{k(\nu')\nu' - k(\nu)\nu}{(\nu')^2 - \nu^2} - \frac{k(\nu')\nu' - k(\nu_m)\nu_m}{(\nu')^2 - \nu_m^{\,2}} \right] d\nu' \tag{32}$$

where ν_m is a reference frequency (2500 cm^{-1} for 20°K MMH and N_2O_4 and 2200 cm^{-1} for 80°K MMH, N_2O_4, and N_2H_4) and P indicates the Cauchy principal value of the integral. Integration was performed using the simple trapezoidal rule; the $k(\nu')$ values used in Eq. (32) were those determined by the nonlinear least-squares technique.

The transmission data recorded for all deposits discussed here were digitized every 2 cm^{-1}. In the determination of n, transmission spectra at 14 thicknesses (HeNe laser interference fringes) (0 → 3.25 μm) were used; for MMH at 80°K, data at 11 thicknesses (0 → 2.29 μm) were used; and for N_2H_4 at 80°K, data at 22 thicknesses (0 → 4.74 μm) were used. The optical constants are shown in Fig. 16 and Table 4 for 20°K MMH, in Fig. 17 and Table 5 for 80°K MMH, and in Fig. 18 and Table 6 for 80°K N_2H_4. These optical properties were determined solely by use of the analytical model with the nonlinear least-squares convergence technique; the Kramers-Kronig determination of n is shown only for comparison purposes. The results of the two techniques are in excellent agreement.

For N_2O_4, absolute transmission spectra at 7 thicknesses (0 to 1.45 μm) for the 20°K deposit and 9 thicknesses (0 → 6.63 μm) for the 80°K deposit were used in determining the optical properties. Usually a minimum of about 15 thicknesses is desired for the analytical model to converge upon a well-defined value of n. The n value appears to be primarily defined by the period of the transmission versus thickness curve at each wavenumber. When only a few thicknesses are obtained, the transmission versus thickness (for each wavenumber) curve is not well defined. It was found that for high wavenumbers (>2100 cm^{-1}) the analytical model had no problem in defining n; however, at the lower wavenumbers a neighborhood (range) of n values seemed to satisfy the transmission data. The k value, which is primarily defined by the magnitude of the transmission, did not have this difficulty and was well-defined over the whole spectral region (700 to 3700 cm^{-1}). Thus to determine n, the k values were used with the subtractive Kramers-Kronig relationship to compute n; these new n values were then used in the analytical model (along with the k values) to see if good agreement occurred with the transmission data. For all wavenumbers, the Kramers-Kronig n's along with the least-squares k's yielded good agreement when the analytical model and transmission data were compared. The optical constants for 20 and 80°K N_2O_4 are shown in Fig. 19 and Table 7 (20°K), and Fig. 20 and Table 8 (80°K), respectively.

The optical properties presented are important for calculating the effects of possible deposits upon cryogenically cooled surfaces. Such surfaces as cryogenically cooled sensor optics and telescopes will be functioning in the wavenumber region investigated. The interpretation of information from these types of instruments, when contaminated with thin films, will require spectral knowledge of n and k. Shown in Fig. 21 are the transmission versus thickness curves at a variety of wavenumbers for the 20 and 80°K data. The excellent agreement between theory and data is typical of the results obtained over the entire spectral region (700 to 3700 cm^{-1}). Figure 21 illustrates the good agreement between theory and data at both high and low wavenumbers and in regions of high absorption.

6.0 SUMMARY

Experimentally determined transmission measurements of condensed propellant gases on a cryogenically cooled germanium window have been made. Thin films of monomethyl hydrazine (MMH), nitrogen tetroxide (N_2O_4), and hydrazine(N_2H_4) were formed at 20 and 77°K. The infrared spectral transmission was studied over the 500 to 3700-cm^{-1} wavenumber range. The propellant thickness was accurately determined using a two-angle laser-interference technique. The density of the films was determined using quartz-crystal microbalances (QCM's) and by determining the refractive index at 0.6328 μm to allow accurate thickness determination. Some fracture and shattering effects were observed for the films condensed at 20°K.

From the transmission data, the optical properties n and k, which are the real and imaginary parts of the refractive index, were determined for the 700 to 3700-cm^{-1} wavenumber range. These results are presented in graphical and tabular form for a wavenumber interval of 2 cm^{-1}. These optical properties can be used to calculate the amount of optical contamination caused by thin films of these gases deposited on any mirror or window substrate, provided the n's and k's of the substrate material are also known.

No major spectral differences were observed between the transmission results of films formed at 20 and 77°K for the same propellant. For MMH, the n's and k's showed little variation: The n values for 77°K were slightly larger than for 20°K; the k values in the absorption bands for 77°K were also slightly larger than for 20°K. The N_2O_4 optical properties showed a stronger variation with temperature than did the MMH. For N_2O_4 the n's and k's were larger at 77°K than 20°K for the three strongest absorption bands.

REFERENCES

1. Pipes, J. G., Roux, J. A., Smith, A. M., and Scott, H. E. "Transmission of Infrared Materials and Condensed Gases at Cryogenic Temperatures." AEDC-TR-77-71 (AD-A044517), September 1977.

2. Tempelmeyer, K. E. and Mills, D. W., Jr. "Refractive Index of Carbon Dioxide Cryodeposit." *Journal of Applied Physics*, Vol. 39, No. 6, May 1968, pp. 2968-2969.

3. Durig, J. R., Harris, W. C., and Wertz, D. W. "Infrared and Raman Spectra of Substituted Hydrazines. I. Methylhydrazine." *Journal of Chemical Physics,* Vol. 50, Number 3, February 1969, pp. 1449-1461.

4. Wiener, R. N. and Nixon, E. R. "Infrared Spectrum of Dinitrogen Tetroxide." *Journal of Chemical Physics*, Vol. 26, Number 4, April 1957,pp. 906-908.

5. Bibart, C. H. and Ewing, G. E. "Vibrational Spectrum, Torsional Potential, and Bonding of Gaseous N_2O_4." *Journal of Chemical Physics*, Vol. 61, Number 4, August 1974, p. 1284-1292.

6. Snyder, R. G. and Hisatsune, I. C. "Infrared Spectrum of Dinitrogen Tetroxide." *Journal of Molecular Spectroscopy*, Vol. 1, 1957, pp. 139-150.

7. Kato, R. and Rolfe, J. "Vibrational Frequencies of NO_2^- and NO_3^- Ions in KBr Crystals." *Journal of Chemical Physics*, Vol. 47, Number 6, September 1967, pp. 1901-1910.

8. Bibart, C. H. and Ewing, G. E. "Vibrational Spectrum of Gaseous N_2O_3." *Journal of Chemical Physics*, Vol. 61, Number 4, August 1974, pp. 1293-1299.

9. Herzberg, G. *Molecular Spectra and Molecular Structure — II, Infrared and Raman Spectra of Polyatomic Molecules.* Van Nostrand Co., Inc., 1945.

10. Devlin, J. P., Pollard, G., and Frech, R. "ATR Infrared Spectra of Uniaxial Nitrate Crystals." *Journal of Chemical Physics*, Vol. 53, Number 11, September 1970, pp. 4147-4151.

11. McGraw, G. E., Bernitt, D. L., and Hisatsune, I. C. "Vibrational Spectra of Isotopic Nitric Acids." *Journal of Chemical Physics*, Vol. 42, Number 1, January 1965, pp. 237-244.

12. Durig, J. R., Bush, S. F., and Mercer, E. E. "Vibrational Spectrum of Hydrazine -d_4 and a Raman Study of Hydrazine Bonding in Hydrazine." *Journal of Chemical Physics*, Vol. 44, Number 11, June 1966, pp. 4238-4247.

13. Giguère, Paul A., and Liu, I. D. "On the Infrared Spectrum of Hydrazine." *Journal of Chemical Physics* Vol. 20, Number 1, January 1952, pp. 136-140.

14. Catalano, Edward, Sandborn, Russell H., and Frazer, Jack W. "On the Infrared Spectrum of Hydrazine Matrix-Isolation Studies of the System NH_2NH_2: N_2.I. *Journal of Chemical Physics*, Vol. 38, Number 9, May 1963, pp. 2265-2272.

15. Vasicek, A. *Optics of Thin Films.* North Holland Publishing Company, Interscience Publishers, Inc., New York, 1960.

16. Heavens, O. S. *Optical Properties of Thin Films.* Dover Publications, Inc., New York, 1965.

17. Herzberger, M. and Salzberg, C. D. "Refractive Indices of Infrared Optical Materials and Color Correction of Infrared Lenses." *Journal of Optical Society of America*, Vol. 52, Number 4, April 1962, pp. 420-426.

1. Pyroelectric detector and collection optics.
2. Stainless steel high vacuum chamber, 85 cm tall by 70 cm in diameter (33.5 in. by 27.5 in. in diameter).
3. Cryogenically cooled infrared window; germanium, 4 mm thick by 70 mm square (0.158 in. by 2.76 in.) and QCM.
4. Helium-neon laser (0.6328 μm) beam (one of two shown) employed to measure cryofilm thickness.
5. Infrared beam, 38 mm in diameter (1.5 in.).
6. 2-mw He-Ne laser.
7. Michelson interferometer.
8. Infrared source and collimator mirror.

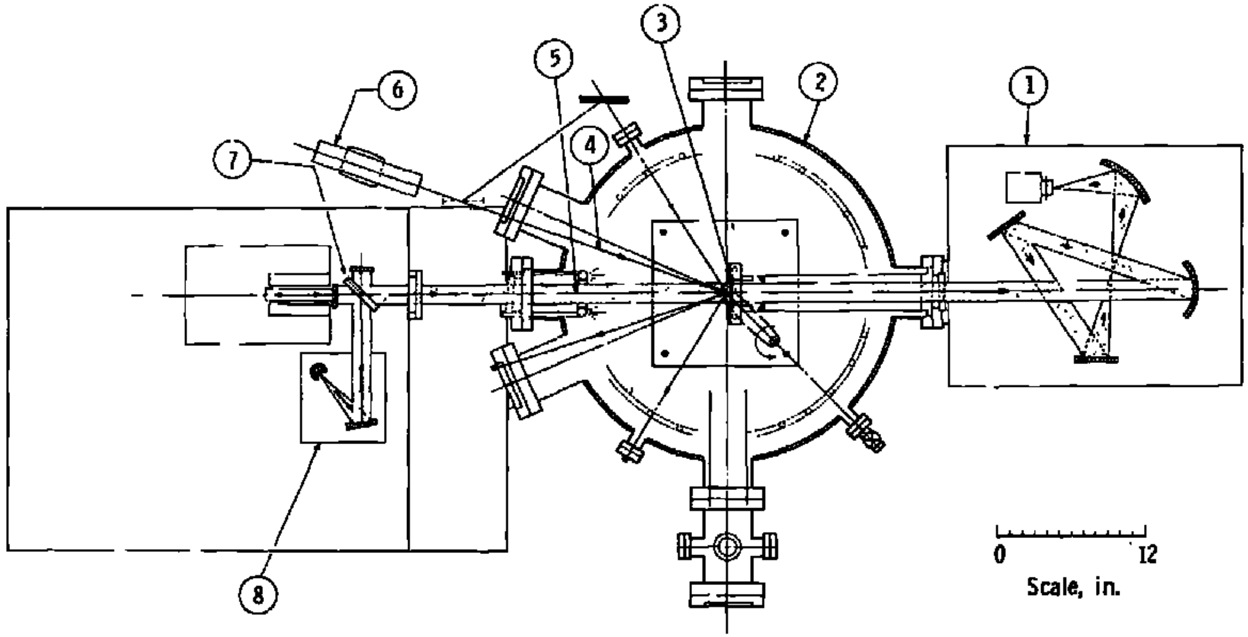


Figure 1. Schematic of the Infrared Optical Transmission Chamber (IROTC) with FTS-14 interferometer-spectrometer.

1. Infrared beam, 38-mm-diameter (1.5 in.).
2. Optical stop required to underfill cryocooled window with infrared beam. Also, this stop is supported by a 3-in. -ID pipe that prevents gas added to chamber from cryopumping on rear of window.
3. Aluminum holder with cryogenic passageways.
4. Germanium window heat sunk with an indium gasket to the aluminum holder.
5. Cover plate.
6. Gaseous helium or liquid nitrogen inlet.
7. Gaseous helium or liquid nitrogen outlet.
8. Crosshatched area illustrates area of window heat sunk to holder. Clear diameter is 50.7 mm (2 in.) while infrared beam diameter is 38 mm (1.5 in.).
9. QCM heat sunk with indium gasket to aluminum holder.

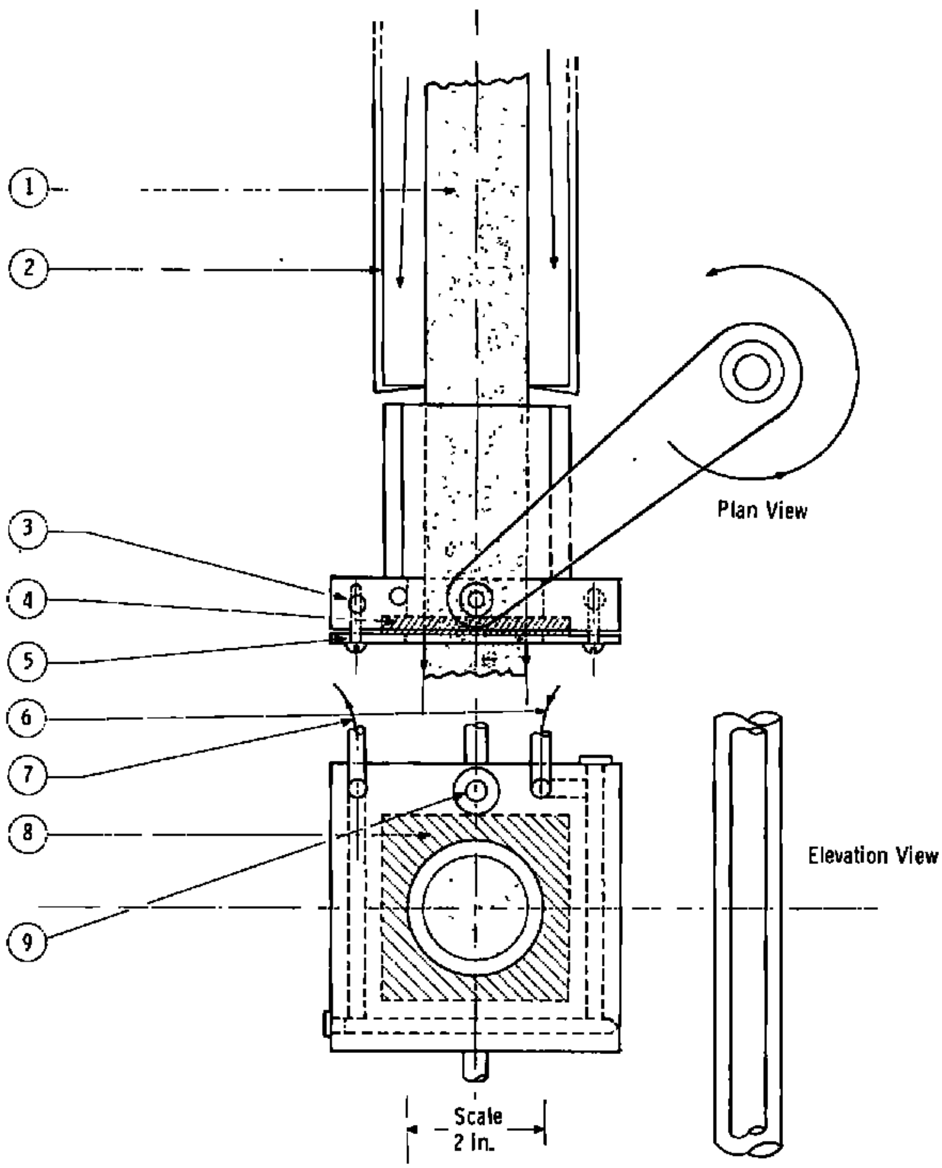


Figure 2. Plan and elevation views of cryogenically cooled sample holder.

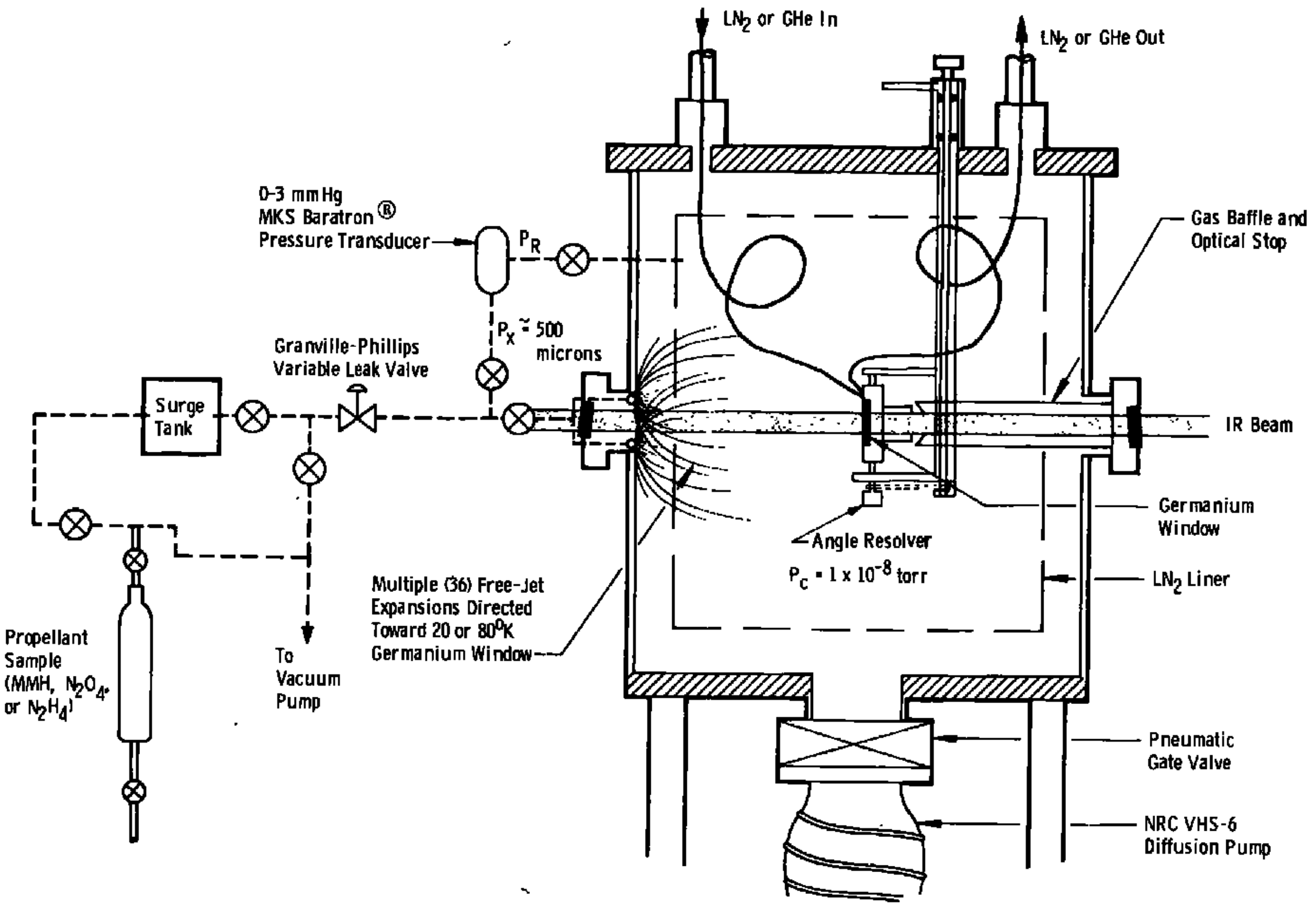
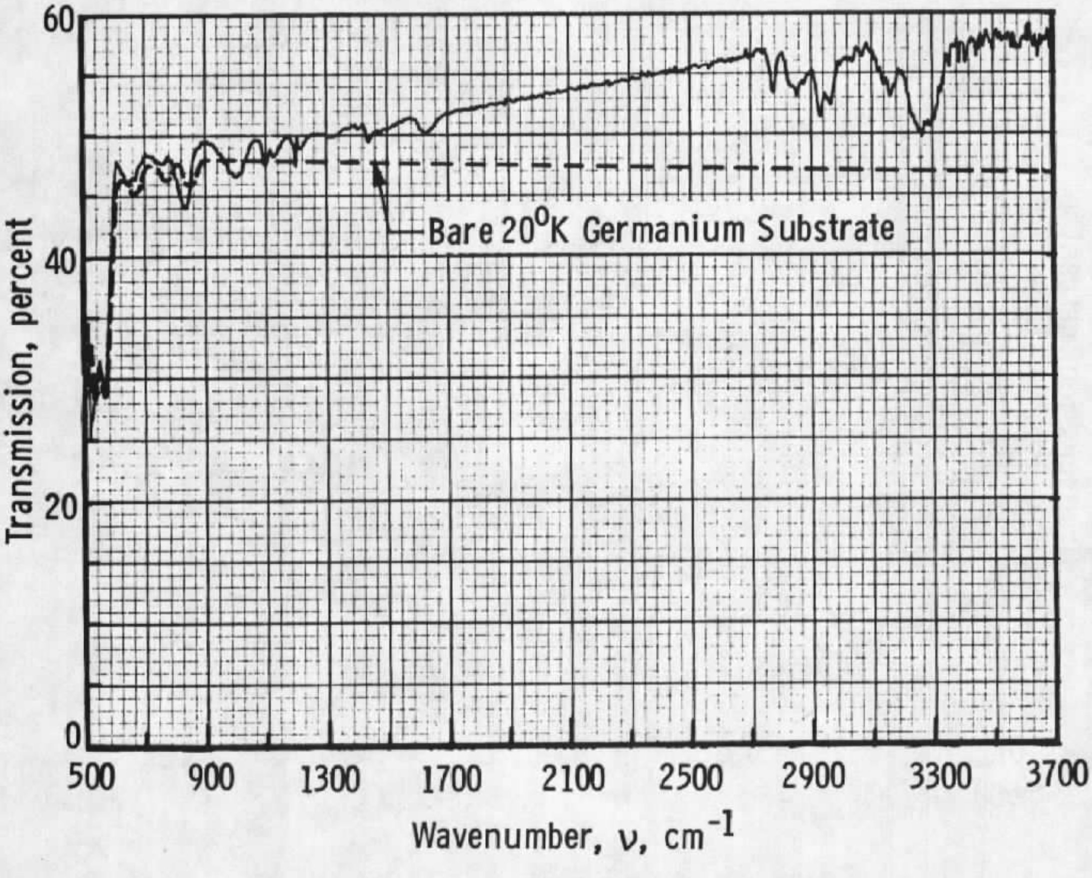
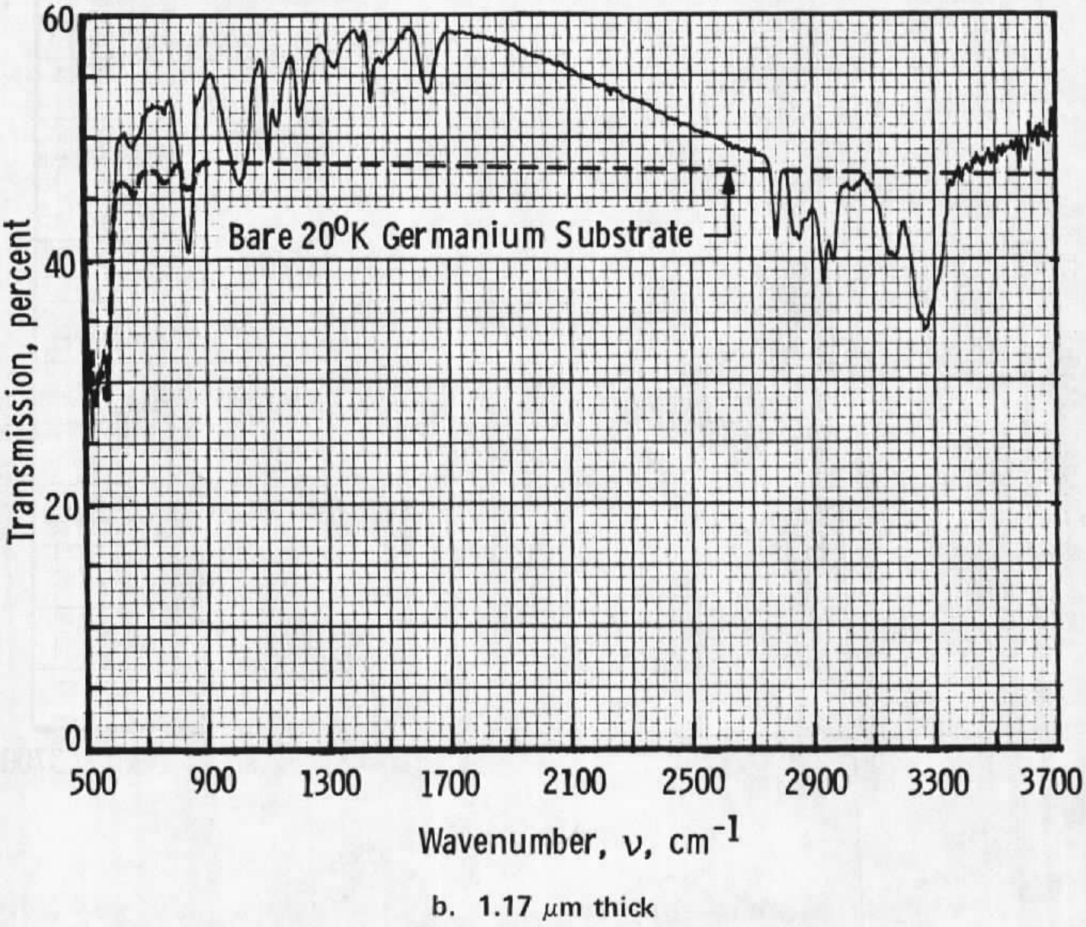


Figure 3. Gas deposition system.

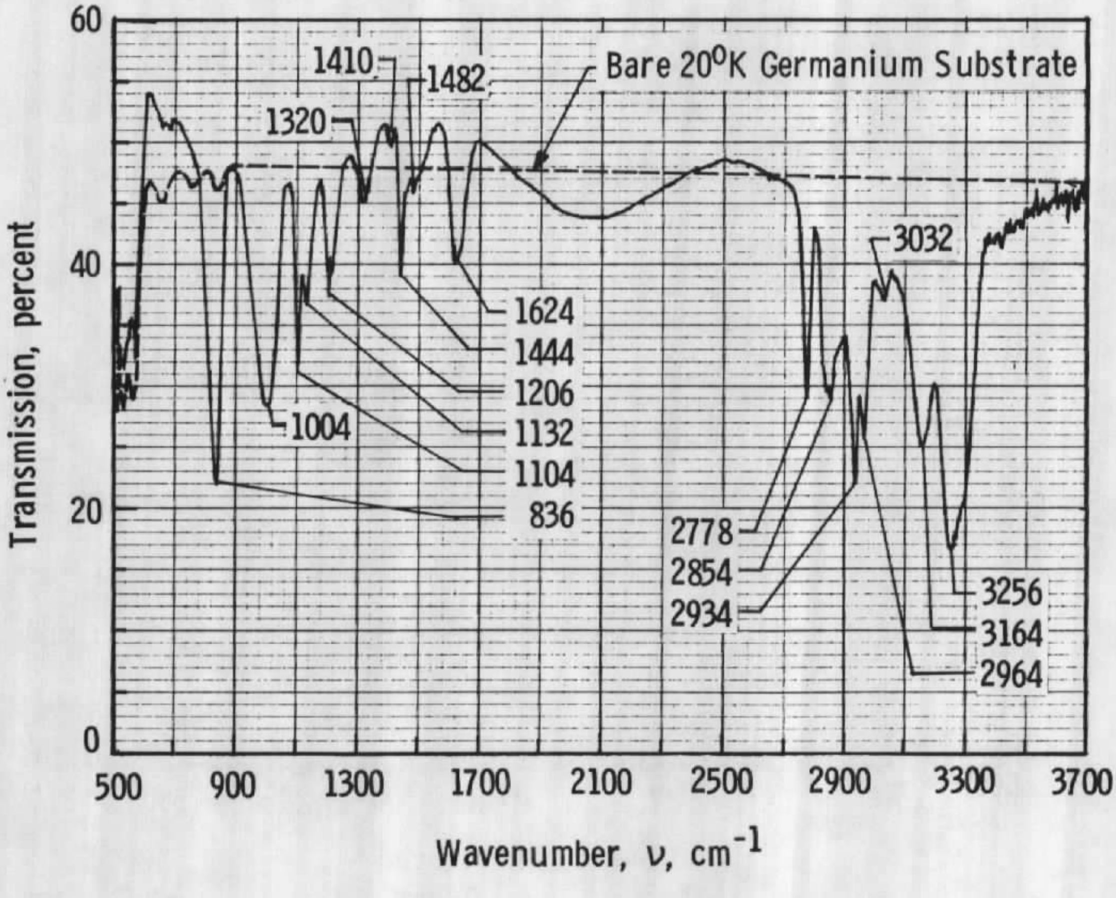


a. 0.47 μm thick

Figure 4. Transmission spectra of MMH condensed on a 20° K germanium substrate.



b. 1.17 μm thick
Figure 4. Continued.



c. 3.27 μm thick
Figure 4. Concluded.

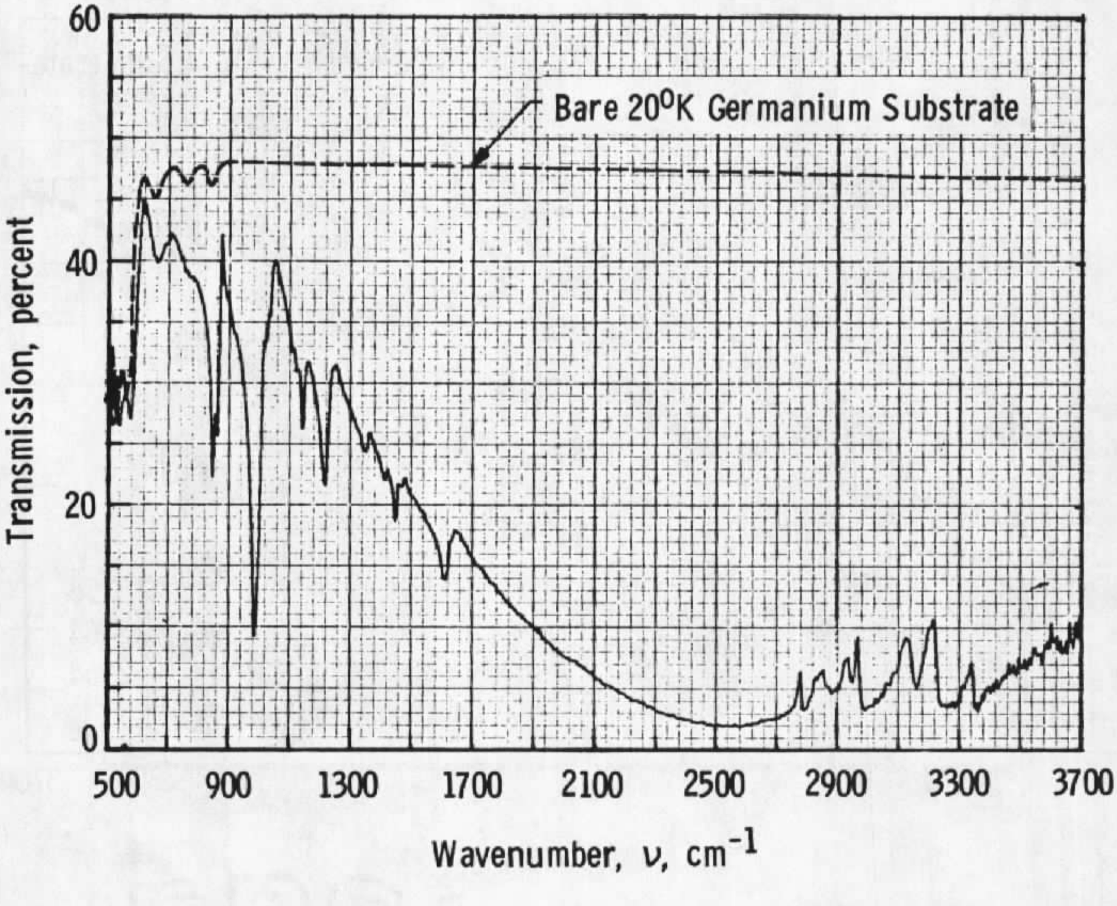
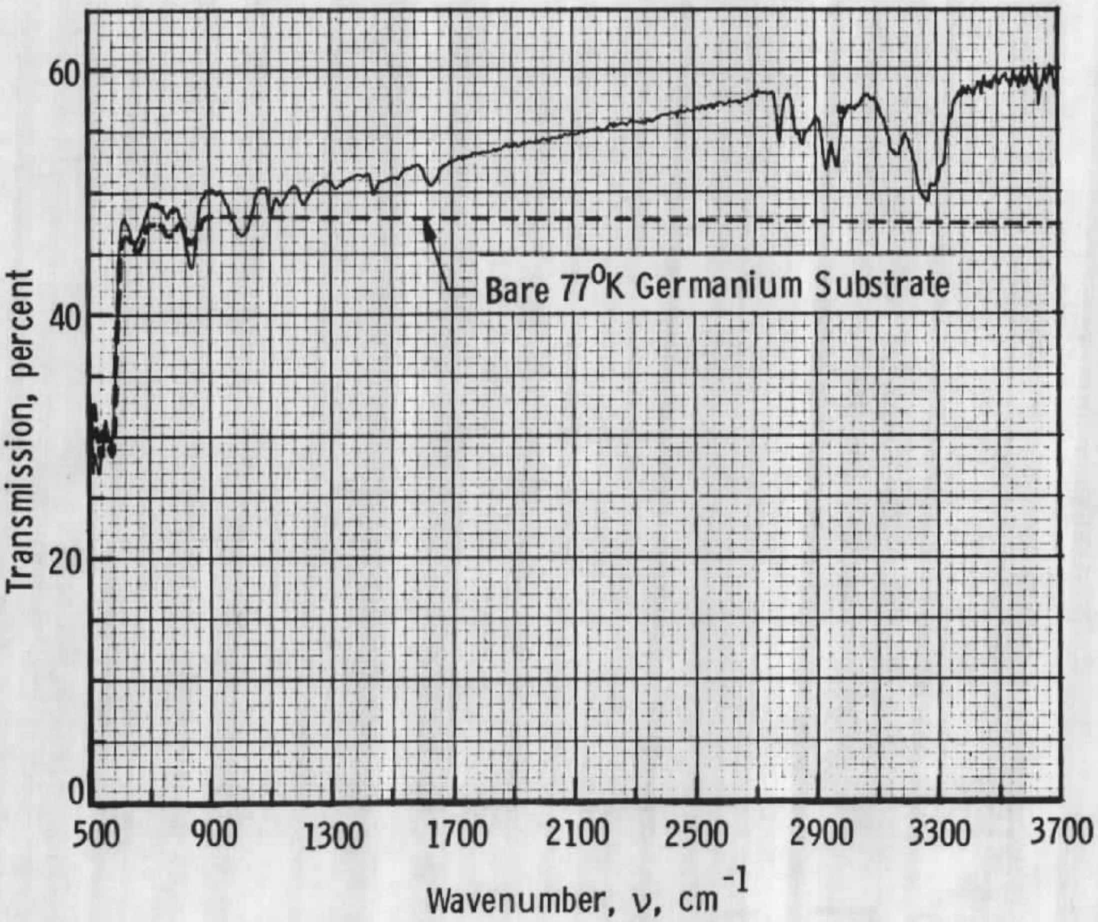
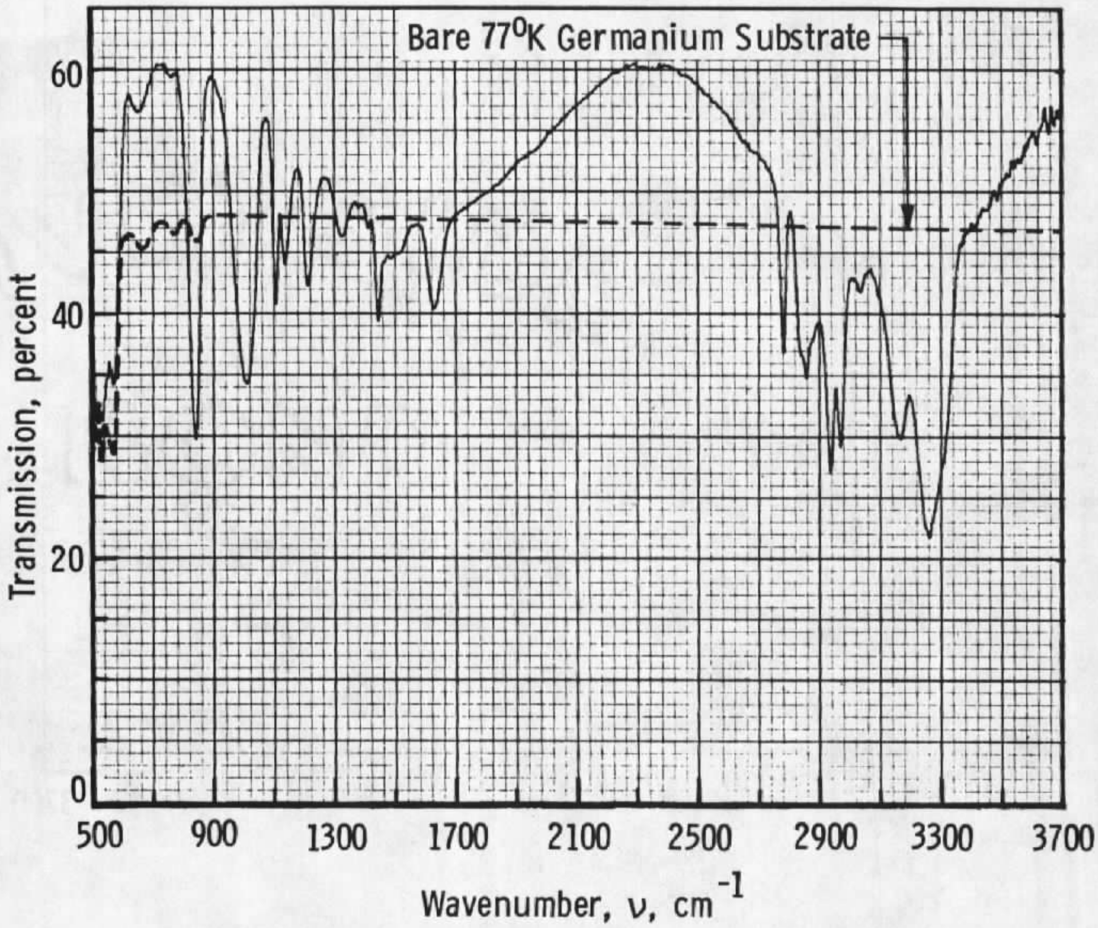


Figure 5. Transmission of 3.27-μm-thick solid MMH formed on 20° K germanium after warmup of the germanium substrate from 20 to 160° K.

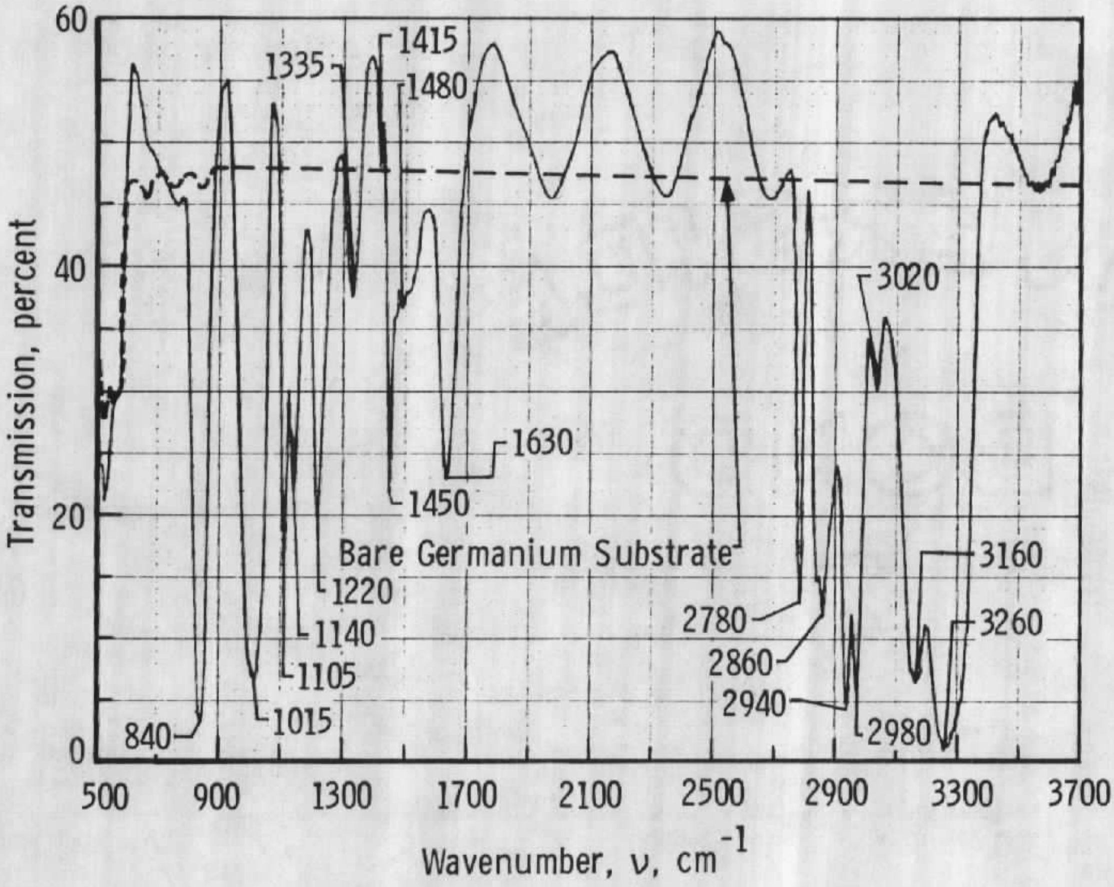


a. 0.44 μm thick

Figure 6. Transmission spectra of MMH condensed on a 77°K germanium substrate.



b. 2.21 μm thick
Figure 6. Continued.



c. 8.84 μm thick
Figure 6. Concluded.

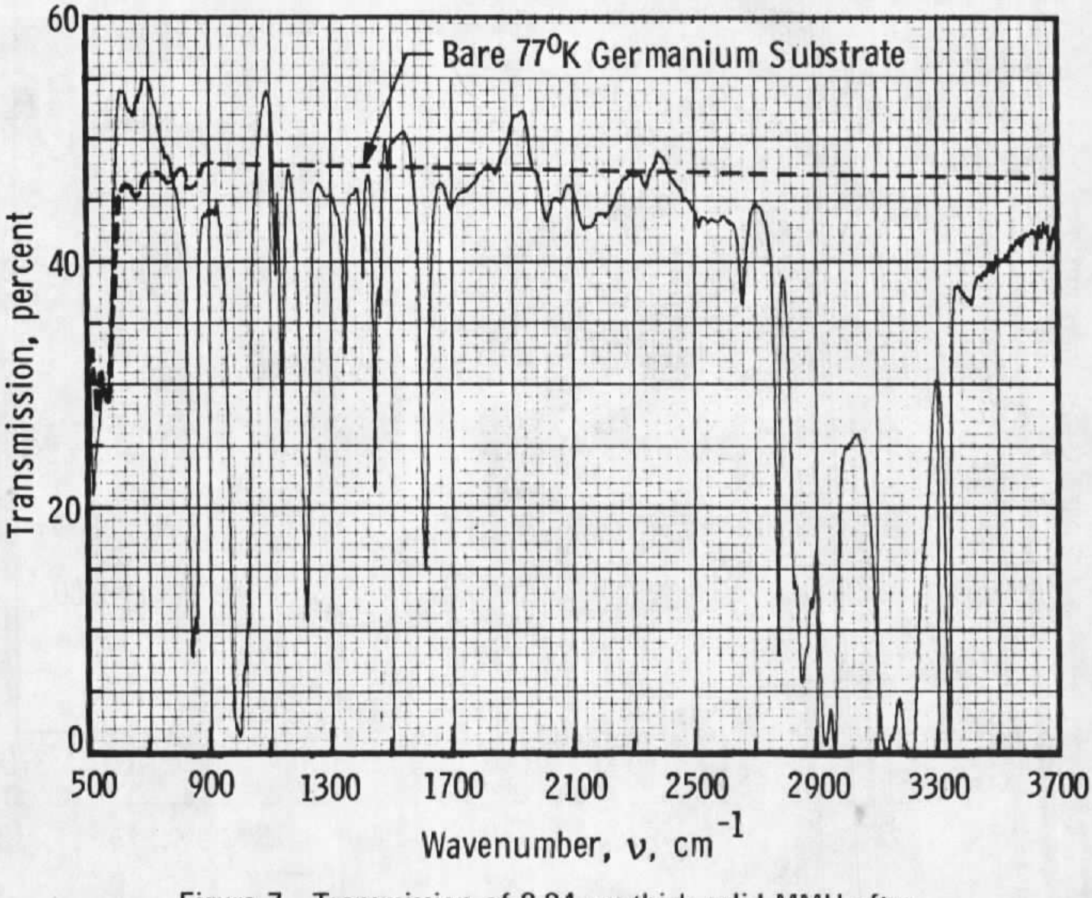


Figure 7. Transmission of 8.84-μm-thick solid MMH after warmup of germanium substrate from 77 to 161°K.

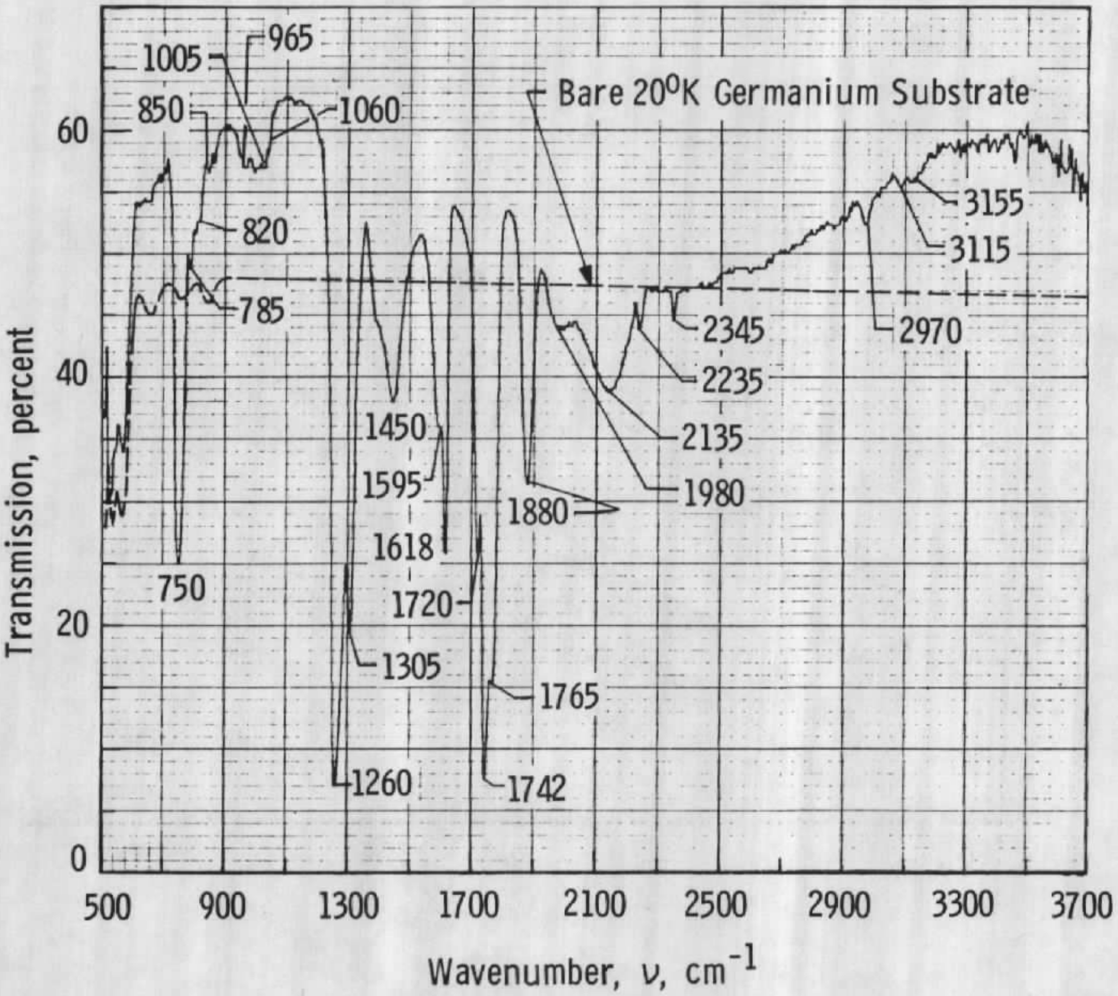


Figure 8. Transmission of 1.45-μm-thick solid N_2O_4 condensed on 20°K germanium.

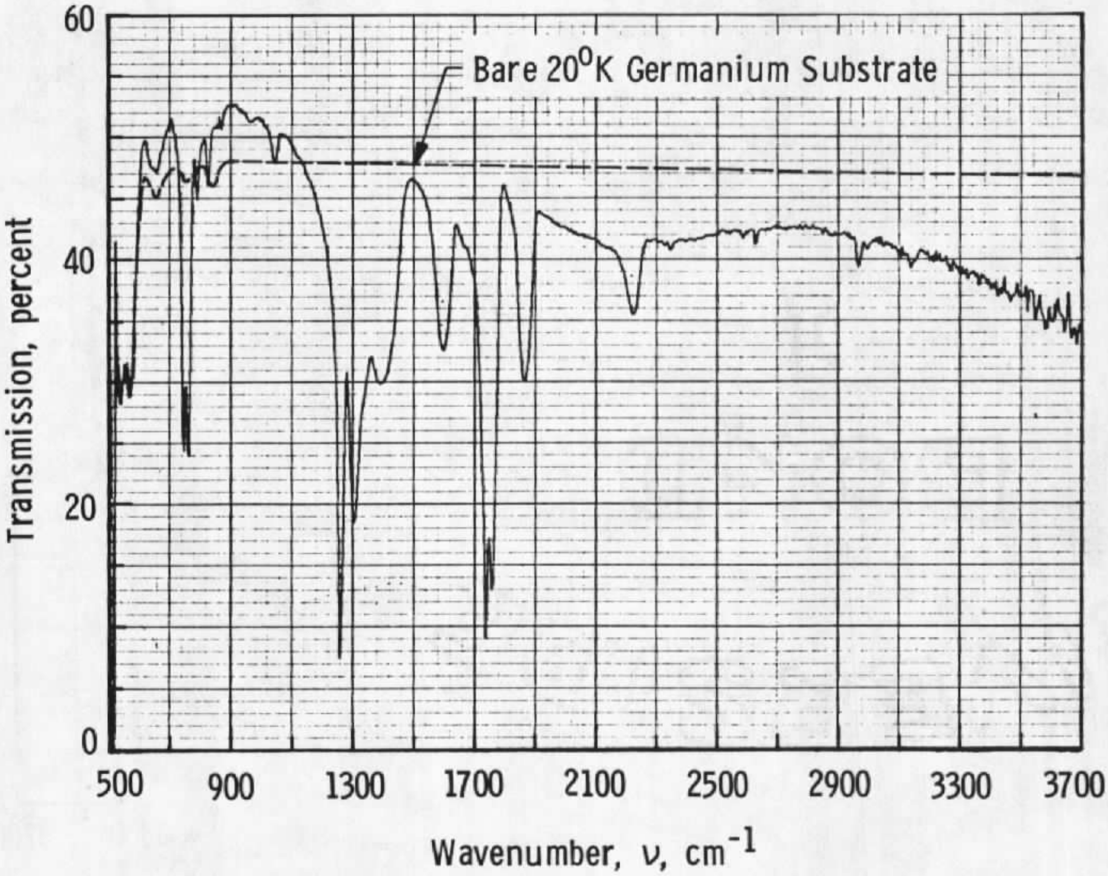
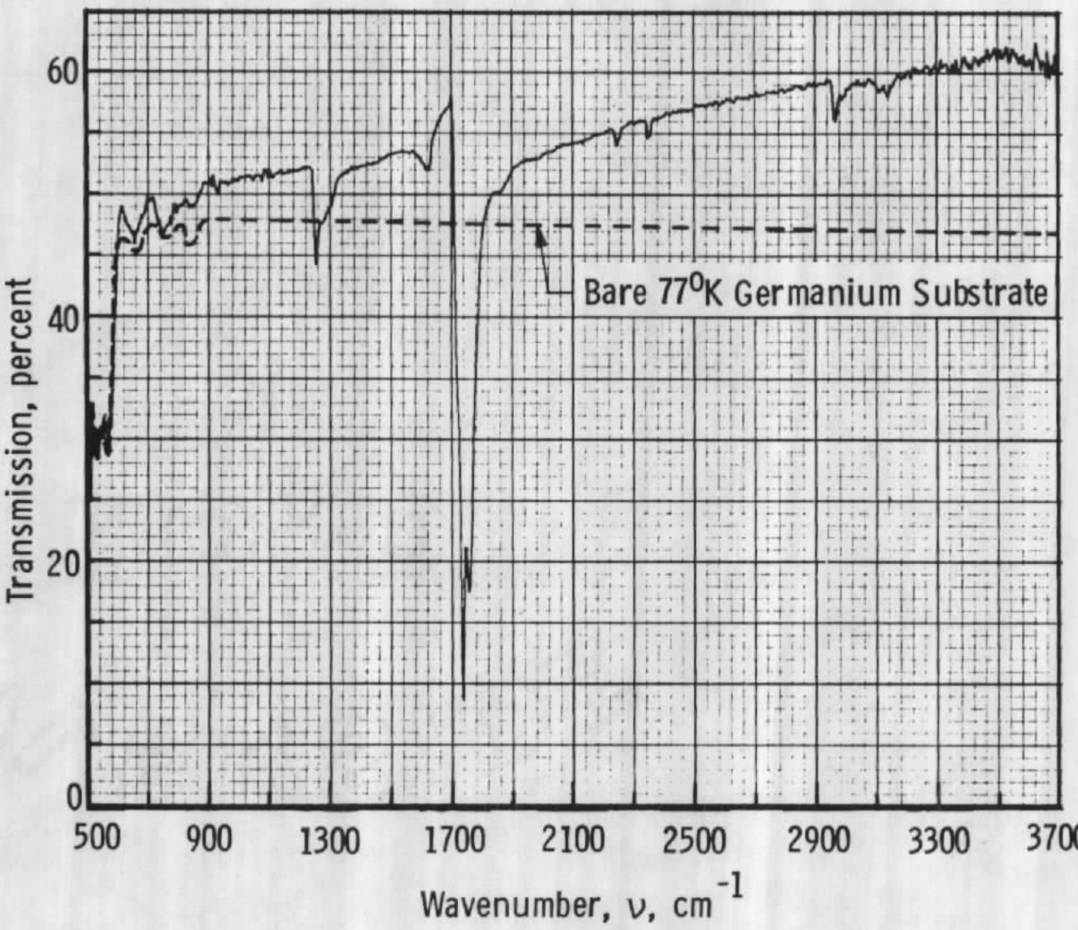
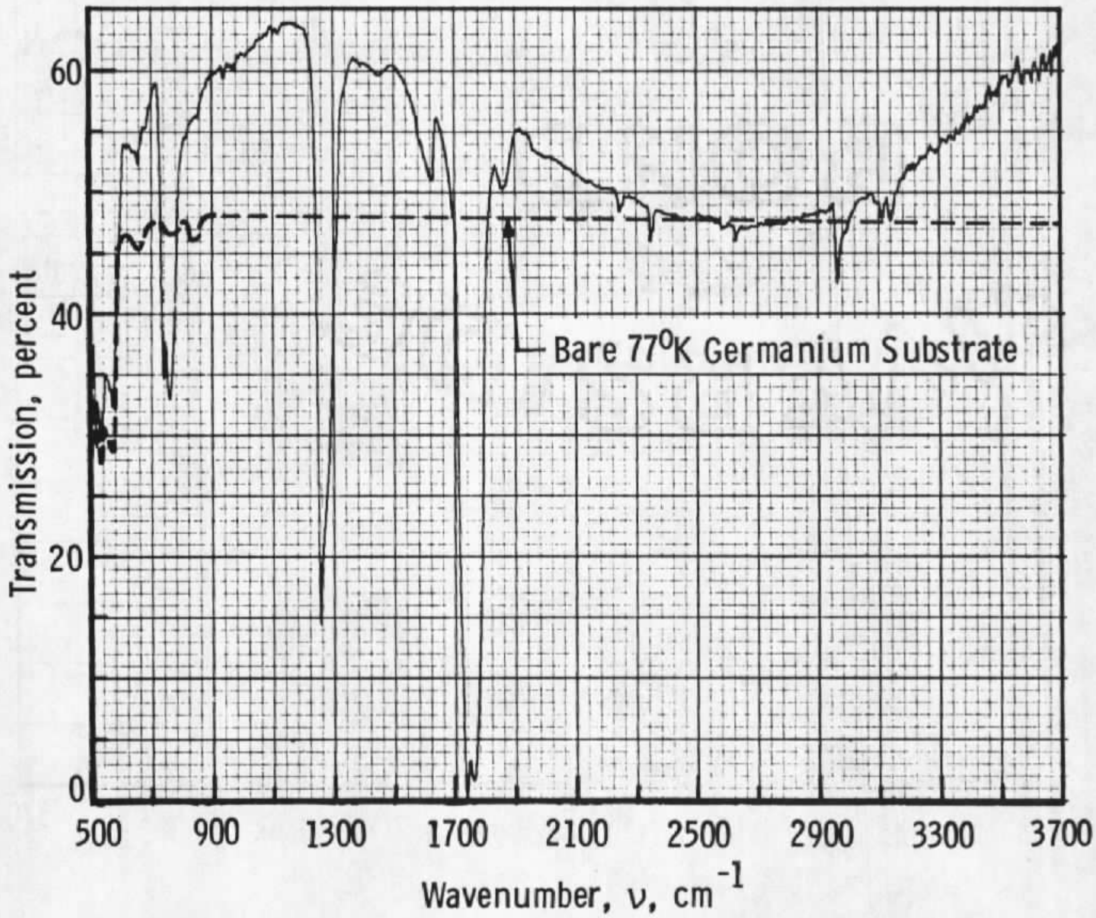


Figure 9. Transmission of 1.45-μm-thick solid N_2O_4 film on germanium after warmup from 20 to 153°K.

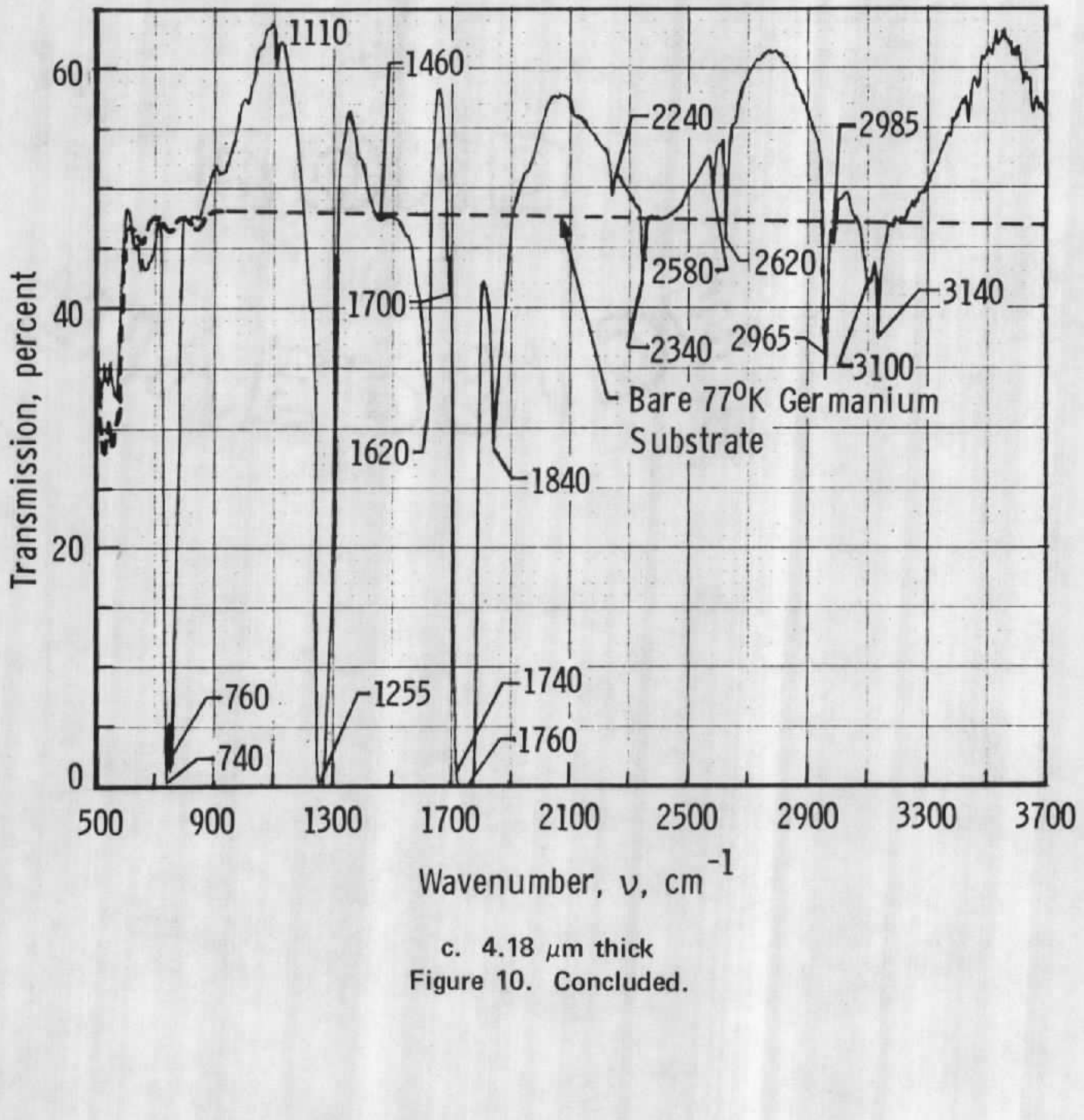


a. 0.42 μm thick

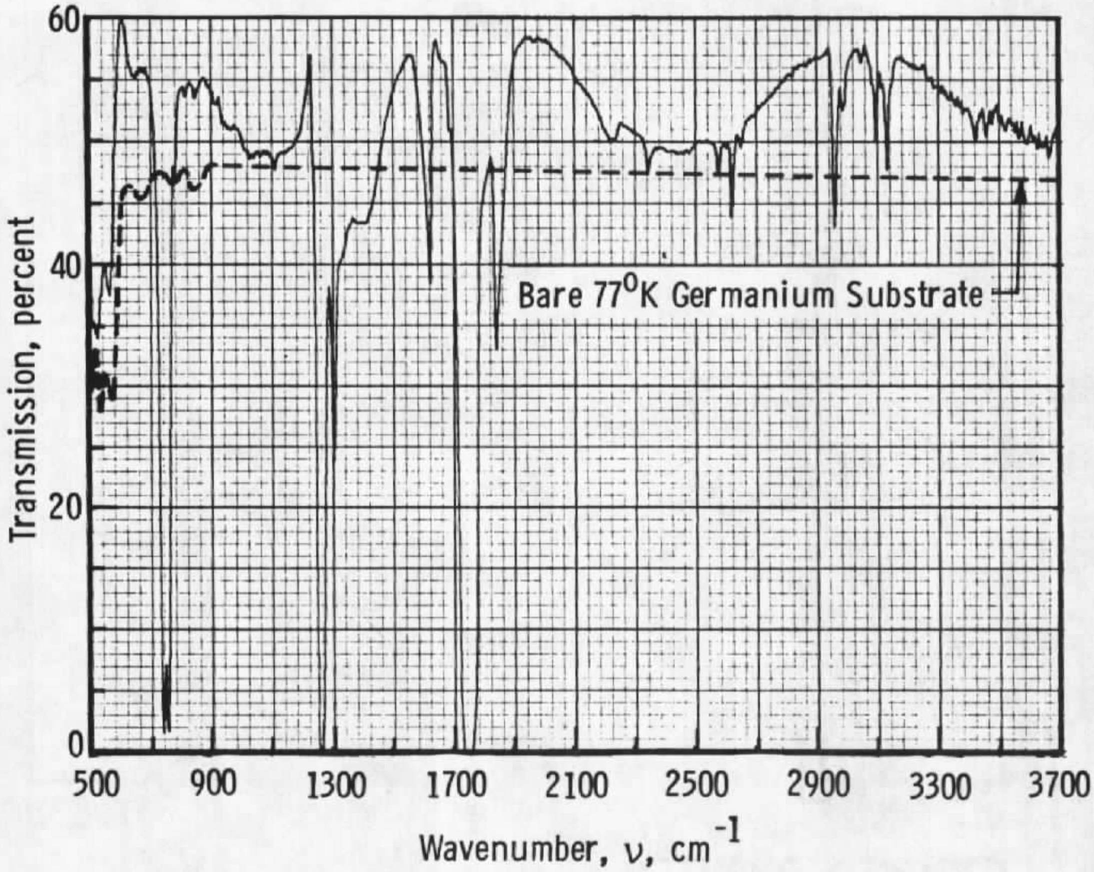
Figure 10. Transimission spectra of N_2O_4 condensed on 77° K germanium.



b. 1.25 μm thick
Figure 10. Continued.

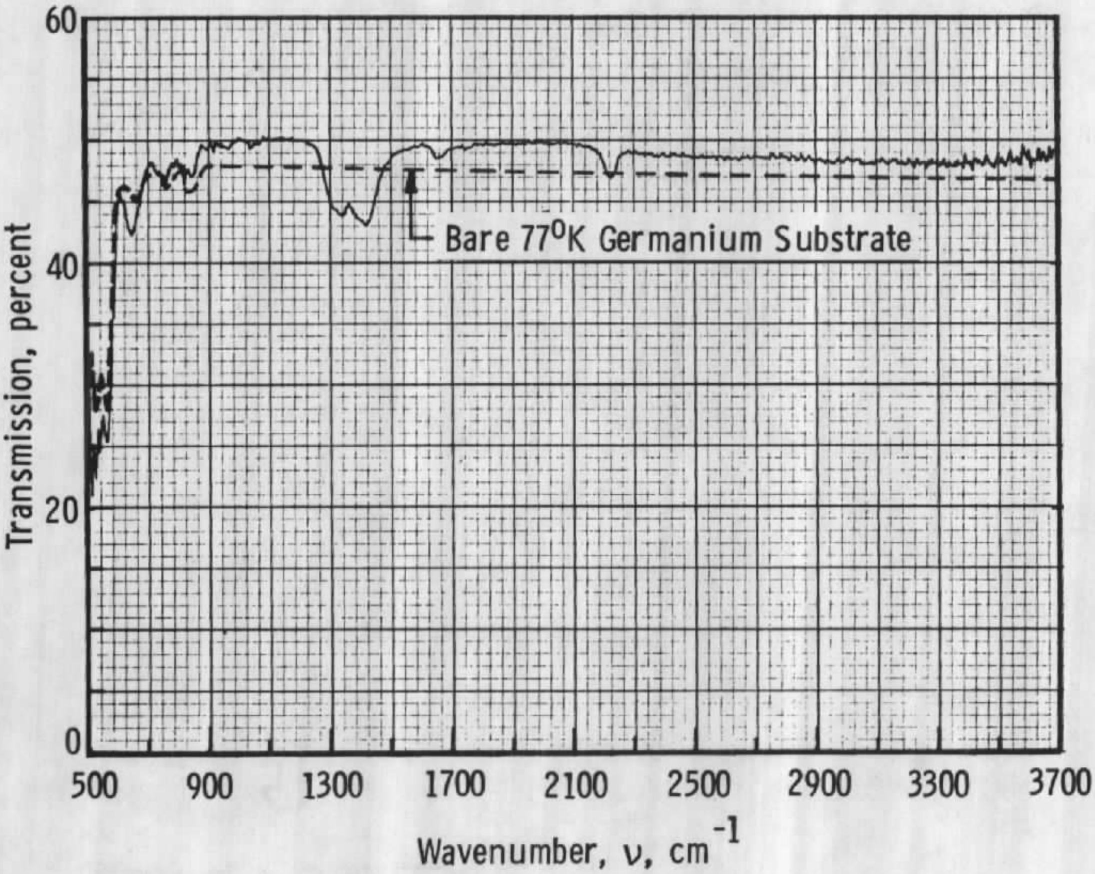


c. 4.18 μm thick
Figure 10. Concluded.

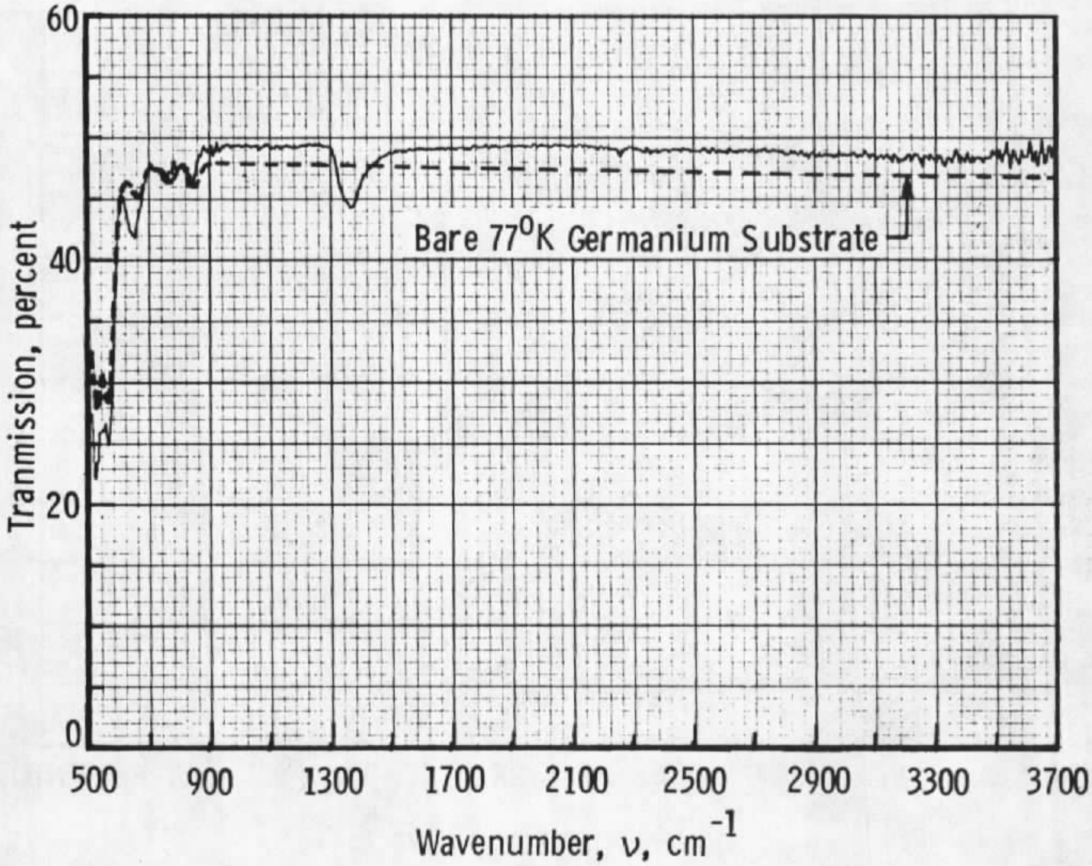


a. 155° K

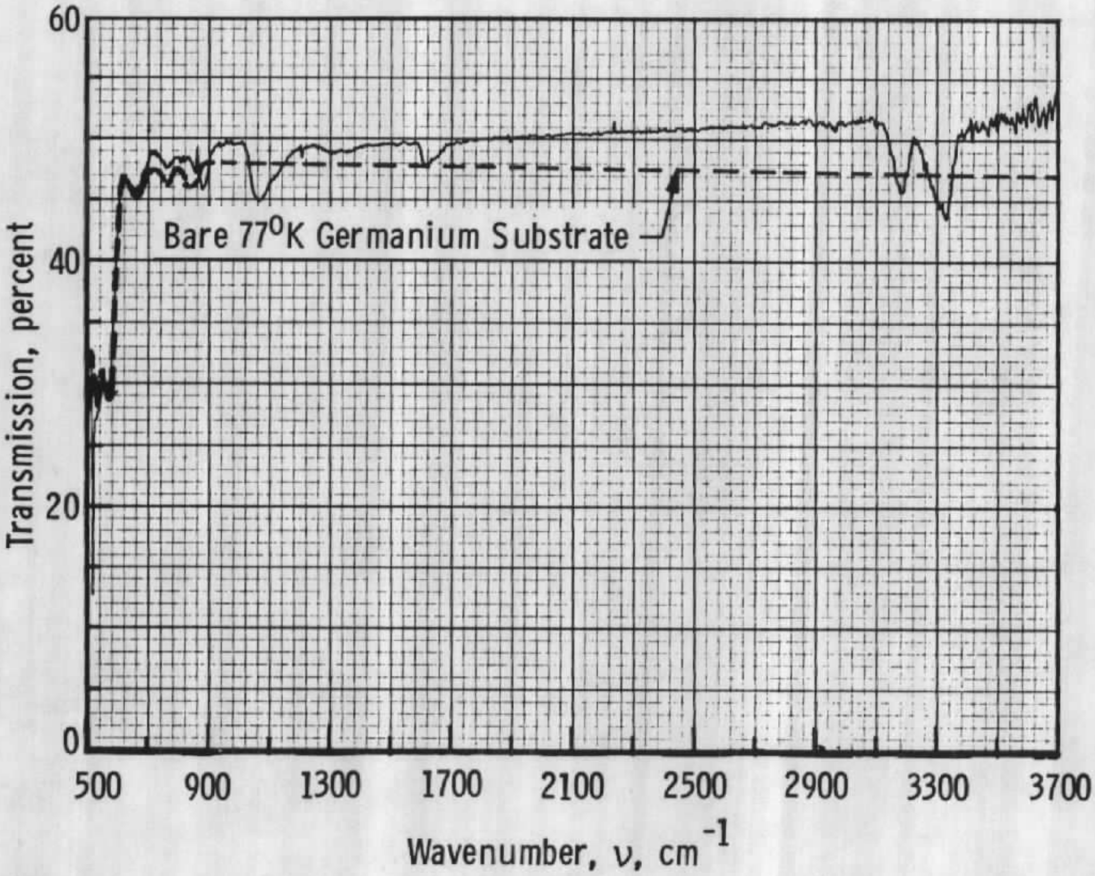
Figure 11. Transmission spectra of 4.18-μm-thick N_2O_4 condensed on a 77° K germanium substrate as a function of warmup temperature.



b. 174°K
Figure 11. Continued.

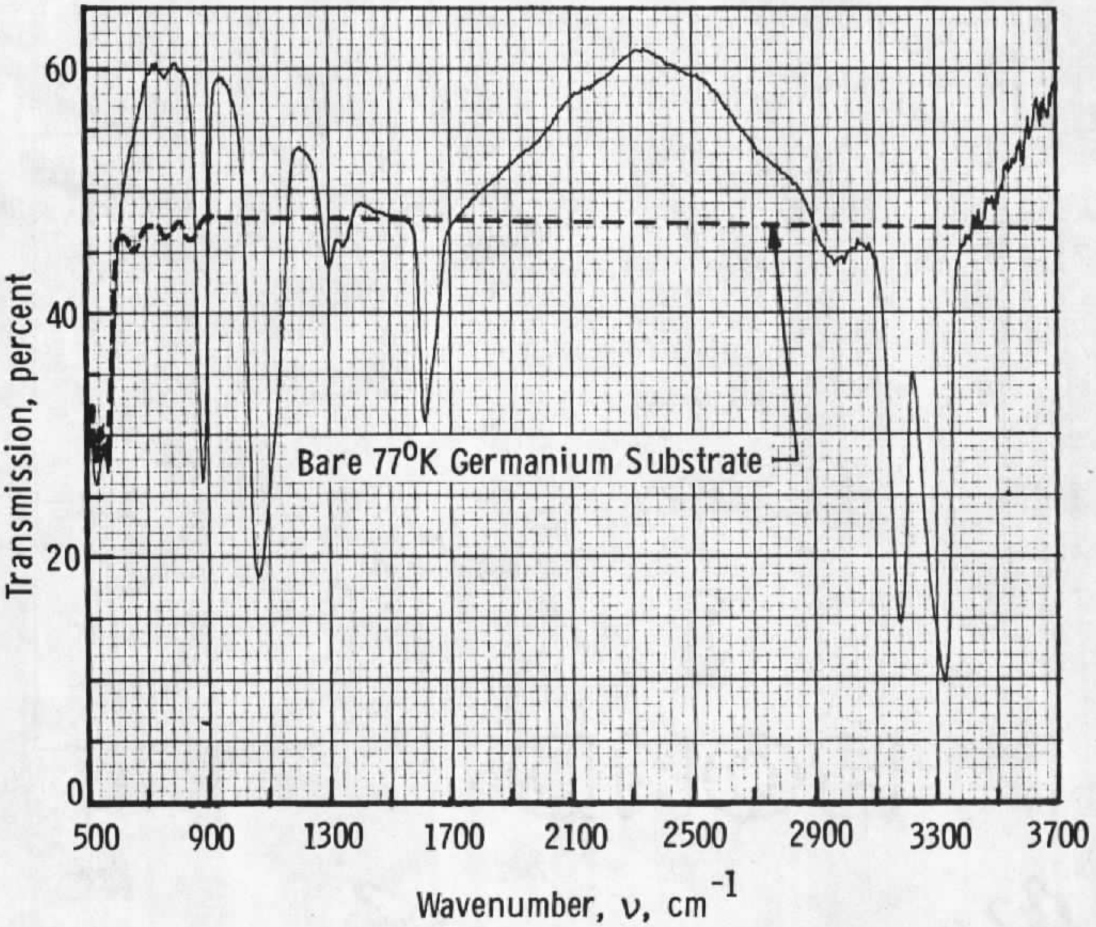


c. 183° K
Figure 11. Concluded.

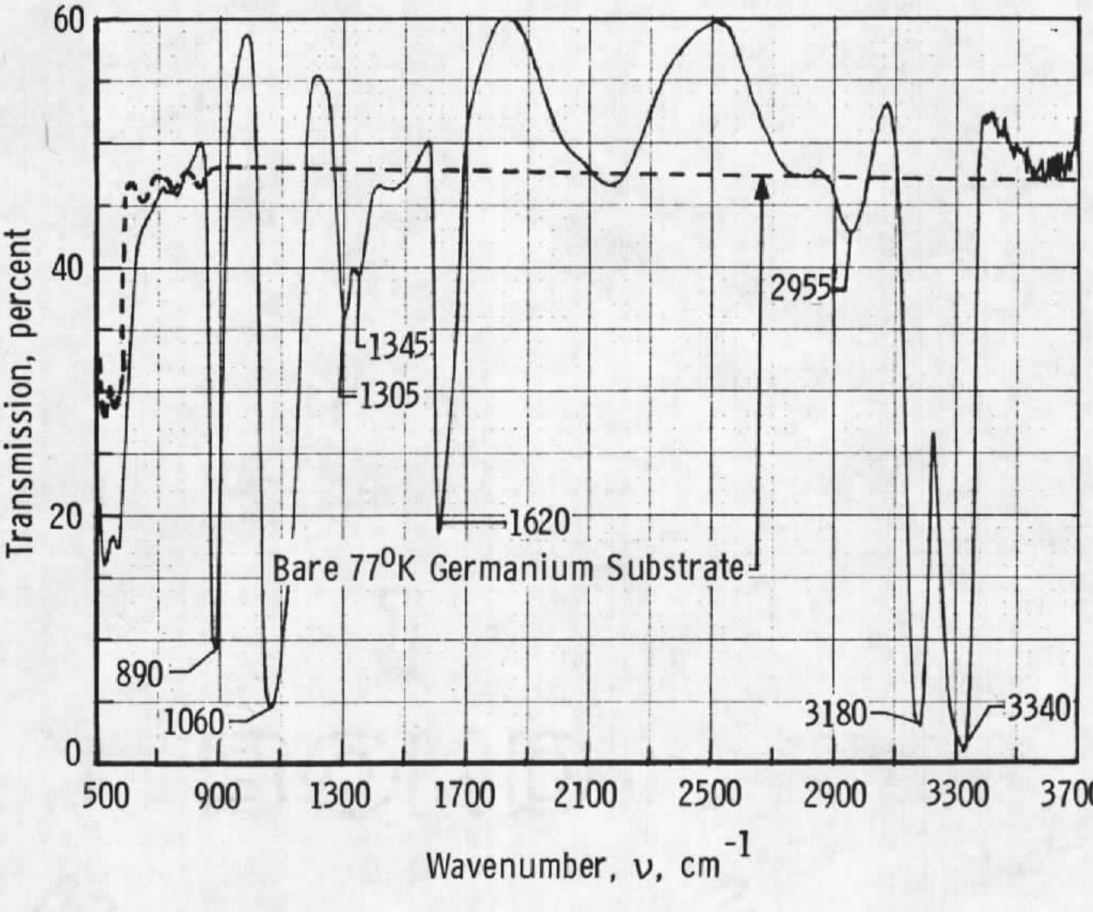


a. 0.22 μm thick

Figure 12. Transmission spectra of hydrazine condensed on 77° germanium.



b. 2.16 μm thick
Figure 12. Continued.



c. 4.74 μm thick
Figure 12. Concluded.

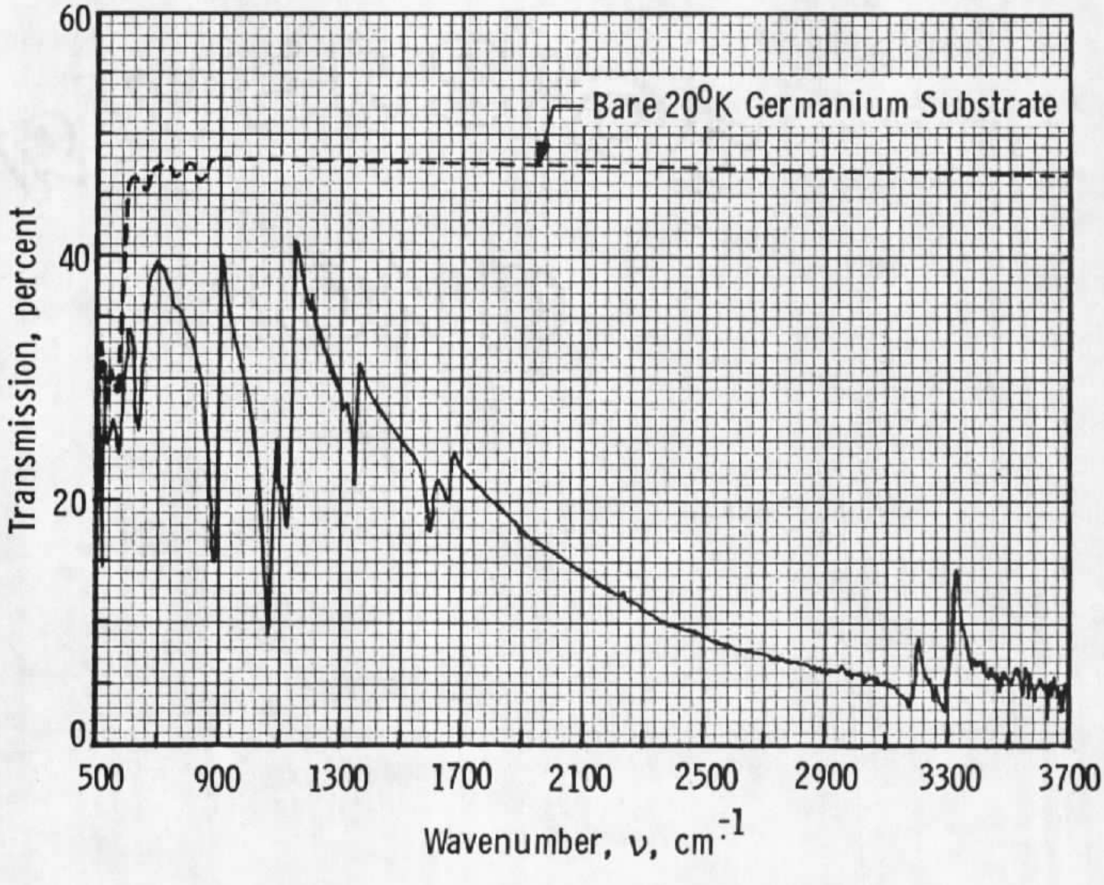


Figure 13. Transmission of ≈1.8-μm-thick hydrazine condensed on a 20°K germanium substrate and warmed up to 127°K.

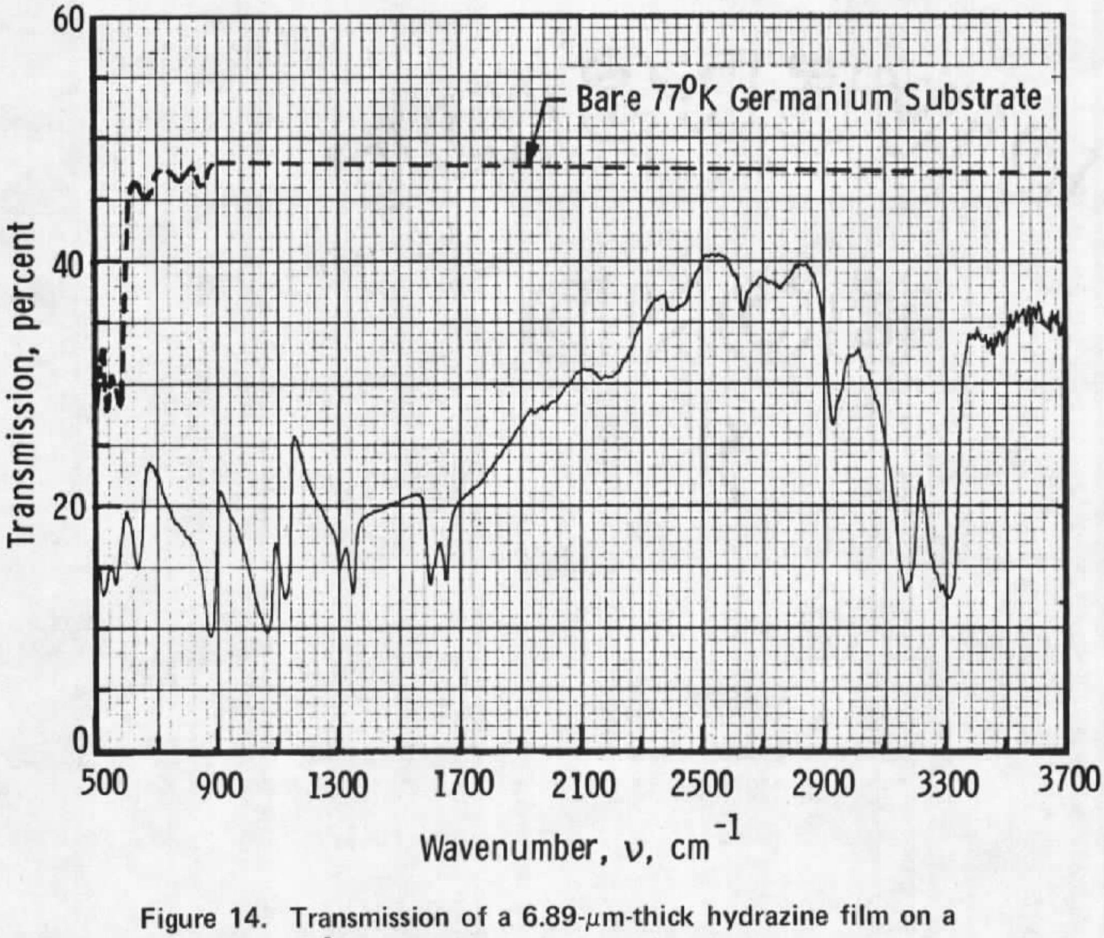


Figure 14. Transmission of a 6.89-μm-thick hydrazine film on a 77°K germanium substrate after fracture.

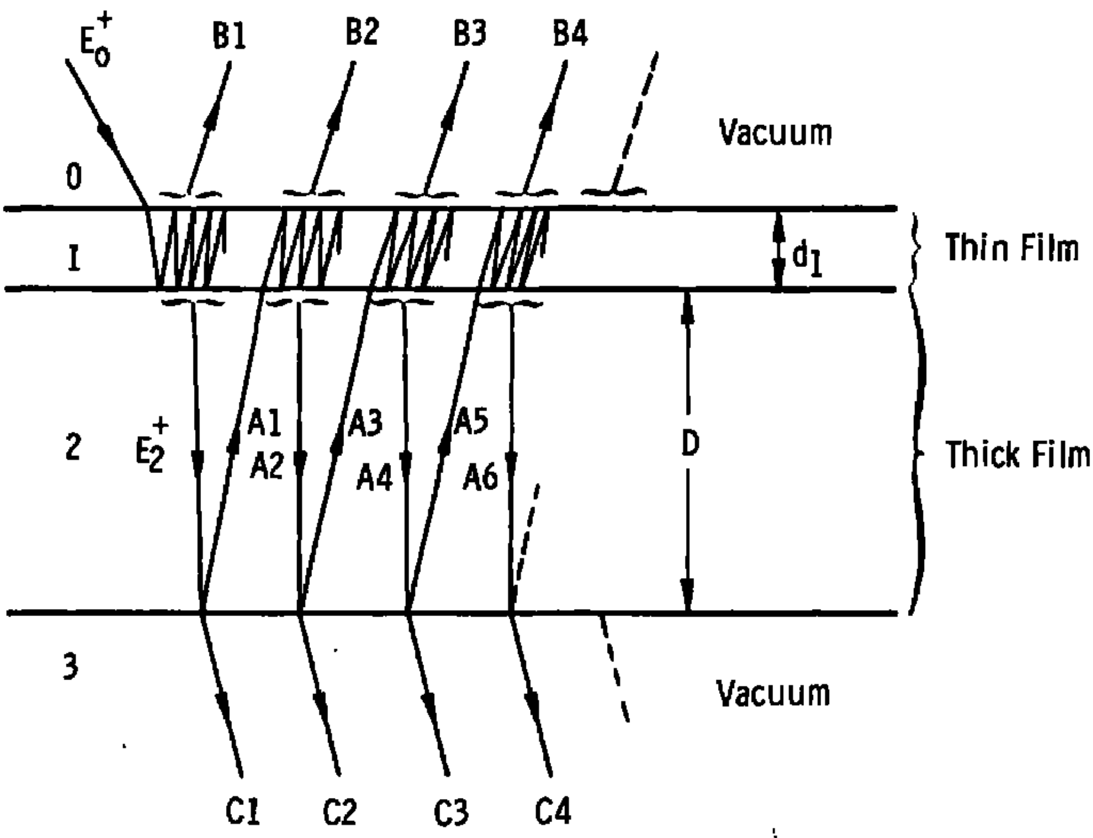


Figure 15. Geometry depicting analytical model for a thin film formed upon a thick film.

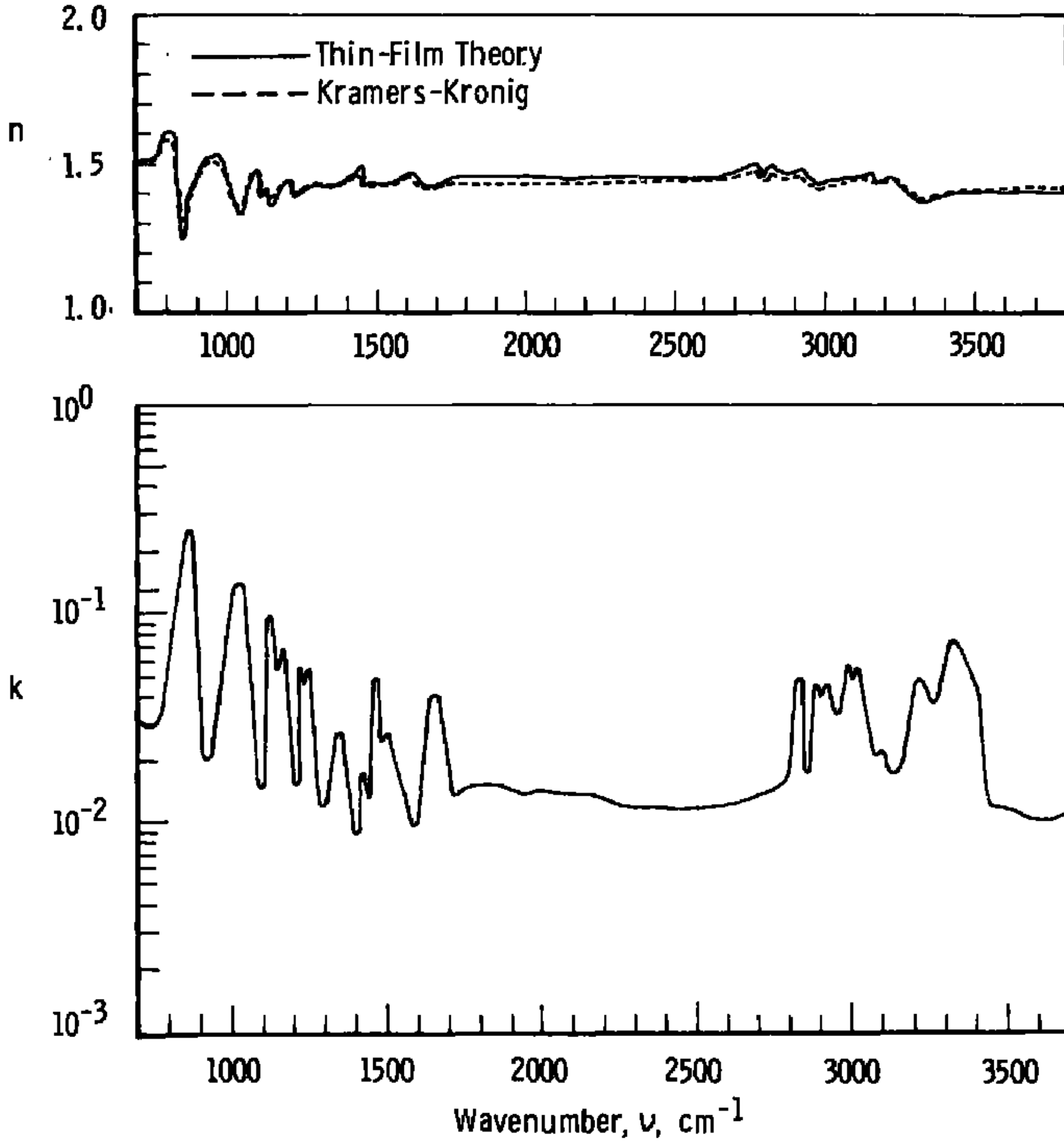


Figure 16. Complex refractive index for MMH on 20°K germanium.

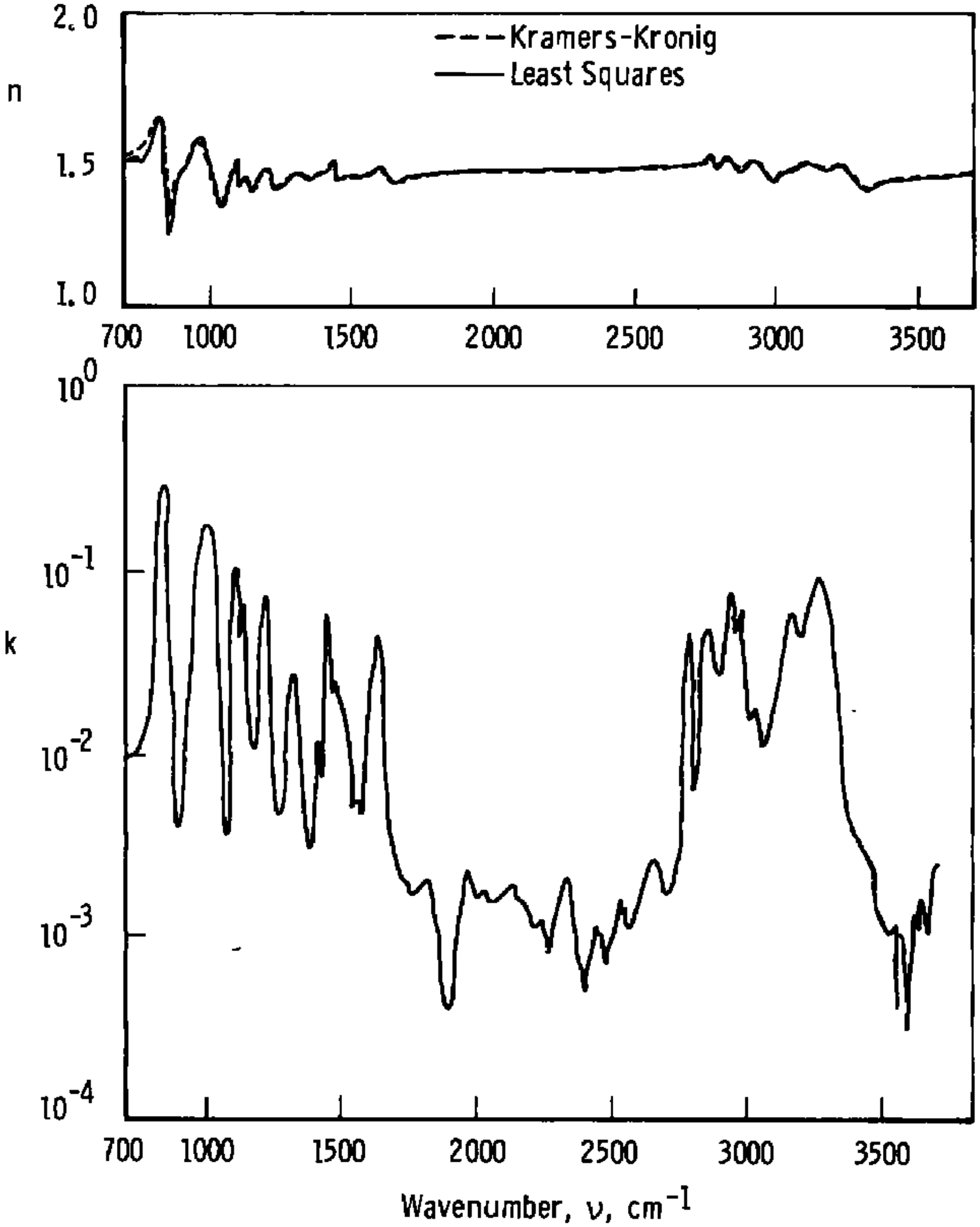


Figure 17. Complex refractive index for MMH on 80° K germanium.

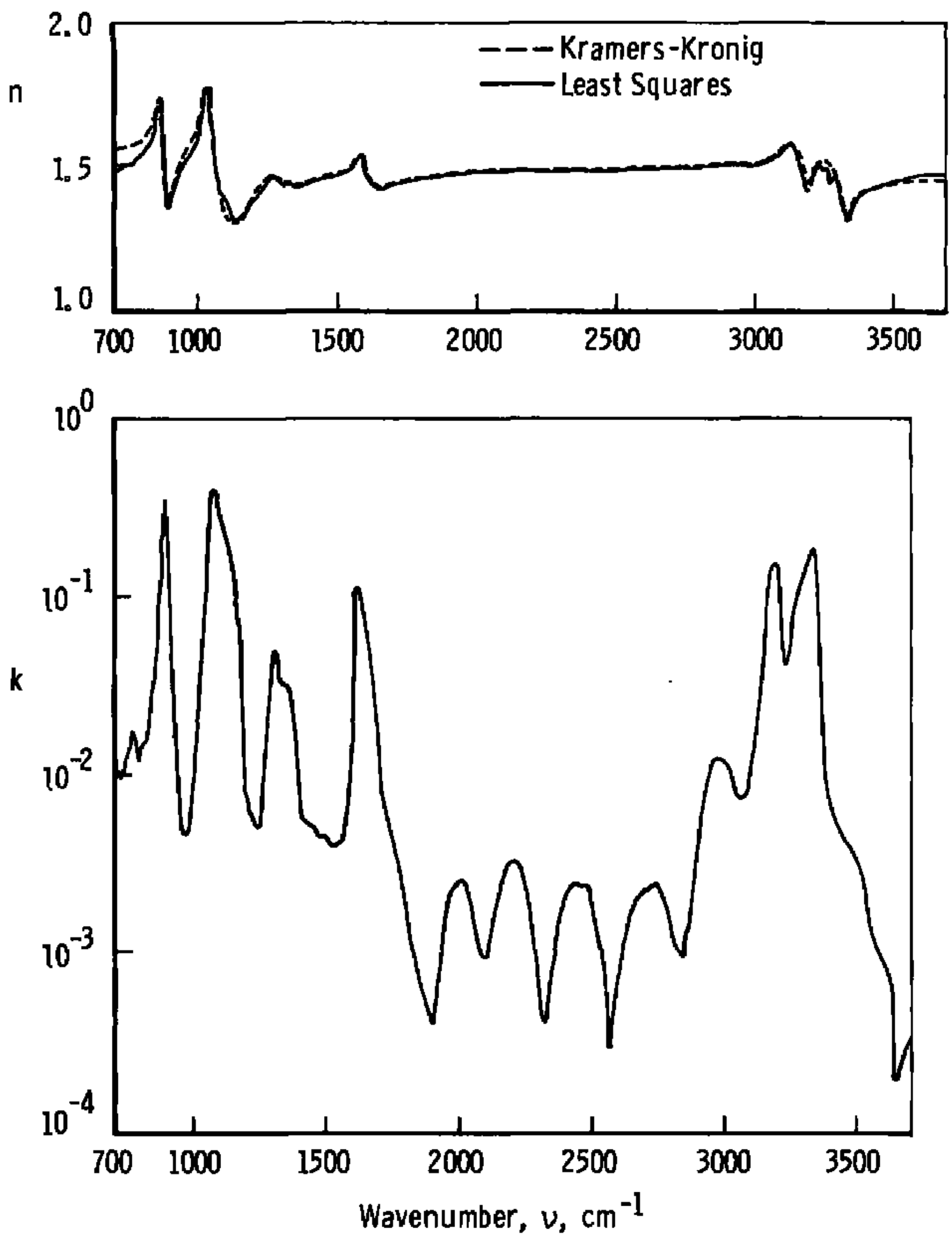


Figure 18. Complex refractive index for N_2H_4 on 80°K germanium.

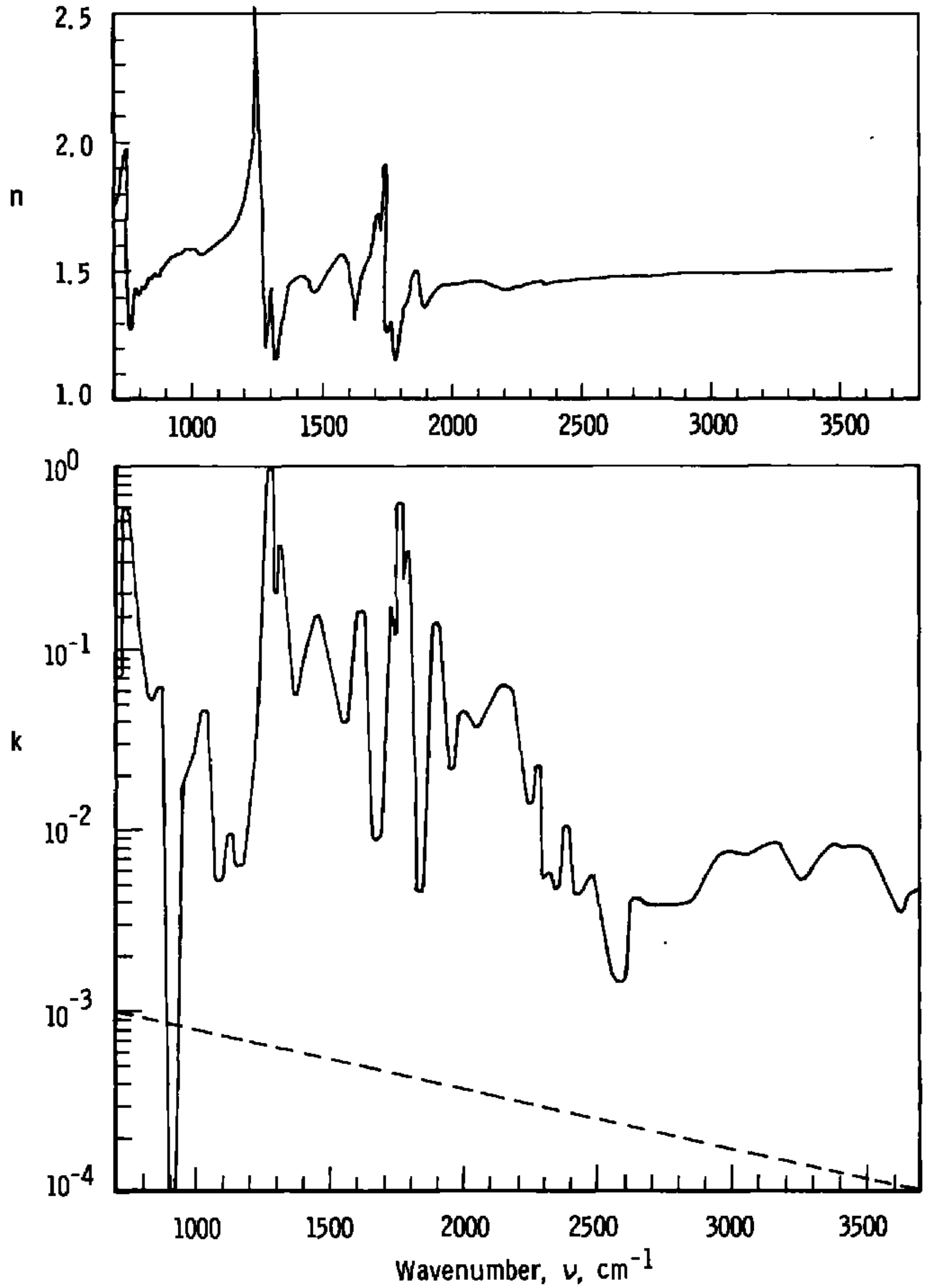


Figure 19. Complex refractive index for N_2O_4 on 20°K germanium.

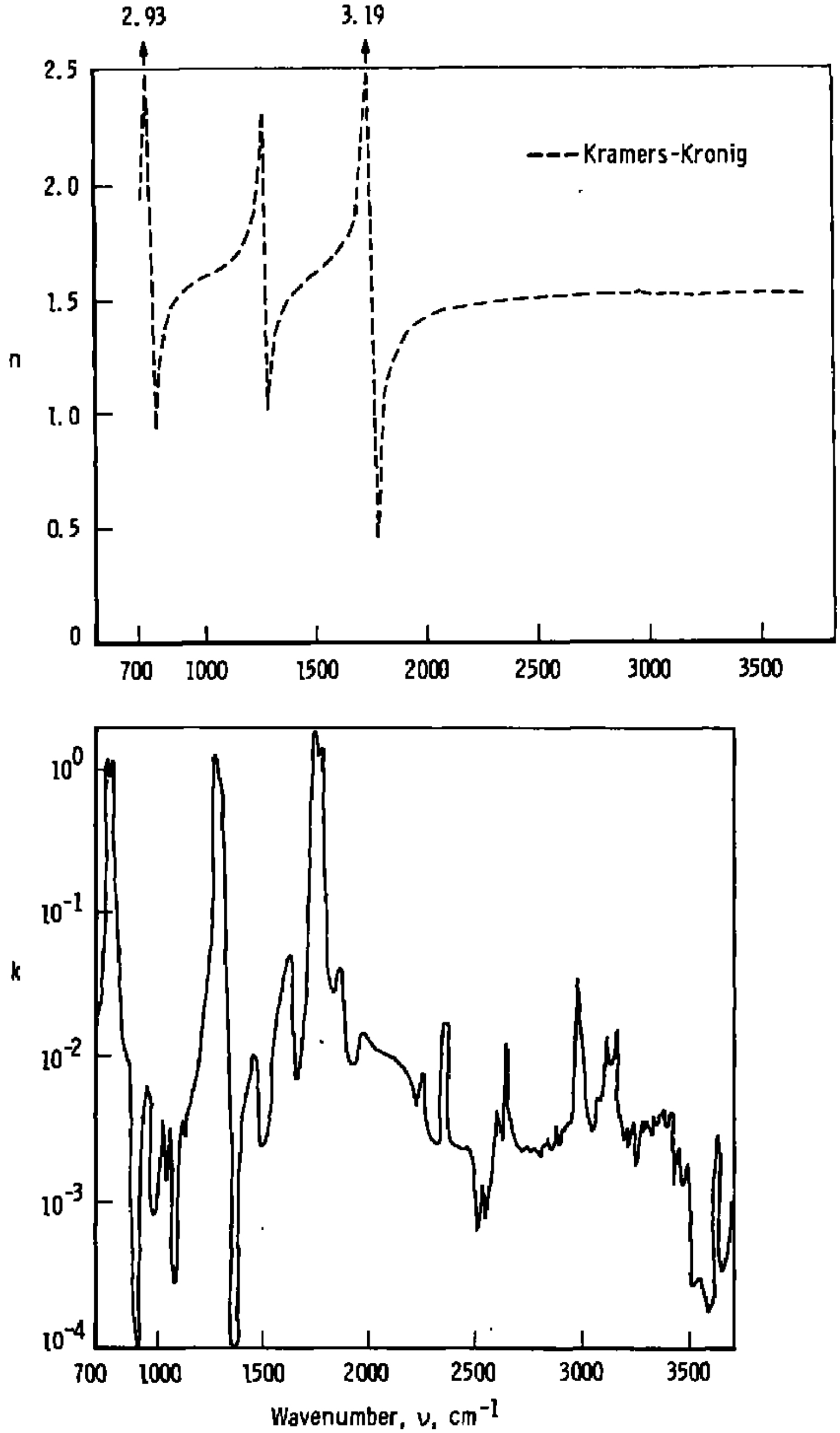
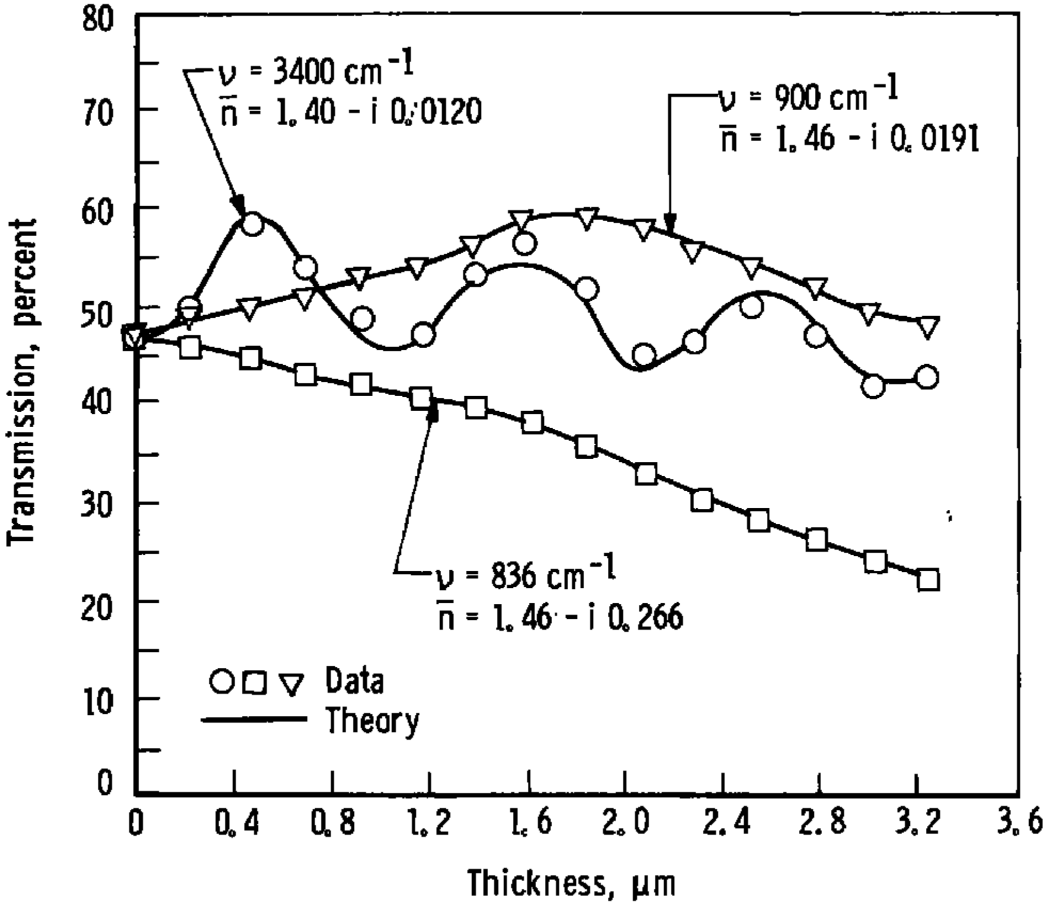
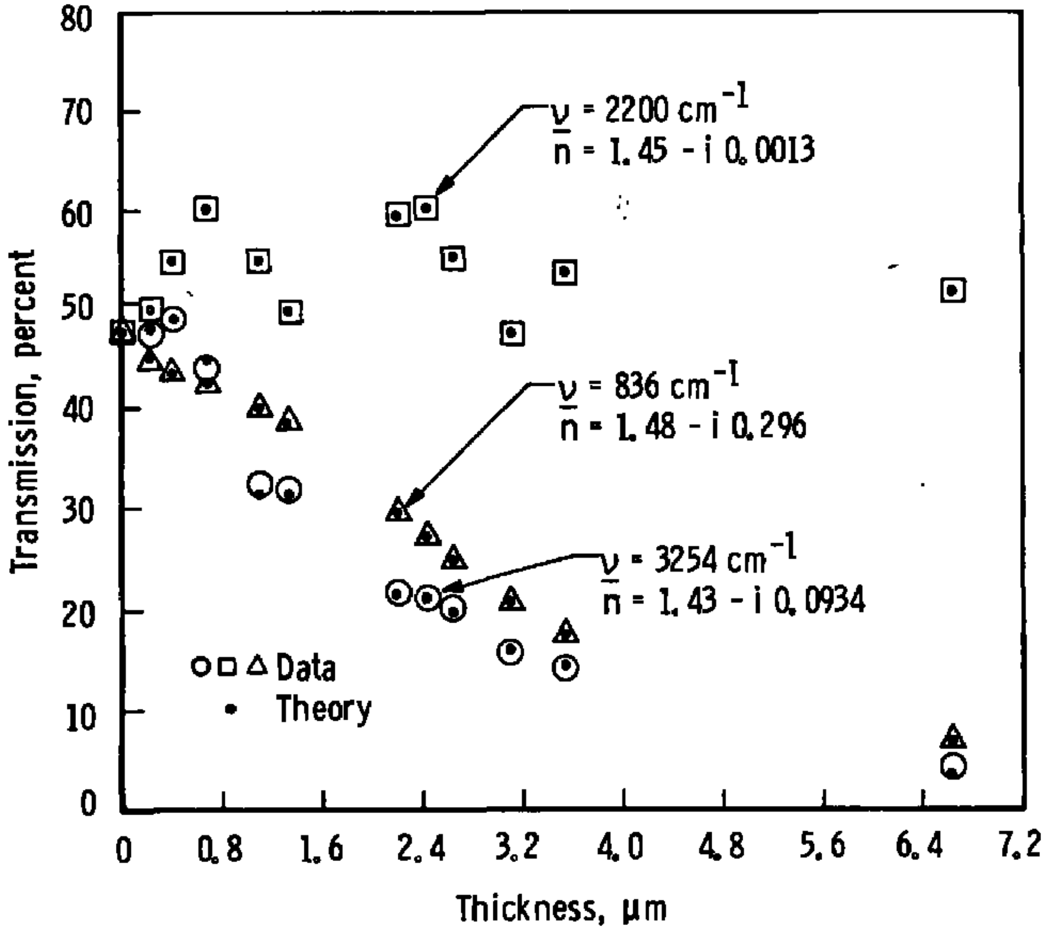


Figure 20. Complex refractive index for N_2O_4 on 80°K germanium.

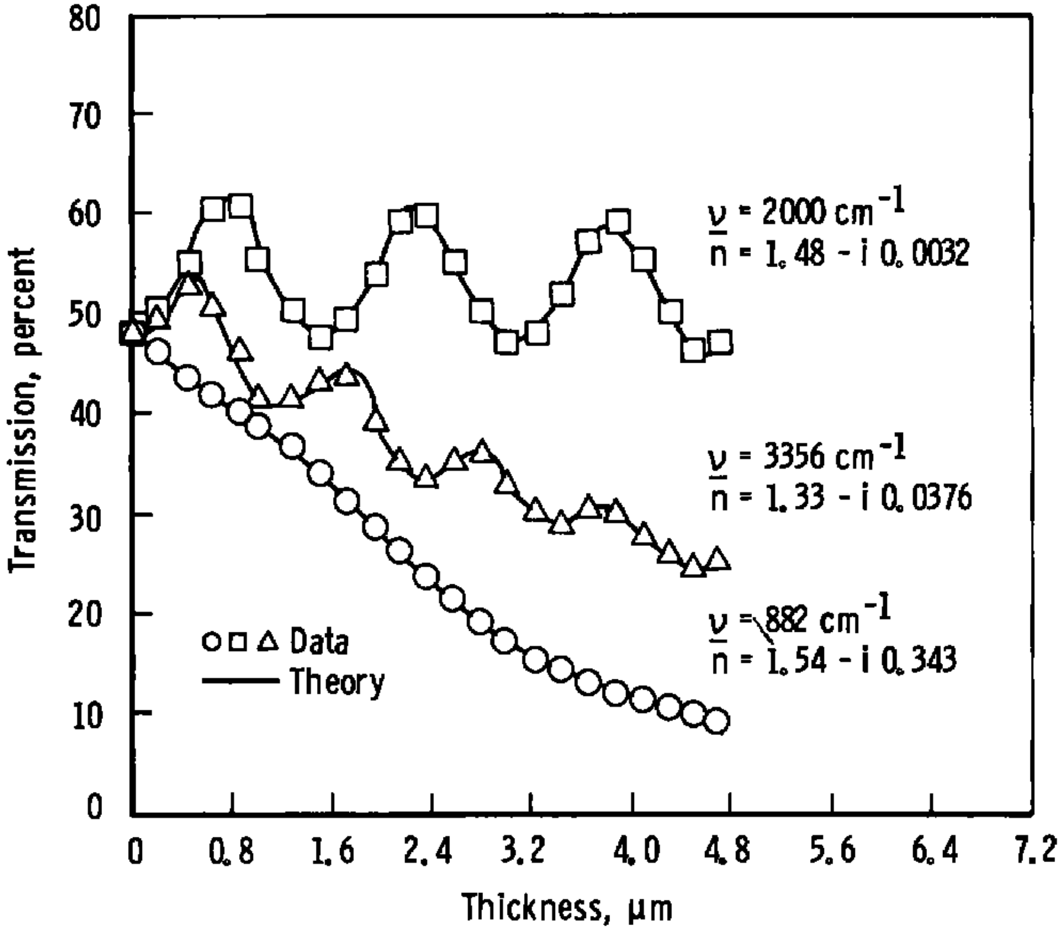


a. MMH on 20°K germanium

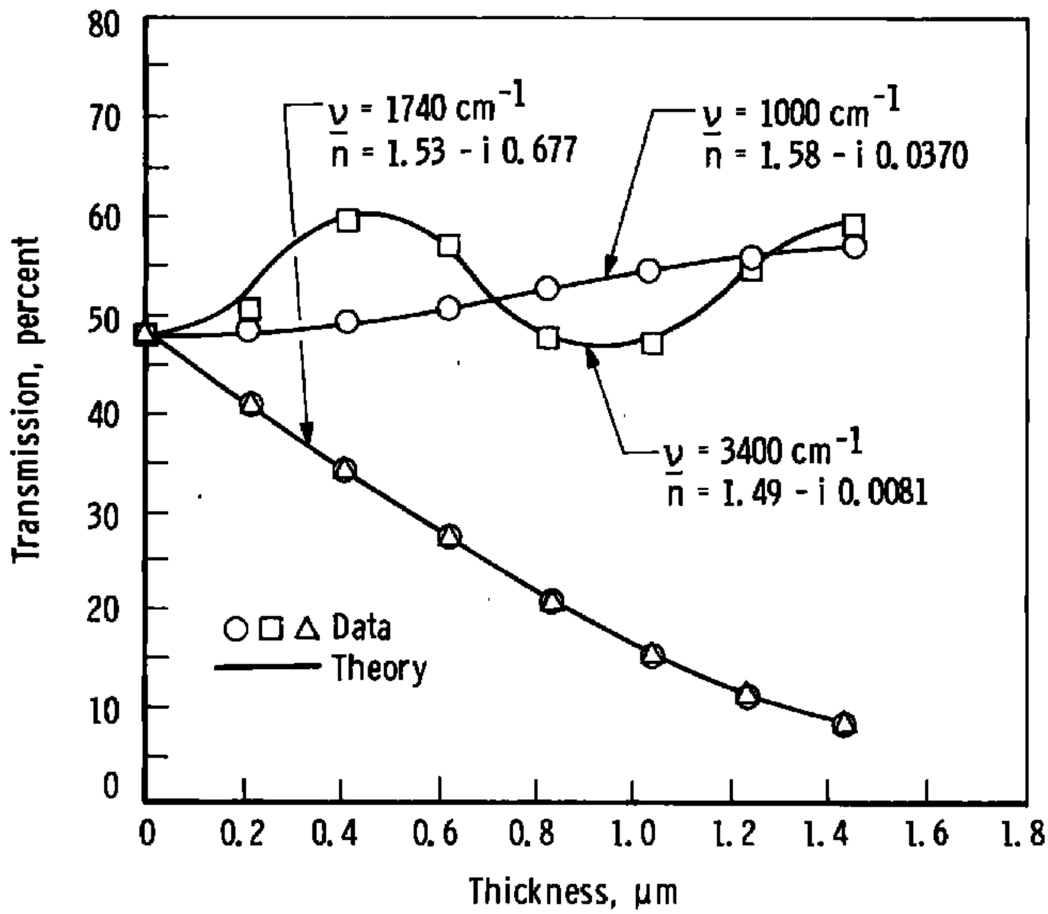
Figure 21. Comparison of theory and data for various deposits on 20 and 80°K germanium for different wavenumbers.



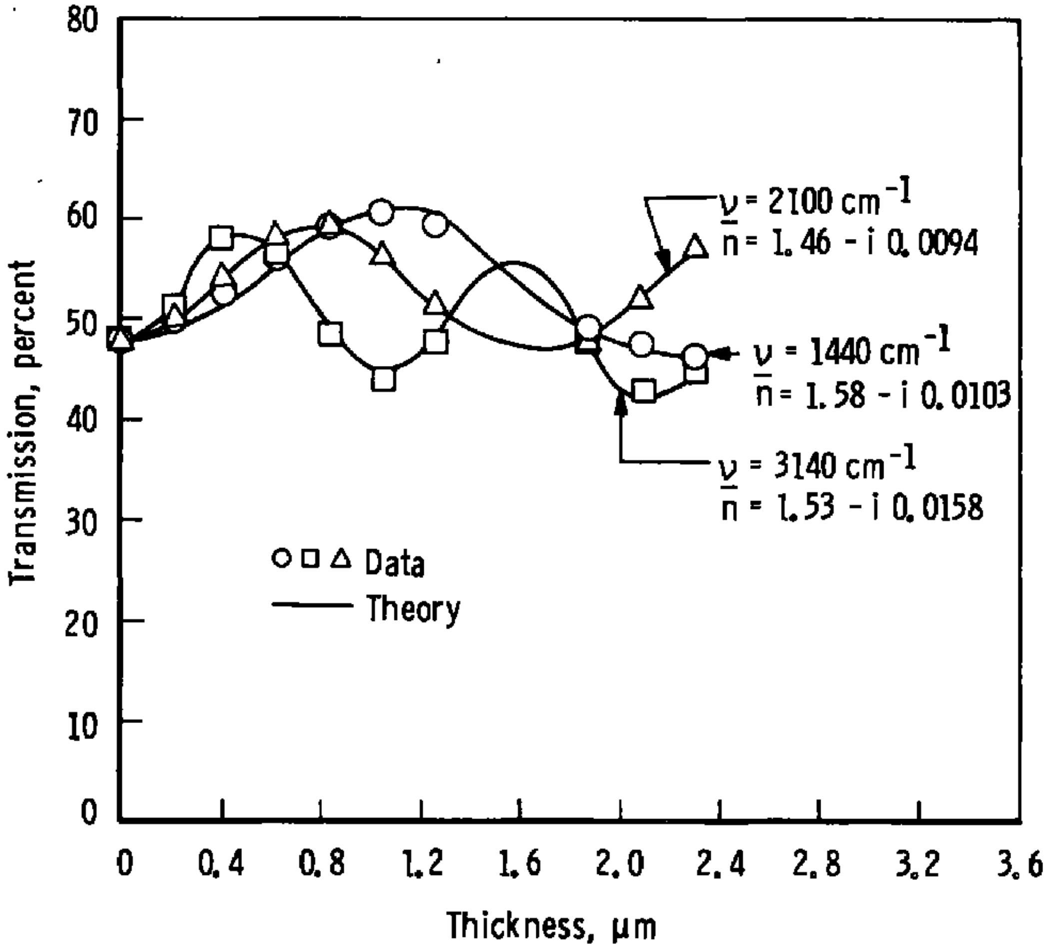
b. MMH on 80°K germanium
Figure 21. Continued.



c. N_2H_4 on 80°K germanium
Figure 21. Continued.



d. N_2O_4 on 20°K germanium
Figure 21. Continued.



e. N_2O_4 on 80°K germanium
Figure 21. Concluded.

Table 1. Absoprtion Band Locations and Vibrational Assignments for Monomethyl Hydrazine (CN_2H_6)

20°K	After Warmup to 160°K	77°K	After Warmup to 161°K	Liquid MMH (Ref. 3)	Assignment
836	845	840	835	813	ν_{18}
---	860	---	860	---	---
1004	985	1015	1010	985	ν_{16}
1104	1105	1105	1120	1094	ν_{15}
1132	1130	1140	1140	1120	ν_{13}
1206	1220	1220	1220	1194	ν_{12}
1320	1350	1335	1345	1295	ν_{11}
1410	1410	1415	1405	1411	ν_{10}
1444	1450	1450	1440	1438	ν_9
---	---	---	1460	---	---
1482	1480	1480	1490	1472	ν_8
1624	1620	1630	1620	1608	ν_7
---	---	---	1700	---	---
---	---	---	1850	---	---
---	---	---	2020	---	---
---	---	---	2060	---	---
---	---	---	2140	---	---
---	---	---	2210	---	---
---	---	---	2340	---	---
---	---	---	2660	---	---
2778	2795	2780	2780	2784	ν_6
2854	2865	2860	2860	2858	$\nu_9+\nu_{10}$
2934	2945	2940	2940	2937	ν_5
2964	2990	2980	2980	2963	ν_4
3032	---	3020	3020	---	$\nu_7+\nu_{10}$
3164	3165	3160	3140	---	$\nu_3+\nu_{11}-\nu_{10}$
3256	3260	3260	3215	3250	ν_3
---	3360	---	3340	---	ν_1 or ν_2

Table 2. Absorption Band Locations and Vibrational Assignments for Nitrogen Tetroxide (N_2O_4)

20°K	After Warmup to 153°K	77°K	After Warmup to 155°K	195°K (Ref. 4)	Assignment (Ref. 4)
750	740	740	740	738	ν_{12}
785	760	760	760	756	ν_{12}+R
---	790	---	---	---	---
820	825	---	815	(813 gas)	ν_2
850	860	---	845	---	---
940-1060	965	---	940-1220	---	---
1050	1040	1110	1110	---	---
1260	1260	1255	1260	1256	ν_{11}
1305	1305	---	1300	1280	ν_{11}+R
1450	1400	1460	1420	---	---
1595	1595	---	---	---	---
1618	---	1620	1620	---	---
1720	---	1700	1690	1696	ν_5
1742	1740	1740	1745	1734	ν_9
1765	1760	1760	1760	1760	ν_9+R
1880	1865	1840	1840	1859	$\nu_4+\nu_5$
1980	---	---	---	---	---
2135	---	---	---	---	---
2235	2220	2240	2220	---	---
2345	---	2340	---	---	---
---	---	2580	2575	2584	$\nu_1+\nu_{11}$
---	2625	2620	2620	2628	$2\nu_7+\nu_{11}$
2970	2965	2965	2960	2958	$\nu_5+\nu_{11}$
---	---	2985	2985	2986	$\nu_5+\nu_{11}$+R
---	---	---	3050	3058	$\nu_1+\nu_9$
3115	---	3100	3100	3105	$2\nu_7+\nu_9$
3155	---	3140	3135	3136	$2\nu_7+\nu_9$+R
---	---	---	3420	3430	$\nu_5+\nu_9$
---	---	---	3460	3460	$\nu_5+\nu_9$+R

Table 3. Absorption Band Locations and Vibrational Assignments for Hydrazine (N_2H_4)

77°K	After Warmup to 127°K	Solid at 80°K (Ref. 12)	Vibration Number Assignment (Ref. 12)
---	630	627	ν_7
890	890	884	ν_6
1060	1075	1066	ν_{12}
---	1130	1126	ν_5
1305	1305	1304	ν_4
1345	1340	1350	ν_{11}
1620	1595	1603	ν_3
---	1650	1655	ν_{10}
2955	---	---	---
3180	3180	3200	ν_2
3340	3300	3310	ν_8, ν_1

Table 4. Condensed MMH Optical Properties at 20°K

ν, cm^{-1}	n	k
3950		0.011100
3940	1.422442	0.014800
3930	1.426586	0.015700
3920	1.427282	0.011100
3910	1.424758	0.009000
3900	1.423519	0.013600
3890	1.424278	0.011100
3880	1.425719	0.015200
3870	1.426549	0.010100
3860	1.425318	0.010900
3850	1.424410	0.010900
3840	1.424880	0.011300
3830	1.424220	0.010600
3820	1.424306	0.011200
3810	1.423791	0.010900
3800	1.423618	0.010900
3790	1.423591	0.012100
3780	1.423774	0.010800
3770	1.423276	0.011800
3760	1.423958	0.012000
3750	1.423843	0.010900
3740	1.423075	0.010900
3730	1.423010	0.012100
3720	1.423751	0.011700
3710	1.423931	0.011200
3700	1.423458	0.010200
3690	1.422481	0.010200
3680	1.422239	0.010900
3670	1.422069	0.010600
3660	1.421557	0.010500
3650	1.421806	0.011700
3640	1.421541	0.010000
3630	1.420693	0.010800
3620	1.420973	0.011900
3610	1.421373	0.010500
3600	1.421138	0.010800
3590	1.420285	0.009200
3580	1.418894	0.009800
3570	1.418568	0.011000
3560	1.418863	0.010700
3550	1.418220	0.010100
3540	1.417439	0.010500
3530	1.416770	0.010600
3520	1.416670	0.011300
3510	1.416408	0.010800
3500	1.415677	0.010400
3490	1.414710	0.010800
3480	1.413943	0.010600
3470	1.413128	0.011200
3460	1.412222	0.010900
3450	1.411161	0.011500
3440	1.410435	0.012000
3430	1.409547	0.011800
3420	1.408593	0.012300
3410	1.407205	0.011800
3400	1.404906	0.012000
3398	1.404884	0.012500
3396	1.404773	0.012300
3394	1.404466	0.012100
3392	1.403891	0.012000
3390	1.403206	0.012000
3388	1.402763	0.012300
3386	1.402530	0.012500
3384	1.402145	0.012100
3382	1.401304	0.012000
3380	1.400753	0.012600
3378	1.400368	0.012400
3376	1.399709	0.012300
3374	1.398945	0.012500
3372	1.396407	0.012600
3370	1.397759	0.012500
3368	1.396538	0.012000
3366	1.395118	0.012700
3364	1.394386	0.013600
3362	1.393848	0.013700
3360	1.392792	0.013700
3358	1.391512	0.014200
3356	1.390396	0.014900
3354	1.389508	0.015600
3352	1.388568	0.016000
3350	1.387113	0.016200
3348	1.385358	0.017200
3346	1.383959	0.018700
3344	1.382888	0.020000
3342	1.381717	0.021200
3340	1.380309	0.022600
3338	1.378905	0.024500
3336	1.378124	0.027000
3334	1.377669	0.028800

Table 4. Continued

ν, cm^{-1}	n	k
3332	1.376911	0.030500
3330	1.376158	0.033000
3328	1.375974	0.035400
3326	1.375925	0.037700
3324	1.375929	0.040000
3322	1.376313	0.042700
3320	1.377047	0.044900
3318	1.377860	0.047000
3316	1.378703	0.049000
3314	1.379808	0.051000
3312	1.380982	0.052600
3310	1.381939	0.053900
3308	1.382634	0.055500
3306	1.383732	0.057500
3304	1.385044	0.059000
3302	1.386489	0.060400
3300	1.387544	0.061500
3298	1.388444	0.062800
3296	1.390290	0.065500
3294	1.392557	0.065600
3292	1.393938	0.066100
3290	1.394895	0.066700
3288	1.395894	0.067600
3286	1.396958	0.068700
3284	1.398150	0.069700
3282	1.399292	0.070700
3280	1.400630	0.072100
3278	1.402153	0.073200
3276	1.403846	0.074400
3274	1.405706	0.075500
3272	1.407626	0.076100
3270	1.409393	0.077000
3268	1.411603	0.078100
3266	1.413739	0.078200
3264	1.415762	0.078800
3262	1.417996	0.079300
3260	1.420273	0.079400
3258	1.422497	0.079600
3256	1.424865	0.079700
3254	1.427203	0.079400
3252	1.429745	0.079500
3250	1.432263	0.078500
3248	1.434546	0.077900
3246	1.436871	0.077200
3244	1.439393	0.076200
3242	1.441767	0.074900
3240	1.444343	0.073500
3238	1.446632	0.071200
3236	1.448144	0.068500
3234	1.449042	0.065500
3232	1.450088	0.064700
3230	1.451145	0.062800
3228	1.452178	0.060800
3226	1.453126	0.058700
3224	1.453979	0.056300
3222	1.454278	0.053500
3220	1.454073	0.051000
3218	1.453446	0.048700
3216	1.452603	0.046800
3214	1.452034	0.045400
3212	1.451567	0.043600
3210	1.450618	0.041600
3208	1.449305	0.040100
3206	1.447867	0.038900
3204	1.446580	0.038000
3202	1.445215	0.037100
3200	1.443663	0.036300
3198	1.441978	0.036000
3196	1.440488	0.036000
3194	1.438996	0.036000
3192	1.437539	0.036400
3190	1.436157	0.037000
3188	1.435011	0.037900
3186	1.433974	0.038900
3184	1.433227	0.040200
3182	1.432704	0.041600
3180	1.432571	0.043100
3178	1.432800	0.044700
3176	1.433382	0.045900
3174	1.434032	0.047100
3172	1.434857	0.048100
3170	1.435925	0.049200
3168	1.437162	0.049800
3166	1.438325	0.050300
3164	1.439665	0.051000
3162	1.441397	0.050700
3160	1.442277	0.050200
3158	1.443250	0.050800
3156	1.444885	0.050800
3154	1.446219	0.050000
3152	1.447294	0.049700
3150	1.448520	0.049300

Table 4. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
3148	1.449741	0.048500	3056	1.435133	0.017600
3146	1.450984	0.048000	3054	1.434328	0.017800
3144	1.452342	0.046900	3052	1.433535	0.018200
3142	1.453203	0.045400	3050	1.432857	0.018700
3140	1.453816	0.044400	3048	1.432321	0.019200
3138	1.454559	0.043400	3046	1.431738	0.019600
3136	1.455206	0.042000	3044	1.431116	0.020200
3134	1.455604	0.040900	3042	1.430716	0.021100
3132	1.456240	0.039700	3040	1.430658	0.021900
3130	1.456657	0.038200	3038	1.430784	0.022500
3128	1.456781	0.036700	3036	1.431044	0.023000
3126	1.456845	0.035500	3034	1.431233	0.023100
3124	1.456887	0.034000	3032	1.431403	0.023400
3122	1.456605	0.032500	3030	1.431825	0.023400
3120	1.456040	0.031200	3028	1.431961	0.022900
3118	1.455457	0.030300	3026	1.431818	0.022600
3116	1.455029	0.029500	3024	1.431593	0.022300
3114	1.454734	0.028700	3022	1.431191	0.021900
3112	1.454481	0.027800	3020	1.430738	0.021800
3110	1.454028	0.026700	3018	1.430332	0.021600
3108	1.453431	0.025900	3016	1.429830	0.021300
3106	1.453012	0.025300	3014	1.429176	0.021100
3104	1.452744	0.024400	3012	1.428552	0.021000
3102	1.452135	0.023200	3010	1.427786	0.020700
3100	1.451157	0.022300	3008	1.426859	0.020600
3098	1.450203	0.021900	3006	1.425863	0.020500
3096	1.449493	0.021500	3004	1.424882	0.020600
3094	1.448863	0.021100	3002	1.423619	0.020600
3092	1.448189	0.020600	3000	1.422213	0.020900
3090	1.447516	0.020300	2998	1.420919	0.021600
3088	1.446991	0.020000	2996	1.419650	0.022000
3086	1.446484	0.019500	2994	1.418009	0.022600
3084	1.445750	0.018900	2992	1.416323	0.023800
3082	1.444922	0.018600	2990	1.414849	0.025300
3080	1.444192	0.018400	2988	1.413455	0.026800
3078	1.443514	0.018100	2986	1.412122	0.028300
3076	1.442817	0.017900	2984	1.410913	0.030900
3074	1.442105	0.017600	2982	1.409858	0.033500
3072	1.441319	0.017400	2980	1.409264	0.036600
3070	1.440448	0.017200	2978	1.409290	0.039800
3068	1.439642	0.017300	2976	1.409931	0.043100
3066	1.438948	0.017300	2974	1.411139	0.046200
3064	1.438303	0.017300	2972	1.412787	0.049100
3062	1.437558	0.017200	2970	1.415066	0.052000
3060	1.436719	0.017200	2968	1.418185	0.054400
3058	1.435882	0.017400	2966	1.421803	0.055700

Table 4. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2964	1.425556	0.056100	2872	1.442885	0.038100
2962	1.429101	0.055300	2870	1.442459	0.038600
2960	1.431867	0.053400	2868	1.441954	0.039300
2958	1.433430	0.051000	2866	1.441335	0.040400
2956	1.433858	0.048700	2864	1.441048	0.042200
2954	1.433231	0.046700	2862	1.441522	0.044400
2952	1.431930	0.045600	2860	1.442784	0.046300
2950	1.430202	0.045200	2858	1.444592	0.047900
2948	1.427959	0.045500	2856	1.446920	0.049000
2946	1.425667	0.047600	2854	1.449417	0.049200
2944	1.424379	0.051100	2852	1.451654	0.048700
2942	1.424481	0.055200	2850	1.453419	0.047800
2940	1.426079	0.059600	2848	1.454686	0.046700
2938	1.429415	0.063800	2846	1.455349	0.045600
2936	1.434326	0.066800	2844	1.455602	0.045000
2934	1.440078	0.068000	2842	1.455830	0.045000
2932	1.445957	0.067500	2840	1.456454	0.045500
2930	1.451101	0.065100	2838	1.457714	0.046200
2928	1.455112	0.061900	2836	1.459843	0.046800
2926	1.458124	0.058300	2834	1.462550	0.046500
2924	1.460075	0.054100	2832	1.465524	0.045400
2922	1.460896	0.050200	2830	1.468237	0.043200
2920	1.460929	0.046600	2828	1.470380	0.040000
2918	1.460420	0.043500	2826	1.471463	0.036500
2916	1.459521	0.040800	2824	1.471475	0.032700
2914	1.458327	0.038500	2822	1.470546	0.029600
2912	1.456961	0.036700	2820	1.469280	0.027100
2910	1.455538	0.035200	2818	1.467919	0.025000
2908	1.454010	0.034000	2816	1.466354	0.023000
2906	1.452338	0.033100	2814	1.464568	0.021400
2904	1.450697	0.032800	2812	1.462628	0.020100
2902	1.449282	0.032800	2810	1.460697	0.019200
2900	1.448216	0.033100	2808	1.458741	0.018400
2898	1.447360	0.033300	2806	1.456542	0.017700
2896	1.446667	0.033600	2804	1.454201	0.017600
2894	1.446109	0.033900	2802	1.451957	0.017800
2892	1.445572	0.034000	2800	1.449605	0.018100
2890	1.444939	0.034300	2798	1.447000	0.018900
2888	1.444367	0.034700	2796	1.444447	0.020500
2886	1.443967	0.035300	2794	1.442101	0.022600
2884	1.443759	0.035800	2792	1.440024	0.025400
2882	1.443588	0.036200	2790	1.438396	0.029000
2880	1.443346	0.036600	2788	1.437601	0.033400
2878	1.443235	0.037200	2786	1.438130	0.038600
2876	1.443336	0.037700	2784	1.440523	0.043900
2874	1.443250	0.037700	2782	1.444962	0.048600

Table 4. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2780	1.451031	0.051400	2640	1.450213	0.014300
2778	1.457680	0.051900	2630	1.449939	0.014100
2776	1.463760	0.050100	2620	1.449555	0.013800
2774	1.468726	0.047000	2610	1.449052	0.013100
2772	1.472386	0.042900	2600	1.448444	0.013400
2770	1.474504	0.038200	2590	1.448206	0.013000
2768	1.475334	0.034000	2580	1.447845	0.013000
2766	1.475229	0.030000	2570	1.447444	0.012500
2764	1.474355	0.026600	2560	1.446962	0.012600
2762	1.473144	0.024100	2550	1.446448	0.012300
2760	1.471790	0.021800	2540	1.446053	0.012600
2758	1.470343	0.020200	2530	1.446097	0.012800
2756	1.468899	0.018800	2520	1.446089	0.012200
2754	1.467534	0.017800	2500	1.445000	0.011900
2752	1.466216	0.017000	2480	1.444562	0.011800
2750	1.464917	0.016300	2470	1.444095	0.011600
2748	1.463703	0.016100	2460	1.443804	0.011900
2746	1.462776	0.015900	2450	1.443657	0.011800
2744	1.462015	0.015800	2440	1.443384	0.011600
2742	1.461392	0.015600	2430	1.443145	0.011800
2740	1.460803	0.015400	2420	1.442929	0.011500
2738	1.460166	0.015100	2410	1.442563	0.011500
2736	1.459562	0.015000	2400	1.442157	0.011500
2734	1.458967	0.014800	2390	1.441911	0.011700
2732	1.458429	0.014800	2380	1.441669	0.011700
2730	1.457957	0.014700	2370	1.441426	0.011800
2728	1.457518	0.014600	2360	1.441114	0.011900
2726	1.456963	0.014500	2350	1.441073	0.012300
2724	1.456491	0.014500	2340	1.441170	0.012300
2722	1.456091	0.014700	2330	1.441161	0.012100
2720	1.455910	0.014700	2320	1.440887	0.012000
2718	1.455592	0.014600	2310	1.440732	0.012100
2716	1.455335	0.014600	2300	1.440743	0.012200
2714	1.455085	0.014600	2290	1.440698	0.011800
2712	1.454875	0.014400	2280	1.440269	0.011600
2710	1.454450	0.014300	2270	1.439928	0.011700
2708	1.454215	0.014400	2260	1.439535	0.011700
2706	1.453850	0.014200	2250	1.439095	0.011800
2704	1.453525	0.014300	2240	1.439152	0.012700
2702	1.453189	0.014400	2230	1.439430	0.012200
2700	1.453036	0.014500	2220	1.439161	0.012000
2690	1.452180	0.014600	2210	1.438593	0.011900
2680	1.451356	0.014500	2200	1.438351	0.012500
2670	1.450910	0.015200	2190	1.438377	0.012600
2660	1.450696	0.014700	2180	1.438378	0.012600
2650	1.450506	0.014900	2170	1.438100	0.012500

Table 4. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2160	1.437928	0.012800	1700	1.430363	0.014100
2150	1.437709	0.012800	1698	1.430306	0.014300
2140	1.437690	0.013200	1696	1.430002	0.014000
2130	1.437646	0.013200	1694	1.429814	0.014200
2120	1.437674	0.013300	1692	1.429542	0.013900
2110	1.437629	0.013400	1690	1.428980	0.013600
2100	1.437604	0.013200	1688	1.428326	0.013900
2090	1.437352	0.013300	1686	1.428137	0.014200
2080	1.437203	0.013300	1684	1.427850	0.013900
2070	1.437024	0.013500	1682	1.427492	0.013900
2060	1.436897	0.013500	1680	1.426793	0.013400
2050	1.436660	0.013700	1678	1.425639	0.013200
2040	1.436656	0.014000	1676	1.424599	0.013900
2030	1.436695	0.014100	1674	1.423831	0.014100
2020	1.436659	0.014000	1672	1.422650	0.014300
2010	1.436492	0.014200	1670	1.421577	0.015400
2000	1.436406	0.014200	1668	1.420691	0.016100
1990	1.436310	0.014500	1666	1.419774	0.017100
1980	1.436264	0.014500	1664	1.418983	0.018400
1970	1.436323	0.014900	1662	1.418307	0.019500
1960	1.436444	0.014800	1660	1.417503	0.020900
1950	1.436546	0.014900	1658	1.417018	0.022800
1940	1.436659	0.014800	1656	1.416794	0.024500
1930	1.436623	0.014500	1654	1.416873	0.026500
1920	1.436410	0.014400	1652	1.417313	0.028400
1910	1.436293	0.014400	1650	1.417876	0.029900
1900	1.436015	0.014100	1648	1.418372	0.031600
1890	1.435649	0.014200	1646	1.419222	0.033500
1880	1.435314	0.014300	1644	1.420357	0.035100
1870	1.434997	0.014400	1642	1.421655	0.036600
1860	1.434746	0.014800	1640	1.423076	0.038000
1850	1.434677	0.015000	1638	1.424577	0.039200
1840	1.434592	0.015200	1636	1.426333	0.040600
1830	1.434566	0.015400	1634	1.428736	0.041800
1820	1.434541	0.015500	1632	1.430965	0.041700
1810	1.434557	0.015600	1630	1.432631	0.041800
1800	1.434550	0.015600	1628	1.434479	0.042500
1790	1.434382	0.015400	1626	1.436577	0.042400
1780	1.434196	0.015600	1624	1.438792	0.042600
1770	1.434060	0.015500	1622	1.441205	0.042200
1760	1.433872	0.015500	1620	1.443332	0.041100
1750	1.433684	0.015500	1618	1.445314	0.040500
1740	1.433485	0.015300	1616	1.447219	0.039100
1730	1.433109	0.015100	1614	1.448995	0.038000
1720	1.432642	0.014800	1612	1.450930	0.036700
1710	1.431787	0.014400	1610	1.452797	0.034600

Table 4. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1608	1.454076	0.032300	1516	1.427112	0.019400
1606	1.455051	0.030000	1514	1.427189	0.019500
1604	1.455772	0.027600	1512	1.427114	0.019900
1602	1.456024	0.024800	1510	1.427009	0.020200
1600	1.455597	0.022300	1508	1.427093	0.020900
1598	1.454893	0.020200	1506	1.427426	0.021300
1596	1.454235	0.018500	1504	1.427642	0.021300
1594	1.453351	0.016400	1502	1.427623	0.021500
1592	1.452072	0.014800	1500	1.427600	0.021700
1590	1.450702	0.013600	1498	1.427503	0.021900
1588	1.449244	0.012500	1496	1.427340	0.022200
1586	1.447900	0.012100	1494	1.427130	0.022600
1584	1.446875	0.011700	1492	1.426971	0.023200
1582	1.445983	0.011200	1490	1.426897	0.023900
1580	1.445186	0.010900	1488	1.427054	0.024800
1578	1.444376	0.010200	1486	1.427534	0.025700
1576	1.443471	0.009800	1484	1.428378	0.026400
1574	1.442427	0.009200	1482	1.429347	0.026700
1572	1.441229	0.008900	1480	1.430432	0.026700
1570	1.440147	0.009000	1478	1.431448	0.026200
1568	1.439337	0.009000	1476	1.431892	0.024900
1566	1.438507	0.008900	1474	1.431521	0.023900
1564	1.437515	0.008800	1472	1.430502	0.023100
1562	1.436530	0.009100	1470	1.429174	0.023200
1560	1.435953	0.009600	1468	1.428318	0.024200
1558	1.435716	0.009700	1466	1.428046	0.024900
1556	1.435182	0.009200	1464	1.427762	0.025300
1554	1.433954	0.008800	1462	1.427139	0.025700
1552	1.432737	0.009400	1460	1.426378	0.026500
1550	1.431966	0.010000	1458	1.425550	0.027500
1548	1.431287	0.010300	1456	1.424469	0.028700
1546	1.430651	0.011000	1454	1.422937	0.030700
1544	1.430163	0.011400	1452	1.421633	0.034300
1542	1.429687	0.011900	1450	1.421713	0.039600
1540	1.429303	0.012400	1448	1.424340	0.045600
1538	1.428785	0.012600	1446	1.429936	0.051000
1536	1.428188	0.013200	1444	1.437766	0.053700
1534	1.427765	0.013900	1442	1.446264	0.053400
1532	1.427474	0.014400	1440	1.454346	0.050300
1530	1.427116	0.015000	1438	1.461111	0.044600
1528	1.426721	0.015500	1436	1.465129	0.036500
1526	1.426371	0.016400	1434	1.465737	0.028300
1524	1.426241	0.017200	1432	1.464021	0.021800
1522	1.426447	0.018200	1430	1.460915	0.016400
1520	1.426747	0.018600	1428	1.456981	0.012900
1518	1.426951	0.019000	1426	1.453165	0.011200

Table 4. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1424	1.449954	0.010300	1332	1.420241	0.024600
1422	1.447023	0.009900	1330	1.421741	0.025500
1420	1.444502	0.010300	1328	1.421027	0.022600
1418	1.442640	0.011200	1326	1.420538	0.027300
1416	1.441170	0.011900	1324	1.422491	0.027800
1414	1.440229	0.013400	1322	1.424413	0.028200
1412	1.440432	0.014900	1320	1.425563	0.028200
1410	1.441350	0.015300	1318	1.427025	0.028000
1408	1.442247	0.015000	1316	1.427994	0.027700
1406	1.442899	0.014100	1314	1.429142	0.027200
1404	1.443135	0.012800	1312	1.430040	0.026800
1402	1.442669	0.011200	1310	1.431145	0.026000
1400	1.441787	0.010200	1308	1.431807	0.025000
1398	1.440767	0.009300	1306	1.432370	0.024000
1396	1.439775	0.008700	1304	1.432701	0.023100
1394	1.438541	0.008000	1302	1.433173	0.022100
1392	1.437256	0.007800	1300	1.433407	0.020900
1390	1.436197	0.008000	1298	1.433432	0.019500
1388	1.435442	0.007900	1296	1.433055	0.018300
1386	1.434532	0.007800	1294	1.432635	0.017200
1384	1.433605	0.007800	1292	1.432025	0.016200
1382	1.432673	0.008000	1290	1.431419	0.015300
1380	1.432002	0.008300	1288	1.430740	0.014500
1378	1.431472	0.008500	1286	1.430094	0.013600
1376	1.430950	0.008400	1284	1.429096	0.012600
1374	1.430250	0.008400	1282	1.428029	0.012000
1372	1.429598	0.008400	1280	1.426862	0.011400
1370	1.428811	0.008300	1278	1.425646	0.010900
1368	1.427964	0.008300	1276	1.424416	0.010800
1366	1.426868	0.008300	1274	1.423310	0.010500
1364	1.425852	0.008700	1272	1.422087	0.010400
1362	1.424966	0.009200	1270	1.420972	0.010400
1360	1.424134	0.009400	1268	1.419809	0.010300
1358	1.423068	0.009900	1266	1.418584	0.010300
1356	1.422108	0.010500	1264	1.417238	0.010400
1354	1.421019	0.011200	1262	1.415963	0.010700
1352	1.420157	0.012300	1260	1.414783	0.011100
1350	1.419427	0.013400	1258	1.413630	0.011300
1348	1.418976	0.014500	1256	1.412271	0.011600
1346	1.418430	0.015600	1254	1.410893	0.012100
1344	1.418121	0.016800	1252	1.409532	0.012700
1342	1.417727	0.018100	1250	1.408140	0.013300
1340	1.417845	0.019600	1248	1.406696	0.014100
1338	1.417930	0.020900	1246	1.405293	0.015000
1336	1.418510	0.022200	1244	1.403695	0.015800
1334	1.418887	0.023500	1242	1.401904	0.017100

Table 4. Continued

ν, cm⁻¹	n	k	ν, cm⁻¹	n	k
1240	1.400209	0.018800	1148	1.384302	0.042600
1238	1.398864	0.020900	1146	1.384305	0.046800
1236	1.397577	0.022700	1144	1.384838	0.051100
1234	1.396407	0.025200	1142	1.386170	0.055600
1232	1.395444	0.027700	1140	1.388341	0.059600
1230	1.394638	0.030400	1138	1.391156	0.063200
1228	1.394036	0.033700	1136	1.394540	0.066200
1226	1.394159	0.037300	1134	1.398626	0.068600
1224	1.394907	0.040900	1132	1.403148	0.069700
1222	1.396213	0.044300	1130	1.407573	0.069400
1220	1.397922	0.047700	1128	1.411517	0.068000
1218	1.400380	0.051100	1126	1.414792	0.065300
1216	1.403619	0.054100	1124	1.416194	0.060900
1214	1.407507	0.056300	1122	1.414853	0.056400
1212	1.411797	0.057800	1120	1.410746	0.053300
1210	1.416044	0.058100	1118	1.404543	0.052600
1208	1.419523	0.057800	1116	1.397602	0.056100
1206	1.423649	0.058800	1114	1.392013	0.063500
1204	1.429529	0.058600	1112	1.389724	0.074500
1202	1.435356	0.054900	1110	1.392617	0.087300
1200	1.439212	0.050000	1108	1.401040	0.098800
1198	1.441612	0.045000	1106	1.413909	0.106800
1196	1.442836	0.039600	1104	1.429349	0.109900
1194	1.442786	0.034200	1102	1.444967	0.107200
1192	1.441421	0.029200	1100	1.458744	0.100100
1190	1.439165	0.025000	1098	1.469762	0.089500
1188	1.436353	0.021700	1096	1.477095	0.076200
1186	1.433292	0.019000	1094	1.480028	0.061700
1184	1.430056	0.017100	1092	1.478526	0.047800
1182	1.426793	0.015600	1090	1.473446	0.036000
1180	1.423436	0.014700	1088	1.466439	0.027500
1178	1.420298	0.014400	1086	1.458957	0.021500
1176	1.417391	0.014300	1084	1.451425	0.017400
1174	1.414478	0.014200	1082	1.444377	0.015300
1172	1.411505	0.014600	1080	1.438250	0.014300
1170	1.408691	0.015200	1078	1.432811	0.013600
1168	1.405849	0.015900	1076	1.427822	0.013500
1166	1.402919	0.016900	1074	1.423291	0.013500
1164	1.399915	0.018300	1072	1.419004	0.013600
1162	1.397058	0.020200	1070	1.414750	0.013700
1160	1.394434	0.022500	1068	1.410474	0.014000
1158	1.392102	0.025000	1066	1.406283	0.014500
1156	1.389932	0.027800	1064	1.401841	0.014700
1154	1.387927	0.030800	1062	1.396826	0.015200
1152	1.386170	0.034400	1060	1.391374	0.016400
1150	1.384911	0.038300	1058	1.385629	0.018100

Table 4. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1056	1.379536	0.020700	964	1.500499	0.094100
1054	1.373272	0.024300	962	1.501491	0.090900
1052	1.366992	0.029200	960	1.502437	0.087900
1050	1.361263	0.035700	958	1.503680	0.084900
1048	1.356861	0.043700	956	1.504571	0.080900
1046	1.354083	0.052100	954	1.504693	0.077100
1044	1.352649	0.060700	952	1.504712	0.074100
1042	1.352657	0.069400	950	1.504869	0.070600
1040	1.354351	0.077800	948	1.504829	0.067200
1038	1.356966	0.084500	946	1.504426	0.063500
1036	1.359401	0.090300	944	1.503477	0.059900
1034	1.361845	0.096300	942	1.502493	0.057100
1032	1.364933	0.102200	940	1.501590	0.053900
1030	1.368405	0.107300	938	1.500173	0.050600
1028	1.372112	0.112300	936	1.498610	0.048200
1026	1.376037	0.116800	934	1.497542	0.045900
1024	1.380264	0.121100	932	1.496599	0.043000
1022	1.384847	0.125100	930	1.495307	0.039900
1020	1.389457	0.128200	928	1.493628	0.036700
1018	1.393986	0.131500	926	1.491639	0.033600
1016	1.398967	0.134700	924	1.489176	0.030300
1014	1.404379	0.137200	922	1.486267	0.027400
1012	1.409687	0.139100	920	1.482712	0.024500
1010	1.414971	0.140900	918	1.478734	0.022500
1008	1.420706	0.142600	916	1.474888	0.021400
1006	1.426577	0.143200	914	1.471221	0.020200
1004	1.432227	0.143400	912	1.467620	0.019700
1002	1.437835	0.143400	910	1.464351	0.019300
1000	1.443274	0.142500	908	1.460908	0.018600
998	1.448358	0.141600	906	1.457550	0.018800
996	1.453370	0.140400	904	1.454589	0.018900
994	1.458219	0.138800	902	1.451474	0.018500
992	1.462926	0.137000	900	1.448297	0.019000
990	1.467474	0.134800	898	1.445597	0.019300
988	1.471518	0.132000	896	1.442868	0.019100
986	1.475216	0.129600	894	1.439781	0.018900
984	1.478913	0.126900	892	1.436302	0.018700
982	1.482340	0.123800	890	1.432526	0.018900
980	1.485361	0.120600	888	1.428831	0.019600
978	1.488115	0.117400	886	1.425607	0.020200
976	1.490283	0.113800	884	1.421794	0.019900
974	1.492286	0.111100	882	1.417194	0.020200
972	1.494709	0.108300	880	1.412537	0.021300
970	1.497098	0.104600	878	1.407812	0.021700
968	1.498613	0.100600	876	1.402007	0.022300
966	1.499564	0.097100	874	1.395447	0.023900

Table 4. Concluded

ν, cm^{-1}	n	k
872	1.388207	0.026000
870	1.380782	0.029800
868	1.372965	0.034000
866	1.366437	0.040500
864	1.360723	0.045600
862	1.356623	0.046500
860	1.336091	0.055900
858	1.323013	0.071000
856	1.313648	0.090200
854	1.307802	0.111900
852	1.306292	0.135800
850	1.309310	0.160900
848	1.317713	0.186100
846	1.331922	0.210500
844	1.351135	0.230300
842	1.373195	0.246000
840	1.397124	0.257200
838	1.422002	0.264000
836	1.446859	0.266300
834	1.470876	0.264600
832	1.493261	0.259100
830	1.512959	0.250300
828	1.530080	0.240200
826	1.544840	0.228400
824	1.556879	0.215200
822	1.566005	0.202100
820	1.573005	0.189200
818	1.578347	0.177200
816	1.581825	0.164800
814	1.583831	0.154500
812	1.585363	0.144900
810	1.586425	0.135800
808	1.586741	0.127300
806	1.586704	0.119700
804	1.586478	0.112700
802	1.586495	0.106400
800	1.586855	0.100100
798	1.587128	0.093200
796	1.586744	0.086100
794	1.585936	0.079300
792	1.584586	0.072100
790	1.582368	0.065000
788	1.578935	0.058100
786	1.574614	0.052400
784	1.570111	0.048000
782	1.565714	0.044100
780	1.561070	0.040800
778	1.556475	0.038600
776	1.552160	0.037000
774	1.548418	0.036200
772	1.545011	0.035400
770	1.542150	0.035200
768	1.539608	0.034900
766	1.537266	0.034500
764	1.535351	0.035000
762	1.533909	0.034500
760	1.532353	0.034400
758	1.531074	0.034200
756	1.530161	0.034100
754	1.529241	0.033300
752	1.527820	0.032400
750	1.526295	0.032300
748	1.525184	0.032300
746	1.524413	0.032200
744	1.523934	0.032000
742	1.523406	0.031100
740	1.522205	0.030000
738	1.520739	0.029700
736	1.519654	0.029800
734	1.518848	0.029500
732	1.517915	0.029300
730	1.517009	0.029200
728	1.516319	0.029300
726	1.515912	0.029200
724	1.515423	0.028700
722	1.514703	0.028200
720	1.513784	0.027800
718	1.512753	0.027500
716	1.511557	0.027500
714	1.510899	0.028100
712	1.510512	0.028100
710	1.509664	0.027500
708	1.508525	0.028200
706	1.507754	0.028600
704	1.507562	0.029900
702	1.507667	0.030100
700		0.030800

Table 5. Condensed MMH Optical Properties at 80°K

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
3700		0.002400	3372	1.402644	0.005100
3690	1.437059	0.001800	3370	1.401617	0.005100
3680	1.436899	0.002200	3368	1.400462	0.005500
3670	1.436474	0.001100	3366	1.399471	0.005900
3660	1.435876	0.001600	3364	1.398416	0.006100
3650	1.435661	0.001600	3362	1.397190	0.006400
3640	1.435365	0.001100	3360	1.395741	0.006700
3630	1.434703	0.001200	3358	1.394245	0.007400
3620	1.434570	0.001300	3356	1.392874	0.008200
3610	1.434100	0.000700	3354	1.391585	0.008900
3600	1.433188	0.000300	3352	1.389923	0.009400
3590	1.432317	0.000900	3350	1.387993	0.010400
3580	1.431927	0.000800	3348	1.386141	0.011900
3570	1.431428	0.001000	3346	1.384339	0.013300
3560	1.430575	0.000400	3344	1.382524	0.015300
3550	1.429794	0.001200	3342	1.381115	0.017600
3540	1.429267	0.001000	3340	1.379941	0.019700
3530	1.428536	0.001000	3338	1.378659	0.021800
3520	1.427590	0.001100	3336	1.377279	0.024300
3510	1.426841	0.001300	3334	1.376199	0.027300
3500	1.425873	0.001300	3332	1.375568	0.030500
3490	1.424796	0.001400	3330	1.375396	0.033700
3480	1.423813	0.002000	3328	1.375731	0.037000
3470	1.422750	0.001800	3326	1.376504	0.039800
3460	1.421499	0.002400	3324	1.377262	0.042200
3450	1.420348	0.002700	3322	1.377877	0.044500
3440	1.419176	0.003000	3320	1.378444	0.047000
3430	1.417855	0.003300	3318	1.379189	0.049600
3420	1.416195	0.003200	3316	1.380765	0.052700
3410	1.414237	0.003700	3314	1.382556	0.054300
3400	1.412161	0.003900	3312	1.383573	0.055600
3398	1.411685	0.003900	3310	1.384929	0.058400
3396	1.411091	0.003900	3308	1.386967	0.059800
3394	1.410495	0.004000	3306	1.388314	0.060500
3392	1.409966	0.004200	3304	1.389264	0.062200
3390	1.409470	0.004200	3302	1.390789	0.063900
3388	1.408810	0.004200	3300	1.392647	0.065100
3386	1.408175	0.004400	3298	1.394065	0.065500
3384	1.407603	0.004500	3296	1.394703	0.066100
3382	1.407009	0.004500	3294	1.395243	0.067600
3380	1.406340	0.004500	3292	1.396259	0.069300
3378	1.405439	0.004300	3290	1.397501	0.070700
3376	1.404279	0.004400	3288	1.398972	0.072300
3374	1.403376	0.005000	3286	1.400465	0.073300

Table 5. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
3284	1.401603	0.074200	3196	1.461593	0.045800
3282	1.402539	0.075600	3194	1.460434	0.045200
3280	1.403758	0.077200	3192	1.459190	0.044900
3278	1.405138	0.078800	3190	1.457779	0.044700
3276	1.406851	0.080500	3188	1.456259	0.045000
3274	1.408971	0.082100	3186	1.455042	0.046000
3272	1.410725	0.082600	3184	1.454166	0.046900
3270	1.411896	0.084000	3182	1.453604	0.048200
3268	1.413718	0.086300	3180	1.453314	0.049400
3266	1.416358	0.088000	3178	1.453135	0.050600
3264	1.418966	0.089100	3176	1.453386	0.052400
3262	1.421848	0.090700	3174	1.454344	0.053800
3260	1.425261	0.091600	3172	1.455251	0.054500
3258	1.428121	0.091400	3170	1.456000	0.055500
3256	1.430748	0.092300	3168	1.457263	0.056900
3254	1.434385	0.093400	3166	1.458971	0.057500
3252	1.438205	0.092600	3164	1.460555	0.057800
3250	1.441538	0.092100	3162	1.462114	0.058100
3248	1.444833	0.091200	3160	1.463813	0.058200
3246	1.447933	0.089800	3158	1.465536	0.058000
3244	1.450627	0.088400	3156	1.466993	0.057500
3242	1.453444	0.087100	3154	1.468416	0.057300
3240	1.456217	0.085200	3152	1.470127	0.057100
3238	1.458540	0.082800	3150	1.471812	0.056200
3236	1.460330	0.080600	3148	1.473364	0.055600
3234	1.461783	0.078300	3146	1.475164	0.054800
3232	1.463033	0.076400	3144	1.476908	0.053400
3230	1.464445	0.074600	3142	1.478258	0.051800
3228	1.465680	0.072300	3140	1.479437	0.050400
3226	1.466616	0.070200	3138	1.480618	0.048800
3224	1.467562	0.068300	3136	1.481747	0.047100
3222	1.468275	0.065800	3134	1.482579	0.045000
3220	1.468698	0.063800	3132	1.483001	0.043000
3218	1.469096	0.061700	3130	1.483280	0.041300
3216	1.469189	0.059300	3128	1.483645	0.039600
3214	1.469016	0.057400	3126	1.483945	0.037700
3212	1.468707	0.055300	3124	1.484026	0.035700
3210	1.468134	0.053400	3122	1.483708	0.033600
3208	1.467300	0.051700	3120	1.483139	0.031900
3206	1.466257	0.050200	3118	1.482527	0.030400
3204	1.465221	0.049300	3116	1.481961	0.029000
3202	1.464511	0.048500	3114	1.481384	0.027700
3200	1.463765	0.047400	3112	1.480719	0.026300
3198	1.462732	0.046400	3110	1.479987	0.025200

Table 5. Continued

ν, cm⁻¹	n	k	ν, cm⁻¹	n	k
3108	1.479318	0.024100	3020	1.448119	0.016800
3106	1.478652	0.023000	3018	1.447622	0.016500
3104	1.477908	0.021900	3016	1.446953	0.016100
3102	1.477003	0.020800	3014	1.446073	0.015800
3100	1.476014	0.020000	3012	1.445070	0.015600
3098	1.475178	0.019400	3010	1.443947	0.015500
3096	1.474461	0.018700	3008	1.442823	0.015600
3094	1.473778	0.018000	3006	1.441719	0.015700
3092	1.473017	0.017200	3004	1.440529	0.015700
3090	1.472081	0.016400	3002	1.439144	0.015800
3088	1.471169	0.016000	3000	1.437545	0.015900
3086	1.470448	0.015500	2998	1.435743	0.016300
3084	1.469756	0.014900	2996	1.433740	0.016800
3082	1.468930	0.014200	2994	1.431529	0.017700
3080	1.467984	0.013600	2992	1.429201	0.019000
3078	1.466965	0.013100	2990	1.426938	0.020800
3076	1.465914	0.012700	2988	1.424710	0.022900
3074	1.464936	0.012500	2986	1.422422	0.025400
3072	1.464138	0.012300	2984	1.420303	0.028800
3070	1.463249	0.011800	2982	1.418611	0.032700
3068	1.462171	0.011500	2980	1.417488	0.037300
3066	1.461106	0.011400	2978	1.417359	0.042600
3064	1.460144	0.011300	2976	1.418435	0.047900
3062	1.459166	0.011200	2974	1.420575	0.053000
3060	1.458116	0.011100	2972	1.423819	0.057800
3058	1.457064	0.011200	2970	1.428121	0.061800
3056	1.456056	0.011300	2968	1.433352	0.064800
3054	1.454978	0.011400	2966	1.439135	0.066300
3052	1.453946	0.011800	2964	1.444914	0.066100
3050	1.452953	0.012100	2962	1.450158	0.064500
3048	1.451969	0.012600	2960	1.454270	0.061300
3046	1.451127	0.013300	2958	1.456801	0.057500
3044	1.450444	0.013900	2956	1.457596	0.053400
3042	1.449804	0.014600	2954	1.456531	0.049700
3040	1.449367	0.015400	2952	1.454021	0.047500
3038	1.449131	0.016100	2950	1.450925	0.047000
3036	1.448949	0.016600	2948	1.447859	0.048100
3034	1.448824	0.017200	2946	1.445224	0.050700
3032	1.448921	0.017700	2944	1.443602	0.054800
3030	1.449130	0.017900	2942	1.443640	0.060000
3028	1.449246	0.017800	2940	1.445564	0.065300
3026	1.449190	0.017600	2938	1.449311	0.070400
3024	1.448967	0.017300	2936	1.455067	0.074700
3022	1.448571	0.017000	2934	1.462573	0.077100

Table 5. Continued

ν, cm⁻¹	n	k
2932	1.470398	0.076400
2930	1.477320	0.073800
2928	1.483139	0.069900
2926	1.487589	0.064700
2924	1.490278	0.059000
2922	1.491555	0.053700
2920	1.491715	0.048600
2918	1.490970	0.044200
2916	1.489581	0.040500
2914	1.487939	0.037600
2912	1.486252	0.035300
2910	1.484606	0.033300
2908	1.482821	0.031600
2906	1.480994	0.030300
2904	1.479217	0.029400
2902	1.477465	0.028600
2900	1.475639	0.028200
2898	1.473942	0.028200
2896	1.472500	0.028500
2894	1.471341	0.028900
2892	1.470313	0.029300
2890	1.469377	0.029800
2888	1.468475	0.030400
2886	1.467694	0.031200
2884	1.467213	0.032300
2882	1.467058	0.033200
2880	1.467095	0.034100
2878	1.467288	0.034800
2876	1.467482	0.035300
2874	1.467673	0.035800
2872	1.467795	0.036100
2870	1.467614	0.036300
2868	1.467152	0.036900
2866	1.466647	0.037900
2864	1.466231	0.039400
2862	1.466286	0.041600
2860	1.467293	0.044200
2858	1.469375	0.046500
2856	1.472236	0.048100
2854	1.475549	0.048800
2852	1.478960	0.048500
2850	1.481966	0.047100
2848	1.483993	0.045000
2846	1.485053	0.043100
2844	1.485554	0.041700
2842	1.485865	0.040800
2840	1.486238	0.040500
2838	1.487099	0.040700
2836	1.488808	0.041100
2834	1.491376	0.040900
2832	1.494404	0.039800
2830	1.497467	0.037600
2828	1.500076	0.034300
2826	1.501745	0.030100
2824	1.502076	0.025500
2822	1.501211	0.021300
2820	1.499596	0.017800
2818	1.497556	0.014800
2816	1.495252	0.012500
2814	1.492854	0.010600
2812	1.490403	0.009200
2810	1.487949	0.008100
2808	1.485566	0.007400
2806	1.483230	0.006800
2804	1.480720	0.006300
2802	1.478007	0.006200
2800	1.475160	0.006500
2798	1.472153	0.007200
2796	1.469075	0.008700
2794	1.466066	0.010800
2792	1.463248	0.013900
2790	1.460906	0.018000
2788	1.459624	0.023400
2786	1.460158	0.029700
2784	1.462972	0.036000
2782	1.468182	0.041500
2780	1.475331	0.044900
2778	1.483367	0.045500
2776	1.490987	0.043300
2774	1.497061	0.038700
2772	1.501064	0.033100
2770	1.502973	0.027000
2768	1.503056	0.021500
2766	1.501982	0.017000
2764	1.500437	0.013500
2762	1.498644	0.010600
2760	1.496654	0.008300
2758	1.494652	0.006700

Table 5. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2756	1.492823	0.005500	2540	1.462682	0.001300
2754	1.491159	0.004600	2530	1.462443	0.001500
2752	1.489620	0.003900	2520	1.462203	0.001200
2750	1.488202	0.003400	2510	1.461764	0.001000
2748	1.486959	0.003100	2500	1.461302	0.001000
2746	1.485861	0.002800	2490	1.460909	0.000900
2744	1.484869	0.002600	2480	1.460405	0.000800
2742	1.483966	0.002400	2470	1.459993	0.001000
2740	1.483096	0.002200	2460	1.459689	0.001000
2738	1.482244	0.002100	2450	1.459497	0.001100
2736	1.481533	0.002100	2440	1.459234	0.000900
2734	1.480891	0.002000	2430	1.458920	0.000800
2732	1.480255	0.001900	2420	1.458523	0.000700
2730	1.479652	0.001900	2410	1.458052	0.000500
2728	1.479096	0.001800	2400	1.457435	0.000600
2726	1.478532	0.001800	2390	1.456964	0.000800
2724	1.478041	0.001800	2380	1.456578	0.001100
2722	1.477609	0.001800	2370	1.456267	0.001300
2720	1.477157	0.001700	2360	1.456101	0.001800
2718	1.476690	0.001700	2350	1.456189	0.002000
2716	1.476257	0.001700	2340	1.456318	0.002100
2714	1.475862	0.001700	2330	1.456372	0.001900
2712	1.475470	0.001700	2320	1.456288	0.001800
2710	1.475107	0.001700	2310	1.456200	0.001600
2708	1.474739	0.001700	2300	1.455983	0.001400
2706	1.474398	0.001700	2290	1.455741	0.001200
2704	1.474036	0.001700	2280	1.455420	0.001100
2702	1.473679	0.001700	2270	1.454941	0.000800
2700	1.473314	0.001800	2260	1.454530	0.001200
2690	1.472033	0.002000	2250	1.454392	0.001200
2680	1.470996	0.002200	2240	1.454223	0.001200
2670	1.470088	0.002300	2230	1.453963	0.001100
2660	1.469431	0.002500	2220	1.453650	0.001100
2650	1.468968	0.002500	2200	1.453000	0.001300
2640	1.468513	0.002200	2180	1.452652	0.001500
2630	1.467849	0.001900	2170	1.452468	0.001500
2620	1.467265	0.001800	2160	1.452168	0.001500
2610	1.466640	0.001500	2150	1.451984	0.001800
2600	1.465972	0.001300	2140	1.451969	0.001900
2590	1.465316	0.001300	2130	1.451918	0.001800
2580	1.464750	0.001100	2120	1.451771	0.001800
2570	1.464070	0.001100	2110	1.451603	0.001700
2560	1.463464	0.001100	2100	1.451432	0.001700
2550	1.463013	0.001400	2090	1.451240	0.001600

Table 5. Continued

ν, cm^{-1}	n	k
2080	1.450984	0.001500
2070	1.450680	0.001500
2060	1.450371	0.001500
2050	1.450074	0.001600
2040	1.449933	0.001800
2030	1.449798	0.001700
2020	1.449587	0.001700
2010	1.449353	0.001700
2000	1.449039	0.001600
1990	1.448690	0.001800
1980	1.448485	0.002000
1970	1.448551	0.002300
1960	1.448776	0.002200
1950	1.448791	0.001700
1940	1.448481	0.001300
1930	1.448079	0.001000
1920	1.447596	0.000700
1910	1.446935	0.000400
1900	1.446192	0.000400
1890	1.445492	0.000500
1880	1.444859	0.000700
1870	1.444292	0.001000
1860	1.443825	0.001300
1850	1.443519	0.001700
1840	1.443250	0.001800
1830	1.442998	0.002000
1820	1.442721	0.002000
1810	1.442356	0.001900
1800	1.441889	0.001900
1790	1.441320	0.001700
1780	1.440600	0.001700
1770	1.439830	0.001700
1760	1.438918	0.001700
1750	1.438050	0.002000
1740	1.437090	0.002000
1730	1.435897	0.002100
1720	1.434527	0.002500
1710	1.433028	0.002700
1700	1.431411	0.003300
1698	1.430800	0.003200
1696	1.430397	0.003400
1694	1.429804	0.003400
1692	1.429234	0.003500
1690	1.428532	0.003800
1688	1.427963	0.004000
1686	1.427343	0.004400
1684	1.426838	0.004600
1682	1.426035	0.004700
1680	1.425122	0.005100
1678	1.424216	0.005700
1676	1.423449	0.006300
1674	1.422563	0.006900
1672	1.421604	0.007600
1670	1.420594	0.008600
1668	1.419717	0.009700
1666	1.418821	0.010900
1664	1.417998	0.012300
1662	1.417262	0.013900
1660	1.416717	0.015600
1658	1.416249	0.017400
1656	1.415860	0.019300
1654	1.415685	0.021600
1652	1.416032	0.024000
1650	1.416551	0.026000
1648	1.417183	0.028200
1646	1.418115	0.030500
1644	1.419353	0.032500
1642	1.420650	0.034500
1640	1.422170	0.036500
1638	1.424087	0.038600
1636	1.426449	0.040300
1634	1.428850	0.041500
1632	1.431294	0.042700
1630	1.434025	0.043800
1628	1.437037	0.044400
1626	1.440075	0.044600
1624	1.443059	0.044400
1622	1.445971	0.044000
1620	1.449008	0.043400
1618	1.452167	0.042300
1616	1.455176	0.040500
1614	1.457675	0.038200
1612	1.459842	0.035900
1610	1.461713	0.033200
1608	1.463132	0.030200
1606	1.464018	0.027200
1604	1.464460	0.024100
1602	1.464375	0.021100

Table 5. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1600	1.463878	0.018300	1512	1.433783	0.018100
1598	1.462952	0.015700	1510	1.433944	0.018400
1596	1.461696	0.013500	1508	1.434234	0.018800
1594	1.460334	0.011800	1506	1.434573	0.018900
1592	1.459006	0.010300	1504	1.434689	0.018800
1590	1.457610	0.009000	1502	1.434564	0.018900
1588	1.456101	0.007900	1500	1.434490	0.019200
1586	1.454698	0.007300	1498	1.434532	0.019500
1584	1.453493	0.006700	1496	1.434503	0.019600
1582	1.452302	0.006100	1494	1.434343	0.019900
1580	1.451081	0.005700	1492	1.434180	0.020300
1578	1.449914	0.005400	1490	1.434170	0.020900
1576	1.448896	0.005300	1488	1.434268	0.021400
1574	1.448001	0.005100	1486	1.434401	0.021900
1572	1.447041	0.004800	1484	1.434703	0.022600
1570	1.445983	0.004700	1482	1.435361	0.023100
1568	1.444962	0.004700	1480	1.436200	0.023200
1566	1.444062	0.004900	1478	1.436757	0.022600
1564	1.443237	0.005000	1476	1.436691	0.021900
1562	1.442545	0.005300	1474	1.436014	0.021400
1560	1.442089	0.005500	1472	1.435046	0.021500
1558	1.441631	0.005300	1470	1.434155	0.022200
1556	1.440855	0.005000	1468	1.433623	0.023200
1554	1.439844	0.004900	1466	1.433589	0.024400
1552	1.438746	0.005000	1464	1.433867	0.025100
1550	1.437645	0.005300	1462	1.433919	0.025400
1548	1.436598	0.005800	1460	1.433680	0.025800
1546	1.435744	0.006500	1458	1.433085	0.026100
1544	1.434992	0.007100	1456	1.431610	0.026400
1542	1.434297	0.007800	1454	1.429274	0.028100
1540	1.433729	0.008600	1452	1.426983	0.031700
1538	1.433187	0.009200	1450	1.425997	0.037400
1536	1.432572	0.010000	1448	1.427595	0.044500
1534	1.432107	0.011000	1446	1.432501	0.051400
1532	1.431869	0.012000	1444	1.440354	0.056400
1530	1.431762	0.012900	1442	1.450046	0.058300
1528	1.431744	0.013800	1440	1.460194	0.056700
1526	1.431765	0.014600	1438	1.469340	0.051500
1524	1.431886	0.015500	1436	1.475850	0.043300
1522	1.432269	0.016400	1434	1.478758	0.033900
1520	1.432784	0.016900	1432	1.478286	0.025200
1518	1.433162	0.017200	1430	1.475408	0.018200
1516	1.433405	0.017500	1428	1.471574	0.013700
1514	1.433608	0.017800	1426	1.467896	0.010800

Table 5. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1424	1.464514	0.008700	1336	1.426498	0.020700
1422	1.461251	0.007400	1334	1.427274	0.022200
1420	1.458214	0.006800	1332	1.428298	0.023400
1418	1.455362	0.006800	1330	1.429406	0.024400
1416	1.452862	0.007600	1328	1.430728	0.025400
1414	1.451368	0.009400	1326	1.432150	0.025900
1412	1.451244	0.011000	1324	1.433552	0.026300
1410	1.452027	0.011800	1322	1.435051	0.026600
1408	1.453062	0.011600	1320	1.436666	0.026500
1406	1.453892	0.010600	1318	1.438160	0.026100
1404	1.454169	0.009000	1316	1.439562	0.025500
1402	1.453719	0.007200	1314	1.440851	0.024700
1400	1.452685	0.005700	1312	1.441997	0.023600
1398	1.451303	0.004500	1310	1.442891	0.022400
1396	1.449725	0.003700	1308	1.443533	0.021000
1394	1.448218	0.003400	1306	1.444062	0.019800
1392	1.446882	0.003200	1304	1.444443	0.018200
1390	1.445600	0.003100	1302	1.444434	0.016600
1388	1.444393	0.003200	1300	1.444267	0.015100
1386	1.443375	0.003400	1298	1.443867	0.013600
1384	1.442447	0.003500	1296	1.443270	0.012200
1382	1.441469	0.003600	1294	1.442554	0.010900
1380	1.440513	0.003900	1292	1.441562	0.009500
1378	1.439752	0.004300	1290	1.440383	0.008500
1376	1.439199	0.004600	1288	1.439272	0.007700
1374	1.438740	0.004700	1286	1.438092	0.006700
1372	1.438123	0.004500	1284	1.436650	0.005900
1370	1.437191	0.004300	1282	1.435150	0.005400
1368	1.436108	0.004400	1280	1.433685	0.005000
1366	1.435037	0.004600	1278	1.432204	0.004700
1364	1.433964	0.004900	1276	1.430669	0.004500
1362	1.432866	0.005300	1274	1.429178	0.004500
1360	1.431736	0.005800	1272	1.427714	0.004500
1358	1.430593	0.006500	1270	1.426165	0.004500
1356	1.429553	0.007400	1268	1.424625	0.004800
1354	1.428647	0.008400	1266	1.423106	0.005000
1352	1.427776	0.009400	1264	1.421472	0.005300
1350	1.427027	0.010700	1262	1.419857	0.005900
1348	1.426475	0.012000	1260	1.418418	0.006500
1346	1.426028	0.013300	1258	1.416862	0.006900
1344	1.425712	0.014800	1256	1.414972	0.007400
1342	1.425644	0.016300	1254	1.413029	0.008500
1340	1.425784	0.017800	1252	1.411303	0.009700
1338	1.426055	0.019200	1250	1.409593	0.010900

Table 5. Continued

ν, cm^{-1}	n	k
1248	1.407677	0.012200
1246	1.405810	0.014100
1244	1.404111	0.016100
1242	1.402491	0.018300
1240	1.400963	0.020900
1238	1.399666	0.023700
1236	1.398631	0.026900
1234	1.397897	0.030200
1232	1.397537	0.033900
1230	1.397666	0.037700
1228	1.398162	0.041500
1226	1.399078	0.045600
1224	1.400734	0.049900
1222	1.403054	0.053900
1220	1.406035	0.057900
1218	1.409874	0.061700
1216	1.414552	0.064300
1214	1.419972	0.067300
1212	1.425996	0.068700
1210	1.432476	0.069100
1208	1.439230	0.068100
1206	1.445805	0.065500
1204	1.451774	0.061500
1202	1.456866	0.056200
1200	1.460472	0.049500
1198	1.462267	0.042400
1196	1.462315	0.035300
1194	1.460641	0.028500
1192	1.457523	0.022900
1190	1.453664	0.018600
1188	1.449460	0.015400
1186	1.445242	0.013300
1184	1.441248	0.012000
1182	1.437422	0.011100
1180	1.433837	0.010900
1178	1.430563	0.010900
1176	1.427389	0.011000
1174	1.424279	0.011500
1172	1.421290	0.012100
1170	1.418291	0.012900
1168	1.415173	0.013900
1166	1.411990	0.015400
1164	1.408909	0.017400
1162	1.406137	0.019900
1160	1.403604	0.022600
1158	1.401248	0.025700
1156	1.399252	0.029400
1154	1.397994	0.033500
1152	1.397309	0.037500
1150	1.396938	0.041500
1148	1.397181	0.046100
1146	1.398370	0.050500
1144	1.400078	0.054400
1142	1.402353	0.058400
1140	1.405508	0.062100
1138	1.409438	0.064900
1136	1.413938	0.067000
1134	1.418773	0.067700
1132	1.423385	0.067200
1130	1.427557	0.065700
1128	1.431236	0.063300
1126	1.434041	0.059600
1124	1.435349	0.055000
1122	1.434404	0.049700
1120	1.430700	0.045100
1118	1.424291	0.042500
1116	1.416419	0.043800
1114	1.409207	0.049600
1112	1.404805	0.059100
1110	1.404862	0.071100
1108	1.410402	0.083200
1106	1.420902	0.092700
1104	1.434980	0.098000
1102	1.450783	0.097900
1100	1.465674	0.091600
1098	1.477234	0.080800
1096	1.484642	0.067600
1094	1.487665	0.053100
1092	1.486165	0.038900
1090	1.480920	0.026900
1088	1.473493	0.017900
1086	1.465208	0.011700
1084	1.457161	0.008100
1082	1.449885	0.006000
1080	1.443402	0.004800
1078	1.437518	0.004200
1076	1.432102	0.003800
1074	1.426957	0.003700

Table 5. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1072	1.421861	0.003500	984	1.519998	0.152500
1070	1.416656	0.003700	982	1.525066	0.147400
1068	1.411513	0.004200	980	1.529640	0.142200
1066	1.406401	0.004800	978	1.533955	0.136800
1064	1.401035	0.005400	976	1.538121	0.131400
1062	1.395247	0.006300	974	1.541816	0.125000
1060	1.388974	0.007600	972	1.544618	0.118600
1058	1.382133	0.009500	970	1.546775	0.112400
1056	1.374761	0.012400	968	1.548503	0.106200
1054	1.366981	0.016500	966	1.549993	0.100400
1052	1.359149	0.022300	964	1.551151	0.094100
1050	1.351956	0.030000	962	1.551909	0.088100
1048	1.345971	0.039100	960	1.552165	0.081800
1046	1.341543	0.049400	958	1.551778	0.075600
1044	1.338919	0.060300	956	1.550960	0.070000
1042	1.338126	0.071300	954	1.550041	0.064400
1040	1.339010	0.081900	952	1.548721	0.058800
1038	1.341166	0.091600	950	1.546850	0.053300
1036	1.343738	0.100200	948	1.544545	0.048300
1034	1.346479	0.108700	946	1.542155	0.043700
1032	1.350122	0.117600	944	1.539322	0.038900
1030	1.354905	0.125600	942	1.535959	0.034800
1028	1.360225	0.132700	940	1.532667	0.031600
1026	1.365557	0.139000	938	1.529805	0.028400
1024	1.370960	0.145200	936	1.526579	0.024800
1022	1.376824	0.151400	934	1.522698	0.021600
1020	1.383469	0.157200	932	1.518783	0.019600
1018	1.390573	0.162200	930	1.515284	0.017600
1016	1.397955	0.166600	928	1.511856	0.015800
1014	1.405625	0.170600	926	1.508361	0.014000
1012	1.413570	0.173800	924	1.504834	0.012600
1010	1.421799	0.176700	922	1.501175	0.011200
1008	1.430535	0.178800	920	1.497624	0.010500
1006	1.439363	0.179700	918	1.494519	0.010000
1004	1.447669	0.179600	916	1.491566	0.009000
1002	1.455641	0.179500	914	1.488427	0.008200
1000	1.463927	0.179100	912	1.485029	0.007300
998	1.472064	0.177400	910	1.481763	0.007100
996	1.479740	0.175400	908	1.478814	0.006800
994	1.487404	0.173300	906	1.475705	0.005900
992	1.495039	0.170000	904	1.472351	0.005700
990	1.502093	0.166200	902	1.469024	0.005200
988	1.508437	0.161700	900	1.465588	0.005000
986	1.514401	0.157500	898	1.462122	0.004800

Table 5. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
896	1.458576	0.004600	808	1.634190	0.096000
894	1.454811	0.004400	806	1.631549	0.085700
892	1.450906	0.004400	804	1.628331	0.075700
890	1.446779	0.004300	802	1.624558	0.066900
888	1.442332	0.004400	800	1.620357	0.058700
886	1.437453	0.004600	798	1.615954	0.051500
884	1.432502	0.005500	796	1.611409	0.044900
882	1.427590	0.006300	794	1.606592	0.038700
880	1.422271	0.006800	792	1.601273	0.033300
878	1.416081	0.007500	790	1.596002	0.029100
876	1.409251	0.008800	788	1.591070	0.025500
874	1.401700	0.010500	786	1.586241	0.022100
872	1.393179	0.012800	784	1.581264	0.019300
870	1.383720	0.016500	782	1.576471	0.017300
868	1.373535	0.021500	780	1.571814	0.015600
866	1.362583	0.028300	778	1.567377	0.014700
864	1.351283	0.037600	776	1.563565	0.014500
862	1.340477	0.049600	774	1.560548	0.014300
860	1.330626	0.063900	772	1.557783	0.013800
858	1.321543	0.080200	770	1.555087	0.013400
856	1.313675	0.099900	768	1.552633	0.013300
854	1.307677	0.122600	766	1.550262	0.012900
852	1.305289	0.149800	764	1.547939	0.013000
850	1.309641	0.180800	762	1.546192	0.013500
848	1.322076	0.210900	760	1.544893	0.013400
846	1.340825	0.237600	758	1.543609	0.013200
844	1.364770	0.260800	756	1.542198	0.012800
842	1.392886	0.278700	754	1.540870	0.012700
840	1.423766	0.290700	752	1.539714	0.012500
838	1.455830	0.296700	750	1.538611	0.012100
836	1.487429	0.296100	748	1.537443	0.011800
834	1.516974	0.290500	746	1.536415	0.011500
832	1.544244	0.280700	744	1.535314	0.011000
830	1.568058	0.266500	742	1.534136	0.010600
828	1.587521	0.249700	740	1.533019	0.010400
826	1.603041	0.232500	738	1.531853	0.009900
824	1.615110	0.214100	736	1.530550	0.009800
822	1.623908	0.196600	734	1.529585	0.010000
820	1.630388	0.179600	732	1.528955	0.009900
818	1.634921	0.163300	730	1.528222	0.009400
816	1.637320	0.147300	728	1.527239	0.009000
814	1.637819	0.132800	726	1.526142	0.008700
812	1.637329	0.119800	724	1.525022	0.008600
810	1.636196	0.107600	722	1.524173	0.008800

Table 5. Concluded

ν, cm^{-1}	n	k
720	1.523568	0.008700
718	1.522886	0.008300
716	1.521881	0.007900
714	1.520519	0.007600
712	1.519295	0.008200
710	1.518690	0.008800
708	1.518333	0.008900
706	1.517686	0.008800
704	1.516879	0.009000
702	1.516373	0.009600
700		0.009900

Table 6. Condensed N_2H_4 Optical Properties at 80°K

ν, cm⁻¹	n	k	ν, cm⁻¹	n	k
3700		0.000100	3372	1.374676	0.009200
3690	1.458706	0.000100	3370	1.370461	0.010400
3680	1.458220	0.000300	3368	1.365487	0.011200
3670	1.457710	0.000100	3366	1.359581	0.013000
3660	1.457023	0.000100	3364	1.353338	0.016100
3650	1.456255	0.000100	3362	1.347232	0.019900
3640	1.455415	0.000200	3360	1.340615	0.024200
3630	1.454748	0.000600	3358	1.333710	0.030100
3620	1.454255	0.000700	3356	1.327041	0.037600
3610	1.453624	0.000500	3354	1.320979	0.046300
3600	1.452659	0.000400	3352	1.315430	0.056500
3590	1.451436	0.000300	3350	1.311311	0.068600
3580	1.450414	0.001000	3348	1.308911	0.081600
3570	1.449592	0.001000	3346	1.308350	0.095300
3560	1.448538	0.001100	3344	1.310184	0.110100
3550	1.447231	0.001200	3342	1.314661	0.124000
3540	1.446064	0.001700	3340	1.320727	0.136800
3530	1.444703	0.001700	3338	1.328845	0.149500
3520	1.443240	0.002200	3336	1.338745	0.160100
3510	1.441753	0.002700	3334	1.349549	0.168700
3500	1.440475	0.003200	3332	1.362134	0.177100
3490	1.438881	0.003400	3330	1.375026	0.180200
3480	1.437163	0.003700	3328	1.385471	0.181600
3470	1.435272	0.004200	3326	1.394743	0.184700
3460	1.433208	0.004100	3324	1.405322	0.187300
3450	1.430485	0.004400	3322	1.417132	0.188800
3440	1.427487	0.004600	3320	1.428247	0.186300
3430	1.424050	0.005200	3318	1.437653	0.183800
3420	1.420031	0.005200	3316	1.445378	0.180000
3410	1.415112	0.005900	3314	1.452472	0.177300
3400	1.408498	0.005700	3312	1.459166	0.174000
3398	1.407231	0.006000	3310	1.464989	0.169600
3396	1.405532	0.006100	3308	1.469286	0.166200
3394	1.404001	0.006200	3306	1.473747	0.163500
3392	1.402093	0.006400	3304	1.478355	0.161000
3390	1.400353	0.006600	3302	1.482860	0.157400
3388	1.398297	0.006800	3300	1.487452	0.155000
3386	1.396395	0.007100	3298	1.491449	0.149900
3384	1.394253	0.007200	3296	1.493714	0.145900
3382	1.391931	0.007100	3294	1.495587	0.143200
3380	1.388979	0.007100	3292	1.498052	0.140900
3378	1.385842	0.007400	3290	1.500664	0.138400
3376	1.382494	0.008000	3288	1.503433	0.136000
3374	1.378850	0.008300	3286	1.506020	0.133200

Table 6. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
3284	1.508538	0.130600	3196	1.447591	0.107700
3282	1.511358	0.128200	3194	1.451996	0.115900
3280	1.513998	0.124600	3192	1.457365	0.122300
3278	1.515862	0.121300	3190	1.463068	0.128300
3276	1.517998	0.118800	3188	1.469695	0.134300
3274	1.520497	0.115400	3186	1.477660	0.139000
3272	1.522201	0.111100	3184	1.486041	0.142000
3270	1.523183	0.107700	3182	1.493933	0.143500
3268	1.524252	0.104500	3180	1.501413	0.144900
3266	1.525541	0.101300	3178	1.509327	0.146100
3264	1.526655	0.097600	3176	1.517232	0.145800
3262	1.527368	0.093800	3174	1.525054	0.145500
3260	1.527603	0.090100	3172	1.533732	0.144800
3258	1.527772	0.086700	3170	1.542385	0.141400
3256	1.527943	0.083300	3168	1.549097	0.136700
3254	1.527695	0.079300	3166	1.555135	0.133600
3252	1.527125	0.076100	3164	1.561860	0.129900
3250	1.526680	0.072700	3162	1.568576	0.124500
3248	1.525984	0.068900	3160	1.574159	0.118300
3246	1.524655	0.065100	3158	1.578499	0.111300
3244	1.522790	0.061500	3156	1.581897	0.105000
3242	1.520576	0.058400	3154	1.584518	0.098000
3240	1.518151	0.055500	3152	1.586491	0.091800
3238	1.515677	0.053100	3150	1.588072	0.085400
3236	1.513249	0.050700	3148	1.589006	0.078800
3234	1.510514	0.048100	3146	1.589344	0.072800
3232	1.507172	0.045700	3144	1.589280	0.066600
3230	1.503591	0.044000	3142	1.588488	0.060600
3228	1.499886	0.042400	3140	1.587168	0.055200
3226	1.495866	0.041000	3138	1.585519	0.050100
3224	1.491344	0.040000	3136	1.583595	0.045500
3222	1.486503	0.039600	3134	1.581419	0.041200
3220	1.481443	0.039900	3132	1.579065	0.037400
3218	1.476144	0.040600	3130	1.576626	0.034000
3216	1.470403	0.042200	3128	1.574261	0.031000
3214	1.464604	0.045000	3126	1.571850	0.028100
3212	1.459185	0.049100	3124	1.569366	0.025500
3210	1.454197	0.053800	3122	1.566779	0.023200
3208	1.449763	0.059900	3120	1.564191	0.021200
3206	1.446105	0.066700	3118	1.561729	0.019700
3204	1.443885	0.074900	3116	1.559450	0.018200
3202	1.443124	0.083000	3114	1.557291	0.017000
3200	1.443382	0.090900	3112	1.555267	0.015800
3198	1.444733	0.099600	3110	1.553183	0.014600

Table 6. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
3108	1.551148	0.013800	3020	1.511096	0.009300
3106	1.549371	0.013100	3018	1.510762	0.009500
3104	1.547637	0.012200	3016	1.510433	0.009600
3102	1.545785	0.011500	3014	1.510094	0.009800
3100	1.544066	0.011100	3012	1.509769	0.010000
3098	1.542550	0.010700	3010	1.509539	0.010300
3096	1.541188	0.010300	3008	1.509372	0.010500
3094	1.539827	0.009800	3006	1.509262	0.010700
3092	1.538395	0.009300	3004	1.509135	0.010800
3090	1.536995	0.009100	3002	1.509004	0.010900
3088	1.535708	0.008800	3000	1.508840	0.011000
3086	1.534518	0.008700	2998	1.508716	0.011100
3084	1.533477	0.008500	2996	1.508615	0.011200
3082	1.532442	0.008200	2994	1.508389	0.011100
3080	1.531311	0.007900	2992	1.508061	0.011300
3078	1.530205	0.007800	2990	1.507960	0.011700
3076	1.529211	0.007700	2988	1.508002	0.011800
3074	1.528313	0.007600	2986	1.508015	0.011900
3072	1.527414	0.007400	2984	1.507946	0.011900
3070	1.526428	0.007200	2982	1.507881	0.012000
3068	1.525470	0.007200	2980	1.507830	0.012100
3066	1.524631	0.007200	2978	1.507772	0.012100
3064	1.523826	0.007100	2976	1.507732	0.012300
3062	1.523023	0.007100	2974	1.507743	0.012300
3060	1.522236	0.007000	2972	1.507714	0.012400
3058	1.521424	0.007000	2970	1.507726	0.012500
3056	1.520640	0.007000	2968	1.507808	0.012600
3054	1.519933	0.007100	2966	1.507889	0.012600
3052	1.519166	0.007000	2964	1.507932	0.012600
3050	1.518396	0.007200	2962	1.508042	0.012700
3048	1.517777	0.007400	2960	1.508152	0.012600
3046	1.517273	0.007500	2958	1.508241	0.012600
3044	1.516694	0.007500	2956	1.508403	0.012600
3042	1.516116	0.007600	2954	1.508572	0.012400
3040	1.515582	0.007700	2952	1.508603	0.012200
3038	1.515056	0.007700	2950	1.508611	0.012100
3036	1.514363	0.007700	2948	1.508639	0.012000
3034	1.513734	0.008000	2946	1.508690	0.011900
3032	1.513268	0.008300	2944	1.508735	0.011800
3030	1.512839	0.008400	2942	1.508808	0.011700
3028	1.512394	0.008700	2940	1.508883	0.011600
3026	1.512055	0.008900	2938	1.509038	0.011500
3024	1.511757	0.009100	2936	1.509219	0.011300
3022	1.511453	0.009200	2934	1.509281	0.010900

Table 6. Continued

ν, cm⁻¹	n	k	ν, cm⁻¹	n	k
2932	1.509190	0.010700	2620	1.490629	0.001300
2930	1.509156	0.010600	2610	1.490226	0.001000
2928	1.509322	0.010600	2600	1.489737	0.000900
2926	1.509586	0.010300	2590	1.489238	0.000700
2924	1.509652	0.009800	2580	1.488821	0.000800
2922	1.509568	0.009500	2570	1.488445	0.000600
2920	1.509552	0.009300	2560	1.487751	0.000300
2918	1.509625	0.009000	2550	1.487087	0.000700
2916	1.509617	0.008600	2540	1.486704	0.000900
2914	1.509490	0.008200	2530	1.486349	0.001000
2912	1.509342	0.008000	2520	1.485897	0.001200
2910	1.509358	0.007800	2510	1.485557	0.001500
2908	1.509340	0.007400	2500	1.485386	0.001900
2906	1.509236	0.007000	2490	1.485309	0.002000
2904	1.509031	0.006700	2480	1.485193	0.002200
2902	1.508888	0.006400	2470	1.485130	0.002300
2900	1.508689	0.006200	2460	1.485118	0.002400
2890	1.507968	0.004600	2450	1.485042	0.002300
2880	1.506735	0.003200	2440	1.484887	0.002300
2870	1.505185	0.002200	2430	1.484814	0.002400
2860	1.503772	0.001700	2420	1.484795	0.002300
2850	1.502395	0.001200	2410	1.484725	0.002200
2840	1.501014	0.000900	2400	1.484678	0.002100
2830	1.499805	0.001100	2390	1.484563	0.001800
2820	1.498823	0.001000	2380	1.484350	0.001600
2810	1.497879	0.001200	2370	1.484136	0.001400
2800	1.497075	0.001300	2360	1.483882	0.001100
2790	1.496372	0.001500	2350	1.483477	0.000800
2780	1.495689	0.001600	2340	1.482989	0.000600
2770	1.495129	0.001900	2330	1.482464	0.000500
2760	1.494701	0.002100	2320	1.481896	0.000400
2750	1.494341	0.002200	2310	1.481291	0.000500
2740	1.494056	0.002400	2300	1.480784	0.000700
2730	1.493784	0.002300	2290	1.480348	0.000900
2720	1.493557	0.002400	2280	1.479889	0.001100
2710	1.493295	0.002200	2270	1.479549	0.001500
2700	1.492875	0.002000	2260	1.479307	0.001800
2690	1.492519	0.002200	2250	1.479061	0.002000
2680	1.492276	0.002000	2240	1.478892	0.002500
2670	1.491969	0.002000	2230	1.478897	0.002700
2660	1.491703	0.001900	2220	1.478937	0.003000
2650	1.491454	0.001800	2200	1.479000	0.003200
2640	1.491126	0.001600	2180	1.479228	0.003100
2630	1.490886	0.001600	2170	1.479271	0.002900

Table 6. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2160	1.479191	0.002600	1720	1.444804	0.006000
2150	1.479065	0.002400	1710	1.441510	0.007000
2140	1.478917	0.002100	1700	1.437155	0.008300
2130	1.478649	0.001700	1698	1.436184	0.008700
2120	1.478244	0.001400	1696	1.435088	0.009100
2110	1.477745	0.001100	1694	1.434000	0.009500
2100	1.477135	0.000900	1692	1.432616	0.009800
2090	1.476514	0.000900	1690	1.431109	0.010400
2080	1.475896	0.000900	1688	1.429401	0.011100
2070	1.475333	0.001100	1686	1.427563	0.012000
2060	1.474834	0.001300	1684	1.425757	0.013500
2050	1.474380	0.001500	1682	1.424044	0.014800
2040	1.474017	0.001900	1680	1.422047	0.016400
2030	1.473790	0.002100	1678	1.420013	0.018600
2020	1.473627	0.002400	1676	1.418229	0.021300
2010	1.473567	0.002500	1674	1.416951	0.024400
2000	1.473469	0.002500	1672	1.415967	0.027400
1990	1.473304	0.002400	1670	1.415293	0.030700
1980	1.473159	0.002400	1668	1.415089	0.034200
1970	1.472978	0.002100	1666	1.415253	0.037300
1960	1.472700	0.001900	1664	1.415630	0.040600
1950	1.472274	0.001500	1662	1.416415	0.043700
1940	1.471767	0.001300	1660	1.417299	0.046400
1930	1.471171	0.001000	1658	1.418200	0.049100
1920	1.470521	0.000800	1656	1.419074	0.051700
1910	1.469764	0.000600	1654	1.420059	0.054400
1900	1.468991	0.000500	1652	1.421345	0.057300
1890	1.468124	0.000400	1650	1.422775	0.059600
1880	1.467199	0.000400	1648	1.424099	0.062100
1870	1.466328	0.000600	1646	1.425554	0.064600
1860	1.465566	0.000700	1644	1.427105	0.067000
1850	1.464622	0.000600	1642	1.428648	0.069400
1840	1.463684	0.000900	1640	1.430204	0.071900
1830	1.462753	0.000900	1638	1.431880	0.074600
1820	1.461639	0.000900	1636	1.433858	0.077500
1810	1.460293	0.001100	1634	1.436286	0.080400
1800	1.459035	0.001500	1632	1.438874	0.082900
1790	1.457784	0.001900	1630	1.441330	0.085400
1780	1.456386	0.002100	1628	1.443937	0.088400
1770	1.454815	0.002700	1626	1.447094	0.091600
1760	1.453238	0.003200	1624	1.450640	0.094600
1750	1.451468	0.003800	1622	1.454736	0.098000
1740	1.449527	0.004500	1620	1.459511	0.101200
1730	1.447382	0.005300	1618	1.465072	0.104300

Table 6. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1616	1.471608	0.107300	1528	1.479512	0.003800
1614	1.479112	0.109300	1526	1.478707	0.003800
1612	1.487443	0.110800	1524	1.477948	0.003900
1610	1.496815	0.111100	1522	1.477386	0.004100
1608	1.506997	0.109800	1520	1.476834	0.004000
1606	1.517636	0.106500	1518	1.476236	0.004000
1604	1.528256	0.100900	1516	1.475618	0.004000
1602	1.537855	0.092400	1514	1.474947	0.003900
1600	1.545385	0.081800	1512	1.474261	0.004100
1598	1.550265	0.069800	1510	1.473692	0.004200
1596	1.552122	0.057200	1508	1.473207	0.004400
1594	1.550892	0.045200	1506	1.472836	0.004500
1592	1.547329	0.035000	1504	1.472403	0.004400
1590	1.542305	0.026700	1502	1.471860	0.004400
1588	1.536589	0.020500	1500	1.471331	0.004500
1586	1.531002	0.016300	1498	1.470899	0.004600
1584	1.525915	0.013200	1496	1.470545	0.004700
1582	1.521290	0.011000	1494	1.470169	0.004600
1580	1.517194	0.009600	1492	1.469727	0.004600
1578	1.513635	0.008500	1490	1.469329	0.004600
1576	1.510594	0.007900	1488	1.468918	0.004500
1574	1.507851	0.007100	1486	1.468420	0.004400
1572	1.505410	0.006800	1484	1.467905	0.004400
1570	1.503276	0.006400	1482	1.467440	0.004400
1568	1.501362	0.006000	1480	1.466896	0.004300
1566	1.499530	0.005700	1478	1.466346	0.004400
1564	1.497778	0.005300	1476	1.465871	0.004500
1562	1.496031	0.005200	1474	1.465427	0.004500
1560	1.494647	0.005300	1472	1.464957	0.004600
1558	1.493526	0.005200	1470	1.464513	0.004600
1556	1.492389	0.004800	1468	1.464061	0.004700
1554	1.491119	0.004600	1466	1.463621	0.004700
1552	1.489900	0.004400	1464	1.463182	0.004800
1550	1.488783	0.004400	1462	1.462741	0.004800
1548	1.487710	0.004200	1460	1.462295	0.004900
1546	1.486616	0.004200	1458	1.461936	0.005000
1544	1.485678	0.004300	1456	1.461641	0.005000
1542	1.484887	0.004300	1454	1.461234	0.004800
1540	1.484116	0.004200	1452	1.460639	0.004700
1538	1.483297	0.004100	1450	1.460072	0.004800
1536	1.482445	0.004000	1448	1.459624	0.004900
1534	1.481686	0.004100	1446	1.459138	0.004800
1532	1.481014	0.004000	1444	1.458597	0.004900
1530	1.480298	0.003900	1442	1.458070	0.004900

Table 6. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1440	1.457532	0.005000	1352	1.436638	0.031900
1438	1.457041	0.005100	1350	1.437489	0.032300
1436	1.456620	0.005200	1348	1.438265	0.032600
1434	1.456120	0.005100	1346	1.438910	0.032700
1432	1.455583	0.005200	1344	1.439392	0.032700
1430	1.455069	0.005200	1342	1.439771	0.032800
1428	1.454533	0.005200	1340	1.440179	0.032800
1426	1.453961	0.005200	1338	1.440428	0.032600
1424	1.453379	0.005200	1336	1.440453	0.032400
1422	1.452667	0.005100	1334	1.440278	0.032300
1420	1.451979	0.005300	1332	1.440044	0.032300
1418	1.451305	0.005300	1330	1.439645	0.032300
1416	1.450616	0.005400	1328	1.439046	0.032400
1414	1.449898	0.005500	1326	1.438320	0.032900
1412	1.449119	0.005500	1324	1.437570	0.033500
1410	1.448263	0.005700	1322	1.436854	0.034600
1408	1.447479	0.005900	1320	1.436381	0.035900
1406	1.446602	0.006000	1318	1.436138	0.037400
1404	1.445676	0.006300	1316	1.436120	0.039000
1402	1.444764	0.006600	1314	1.436489	0.040900
1400	1.443818	0.006900	1312	1.437261	0.042600
1398	1.442773	0.007300	1310	1.438397	0.044300
1396	1.441816	0.007900	1308	1.439807	0.045700
1394	1.440889	0.008400	1306	1.441413	0.046900
1392	1.439870	0.008900	1304	1.443225	0.048000
1390	1.438733	0.009600	1302	1.445344	0.048800
1388	1.437669	0.010500	1300	1.447606	0.049200
1386	1.436681	0.011500	1298	1.449899	0.049200
1384	1.435816	0.012600	1296	1.452226	0.049000
1382	1.434957	0.013700	1294	1.454538	0.048300
1380	1.434204	0.015000	1292	1.456791	0.047400
1378	1.433603	0.016400	1290	1.459014	0.046100
1376	1.433136	0.017700	1288	1.461041	0.044300
1374	1.432763	0.019200	1286	1.462686	0.042200
1372	1.432599	0.020600	1284	1.464034	0.040000
1370	1.432534	0.022000	1282	1.465139	0.037600
1368	1.432549	0.023300	1280	1.465965	0.035000
1366	1.432652	0.024700	1278	1.466378	0.032200
1364	1.432885	0.026000	1276	1.466369	0.029400
1362	1.433334	0.027400	1274	1.466023	0.026700
1360	1.433958	0.028500	1272	1.465403	0.024000
1358	1.434577	0.029400	1270	1.464369	0.021300
1356	1.435167	0.030300	1268	1.463014	0.018900
1354	1.435828	0.031100	1266	1.461448	0.016700

Table 6. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1264	1.459650	0.014600	1176	1.343914	0.021800
1262	1.457656	0.012900	1174	1.338622	0.025300
1260	1.455624	0.011400	1172	1.333502	0.029400
1258	1.453546	0.010100	1170	1.328542	0.033900
1256	1.451478	0.009000	1168	1.323743	0.039100
1254	1.449309	0.007900	1166	1.319284	0.044800
1252	1.447067	0.007100	1164	1.315306	0.051100
1250	1.444832	0.006500	1162	1.311931	0.057700
1248	1.442663	0.006000	1160	1.309065	0.064400
1246	1.440516	0.005700	1158	1.306516	0.071200
1244	1.438440	0.005400	1156	1.304333	0.078300
1242	1.436405	0.005300	1154	1.302749	0.085700
1240	1.434413	0.005100	1152	1.301699	0.092900
1238	1.432444	0.005100	1150	1.301033	0.100100
1236	1.430499	0.005000	1148	1.300804	0.107300
1234	1.428516	0.005000	1146	1.300834	0.114100
1232	1.426565	0.005100	1144	1.300974	0.121000
1230	1.424677	0.005200	1142	1.301315	0.127900
1228	1.422837	0.005300	1140	1.301972	0.134900
1226	1.420948	0.005300	1138	1.303031	0.141900
1224	1.418944	0.005300	1136	1.304412	0.148600
1222	1.416913	0.005500	1134	1.305834	0.155100
1220	1.414907	0.005600	1132	1.307370	0.161700
1218	1.412877	0.005800	1130	1.309141	0.168300
1216	1.410799	0.005900	1128	1.311033	0.174700
1214	1.408691	0.006100	1126	1.313043	0.181300
1212	1.406508	0.006200	1124	1.315478	0.188000
1210	1.404178	0.006300	1122	1.318256	0.194300
1208	1.401806	0.006600	1120	1.320911	0.200200
1206	1.399308	0.006700	1118	1.323220	0.206200
1204	1.396614	0.007000	1116	1.325697	0.212900
1202	1.393981	0.007600	1114	1.328825	0.219700
1200	1.391387	0.007900	1112	1.332357	0.226000
1198	1.388529	0.008200	1110	1.335537	0.231800
1196	1.385404	0.008600	1108	1.338484	0.238200
1194	1.382200	0.009300	1106	1.341507	0.244900
1192	1.379004	0.010000	1104	1.344762	0.251900
1190	1.375645	0.010600	1102	1.348208	0.259400
1188	1.371910	0.011200	1100	1.352264	0.267300
1186	1.367838	0.012100	1098	1.356757	0.275400
1184	1.363446	0.013200	1096	1.361684	0.283600
1182	1.358729	0.014700	1094	1.367533	0.292900
1180	1.353896	0.016800	1092	1.374546	0.301400
1178	1.349052	0.019200	1090	1.382238	0.309900

Table 6. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1088	1.390024	0.317600	1000	1.630409	0.012400
1086	1.398266	0.326300	998	1.624462	0.011400
1084	1.408099	0.335500	996	1.618780	0.010200
1082	1.419082	0.343100	994	1.613302	0.009400
1080	1.430306	0.350500	992	1.608128	0.008700
1078	1.442494	0.358200	990	1.603123	0.008000
1076	1.455838	0.364900	988	1.598274	0.007700
1074	1.469816	0.371000	986	1.594039	0.007700
1072	1.484855	0.376900	984	1.590130	0.007200
1070	1.501312	0.381900	982	1.586130	0.006500
1068	1.518361	0.384900	980	1.582128	0.006200
1066	1.536046	0.387800	978	1.578186	0.005600
1064	1.555072	0.389400	976	1.574187	0.005400
1062	1.575124	0.388900	974	1.570468	0.005400
1060	1.595373	0.386400	972	1.567069	0.005300
1058	1.615640	0.382200	970	1.563547	0.004800
1056	1.636191	0.376700	968	1.559809	0.004600
1054	1.657529	0.369300	966	1.556291	0.004800
1052	1.679052	0.358700	964	1.553006	0.004700
1050	1.699626	0.345000	962	1.549613	0.004500
1048	1.718495	0.328700	960	1.546180	0.004500
1046	1.735684	0.310500	958	1.542782	0.004400
1044	1.750690	0.289800	956	1.539272	0.004300
1042	1.763199	0.267600	954	1.535621	0.004300
1040	1.772989	0.244000	952	1.532073	0.004600
1038	1.779405	0.218800	950	1.528589	0.004700
1036	1.782029	0.193900	948	1.524924	0.004700
1034	1.781475	0.169700	946	1.521145	0.005000
1032	1.777737	0.146400	944	1.517365	0.005200
1030	1.771255	0.125200	942	1.513392	0.005400
1028	1.762927	0.106400	940	1.509341	0.005800
1026	1.753253	0.089400	938	1.505195	0.006100
1024	1.742413	0.074800	936	1.500640	0.006200
1022	1.731007	0.062400	934	1.495847	0.006900
1020	1.719643	0.052300	932	1.490949	0.007400
1018	1.708540	0.043600	930	1.485712	0.007900
1016	1.697525	0.036300	928	1.479854	0.008400
1014	1.686868	0.030700	926	1.473294	0.009100
1012	1.676955	0.026300	924	1.466039	0.010400
1010	1.667750	0.022700	922	1.458098	0.012000
1008	1.659253	0.019900	920	1.449208	0.014300
1006	1.651450	0.017500	918	1.439272	0.017500
1004	1.644064	0.015300	916	1.428180	0.022100
1002	1.636975	0.013600	914	1.416084	0.028700

Table 6. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
912	1.403518	0.038000	824	1.615728	0.015900
910	1.391050	0.050000	822	1.612858	0.015600
908	1.379196	0.065100	820	1.610219	0.015200
906	1.368707	0.083500	818	1.607705	0.014900
904	1.360768	0.105300	816	1.605108	0.014300
902	1.356348	0.129600	814	1.602568	0.014400
900	1.355713	0.155300	812	1.600549	0.014600
898	1.359043	0.182300	810	1.598790	0.014400
896	1.366957	0.209900	808	1.596988	0.014200
894	1.379791	0.237000	806	1.595258	0.014100
892	1.397002	0.262200	804	1.593580	0.013900
890	1.418278	0.285700	802	1.592138	0.014080
888	1.444062	0.307000	800	1.590871	0.013700
886	1.474415	0.324300	798	1.589440	0.013200
884	1.508168	0.336300	796	1.587921	0.013000
882	1.543985	0.342500	794	1.586497	0.012700
880	1.581405	0.343300	792	1.584891	0.012300
878	1.619633	0.336900	790	1.583211	0.012300
876	1.656140	0.322300	788	1.581758	0.012500
874	1.688415	0.301000	786	1.580572	0.012600
872	1.715556	0.274800	784	1.579231	0.012400
870	1.736376	0.244000	782	1.577567	0.012400
868	1.749282	0.210600	780	1.576164	0.013200
866	1.754400	0.178400	778	1.575215	0.013700
864	1.753295	0.148700	776	1.574178	0.013900
862	1.747806	0.123000	774	1.573185	0.014700
860	1.739161	0.100800	772	1.572515	0.015300
858	1.728193	0.082500	770	1.572130	0.016000
856	1.716706	0.069200	768	1.571790	0.016300
854	1.705930	0.058400	766	1.571647	0.016800
852	1.695577	0.049700	764	1.571510	0.016900
850	1.685954	0.043400	762	1.571378	0.016900
848	1.677492	0.038300	760	1.571191	0.017100
846	1.669838	0.034000	758	1.570945	0.016800
844	1.662734	0.030400	756	1.571064	0.017500
842	1.656238	0.027600	754	1.571561	0.016900
840	1.650353	0.025200	752	1.571425	0.015900
838	1.645033	0.023200	750	1.570830	0.015500
836	1.640076	0.021300	748	1.570605	0.015400
834	1.635300	0.019600	746	1.570468	0.014800
832	1.630743	0.018400	744	1.570100	0.014100
830	1.626537	0.017400	742	1.569666	0.013700
828	1.622637	0.016700	740	1.569135	0.012900
826	1.618984	0.016100	738	1.568316	0.012400

Table 6. Concluded

ν, cm^{-1}	n	k
736	1.567670	0.012300
734	1.567207	0.011900
732	1.566506	0.011300
730	1.565591	0.011100
728	1.564782	0.011100
726	1.564534	0.011500
724	1.564545	0.011000
722	1.564021	0.010000
720	1.562910	0.009500
718	1.562000	0.009500
716	1.561204	0.009300
714	1.560281	0.009000
712	1.559130	0.009100
710	1.557882	0.009200
708	1.557026	0.010400
706	1.556631	0.010900
704	1.556340	0.011600
702	1.556398	0.012400
700		0.012600

Table 7. Condensed N_2O_4 Optical Properties at 20°K

ν, cm^{-1}	n	k
3700		0.008000
3690	1.499297	0.004300
3680	1.497327	0.005700
3670	1.497484	0.006200
3660	1.498334	0.006400
3650	1.498117	0.004400
3640	1.496201	0.004000
3630	1.494602	0.005600
3620	1.496845	0.009400
3610	1.498653	0.005800
3600	1.497778	0.004500
3590	1.497217	0.005800
3580	1.497205	0.003800
3570	1.496267	0.004500
3560	1.496333	0.004700
3550	1.496005	0.003700
3540	1.495945	0.004500
3530	1.495712	0.003000
3520	1.494059	0.002200
3510	1.492410	0.003600
3500	1.493002	0.005600
3490	1.493238	0.004200
3480	1.492830	0.004800
3470	1.491679	0.004400
3460	1.491199	0.006000
3450	1.491986	0.007700
3440	1.493518	0.006800
3430	1.492668	0.005200
3420	1.491526	0.006000
3410	1.491234	0.007300
3400	1.492548	0.008100
3390	1.492055	0.006300
3380	1.491519	0.007700
3370	1.492273	0.009200
3360	1.493372	0.007500
3350	1.492931	0.007600
3340	1.492673	0.007000
3330	1.491643	0.007100
3320	1.492182	0.009000
3310	1.492624	0.008000
3300	1.492679	0.008100
3290	1.492736	0.008800
3280	1.493772	0.008400
3270	1.493357	0.007400
3260	1.493966	0.008200
3250	1.493678	0.006600
3240	1.494134	0.006800
3230	1.493074	0.005400
3220	1.492219	0.004700
3210	1.491081	0.006800
3200	1.491510	0.005300
3190	1.490370	0.007000
3180	1.490854	0.006400
3170	1.490838	0.008200
3160	1.491640	0.005900
3150	1.491600	0.007600
3140	1.489125	0.002100
3130	1.486714	0.009000
3120	1.488723	0.009800
3110	1.490638	0.010000
3100	1.490795	0.008500
3090	1.491717	0.010000
3080	1.492068	0.007200
3070	1.491858	0.007700
3060	1.490776	0.005800
3050	1.490147	0.007200
3040	1.489976	0.007000
3030	1.490489	0.007200
3020	1.489542	0.005600
3010	1.488386	0.006300
3000	1.487241	0.007000
2990	1.487150	0.008500
2980	1.486709	0.009400
2970	1.488862	0.012600
2960	1.492317	0.012000
2950	1.493678	0.007500
2940	1.492098	0.006200
2930	1.490621	0.005100
2920	1.488710	0.005200
2910	1.488555	0.007300
2900	1.489175	0.007000
2890	1.489197	0.006300
2880	1.488861	0.006800
2870	1.489288	0.006500
2860	1.489358	0.006000
2850	1.489281	0.005200
2840	1.488709	0.004500
2830	1.487902	0.003900

Table 7. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2820	1.486897	0.003900	2370	1.457409	0.004500
2810	1.486539	0.004300	2368	1.457230	0.004200
2800	1.486032	0.003900	2366	1.456261	0.004500
2790	1.485481	0.003900	2364	1.455857	0.004800
2780	1.484605	0.004100	2362	1.455149	0.005100
2770	1.484338	0.004500	2360	1.454758	0.005300
2760	1.484496	0.005300	2358	1.453461	0.005100
2750	1.484322	0.003800	2356	1.451933	0.006000
2740	1.483535	0.004600	2354	1.450379	0.007500
2730	1.483223	0.004400	2352	1.449122	0.009800
2720	1.483125	0.004700	2350	1.449168	0.013900
2710	1.482934	0.004400	2348	1.451435	0.017400
2700	1.482447	0.003900	2346	1.455464	0.019900
2690	1.482231	0.004400	2344	1.460969	0.020200
2680	1.481437	0.003000	2342	1.465878	0.016700
2670	1.480093	0.003500	2340	1.467379	0.010500
2660	1.479834	0.004900	2338	1.465220	0.006100
2650	1.479401	0.003800	2336	1.461969	0.004400
2640	1.479104	0.005500	2334	1.459804	0.005000
2630	1.479882	0.005500	2332	1.458939	0.005200
2620	1.479776	0.003800	2330	1.458232	0.005000
2610	1.478554	0.003900	2328	1.457566	0.005100
2600	1.477847	0.004200	2326	1.457168	0.005100
2590	1.478210	0.005000	2324	1.456610	0.004600
2580	1.478471	0.003900	2322	1.455786	0.004500
2570	1.477831	0.002600	2320	1.455213	0.004700
2560	1.476758	0.002600	2318	1.454451	0.004300
2550	1.475536	0.001400	2316	1.453632	0.004700
2540	1.474130	0.002100	2314	1.453200	0.005200
2530	1.473468	0.002200	2312	1.452911	0.005100
2520	1.472742	0.001900	2310	1.452372	0.005300
2500	1.469000	0.001900	2308	1.452106	0.005600
2480	1.468044	0.004000	2306	1.451868	0.005600
2470	1.467778	0.005100	2304	1.451534	0.005500
2460	1.467322	0.004500	2302	1.451060	0.005600
2450	1.467222	0.005600	2300	1.450958	0.005800
2440	1.466684	0.004100	2298	1.450806	0.005500
2430	1.465338	0.004200	2296	1.450179	0.004800
2420	1.464203	0.004600	2294	1.449327	0.005100
2410	1.463500	0.004800	2292	1.448952	0.005200
2400	1.462598	0.004300	2290	1.448367	0.004900
2380	1.460500	0.004600	2288	1.447728	0.005000
2378	1.459551	0.004300	2286	1.446985	0.005000
2376	1.459585	0.004200	2284	1.446359	0.005100
2374	1.458626	0.004000	2282	1.445673	0.005400
2372	1.458223	0.003900	2280	1.445167	0.005400

Table 7. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2278	1.444700	0.005900	2186	1.419168	0.038200
2276	1.444163	0.005400	2184	1.419316	0.039200
2274	1.443580	0.006000	2182	1.419480	0.041300
2272	1.443243	0.005700	2180	1.420063	0.042300
2270	1.442347	0.005200	2178	1.420254	0.043700
2268	1.441316	0.005500	2176	1.420455	0.045000
2266	1.440476	0.005600	2174	1.421111	0.047100
2264	1.439679	0.005600	2172	1.422005	0.048000
2262	1.438632	0.005600	2170	1.422550	0.049200
2260	1.437537	0.005500	2168	1.423386	0.050700
2258	1.435983	0.005500	2166	1.424255	0.051500
2256	1.433971	0.005500	2164	1.424683	0.052300
2254	1.431842	0.006900	2162	1.425417	0.054100
2252	1.430080	0.008100	2160	1.426621	0.055000
2250	1.428338	0.010000	2158	1.427276	0.055500
2248	1.426838	0.012200	2156	1.428066	0.057100
2246	1.425801	0.015200	2154	1.429191	0.058000
2244	1.426060	0.018700	2152	1.430339	0.058800
2242	1.427367	0.021400	2150	1.431268	0.059700
2240	1.428614	0.022900	2148	1.432399	0.060500
2238	1.429990	0.025400	2146	1.433620	0.061600
2236	1.433435	0.028000	2144	1.435150	0.062100
2234	1.437767	0.027400	2142	1.436443	0.062600
2232	1.440926	0.024500	2140	1.437798	0.062900
2230	1.442301	0.021400	2138	1.438884	0.063200
2228	1.441846	0.017000	2136	1.440139	0.063600
2226	1.439620	0.014500	2134	1.441513	0.064100
2224	1.436513	0.012400	2132	1.442992	0.063900
2222	1.433114	0.012400	2130	1.444165	0.064000
2220	1.430164	0.013200	2128	1.445480	0.063800
2218	1.428286	0.015000	2126	1.446363	0.063500
2216	1.426978	0.016100	2124	1.447294	0.063500
2214	1.425597	0.017000	2122	1.448477	0.063900
2212	1.424213	0.018600	2120	1.449776	0.063200
2210	1.423175	0.019900	2118	1.450780	0.063300
2208	1.422193	0.021500	2116	1.451919	0.062700
2206	1.421390	0.023000	2114	1.453197	0.062700
2204	1.420975	0.024900	2112	1.454331	0.061500
2202	1.420510	0.025900	2110	1.454831	0.060700
2200	1.420111	0.027700	2108	1.455453	0.060500
2198	1.419660	0.028900	2106	1.456185	0.059800
2196	1.419550	0.030700	2104	1.456573	0.059100
2194	1.419452	0.032000	2102	1.457126	0.059200
2192	1.419218	0.033000	2100	1.458246	0.058800
2190	1.418658	0.034800	2098	1.458853	0.057600
2188	1.418884	0.036700	2096	1.459207	0.057200

Table 7. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2094	1.459941	0.057000	2002	1.442732	0.040300
2092	1.460634	0.055800	2000	1.442632	0.040900
2090	1.460957	0.055300	1998	1.442264	0.041500
2088	1.461689	0.054800	1996	1.442050	0.042000
2086	1.462180	0.053500	1994	1.442080	0.043200
2084	1.462410	0.052700	1992	1.442717	0.043400
2082	1.462441	0.051800	1990	1.442469	0.043000
2080	1.462688	0.051200	1988	1.441941	0.043500
2078	1.462934	0.050500	1986	1.441922	0.044700
2076	1.463031	0.049300	1984	1.442660	0.045000
2074	1.462929	0.048900	1982	1.442701	0.044700
2072	1.463464	0.048300	1980	1.442733	0.045100
2070	1.463502	0.046700	1978	1.442680	0.045400
2068	1.463111	0.045700	1976	1.443009	0.045700
2066	1.462585	0.045100	1974	1.443589	0.046400
2064	1.462309	0.044300	1972	1.444138	0.045500
2062	1.461913	0.044000	1970	1.444159	0.045800
2060	1.462043	0.043400	1968	1.444672	0.045800
2058	1.462029	0.042600	1966	1.445230	0.045500
2056	1.461612	0.041000	1964	1.445955	0.045200
2054	1.460781	0.040600	1962	1.446259	0.044000
2052	1.459966	0.039500	1960	1.446585	0.043600
2050	1.458945	0.039400	1958	1.446524	0.042300
2048	1.458348	0.039300	1956	1.446720	0.041800
2046	1.458088	0.039200	1954	1.446749	0.040700
2044	1.457778	0.038500	1952	1.446688	0.039100
2042	1.457108	0.037900	1950	1.446137	0.038300
2040	1.456398	0.037600	1948	1.445693	0.036600
2038	1.455682	0.037200	1946	1.445112	0.036000
2036	1.455313	0.037200	1944	1.444725	0.034200
2034	1.454661	0.036200	1942	1.443604	0.032500
2032	1.453586	0.035700	1940	1.442665	0.031500
2030	1.452216	0.035600	1938	1.441562	0.029400
2028	1.451344	0.035900	1936	1.439898	0.027500
2026	1.450616	0.036100	1934	1.437310	0.025500
2024	1.449784	0.035700	1932	1.434837	0.024800
2022	1.448555	0.036100	1930	1.432149	0.023500
2020	1.447705	0.036600	1928	1.429855	0.023100
2018	1.446987	0.037200	1926	1.426921	0.021600
2016	1.446584	0.037800	1924	1.423871	0.021000
2014	1.446262	0.038200	1922	1.420252	0.020400
2012	1.446291	0.038600	1920	1.416909	0.020000
2010	1.445665	0.037900	1918	1.412439	0.019500
2008	1.444745	0.038300	1916	1.407929	0.019900
2006	1.443776	0.038800	1914	1.403121	0.021300
2004	1.443272	0.039500	1912	1.398618	0.022200

Table 7. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1910	1.393402	0.024400	1818	1.388174	0.003400
1908	1.388566	0.026700	1816	1.381749	0.003800
1906	1.383024	0.029700	1814	1.374900	0.004400
1904	1.377673	0.033700	1812	1.368757	0.004600
1902	1.371961	0.038800	1810	1.361350	0.004900
1900	1.367265	0.045300	1808	1.354432	0.005500
1898	1.363260	0.052800	1806	1.346233	0.005700
1896	1.359578	0.059600	1804	1.338009	0.006300
1894	1.355879	0.069500	1802	1.328029	0.006900
1892	1.354654	0.080700	1800	1.318380	0.008700
1890	1.355531	0.092200	1798	1.306654	0.009600
1888	1.359107	0.103800	1796	1.294039	0.011900
1886	1.364079	0.113900	1794	1.279303	0.015800
1884	1.370658	0.123600	1792	1.264056	0.020400
1882	1.378685	0.133000	1790	1.245071	0.026900
1880	1.388427	0.140200	1788	1.224907	0.038000
1878	1.399431	0.147400	1786	1.203689	0.054500
1876	1.412729	0.152000	1784	1.184443	0.075500
1874	1.426224	0.153300	1782	1.164240	0.101000
1872	1.440082	0.153100	1780	1.149955	0.137400
1870	1.453924	0.150000	1778	1.144651	0.178300
1868	1.467148	0.143600	1776	1.148784	0.216800
1866	1.477455	0.134500	1774	1.161297	0.258900
1864	1.485744	0.125300	1772	1.191300	0.296400
1862	1.492520	0.115800	1770	1.226440	0.310300
1860	1.498727	0.105200	1768	1.243997	0.303100
1858	1.502664	0.093100	1766	1.246580	0.316100
1856	1.505165	0.081100	1764	1.264544	0.344900
1854	1.505005	0.067900	1762	1.289567	0.347700
1852	1.502302	0.055100	1760	1.308365	0.348200
1850	1.496902	0.044300	1758	1.316026	0.344400
1848	1.491339	0.035400	1756	1.317127	0.342600
1846	1.484326	0.026600	1754	1.311884	0.352200
1844	1.476500	0.019500	1752	1.297578	0.356700
1842	1.467646	0.014400	1750	1.274660	0.393100
1840	1.459410	0.010600	1748	1.274460	0.459800
1838	1.451006	0.008300	1746	1.299024	0.520800
1836	1.443754	0.006800	1744	1.351107	0.590200
1834	1.436482	0.005700	1742	1.426981	0.641300
1832	1.430202	0.005200	1740	1.534353	0.677700
1830	1.423559	0.004400	1738	1.648384	0.666700
1828	1.417760	0.004500	1736	1.772272	0.625100
1826	1.411535	0.004000	1734	1.883536	0.536700
1824	1.405776	0.004000	1732	1.921092	0.351800
1822	1.399658	0.004300	1730	1.873813	0.249600
1820	1.394633	0.004500	1728	1.807230	0.177800

Table 7. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1726	1.740178	0.154700	1626	1.385748	0.031900
1724	1.692362	0.163700	1624	1.373951	0.047700
1722	1.668821	0.179000	1622	1.368970	0.062000
1720	1.662639	0.193700	1620	1.336453	0.051100
1718	1.665217	0.204200	1618	1.300077	0.107200
1716	1.680276	0.210200	1616	1.301040	0.182800
1714	1.696413	0.205300	1614	1.346900	0.236400
1712	1.718936	0.190400	1612	1.401141	0.264100
1710	1.725987	0.166200	1610	1.466342	0.262200
1700	1.690078	0.040400	1608	1.508262	0.232000
1698	1.677598	0.028700	1606	1.504733	0.169700
1696	1.655248	0.021800	1604	1.501972	0.208700
1694	1.643646	0.017100	1602	1.523884	0.181200
1692	1.626929	0.013900	1600	1.527627	0.162900
1690	1.617045	0.011900	1598	1.519945	0.156600
1688	1.603921	0.011600	1596	1.520518	0.155000
1686	1.596453	0.010900	1594	1.520505	0.154300
1684	1.586502	0.011400	1592	1.524874	0.153900
1682	1.580808	0.010600	1590	1.528463	0.153000
1680	1.572241	0.010300	1588	1.534796	0.151300
1678	1.566919	0.010100	1586	1.539644	0.147900
1676	1.559405	0.009800	1584	1.545558	0.144300
1674	1.554644	0.009800	1582	1.550426	0.139800
1672	1.547778	0.009400	1580	1.555692	0.133900
1670	1.543475	0.009700	1578	1.558676	0.127400
1668	1.537223	0.009100	1576	1.562564	0.122300
1666	1.532799	0.009000	1574	1.565994	0.115100
1664	1.526681	0.009100	1572	1.568685	0.106400
1662	1.522858	0.009200	1570	1.568252	0.097500
1660	1.516869	0.008400	1568	1.567424	0.090400
1658	1.512328	0.008600	1566	1.565935	0.083600
1656	1.506214	0.008700	1564	1.564269	0.076100
1654	1.501955	0.009100	1562	1.561021	0.069600
1652	1.495879	0.009100	1560	1.557778	0.063500
1650	1.491199	0.009600	1558	1.553005	0.057400
1648	1.485225	0.010400	1556	1.548199	0.053300
1646	1.480976	0.010800	1554	1.542757	0.049400
1644	1.474439	0.010400	1552	1.537890	0.046900
1642	1.468660	0.011100	1550	1.533330	0.045300
1640	1.461718	0.012200	1548	1.529397	0.042600
1638	1.455800	0.012500	1546	1.524610	0.040900
1636	1.447411	0.012800	1544	1.520274	0.039400
1634	1.439202	0.014000	1542	1.515190	0.038100
1632	1.428445	0.015000	1540	1.510782	0.038300
1630	1.416995	0.018000	1538	1.507156	0.038800
1628	1.401832	0.021700	1536	1.503905	0.037800

Table 7. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1534	1.499771	0.037800	1442	1.458066	0.153800
1532	1.496124	0.038100	1440	1.464355	0.155200
1530	1.492458	0.038600	1438	1.470590	0.154200
1528	1.489381	0.039400	1436	1.476766	0.151300
1526	1.486338	0.039900	1434	1.480285	0.147700
1524	1.483281	0.040200	1432	1.483451	0.144700
1522	1.479301	0.040600	1430	1.486396	0.142900
1520	1.476485	0.043200	1428	1.490034	0.138700
1518	1.474277	0.044000	1426	1.491803	0.134500
1516	1.471957	0.044600	1424	1.493061	0.130100
1514	1.468553	0.045400	1422	1.492368	0.125700
1512	1.466438	0.047700	1420	1.492189	0.123500
1510	1.463989	0.048200	1418	1.491498	0.120300
1508	1.461392	0.049200	1416	1.491288	0.117700
1506	1.458784	0.051600	1414	1.489803	0.115000
1504	1.457231	0.052300	1412	1.488513	0.112400
1502	1.453790	0.052900	1410	1.486641	0.111800
1500	1.451046	0.055500	1408	1.486098	0.109900
1498	1.448889	0.058200	1406	1.484817	0.109000
1496	1.447102	0.058900	1404	1.484047	0.106900
1494	1.444786	0.062100	1402	1.482743	0.106200
1492	1.442856	0.062600	1400	1.482100	0.104100
1490	1.439918	0.065500	1398	1.479667	0.102000
1488	1.438194	0.068200	1396	1.477954	0.101900
1486	1.436953	0.070900	1394	1.476493	0.101400
1484	1.434842	0.071300	1392	1.475229	0.099800
1482	1.431591	0.074500	1390	1.473168	0.100200
1480	1.429543	0.078000	1388	1.472859	0.100200
1478	1.427676	0.081100	1386	1.472875	0.100000
1476	1.425192	0.083900	1384	1.473890	0.098200
1474	1.423480	0.089600	1382	1.473425	0.095000
1472	1.423194	0.093400	1380	1.472106	0.091700
1470	1.422727	0.096900	1378	1.469647	0.089400
1468	1.422081	0.100600	1376	1.469057	0.088000
1466	1.420131	0.103300	1374	1.467574	0.083300
1464	1.418692	0.109900	1372	1.464926	0.078900
1462	1.419444	0.116300	1370	1.460193	0.074900
1460	1.420594	0.120400	1368	1.456627	0.072500
1458	1.421616	0.126700	1366	1.451537	0.068000
1456	1.424411	0.132700	1364	1.447132	0.065400
1454	1.427468	0.137000	1362	1.441044	0.060900
1452	1.431554	0.143100	1360	1.434040	0.056100
1450	1.436860	0.146800	1358	1.424446	0.053600
1448	1.442829	0.150000	1356	1.415840	0.051300
1446	1.447637	0.150700	1354	1.404260	0.049000
1444	1.452945	0.153500	1352	1.392642	0.049600

Table 7. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1350	1.380736	0.052800	1258	1.692565	1.050200
1348	1.371121	0.055600	1256	1.815905	1.056700
1346	1.359229	0.058300	1254	1.935321	1.054900
1344	1.348749	0.063900	1252	2.077381	1.026200
1342	1.337737	0.069600	1250	2.211649	0.973000
1340	1.328800	0.075800	1248	2.374649	0.873700
1338	1.318591	0.082300	1246	2.553176	0.744800
1336	1.310050	0.088200	1244	2.555391	0.320000
1334	1.298564	0.094200	1242	2.394396	0.216200
1332	1.287516	0.101000	1240	2.272919	0.153500
1330	1.275334	0.111200	1238	2.210900	0.129300
1328	1.264287	0.118300	1236	2.148242	0.105400
1326	1.249452	0.128600	1234	2.110494	0.085200
1324	1.234309	0.139600	1232	2.065501	0.069700
1322	1.215532	0.154700	1230	2.036674	0.057700
1320	1.195664	0.173700	1228	2.002502	0.047600
1318	1.175208	0.202900	1226	1.979851	0.039600
1316	1.161743	0.239500	1224	1.952419	0.033100
1314	1.151171	0.278600	1222	1.934182	0.027800
1312	1.152134	0.330500	1220	1.911860	0.023700
1310	1.168616	0.383300	1218	1.896991	0.019800
1308	1.203089	0.427400	1216	1.878200	0.017000
1306	1.246053	0.460000	1214	1.865843	0.014500
1304	1.297071	0.476000	1212	1.850205	0.012400
1302	1.346231	0.476600	1210	1.839950	0.010000
1300	1.391206	0.458600	1208	1.824946	0.006800
1298	1.419504	0.428000	1206	1.812627	0.005600
1296	1.433499	0.393600	1204	1.799216	0.009300
1294	1.434835	0.362400	1202	1.793832	0.011900
1292	1.424147	0.323900	1200	1.785488	0.010000
1290	1.379094	0.282900	1198	1.779830	0.010200
1288	1.320484	0.289300	1196	1.771175	0.008900
1286	1.268154	0.318200	1194	1.765505	0.008200
1284	1.234176	0.361200	1192	1.757567	0.008800
1282	1.207789	0.413700	1190	1.752915	0.007400
1280	1.201306	0.471600	1188	1.745071	0.007600
1278	1.202387	0.529200	1186	1.740771	0.007900
1276	1.214129	0.578800	1184	1.734844	0.008300
1274	1.228476	0.639300	1182	1.731021	0.007000
1272	1.255618	0.688400	1180	1.724715	0.007600
1270	1.274627	0.739000	1178	1.721457	0.007700
1268	1.314195	0.810200	1176	1.716696	0.007800
1266	1.367464	0.870400	1174	1.713567	0.006700
1264	1.433910	0.913400	1172	1.708217	0.006600
1262	1.502440	0.972900	1170	1.705521	0.007000
1260	1.593700	1.005900	1168	1.700784	0.005700

Table 7. Continued

ν, cm^{-1}	n	k
1166	1.697432	0.005900
1164	1.692754	0.006200
1162	1.690391	0.006400
1160	1.686262	0.006400
1158	1.683957	0.006400
1156	1.679941	0.006600
1154	1.677871	0.006800
1152	1.674458	0.007300
1150	1.673123	0.007200
1148	1.670259	0.007000
1146	1.668050	0.005400
1144	1.664164	0.006100
1142	1.662076	0.005800
1140	1.658640	0.006100
1138	1.656763	0.006700
1136	1.654127	0.007000
1134	1.652673	0.007100
1132	1.649960	0.007000
1130	1.648193	0.007200
1128	1.645083	0.007300
1126	1.644852	0.009600
1124	1.642953	0.007300
1122	1.640796	0.007300
1120	1.638843	0.009600
1118	1.638550	0.007500
1116	1.635828	0.008100
1114	1.635116	0.008200
1112	1.634066	0.008100
1110	1.632683	0.005500
1108	1.629514	0.005500
1106	1.627285	0.005100
1104	1.623609	0.005000
1102	1.622457	0.008100
1100	1.622708	0.008500
1098	1.622275	0.005800
1096	1.619284	0.005200
1094	1.617108	0.005100
1092	1.614785	0.005300
1090	1.613141	0.005600
1088	1.610202	0.004900
1086	1.609365	0.008000
1084	1.607520	0.005800
1082	1.607856	0.003900
1080	1.606277	0.005300
1078	1.603398	0.003800
1076	1.600664	0.007800
1074	1.599520	0.004000
1072	1.596375	0.007600
1070	1.596341	0.007300
1068	1.594518	0.006300
1066	1.592116	0.005400
1064	1.588440	0.006000
1062	1.585259	0.006200
1060	1.582462	0.010100
1058	1.581212	0.010200
1056	1.580249	0.014000
1054	1.580683	0.012900
1052	1.578978	0.012200
1050	1.574087	0.009300
1048	1.568659	0.014200
1046	1.564843	0.016600
1044	1.563269	0.023800
1042	1.561553	0.025700
1040	1.562488	0.034300
1038	1.565082	0.037000
1036	1.570734	0.040200
1034	1.570972	0.035600
1032	1.566438	0.034200
1030	1.565119	0.047500
1028	1.572839	0.048800
1026	1.578248	0.049500
1024	1.578696	0.042400
1022	1.578699	0.049100
1020	1.583724	0.048000
1018	1.588448	0.045900
1016	1.588747	0.038100
1014	1.585778	0.036400
1012	1.580888	0.033900
1010	1.579997	0.040900
1008	1.582669	0.040600
1006	1.584525	0.038900
1004	1.583133	0.036600
1002	1.582799	0.038100
1000	1.583023	0.037000
998	1.582977	0.035900
996	1.578452	0.033300
994	1.574364	0.039400
992	1.581998	0.052200
990	1.592471	0.044500
988	1.593994	0.035100
986	1.596768	0.037300
984	1.593977	0.018300

Table 7. Continued

ν, cm^{-1}	n	k
982	1.583136	0.018500
980	1.577999	0.024900
978	1.575938	0.022000
976	1.572905	0.028200
974	1.574094	0.030300
972	1.571452	0.028000
970	1.569807	0.036400
968	1.577805	0.044500
966	1.588011	0.037700
964	1.589871	0.027900
962	1.583855	0.019700
960	1.578108	0.022100
958	1.576005	0.023600
956	1.577634	0.025100
954	1.577164	0.022200
952	1.575177	0.019900
950	1.575432	0.024700
948	1.573818	0.016000
946	1.570183	0.021900
944	1.574335	0.025900
942	1.579070	0.018900
940	1.578718	0.013000
938	1.574400	0.005700
936	1.564177	0.000001
934	1.552345	0.005800
932	1.553250	0.020800
930	1.560039	0.020700
928	1.563082	0.015400
926	1.559598	0.014300
924	1.559668	0.014100
922	1.563351	0.018100
920	1.561660	0.000900
918	1.554646	0.007300
916	1.552985	0.004000
914	1.549131	0.002200
912	1.539644	0.000001
910	1.538414	0.014800
908	1.546258	0.015500
906	1.549261	0.005500
904	1.543140	0.000001
902	1.536951	0.000001
900	1.532585	0.000001
898	1.526810	0.000001
896	1.519624	0.001900
894	1.522051	0.016400
892	1.528656	0.008800
890	1.524393	0.000001
888	1.514780	0.000001
886	1.510694	0.006300
884	1.507636	0.003800
882	1.505685	0.009100
880	1.500600	0.002800
878	1.494667	0.007800
876	1.486478	0.007200
874	1.478515	0.013300
872	1.473470	0.025100
870	1.474701	0.031400
868	1.472433	0.035500
866	1.468931	0.042300
864	1.468474	0.056400
862	1.482503	0.071400
860	1.499004	0.065700
858	1.501332	0.047600
856	1.491467	0.045400
854	1.486774	0.049800
852	1.485632	0.053100
850	1.485569	0.053800
848	1.484916	0.057300
846	1.484174	0.056100
844	1.486387	0.063400
842	1.488979	0.057300
840	1.487233	0.055500
838	1.484023	0.054600
836	1.484428	0.055300
834	1.480659	0.047900
832	1.472124	0.044700
830	1.457641	0.046400
828	1.451977	0.059900
826	1.455167	0.070600
824	1.452363	0.057900
822	1.442294	0.071400
820	1.437298	0.075100
818	1.436159	0.088900
816	1.436714	0.094000
814	1.438726	0.101700
812	1.442478	0.108700
810	1.446129	0.108000
808	1.445197	0.110200
806	1.450553	0.117200
804	1.456234	0.110500
802	1.447613	0.095400
800	1.433002	0.103400

Table 7. Concluded

ν, cm^{-1}	n	k
798	1.426463	0.111600
796	1.421243	0.115900
794	1.411204	0.122700
792	1.405181	0.140400
790	1.407999	0.158200
788	1.419335	0.170700
786	1.433717	0.175100
784	1.448786	0.168300
782	1.452278	0.147700
780	1.438102	0.125000
778	1.407410	0.115600
776	1.377107	0.124100
774	1.352937	0.140200
772	1.325826	0.147600
770	1.284990	0.169800
768	1.247588	0.219000
766	1.227981	0.285200
764	1.231862	0.355200
762	1.249166	0.416900
760	1.283482	0.481400
758	1.321189	0.524600
756	1.368748	0.576200
754	1.420791	0.616400
752	1.489047	0.652200
750	1.564527	0.680700
748	1.646607	0.674300
746	1.716405	0.674800
744	1.799191	0.659200
742	1.874199	0.634100
740	1.975029	0.596600
738	2.086542	0.526600
736	2.119870	0.306800
734	2.057575	0.223200
732	1.969515	0.133300
730	1.923767	0.178800
728	1.916525	0.150200
726	1.908514	0.121100
724	1.880579	0.103600
722	1.866783	0.084700
720	1.842905	0.072300
718	1.821935	0.054900
716	1.798861	0.060800
714	1.790910	0.057200
712	1.775399	0.047600
710	1.767195	0.051600
708	1.752021	0.036900
706	1.728410	0.033000
704	1.709982	0.056600
702	1.714605	0.067700
700		0.066500

Table 8. Condensed N_2O_4 Optical Properties at 80°K

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
3690		0.000100	3250	1.531319	0.001870
3680	1.537580	0.000100	3240	1.529943	0.002654
3670	1.537455	0.000637	3230	1.530061	0.003294
3660	1.537535	0.000100	3220	1.530103	0.003657
3650	1.536958	0.000339	3210	1.529700	0.002399
3640	1.536140	0.000100	3200	1.528644	0.003355
3630	1.537063	0.003014	3190	1.528301	0.003192
3620	1.538148	0.000606	3180	1.526786	0.002925
3610	1.537757	0.000255	3170	1.525064	0.004094
3600	1.536969	0.000100	3160	1.523422	0.006427
3590	1.536821	0.000100	3150	1.522805	0.009300
3580	1.536319	0.000181	3140	1.526781	0.015801
3570	1.536246	0.000212	3130	1.531234	0.012301
3560	1.535975	0.000366	3120	1.530665	0.008985
3550	1.535899	0.000100	3110	1.531611	0.013817
3540	1.535367	0.000100	3100	1.534380	0.009765
3530	1.535248	0.000306	3090	1.535431	0.008771
3520	1.534841	0.000100	3080	1.534176	0.005118
3510	1.534498	0.000100	3070	1.532686	0.004643
3500	1.533759	0.000261	3060	1.531216	0.005121
3490	1.533231	0.000517	3050	1.531441	0.004345
3480	1.533158	0.001812	3040	1.529387	0.003165
3470	1.533470	0.001312	3030	1.527538	0.003191
3460	1.532983	0.001462	3020	1.524851	0.004963
3450	1.532744	0.001805	3010	1.524354	0.006775
3440	1.532771	0.002302	3000	1.522672	0.009108
3430	1.531956	0.001403	2990	1.523903	0.012163
3420	1.531420	0.003508	2980	1.522117	0.014478
3410	1.532234	0.004356	2970	1.524751	0.020322
3400	1.533172	0.003999	2960	1.540516	0.034650
3390	1.533254	0.003736	2950	1.549048	0.005112
3380	1.532894	0.003119	2940	1.540858	0.003410
3370	1.532703	0.004162	2930	1.535286	0.003172
3360	1.533112	0.003916	2920	1.535048	0.003610
3350	1.533284	0.003917	2910	1.532968	0.003109
3340	1.533189	0.003396	2900	1.533006	0.003394
3330	1.533097	0.003659	2890	1.531662	0.002927
3320	1.532653	0.002881	2880	1.531214	0.002467
3310	1.532536	0.003912	2870	1.530062	0.003305
3300	1.532426	0.003189	2860	1.530401	0.002911
3290	1.532477	0.003784	2850	1.529320	0.002385
3280	1.532226	0.003195	2840	1.528869	0.002557
3270	1.532614	0.003668	2830	1.528141	0.002804
3260	1.532236	0.002390	2820	1.528113	0.002552

Table 8. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
2810	1.527320	0.002475	2394	1.502004	0.002435
2800	1.527155	0.002463	2392	1.501657	0.002427
2790	1.526232	0.002073	2390	1.501427	0.002562
2780	1.525937	0.002507	2388	1.501194	0.002465
2770	1.525214	0.002271	2386	1.500934	0.002500
2760	1.525083	0.002487	2384	1.500608	0.002422
2750	1.524232	0.002188	2382	1.500243	0.002429
2740	1.523947	0.002401	2380	1.499849	0.002496
2730	1.523165	0.002504	2378	1.499524	0.002588
2720	1.523211	0.002584	2376	1.499138	0.002578
2710	1.522276	0.002205	2374	1.498756	0.002691
2700	1.521916	0.002334	2372	1.498226	0.002619
2690	1.520910	0.002542	2370	1.497672	0.002855
2680	1.520716	0.002460	2368	1.497105	0.003025
2670	1.519305	0.002693	2366	1.496498	0.003183
2660	1.519300	0.003321	2364	1.495575	0.003367
2650	1.517552	0.003527	2362	1.494240	0.003819
2640	1.516324	0.004351	2360	1.492559	0.005246
2630	1.519903	0.012112	2358	1.492119	0.008377
2620	1.523263	0.003153	2356	1.493770	0.011158
2610	1.520714	0.002767	2354	1.494795	0.010762
2600	1.518450	0.002636	2352	1.494213	0.012391
2590	1.518796	0.004296	2350	1.497287	0.018101
2580	1.519172	0.003249	2348	1.504773	0.018509
2570	1.518808	0.001591	2346	1.509216	0.011246
2560	1.517210	0.001192	2344	1.507872	0.005756
2550	1.516085	0.000848	2342	1.505197	0.004255
2540	1.514842	0.001053	2340	1.503558	0.003464
2530	1.514205	0.001232	2338	1.502345	0.003067
2520	1.513322	0.000872	2336	1.501272	0.002777
2510	1.512138	0.000646	2334	1.500360	0.002840
2500	1.510710	0.000976	2332	1.499697	0.002990
2490	1.509830	0.001694	2330	1.499411	0.003271
2480	1.509269	0.002143	2328	1.499204	0.003027
2470	1.508668	0.002093	2326	1.498823	0.002787
2460	1.507883	0.002366	2324	1.498279	0.002605
2450	1.507334	0.002589	2322	1.497788	0.002613
2440	1.506630	0.002345	2320	1.497260	0.002580
2430	1.505721	0.002360	2318	1.496914	0.002747
2420	1.504792	0.002397	2316	1.496614	0.002763
2410	1.503806	0.002342	2314	1.496306	0.002694
2400	1.502478	0.002319	2312	1.496007	0.002772
2398	1.502264	0.002423	2310	1.495732	0.002606
2396	1.502122	0.002650	2308	1.495181	0.002422

Table 8. Continued

ν, cm^{-1}	n	k
2306	1.494715	0.002726
2304	1.494525	0.002919
2302	1.494409	0.002819
2300	1.494142	0.002683
2298	1.493754	0.002465
2296	1.493242	0.002425
2294	1.492771	0.002446
2292	1.492300	0.002517
2290	1.491846	0.002616
2288	1.491470	0.002815
2286	1.491134	0.002930
2284	1.490817	0.003092
2282	1.490780	0.003379
2280	1.490606	0.002939
2278	1.489950	0.002647
2276	1.489345	0.003056
2274	1.489083	0.003155
2272	1.488723	0.003090
2270	1.488209	0.003051
2268	1.487648	0.003142
2266	1.487114	0.003225
2264	1.486512	0.003262
2262	1.485474	0.003147
2260	1.484093	0.003796
2258	1.483283	0.005497
2256	1.483608	0.007052
2254	1.484373	0.007615
2252	1.484384	0.007275
2250	1.483485	0.007749
2248	1.483292	0.009916
2246	1.485097	0.012038
2244	1.487922	0.011942
2242	1.489800	0.009940
2240	1.490102	0.007696
2238	1.489317	0.006026
2236	1.488272	0.005174
2234	1.487289	0.004744
2232	1.486378	0.004371
2230	1.485552	0.004469
2228	1.484899	0.004378
2226	1.484227	0.004454
2224	1.483629	0.004536
2222	1.483132	0.004740
2220	1.482561	0.004668

ν, cm^{-1}	n	k
2218	1.481954	0.005012
2216	1.481605	0.005314
2214	1.481383	0.005484
2212	1.481064	0.005487
2210	1.480609	0.005446
2208	1.480103	0.005675
2206	1.479660	0.005811
2204	1.479239	0.006099
2200	1.478840	0.006487
2196	1.477895	0.006701
2194	1.477641	0.007067
2192	1.477476	0.007215
2190	1.477253	0.007315
2188	1.477029	0.007465
2186	1.476866	0.007521
2184	1.476567	0.007396
2182	1.476024	0.007361
2180	1.475637	0.007817
2178	1.475554	0.008023
2176	1.475409	0.007899
2174	1.475011	0.007815
2172	1.474553	0.007915
2170	1.474114	0.008083
2168	1.473911	0.008432
2166	1.473750	0.008447
2164	1.473358	0.008320
2162	1.473157	0.008770
2160	1.473095	0.008585
2158	1.472719	0.008327
2156	1.472176	0.008396
2154	1.471847	0.008538
2152	1.471539	0.008515
2150	1.471156	0.008497
2148	1.470656	0.008448
2146	1.470065	0.008470
2144	1.469481	0.008798
2142	1.469085	0.009117
2140	1.468978	0.009569
2138	1.468886	0.009446
2136	1.468420	0.009265
2134	1.468023	0.009698
2132	1.467919	0.009786
2130	1.467704	0.009583
2128	1.467187	0.009472

Table 8. Continued

v, cm^{-1}	n	k	v, cm^{-1}	n	k
2126	1.466622	0.009573	2038	1.443294	0.010574
2124	1.466367	0.010005	2036	1.442443	0.010370
2122	1.466134	0.009805	2034	1.441452	0.010497
2120	1.465682	0.009797	2032	1.440671	0.010870
2118	1.465324	0.010111	2030	1.440078	0.010980
2116	1.465148	0.010047	2028	1.439359	0.010914
2114	1.464940	0.010082	2026	1.438533	0.010991
2112	1.464602	0.009744	2024	1.437718	0.011045
2110	1.464081	0.009654	2022	1.435810	0.011095
2108	1.463685	0.009734	2020	1.435559	0.011285
2106	1.463234	0.009423	2018	1.435240	0.011712
2104	1.462565	0.009322	2016	1.434558	0.011400
2102	1.461958	0.009489	2014	1.433410	0.011369
2100	1.461434	0.009450	2012	1.432249	0.011865
2098	1.460834	0.009554	2010	1.431755	0.012529
2096	1.460296	0.009712	2008	1.431153	0.012245
2094	1.459895	0.009932	2006	1.430127	0.012293
2092	1.459529	0.009932	2004	1.429296	0.012853
2090	1.459128	0.009965	2002	1.428795	0.012931
2088	1.458773	0.009972	2000	1.427890	0.012628
2086	1.458350	0.009754	1998	1.426813	0.012916
2084	1.457723	0.009527	1996	1.426052	0.013351
2082	1.456941	0.009487	1994	1.425514	0.013364
2080	1.456306	0.009707	1992	1.424700	0.013139
2078	1.455731	0.009717	1990	1.423526	0.012940
2076	1.455128	0.009779	1988	1.422347	0.013329
2074	1.454517	0.009943	1986	1.421525	0.013700
2072	1.454071	0.010033	1984	1.420775	0.013752
2070	1.453530	0.010010	1982	1.419899	0.013761
2068	1.452710	0.009768	1980	1.418942	0.013816
2066	1.452045	0.010484	1978	1.417856	0.013807
2064	1.451618	0.010431	1976	1.416923	0.014233
2062	1.451338	0.010282	1974	1.416280	0.014399
2060	1.450602	0.010253	1972	1.415437	0.014073
2058	1.450062	0.010325	1970	1.414467	0.014035
2056	1.449455	0.010300	1968	1.413488	0.013962
2054	1.448895	0.010349	1966	1.412306	0.013705
2052	1.448258	0.010193	1964	1.411076	0.013936
2050	1.447468	0.010102	1962	1.410289	0.014355
2048	1.446646	0.010217	1960	1.409886	0.014232
2046	1.445983	0.010384	1958	1.409237	0.013510
2044	1.445278	0.010340	1956	1.408226	0.012721
2042	1.444537	0.010468	1954	1.407043	0.011993
2040	1.443889	0.010611	1952	1.405468	0.010810

Table 8. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1950	1.403344	0.010040	1862	1.288642	0.040633
1948	1.401134	0.009812	1860	1.285734	0.040897
1946	1.399054	0.009706	1858	1.282548	0.041285
1944	1.397213	0.009863	1856	1.279429	0.041561
1942	1.395406	0.009653	1854	1.276222	0.041843
1940	1.393389	0.009440	1852	1.273140	0.041632
1938	1.391316	0.009583	1850	1.269619	0.040900
1936	1.389326	0.009593	1848	1.265627	0.039771
1934	1.387223	0.009683	1846	1.259882	0.037996
1932	1.385376	0.010119	1844	1.254408	0.038948
1930	1.383642	0.010061	1842	1.250332	0.039402
1928	1.381733	0.009858	1840	1.245682	0.036615
1926	1.379667	0.009825	1838	1.239656	0.035031
1924	1.377691	0.009641	1836	1.233657	0.033126
1922	1.375367	0.009151	1834	1.225629	0.028947
1920	1.372821	0.008929	1832	1.215442	0.026432
1918	1.369936	0.008724	1830	1.204090	0.025624
1916	1.367009	0.008900	1828	1.193283	0.025610
1914	1.364371	0.009604	1826	1.182022	0.025945
1912	1.362004	0.009513	1824	1.171029	0.026141
1910	1.359170	0.009352	1822	1.158799	0.026178
1908	1.355849	0.009152	1820	1.146342	0.026398
1906	1.352154	0.009552	1818	1.132447	0.026703
1904	1.348615	0.010597	1816	1.118217	0.026948
1902	1.345601	0.011216	1814	1.102023	0.027429
1900	1.342308	0.011988	1812	1.085312	0.028085
1898	1.338695	0.012768	1810	1.066253	0.029139
1896	1.335357	0.013587	1808	1.046818	0.030598
1894	1.331651	0.014853	1806	1.024526	0.032038
1892	1.327851	0.015921	1804	1.001039	0.033436
1890	1.323881	0.017866	1802	0.972924	0.035474
1888	1.320504	0.020126	1800	0.943533	0.038682
1886	1.317280	0.022111	1798	0.908349	0.042524
1884	1.314192	0.024238	1796	0.873067	0.046795
1882	1.311250	0.026649	1794	0.824703	0.046522
1880	1.308673	0.028714	1792	0.741137	0.036491
1878	1.306092	0.030953	1790	0.649981	0.107070
1876	1.303829	0.032930	1788	0.590447	0.186060
1874	1.301593	0.034906	1786	0.551237	0.266820
1872	1.299581	0.036503	1784	0.521005	0.351190
1870	1.297545	0.038108	1782	0.502058	0.436380
1868	1.295711	0.039173	1780	0.488809	0.521900
1866	1.293659	0.040023	1778	0.486043	0.614460
1864	1.291419	0.040289	1776	0.491918	0.703040

Table 8. Continued

ν, cm^{-1}	n	k
1774	0.504538	0.793420
1772	0.523106	0.885960
1770	0.552427	0.983340
1768	0.595650	1.082100
1766	0.649039	1.174600
1764	0.711919	1.267900
1762	0.794305	1.371200
1760	0.906943	1.461500
1758	1.049115	1.532200
1756	1.203543	1.552500
1754	1.351627	1.538100
1752	1.479045	1.485700
1750	1.574821	1.407800
1748	1.631670	1.320000
1746	1.644160	1.228100
1744	1.608154	1.157400
1742	1.523547	1.126900
1740	1.405468	1.172200
1738	1.287126	1.334200
1736	1.238801	1.629300
1734	1.445720	2.105300
1732	2.038287	2.445300
1730	2.764084	2.267600
1728	3.169884	1.655800
1726	3.193461	1.151300
1724	3.067915	0.841540
1722	2.926185	0.625740
1720	2.794111	0.523070
1718	2.706709	0.451000
1716	2.645454	0.394570
1714	2.605086	0.339380
1712	2.569113	0.274890
1710	2.525435	0.201280
1708	2.468721	0.142430
1706	2.402046	0.084383
1704	2.334302	0.061312
1702	2.277156	0.040263
1700	2.224779	0.027329
1698	2.176767	0.021595
1696	2.135405	0.021238
1694	2.102072	0.025977
1692	2.078529	0.031054
1690	2.060046	0.028919
1688	2.040126	0.023593
1686	2.019632	0.020621
1684	2.000203	0.018355
1682	1.982500	0.016727
1680	1.965755	0.015755
1678	1.950817	0.014863
1676	1.936770	0.014260
1674	1.923969	0.012933
1672	1.911226	0.011942
1670	1.899630	0.011103
1668	1.888072	0.009941
1666	1.877226	0.009180
1664	1.866396	0.008645
1662	1.856677	0.008446
1660	1.846945	0.008077
1658	1.838075	0.007808
1656	1.829124	0.007798
1654	1.821201	0.007701
1652	1.812859	0.007133
1650	1.804959	0.006941
1648	1.796670	0.006804
1646	1.789143	0.006980
1644	1.781025	0.006784
1642	1.773095	0.006962
1640	1.764240	0.007483
1638	1.755678	0.008840
1636	1.745532	0.010558
1634	1.734421	0.014915
1632	1.724692	0.025437
1630	1.723641	0.039790
1628	1.728121	0.046758
1626	1.731707	0.046935
1624	1.732375	0.048534
1622	1.733639	0.048635
1620	1.733484	0.047559
1618	1.732879	0.046993
1616	1.731640	0.046535
1614	1.731343	0.046399
1612	1.730568	0.045174
1610	1.729898	0.043718
1608	1.728072	0.042131
1606	1.726543	0.040877
1604	1.724423	0.039938
1602	1.723073	0.038963
1600	1.720960	0.037808

Table 8. Continued

ν, cm⁻¹	n	k	ν, cm⁻¹	n	k
1598	1.719496	0.037036	1510	1.634102	0.003262
1596	1.717723	0.036250	1508	1.631832	0.003191
1594	1.716538	0.034870	1506	1.630489	0.003178
1592	1.714430	0.033623	1504	1.628317	0.002772
1590	1.712920	0.032504	1502	1.626663	0.002459
1588	1.710469	0.031091	1500	1.624113	0.002424
1586	1.708405	0.030369	1498	1.622537	0.002589
1584	1.706203	0.030375	1496	1.620355	0.002755
1582	1.705430	0.030055	1494	1.618934	0.002621
1580	1.704557	0.029377	1492	1.616597	0.002760
1578	1.704252	0.027488	1490	1.615209	0.002956
1576	1.702742	0.025264	1488	1.613058	0.003053
1574	1.700919	0.022673	1486	1.611702	0.003118
1572	1.697692	0.020748	1484	1.609403	0.003216
1570	1.695402	0.020169	1482	1.607938	0.003433
1568	1.692963	0.018923	1480	1.605684	0.003841
1566	1.690956	0.017615	1478	1.604345	0.004110
1564	1.687966	0.016608	1476	1.602262	0.004736
1562	1.685735	0.016072	1474	1.601047	0.004931
1560	1.683357	0.015918	1472	1.599132	0.005691
1558	1.682123	0.015277	1470	1.598155	0.005901
1556	1.680026	0.014020	1468	1.596226	0.006226
1554	1.678090	0.012796	1466	1.595193	0.006787
1552	1.675100	0.011905	1464	1.593282	0.006952
1550	1.673006	0.011551	1462	1.592293	0.007730
1548	1.670423	0.011295	1460	1.590504	0.008072
1546	1.668792	0.011139	1458	1.589794	0.008356
1544	1.666772	0.010964	1456	1.588537	0.009452
1542	1.665733	0.010471	1454	1.588153	0.009333
1540	1.663680	0.009341	1452	1.586384	0.009391
1538	1.661927	0.008459	1450	1.585839	0.009946
1536	1.659401	0.007965	1448	1.584527	0.009926
1534	1.657666	0.007325	1446	1.583854	0.009592
1532	1.655285	0.007072	1444	1.581981	0.009833
1530	1.653694	0.006476	1442	1.581378	0.010057
1528	1.651231	0.006036	1440	1.580045	0.010313
1526	1.649549	0.005806	1438	1.579696	0.009962
1524	1.647284	0.005592	1436	1.578177	0.009742
1522	1.645918	0.005326	1434	1.577560	0.009310
1520	1.643847	0.004922	1432	1.575690	0.008819
1518	1.642158	0.004106	1430	1.574881	0.008705
1516	1.639757	0.004102	1428	1.573109	0.008245
1514	1.638245	0.003703	1426	1.572054	0.007576
1512	1.635828	0.003284	1424	1.569794	0.007416

Table 8. Continued

ν, cm^{-1}	n	k	ν, cm^{-1}	n	k
1422	1.568672	0.007191	1334	1.419581	0.003816
1420	1.566555	0.007055	1332	1.410737	0.004592
1418	1.565726	0.007043	1330	1.403268	0.004733
1416	1.563627	0.006248	1328	1.392307	0.004855
1414	1.562525	0.006137	1326	1.382080	0.005505
1412	1.560124	0.005341	1324	1.367932	0.006435
1410	1.558542	0.004965	1322	1.354014	0.008784
1408	1.555761	0.004965	1320	1.335462	0.012754
1406	1.554672	0.005159	1318	1.317013	0.020306
1404	1.552277	0.004607	1316	1.295522	0.033280
1402	1.550965	0.004333	1314	1.278386	0.051915
1400	1.548269	0.003926	1312	1.265518	0.076438
1398	1.546602	0.003284	1310	1.264302	0.099460
1396	1.543285	0.003107	1308	1.263605	0.112200
1394	1.541385	0.003182	1306	1.259616	0.119320
1392	1.538049	0.003286	1304	1.247240	0.129670
1390	1.536275	0.003971	1302	1.236552	0.145190
1388	1.533892	0.004912	1300	1.225909	0.162590
1386	1.533536	0.004841	1298	1.218067	0.178510
1384	1.531281	0.003678	1296	1.206672	0.194580
1382	1.529404	0.002306	1294	1.195314	0.212560
1380	1.525598	0.001624	1292	1.182014	0.232100
1378	1.523147	0.001226	1290	1.167611	0.252830
1376	1.519280	0.000925	1288	1.151851	0.273480
1374	1.516961	0.000867	1286	1.121265	0.293700
1372	1.512996	0.000297	1284	1.046817	0.312710
1370	1.510203	0.000100	1282	1.027262	0.483410
1368	1.505830	0.000100	1280	1.077959	0.560590
1366	1.503050	0.000100	1278	1.136493	0.607550
1364	1.498586	0.000100	1276	1.169533	0.654040
1362	1.495634	0.000100	1274	1.215428	0.689820
1360	1.490906	0.000100	1272	1.244755	0.729820
1358	1.487693	0.000100	1270	1.290650	0.770760
1356	1.482623	0.000100	1268	1.329273	0.811390
1354	1.479070	0.000100	1266	1.382752	0.847340
1352	1.473564	0.000100	1264	1.418766	0.882540
1350	1.469564	0.000100	1262	1.494571	0.948100
1348	1.463490	0.000100	1260	1.551210	0.959750
1346	1.458814	0.000100	1258	1.626553	1.011100
1344	1.451603	0.000149	1256	1.692886	1.073100
1342	1.446170	0.001284	1254	1.846693	1.144800
1340	1.439160	0.002342	1252	2.021496	1.203800
1338	1.433940	0.002808	1250	2.310445	1.155400
1336	1.426018	0.003252	1248	2.687009	1.098200

Table 8. Continued

ν, cm^{-1}	n	k
1246	2.760905	0.340720
1244	2.514939	0.236170
1242	2.349536	0.151400
1240	2.271950	0.105250
1238	2.176122	0.089690
1236	2.137226	0.075158
1234	2.080580	0.060380
1232	2.050738	0.051932
1230	2.008978	0.047149
1228	1.989603	0.043413
1226	1.959625	0.040114
1224	1.945904	0.037332
1222	1.922690	0.034758
1220	1.912353	0.031987
1218	1.892795	0.029227
1216	1.884056	0.027689
1214	1.868069	0.026060
1212	1.861322	0.024080
1210	1.847203	0.022340
1208	1.841240	0.021084
1206	1.828956	0.019774
1204	1.823839	0.018656
1202	1.812908	0.017884
1200	1.808489	0.017054
1198	1.799006	0.016922
1196	1.795792	0.016301
1194	1.787318	0.015335
1192	1.784216	0.015090
1190	1.776793	0.014627
1188	1.774509	0.014031
1186	1.767612	0.013134
1184	1.765216	0.012490
1182	1.758860	0.012169
1180	1.756921	0.011395
1178	1.750959	0.010883
1176	1.749141	0.010400
1174	1.743664	0.009829
1172	1.742057	0.009406
1170	1.736873	0.008721
1168	1.735403	0.008432
1166	1.730537	0.007724
1164	1.729008	0.007249
1162	1.724310	0.006999
1160	1.723084	0.006611
1158	1.718722	0.006229
1156	1.717526	0.005834
1154	1.713346	0.005498
1152	1.712107	0.005095
1150	1.708150	0.005060
1148	1.707344	0.004849
1146	1.703632	0.004147
1144	1.702379	0.003828
1142	1.698462	0.003632
1140	1.697757	0.004025
1138	1.694434	0.003284
1136	1.693243	0.002784
1134	1.689548	0.003118
1132	1.688945	0.003209
1130	1.685675	0.002768
1128	1.684454	0.002639
1126	1.681130	0.003300
1124	1.680565	0.003486
1122	1.677545	0.003569
1120	1.676553	0.003989
1118	1.673827	0.005287
1116	1.674591	0.006639
1114	1.673906	0.006549
1112	1.674791	0.005134
1110	1.672736	0.003781
1108	1.672003	0.002184
1106	1.668526	0.001215
1104	1.667334	0.001480
1102	1.664625	0.001419
1100	1.663991	0.001382
1098	1.661946	0.001835
1096	1.661376	0.000606
1094	1.658349	0.000733
1092	1.658304	0.001938
1090	1.656629	0.000576
1088	1.655737	0.000100
1086	1.652984	0.000100
1084	1.652457	0.000242
1082	1.650144	0.000100
1080	1.649608	0.000100
1078	1.647304	0.000100
1076	1.646822	0.000100
1074	1.644570	0.000100
1072	1.644021	0.000100

Table 8. Continued

ν, cm^{-1}	n	k
1070	1.641801	0.000272
1068	1.641353	0.000371
1066	1.639123	0.000447
1064	1.638543	0.000842
1062	1.636935	0.001655
1060	1.637365	0.001627
1058	1.635655	0.000831
1056	1.635210	0.000809
1054	1.633322	0.000563
1052	1.632778	0.000100
1050	1.630506	0.000100
1048	1.629871	0.000100
1046	1.627778	0.000160
1044	1.626999	0.000100
1042	1.624481	0.000315
1040	1.623908	0.001475
1038	1.622557	0.002009
1036	1.622318	0.001826
1034	1.620197	0.002181
1032	1.620219	0.003417
1030	1.619126	0.003242
1028	1.619019	0.003202
1026	1.617335	0.003419
1024	1.617278	0.003600
1022	1.615828	0.003759
1020	1.615697	0.003669
1018	1.614153	0.003947
1016	1.614156	0.004054
1014	1.612857	0.004105
1012	1.612926	0.004018
1010	1.611445	0.003695
1008	1.611259	0.003713
1006	1.610039	0.003761
1004	1.610052	0.003101
1002	1.608384	0.002648
1000	1.607946	0.002316
998	1.606139	0.001893
996	1.605395	0.001555
994	1.603517	0.001647
992	1.602909	0.001335
990	1.600773	0.001108
988	1.599608	0.001436
986	1.597917	0.001623
984	1.597615	0.002175

ν, cm^{-1}	n	k
982	1.596104	0.001815
980	1.594518	0.000851
978	1.591697	0.002556
976	1.591785	0.004327
974	1.591005	0.004077
972	1.590525	0.004160
970	1.588919	0.004777
968	1.588938	0.005336
966	1.587916	0.005403
964	1.587930	0.005322
962	1.586419	0.004920
960	1.585720	0.004877
958	1.584212	0.005485
956	1.584237	0.005519
954	1.582933	0.005195
952	1.582339	0.004934
950	1.580931	0.005210
948	1.580840	0.004858
946	1.578589	0.003539
944	1.576799	0.004259
942	1.575451	0.006094
940	1.576365	0.006253
938	1.575424	0.005021
936	1.574523	0.004376
934	1.573001	0.004605
932	1.572743	0.003768
930	1.569777	0.001991
928	1.567839	0.003711
926	1.567610	0.005636
924	1.568761	0.003476
922	1.565966	0.000744
920	1.563204	0.000990
918	1.560988	0.002327
916	1.560792	0.002120
914	1.559186	0.001429
912	1.557620	0.000100
910	1.554706	0.000100
908	1.553031	0.000100
906	1.550586	0.000100
904	1.549003	0.000100
902	1.546531	0.000100
900	1.544905	0.000100
898	1.542356	0.000100
896	1.540628	0.000100

Table 8. Continued

ν, cm^{-1}	n	k
894	1.537949	0.000100
892	1.536035	0.000100
890	1.532896	0.000100
888	1.530655	0.000785
886	1.528473	0.002032
884	1.527205	0.001424
882	1.524433	0.001245
880	1.522421	0.001023
878	1.518906	0.000129
876	1.515258	0.000139
874	1.511362	0.001693
872	1.508063	0.002297
870	1.505082	0.003411
868	1.502445	0.004809
866	1.499717	0.006166
864	1.497311	0.006486
862	1.493717	0.007495
860	1.491114	0.009244
858	1.489117	0.010971
856	1.487238	0.010505
854	1.484161	0.011023
852	1.481981	0.011733
850	1.479195	0.010721
848	1.475337	0.009760
846	1.470399	0.009877
844	1.465882	0.010660
842	1.462244	0.012236
840	1.459022	0.011715
838	1.453845	0.010191
836	1.447850	0.010999
834	1.442583	0.011939
832	1.437531	0.012095
830	1.431426	0.011469
828	1.423368	0.011180
826	1.415986	0.014012
824	1.409524	0.015781
822	1.402850	0.015690
820	1.394432	0.017280
818	1.385895	0.017400
816	1.376808	0.020735
814	1.366903	0.019698
812	1.355398	0.024281
810	1.345734	0.027229
808	1.335831	0.030186
806	1.325596	0.030736
804	1.311993	0.030634
802	1.296103	0.030184
800	1.275672	0.031734
798	1.256049	0.035634
796	1.229065	0.036287
794	1.196241	0.042019
792	1.158324	0.062518
790	1.128056	0.087216
788	1.096304	0.118880
786	1.080551	0.156960
784	1.066064	0.186000
782	1.077471	0.204090
780	1.030262	0.159220
778	0.846503	0.097661
776	0.715188	0.399190
774	0.755577	0.562360
772	0.831371	0.682910
770	0.895798	0.773770
768	0.956278	0.839620
766	0.984950	0.904020
764	1.090314	1.073100
762	1.202958	1.062700
760	1.287977	1.117600
758	1.385140	1.184600
756	1.535766	1.201200
754	1.653577	1.174600
752	1.771181	1.129700
750	1.843371	1.058800
748	1.875033	0.967510
746	1.838123	0.939750
744	1.827380	0.991020
742	1.850478	1.089200
740	2.030000	1.248200
738	2.247849	1.235800
736	2.558798	1.197000
734	2.913139	1.027700
732	2.927406	0.270190
730	2.632752	0.184480
728	2.462584	0.124730
726	2.382571	0.092489
724	2.294755	0.070682
722	2.244285	0.053178
720	2.185122	0.040943

Table 8. Concluded

ν, cm^{-1}	n	k
718	2.148431	0.034379
716	2.107284	0.027786
714	2.076719	0.022106
712	2.045769	0.021133
710	2.025604	0.021104
708	2.002274	0.019039
706	1.985149	0.017309
704	1.965526	0.018504
702	1.952507	0.017913
700		0.018764