Rate Coefficients for Vibrational Energy Transfer Involving the Hydrogen Halides

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A comprehensive compilation of rate coefficients for vibration-to-vibration (V — V) and vibration-to-translation (V — T) energy transfer processes involving hydrogen halide molecules is presented. The literature has been surveyed from 1966 to July 1981. Rate coefficients are grouped according to room temperature and low and high temperature results. Measured results are identified according to the type of process: V — V, V — T, or the sum of V — V and V — T processes. The method of measurement is identified along with the energy discrepancy, percent error, authors, and year of publication. The results are seen to be in excellent agreement when multiple measurements are available.

Key words: energy transfer; hydrogen halide; molecular relaxation; vibration.

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1. Introduction

The subject of vibrational energy transfer is a mature field of measurement science, in spite of its short history. Detailed measurements began in the late years of the 60's with the introduction of lasers. Before that, shock tube and spectrophone measurements provided the only known vibrational relaxation rates. The hydrogen halides, as a group of molecules, were the subject of intense investigation for vibrational energy transfer rates because of their excellent properties as chemical lasers. The measurements were greatly facilitated by the advent of hydrogen halide lasers which could directly excite the corresponding molecule, and the results of the energy transfer measurements in turn provided the necessary information to enhance the output and efficiency of the lasers.

In the heyday of hydrogen halide laser research, nearly every conceivable measurement method was brought to bear on the study of important energy transfer rates. Thus it is possible to find in the literature a nearly complete set of vibration-to-vibration (V — V) and vibration-to-translation (V — T) energy transfer rates for the hydrogen halides. The rates encompass relaxation not only of the $v = 1$ levels, but often many higher levels from $v = 2$–7. These rates not only are useful for chemical laser research, but they are also needed for other studies involving product state distributions, reaction dynamics, combustion and plasma systems, and atmospheric emissions. Thus it is valuable at this time to collect all of these rates into a single compilation for ready reference.

2. Scope

The compilation contains all measurements involving a hydrogen halide molecule as either the molecule which is relaxed or as the molecule which relaxes vibrational energy in another molecule. The literature was surveyed from 1966 to July 1981, and in the interest of completeness, data contained in material to be published were solicited from the main contributors to the field. References cited in each paper were checked thoroughly for additional measurements.

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Theoretical papers were scanned for tables of experimental values that might have been missed. Technical reports and meeting abstracts were reviewed for unpublished data.

3. Arrangement of Table

The table lists each process under one of the main groupings, HF, HCl, HBr, HI, DF, DCl, DBr or DI. These are ordered alphabetically. The alphabetical rearrangement suggested by the Chemical Abstracts method (FH instead of HF) is not followed. All other molecules are also alphabetized according to their commom chemical formulation (e.g., SF_6 instead of F_6S). The hydrocarbons are ordered according to the method of *Chemical Abstracts*. When the hydrogen halide is the relaxer of another molecule, e.g., $CO(v=1) + HF(v=0) \rightarrow CO(v=0) + HF(v=0)$, the reader is referred to the listing beginning with the other molecule (e.g., CO). Thus the reader can scan just the list of the suitable hydrogen halide in order to determine whether any measurement has been made. The V − V processes are listed first, in order of $v = 1$ and $v = 2$ followed by any V − T processes, in order $v = 1$, $v = 2$, $v = 3$, etc.

3.1. Categorization of Process

Determining the type of process (V − V, V − T, etc.) is perhaps the most difficult task of all. Some general decisions on policy had to be made in order to categorize the table in a simple and consistent way. A review of the measurement scheme is useful to understand the scheme presented in the table. Consider a typical pulsed relaxation measurement of HCl with HBr:

$$\text{V}-\text{V}\quad HCl(v=1)+HBr(v=0) \underset{k'_{V-V}}{\overset{k_{V-V}}{\rightleftarrows}} HCl(v=0) + HBr(v=1)+\Delta E$$

$$\text{V}-\text{T}\quad HCl(v=1)+HBr(v=0) \xrightarrow{k_{HCl-HBr}} HCl(v=0) + HBr(v=0)+\Delta E'$$

$$\text{V}-\text{T}\quad HBr(v=1)+HCl(v=0) \xrightarrow{k_{HBr-HCl}} HBr(v=0) + HCl(v=0)+\Delta E''$$

$$\text{V}-\text{T}\quad HCl(v=1)+HCl(v=0) \xrightarrow{k_{HCl-HCl}} HCl(v=0) + HCl(v=0)+\Delta E'$$

$$\text{V}-\text{T}\quad HBr(v=1)+HBr(v=0) \xrightarrow{k_{HBr-HBr}} HBr(v=0) + HBr(v=0)+\Delta E''$$

First of all, the measurement involves not only a V − V equilibrium, but at least four other V − T processes. In many cases the relaxation with a buffer gas is also included and may be extracted as well. The general solution to such a kinetic scheme is discussed thoroughly in ref. 62 of the compilation. If the V − V rate is rapid enough to be separable from all the V − T processes, then a measurement of the sum of the forward and reverse V − V rate constants is obtained: $k_{V-V} + k'_{V-V}$. This result taken together with detailed balancing, $k_{V-V}/k'_{V-V} = e^{\Delta E/kT}$, allows k_{V-V} to be determined. As written, the value of k_{V-V} is for the forward, exothermic direction (positive ΔE). For pure V − V processes, the exothermic direction is given in the table. Often, however, the V − T processes are not slow enough to separate the V − V process, and the reported V − V rate constant (k_{V-V}) is contaminated with one or more of the V − T rate constants. In the table, if a process is listed as pure V − V, the measurement was judged to have obtained just the V − V component. In many cases the maximum extent of V − T contamination is listed. If the V − V and V − T processes are too fully merged to be separable, or if not enough information is given, the process is listed as the sum of V − V and V − T. If the V − T contribution is properly extracted for a particular process, it is listed as pure V − T. The relaxation of hydrogen halides with polyatomic molecules, when no V − V equilibrium is observed and when the state of the polyatomic is uncertain, is listed as V − V and V − T. Relaxation of polyatomic molecules where the energy is degraded among the modes of the polyatomic are listed as V − T. There is general agreement that relaxation of the $v = 2$ state of a hydrogen halide involves a clear V − V equilibrium. However, relaxation of $v = 3$ and higher levels of the hydrogen halides may contain substantial V − T contributions. Thus, the V − V relaxation of $HF(v=2)$ by HF is listed as a V − V process in the exothermic direction as $HF(v=1) + HF(v=1) \rightarrow HF(v=2) + HF(v=0) + \Delta E$, but the relaxation of $HF(v=3)$ and higher levels is listed in the endothermic direction as $HF(v=3) + HF(v=0) \rightarrow HF(v=2) + HF(v=1) + \Delta E$. This allows for the possibility that a substantial V − T contribution may exist in the observed rate and for the fact that in almost all cases the process is actually measured in the endothermic direction. In some cases, the relaxation is accompanied by reaction, reactive exchange, or electronic-to-vibrational E − V transfer. These are so noted in the table.

3.2. Explanation of Rate Coefficients

The rate coefficients are listed along with any special remarks pertaining to method or the quantity reported. Because of the kinetic complexity, very often only upper limits can be prescribed. Usually, the lower values of a rate coefficient for a V − T process are more reliable, since any impurities tend to increase the rate. The agreement between several measurements is frequently excellent. No attempt has been made to choose a best value. However, when a value is believed to be seriously in error, or when a series of values have relative significance even though the absolute values are in doubt, that fact is indicated by a note below the entry. The reader unfamiliar with the field should note that clean, single-state, laser fluorescence results are often the best. However, many recent flow tube measurements are of excellent quality.

The values for room temperature are listed first in chronological order, so that comparisons and the most recent measurements may be quickly discerned. Following the room temperature results, low and high temperature experiments are listed in order of increasing temperature. Rate coefficients are only given for the two extremes of the temperature, and where applicable a note about the position of a minimum or maximum in the rate is stated. Three significant figures are only listed when warranted by very small quoted errors. Two significant figures with the usual round-up and round-down at >0.05 or <0.05 is the norm.

3.3. Error Quotations

The errors tabulated are taken from the authors' own statements or when possible from the scatter in the data presented. These are quoted in multiples of 5%, following the prescription that errors of 7, 8, 9, 10, and 11% are listed as 10% and errors of 12, 13, 14, 15, and 16% are listed as 15%, etc. Very small errors are listed as 1%, 2%, 3%, etc. Typically the errors represent one standard deviation from the mean. In many cases, the authors have not stated their method of quoting errors. In a very few cases, the error represents two standard deviations from the mean.

3.4. Energy Discrepancy

The energy difference ΔE is listed in cm^{-1}. The reader may find the value of ΔE useful to calculate the rate constant for the endothermic V − V process by detailed balancing, or to obtain a feeling for the amount of energy deposited into rotation and translation. Sometimes, in cases where both V − V and V − T processes contribute significantly, both values of the energy discrepancies are given. In some cases where several final vibrational states are accessible, the energy discrepancy for each particular state is noted. In cases where final vibrational and/or rotational states have not been precisely determined, ΔE is still listed for the ground state energy difference. This "nominal" energy difference is a useful piece of information, but must be used with extreme caution when considering reverse processes that might be calculated by detailed balancing. The correct final vibrational and rotational states must be known for the forward process in order to successfully apply detailed balancing. The reader unfamiliar with the V − V and V − T literature should not attempt to apply such reversibility criteria without finding out from the original literature whether the final states have been defined. Ordinarily ΔE is listed in the exothermic (positive) direction. A minus sign is used when a process is endothermic as written. The endothermic direction is listed when the experimental measurement was made in the endothermic direction and it is not possible to ascertain the final states in order to apply detailed balancing.

3.5. Temperature Ranges

All measurements near room temperature are grouped together first, followed by other temperature range experiments listed from low to high temperatures. The end points of the investigated temperature range are given. A value of 295 K is chosen for all room temperature measurements where the actual temperature was not specified. In a few cases, chronologically earlier measurements at 350 K are listed after the full list of room temperature values and might appear out of place. However, 350 K was deemed sufficiently different from 295 K to warrant its inclusion as a high temperature result.

3.6. Code of Experimental Techniques

The code to the experimental techniques is:

CB	crossed beam
CD	chemiluminescence depletion
DR	double resonance
DR-LF	double resonance-laser fluorescence
FP	flash photolysis
FR	flow reactor
FT	flow tube
LF	laser fluorescence
LF-DF	laser fluorescence-discharge flow
LF-MS	laser fluorescence-mass spectrometer
LF-ST	laser fluorescence-shock tube
LG	laser gain
SP	spectrophone
ST	shock tube

Laser fluorescence (LF) typically involves a direct laser excitation followed by time-resolved infrared fluorescence. In several experiments, especially for reactive atom deactivation, the laser fluorescence method is actually coupled with a discharge flow tube to make the measurement (LF-DF). Flow tube measurements (FT) typically involve a chemical reaction which generates vibrationally excited molecules and then the measurement of fluorescence quenching using the time axis of the flow tube. In some of the experiments, a well-developed laminar-profile flow tube was not used, but rather a flow reactor chamber was employed (FR). The combination of a shock-heated gas with laser-fluorescence, time-resolved decay measurements results in the LF-ST method. The laser gain method (LG) often involves extensive modeling of a laser output and not necessarily specific time-to-threshold measurements. Double resonance (DR) indicates the use of two lasers in conjunction, either in a pulse-probe experiment, or a pulsed production of some reaction species. Other special qualifications are frequently described in the table under individual listings.

3.7. Method of Literature Citation

The reference number, author, or first and last author, and date of the publication are given in the table. The complete citation is given in the bibliography at the end. Many groups have developed significant measurement skills and were frequently involved in many of the important measurements. The reader can quickly assess which values were obtained by each of several different groups without referring to the complete bibliography.

4. Reliability of Methods

As a technique, the laser fluorescence method has proven to be the most reliable and accurate. However, flow tube and double resonance methods also give excellent, accurate results. The methods with the greatest uncertainty appear to be laser gain, spectrophone, flash photolysis, shock tube studies and improperly done flow tube (flow reactor) measurements. Chemiluminescence depletion has typically only achieved relative rate coefficients. The combined methods, for example, laser fluorescence-discharge flow, are obviously more difficult technically, and thus have greater uncertainties introduced by the measurement of reactive atom densities. Thus, while the time decay signals are as reliable as any laser fluorescence experiment, the uncertainties due to gas purities and density measurements are greater in the discharge flow.

5. Current State of the Field

It can be readily seen from the scope of table 1 that skills are now highly developed for measurements involving hydrogen halide vibrational energy transfer. Rate coefficients can be obtained to within a few percent precision. The major difficulties and uncertainties are still associated with more mundane aspects of pressure measurement and gas sample purity. Extremely straight-forward methods exist to directly excite and probe higher vibrational levels. HF and HCl have been the most extensively studied, with far fewer measurements on HBr and HI. HI will perhaps always remain very difficult to study because of its weak transition moment. HF and HCl have captivated researchers because of the very qualities which make them good laser candidates: their slow vibrational deactivation, high oscillator strength, and ease of chemical formation with concomitant vibrational excitation.

Overall, the field of vibrational energy transfer has rapidly blossomed and is very mature. However, a number of major questions still exist. Experimentalists still need to resolve the extent of V — V transfer versus V — T transfer in the deactivation of high vibrational levels of the hydrogen halides. Further work needs to be done on direct two-quantum V — V transfers $(2+0 \rightarrow 0+2)$, where precise energy resonance is expected to be extremely important. The exact nature of the deactivation of HF to high rotational levels, which creates a seeming V↔R equilibrium, will require further investigation. There is now tremendous impetus for theoretical description. Experiments in this field developed rapidly. Now there are many excellent theoretical studies being done. These will undoubtedly stimulate more detailed experiments, for which elegant tools of investigation are already available.

6. Acknowledgments

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Table 1. Rate coefficients for vibrational energy transfer involving the hydrogen halides

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$BC\ell_3(\nu_4) + DC\ell(v=0) \rightarrow BC\ell_3(0) + DC\ell(v=0)$	V-T	5.1×10^{-12}		243	295	DR	111 Houston...Steinfeld 1973
		May be near resonant V-R transfer					
$BC\ell_3(\nu_4) + HC\ell(v=0) \rightarrow BC\ell_3(0) + HC\ell(v=0)$	V-T	8.2×10^{-12}		243	295	DR	111 Houston...Steinfeld 1973
		May be near resonant V-R transfer					
		3.4×10^{-12}		243	300	DR	87 Frankel...Poulsen 1974
		7.3×10^{-12} 3.6×10^{-12}		243	220-340	DR	87 Frankel...Poulsen 1974
$CD_4(\nu_4) + DC\ell(v=0) \rightarrow CD_4(0) + DC\ell(v=0)$	V-T	6.3×10^{-14}	±15	996	295	LF	176 Zittel and Moore 1973
$CD_4(\nu_4) + HC\ell(v=0) \rightarrow CD_4(0) + HC\ell(v=0)$	V-T	4.2×10^{-13}	±20	996	295	LF	176 Zittel and Moore 1973
$CH_4(\nu_4) + DC\ell(v=0) \rightarrow CH_4(0) + DC\ell(v=0)$	V-T	3.9×10^{-14}	±25	1306	295	LF	176 Zittel and Moore 1973
$CH_4(\nu_4) + HC\ell(v=0) \rightarrow CH_4(0) + HC\ell(v=0)$	V-T	2.0×10^{-13}	±15	1306	295	LF	176 Zittel and Moore 1973
$C\ell_2(v=1) + HC\ell(v=0) \rightarrow C\ell_2(v=0) + HC\ell(v=0)$	V-T	2.7×10^{-12} 6.5×10^{-12}	±25	595	400-1100	ST	48 Breshears and Bird 1969
$C\ell_2(v=1) + DC\ell(v=0) \rightarrow C\ell_2(v=0) + DC\ell(v=0)$	V-T	4.2×10^{-13} 2.5×10^{-12}	±25	595	400-1100	ST	48 Breshears and Bird 1969
$CO(v=1) + DBr(v=0) \rightarrow CO(v=0) + DBr(v=1)$	V-V	1.25×10^{-13}	±10	303	295	LF	177 Zittel and Moore 1973
$CO(v=4) + DBr(v=0) \rightarrow CO(v=3) + DBr(v=1)$	V-V & V-T	8.8×10^{-13}		224	298	FR	46 Braithwaite and Smith 1975
$CO(v=5) + DBr(v=0) \rightarrow CO(v=4) + DBr(v=1)$	V-V & V-T	1.7×10^{-12}		198	298	FR	46 Braithwaite and Smith 1975
$CO(v=6) + DBr(v=0) \rightarrow CO(v=5) + DBr(v=1)$	V-V & V-T	2.4×10^{-12}		172	298	FR	46 Braithwaite and Smith 1975
$CO(v=7) + DBr(v=0) \rightarrow CO(v=6) + DBr(v=1)$	V-V & V-T	3.1×10^{-12}		145	298	FR	46 Braithwaite and Smith 1975
$CO(v=8) + DBr(v=0) \rightarrow CO(v=7) + DBr(v=1)$	V-V & V-T	5.0×10^{-12}		119	298	FR	46 Braithwaite and Smith 1975
$CO(v=9) + DBr(v=0) \rightarrow CO(v=8) + DBr(v=1)$	V-V & V-T	8.2×10^{-12}		94	298	FR	46 Braithwaite and Smith 1975
$CO(v=10) + DBr(v=0) \rightarrow CO(v=9) + DBr(v=1)$	V-V & V-T	1.0×10^{-11}		67	298	FR	46 Braithwaite and Smith 1975
$CO(v=11) + DBr(v=0) \rightarrow CO(v=10) + DBr(v=1)$	V-V & V-T	1.4×10^{-11}		42	298	FR	46 Braithwaite and Smith 1975
$CO(v=12) + DBr(v=0) \rightarrow CO(v=11) + DBr(v=1)$	V-V & V-T	1.7×10^{-11}		16	298	FR	46 Braithwaite and Smith 1975
		The rate constants in Ref. 46 are internally consistent, but their absolute magnitudes may be in error					
$CO(v=1) + DC\ell(v=0) \rightarrow CO(v=0) + DC\ell(v=1)$	V-V	1.45×10^{-12}	±10	52	295	LF	177 Zittel and Moore 1973
		V-T contribution is less than 0.5%					
$^{13}CO(v=1) + DC\ell(v=0) \rightarrow {}^{13}CO(v=0) + DC\ell(v=1)$	V-V	2.1×10^{-12}	±10	5	295	LF	177 Zittel and Moore 1973
$CO(v=2) + DC\ell(v=0) \rightarrow CO(v=1) + DC\ell(v=1)$	V-V	3.7×10^{-12}	±10	26	295	LF	73 Dasch and Moore 1980
		Direct excitation to CO(v=2)					
$CO(v=4) + DC\ell(v=0) \rightarrow CO(v=3) + DC\ell(v=1)$	V-V & V-T	6.3×10^{-12}		-27	298	FR	46 Braithwaite and Smith 1975
$CO(v=5) + DC\ell(v=0) \rightarrow CO(v=4) + DC\ell(v=1)$	V-V & V-T	7.5×10^{-12}		-53	298	FR	46 Braithwaite and Smith 1975
$CO(v=6) + DC\ell(v=0) \rightarrow CO(v=5) + DC\ell(v=1)$	V-V & V-T	6.8×10^{-12}		-79	298	FR	46 Braithwaite and Smith 1975
$CO(v=7) + DC\ell(v=0) \rightarrow CO(v=6) + DC\ell(v=1)$	V-V & V-T	8.1×10^{-12}		-106	298	FR	46 Braithwaite and Smith 1975
$CO(v=8) + DC\ell(v=0) \rightarrow CO(v=7) + DC\ell(v=1)$	V-V & V-T	7.4×10^{-12}		-132	298	FR	46 Braithwaite and Smith 1975
$CO(v=9) + DC\ell(v=0) \rightarrow CO(v=8) + DC\ell(v=1)$	V-V & V-T	6.6×10^{-12}		-157	298	FR	46 Braithwaite and Smith 1975
$CO(v=10) + DC\ell(v=0) \rightarrow CO(v=9) + DC\ell(v=1)$	V-V & V-T	5.4×10^{-12}		-184	298	FR	46 Braithwaite and Smith 1975
$CO(v=11) + DC\ell(v=0) \rightarrow CO(v=10) + DC\ell(v=1)$	V-V & V-T	3.9×10^{-12}		-209	298	FR	46 Braithwaite and Smith 1975
$CO(v=12) + DC\ell(v=0) \rightarrow CO(v=11) + DC\ell(v=1)$	V-V & V-T	3.3×10^{-12}		-235	298	FR	46 Braithwaite and Smith 1975
		The rate constants in Ref. 46 are internally consistent, but their absolute magnitudes may be in error					
$CO(v=1) + DI(v=0) \rightarrow CO(v=0) + DI(v=1)$	V-V	7.4×10^{-15}	±15	548	295	LF	177 Zittel and Moore 1973
		V-T contribution is less than 10%					
$CO(v=1) + HBr(v=0) \rightarrow CO(v=0) + HBr(v=0)$	V-T	$<6.8 \times 10^{-16}$		2143	296	LF	61 Chen 1971
$CO(v=4) + HBr(v=0) \rightarrow CO(v=3) + HBr(v=0)$	V-T	5.3×10^{-14}		2064	298	FR	46 Braithwaite and Smith 1975
$CO(v=5) + HBr(v=0) \rightarrow CO(v=4) + HBr(v=0)$	V-T	6.8×10^{-14}		2038	298	FR	46 Braithwaite and Smith 1975

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
CO(v=6) + HBr(v=0) → CO(v=5) + HBr(v=0)	V-T	1.2×10^{-13}		2012	298	FR	46 Braithwaite and Smith 1975
CO(v=7) + HBr(v=0) → CO(v=6) + HBr(v=0)	V-T	1.5×10^{-13}		1985	298	FR	46 Braithwaite and Smith 1975
CO(v=8) + HBr(v=0) → CO(v=7) + HBr(v=0)	V-T	2.7×10^{-13}		1959	298	FR	46 Braithwaite and Smith 1975
CO(v=9) + HBr(v=0) → CO(v=8) + HBr(v=0)	V-T	3.5×10^{-13}		1934	298	FR	46 Braithwaite and Smith 1975
CO(v=10) + HBr(v=0) → CO(v=9) + HBr(v=0)	V-T	5.0×10^{-13}		1907	298	FR	46 Braithwaite and Smith 1975
CO(v=11) + HBr(v=0) → CO(v=10) + HBr(v=0)	V-T	6.6×10^{-13}		1882	298	FR	46 Braithwaite and Smith 1975
CO(v=12) + HBr(v=0) → CO(v=11) + HBr(v=0)	V-T	8.2×10^{-13}		1856	298	FR	46 Braithwaite and Smith 1975
		The rate constants in Ref. 46 are internally consistent, but their absolute magnitudes may be in error					
CO(v=4) + HCℓ(v=0) → CO(v=3) + HCℓ(v=0)	V-T	2.0×10^{-14}		2064	298	FR	46 Braithwaite and Smith 1975
CO(v=5) + HCℓ(v=0) → CO(v=4) + HCℓ(v=0)	V-T	2.8×10^{-14}		2038	298	FR	46 Braithwaite and Smith 1975
CO(v=6) + HCℓ(v=0) → CO(v=5) + HCℓ(v=0)	V-T	3.9×10^{-14}		2012	298	FR	46 Braithwaite and Smith 1975
CO(v=7) + HCℓ(v=0) → CO(v=6) + HCℓ(v=0)	V-T	3.8×10^{-14}		1985	298	FR	46 Braithwaite and Smith 1975
CO(v=8) + HCℓ(v=0) → CO(v=7) + HCℓ(v=0)	V-T	4.7×10^{-14}		1959	298	FR	46 Braithwaite and Smith 1975
CO(v=9) + HCℓ(v=0) → CO(v=8) + HCℓ(v=0)	V-T	5.6×10^{-14}		1934	298	FR	46 Braithwaite and Smith 1975
CO(v=10) + HCℓ(v=0) → CO(v=9) + HCℓ(v=0)	V-T	6.9×10^{-14}		1907	298	FR	46 Braithwaite and Smith 1975
CO(v=11) + HCℓ(v=0) → CO(v=10) + HCℓ(v=0)	V-T	6.8×10^{-14}		1882	298	FR	46 Braithwaite and Smith 1975
CO(v=12) + HCℓ(v=0) → CO(v=11) + HCℓ(v=0)	V-T	9×10^{-14}		1856	298	FR	46 Braithwaite and Smith 1975
		The rate constants in Ref. 46 are internally consistent, but their absolute magnitudes may be in error					
CO(v=1) + HF(v=0) → CO(v=0) + HF(v=0)	V-T	9.3×10^{-15}	±35	2143	295	LF	37 Bott and Cohen 1973
	V-T	1.5×10^{-14}	±5	2143	295	LF	92 Green and Hancock 1973
CO_2(001) + DBr(v=0) → CO_2(000) + DBr(v=1)	V-V	2.84×10^{-13}	±1	540	295	LF	167 Stephenson...Moore 1972
CO_2(001) + DBr(v=0) → CO_2(nm0) + DBr(v=0)	V-T	$<2.8 \times 10^{-14}$		2349	295	LF	167 Stephenson...Moore 1972
CO_2(001) + DCℓ(v=0) → CO_2(000) + DCℓ(v=1)	V-V	3.1×10^{-12}	±5	258	295	LF	167 Stephenson...Moore 1972
		3.1×10^{-12} 2.9×10^{-12}	±5	258	295-510	LF	167 Stephenson...Moore 1972
CO_2(001) + DCℓ(v=0) → CO_2(nm0) + DCℓ(v=0)	V-T	$<1.4 \times 10^{-13}$		2349	295	LF	167 Stephenson...Moore 1972
CO_2(001) + DF(v=0) → CO_2(nm0) + DF(v=0)	V-T	7.3×10^{-13}	±10	2349	295	LF	38 Bott and Cohen 1973
		8.0×10^{-13}	±20	2349	295	LF	127 Lucht and Cool 1974
		4.6×10^{-13}		2349	295	LF	102 Hinchen and Hobbs 1975
		6.8×10^{-13}	±20	2349	350	LF	166 Stephens and Cool 1972
		6.7×10^{-13} 8.3×10^{-13}		2349	348-373	LF	58 Chang and Wolga 1972
		5.1×10^{-13}	±10	2349	470	LF-ST	38 Bott and Cohen 1973
		8.0×10^{-13} 5.5×10^{-13}	±20	2349	295-670	LF	127 Lucht and Cool 1974
CO_2(001) + DI(v=0) → CO_2(000) + DI(v=1)	V-V & V-T	3.7×10^{-14}	±10	737 70(010)	295	LF	167 Stephenson...Moore 1972
CO_2(001) + HBr(v=0) → CO_2(nm0) + HBr(v=0)	V-T	$<7.4 \times 10^{-14}$		2349	295	LF	167 Stephenson...Moore 1972
CO_2(001) + HCℓ(v=0) → CO_2(nm0) + HCℓ(v=0)	V-T	1.3×10^{-13}	±20	2349	295	LF	167 Stephenson...Moore 1972
		1.5×10^{-13}		2349	295	SP	161 Slobodskaya and Rityn 1975
		Rate contains small V-T contribution of HCℓ(v=1) with CO_2					
		1.1×10^{-13}		2349	295	LF	80 Doyennette...Henry 1978
		1.1×10^{-13} 4.9×10^{-13}		2349	295-900	LF	80 Doyennette...Henry 1978
CO_2(010) + HCℓ(v=0) → CO_2(000) + HCℓ(v=0)	V-T	2.9×10^{-12}		667	295	SP	161 Slobodskaya and Rityn 1975

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$CO_2(001) + HF(v=0) \rightarrow CO_2(nm0) + HF(v=0)$	V-T	1.63×10^{-12}	±5	2349	294	LF	94,95 Hancock and Green 1972
		1.05×10^{-12}	±10	2349	295	LF	37 Bott and Cohen 1973
		1.5×10^{-12}	±20	2349	295	LF	127 Lucht and Cool 1974
		1.5×10^{-12} 9.0×10^{-13}	±20	2349	205-358	LF	129 Lucht and Cool 1974
		1.3×10^{-12}	±10	2349	350	LF	166 Stephens and Cool 1972
		8.2×10^{-13} 8.5×10^{-13}		2349	348-373	LF	58 Chang...Wolga 1972
		1.5×10^{-12} 5.1×10^{-13}	±20	2349	295-700	LF	127 Lucht and Cool 1974
$CO_2(001) + HI(v=0) \rightarrow CO_2(000) + HI(v=1)$	V-V	6.8×10^{-12}	±5	116	295	LF	64 Chen...Moore 1968
$CO_2(001) + HI(v=0) \rightarrow CO_2(nm0) + HI(v=0)$	V-T	$<7.1 \times 10^{-14}$		2349	295	LF	167 Stephenson...Moore 1972
$DBr(v=1) + Br \rightarrow DBr(v=0) + Br$	V-T	4.1×10^{-12}	±20	1840	295	LF-DF	85 Fernando and Smith 1979
DBr + CO, see CO + DBr							
$DBr(v=1) + CO_2(000) \rightarrow DBr(v=0) + CO_2(nmo)$	V-T	3.4×10^{-14}	±20	1840	295	LF	167 Stephenson...Moore 1972
DBr + CO_2, see also CO_2 + DBr							
$D^{79}Br(v=1) + D^{81}Br(v=0) \rightarrow D^{79}Br(v=0) + D^{81}Br(v=1)$	V-V	8.34×10^{-12}	±2	0.6	295	LF	109 Horwitz and Leone 1978
$DBr(v=1) + DBr(v=0) \rightarrow DBr(v=0) + DBr(v=0)$	V-T	5.2×10^{-15}	±20	1840	295	LF	65 Chen and Chen 1972
		2.4×10^{-14} 7.3×10^{-13}		1840	700-2000	ST	49 Breshears and Bird 1970
$DBr(v=1) + DF(v=0) \rightarrow DBr(v=0) + DF(v=0)$	V-T	7.1×10^{-13}	±30	1840	295	LF	26 Bott 1974
DBr + DF, see also DF + DBr							
$DBr(v=1) + HBr(v=0) \rightarrow DBr(v=0) + HBr(v=0)$	V-T	1.1×10^{-14}	±20	1840	295	LF	65 Chen and Chen 1972
DBr + HBr, see also HBr + DBr							
DBr + HCN, see HCN + DBr							
DBr + H_2, see H_2 + DBr							
$DBr(v=1) + O_2(v=0) \rightarrow DBr(v=0) + O_2(v=1)$	V-V	1.9×10^{-13}	±15	284	295	LF	85 Fernando and Smith 1979
$DC\ell(v=1) + Ar \rightarrow DC\ell(v=0) + Ar$	V-T	$<9.3 \times 10^{-18}$		2091	295	LF	177 Zittel and Moore 1973
		1.9×10^{-18}	±35	2091	295	LF	165 Steele and Moore 1974
		1.9×10^{-18} 9.6×10^{-17}	±35	2091	295-640	LF	165 Steele and Moore 1974
$DC\ell + BC\ell_3$, see $BC\ell_3 + DC\ell$							
$DC\ell(v=1) + Br \rightarrow DC\ell(v=0) + Br$	V-T	9.4×10^{-13}	±20	2091	296	LF-DF	54 Brown...Van der Merwe 1976
		2.3×10^{-13}	±30	2091	294	LF-DF	130 Macdonald and Moore 1976
		The authors state that results in Ref. 54 may be in error					
$DC\ell(v=1) + CD_4 \rightarrow DC\ell(v=0) + CD_4^{\dagger}$	V-V & V-T	1.5×10^{-12}	±10	$-17(\nu_2)$ $-168(\nu_3)$ $7(\nu_2+\nu_4)$	295	LF	176 Zittel and Moore 1973
$DC\ell + CD_4$, see also $CD_4 + DC\ell$							
$DC\ell(v=1) + CH_4 \rightarrow DC\ell(v=0) + CH_4^{\dagger}$	V-V & V-T	8.6×10^{-13}	±10	$558(\nu_3)$ $785(\nu_4)$	295	LF	176 Zittel and Moore 1973
$DC\ell + CH_4$, see also $CH_4 + DC\ell$							
$DC\ell(v=1) + C\ell \rightarrow DC\ell(v=0) + C\ell$	V-T	$\sim 5.3 \times 10^{-12}$ Preliminary estimate		2091	295	LF-DF	52 Brown...Smith 1975
		6.4×10^{-12}	±25	2091	295	LF-DF	53 Brown...Smith 1975
		5.5×10^{-12}	±30	2091	294	LF-DF	130 Macdonald and Moore 1976

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$DC\ell(v=1) + C\ell \rightarrow DC\ell(v=0) + C\ell$ (cont'd.)		$\sim 4.0 \times 10^{-12}$ $\sim 9 \times 10^{-12}$		2091	263- 397	LF-DF	52 Brown...Smith 1975
		Preliminary estimate					
		3.1×10^{-12} 6.3×10^{-12}	±25	2091	195- 325	LF-DF	53 Brown...Smith 1975
$DC\ell + C\ell_2$, see $C\ell_2 + DC\ell$							
$DC\ell(v=1) + CO(v=1) \rightarrow DC\ell(v=2) + CO(v=0)$	V-V	2.3×10^{-12}	±10	106	295	LF	73 Dasch and Moore 1980
		Direct excitation to $DC\ell(v=2)$, V-T contribution is less than 10%					
$DC\ell(v=1) + CO(v=0) \rightarrow DC\ell(v=0) + CO(v=0)$	V-T	1.5×10^{-13} 5.4×10^{-13}	±5	2091	1350- 1850	ST	22 Borrell...Gutteridge 1974
$DC\ell + CO$, see also $CO + DC\ell$							
$DC\ell(v=1) + CO_2(000) \rightarrow DC\ell(v=0) + CO_2(nm0)$	V-T	$<3.9 \times 10^{-14}$		2091	295	LF	167 Stephenson...Moore 1972
$DC\ell + CO_2$, see also $CO_2 + DC\ell$							
$DC\ell(v=1) + D \rightarrow DC\ell(v=0) + D$	V-T & Rx	2.0×10^{-12}	±35	2091	295	LF-DF	41 Bott and Heidner 1976
$DC\ell(v=1) + DBr(v=0) \rightarrow DC\ell(v=0) + DBr(v=1)$	V-V	4.8×10^{-13}	±10	251	295	LF	177 Zittel and Moore 1973
		V-T contribution is less than 6%					
$DC\ell(v=1) + DC\ell(v=1) \rightarrow DC\ell(v=2) + DC\ell(v=0)$	V-V	4.3×10^{-12}	±10	54	295	LF	73 Dasch and Moore 1980
		Direct excitation to $DC\ell(v=2)$, V-T contribution is less than 1%					
$D^{35}C\ell(v=1) + D^{37}C\ell(v=0) \rightarrow D^{35}C\ell(v=0) + D^{37}C\ell(v=1)$	V-V	1.18×10^{-11}	±10	3	295	LF	109 Horwitz and Leone 1978
$DC\ell(v=1) + DC\ell(v=0) \rightarrow DC\ell(v=0) + DC\ell(v=0)$	V-T	7.7×10^{-15}	$^{+10}_{-35}$	2091	295	LF	62 Chen and Moore 1971
		6.8×10^{-15}	±10	2091	295	LF	177 Zittel and Moore 1973
		3.2×10^{-14} 9.5×10^{-13}	±30	2091	700- 2100	ST	47 Breshears and Bird 1969
$DC\ell(v=1) + D_2(v=0) \rightarrow DC\ell(v=0) + D_2(v=0)$	V-T	1.8×10^{-15}	±10	2091	295	LF	177 Zittel and Moore 1973
		No V-V component observed					
$DC\ell(v=1) + DI(v=0) \rightarrow DC\ell(v=0) + DI(v=1)$	V-V	5.5×10^{-14}	±10	496	295	LF	177 Zittel and Moore 1973
		V-T contribution is less than 12%					
$DC\ell(v=1) + H \rightarrow DC\ell(v=0) + H$	V-T & Rx & Exchange	1.8×10^{-12}	±30	2091	295	LF-DF	41 Bott and Heidner 1976
$DC\ell(v=1) + HC\ell(v=0) \rightarrow DC\ell(v=0) + HC\ell(v=0)$	V-T	1.8×10^{-14}	±10	2091	295	LF	62 Chen and Moore 1971
$DC\ell + HC\ell$, see also $HC\ell + DC\ell$							
$DC\ell + HCN$, see $HCN + DC\ell$							
$DC\ell(v=1) + HD(v=0) \rightarrow DC\ell(v=0) + HD(v=0)$	V-T	8.3×10^{-15}	±10	2091	295	LF	177 Zittel and Moore 1973
		No V-V component observed					
$DC\ell(v=1) + {}^3He \rightarrow DC\ell(v=0) + {}^3He$	V-T	2.2×10^{-16}	$^{+15}_{-20}$	2091	295	LF	165 Steele and Moore 1974
$DC\ell(v=1) + He \rightarrow DC\ell(v=0) + He$	V-T	$<6.2 \times 10^{-17}$		2091	295	LF	177 Zittel and Moore 1973
		5.9×10^{-17}	±10	2091	295	LF	165 Steele and Moore 1974
		5.9×10^{-17} 2.6×10^{-15}	±10	2091	295- 680	LF	165 Steele and Moore 1974
$DC\ell(v=1) + n\text{-}H_2(v=0) \rightarrow DC\ell(v=0) + n\text{-}H_2(v=0)$	V-T	2.1×10^{-14}	±10	2091	295	LF	177 Zittel and Moore 1973
$DC\ell(v=1) + p\text{-}H_2(v=0) \rightarrow DC\ell(v=0) + p\text{-}H_2(v=0)$	V-T	2.0×10^{-14}	±10	2091	295	LF	177 Zittel and Moore 1973
$DC\ell + H_2$, see also $H_2 + DC\ell$							
$DC\ell(v=1) + Ne \rightarrow DC\ell(v=0) + Ne$		$<1.9 \times 10^{-17}$		2091	295	LF	177 Zittel and Moore 1973
		1.0×10^{-17}	±15	2091	295	LF	165 Steele and Moore 1974
$DC\ell + N_2$, see $N_2 + DC\ell$							
$DC\ell(v=1) + NO(v=0) \rightarrow DC\ell(v=0) + NO(v=1)$	V-V	1.0×10^{-12}	±15	215	295	LF	177 Zittel and Moore 1973
$DC\ell(v=1) + O \rightarrow DC\ell(v=0) + O$	V-T & Rx	1.3×10^{-12}	±40	2091	295	LF-DF	55 Brown...Smith 1975

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$DC\ell(v=1) + O \rightarrow DC\ell(v=0) + O$ (cont'd.)		8.1×10^{-13} 1.6×10^{-12}	±40	2091	196-400	LF-DF	55 Brown...Smith 1975
$DC\ell(v=1) + O_2(v=0) \rightarrow DC\ell(v=0) + O_2(v=1)$	V-V	1.9×10^{-14}	±10	535	295	LF	177 Zittel and Moore 1973
		V-T contribution is less than 1%					
$DC\ell(v=1) + SF_6 \rightarrow DC\ell(v=0) + SF_6$†	V-V & V-T	1.1×10^{-14}	±10	2091 $1126(\nu_3)$	295	LF	177 Zittel and Moore 1973
$D_2(v=1) + DF(v=0) \rightarrow D_2(v=0) + DF(v=1)$	V-V	9.3×10^{-13}	±20	83	295	LF	100 Hinchen 1973
		8.6×10^{-13}	±10	83	295	LF	26 Bott 1974
		6.2×10^{-13}	±40	83	298	FT	122 Kwok and Wilkins 1975
		9.6×10^{-13}		83	295	LF	32 Bott 1979
		1.0×10^{-12} 9.6×10^{-13}		83	200-295	LF	33 Bott 1981
		8.7×10^{-13} 9.7×10^{-13}	±10	83	490-732	LF-ST	26 Bott 1974
$D_2(v=1) + DF(v=1) \rightarrow D_2(v=0) + DF(v=2)$	V-V	1.4×10^{-12}	±35	175	298	FT	122 Kwok and Wilkins 1975
		Measured from deactivation of v=2					
	V-V	1.3×10^{-12}		175	295	LF	32 Bott 1979
		Sequential absorption to DF(v=2) followed by deactivation					
$D_2(v=1) + DF(v=0) \rightarrow D_2(v=0) + DF(v=0)$	V-T	8.9×10^{-13}	±45	2992	295	LF	100 Hinchen 1973
		Probably incorrect					
		$\leq 3.1 \times 10^{-15}$	±40	2992	295	LF	27 Bott 1974
		Value reported is for $k_{DF-D_2} + 0.667\, k_{D_2-DF}$					
		$\leq 3.8 \times 10^{-15}$ $\leq 6.4 \times 10^{-15}$	±25	2992	363-436	LF-ST	27 Bott 1974
$D_2(v=1) + HBr(v=0) \rightarrow D_2(v=0) + HBr(v=1)$	V-V	1.2×10^{-13}	±10	435	296	LF	61 Chen 1971
$D_2(v=1) + HBr(v=0) \rightarrow D_2(v=0) + HBr(v=0)$	V-T	$\ll 9.9 \times 10^{-15}$		2992	296	LF	61 Chen 1971
$D_2(v=1) + HC\ell(v=0) \rightarrow D_2(v=0) + HC\ell(v=1)$	V-V	2.8×10^{-13}	±10	108	296	LF	63 Chen and Moore 1971
		Erroneously reported as 10^{-12} in original publication					
		2.8×10^{-13}	±10	108	296	LF	108 Hopkins...Sharma 1973
		3.7×10^{-13}	±10	108	295	LF	4 Allée...Doyennette 1974
		3.3×10^{-13}	±10	108	295	LF	40 Bott and Cohen 1975
		3.9×10^{-13} 2.3×10^{-13}	±10	108	196-342	LF	108 Hopkins...Sharma 1973
		3.2×10^{-13} 3.3×10^{-13}	±10	108	469-742	LF	40 Bott and Cohen 1975
		3.7×10^{-13} 6.6×10^{-13}	±10	108	295-1000	LF	4 Allée...Doyennette 1974
$DF(v=1) + Ar \rightarrow DF(v=0) + Ar$	V-T	$<9.3 \times 10^{-16}$		2907	295	LF	100 Hinchen 1973
		$<1.2 \times 10^{-15}$		2907	296	LF	97 Hancock and Saunders 1976
		$<2.0 \times 10^{-16}$		2907	198	LF	97 Hancock and Saunders 1976
		$<2.9 \times 10^{-16}$ $<9.9 \times 10^{-16}$		2907	910-1150	ST	29 Bott 1975
		7.7×10^{-16} 1.9×10^{-14}		2907	1700-4000	ST	36 Bott and Cohen 1973
		1.5×10^{-14} 4.8×10^{-13}		2907	1500-5000	ST	171 Vasil'ev...Tal'roze 1973
$DF(v=1) + BF_3 \rightarrow DF(v=0) + BF_3$†	V-V & V-T	2.2×10^{-13}	±15	2907	295	LF	24 Bott 1977
$DF(v=1) + CBrF_3 \rightarrow DF(v=0) + CBrF_3$†	V-V & V-T	1.7×10^{-14}	±10	2907	295	LF	24 Bott 1977
$DF(v=1) + CF_4 \rightarrow DF(v=0) + CF_4$†	V-V & V-T	3.4×10^{-14}		2907	295	LF	173 Wendelken...Noetzel 1975

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$DF(v=1) + CF_4 \rightarrow DF(v=0) + CF_4^\dagger$ (cont'd.)		3.1×10^{-14}	±10	2907	295	LF	24 Bott 1977
		4.6×10^{-14} 3.3×10^{-14}		2907	295- 800		172 Wendelken and Stout, private communication in 24
		3.1×10^{-14} $\sim 1.2 \times 10^{-14}$		2907	295- 800	LF-ST	24 Bott 1977
$DF(v=1) + CF_3H \rightarrow DF(v=0) + CF_3H^\dagger$	V-V & V-T	6.0×10^{-13}	±15	2907	295	LF	24 Bott 1977
$DF(v=1) + CH_3F \rightarrow DF(v=0) + CH_3F^\dagger$	V-V & V-T	1.1×10^{-11}	±10	2907	295	LF	24 Bott 1977
$DF(v=1) + CH_4 \rightarrow DF(v=0) + CH_4^\dagger$	V-V & V-T	6.8×10^{-12}	±15	2907	295	LF	24 Bott 1977
		6.8×10^{-12} 4.6×10^{-12}	±20	2907	295- 740	LF-ST	24 Bott 1977
$DF(v=1) + C_2H_2 \rightarrow DF(v=0) + C_2H_2^\dagger$	V-V & V-T	1.2×10^{-12}	±15	2907	295	LF	24 Bott 1977
$DF(v=1) + C_2H_2F_2 \rightarrow DF(v=0) + C_2H_2F_2^\dagger$	V-V & V-T	5.7×10^{-13}	±10	2907	295	LF	24 Bott 1977
$DF(v=1) + C_2H_4 \rightarrow DF(v=0) + C_2H_4^\dagger$	V-V & V-T	5.4×10^{-12}	±15	2907	295	LF	24 Bott 1977
$DF(v=1) + C_2H_6 \rightarrow DF(v=0) + C_2H_6^\dagger$	V-V & V-T	1.9×10^{-11}	±15	2907	295	LF	24 Bott 1977
$DF(v=1) + C_4H_{10} \rightarrow DF(v=0) + C_4H_{10}^\dagger$	V-V & V-T	3.9×10^{-11}	±15	2907	295	LF	24 Bott 1977
$DF(v=1) + Cl \rightarrow DF(v=1) + Cl$	V-T	2.0×10^{-12}	±15	2907	295	LF-DF	151 Quigley and Wolga 1975
		6.9×10^{-12} 1.0×10^{-12}	±50	2907	1500- 3350	ST	18 Blauer and Solomon 1973
$DF(v=1) + Cl_2 \rightarrow DF(v=0) + Cl_2^\dagger$	V-V & V-T	$<1.2 \times 10^{-14}$		2907	295	LF	151 Quigley and Wolga 1975
$DF(v=1) + CO(v=0) \rightarrow DF(v=0) + CO(v=1)$	V-V & V-T	1.2×10^{-13}	±10	764	295	LF	26 Bott 1974
		8.6×10^{-14} 1.2×10^{-13}	±10	764	473- 725	LF-ST	26 Bott 1974
$DF(v=3) + CO(v=0) \rightarrow DF(v=2) + CO(v=1)$	V-V & V-T	5.0×10^{-13}		582	295	FR	147 Poole and Smith 1977
$DF(v=4) + CO(v=0) \rightarrow DF(v=3) + CO(v=1)$	V-V & V-T	1.2×10^{-12}		494	295	FR	147 Poole and Smith 1977
$DF(v=5) + CO(v=0) \rightarrow DF(v=4) + CO(v=1)$	V-V & V-T	2.8×10^{-12}		408	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$DF(v=1) + CO_2(000) \rightarrow DF(v=0) + CO_2(001)$	V-V	1.5×10^{-12}	±35	557		LG	13 Basov...Oraevsky 1971
		DF vibrational level not determined					
		4.0×10^{-12}		557	295	FR	3 Airey and Smith 1972
		4.7×10^{-12}		557	295	LF	38 Bott and Cohen 1973
		May include small V-T contribution					
		7.0×10^{-12}	±40	557	295	LF	127 Lucht and Cool 1974
		V-V contribution only					
		6.2×10^{-12}		557	295	LF	102 Hinchen and Hobbs 1975
		$\leq 3.1 \times 10^{-12}$		557	295	LF	129 Lucht and Cool 1975
		4.8×10^{-12}		557	295	LF	32 Bott 1979
		$\leq 6.0 \times 10^{-12}$ $\leq 4.3 \times 10^{-12}$	±50	557	208- 359	LF	129 Lucht and Cool 1975
		V-V contribution only					
		6.3×10^{-12}	±15	557	350	LF	166 Stephens and Cool 1972
		May include small V-T contribution					
		$\sim 3.3 \times 10^{-13}$		557	400	FT	170 Vasil'ev...Tal'roze 1972
		7.0×10^{-12} 5.8×10^{-12}	±40	557	295- 670	LF	127 Lucht and Cool 1974
		V-V contribution only					
		4.7×10^{-12} 3.1×10^{-12}		557	295- 720	LF	38 Bott and Cohen 1973
		There is a minimum in the probability at 400 K					

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule•s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$DF(v=2) + CO_2(000) \rightarrow DF(v=1) + CO_2(001)$	V-V & V-T	6.8×10^{-12}		465	295	FR	3 Airey and Smith 1972
		1.5×10^{-11}		465	295	LF	102 Hinchen and Hobbs 1975
		1.8×10^{-11}		465	295	LF	32 Bott 1979
$DF(v=3) + CO_2(000) \rightarrow DF(v=2) + CO_2(001)$	V-V & V-T	1.6×10^{-11}		376	295	FR	3 Airey and Smith 1972
		1.7×10^{-11}		376	295	FR	147 Poole and Smith 1977
		4.6×10^{-11}		376	295	LF	32 Bott 1979
		Sequential absorption to DF(v=3)					
$DF(v=4) + CO_2(000) \rightarrow DF(v=3) + CO_2(001)$	V-V & V-T	2.7×10^{-11}		288	295	FR	147 Poole and Smith 1977
$DF(v=n) + CO_2(000) \rightarrow DF(v=n-1) + CO_2(001)$	V-V & V-T	$\frac{n=1}{1.0}$ $\frac{2}{1.7}$ $\frac{3}{2.9}$ $\frac{4}{3.8}$			295	CD	51 Brown...Polanyi 1978
		Relative deactivation rates only					
$DF(v=5) + CO_2(000) \rightarrow DF(v=4) + CO_2(001)$	V-V & V-T	3.9×10^{-11}		202	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$DF + CO_2$, see also $CO_2 + DF$							
$DF(v=1) + D \rightarrow DF(v=0) + D$	V-T	$<1.3 \times 10^{-13}$		2907	295	LF-DF	99 Heidner and Bott 1975
$DF(v=1) + DBr(v=0) \rightarrow DF(v=0) + DBr(v=1)$	V-V & V-T	1.7×10^{-13}	±20	1067	295	LF	26 Bott 1974
		6.2×10^{-13}		1067	295	LF	173 Wendelken...Noetzel 1975
		1.3×10^{-13} 1.4×10^{-13}	±20	1067	466- 735	LF-ST	26 Bott 1974
$DF(v=3) + D_2(v=0) \rightarrow DF(v=2) + D_2(v=1)$	V-V & V-T	6.7×10^{-13}	±40	-264	298	FT	122 Kwok and Wilkins 1975
		4.8×10^{-13}		-264	295	LF	32 Bott 1979
		Sequential absorption to DF(v=3)					
	V-V & V-T	4.0×10^{-13} 4.8×10^{-13}		-264	200- 295	LF	33 Bott 1981
		Sequential absorption to DF(v=3)					
$DF(v=4) + D_2(v=0) \rightarrow DF(v=3) + D_2(v=1)$	V-V & V-T	7.5×10^{-13}	±40	-353	298	FT	122 Kwok and Wilkins 1975
		5.9×10^{-13}		-353	295	LF	32 Bott 1979
		Sequential absorption to DF(v=4)					
$DF(v=1) + D_2(v=0) \rightarrow DF(v=0) + D_2(v=0)$	V-T	1.2×10^{-13}		2907	295	LF	100 Hinchen 1973
		Probably incorrect					
		3.1×10^{-15}	±40	2907	295	LF	27 Bott 1973
		Value reported is for $k_{DF-D_2} + 0.667\ k_{D_2-DF}$					
		$\leq 3.8 \times 10^{-15}$ $\leq 6.4 \times 10^{-15}$	±25	2907	363- 436	LF-ST	27 Bott 1973
$DF + D_2$, see also $D_2 + DF$							
$DF(v=3) + D_2O \rightarrow DF(v=2) + D_2O^{\dagger}$	V-V & V-T	1.5×10^{-11}		2726	295	FR	147 Poole and Smith 1977
$DF(v=4) + D_2O \rightarrow DF(v=3) + D_2O^{\dagger}$	V-V & V-T	3.1×10^{-11}		2638	295	FR	147 Poole and Smith 1977
$DF(v=5) + D_2O \rightarrow DF(v=4) + D_2O^{\dagger}$	V-V & V-T	3.0×10^{-11}		2552	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$DF(v=1) + DF(v=1) \rightarrow DF(v=2) + DF(v=0)$	V-V	3.2×10^{-11}		92	295	LF	23 Bott 1973
		3.25×10^{-11}	±10	92	295	LF	38 Bott 1973
		2.9×10^{-11}	±15	92	295	LF	83 Ernst...Sackett 1973
		2.2×10^{-11} 1.4×10^{-11}		92	444- 739	LF-ST	23 Bott 1973
$DF(v=3) + DF(v=0) \rightarrow DF(v=2) + DF(v=1)$	V-V & V-T	5.4×10^{-12}		-181	295	FR	146 Poole and Smith 1977
$DF(v=4) + DF(v=0) \rightarrow DF(v=3) + DF(v=1)$	V-V & V-T	6.9×10^{-12}		-269	295	FR	146 Poole and Smith 1977
$DF(v=5) + DF(v=0) \rightarrow DF(v=4) + DF(v=0)$	V-V & V-T	8.2×10^{-12}		-355	295	FR	146 Poole and Smith 1977
		The rate constants in Ref. 146 are internally consistent, but their absolute magnitudes may be in error					

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$DF(v=1) + DF(v=0) \rightarrow DF(v=0) + DF(v=0)$	V-T	8.0×10^{-13}	±15	2907	300	LF	1 Ahl and Cool 1973
		6.4×10^{-13}	±15	2907	295	LF	38 Bott and Cohen 1973
		6.5×10^{-13}	±10	2907	295	LF	37 Bott and Cohen 1973
		4.9×10^{-13}	±20	2907	295	LF	83 Ernst...Sackett 1973
		7.4×10^{-13}	±15	2907	295	LF	100 Hinchen 1973
		7.3×10^{-13}	±10	2907	295	LF	101 Hinchen 1973
		8.3×10^{-13}	±20	2907	295	LF	127 Lucht and Cool 1974
		7.7×10^{-13}	±40	2907	297	LF	128 Lucht and Cool 1974
		6.7×10^{-13}	±15	2907	300	LF	28 Bott 1974
		Corrected Ahl and Cool for gas dynamic pressure error					
		6.9×10^{-13}	±15	2907	295	LF	28 Bott 1974
		Corrected Lucht and Cool for gas dynamic pressure error					
		5.46×10^{-13}	±4	2907	295	LF	93 Hancock and Green 1975
		Pointed out that rates without helium diluent are slower					
		8.79×10^{-13}	±3	2907	296	LF	97 Hancock and Saunders 1976
		With helium diluent					
		4.7×10^{-13}		2907	296	LF	97 Hancock and Saunders 1976
		Without helium diluent General model proposed by many authors that V-R transfer populates high J states creating a bottleneck for relaxation when a diluent gas is not present					
		1.6×10^{-12}		2907	200	LF	93 Hancock and Green 1975
		6.7×10^{-13}	±35	2907	198	LF	97 Hancock and Saunders 1976
		There were no $(DF)_n$ polymers at the pressures used					
		1.0×10^{-12} 4.1×10^{-13}	±30	2907	204- 359	LF	129 Lucht and Cool 1975
		6.6×10^{-13}	±20	2907	350	LF	1 Ahl and Cool 1973
		Uncorrected for gas dynamic pressure error					
		7.3×10^{-13}	±10	2907	350	LF	166 Stephens and Cool 1973
		Uncorrected for gas dynamic pressure error					
		8.3×10^{-13} 4.4×10^{-13}	±20	2907	295- 670	LF	127 Lucht and Cool 1974
		Uncorrected for gas dynamic pressure error					
		7.7×10^{-13} 3.5×10^{-13}	±40	2907	295- 678	LF	128 Lucht and Cool 1974
		Uncorrected for gas dynamic pressure error					
		6.4×10^{-13} 3.4×10^{-13}	±15	2907	295- 900	LF-ST	38 Bott and Cohen 1973
		7.3×10^{-13} 3.5×10^{-13}	±10	2907	295- 900	LF-ST	101 Hinchen 1973
		7.1×10^{-13} 5.0×10^{-12}	±50	2907	1600- 3600	ST	19 Blauer...Owens 1972
		3.1×10^{-13} 7.7×10^{-12}	±20	2907	800- 4000	ST	36 Bott and Cohen 1973
		6.0×10^{-13} 1.0×10^{-11}		2907	1500- 5000	ST	171 Vasil'ev...Tal'roze 1973
		There is a minimum in the rate of this process at ~1500 K and a minimum in the probability at ~700 K					
$DF(v=1) + (DF)_n \rightarrow DF(v=0) + (DF)_n$	V-T			2907	198- 295	LF	97 Hancock and Saunders 1976
		There is a strong rate enhancement over DF monomer					
$DF(v=1) + F \rightarrow DF(v=0) + F$	V-T	6.5×10^{-13}	±20	2907	295	LF-DF	151 Quigley and Wolga 1975
		1.2×10^{-11} 2.2×10^{-12}	±50	2907	1560- 2800	ST	18 Blauer and Solomon 1973

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
DF(v=1) + F → DF(v=0) + F (cont'd.)		2.5×10^{-11}	±25	2907	1900- 3000	ST	36 Bott and Cohen 1973
		The rate constant is essentially constant over the whole range of temperature					
DF(v=1) + F_2 → DF(v=0) + $F_2^\dagger$	V-V & V-T	$<8 \times 10^{-15}$		2907	295	LF	151 Quigley and Wolga 1975
DF(v=1) + H → DF(v=0) + H	V-T & Exchange	1.1×10^{-13}	±30	2907	295	LF-DF	99 Heidner and Bott 1975
DF(v=1) + HBr(v=0) → DF(v=0) + HBr(v=1)	V-V & V-T	2.2×10^{-12}	±10	348	295	LF	26 Bott 1974
		Probably mainly V-V contribution					
		1.2×10^{-12} 1.0×10^{-12}	±10	348	471- 739	LF-ST	26 Bott 1974
DF(v=1) + HBr(v=0) → DF(v=0) + HBr(v=0)	V-T	$<2.2 \times 10^{-12}$		2907	295	LF	26 Bott 1974
DF(v=1) + HCℓ(v=0) → DF(v=0) + HCℓ(v=1)	V-V	1.2×10^{-11}	±10	21	295	LF	26 Bott 1974
		V-T contribution is less than 5%					
		5.2×10^{-12} 5.0×10^{-12}	±10	21	475- 745	LF-ST	26 Bott 1974
DF(v=1) + HCℓ(v=0) → DF(v=0) + HCℓ(v=0)	V-T	$<5.6 \times 10^{-13}$		2907	295	LF	26 Bott 1974
		$<3.5 \times 10^{-13}$ $<3 \times 10^{-13}$		2907	475- 745	LF-ST	26 Bott 1974
DF(v=1) + HCN → DF(v=0) + HCN†	V-V & V-T	3.3×10^{-12}	±15	2907 $-405(\nu_3)$	298	LF	135 McGarvey...Cool 1977
		5.1×10^{-12} 2.2×10^{-12}		2907 $-405(\nu_3)$	240- 450	LF	135 McGarvey...Cool 1977
DF(v=3) + HCN → DF(v=2) + HCN†	V-V & V-T	8.6×10^{-12}		2726 $-586(\nu_3)$ $-74(\nu_1+\nu_2)$	295	FR	147 Poole and Smith 1977
DF(v=4) + HCN → DF(v=3) + HCN†	V-V & V-T	1.3×10^{-11}		2638	295	FR	147 Poole and Smith 1977
DF(v=5) + HCN → DF(v=4) + HCN†	V-V & V-T	2.3×10^{-11}		2552	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
DF + HCN, see also HCN + DF							
DF(v=1) + He → DF(v=0) + He	V-T	$<9.3 \times 10^{-16}$		2907	295	LF	100 Hinchen 1973
		$\leq 1.2 \times 10^{-15}$		2907	295	LF	93 Hancock and Green 1975
		$\leq 4 \times 10^{-16}$		2907	200	LF	93 Hancock and Green 1975
		6.4×10^{-16} 1.0×10^{-13}		2907	900- 2600	ST	29 Bott 1975
		1.5×10^{-14} 3.1×10^{-13}		2907	1500- 3500	ST	169 Vasil'ev...Papin 1975
DF(v=1) + HF(v=0) → DF(v=0) + HF(v=0)	V-T	2.2×10^{-12}		2907	295	FT	3 Airey and Smith 1972
		1.4×10^{-12}	±15	2907	300	LF	1 Ahl and Cool 1973
		1.1×10^{-12}	±15	2907	295	LF	37 Bott and Cohen 1973
		1.0×10^{-12}	±10	2907	295	LF	100 Hinchen 1973
		9.9×10^{-13}	±10	2907	295	LF	101 Hinchen 1973
		1.6×10^{-12}	±45	2907	295	FT	122 Kwok and Wilkins 1975
		1.1×10^{-12}		2907	295	LF	32 Bott 1979
		1.7×10^{-12} 7.3×10^{-13}	±20	2907	210- 364	LF	129 Lucht and Cool 1975
		1.2×10^{-12}	±15	2907	350	LF	1 Ahl and Cool 1973
		9.9×10^{-13} 5.5×10^{-13}	±10	2907	295- 573	LF-ST	101 Hinchen 1973

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule•s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$DF(v=2) + HF(v=0) \rightarrow DF(v=1) + HF(v=0)$	V-T	3.0×10^{-12} The rate constants in Ref. 3 are internally consistent, but their absolute magnitudes may be in error		2815	295	FR	3 Airey and Smith 1972
		4.6×10^{-12}	±35	2815	298	FT	122 Kwok and Wilkins 1975
		4.0×10^{-12} Sequential absorption to DF(v=2)		2815	295	LF	32 Bott 1979
$DF(v=3) + HF(v=0) \rightarrow DF(v=2) + HF(v=0)$	V-T	8.3×10^{-12}	±40	2726	298	FT	122 Kwok and Wilkins 1975
		9.3×10^{-12} Sequential absorption to DF(v=3)		2726	295	LF	32 Bott 1979
		$\sim 7 \times 10^{-11}$ Sequential absorption to DF(v=3)		2726	200	LF	33 Bott 1981
$DF(v=4) + HF(v=0) \rightarrow DF(v=3) + HF(v=0)$	V-T	2.7×10^{-12}	±40	2638	298	FT	122 Kwok and Wilkins 1975
$DF(v=1) + H_2(v=0) \rightarrow DF(v=0) + H_2(v=0)$	V-T	1.4×10^{-13} Probably incorrect		2907	295	LF	100 Hinchen 1973
		2.0×10^{-14}	±10	2907	295	LF	27 Bott 1974
		1.7×10^{-14}		2907	295	LF	32 Bott 1979
		1.3×10^{-14}		2907	200	LF	33 Bott 1981
		1.1×10^{-13} 8.6×10^{-14}		2907	445–690	LF-ST	27 Bott 1974
		1.7×10^{-13} 3.2×10^{-12}		2907	800–4000	ST	36 Bott and Cohen 1973
$DF(v=2) + H_2(v=0) \rightarrow DF(v=1) + H_2(v=0)$	V-T	6.0×10^{-14} Sequential absorption to DF(v=2)		2815	295	LF	32 Bott 1979
$DF(v=3) + H_2(v=0) \rightarrow DF(v=2) + H_2(v=0)$	V-T	1.4×10^{-13} Sequential absorption to DF(v=3)		2726	295	LF	32 Bott 1979
		9.9×10^{-14} Sequential absorption to DF(v=3)		2726	200	LF	33 Bott 1981
$DF(v=4) + H_2(v=0) \rightarrow DF(v=3) + H_2(v=0)$	V-T	2.8×10^{-13} Sequential absorption to DF(v=4)		2638	295	LF	32 Bott 1979
$DF(v=1) + NF_3 \rightarrow DF(v=0) + NF_3{}^{\dagger}$	V-T	1.5×10^{-14}		2907	295	LF	173 Wendelken...Noetzel 1975
		1.6×10^{-14}	±15	2907	295	LF	24 Bott 1977
$DF(v=1) + N_2(v=0) \rightarrow DF(v=0) + N_2(v=1)$	V-V & V-T	6.2×10^{-14} Probably incorrect	±25	577	295	LF	100 Hinchen 1973
		2.8×10^{-14}	±10	577	295	LF	26 Bott 1974
		2.3×10^{-14}		577	295	LF	173 Wendelken...Noetzel 1975
		2.3×10^{-14}		577	295	LF	32 Bott 1979
		2.3×10^{-14}		577	200	LF	33 Bott 1981
		2.6×10^{-14} 6.4×10^{-14}		577	472–1114	LF-ST	26 Bott 1974
		1.7×10^{-14} 4.7×10^{-14}	±300	577	1400–3000	ST	19 Blauer...Owens 1972
		1.1×10^{-14} 4.0×10^{-14}		577	1200–4000	ST	36 Bott and Cohen 1973
$DF(v=2) + N_2(v=0) \rightarrow DF(v=1) + N_2(v=1)$	V-V & V-T	7.3×10^{-14} Sequential absorption to DF(v=2)		485	295	LF	32 Bott 1979
$DF(v=3) + N_2(v=0) \rightarrow DF(v=2) + N_2(v=1)$	V-V & V-T	3.9×10^{-14}		395	295	FR	147 Poole and Smith 1977
		1.6×10^{-13} Sequential absorption to DF(v=3)		395	295	LF	32 Bott 1979
		1.7×10^{-13} Sequential absorption to DF(v=3)		395	200	LF	33 Bott 1981

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$DF(v=4) + N_2(v=0) \rightarrow DF(v=3) + N_2(v=1)$	V-V & V-T	6.5×10^{-14}		308	295	FR	147 Poole and Smith 1977
		2.9×10^{-13}		308	295	LF	32 Bott 1979
$DF(v=5) + N_2(v=0) \rightarrow DF(v=4) + N_2(v=1)$	V-V & V-T	1.0×10^{-13}		221	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$DF(v=1) + NO(v=0) \rightarrow DF(v=0) + NO(v=1)$	V-V & V-T	2.5×10^{-13}	±10	1031	295	LF	26 Bott 1974
		1.8×10^{-13} 2.1×10^{-13}	±10	1031	476- 725	LF-ST	26 Bott 1974
		1.2×10^{-13} 4.0×10^{-13}		1031	1060- 2080	ST	20 Blauer...Owens 1972
$DF(v=1) + O \rightarrow DF(v=0) + O$	V-T	7.8×10^{-12}	±30	2907	295	LF	151 Quigley and Wolga 1975
$DF(v=1) + O_2 \rightarrow DF(v=0) + O_2^{\dagger}$	V-V & V-T	2.3×10^{-15}		1351(v=1) -205(v=2)	295	LF	26 Bott 1974
		$<1.6 \times 10^{-14}$		1351(v=1) -205(v=2)	295	LF	151 Quigley and Wolga 1975
		3.5×10^{-15} 8.5×10^{-15}		1351(v=1) -250(v=2)	550- 870	LF-ST	26 Bott 1974
		1.2×10^{-14} 1.9×10^{-13}		1351(v=1) -250(v=2)	1200- 3500	ST	169 Vasil'ev...Papin 1975
$DF(v=1) + SO_2 \rightarrow DF(v=0) + SO_2^{\dagger}$		3.9×10^{-13}	±15	2907	295	LF	24 Bott 1977
$DI(v=1) + DI(v=0) \rightarrow DI(v=0) + DI(v=0)$	V-T	2.5×10^{-13} 5.6×10^{-13}		1600	700- 2000	ST	49 Breshears and Bird 1970
DI + CO, see CO + DI							
$DI + CO_2$, see $CO_2 + DI$							
$DI + N_2$, see $N_2 + DI$							
$HBr(v=1) + Ar \rightarrow HBr(v=0) + Ar$	V-T	$\leq 3.7 \times 10^{-18}$	±10	2559	296	LF	60 Chen 1971
$HBr(v=1) + Br \rightarrow HBr(v=0) + Br$	V-T & V-E	$\sim 1.9 \times 10^{-12}$		2559	295	FP	74 Donovan...Stevenson 1970
		1.6×10^{-12}	±45	2559	295	FP	75 Donovan...Stevenson 1970
		2.4×10^{-13} V-T contribution only	±25	2559	295	LF-DF	113 Karny and Katz 1976
		2.6×10^{-12} V-T contribution only	±40	2559	294	LF-DF	130 Macdonald and Moore 1976
		4.6×10^{-12} V-T contribution only	±10	2559	295	LF-DF	85 Fernando and Smith 1979
		$\geq 1.5 \times 10^{-15}$ Contribution due to V-E transfer only		-1126	295	LF-DF	126 Leone and Wodarczyk 1974
$HBr(v=1) + Br_2 \rightarrow HBr(v=0) + Br_2^{\dagger}$	V-V & V-T	1.5×10^{-12} Probably incorrect	±30	2559	295	FP	75 Donovan...Stevenson 1970
		2.2×10^{-14}	±10	2559	295	LF-DF	113 Karny and Katz 1976
$HBr(v=1) + CD_4 \rightarrow HBr(v=0) + CD_4^{\dagger}$	V-V & V-T	$\geq 1.5 \times 10^{-12}$	±15	$447(\nu_1)$ $297(\nu_3)$	295	LF	107 Hopkins and Chen 1973
$HBr(v=1) + CH_4 \rightarrow HBr(v=0) + CH_4^{\dagger}$	V-V & V-T	3.5×10^{-13}	±20	$-352(\nu_1)$ $-445(\nu_3)$	295	FP	75 Donovan...Stevenson 1970
		4.5×10^{-13}	±10	$-352(\nu_1)$ $-445(\nu_3)$	295	LF	107 Hopkins and Chen 1973
$HBr(v=1) + CO(v=0) \rightarrow HBr(v=0) + CO(v=1)$	V-V	3.04×10^{-13}	±5	416	296	LF	61 Chen 1971
		2.8×10^{-13} 5.1×10^{-13}		416	295- 700	LF	160 Seoudi...Henry 1980
$HBr(v=1) + CO(v=0) \rightarrow HBr(v=0) + CO(v=0)$	V-T	1.7×10^{-13} Probably incorrect	±20	2559	295	FP	75 Donovan...Stevenson 1970

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule•s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HBr(v=1) + CO(v=0) \rightarrow HBr(v=0) + CO(v=0)$ (cont'd.)		$<4.8 \times 10^{-15}$		2559	295	LF	60 Chen 1971
		3.3×10^{-14} 1.6×10^{-13}	±5	2559	1200– 2000	ST	22 Borrell...Gutteridge 1974
HBr + CO, see also CO + HBr							
$HBr(v=1) + CO_2(000) \rightarrow HBr(v=0) + CO_2(001)$	V-V	8.6×10^{-12}	±10	210	295	LF	167 Stephenson...Moore 1972
		1.1×10^{-11}		210	295	LF	159 Seoudi...Henry 1979
		CO_2 excited directly, V-T contribution is less than 2%					
		1.1×10^{-11} 7.4×10^{-12}		210	295– 900	LF	159 Seoudi...Henry 1979
		V-T contribution is less than 10% at 900 K					
$HBr(v=1) + CO_2(000) \rightarrow HBr(v=0) + CO_2(nm0)$	V-T	$<2.0 \times 10^{-13}$		2559	295	LF	167 Stephenson...Moore 1972
		Value reported is for $k_{CO_2-HBr} + 0.377\ k_{HBr-CO_2}$					
HBr + CO_2, see also CO_2 + HBr							
$HBr(v=1) + DBr(v=0) \rightarrow HBr(v=0) + DBr(v=1)$	V-V	6.0×10^{-14}	±10	719	295	LF	65 Chen and Chen 1972
$HBr(v=1) + DCN \rightarrow HBr(v=0) + DCN^{\dagger}$	V-V & V-T	1.7×10^{-12}	±10	$-71(\nu_3)$	295	LF	7 Arnold...Smith 1980
$HBr(v=1) + D_2(v=0) \rightarrow HBr(v=0) + D_2(v=0)$	V-T	$\leq 1.2 \times 10^{-15}$	±15	2559	296	LF	61 Chen 1971
		1.2×10^{-15}	±15	2559	295	LF	107 Hopkins and Chen 1973
HBr + D_2, see also D_2 + HBr							
$HBr(v=1) + DF(v=0) \rightarrow HBr(v=0) + DF(v=0)$	V-T	$\sim 3 \times 10^{-13}$	±20	2559	295	LF	26 Bott 1974
$H^{79}Br(v=1) + H^{81}Br(v=0) \rightarrow H^{79}Br(v=0) + H^{81}Br(v=1)$	V-V	1.50×10^{-11}	±4	0.4	295	LF	109 Horwitz and Leone 1978
$HBr(v=1) + HBr(v=1) \rightarrow HBr(v=2) + HBr(v=0)$		4.6×10^{-12}	±20	90	296	LF	104 Hopkins and Chen 1972
		6.6×10^{-12}	±15	90	295	LF	56 Burak...Szöke 1972
		2.9×10^{-12}	±10	90	295	LF	72 Dasch and Moore 1980
		Direct excitation to HBr(v=2)					
		6.9×10^{-12} 6.8×10^{-12}	±10	90	320– 640	LF	140 Noter...Szöke 1973
$HBr(v=1) + HBr(v=0) \rightarrow HBr(v=0) + HBr(v=0)$	V-T	6.2×10^{-14}	±50	2559	295	FP	75 Donovan...Stevenson 1970
		1.8×10^{-14}	±10	2559	296	LF	60 Chen 1971
		1.8×10^{-14}	±10	2559	296	LF	65 Chen and Chen 1972
		1.9×10^{-14}	±35	2559	300	LF	1 Ahl and Cool 1973
		2.5×10^{-14}	±15	2559	295	LF	37 Bott and Cohen 1973
		3.0×10^{-14} 3.2×10^{-14}	±10	2559	169– 505	LF	178 Zittel and Moore 1973
		Minimum in the rate at 374 K (1.9×10^{-14})					
		2.2×10^{-14}	±33	2559	350	LF	1 Ahl and Cool 1973
				2559	460– 1370	ST	21 Borrell 1966
		The results in Ref. 21 are orders of magnitude too large					
		7.2×10^{-14} 6.1×10^{-13}	±20	2559	800– 1800	ST	116 Kiefer...Bird 1969
$HBr(v=2) + HBr(v=0) \rightarrow HBr(v=1) + HBr(v=0)$	V-T	$<3.1 \times 10^{-13}$		2469	295	LF	72 Dasch and Moore 1980
		Direct excitation to HBr(v=2)					
$HBr(v=1) + HC\ell(v=0) \rightarrow HBr(v=0) + HC\ell(v=0)$	V-T	2.5×10^{-13}	±40	2559	295	FP	75 Donovan...Stevenson 1970
		Probably incorrect					
		4.1×10^{-14}	±10	2559	296	LF	60 Chen 1971
$HBr(v=1) + HC\ell(v=1) \rightarrow HBr(v=2) + HC\ell(v=0)$	V-V	2.3×10^{-12}	±20	418	295	LF	72 Dasch and Moore 1980
		Direct excitation to HBr(v=2)					

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HBr(v=1) + HCN \rightarrow HBr(v=0) + HCN^{\dagger}$	V-V & V-T	1.40×10^{-12}	±4	2559 -773(001)	295	LF	7 Arnold...Smith 1980
HBr + HCN, see also HCN + HBr							
$HBr(v=1) + HD(v=0) \rightarrow HBr(v=0) + HD(v=0)$	V-T	2.0×10^{-15}	±5	2559	295	LF	107 Hopkins and Chen 1973
$HBr(v=1) + {}^3He \rightarrow HBr(v=0) + {}^3He$	V-T	4.7×10^{-16}	±5	2559	295	LF	107 Hopkins and Chen 1973
$HBr(v=1) + He \rightarrow HBr(v=0) + He$	V-T	$<1 \times 10^{-16}$		2559	295	FP	75 Donovan...Stevenson 1970
		$\leq 2.7 \times 10^{-17}$	±10	2559	296	LF	60 Chen 1971
		2.8×10^{-16}	±10	2559	295	LF	107 Hopkins and Chen 1973
$HBr(v=1) + HF(v=0) \rightarrow HBr(v=0) + HF(v=0)$	V-T	4.9×10^{-13}	±20	2559	300	LF	1 Ahl and Cool 1973
		2.8×10^{-13}	±10	2559	295	LF	37 Bott and Cohen 1973
		4.0×10^{-13}	±20	2559	350	LF	1 Ahl and Cool 1973
$HBr(v=1) + H_2(v=0) \rightarrow HBr(v=0) + H_2(v=0)$	V-T	1.9×10^{-14}	±35	2559	295	FP	75 Donovan...Stevenson 1970
		6.4×10^{-15}	±5	2559	295	LF	60 Chen 1971
		The same rate is observed for both normal and para hydrogen					
$HBr + H_2$, see also $H_2 + HBr$							
$HBr(v=1) + H_2O \rightarrow HBr(v=0) + H_2O^{\dagger}$	V-V & V-T	8.6×10^{-14}	±10	2559 $964(\nu_2)$	295	LF	107 Hopkins and Chen 1973
$HBr(v=1) + HI(v=0) \rightarrow HBr(v=0) + HI(v=1)$	V-V	6.6×10^{-13}	±15	329	296	LF	60 Chen 1971
$HBr(v=1) + Kr \rightarrow HBr(v=0) + Kr$	V-T	$<3 \times 10^{-17}$		2559	296	LF	104 Hopkins and Chen 1972
$HBr(v=1) + Ne \rightarrow HBr(v=0) + Ne$	V-T	$\leq 1.4 \times 10^{-17}$	±10	2559	296	LF	60 Chen 1971
$HBr(v=1) + NO(v=0) \rightarrow HBr(v=0) + NO(v=1)$	V-V	2.3×10^{-13} 4.7×10^{-13}		683	295- 700	LF	160 Seoudi...Henry 1980
$HBr(v=1) + N_2(v=0) \rightarrow HBr(v=0) + N_2(v=1)$	V-V	1.2×10^{-14} Probably incorrect	±15	228	295	FP	75 Donovan...Stevenson 1970
		9.8×10^{-14}	±10	228	296	LF	61 Chen 1971
		1.02×10^{-13} 9.5×10^{-14}		228	295- 700	LF	160 Seoudi...Henry 1980
$HBr(v=1) + N_2(v=0) \rightarrow HBr(v=0) + N_2(v=0)$	V-T	$<3.2 \times 10^{-15}$		2559	296	LF	61 Chen 1971
$HBr + N_2$, see also $N_2 + HBr$							
$HBr(v=1) + N_2O(000) \rightarrow HBr(v=0) + N_2O(001)$	V-V	5.6×10^{-12} Direct excitation to $N_2O(001)$		336	295	LF	159 Seoudi...Henry 1979
		5.6×10^{-12} 6.7×10^{-12}		336	295- 900	LF	159 Seoudi...Henry 1979
$HBr(v=1) + OCS \rightarrow HBr(v=0) + OCS^{\dagger}$	V-V & V-T	5.6×10^{-12}	±10	$497(\nu_3)$ $-19(\nu_2+\nu_3)$	296	LF	103 Hopkins and Chen 1973
HBr + OCS, see also OCS + HBr							
$HBr(v=1) + O_2(v=0) \rightarrow HBr(v=0) + O_2(v=1)$	V-V & V-T	4.9×10^{-15}	±5	1003(v=1)	296	LF	61 Chen 1971
		5.1×10^{-15} 3.5×10^{-14}		1003(v=1)	295- 700	LF	160 Seoudi...Henry 1980
$HBr(v=1) + SF_6 \rightarrow HBr(v=0) + SF_6^{\dagger}$	V-V & V-T	2.5×10^{-14}	±15	2559	295	FP	75 Donovan...Stevenson 1970
$HCl(v=1) + Ar \rightarrow HCl(v=0) + Ar$	V-T	$<6 \times 10^{-17}$		2886	295	LF	62 Chen and Moore 1971
		3.4×10^{-18}	±20	2886	295	LF	165 Steele and Moore 1974
		3.4×10^{-18} 1.4×10^{-16}	±20	2886	295- 700	LF	165 Steele and Moore 1974
		8.2×10^{-16} 1.8×10^{-14}	±70	2886	1166- 1950	ST	157 Seery 1973
		$\sim 3.3 \times 10^{-15}$ $\sim 2.4 \times 10^{-14}$		2886	1000- 2100	ST	45 Bowman and Seery 1969

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell + BC\ell_3$, see $BC\ell_3 + HC\ell$							
$HC\ell(v=1) + Br \rightarrow HC\ell(v=0) + Br$	V-T & V-E	$\gtrsim 9 \times 10^{-14}$	$^{+0}_{-50}$	-799	295	LF	126 Leone and Wodarczyk 1974
		V-E contribution only					
		2.8×10^{-13}	±20	2886	295	LF-DF	124 Leone...Moore 1975
		Mainly V-T contribution, total V-T and V-E would be ~3.7×10^{-13}					
		7.0×10^{-13}	±25	2886	295	LF-DF	9 Arnoldi and Wolfrum 1976
		Total of V-T and V-E processes; V-T only is 4.15×10^{-13}					
		5.6×10^{-13}	±15	2886	295	LF-DF	54 Brown...Van der Merwe 1976
		V-T contribution only					
		2.6×10^{-13}	±20	2886	295	LF-DF	114 Karny and Katz 1976
		4.1×10^{-13}	±20	2886	295	LF-DF	85 Fernando and Smith 1979
		2.8×10^{-13}	±20	2886	210	LF-DF	54 Brown...Van der Merwe 1976
		(2.6×10^{-13} for V-T contribution only)					
		9.5×10^{-13}	±15	2886	371	LF-DF	54 Brown...Van der Merwe 1976
		(7.7×10^{-13} for V-T contribution only)					
		3.3×10^{-13} 3.8×10^{-13}	±55	2886	295- 390	LF-DF	132 Macdonald and Moore 1980
		Not as accurate as earlier measurement in Ref. 124					
$HC\ell(v=2) + Br \rightarrow HC\ell(v=1) + Br$	V-T, V-E & Rx	1.8×10^{-12}	±20	2782	298	LF-DF	124 Leone...Moore 1975
		1.5×10^{-12}	±65	2782	295	LF-DF	9 Arnoldi and Wolfrum 1976
		Thought to be mainly reaction					
		$>5 \times 10^{-13}$ $<5 \times 10^{-12}$		2782	295	CD	79 Douglas...Sloan 1973
		Estimate for reactive contribution only					
		1.7×10^{-12}	±15	2782	295	LF-DF	132 Macdonald and Moore 1980
		Relaxation to v=1 observed to be dominant process; reaction contributes less than 17%					
		1.7×10^{-12} 3.3×10^{-12}	±15	2782	295- 390	LF-DF	132 Macdonald and Moore 1980
		Reaction contributes less than 34% at 390 K					
$HC\ell(v=3) + Br \rightarrow HC\ell(v=2) + Br$	V-T, V-E & Rx	$>3.5 \times 10^{-12}$ $<3.5 \times 10^{-11}$		2678	295	CD	79 Douglas...Sloan 1973
		Estimate for the reactive contribution only					
$HC\ell(v=4) + Br \rightarrow HC\ell(v=3) + Br$	V-T, V-E & Rx	$>5 \times 10^{-12}$ $<5 \times 10^{-11}$		2575	295	CD	79 Douglas...Sloan 1973
		Estimate for the reactive contribution only					
$HC\ell(v=1) + Br_2 \rightarrow HC\ell(v=0) + Br_2^\dagger$	V-V & V-T	3.26×10^{-14}	±4	2886	295	LF	124 Leone...Moore 1975
$HC\ell(v=1) + CD_4 \rightarrow HC\ell(v=0) + CD_4^\dagger$	V-V & V-T	3.4×10^{-13}	±20	2886 627(ν_3)	295	LF	176 Zittel and Moore 1973
$HC\ell + CD_4$, see also $CD_4 + HC\ell$							
$HC\ell(v=2) + CFC\ell_3 \rightarrow HC\ell(v=1) + CFC\ell_3^\dagger$	V-V & V-T	~2×10^{-13}	±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + CFC\ell_3 \rightarrow HC\ell(v=2) + CFC\ell_3^\dagger$	V-V & V-T	2.8×10^{-13}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + CFC\ell_3 \rightarrow HC\ell(v=3) + CFC\ell_3^\dagger$	V-V & V-T	7.5×10^{-13}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + CFC\ell_3 \rightarrow HC\ell(v=4) + CFC\ell_3^\dagger$	V-V & V-T	2.4×10^{-12}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + CFC\ell_3 \rightarrow HC\ell(v=5) + CFC\ell_3^\dagger$	V-V & V-T	6.7×10^{-12}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + CFC\ell_3 \rightarrow HC\ell(v=6) + CFC\ell_3^\dagger$	V-V & V-T	1.5×10^{-11}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + CF_2C\ell_2 \rightarrow HC\ell(v=2) + CF_2C\ell_2^\dagger$	V-V & V-T	$<1 \times 10^{-13}$		2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + CF_2C\ell_2 \rightarrow HC\ell(v=3) + CF_2C\ell_2^\dagger$	V-V & V-T	3×10^{-13}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + CF_2C\ell_2 \rightarrow HC\ell(v=4) + CF_2C\ell_2^\dagger$	V-V & V-T	1.6×10^{-12}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + CF_2C\ell_2 \rightarrow HC\ell(v=5) + CF_2C\ell_2^\dagger$	V-V & V-T	3.2×10^{-12}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + CF_2C\ell_2 \rightarrow HC\ell(v=6) + CF_2C\ell_2^\dagger$	V-V & V-T	4.9×10^{-12}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + CF_3C\ell \rightarrow HC\ell(v=2) + CF_3C\ell^\dagger$	V-V & V-T	1.4×10^{-13}	±30	2679	298	FT	14 Berquist...Kaufman 1982

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=4) + CF_3C\ell \rightarrow HC\ell(v=3) + CF_3C\ell^\dagger$	V-V & V-T	3.4×10^{-13}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + CF_3C\ell \rightarrow HC\ell(v=4) + CF_3C\ell^\dagger$	V-V & V-T	6.5×10^{-13}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + CF_3C\ell \rightarrow HC\ell(v=5) + CF_3C\ell^\dagger$	V-V & V-T	9.5×10^{-13}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + CF_3C\ell \rightarrow HC\ell(v=6) + CF_3C\ell^\dagger$	V-V & V-T	1.2×10^{-12}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + CF_4 \rightarrow HC\ell(v=2) + CF_4^\dagger$	V-V & V-T	1.8×10^{-13}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + CF_4 \rightarrow HC\ell(v=3) + CF_4^\dagger$	V-V & V-T	3.6×10^{-13}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + CF_4 \rightarrow HC\ell(v=4) + CF_4^\dagger$	V-V & V-T	2.7×10^{-13}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + CF_4 \rightarrow HC\ell(v=5) + CF_4^\dagger$	V-V & V-T	3.9×10^{-13}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + CF_4 \rightarrow HC\ell(v=6) + CF_4^\dagger$	V-V & V-T	4.7×10^{-13}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + CF_3OC\ell \rightarrow HC\ell(v=0) + CF_3OC\ell^\dagger$	V-V & V-T	6.8×10^{-14}	±10	2886	295	LF	70 Coombe...Pilipovich 1975
$HC\ell(v=2) + CH_3C\ell \rightarrow HC\ell(v=1) + CH_3C\ell^\dagger$	V-V & V-T	9.5×10^{-12}	±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + CH_3C\ell \rightarrow HC\ell(v=2) + CH_3C\ell^\dagger$	V-V & V-T	3.0×10^{-11}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + CH_3C\ell \rightarrow HC\ell(v=3) + CH_3C\ell^\dagger$	V-V & V-T	1.1×10^{-10}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + CH_3C\ell \rightarrow HC\ell(v=4) + CH_3C\ell^\dagger$	V-V & V-T	1.7×10^{-10}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + CH_3C\ell \rightarrow HC\ell(v=5) + CH_3C\ell^\dagger$	V-V & V-T	2.9×10^{-10}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + CH_3C\ell \rightarrow HC\ell(v=6) + CH_3C\ell^\dagger$	V-V & V-T	3.3×10^{-10}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + CH_3F \rightarrow HC\ell(v=0) + CH_3F^\dagger$	V-V & V-T	$<9 \times 10^{-12}$		2886	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=2) + CH_3F \rightarrow HC\ell(v=1) + CH_3F^\dagger$	V-V & V-T	1.1×10^{-11}	±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + CH_3F \rightarrow HC\ell(v=2) + CH_3F^\dagger$	V-V & V-T	2.6×10^{-11}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + CH_3F \rightarrow HC\ell(v=3) + CH_3F^\dagger$	V-V & V-T	3.5×10^{-11}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + CH_3F \rightarrow HC\ell(v=4) + CH_3F^\dagger$	V-V & V-T	7.2×10^{-11}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + CH_3F \rightarrow HC\ell(v=5) + CH_3F^\dagger$	V-V & V-T	9.8×10^{-11}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + CH_3F \rightarrow HC\ell(v=6) + CH_3F^\dagger$	V-V & V-T	8.0×10^{-11}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + CH_4 \rightarrow HC\ell(v=0) + CH_4^\dagger$	V-V & V-T	2.6×10^{-12}	±10	$-30(\nu_1)$ $-133(\nu_3)$	295	LF	63 Chen and Moore 1971
		2.7×10^{-12}		$-30(\nu_1)$ $-133(\nu_3)$	296	LF	156 Schramm and Rapp 1980
		$\sim 3.8 \times 10^{-12}$	>±30	$-30(\nu_1)$ $-133(\nu_3)$	298	FT	14 Berquist...Kaufman 1982
		3.6×10^{-12} 2.7×10^{-12}		$-30(\nu_1)$ $-133(\nu_3)$	194- 296	LF	156 Schramm and Rapp 1980
$HC\ell(v=2) + CH_4 \rightarrow HC\ell(v=1) + CH_4^\dagger$	V-V & V-T	3.8×10^{-12}	±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + CH_4 \rightarrow HC\ell(v=2) + CH_4^\dagger$	V-V & V-T	4.2×10^{-12}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + CH_4 \rightarrow HC\ell(v=3) + CH_4^\dagger$	V-V & V-T	6.0×10^{-12}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + CH_4 \rightarrow HC\ell(v=4) + CH_4^\dagger$	V-V & V-T	1.2×10^{-11}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + CH_4 \rightarrow HC\ell(v=5) + CH_4^\dagger$	V-V & V-T	2.0×10^{-11}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + CH_4 \rightarrow HC\ell(v=6) + CH_4^\dagger$	V-V & V-T	2.5×10^{-11}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell + CH_4$, see also $CH_4 + HC\ell$							
$HC\ell(v=1) + 1,1\text{-}C_2H_2C\ell_2 \rightarrow HC\ell(v=0) + 1,1\text{-}C_2H_2C\ell_2^\dagger$	V-V & V-T	3.1×10^{-13}	±20	2886	295	LF	70 Coombe...Pilipovitch 1975
$HC\ell(v=1) + trans\text{-}C_2H_2C\ell_2 \rightarrow HC\ell(v=0) + trans\text{-}C_2H_2C\ell_2$	V-V & V-T	3.1×10^{-13}	±20	2886	295	LF	70 Coombe...Pilipovitch 1975
$HC\ell(v=1) + C_2H_6 \rightarrow HC\ell(v=0) + C_2H_6^\dagger$	V-V & V-T	2.0×10^{-11}	±30	2886	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=2) + C_2H_6 \rightarrow HC\ell(v=1) + C_2H_6^\dagger$	V-V & V-T	2.1×10^{-11}	±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + C_2H_6 \rightarrow HC\ell(v=2) + C_2H_6^\dagger$	V-V & V-T	2.0×10^{-11}	±30	2679	298	FT	14 Berquist...Kaufman 1982

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E (cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=4) + C_2H_6 \rightarrow HC\ell(v=3) + C_2H_6^{\dagger}$	V-V & V-T	2.3×10^{-11}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + C_2H_6 \rightarrow HC\ell(v=4) + C_2H_6^{\dagger}$	V-V & V-T	2.7×10^{-11}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + C_2H_6 \rightarrow HC\ell(v=5) + C_2H_6^{\dagger}$	V-V & V-T	4.3×10^{-11}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + C_2H_6 \rightarrow HC\ell(v=6) + C_2H_6^{\dagger}$	V-V & V-T	5.3×10^{-11}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + C_3H_8 \rightarrow HC\ell(v=0) + C_3H_8^{\dagger}$	V-V & V-T	4.7×10^{-11}	±30	2886	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=2) + C_3H_8 \rightarrow HC\ell(v=1) + C_3H_8^{\dagger}$	V-V & V-T	4.1×10^{-11}	±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + C_3H_8 \rightarrow HC\ell(v=2) + C_3H_8^{\dagger}$	V-V & V-T	3.8×10^{-11}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + C_3H_8 \rightarrow HC\ell(v=3) + C_3H_8^{\dagger}$	V-V & V-T	3.8×10^{-11}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + C_3H_8 \rightarrow HC\ell(v=4) + C_3H_8^{\dagger}$	V-V & V-T	5.3×10^{-11}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + C_3H_8 \rightarrow HC\ell(v=5) + C_3H_8^{\dagger}$	V-V & V-T	8.6×10^{-11}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + C_3H_8 \rightarrow HC\ell(v=6) + C_3H_8^{\dagger}$	V-V & V-T	9.6×10^{-11}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + iso\text{-}C_4H_8 \rightarrow HC\ell(v=0) + iso\text{-}C_4H_8^{\dagger}$	V-V & V-T	6.5×10^{-11}	±30	2886	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=2) + iso\text{-}C_4H_8 \rightarrow HC\ell(v=1) + iso\text{-}C_4H_8^{\dagger}$	V-V & V-T	5.5×10^{-11}	±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + iso\text{-}C_4H_8 \rightarrow HC\ell(v=2) + iso\text{-}C_4H_8^{\dagger}$	V-V & V-T	5.6×10^{-11}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + iso\text{-}C_4H_8 \rightarrow HC\ell(v=3) + iso\text{-}C_4H_8^{\dagger}$	V-V & V-T	6.2×10^{-11}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + iso\text{-}C_4H_8 \rightarrow HC\ell(v=4) + iso\text{-}C_4H_8^{\dagger}$	V-V & V-T	7.5×10^{-11}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + iso\text{-}C_4H_8 \rightarrow HC\ell(v=5) + iso\text{-}C_4H_8^{\dagger}$	V-V & V-T	1.0×10^{-10}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + iso\text{-}C_4H_8 \rightarrow HC\ell(v=6) + iso\text{-}C_4H_8^{\dagger}$	V-V & V-T	1.2×10^{-10}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + C\ell \rightarrow HC\ell(v=0) + C\ell$	V-T	1.1×10^{-11}	±60	2886	294	DR-LF	71 Craig and Moore 1971
		9.7×10^{-13} Probably incorrect	±10	2886	295	FR	152 Ridley and Smith 1971
		8.8×10^{-12}		2886	298	LF-DF	52 Brown...Smith 1975
		8.3×10^{-12}	±25	2886	295	LF-DF	53 Brown...Smith 1975
		8.8×10^{-12}	±30	2886	294	LF-DF	133 Macdonald...Wodarczyk 1975
		6×10^{-12}	±40	2886	294	DR-LF	133 Macdonald...Wodarczyk 1975
		5.8×10^{-12}	±15	2886	295	LF-DF	9 Arnoldi and Wolfrum 1976
		6.1×10^{-12}	±25	2886	295	LF-DF	117 Kneba and Wolfrum 1979
		7.4×10^{-12}	±10	2886	294	LF-DF	132 Macdonald and Moore 1980
		1.1×10^{-11} The quoted rate is for isotopic exchange, $^{37}C\ell + H^{35}C\ell(v=1)$, which is twice the deactivation rate		0	295	LF-MS	117 Kneba and Wolfrum 1979
		2.6×10^{-12} 1.5×10^{-11}	±20	2886	195- 397	LF-DF	53 Brown...Smith 1975
	V-T	6.7×10^{-12} 1.5×10^{-11}		2886	263- 397	LF-DF	52 Brown...Smith 1975
		7.4×10^{-12} 8.1×10^{-12}	±10	2886	294- 439	LF-DF	132 Macdonald and Moore 1980
$HC\ell(v=2) + C\ell \rightarrow HC\ell(v=1) + C\ell$	V-T	3.1×10^{-12} Probably incorrect	±35	2782	295	FR	152 Ridley and Smith 1971
		3.3×10^{-11} Observed to be entirely relaxation to v=1	±15	2782	294	LF-DF	132 Macdonald and Moore 1980

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=2) + C\ell \rightarrow HC\ell(v=1) + C\ell$ (cont'd.)		3.3×10^{-11} 3.2×10^{-11}	±15	2782	294- 439	LF-DF	132 Macdonald and Moore 1980
$HC\ell(v=3) + C\ell \rightarrow HC\ell(v=2) + C\ell$		8.1×10^{-12}	±10	2678	295	FR	152 Ridley and Smith 1971
		Probably incorrect					
$HC\ell(v=1) + C\ell_2 \rightarrow HC\ell(v=0) + C\ell_2^{\dagger}$	V-V & V-T	5.6×10^{-15}	±20	2886	295	LF	71 Craig and Moore 1971
		6.9×10^{-15}	±20	2886	295	LF	40 Bott and Cohen 1975
		When corrected for CO_2 impurity gives 5.6×10^{-15}					
		1.1×10^{-14} 3.9×10^{-14}	±20	2886	449- 679	LF-ST	40 Bott and Cohen 1975
		The correction for CO_2 impurity is not needed since $HC\ell$ deactivated by CO_2 is temperature insensitive					
$HC\ell + C\ell_2$, see also $C\ell_2 + HC\ell$							
$HC\ell(v=1) + CO(v=0) \rightarrow HC\ell(v=0) + CO(v=1)$	V-V	8.3×10^{-14}	±10	743	295	LF	63 Chen and Moore 1971
		7.28×10^{-14}	±4	743	295	LF	4 Allée...Doyennette 1974
		7.28×10^{-14} 2.7×10^{-13}	±5	743	295- 1000	LF	4 Allée...Doyennette 1974
		1.5×10^{-13} 6.6×10^{-13}	±10	743	660- 1600	ST	158 Seery 1975
$HC\ell(v=2) + CO(v=0) \rightarrow HC\ell(v=1) + CO(v=1)$	V-V & V-T	$\sim 1.2 \times 10^{-12}$	>±30	639	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + CO(v=0) \rightarrow HC\ell(v=2) + CO(v=1)$	V-V & V-T	1.7×10^{-12}	±30	536	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + CO(v=0) \rightarrow HC\ell(v=3) + CO(v=1)$	V-V & V-T	4×10^{-12}	±30	433	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + CO(v=0) \rightarrow HC\ell(v=4) + CO(v=1)$	V-V & V-T	1.7×10^{-11}	±30	330	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + CO(v=0) \rightarrow HC\ell(v=5) + CO(v=1)$	V-V & V-T	3.5×10^{-11}	±30	228	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + CO(v=0) \rightarrow HC\ell(v=6) + CO(v=1)$	V-V & V-T	3.8×10^{-11}	±30	126	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + CO(v=0) \rightarrow HC\ell(v=0) + CO(v=0)$	V-T	6.4×10^{-14} 4.5×10^{-14}	±20	2886	660- 1600	ST	158 Seery 1975
		2.1×10^{-14} 1.8×10^{-13}	±10	2886	1200- 2000	ST	22 Borrell...Gutteridge 1974
$HC\ell + CO$, see also $CO + HC\ell$							
$HC\ell(v=1) + CO_2(000) \rightarrow HC\ell(v=0) + CO_2(001)$	V-V	2.9×10^{-12}	±5	536(001) -131(011)	295	LF	64 Chen...Moore 1968
		2.1×10^{-12}		536(001) -131(011)	295	FR	153 Ridley and Smith 1972
		2.6×10^{-12}	±5	536(001) -131(011)	295	LF	167 Stephenson...Moore 1972
		Reports that the results of Ref. 64 are slightly high					
		2.6×10^{-12}		536	295	LF	80 Doyennette...Henry 1978
		1.9×10^{-12}	±30	536	298	FT	15 Berquist...Kaufman 1982
		2.6×10^{-12} 3.0×10^{-12}	±5	536	295- 510	LF	167 Stephenson...Moore 1972
		2.6×10^{-12} 4.4×10^{-12}		536	295- 900	LF	80 Doyennette...Henry 1978
$HC\ell(v=2) + CO_2(000) \rightarrow HC\ell(v=0) + CO_2(001)$	V-V & V-T	6.8×10^{-12}		433	295	FR	153 Ridley and Smith 1972
		9.0×10^{-12}	±30	433	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=3) + CO_2(000) \rightarrow HC\ell(v=2) + CO_2(001)$	V-V & V-T	1.55×10^{-11}		330	295	FR	153 Ridley and Smith 1972
		The rate constants in Ref. 153 are internally consistent, but their absolute magnitudes may be in error					
		2.3×10^{-11}	±30	330	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=n) + CO_2(000) \rightarrow HC\ell(v=n-1) + CO_2(001)$	V-V & V-T	$\frac{n=3}{1.0}$ $\frac{n=4}{2.3}$ Relative rates only			295	CD	11 Bartoszek...Polanyi 1978

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=4) + CO_2(000) \rightarrow HC\ell(v=3) + CO_2(001)$	V-V & V-T	7.0×10^{-11}	±30	227	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=5) + CO_2(000) \rightarrow HC\ell(v=4) + CO_2(001)$	V-V & V-T	1.4×10^{-10}	±30	124	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=6) + CO_2(000) \rightarrow HC\ell(v=5) + CO_2(001)$	V-V & V-T	1.7×10^{-10}	±30	22	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=7) + CO_2(000) \rightarrow HC\ell(v=6) + CO_2(001)$	V-V & V-T	1.0×10^{-10}	±30	-80	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=1) + CO_2(000) \rightarrow HC\ell(v=0) + CO_2(nm0)$	V-T	$\leq 1.1 \times 10^{-12}$		2886	295	LF	167 Stephenson...Moore 1972
		2.9×10^{-13}		2886	295	LF	80 Doyennette...Henry 1978
		2.9×10^{-13} 3.4×10^{-13}		2886	295- 900	LF	80 Doyennette...Henry 1978
$HC\ell + CO_2$, see also $CO_2 + HC\ell$							
$HC\ell(v=1) + D \rightarrow HC\ell(v=0) + D$	V-T & Exchange & Rx	8.3×10^{-12}	±30	2886	295	LF-MS	9 Arnoldi and Wolfrum 1976
		The exchange rate is 20 times slower than the relaxation					
		1.1×10^{-11}	±30	2886	295	LF-DF	41 Bott and Heidner 1976
$HC\ell(v=1) + DC\ell(v=0) \rightarrow HC\ell(v=0) + DC\ell(v=1)$	V-V	1.00×10^{-13}	±5	795	295	LF	64 Chen and Moore 1971
$HC\ell(v=2) + DC\ell(v=0) \rightarrow HC\ell(v=1) + DC\ell(v=1)$	V-V	4.0×10^{-13}	±15	691	295	LF	72 Dasch and Moore 1980
		Direct excitation to $HC\ell(v=2)$					
$HC\ell(v=5) + DC\ell(v=0) \rightarrow HC\ell(v=4) + DC\ell(v=1)$	V-V & V-T	3.3×10^{-11}	±30	432	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + DC\ell(v=0) \rightarrow HC\ell(v=5) + DC\ell(v=1)$	V-V & V-T	5.9×10^{-11}	±30	330	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + DC\ell(v=0) \rightarrow HC\ell(v=6) + DC\ell(v=1)$	V-V & V-T	1.1×10^{-10}	±30	228	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + DCN \rightarrow HC\ell(v=0) + DCN^{\dagger}$	V-V & V-T	2.22×10^{-12}	±5	2886	296	LF	7 Arnold and Smith 1980
$HC\ell(v=1) + D_2(v=0) \rightarrow HC\ell(v=0) + D_2(v=0)$	V-T	$\leq 5.2 \times 10^{-16}$	±15	2886	295	LF	105 Hopkins and Chen 1972
		Value reported is for $k_{HC\ell-D_2} + 0.60\ k_{D_2-HC\ell}$					
$HC\ell + D_2$, see also $D_2 + HC\ell$							
$HC\ell(v=1) + DF(v=0) \rightarrow HC\ell(v=0) + DF(v=0)$	V-T	$<5.3 \times 10^{-13}$		2886	295	LF	26 Bott 1974
		$<3.5 \times 10^{-13}$ $<3 \times 10^{-13}$		2886	475- 745	LF-ST	26 Bott 1974
$HC\ell(v=1) + H \rightarrow HC\ell(v=0) + H$	V-T & Rx	6.5×10^{-12}	±35	2886	295	LF-DF	10 Arnoldi and Wolfrum 1974
		6.8×10^{-12}	±25	2886	295	LF-DF	99 Heidner and Bott 1975
		7.0×10^{-12}	±15	2886	295	LF-DF	9 Arnoldi and Wolfrum 1976
		The deactivation is 50 times faster than reaction					
		7.6×10^{-12}	±30	2886	295	LF-DF	41 Bott and Heidner 1976
		3.4×10^{-12}	±15	2886	296	LF-DF	132 Macdonald and Moore 1980
		The reactive channel may be as much as 50%					
$HC\ell(v=2) + H \rightarrow HC\ell(v=1) + H$	V-T & Rx	2.6×10^{-11}	±20	2782	296	LF-DF	132 Macdonald and Moore 1980
		Deactivation to v=1 is only 35% of total					
$HC\ell(v=1) + HBr(v=0) \rightarrow HC\ell(v=0) + HBr(v=1)$	V-V	1.2×10^{-12}	±35	327	295	FP	74 Donovan...Stevenson 1970
		1.1×10^{-12}	±10	327	295	LF	63 Chen and Moore 1970
		V-T contribution is less than 3%					
		1.1×10^{-12}	±10	327	295	LF	60 Chen 1971
		8.4×10^{-13}		327	295	FR	153 Ridley and Smith 1972
		The rate constants in Ref. 153 are internally consistent, but their absolute magnitudes may be in error					
		9.6×10^{-13}	±10	327	295	LF	40 Bott and Cohen 1975
$HC\ell(v=2) + HBr(v=0) \rightarrow HC\ell(v=1) + HBr(v=1)$	V-V	2.9×10^{-12}	±10	223	295	LF	72 Dasch and Moore 1980
		Direct excitation to $HC\ell(v=2)$					
$HC\ell(v=2) + HBr(v=0) \rightarrow HC\ell(v=0) + HBr(v=2)$	V-V	$<3.1 \times 10^{-14}$		641	295	LF	72 Dasch and Moore 1980
$HC\ell(v=1) + HC\ell(v=1) \rightarrow HC\ell(v=2) + HC\ell(v=0)$	V-V	4.6×10^{-12}	±20	104	295	LF	57 Burak...Szöke 1972
		4.6×10^{-12}	±15	104	295	LF	106 Hopkins and Chen 1972

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=1) + HC\ell(v=1) \rightarrow HC\ell(v=2) + HC\ell(v=0)$ (cont'd.)		2.3×10^{-12}		104	295	FR	153 Ridley and Smith 1972
		The rate constants in Ref. 153 are internally consistent, but their absolute magnitudes may be in error					
		5.1×10^{-12}	±10	104	295	LF	125 Leone and Moore 1973
		Direct excitation to $HC\ell(v=2)$					
		4.7×10^{-12}	±10	104	295	LF	72 Dasch and Moore 1980
		Direct excitation to $HC\ell(v=2)$					
		5.1×10^{-12}	±15	104	294	LF	132 Macdonald and Moore 1980
		Direct excitation to $HC\ell(v=2)$					
		4.6×10^{-12}		104	296	LF	156 Schramm and Rapp 1980
		5.6×10^{-12}	±30	104	298	FT	14 Berquist...Kaufman 1982
		4.6×10^{-12} 4.6×10^{-12}		104	193- 296	LF	156 Schramm and Rapp 1980
		5.1×10^{-12} 3.2×10^{-12}	±15	104	294- 439	LF	132 Macdonald and Moore 1980
		4.6×10^{-12} 4.5×10^{-12}	±10	104	320- 700	LF	140 Noter...Szöke 1973
$HC\ell(v=3) + HC\ell(v=0) \rightarrow HC\ell(v=2) + HC\ell(v=1)$	V-V & V-T	1.8×10^{-12}		-207	295	FR	153 Ridley and Smith 1972
		The rate constants in Ref. 153 are internally consistent, but their absolute magnitudes may be in error					
		3.1×10^{-12}	±30	-207	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + HC\ell(v=0) \rightarrow HC\ell(v=3) + HC\ell(v=1)$	V-V & V-T	$\sim 3.6 \times 10^{-12}$	>±30	-310	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + HC\ell(v=0) \rightarrow HC\ell(v=4) + HC\ell(v=1)$	V-V & V-T	1.8×10^{-11}	±30	-413	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + HC\ell(v=0) \rightarrow HC\ell(v=5) + HC\ell(v=1)$	V-V & V-T	3.9×10^{-11}	±30	-515	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + HC\ell(v=0) \rightarrow HC\ell(v=6) + HC\ell(v=1)$	V-V & V-T	5.8×10^{-11}	±30	-617	298	FT	14 Berquist...Kaufman 1982
$H^{35}C\ell(v=1) + H^{37}C\ell(v=0) \rightarrow H^{35}C\ell(v=0) + H^{37}C\ell(v=1)$	V-V	1.9×10^{-11}	±30	2	295	LF	125 Leone and Moore 1973
		1.91×10^{-11}	±2	2	295	LF	109 Horwitz and Leone 1978
		2.95×10^{-11} 8.23×10^{-12}	±10	2	192- 620	LF	110 Horwitz and Leone 1979
$HC\ell(v=1) + HC\ell(v=0) \rightarrow HC\ell(v=0) + HC\ell(v=0)$	V-T	3.7×10^{-18}		2886	290	SP	84 Ferguson and Read 1967
		Value is unreasonably small					
		2.6×10^{-14}	±10	2886	295	LF	62 Chen and Moore 1971
		$>2 \times 10^{-13}$ $<9 \times 10^{-12}$		2886		LG	91 Gorschkov...Oraevsky 1971
		2.2×10^{-14}		2886	295	LF	134 Margottin-Maclau...Henry 1971
		1.4×10^{-13}		2886	295	LF	5 Arbartzumian...Chekalin 1972
		Direct excitation to v=3, detect v = 3-2, 2-1, probably incorrect					
		3.7×10^{-14}	±25	2886	300	LF	1 Ahl and Cool 1973
		2.6×10^{-14}	±15	2886	295	LF	37 Bott and Cohen 1973
		2.8×10^{-14}	±20	2886	295	LF	156 Schramm and Rapp 1980
		3.5×10^{-14} 2.8×10^{-14}	±20	2886	190- 295	LF	156 Schramm and Rapp 1980
		3.8×10^{-14} 4.9×10^{-14}	±15 ±10	2886	196- 342	LF	108 Hopkins...Sharma 1973
		3.3×10^{-14}	±25	2886	350	LF	1 Ahl and Cool 1973
		8.7×10^{-14} 4.9×10^{-14}	±10	2886	144- 584	LF	178 Zittel and Moore 1973
		There is a minimum in the rate at 410-470 K (2.0×10^{-14})					
		$\sim 4.9 \times 10^{-14}$		2886	470	LF	37 Bott and Cohen 1973

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=1) + HC\ell(v=0) + HC\ell(v=0) + HC\ell(v=0)$ (cont'd.)		9.5×10^{-14} 1.3×10^{-12}	±30	2886	700- 1900	ST	47 Breshears and Bird 1969
		1.5×10^{-13} 1.1×10^{-12}		2886	1100- 2000	ST	45 Bowman and Seery 1969
		8.8×10^{-15} 4.3×10^{-14} Values are many times too small		2886	1300- 2200	ST	21 Borrell 1966
$HC\ell(v=2) + HC\ell(v=0) \rightarrow HC\ell(v=1) + HC\ell(v=0)$	V-T	$<3.1 \times 10^{-13}$		2782	295	LF	72 Dasch and Moore 1980
$HC\ell(v=1) + HCN(000) \rightarrow HC\ell(v=0) + HCN(nm0)$	V-T	1.43×10^{-12} (001) channel in HCN is very minor	±3	2886	296	LF	7 Arnold...Smith 1980
$HC\ell + HCN$, see also $HCN + HC\ell$							
$HC\ell(v=1) + HD(v=0) \rightarrow HC\ell(v=0) + HD(v=0)$	V-T	2.5×10^{-15}	±15	2886	295	LF	105 Hopkins and Chen 1972
$HC\ell + HD$, see also $HD + HC\ell$							
$HC\ell(v=1) + {}^3He + HC\ell(v=0) + {}^3He$	V-T	1.2×10^{-16}	$^{+20}_{-40}$	2886	295	LF	165 Steele and Moore 1974
$HC\ell(v=1) + He + HC\ell(v=0) + He$	V-T	$<6 \times 10^{-17}$		2886	295	LF	62 Chen and Moore 1971
		5.6×10^{-17}	±10	2886	295	LF	165 Steele and Moore 1974
		4.1×10^{-17} 1.1×10^{-16}	±15	2886	196- 342	LF	108 Hopkins and Chen 1973
		5.6×10^{-17} 2.1×10^{-15}	±10	2886	295- 700	LF	165 Steele and Moore 1974
		3.9×10^{-14} 1.4×10^{-13}	±20	2886	1160- 1630	ST	157 Seery 1973
$HC\ell(v=1) + HF(v=0) \rightarrow HC\ell(v=0) + HF(v=0)$	V-T	6.2×10^{-13}	±15	2886	300	LF	1 Ahl and Cool 1973
		4.6×10^{-13}	±15	2886	295	LF	37 Bott and Cohen 1973
		4.0×10^{-13}	±15	2886	295	LF	40 Bott and Cohen 1975
		4.9×10^{-13}	±25	2886	350	LF	1 Ahl and Cool 1973
		1.9×10^{-13}	±10	2886	470	LF	37 Bott and Cohen 1973
		4.2×10^{-13} 7.9×10^{-13}	±15	2886	468- 632	LF-ST	40 Bott and Cohen 1975
$HC\ell(v=2) + HF(v=0) \rightarrow HC\ell(v=1) + HF(v=0)$	V-T	$\sim 5 \times 10^{-13}$	>±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + HF(v=0) \rightarrow HC\ell(v=2) + HF(v=0)$	V-T	2.5×10^{-12}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + HF(v=0) \rightarrow HC\ell(v=3) + HF(v=0)$	V-T	8×10^{-12}	±30	2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + HF(v=0) \rightarrow HC\ell(v=4) + HF(v=0)$	V-T	2.5×10^{-11}	±30	2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + HF(v=0) \rightarrow HC\ell(v=5) + HF(v=0)$	V-T	4.5×10^{-11}	±30	2371	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + HF(v=0) \rightarrow HC\ell(v=6) + HF(v=0)$	V-T	5.2×10^{-11}	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + H_2(v=0) \rightarrow HC\ell(v=0) + H_2(v=0)$	V-T	5.2×10^{-15} Strictly V-T process, no double exponential observed for V-V contribution	±20	2886	295	LF	62 Chen and Moore 1971
		5.5×10^{-15}	±10	2886	295	LF	40 Bott and Cohen 1975
		$\sim 4.8 \times 10^{-15}$ Crude estimate only		2886	295	LG	136 Menard-Bourcin...Henry 1975
		5.9×10^{-15}		2886	296	LF	156 Schramm and Rapp 1980
		4.3×10^{-15} 5.9×10^{-15}		2886	143- 296	LF	156 Schramm and Rapp 1980
		1.3×10^{-14} 9.1×10^{-14}	±10	2886	403- 770	LF-ST	40 Bott and Cohen 1975
		1.6×10^{-13} 7.5×10^{-13}		2886	1000- 2000	ST	155 Rosen...Taylor 1979
$HC\ell(v=2) + H_2(v=0) \rightarrow HC\ell(v=1) + H_2(v=0)$	V-T	$\sim 9.7 \times 10^{-15}$ Crude estimate only		2782	295	LG	136 Menard-Bourcin...Henry 1975

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=3) + H_2(v=0) \rightarrow HC\ell(v=2) + H_2(v=0)$	V-T	$\sim 1.6 \times 10^{-14}$ Crude estimate only		2679	295	LG	136 Menard-Bourcin...Henry 1975
$HC\ell(v=4) + H_2(v=0) \rightarrow HC\ell(v=3) + H_2(v=0)$	V-T	$\sim 2.1 \times 10^{-14}$ Crude estimate only		2576	295	LG	136 Menard-Bourcin...Henry 1975
$HC\ell + H_2$, see also $H_2 + HC\ell$							
$HC\ell(v=1) + H_2O \rightarrow HC\ell(v=0) + H_2O^{\dagger}$	V-V & V-T	1.5×10^{-11}	±60	2886	295	LF	62 Chen and Moore 1971
$HC\ell(v=1) + H_2S \rightarrow HC\ell(v=0) + H_2S^{\dagger}$	V-V & V-T	2.3×10^{-12}	±10	$202(\nu_3)$ $276(\nu_1)$	295	LF	70 Coombe...Pilipovitch 1975
$HC\ell(v=1) + H_2Se \rightarrow HC\ell(v=0) + H_2Se^{\dagger}$	V-V & V-T	8.0×10^{-13}	±10	2886 $626(\nu_3)$ $536(\nu_1)$	295	LF	70 Coombe...Pilipovitch 1975
$HC\ell(v=1) + HI(v=0) \rightarrow HC\ell(v=0) + HI(v=1)$	V-V	1.6×10^{-13}	±10	653	295	LF	64 Chen...Moore 1968
		1.6×10^{-13} V-T contribution is less than 15%	±15	653	295	LF	63 Chen and Moore 1971
$HC\ell(v=1) + HNO_3 \rightarrow HC\ell(v=0) + HNO_3^{\dagger}$	V-V & V-T	$\sim 3.1 \times 10^{-12}$		2886	295	LF	70 Coombe...Pilipovitch 1975
$HC\ell(v=1) + Kr \rightarrow HC\ell(v=0) + Kr$		4.4×10^{-14} 4.8×10^{-13}	±70	2886	1900- 4000	ST	157 Seery 1973
$HC\ell(v=1) + Ne \rightarrow HC\ell(v=0) + Ne$		$<6 \times 10^{-17}$		2886	295	LF	62 Chen and Moore 1971
		2.8×10^{-17}	±30	2886	295	LF	165 Steele and Moore 1974
		1.5×10^{-14} 8.5×10^{-14}	±30	2886	1160- 1950	ST	157 Seery 1973
$HC\ell(v=1) + NO(v=0) \rightarrow HC\ell(v=0) + NO(v=1)$	V-V	9.6×10^{-14}	±10	1010	295	LF	177 Zittel and Moore 1973
		2.9×10^{-13}	±30	1010	298	FT	14 Berquist...Kaufman 1982
		1.2×10^{-13} 1.0×10^{-13}		1010	194- 295	LF	156 Schramm and Rapp 1980
$HC\ell(v=2) + NO(v=0) \rightarrow HC\ell(v=1) + NO(v=1)$	V-V & V-T	6.8×10^{-13}	±30	906	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + NO(v=0) \rightarrow HC\ell(v=2) + NO(v=1)$	V-V & V-T	2.5×10^{-12}	±30	803	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + NO(v=0) \rightarrow HC\ell(v=3) + NO(v=1)$	V-V & V-T	1.0×10^{-11}	±30	700	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + NO(v=0) \rightarrow HC\ell(v=4) + NO(v=1)$	V-V & V-T	2.7×10^{-11}	±30	597	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + NO(v=0) \rightarrow HC\ell(v=5) + NO(v=1)$	V-V & V-T	5.1×10^{-11}	±30	495	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + NO(v=0) \rightarrow HC\ell(v=6) + NO(v=1)$	V-V & V-T	3.7×10^{-11} Reaction for v = 5,6,7 is unlikely	±30	393	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + NO_3C\ell \rightarrow HC\ell(v=0) + NO_3C\ell^{\dagger}$	V-V & V-T	8.0×10^{-13}	±15	2886	295	LF	70 Coombe...Pilipovitch 1975
$HC\ell(v=1) + N_2(v=0) \rightarrow HC\ell(v=0) + N_2(v=1)$	V-V	2.7×10^{-14}	±10	555	295	LF	63 Chen and Moore 1971
		2.94×10^{-14}	±4	555	295	LF	4 Allée...Doyennette 1974
		2.7×10^{-14}	±10	555	295	LF	40 Bott and Cohen 1975
		2.6×10^{-14}		555	296	LF	156 Schramm and Rapp 1980
		2.4×10^{-14} 2.6×10^{-14}		555	193- 296	LF	156 Schramm and Rapp 1980
		3.1×10^{-14} 4.6×10^{-14}	±10	555	463- 686	LF-ST	40 Bott and Cohen 1975
		2.94×10^{-14} 9.10×10^{-14}	±4	555	300- 1000	LF	4 Allée...Doyennette 1974
$HC\ell(v=3) + N_2(v=0) \rightarrow HC\ell(v=2) + N_2(v=1)$	V-V & V-T	$\sim 1.4 \times 10^{-13}$	>±30	349	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + N_2(v=0) \rightarrow HC\ell(v=3) + N_2(v=1)$	V-V & V-T	4.5×10^{-13}	±30	246	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + N_2(v=0) \rightarrow HC\ell(v=4) + N_2(v=1)$	V-V & V-T	8.1×10^{-13}	±30	143	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + N_2(v=0) \rightarrow HC\ell(v=5) + N_2(v=1)$	V-V & V-T	1.2×10^{-12}	±30	41	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=7) + N_2(v=0) \rightarrow HC\ell(v=6) + N_2(v=1)$	V-V & V-T	7.0×10^{-13}	±30	-61	298	FT	14 Berquist...Kaufman 1982

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=1) + NO_2 \rightarrow HC\ell(v=0) + NO_2^{\dagger}$	V-V & V-T	9.5×10^{-13}	±30	2886	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=2) + NO_2 \rightarrow HC\ell(v=1) + NO_2^{\dagger}$	V-V & V-T	$\sim 1.2 \times 10^{-12}$	>±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + NO_2 \rightarrow HC\ell(v=2) + NO_2^{\dagger}$	V-V & V-T	2.0×10^{-12}	±30	2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + NO_2 \rightarrow HC\ell(v=3) + NO_2^{\dagger}$	V-V & V-T	4.0×10^{-12}	±30	2576	298	FT	14 Berquist...Kaufman 1982
		Reaction unlikely					
$HC\ell(v=1) + N_2O(000) \rightarrow HC\ell(v=0) + N_2O(001)$	V-V	1.1×10^{-12}		662	295	LF	80 Doyennette...Henry 1978
		1.8×10^{-12}	±30	662	298	FT	15 Berquist...Kaufman 1982
		1.1×10^{-12} 1.9×10^{-12}		662	295- 700	LF	80 Doyennette...Henry 1978
$HC\ell(v=2) + N_2O(000) \rightarrow HC\ell(v=1) + N_2O(001)$	V-V & V-T	4.5×10^{-12}	±30	558	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=3) + N_2O(000) \rightarrow HC\ell(v=2) + N_2O(001)$	V-V & V-T	1.2×10^{-11}	±30	455	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=4) + N_2O(000) \rightarrow HC\ell(v=3) + N_2O(001)$	V-V & V-T	4.5×10^{-11}	±30	352	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=5) + N_2O(000) \rightarrow HC\ell(v=4) + N_2O(001)$	V-V & V-T	9.6×10^{-11}	±30	249	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=6) + N_2O(000) \rightarrow HC\ell(v=5) + N_2O(001)$	V-V & V-T	1.5×10^{-10}	±30	147	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=7) + N_2O(000) \rightarrow HC\ell(v=6) + N_2O(001)$	V-V & V-T	1.5×10^{-10}	±30	45	298	FT	15 Berquist...Kaufman 1982
$HC\ell(v=1) + N_2O(000) \rightarrow HC\ell(v=0) + N_2O(nm0)$	V-T	3.1×10^{-13}		2886	295	LF	80 Doyennette...Henry 1978
		3.1×10^{-13} 3.6×10^{-13}		2886	295- 700	LF	80 Doyennette...Henry 1978
$HC\ell + N_2O$, see also $N_2O + HC\ell$							
$HC\ell(v=1) + O \rightarrow HC\ell(v=0) + O$	V-T & Rx	3.7×10^{-12}	±35	2886	298	LF-DF	10 Arnoldi and Wolfrum 1974
		It is thought that the reactive channel is dominant					
		9×10^{-13}		2886	298	LF-DF	52 Brown...Smith 1975
		1.0×10^{-12}	±20	2886	300	LF-DF	55 Brown...Smith 1975
		3.5×10^{-13}	±5	2886	295	LF-DF	115 Karny...Szőke 1975
		Reactive contribution is thought to be 1.8×10^{-13}					
		8.9×10^{-13}	±15	2886	296	LF-DF	131 Macdonald and Moore 1978
		4.3×10^{-13} 2.8×10^{-12}	±20	2886	196- 400	LF-DF	55 Brown...Smith 1975
$HC\ell(v=2) + O \rightarrow HC\ell(v=1) + O$	V-T & Rx	5.2×10^{-12}	±10	2782	296	LF-DF	131 Macdonald and Moore 1978
		Reactive contribution is 1.5×10^{-12} (±90% error)					
$HC\ell(v=1) + OCS \rightarrow HC\ell(v=0) + OCS^{\dagger}$	V-V & V-T	6.2×10^{-13}	±10	812(001) -32(101)	296	LF	103 Hopkins and Chen 1973
$HC\ell(v=1) + O_2(v=0) \rightarrow HC\ell(v=0) + O_2(v=1)$	V-V	3.3×10^{-15}	±10	1330(v=1) -203(v=2)	295	LF	177 Zittel and Moore 1973
$HC\ell(v=1) + {}^{18}O_2(v=0) \rightarrow HC\ell(v=0) + {}^{18}O_2(v=1)$		5.4×10^{-15}	±15	1417(v=1) -30(v=2)	295	LF	177 Zittel and Moore 1973
		Concluded that $\Delta V=2$ changes in O_2 may be important					
$HC\ell(v=2) + O_2(v=0) \rightarrow HC\ell(v=1) + O_2(v=1)$	V-V & V-T	7.6×10^{-15}	±20	1226(v=1)	295	FT	168 Thomas and Thrush 1977
$HC\ell + O_3$, see $O_3 + HC\ell$							
$HC\ell(v=1) + PF_3H_2 \rightarrow HC\ell(v=0) + PF_3H_2^{\dagger}$	V-V & V-T	9.3×10^{-13}	±35	2886	295	LF	70 Coombe...Pilipovich 1975
$HC\ell(v=1) + SF_6 \rightarrow HC\ell(v=0) + SF_6^{\dagger}$	V-V & V-T	3.0×10^{-15}	±10	2886	295	LF	177 Zittel and Moore 1973
		5.5×10^{-13}	±30	2886	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=2) + SF_6 \rightarrow HC\ell(v=1) + SF_6^{\dagger}$	V-V & V-T	$\sim 1 \times 10^{-13}$	>±30	2762	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=3) + SF_6 \rightarrow HC\ell(v=2) + SF_6^{\dagger}$	V-V & V-T	$\lesssim 1 \times 10^{-13}$		2679	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=4) + SF_6 \rightarrow HC\ell(v=3) + SF_6^{\dagger}$	V-V & V-T	$\lesssim 1 \times 10^{-13}$		2576	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=5) + SF_6 \rightarrow HC\ell(v=4) + SF_6^{\dagger}$	V-V & V-T	$\lesssim 1 \times 10^{-13}$		2473	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=6) + SF_6 \rightarrow HC\ell(v=5) + SF_6^{\dagger}$	V-V & V-T	$\sim 1 \times 10^{-13}$	±30	2371	298	FT	14 Berquist...Kaufman 1982

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HC\ell(v=7) + SF_6 \rightarrow HC\ell(v=6) + SF_6^\dagger$	V-V & V-T	$\sim 1.6 \times 10^{-13}$	±30	2269	298	FT	14 Berquist...Kaufman 1982
$HC\ell(v=1) + SiHC\ell_3 \rightarrow HC\ell(v=0) + SiHC\ell_3^\dagger$	V-V & V-T	1.3×10^{-13}	±5	2886	295	LF	70 Coombe...Pilipovitch 1975
$HC\ell(v=1) + SiH_2C\ell_2 \rightarrow HC\ell(v=0) + SiH_2C\ell_2^\dagger$	V-V & V-T	4.3×10^{-13}	±10	2886	295	LF	70 Coombe...Pilipovitch 1975
$HC\ell(v=1) + SOC\ell_2 \rightarrow HC\ell(v=0) + SOC\ell_2^\dagger$	V-V & V-T	3.4×10^{-13}	±10	2886	295	LF	70 Coombe...Pilipovitch 1975
$HCN(001) + DBr(v=0) \rightarrow HCN(nm0) + DBr(v=0)$	V-T	1.3×10^{-13}	±25	3312	296	LF	7 Arnold...Smith 1980
$HCN(001) + DC\ell(v=0) \rightarrow HCN(nm0) + DC\ell(v=0)$	V-T	1.5×10^{-13}	±20	3312	296	LF	7 Arnold...Smith 1980
$HCN(001) + DF(v=0) \rightarrow HCN(000) + DF(v=1)$	V-V & V-T	9.6×10^{-13}	±35	405	298	LF	135 McGarvey...Cool 1977
		1.4×10^{-12} 6.9×10^{-13}	±35	405	240- 450	LF	135 McGarvey...Cool 1977
$HCN(001) + HBr(v=0) \rightarrow HCN(nm0) + HBr(v=0)$	V-T	2.63×10^{-13}	±5	3312	296	LF	7 Arnold...Smith 1980
$HCN(001) + HC\ell(v=0) \rightarrow HCN(nm0) + HC\ell(v=0)$	V-T	3.17×10^{-13}	±5	3312	296	LF	7 Arnold...Smith 1980
$HCN(001) + HF(v=0) \rightarrow HCN(nm0) + HF(v=0)$	V-T	1.3×10^{-12}	±15	3312	298	LF	135 McGarvey...Cool 1977
		V-V contribution is less than 20%					
		1.4×10^{-12} 7.4×10^{-13}	±25	3312	240- 449	LF	135 McGarvey...Cool 1977
$HD(v=1) + HC\ell(v=0) \rightarrow HD(v=0) + HC\ell(v=1)$	V-V	1.05×10^{-13}	±10	741	295	LF	105 Hopkins and Chen 1972
$HF(v=1) + Ar \rightarrow HF(v=0) + Ar$	V-T	$<1.9 \times 10^{-15}$		3962	294	LF	95 Hancock and Green 1972
		$<1.9 \times 10^{-15}$		3962	295	LF	94 Hancock and Green 1972
		$<1.9 \times 10^{-15}$		3962	295	LF	100 Hinchen 1973
		$<1.1 \times 10^{-14}$		3962	350	LF	2 Airey and Fried 1971
		$<3.1 \times 10^{-15}$		3962	350	LF	89 Fried...Taylor 1973
		2.5×10^{-15} 6.2×10^{-14}	±20	3962	800- 2400	LF-ST	16 Blair...Schott 1973
		8.3×10^{-14} 6×10^{-13}		3962	1350- 4000	ST	34 Bott and Cohen 1971
		9.5×10^{-15} 4.2×10^{-13}		3962	1500- 5000	ST	171 Vasil'ev...Tal'roze 1973
$HF(v=3) + Ar \rightarrow HF(v=2) + Ar$	V-T	$\sim 1 \times 10^{-15}$		3622	296	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
		$<1 \times 10^{-15}$		3622	295	LF	162 Wrigley and Smith 1981
$HF(v=4) + Ar \rightarrow HF(v=3) + Ar$	V-T	$<2 \times 10^{-15}$		3459	295	LF	162 Wrigley and Smith 1981
$HF(v=6) + Ar \rightarrow HF(v=5) + Ar$	V-T	$<6 \times 10^{-15}$		3143	295	LF	162 Wrigley and Smith 1981
$HF(v=1) + BF_3 \rightarrow HF(v=0) + BF_3^\dagger$	V-V & V-T	4.7×10^{-4}	±10	3962	295	LF	39 Bott and Cohen 1974
$HF(v=1) + Br \rightarrow HF(v=0) + Br(Br^*)$	V-T & V-E	$\geq 3.1 \times 10^{-11}$	±50	$274(Br^*)$	295	LF-DF	150 Quigley and Wolga 1975
		The analysis states incorrectly that $k_e = k_{e'}$ for V-E equilibrium, however the result matches a correct analysis of the data					
		6.3×10^{-11}	±20	$274(Br^*)$	295	LF	175 Wodarczyk and Sackett 1976
		Calculated from reverse E-V measurements assuming that the V-E transfer is 100% of the deactivation					
		1.5×10^{-10} 3.2×10^{-11}		3962	1500- 2600	ST	18 Blauer and Solomon 1973
$HF(v=n) + Br \rightarrow HF(v=n-1) + Br(Br^*)$	V-T & V-E	$\frac{n=1}{1}\ \frac{2}{1}\ \frac{3}{1}\ \frac{4}{3}\ \frac{5}{8}\ \frac{6}{10}$			295	CD	78 Douglas...Sloan 1976
		Relative rate information only					
$HF(v=1) + CBrF_3 \rightarrow HF(v=0) + CBrF_3^\dagger$	V-V & V-T	$\leq 1.2 \times 10^{-14}$	±15	3962	295	LF	39 Bott and Cohen 1974
$HF(v=3) + CD_4 \rightarrow HF(v=2) + CD_4^\dagger$	V-V & V-T	1.8×10^{-12}	±35	3622 $1364(v_3)$	295	LF	123 Lampert...Crim 1980
		Direct excitation to HF(v=3)					
$HF(v=4) + CD_4 \rightarrow HF(v=3) + CD_4^\dagger$	V-V & V-T	5.5×10^{-12}	±15	3459 $1201(v_3)$	295	LF	123 Lampert...Crim 1980
		Direct excitation to HF(v=4)					

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=1) + CF_4 → HF(v=0) + $CF_4^\dagger$	V-V & V-T	$\leq 1.3 \times 10^{-14}$	±15	3962	295	LF	39 Bott and Cohen 1974
		$<1.2 \times 10^{-14}$	±30	3962	298	FT	119 Kwok and Cohen 1974
HF(v=2) + CF_4 → HF(v=1) + $CF_4^\dagger$	V-V & V-T	2.2×10^{-14}	±50	3789	298	FT	119 Kwok and Cohen 1974
HF(v=3) + CF_4 → HF(v=2) + $CF_4^\dagger$	V-V & V-T	6.3×10^{-14}	±50	3622	298	FT	119 Kwok and Cohen 1974
HF(v=1) + CH_4 → HF(v=0) + $CH_4^\dagger$	V-V & V-T	2.1×10^{-12}		3962 941(ν_3)	320	FT	6 Anlauf...Herman 1973
		1.6×10^{-12}	±15	3962 941(ν_3)	295	LF	96 Hancock and Green 1973
		6.5×10^{-13}	±30	3962 941(ν_3)	298	FT	119 Kwok and Cohen 1974
		8.0×10^{-13}	±15	3962 941(ν_3)	295	LF	24 Bott 1977
		1.1×10^{-12}		3962	295	FT	8 Arnold and Kimbell 1978
HF(v=2) + CH_4 → HF(v=1) + $CH_4^\dagger$	V-V & V-T	7.6×10^{-12}		3789 769(ν_3)	320	FT	6 Anlauf...Herman 1973
		2.2×10^{-12}	±50	3789 769(ν_3)	298	FT	119 Kwok and Cohen 1974
		1.8×10^{-12}		3789	295	FR	147 Poole and Smith 1977
HF(v=3) + CH_4 → HF(v=2) + $CH_4^\dagger$	V-V & V-T	2.7×10^{-12}	±50	3622 602(ν_3)	298	FT	119 Kwok and Cohen 1974
		4.7×10^{-12}		3622 602(ν_3)	295	FR	147 Poole and Smith 1977
		1.8×10^{-11}	±25	3622 602(ν_3)	295	LF	123 Lampert...Crim 1980
		Direct excitation to HF(v=3)					
HF(v=4) + CH_4 → HF(v=3) + $CH_4^\dagger$	V-V & V-T	1.3×10^{-11}		3459 439(ν_3)	295	FR	147 Poole and Smith 1977
		4.7×10^{-11}	±15	3459 439(ν_3)	295	LF	123 Lampert...Crim 1980
		Direct excitation to HF(v=4)					
HF(v=5) + CH_4 → HF(v=4) + $CH_4^\dagger$	V-V & V-T	3.2×10^{-11}		3299	295	FR	147 Poole and Smith 1977
		1.0×10^{-10}	±30	3299	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=6) + CH_4 → HF(v=5) + $CH_4^\dagger$	V-V & V-T	4.8×10^{-11}		3143	295	FR	147 Poole and Smith 1977
		1.4×10^{-10}	±30	3143	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=7) + CH_4 → HF(v=6) + $CH_4^\dagger$	V-V & V-T	3.9×10^{-11}		2988	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
		3.5×10^{-10}	±30	2988	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=1) + C_2F_4 → HF(v=0) + $C_2F_4^\dagger$	V-V & V-T	1.0×10^{-13}		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + C_2F_4 → HF(v=1) + $C_2F_4^\dagger$	V-V & V-T	2.7×10^{-13}		3789	298	FT	8 Arnold and Kimbell 1978
HF(v=1) + C_2F_6 → HF(v=0) + $C_2F_6^\dagger$	V-V & V-T	$\leq 4.9 \times 10^{-15}$	±35	3962	295	LF	39 Bott and Cohen 1974
HF(v=1) + C_2HF_3 → HF(v=0) + $C_2HF_3^\dagger$	V-V & V-T	5.9×10^{-13}		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + C_2HF_3 → HF(v=1) + $C_2HF_3^\dagger$	V-V & V-T	1.3×10^{-12}		3789	298	FT	8 Arnold and Kimbell 1978
HF(v=1) + C_2H_2 → HF(v=0) + $C_2H_2^\dagger$	V-V & V-T	1.9×10^{-12}		3962	320	FT	6 Anlauf...Herman 1973
HF(v=2) + C_2H_2 → HF(v=1) + $C_2H_2^\dagger$	V-V & V-T	6.6×10^{-12}		3789	320	FT	6 Anlauf...Herman 1973
HF(v=1) + 1,1-$C_2H_2F_2$ → HF(v=0) + 1,1-$C_2H_2F_2^\dagger$	V-V & V-T	8.3×10^{-13}		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + 1,1-$C_2H_2F_2$ → HF(v=1) + 1,1-$C_2H_2F_2^\dagger$	V-V & V-T	2.0×10^{-12}		3789	298	FT	8 Arnold and Kimbell 1978

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=1) + cis\text{-}1,2\text{-}C_2H_2F_2 \rightarrow HF(v=0) + cis\text{-}1,2\text{-}C_2H_2F_2^\dagger$	V-V & V-T	9.6×10^{-13}		3962	298	FT	8 Arnold and Kimbell 1978
$HF(v=2) + cis\text{-}1,2\text{-}C_2H_2F_2 \rightarrow HF(v=1) + cis\text{-}1,2\text{-}C_2H_2F_2^\dagger$	V-V & V-T	1.8×10^{-12}		3789	298	FT	8 Arnold and Kimbell 1978
$HF(v=1) + trans\text{-}1,2\text{-}C_2H_2F_2 \rightarrow HF(v=0) + trans\text{-}1,2\text{-}C_2H_2F_2^\dagger$	V-V & V-T	9.0×10^{-13}		3962	298	FT	8 Arnold and Kimbell 1978
$HF(v=2) + trans\text{-}1,2\text{-}C_2H_2F_2 \rightarrow HF(v=1) + trans\text{-}1,2\text{-}C_2H_2F_2^\dagger$	V-V & V-T	2.0×10^{-12}		3789	298	FT	8 Arnold and Kimbell 1978
$HF(v=1) + C_2H_3F \rightarrow HF(v=0) + C_2H_3F^\dagger$	V-V & V-T	1.05×10^{-12}		3962	298	FT	8 Arnold and Kimbell 1978
$HF(v=2) + C_2H_3F \rightarrow HF(v=1) + C_2H_3F^\dagger$	V-V & V-T	2.7×10^{-12}		3789	298	FT	8 Arnold and Kimbell 1978
$HF(v=1) + C_2H_4 \rightarrow HF(v=0) + C_2H_4^\dagger$	V-V & V-T	$\geq 1.7 \times 10^{-12}$		3962	320	FT	6 Anlauf...Herman 1973
		1.5×10^{-12}		3962	298	FT	8 Arnold and Kimbell 1978
$HF(v=2) + C_2H_4 \rightarrow HF(v=1) + C_2H_4^\dagger$	V-V & V-T	$\geq 7.3 \times 10^{-12}$		3789	320	FT	6 Anlauf...Herman 1973
		4.0×10^{-12}		3789	298	FT	8 Arnold and Kimbell 1978
$HF(v=1) + C_2H_6 \rightarrow HF(v=0) + C_2H_6^\dagger$	V-V & V-T	1.9×10^{-12}		3962	320	FT	6 Anlauf...Herman 1973
		3.4×10^{-12}	±15	3962	295	LF	96 Hancock and Green 1973
		1.8×10^{-12}	±10	3962	295	LF	24 Bott 1977
		2.9×10^{-12}		3962	298	FT	8 Arnold and Kimbell 1978
$HF(v=2) + C_2H_6 \rightarrow HF(v=1) + C_2H_6^\dagger$	V-V & V-T	9.3×10^{-12}		3789	320	FT	6 Anlauf...Herman 1973
$HF(v=1) + C_3H_6 \rightarrow HF(v=0) + C_3H_6^\dagger$	V-V & V-T	9.9×10^{-12}	±15	3962	295	LF	96 Hancock and Green 1973
$HF(v=1) + C_3H_8 \rightarrow HF(v=0) + C_3H_8^\dagger$	V-V & V-T	2.8×10^{-12}		3962	320	FT	6 Anlauf...Herman 1973
		4.2×10^{-12}	±15	3962	295	LF	96 Hancock and Green 1973
		2.6×10^{-12}	±10	3962	295	LF	24 Bott 1977
$HF(v=2) + C_3H_8 \rightarrow HF(v=1) + C_3H_8^\dagger$	V-V & V-T	9.9×10^{-12}		3789	320	FT	6 Anlauf...Herman 1973
$HF(v=1) + C_4F_8 \rightarrow HF(v=0) + C_4F_8^\dagger$	V-V & V-T	$\leq 1.9 \times 10^{-14}$	±15	3962	295	LF	39 Bott and Cohen 1974
$HF(v=1) + C_4H_{10} \rightarrow HF(v=0) + C_4H_{10}^\dagger$	V-V & V-T	5.3×10^{-12}	±15	3962	295	LF	96 Hancock and Green 1973
		4.0×10^{-12}	±10	3962	295	LF	24 Bott 1977
$HF(v=1) + C\ell \rightarrow HF(v=0) + C\ell$	V-T	7.4×10^{-13}	±25	3962	295	LF-DF	151 Quigley and Wolga 1975
		3.8×10^{-11}		3962	3000	ST	19 Blauer...Owens 1972
		1.3×10^{-12} 1.7×10^{-11}	±50	3962	1850- 3200	ST	18 Blauer and Solomon 1973
$HF(v=n) + C\ell \rightarrow HF(v=n-1) + C\ell$	V-T	$\frac{n=1}{1}\ \frac{2}{1}\ \frac{3}{10}\ \frac{4}{30}\ \frac{5}{50}\ \frac{6}{50}$ Relative rate information only			295	CD	78 Douglas...Sloan 1976
$HF(v=1) + C\ell_2 \rightarrow HF(v=0) + C\ell_2^\dagger$	V-V & V-T	1.0×10^{-14}	±20	3962	295	LF	151 Quigley and Wolga 1975
$HF(v=1) + C\ell F \rightarrow HF(v=0) + C\ell F^\dagger$	V-V & V-T	$\leq 2.5 \times 10^{-14}$	±25	3962	295	LF	39 Bott and Cohen 1974
$HF(v=1) + C\ell F_3 \rightarrow HF(v=0) + C\ell F_3$	V-V & V-T	3.5×10^{-12}	±15	3962	295	LF	96 Hancock and Green 1973
		6.2×10^{-12}	±30	3962	295	LG	59 Chebotarev...Pshezhetskii 1976
$HF(v=2) + C\ell F_3 \rightarrow HF(v=1) + C\ell F_3^\dagger$	V-V & V-T	1.1×10^{-13}	±15	3789	295	LG	59 Chebotarev...Pshezhetskii 1976
$HF(v=2) + C\ell F_5 \rightarrow HF(v=1) + C\ell F_5^\dagger$	V-V & V-T	$\sim 5.6 \times 10^{-12}$	±35	3789	295	LG	59 Chebotarev...Pshezhetskii 1976
$HF(v=1) + CO(v=0) \rightarrow HF(v=0) + CO(v=1)$	V-V & V-T	5.6×10^{-14}	±10	1816(v=1) -301(v=2)	295	LF	37 Bott and Cohen 1973
		7.7×10^{-14}	±20	1816(v=1) -301(v=2)	295	LF	92 Green and Hancock 1973
$HF(v=2) + CO(v=0) \rightarrow HF(v=1) + CO(v=1)$	V-V & V-T	2.9×10^{-13}		1646(v=1)	295	FR	147 Poole and Smith 1977

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author of First and Last Author, Year of Publication
$HF(v=3) + CO(v=0) \rightarrow HF(v=2) + CO(v=1)$	V-V & V-T	1.2×10^{-12}		1478(v=1)	295	FR	147 Poole and Smith 1977
		2.9×10^{-12}	±10	1478(v=1)	296	LF	163 Smith and Wrigley 1980
$HF(v=4) + CO(v=0) \rightarrow HF(v=3) + CO(v=1)$	V-V & V-T	5.4×10^{-12}		1315(v=1)	295	FR	147 Poole and Smith 1977
		1.38×10^{-11}	±10	1315(v=1)	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
$HF(v=5) + CO(v=0) \rightarrow HF(v=4) + CO(v=1)$	V-V & V-T	1.2×10^{-11}		1154(v=1)	295	FR	147 Poole and Smith 1977
$HF(v=6) + CO(v=0) \rightarrow HF(v=5) + CO(v=1)$	V-V & V-T	2.6×10^{-11}		996(v=1)	295	FR	147 Poole and Smith 1977
		4.1×10^{-11}	±35	996(v=1)	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
$HF(v=7) + CO(v=0) \rightarrow HF(v=6) + CO(v=1)$	V-V & V-T	2.3×10^{-11}		841(v=1)	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
HF + CO, see also CO + HF							
$HF(v=1) + COF_2 \rightarrow HF(v=1) + COF_2^{\dagger}$	V-V & V-T	1.8×10^{-12}	±10	3962	295	LF	39 Bott and Cohen 1974
$HF(v=1) + CO_2(000) \rightarrow HF(v=0) + CO_2(001)$	V-V & V-T	1.2×10^{-12}		1612(001) 243(101)	295	FR	3 Airey and Smith 1972
		The rate constants in Ref. 3 are internally consistent, but their absolute magnitudes may be in error					
		1.82×10^{-12}	±2	1612(001) 243(101)	298	LF	94 Hancock and Green 1972
		1.82×10^{-12}	±4	1612(001) 243(101)	294	LF	95 Hancock and Green 1972
		1.11×10^{-12}	±5	1612(001) 243(101)	295	LF	37 Bott and Cohen 1973
		2.2×10^{-12}	±20	1612(001) 243(101)	295	LF	127 Lucht and Cool 1974
		1.3×10^{-12}	±30	1612(001) 243(101)	298	FT	119 Kwok and Cohen 1974
		1.2×10^{-12}	±10	1612(001) 243(101)	295	LF	31 Bott 1976
		1.2×10^{-12}		1612(001) 243(101)	298	FT	8 Arnold and Kimbell 1978
		1.7×10^{-12} 1.1×10^{-12}	±20	1612(001) 243(101)	205- 358	LF	129 Lucht and Cool 1975
		1.3×10^{-12}		1612(001) 243(101)	350	LF	166 Stephens and Cool 1972
		$\sim 1.1 \times 10^{-12}$		1612(001) 243(101)	400	FT	170 Vasil'ev...Tal'roze 1972
		2.2×10^{-12} 1.2×10^{-12}	±20	1612(001) 243(101)	295- 670	LF	127 Lucht and Cool 1974
		9.2×10^{-13} 1.0×10^{-12}	±5	1612(001) 243(101)	450- 1100	LF-ST	37 Bott and Cohen 1973
$HF(v=2) + CO_2(000) \rightarrow HF(v=1) + CO_2(001)$	V-V & V-T	4.4×10^{-12}		1440(001)	295	FR	3 Airey and Smith 1972
		Value given includes correction for radiative lifetime noted in 147.					
		The rate constants in Ref. 3 are internally consistent, but their absolute magnitudes may be in error					
		4.8×10^{-12}		1440(001)	298	FT	119 Kwok and Cohen 1974
		6.2×10^{-12}	±10	1440(001)	295	LF	31 Bott 1976
		3.4×10^{-12}		1440(001)	295	FR	147 Poole and Smith 1977
$HF(v=3) + CO_2(000) \rightarrow HF(v=2) + CO_2(001)$	V-V & V-T	6.4×10^{-12}		1273(001)	295	FR	3 Airey and Smith 1972
		Value given includes correction for radiative lifetime noted in 147					
		5×10^{-12}	±50	1273(001)	298	FT	119 Kwok and Cohen 1974

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=3) + CO_2(000) \rightarrow HF(v=2) + CO_2(001)$ (cont'd.)		1.2×10^{-11}	±10	1273(001)	295	LF	31 Bott 1976
		1.2×10^{-11}		1273(001)	295	FT	118 Kwok, private communication in Ref. 31
		7.0×10^{-12}		1273(001)	295	FR	147 Poole and Smith 1977
		1.01×10^{-11}	±15	1273(001)	295	LF	77 Douglas and Moore 1979
		Direct excitation to HF(v=3)					
		1.04×10^{-11}	±15	1273(001)	296	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
$HF(v=4) + CO_2(000) \rightarrow HF(v=3) + CO_2(001)$	V-V & V-T	1.2×10^{-11}		1109(001)	295	FT	3 Airey and Smith 1972
		Value given includes correction for radiative lifetime noted in 147					
		1.3×10^{-11}		1109(001)	295	FR	147 Poole and Smith 1977
		2.3×10^{-11}	±25	1109(001)	295	LF	77 Douglas and Moore 1979
		2.2×10^{-11}	±10	1109(001)	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
$HF(v=5) + CO_2(000) \rightarrow HF(v=4) + CO_2(001)$	V-V & V-T	2.0×10^{-11}		949(001)	295	FT	3 Airey and Smith 1972
		Value given includes correction for radiative lifetime noted in 147					
		2.7×10^{-11}		949(001)	295	FR	147 Poole and Smith 1977
		8.1×10^{-11}	±30	949(001)	298	FT	81 Dzelzkalns and Kaufman 1982
$HF(v=6) + CO_2(000) \rightarrow HF(v=5) + CO_2(001)$	V-V & V-T	3.5×10^{-11}		794(001)	295	FR	147 Poole and Smith 1977
		7.1×10^{-11}	±35	794(001)	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
		1.6×10^{-10}	±30	794(001)	298	FT	81 Dzelzkalns and Kaufman 1982
$HF(v=7) + CO_2(000) \rightarrow HF(v=6) + CO_2(001)$	V-V & V-T	3.2×10^{-11}		640(001)	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
		3.0×10^{-10}	±30	640(001)	298	FT	81 Dzelzkalns and Kaufman 1982
$HF(v=n) + CO_2(000) \rightarrow HF(v=n-1) + CO_2(001)$	V-V & V-T	$\frac{n=1}{1.0}$ $\frac{2}{4}$ $\frac{3}{1.21}$ $\frac{4}{2.16}$ $\frac{5}{1.89}$ $\frac{6}{3.76}$			295	CD	51 Brown...Polanyi 1978
		Relative rate information only					
$HF(v=1) + CS_2 \rightarrow HF(v=0) + CS_2^{\dagger}$	V-V & V-T	4.9×10^{-13}		3962	295	LF	173 Wendelken...Noetzel 1975
$HF(v=1) + D \rightarrow HF(v=0) + D$	V-T & Exchange	3×10^{-14}	±90	3962	295	LF-DF	99 Heidner and Bott 1975
$HF(v=3) + D \rightarrow HF(v=2) + D$	V-T & Rx & Exchange	9.8×10^{-11}		3622	295	LF-DF	43 Bott and Heidner 1977
		Sequential absorption to HF(v=3)					
		1.3×10^{-10} 9.8×10^{-11}		3622	200- 295	LF-DF	43 Bott and Heidner 1977
		Provides evidence that the v=3 relaxation is due mainly to reaction (HD) channel			295	CD	12 Bartoszek...Polanyi 1978
$HF(v=1) + DBr(v=0) \rightarrow HF(v=0) + DBr(v=1)$	V-V & V-T	1.4×10^{-13}	±35	2119(v=1) 279(v=2)	295	LF	39 Bott and Cohen 1974
$HF(v=1) + D_2(v=0) \rightarrow HF(v=0) + D_2(v=1)$	V-V & V-T	1.14×10^{-13}	±10	967	294	LF	95 Hancock and Green 1972
		9.6×10^{-14}	±20	967	295	LF	37 Bott and Cohen 1973
		9.0×10^{-14}	±10	967	295	LF	44 Bott and Heidner 1980
		8.2×10^{-14}	±10	967	200	LF	44 Bott and Heidner 1980
		1.2×10^{-13} 1.0×10^{-13}	±20	967	450- 1000	LF-ST	37 Bott and Cohen 1973
		8.5×10^{-14} 1.3×10^{-12}		967	1500- 3300	ST	34 Bott and Cohen 1971
$HF(v=2) + D_2(v=0) \rightarrow HF(v=1) + D_2(v=1)$	V-V & V-T	2.6×10^{-13}		796	295	FR	146 Poole and Smith 1977
$HF(v=3) + D_2(v=0) \rightarrow HF(v=2) + D_2(v=1)$	V-V & V-T	5.9×10^{-13}		628	295	FR	146 Poole and Smith 1977

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=3) + D_2(v=0) \rightarrow HF(v=2) + D_2(v=1)$ (cont'd.)		1.3×10^{-12}	±20	628	295	LF	77 Douglas and Moore 1979
		Direct excitation to HF(v=3)					
		1.5×10^{-12}	±15	628	295	LF	44 Bott and Heidner 1980
		Sequential absorption to HF(v=3)					
		1.5×10^{-12}	±15	628	200	LF	44 Bott and Heidner 1980
$HF(v=4) + D_2(v=0) \rightarrow HF(v=3) + D_2(v=1)$	V-V & V-T	1.2×10^{-12}		466	295	FR	146 Poole and Smith 1977
		3.3×10^{-12}	±20	466	295	LF	77 Douglas and Moore 1979
		Direct excitation to HF(v=4)					
$HF(v=5) + D_2(v=0) \rightarrow HF(v=4) + D_2(v=1)$	V-V & V-T	3.1×10^{-12}		304	295	FR	146 Poole and Smith 1977
		1.3×10^{-11}	±30	304	298	FT	81 Dzelzkalns and Kaufman 1982
$HF(v=6) + D_2(v=0) \rightarrow HF(v=5) + D_2(v=1)$	V-V & V-T	8.2×10^{-12}		146	295	FR	146 Poole and Smith 1977
		4.2×10^{-11}	±30	146	298	FT	81 Dzelzkalns and Kaufman 1982
$HF(v=7) + D_2(v=0) \rightarrow HF(v=6) + D_2(v=1)$	V-V & V-T	$\sim 6.1 \times 10^{-12}$		-10	295	FR	146 Poole and Smith 1977
		The rate constants in Ref. 146 are internally consistent, but their absolute magnitudes may be in error					
		1.0×10^{-10}	±30	-10	298	FT	81 Dzelzkalns and Kaufman 1982
$HF(v=1) + D_2O \rightarrow HF(v=0) + D_2O^\dagger$	V-V & V-T	1.3×10^{-10}	±15	$1176(\nu_3)$	294	LF	95 Hancock and Green 1972
		1.6×10^{-11} 1.1×10^{-11}		$1176(\nu_3)$	1200- 3300	ST	20 Blauer...Owens 1972
$HF(v=2) + D_2O \rightarrow HF(v=1) + D_2O^\dagger$	V-V & V-T	4.0×10^{-11}		3789	295	FR	147 Poole and Smith 1977
$HF(v=3) + D_2O \rightarrow HF(v=2) + D_2O^\dagger$	V-V & V-T	6.5×10^{-11}		3622	295	FR	147 Poole and Smith 1977
$HF(v=4) + D_2O \rightarrow HF(v=3) + D_2O^\dagger$	V-V & V-T	8.0×10^{-11}		3459	295	FR	147 Poole and Smith 1977
$HF(v=5) + D_2O \rightarrow HF(v=4) + D_2O^\dagger$	V-V & V-T	7.1×10^{-11}		3299	295	FR	147 Poole and Smith 1977
$HF(v=6) + D_2O \rightarrow HF(v=5) + D_2O^\dagger$	V-V & V-T	4.8×10^{-11}		3143	295	FR	147 Poole and Smith 1977
$HF(v=7) + D_2O \rightarrow HF(v=6) + D_2O^\dagger$	V-V & V-T	3.1×10^{-11}		2988	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$HF(v=1) + DF(v=0) \rightarrow HF(v=0) + DF(v=1)$	V-V & V-T	3.3×10^{-12}	±35	1055	300	LF	1 Ahl and Cool 1973
		V-V contribution only					
		2.4×10^{-12}	±5	1055	295	LF	37 Bott and Cohen 1973
		May contain a small V-T contribution					
		2.1×10^{-12}	±10	1055	295	LF	100 Hinchen 1973
		V-V contribution estimated to be 7.4×10^{-13}					
		4.2×10^{-12}	±20	1055	295	LF	93 Hancock and Green 1975
		Contains V-T contribution					
		3.24×10^{-12}	±3	1055	296	LF	97 Hancock and Saunders 1976
		Contains V-T contribution					
		There appears to be no V-R mechanism in HF deactivated by DF, as in HF deactivated by HF, probably because the energy difference is much smaller					
		6.2×10^{-12}		1055	200	LF	93 Hancock and Green 1975
		2.8×10^{-12}		1055	198	LF	97 Hancock and Saunders 1976
		5.5×10^{-12} 2.4×10^{-12}	±20	1055	210- 364	LF	129 Lucht and Cool 1975
		Polymer $(DF)_n$ quenching observed in Refs. 129 and 97					
		2.9×10^{-12}	±45	1055	350	LF	1 Ahl and Cool 1973
		V-V contribution only					
		4.2×10^{-12} 2.2×10^{-12}	±20	1055	297- 678	LF	128 Lucht and Cool 1974
		1.3×10^{-12} 1.3×10^{-12}	±5	1055	450- 1100	LF-ST	37 Bott and Cohen 1973

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=1) + DF(v=0) \rightarrow HF(v=0) + DF(v=1)$ (cont'd.)		4.5×10^{-13} 3.1×10^{-12}	±50	1055	1700– 3300	ST	19 Blauer...Owens 1972
$HF(v=1) + DF(v=0) \rightarrow HF(v=0) + DF(v=0)$	V-T	$<1.4 \times 10^{-12}$	±15	3962	300	LF	1 Ahl and Cool 1973
		$<1.3 \times 10^{-12}$	±50	3962	295	LF	100 Hinchen 1973
		$<1.2 \times 10^{-12}$	±15	3962	350	LF	1 Ahl and Cool 1973
$HF(v=1) + (DF)_n \rightarrow HF(v=0) + (DF)_n^\dagger$	V-V & V-T			3962	198– 296	LF	97 Hancock and Saunders 1976
		Strong rate enhancement over monomer					
$HF(v=1) + F \rightarrow HF(v=0) + F$	V-T	2.8×10^{-13}	±25	3962	295	LF-DF	149 Quigley and Wolga 1974
		2.8×10^{-13}	±25	3962	295	LF-DF	151 Quigley and Wolga 1975
		4.5×10^{-12} 1.3×10^{-11}	±20	3962	1500– 2400	LF-ST	16 Blair...Schott 1973
		5.0×10^{-11}		3962	1800– 3300	ST	35 Bott and Cohen 1971
		The rate constant is essentially constant over this temperature range					
		1.5×10^{-12} 1.5×10^{-11}		3962	1700– 3500	ST	164 Solomon...Hnat 1971
				3962	2500	ST	17 Blauer and Solomon 1973
		Rates found to be seven times slower than reported in Ref. 164					
$HF(v=2) + F \rightarrow HF(v=1) + F$	V-T	Rate is 6 times faster than v=1		3789	2500	ST	17 Blauer and Solomon 1973
$HF(v=1) + Fe(CO)_5 \rightarrow HF(v=0) + Fe(CO)_5^\dagger$	V-V & V-T	$\sim 6.2 \times 10^{-12}$ Estimate only		3962	295	LF	37 Bott and Cohen 1973
$HF(v=1) + F_2 \rightarrow HF(v=0) + F_2^\dagger$	V-V & V-T	$<4.7 \times 10^{-13}$		3962	350	LF	2 Airey and Fried 1971
		$<3 \times 10^{-15}$		3962	350	LF	89 Fried...Taylor 1973
$HF(v=1) + H \rightarrow HF(v=0) + H$	V-T	$<3.2 \times 10^{-12}$		3962	295	FT	121 Kwok and Wilkins 1974
		$<1.4 \times 10^{-14}$		3962	295	LF-DF	149 Quigley and Wolga 1974
		2.3×10^{-13}	±30	3962	295	LF-DF	99,98 Heidner and Bott 1975,1977
$HF(v=2) + H \rightarrow HF(v=1) + H$	V-T	$<1.8 \times 10^{-11}$		3789	295	FT	121 Kwok and Wilkins 1974
		1.1×10^{-12}	±50	3789	295	LF-DF	42 Bott and Heidner 1977
		Sequential absorption to HF(v=2)					
		8.3×10^{-13}	±40	3789	295	LF-DF	98 Heidner and Bott 1977
$HF(v=3) + H \rightarrow HF(v=2) + H$	V-T & Rx	3.0×10^{-11}		3622	295	FT	121 Kwok and Wilkins 1974
		1.05×10^{-10}	±25	3622	295	LF-DF	42 Bott and Heidner 1977 98 Heidner and Bott 1977
		1.66×10^{-10} 1.05×10^{-10}		3622	200– 295	LF-DF	43 Bott and Heidner 1978
		It is thought that relaxation of HF(v=3) is much faster because the reactive channel opens up					
$HF(v=1) + HBr(v=0) \rightarrow HF(v=0) + HBr(v=1)$	V-V & V-T	2.2×10^{-13}	±35	1400	300	LF	1 Ahl and Cool 1973
		V-V contribution only					
		2.3×10^{-13}	±15	1400	295	LF	37 Bott and Cohen 1973
		Contains V-T contribution					
		1.5×10^{-13}	±35	1400	350	LF	1 Ahl and Cool 1973
$HF(v=4) + HBr(v=0) \rightarrow HF(v=3) + HBr(v=1)$	V-V & V-T	2.2×10^{-11}	±10	900	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
$HF(v=1) + HBr(v=0) \rightarrow HF(v=0) + HBr(v=0)$	V-T	$<1.5 \times 10^{-13}$		3962	300	LF	1 Ahl and Cool 1973
		$<1.0 \times 10^{-13}$		3962	350	LF	1 Ahl and Cool 1973
$HF(v=1) + HC\ell(v=0) \rightarrow HF(v=0) + HC\ell(v=1)$	V-V & V-T	5.3×10^{-13}	±5	1074	295	LF	37 Bott and Cohen 1973
		Contains V-T contribution					

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number. Author or First and Last Author, Year of Publication
$HF(v=1) + HCl(v=0) \rightarrow HF(v=0) + HCl(v=1)$ (cont'd.)		7.4×10^{-13}		1074	300	LF	1 Ahl and Cool 1973
		V-V contribution only					
		6.7×10^{-13}		1074	350	LF	1 Ahl and Cool 1973
		4.2×10^{-13} 6×10^{-13}	±5	1074	450- 1100	LF-ST	37 Bott and Cohen 1973
		2.5×10^{-14} 1.7×10^{-13}		1074	1420- 2900	ST	20 Blauer...Owens 1972
$HF(v=3) + HCl(v=0) \rightarrow HF(v=2) + HCl(v=1)$	V-V & V-T	1.2×10^{-11}	±10	739	295	LF	31 Bott 1976
		Sequential absorption to HF(v=3)					
		1.2×10^{-11}	±15	739	296	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
$HF(v=1) + HCl(v=0) \rightarrow HF(v=0) + HCl(v=0)$	V-T	$<4.9 \times 10^{-13}$		3962	300	LF	1 Ahl and Cool 1973
		$<4.3 \times 10^{-13}$		3962	350	LF	1 Ahl and Cool 1973
$HF(v=1) + HCN(000) \rightarrow HF(v=0) + HCN(001)$	V-V & V-T	5.3×10^{-12}	±25	650(001) -44(011)	298	LF	135 McGarvey...Cool 1977
		7.2×10^{-12} 3.3×10^{-12}	±20	650(001) -44(011)	240- 449	LF	135 McGarvey...Cool 1977
$HF(v=2) + HCN \rightarrow HF(v=1) + HCN^{\dagger}$	V-V & V-T	1.7×10^{-11}		3789	295	FR	147 Poole and Smith 1977
$HF(v=3) + HCN \rightarrow HF(v=2) + HCN^{\dagger}$	V-V & V-T	4.3×10^{-11}		3622	295	FR	147 Poole and Smith 1977
$HF(v=4) + HCN \rightarrow HF(v=3) + HCN^{\dagger}$	V-V & V-T	8.6×10^{-11}		3459	295	FR	147 Poole and Smith 1977
$HF(v=5) + HCN \rightarrow HF(v=4) + HCN^{\dagger}$	V-V & V-T	1.1×10^{-10}		3299	295	FR	147 Poole and Smith 1977
$HF(v=6) + HCN \rightarrow HF(v=5) + HCN^{\dagger}$	V-V & V-T	7.4×10^{-11}		3143	295	FR	147 Poole and Smith 1977
$HF(v=7) + HCN \rightarrow HF(v=6) + HCN^{\dagger}$	V-V & V-T	$\sim 5.2 \times 10^{-11}$		2988	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
HF + HCN, see also HCN + HF							
$HF(v=2) + HD(v=0) \rightarrow HF(v=1) + HD(v=1)$	V-V & V-T	1.2×10^{-12}		159	295	FR	146 Poole and Smith 1977
$HF(v=3) + HD(v=0) \rightarrow HF(v=2) + HD(v=1)$	V-V & V-T	5.1×10^{-12}		-8	295	FR	146 Poole and Smith 1977
$HF(v=4) + HD(v=0) \rightarrow HF(v=3) + HD(v=1)$	V-V & V-T	2.1×10^{-12}		-172	295	FR	146 Poole and Smith 1977
$HF(v=5) + HD(v=0) \rightarrow HF(v=4) + HD(v=1)$	V-V & V-T	1.3×10^{-12}		-333	295	FR	146 Poole and Smith 1977
$HF(v=6) + HD(v=0) \rightarrow HF(v=5) + HD(v=1)$	V-V & V-T	1.3×10^{-12}		-491	295	FR	146 Poole and Smith 1977
		The rate constants in Ref. 146 are internally consistent, but their absolute magnitudes may be in error					
$HF(v=1) + He \rightarrow HF(v=0) + He$	V-T	$<3 \times 10^{-16}$		3962	295	LF	39 Bott and Cohen 1974
		$<1.9 \times 10^{-15}$		3962	295	LF	100 Hinchen 1973
		9.2×10^{-15} 2.7×10^{-13}		3962	1500- 3500	ST	169 Vasil'ev...Papin 1975
		3.6×10^{-15} 5.2×10^{-13}		3962	1160- 3650	ST	34 Bott and Cohen 1971
$HF(v=1) + HF(v=1) \rightarrow HF(v=2) + HF(v=0)$	V-V	4.3×10^{-11}		173	295	FR	3 Airey and Smith 1972
		The rate constants in Ref. 3 are internally consistent, but their absolute magnitudes may be in error					
		4.7×10^{-11}		173	295	LF	143 Osgood...Sackett 1972
		1.7×10^{-11}		173	295	LG	25 Bott 1972
		Rate first described in Ref. 25 as 3.7×10^{-11}, then corrected for faster V-T deactivation of HF(v=2) in Ref. 67 (Cohen and Bott 1976)					
		4.8×10^{-11}	±25	173	295	LF	144 Osgood...Javan 1974
		Correction for faster V-T deactivation of HF(v=2) would give 3.1×10^{-11} according to Ref. 67					
		3.8×10^{-11}	±30	173	298	FT	122 Kwok and Wilkins 1975

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=1) + HF(v=1) \rightarrow HF(v=2) + HF(v=0)$ (cont'd.)		3.1×10^{-11}		173	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
		It is possible that this V-V rate has a significant V-T contribution in all measurements					
$HF(v=3) + HF(v=0) \rightarrow HF(v=2) + HF(v=1)$	V-V & V-T	2.0×10^{-11}		-340 3622	295	FT	3 Airey and Smith 1972
		V-T relaxation underestimated according to Ref. 67					
		4.3×10^{-11}	±25	-340 3622	295	LF	144 Osgood...Javan 1974
		Measured in reverse direction, presumed V-V contribution tabulated here					
		2.5×10^{-11}	±40	-340 3622	298	FT	122 Kwok and Wilkins 1975
		1.8×10^{-11}		-340 3622	295	FR	146 Poole and Smith 1977
		The rate constants in Ref. 146 are internally consistent, but their absolute magnitudes may be in error					
		2.7×10^{-11}	±15	-340 3622	295	LF	76 Douglas and Moore 1978
		Direct excitation to HF(v=3)					
		3.2×10^{-11}	±20	-340 3622	295	LF	123 Lampert and Crim 1980
		Direct excitation to HF(v=3)					
		3.02×10^{-11}	±10	-340 3622	295	LF	112 Jursich and Crim 1981
		Direct excitation to HF(v=3)					
		3.1×10^{-11} 1.9×10^{-11}	±10	-340 3622	295- 650	LF	86 Foster and Crim 1981
		V-T contribution thought to be a substantial fraction of the total rate					
$HF(v=4) + HF(v=0) \rightarrow HF(v=3) + HF(v=1)$	V-V & V-T	5.3×10^{-11}		-503 3459	295	FR	3 Airey and Smith 1972
		3.7×10^{-11}	±25	-503 3459	295	LF	144 Osgood...Javan 1974
		Measured in reverse direction, presumed V-V contribution tabulated here					
		2.7×10^{-11}	±40	-503 3459	298	FT	122 Kwok and Wilkins 1975
		3.2×10^{-11}		-503 3459	295	FR	146 Poole and Smith 1977
		The rate constants in Ref. 146 are internally consistent, but their absolute magnitudes may be in error					
		7.2×10^{-11}	±10	-503 3459	295	LF	76 Douglas and Moore 1978
		Direct excitation to HF(v=4)					
		7.0×10^{-11}	±15	-503 3459	295	LF	77 Douglas and Moore 1979
		8.8×10^{-11}	±15	-503 3459	295	LF	123 Lampert and Crim 1980
		Direct excitation to HF(v=4)					
		7.28×10^{-11}	±4	-503 3459	295	LF	112 Jursich and Crim 1981
		7.2×10^{-11} 4.6×10^{-11}	±10	-503 3459	295- 670	LF	86 Foster and Crim 1981
		V-T contribution thought to be substantial					
$HF(v=5) + HF(v=0) \rightarrow HF(v=4) + HF(v=1)$	V-V & V-T	8.1×10^{-11}		-662 3299	295	FR	3 Airey and Smith 1972
		8.7×10^{-12}	±60	-662 3299	298	FT	122 Kwok and Wilkins 1975

[illegible] energy transfer (continued)

[illegible]		[illegible] molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=5) + HF(v=0) [illegible] (cont.)		4.6×10^{-11}		−662	295	FR	146 Poole and Smith 1977
		The rate constants in Ref. 146 are internally consistent, but their absolute magnitudes may be in error					
		5.8×10^{-11}		−662 3299	295	FT	120 Kwok and Cohen, private communication, in Ref. 174
		1.51×10^{-10}	±4	−662 3299	295	LF	112 Jursich and Crim 1981
		Direct excitation to HF(v=5)					
		1.6×10^{-10}	±30	−622 3299	298	FT	81 Dzelzkalns and Kaufman 1982
		1.49×10^{-10} 8.1×10^{-11}	±10 ~1% at 295	−662 3299	295- 625	LF	86 Foster and Crim 1981
		V-T contribution thought to be substantial					
HF(v=6) + HF(v=0) → HF(v=5) + HF(v=1)	V-V & V-T	1.0×10^{-10}		−819 3143	295	FT	120 Kwok and Cohen, private communication, in Ref. 174
		5.1×10^{-11}		−819 3143	295	FR	146 Poole and Smith 1977
		2.9×10^{-10}	±30	−819 3143	298	FT	81 Dzelzkalns and Kaufman 1982
		V-T contribution thought to be substantial					
HF(v=7) + HF(v=0) → HF(v=6) + HF(v=1)	V-V & V-T	4.3×10^{-11}		2988	295	FR	146 Poole and Smith 1977
		The rate constants in Ref. 146 are internally consistent, but their absolute magnitudes may be in error					
		4.6×10^{-10}	±30	2988	298	FT	81 Dzelzkalns and Kaufman 1982
		V-T contribution thought to be substantial					
		Theory predicts V-T is substantial, see e.g. Ref. 68, where 95% of rate for v=7 is V-T					68 Coltrin and Marcus 1980
HF(v=1) + HF(v=0) → HF(v=0) + HF(v=0)	V-T	1.8×10^{-12}	±10	3962	295	LF	25 Bott 1972
		2.70×10^{-12}	±1	3962	294	LF	94 Hancock and Green 1972
		2.7×10^{-12}	±10	3962	294	LF	95 Hancock and Green 1972
		With Ar diluent					
		1.4×10^{-12}	±10	3962	294	LF	95 Hancock and Green 1972
		Without Ar diluent Rate is slower presumably because V-R transfer forms a bottleneck to relaxation					
		2.7×10^{-12}	±1	3962	295	LF	92 Green and Hancock 1973
		2.25×10^{-12}	±1	3962	295	LF	28 Bott 1974
		Corrected Green and Hancock result for error in partial pressure measurement					
		2.6×10^{-12}	±10	3962	295	LF	89 Fried and Taylor 1973
		1.9×10^{-12}	±10	3962	295	LF	100 Hinchen 1973
		1.8×10^{-12}	±10	3962	295	LF	101 Hinchen 1973
		2.2×10^{-12}	±15	3962	300	LF	1 Ahl and Cool 1973
		1.81×10^{-12}	±15	3962	300	LF	28 Bott 1974
		Corrected Ahl and Cool result for error in partial pressure measurement					
		1.7×10^{-12}		3962	295	LF	37 Bott and Cohen 1973
		2.6×10^{-12}	±20	3962	295	LF	127 Lucht and Cool 1974
		2.6×10^{-12}	±25	3962	295	LF	128 Lucht and Cool 1974
		Noted that without Ar diluent the rate is slower					
		2.18×10^{-12}	±15	3962	295	LF	28 Bott 1974
		Corrected Lucht and Cool result for error in partial pressure measurement					
		1.7×10^{-12}		3962	295	LF	144 Osgood...Javan 1974
		1.6×10^{-12}	±20	3962	298	FT	122 Kwok and Wilkins 1975
		1.45×10^{-12}	±4	3962	295	LF	93 Hancock and Green 1975

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=1) + HF(v=0) \rightarrow HF(v=0) + HF(v=0)$ (cont'd.)		3×10^{-12}	±50	3962	200	LF	93 Hancock and Green 1975
		2.2×10^{-12} 1.5×10^{-12}	±10	3962	205- 358	LF	129 Lucht and Cool 1975
		4.3×10^{-12}		3962	330	SP	154 Rityn...Slobodskaya 1974
		Possibly some residual water vapor present					
		3.4×10^{-12}		3962	350	LF	2 Airey and Fried 1971
		1.90×10^{-12}	±5	3962	350	LF	166 Stephens and Cool 1972
		1.80×10^{-12}	±10	3962	350	LF	1 Ahl and Cool 1973
		2.6×10^{-12} 1.4×10^{-12}	±20	3962	300- 670	LF	127 Lucht and Cool 1974
		2.6×10^{-12} 1.4×10^{-12}	±15	3962	300- 678	LF	128 Lucht and Cool 1974
		1.2×10^{-12} 1.3×10^{-12}	±10	3962	295- 730	LF	89 Fried...Taylor 1973
		1.8×10^{-12} 1.0×10^{-12}	±10	3962	295- 900	LF-ST	101 Hinchen 1973
		1.8×10^{-12} 7.5×10^{-13}	±10	3962	295- 1000	LF	25 Bott 1972
		1.4×10^{-12} 3.6×10^{-12}	±20	3962	600- 2400	LF-ST	16 Blair...Schott 1973
		8.3×10^{-13} 6.0×10^{-12}		3962	1350- 4000	ST	34 Bott and Cohen 1971
		9.5×10^{-14} 1.5×10^{-11}	±30	3962	1400- 4100	ST	164 Solomon...Hnat 1971
		8.9×10^{-13} 4.8×10^{-11}		3962	1500- 5000	ST	171 Vasil'ev...Tal'roze 1973
		There is a broad minimum in the rate constant at 1200 K There is a minimum in the probability at 900 K					
$HF(v=2) + HF(v=0) \rightarrow HF(v=1) + HF(v=0)$	V-T	$\sim 1.2 \times 10^{-11}$		3789	295	LG	67 Cohen and Bott 1976
HF + H_2, see also H_2 + HF, especially HF(v=1,2)							
$HF(v=3) + H_2(v=0) \rightarrow HF(v=2) + H_2(v=1)$	V-V & V-T	3.6×10^{-13}	±10	-535	295	LF	31 Bott 1976
		Sequential absorption to HF(v=3)					
		1.5×10^{-13}		-535	295	FR	146 Poole and Smith 1977
		3.1×10^{-13}	±20	-535	295	LF	77 Douglas and Moore 1979
		Direct excitation to HF(v=3)					
		3.5×10^{-13}	±10	-535	295	LF	44 Bott and Heidner 1980
		Sequential absorption to HF(v=3)					
		1.8×10^{-13}	±15	-535	200	LF	44 Bott and Heidner 1980
$HF(v=4) + H_2(v=0) \rightarrow HF(v=3) + H_2(v=0)$	V-T	2.1×10^{-13}		3459	295	FR	146 Poole and Smith 1977
		4.7×10^{-13}	±25	3459	295	LF	77 Douglas and Moore 1979
		Thought to be mainly V-T					
$HF(v=5) + H_2(v=0) \rightarrow HF(v=4) + H_2(v=0)$	V-T	4.9×10^{-13}		3299	295	FR	146 Poole and Smith 1977
		1.8×10^{-12}	±30	3299	298	FT	81 Dzelzkalns and Kaufman 1982
		Thought to be mainly V-T					
$HF(v=6) + H_2(v=0) \rightarrow HF(v=5) + H_2(v=0)$	V-T	9.9×10^{-13}		3143	295	FR	146 Poole and Smith 1977
		3.4×10^{-12}	±30	3143	298	FT	81 Dzelzkalns and Kaufman 1982
		Thought to be mainly V-T					
$HF(v=7) + H_2(v=0) \rightarrow HF(v=6) + H_2(v=0)$	V-T	1.6×10^{-12}		2988	295	FR	146 Poole and Smith 1977
		The rate constants in Ref. 146 are internally consistent, but their absolute magnitudes may be in error					

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author of First and Last Author, Year of Publication
HF(v=7) + H_2(v=0) → HF(v=6) + H_2(v=0) (cont'd.)		9.0×10^{-12}	±30	2988	298	FT	81 Dzelzkalns and Kaufman 1982
		Thought to be mainly V-T					
HF(v=1) + H_2(v=0) → HF(v=0) + H_2(v=0)	V-T	$<3 \times 10^{-14}$		3962	295	LF	95 Hancock and Green 1972
		$<1.8 \times 10^{-14}$	±35	3962	295	LF	37 Bott and Cohen 1973
		The intercept was misquoted; the result in Ref. 27 is better					
		$\sim 1.2 \times 10^{-13}$			295	LF	100 Hinchen 1973
		Estimate only					
		1.2×10^{-14}	±30	3962	295	LF	27 Bott 1974
		3.5×10^{-14}		3962	295	LF	141 Osgood, private communication in Ref. 27
		$\lesssim 3.1 \times 10^{-14}$ $\lesssim 3.1 \times 10^{-14}$	±30	3962	457- 611	LF-ST	27 Bott 1974
HF + H_2, see also H_2 + HF							
HF(v=1) + H_2O → HF(v=0) + $H_2O^†$	V-V & V-T	1.3×10^{-10}	±15	206(001) 310(100)	294	LF	95 Hancock and Green 1972
		1.0×10^{-10} 4.9×10^{-12}		206(001) 310(100)	1630- 2920	ST	20 Blauer...Owens 1972
HF(v=2) + H_2O → HF(v=1) + $H_2O^†$	V-V & V-T	4.0×10^{-10}		3789	295	FR	147 Poole and Smith 1977
HF(v=3) + H_2O → HF(v=2) + $H_2O^†$	V-V & V-T	6.2×10^{-10}		3622	295	FR	147 Poole and Smith 1977
HF(v=4) + H_2O → HF(v=3) + $H_2O^†$	V-V & V-T	7.6×10^{-10}		3459	295	FR	147 Poole and Smith 1977
HF(v=5) + H_2O → HF(v=4) + $H_2O^†$	V-V & V-T	6.5×10^{-10}		3299	295	FR	147 Poole and Smith 1977
HF(v=6) + H_2O → HF(v=5) + $H_2O^†$	V-V & V-T	3.7×10^{-10}		3143	295	FR	147 Poole and Smith 1977
HF(v=7) + H_2O → HF(v=6) + $H_2O^†$	V-V & V-T	3.1×10^{-10}		2988	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
HF(v=1) + H_2S → HF(v=0) + $H_2S^†$	V-V & V-T	1.9×10^{-12}	±10	3962	295	LF	39 Bott and Cohen 1974
		2.3×10^{-12}	±30	3962	298	FT	119 Kwok and Wilkins 1974
HF(v=2) + H_2S → HF(v=1) + $H_2S^†$	V-V & V-T	8.6×10^{-12}	±50	3789	298	FT	119 Kwok and Wilkins 1974
HF(v=3) + H_2S → HF(v=2) + $H_2S^†$	V-V & V-T	1.0×10^{-11}	±50	3622	298	FT	119 Kwok and Wilkins 1974
HF(v=1) + HI(v=0) → HF(v=0) + HI(v=1)	V-V & V-T	1.1×10^{-13}	±60	1950(v=1) -418(v=2)	300	LF	1 Ahl and Cool 1973
		7.2×10^{-14}	±75	1950(v=1) -418(v=2)	350	LF	1 Ahl and Cool 1973
HF(v=6) + HI(v=0) → HF(v=5) + HI(v=1)	V-V & V-T	2.0×10^{-10}	±10		295	LF	162 Wrigley and Smith 1981
		Deactivation of laser initiated reaction product					
HF(v=1) + I → HF(v=0) + I	V-T	3.8×10^{-12} 3.6×10^{-11}	±50	3962	1600- 3000	ST	18 Blauer and Solomon 1973
HF(v=2) + I → HF(v=0) + I(I^*)	V-T & V-E	$\lesssim 3 \times 10^{-12}$	±35	7751 147(I^*)	295	LF	148 Pritt and Coombe 1976
		V-E contribution to the total deactivation from reverse process					
		$\lesssim 9.4 \times 10^{-13}$		7751 147(I^*)	295	LF	69 Coombe and Pritt 1977
		Value obtained from V-E contribution to the total deactivation, E-V channel established to be 35%					
HF(v=1) + NF_3 → HF(v=0) + $NF_3^†$	V-V & V-T	$<9 \times 10^{-15}$		3962	295	LF	39 Bott and Cohen 1974
HF + NaF, see NaF + HF							
HF(v=2) + NH_3 → HF(v=1) + $NH_3^†$	V-V & V-T	1.9×10^{-10}		3789	295	FR	147 Poole and Smith 1977
HF(v=3) + NH_3 → HF(v=2) + $NH_3^†$	V-V & V-T	1.9×10^{-10}		3622	295	FR	147 Poole and Smith 1977
HF(v=4) + NH_3 → HF(v=3) + $NH_3^†$	V-V & V-T	2.3×10^{-10}		3459	295	FR	147 Poole and Smith 1977
HF(v=5) + NH_3 → HF(v=4) + $NH_3^†$	V-V & V-T	4.0×10^{-10}		3299	295	FR	147 Poole and Smith 1977

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=6) + NH_3 \rightarrow HF(v=5) + NH_3^{\dagger}$	V-V & V-T	2.8×10^{-10}		3143	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$HF(v=1) + N_2(v=0) \rightarrow HF(v=0) + N_2(v=1)$	V-V & V-T	4.0×10^{-15}	±50	1630	294	LF	94 Hancock and Green 1972
		3.9×10^{-15}	±50	1630	294	LF	95 Hancock and Green 1972
		4.7×10^{-15}	±10	1630	295	LF	37 Bott and Cohen 1973
		May contain large V-T contribution					
		4.5×10^{-15}	±15	1630	295	LF	31 Bott 1976
		4.3×10^{-15}	±15	1630	295	LF	44 Bott and Heidner 1980
		6.2×10^{-15}	±10	1630	200	LF	44 Bott and Heidner 1980
		$<1.2 \times 10^{-14}$		1630	350	LF	2 Airey and Fried 1971
		6.2×10^{-15}	±50	1630	350	LF	89 Fried...Taylor 1973
		6.2×10^{-15} 9.1×10^{-14}	±10	1630	450- 1700	LF-ST	37 Bott and Cohen 1973
		5.3×10^{-14} 4.3×10^{-13}		1630	1500- 3200	ST	34 Bott and Cohen 1971
		9.5×10^{-14} 2.2×10^{-13}	±60	1630	1400- 3200	ST	19 Blauer...Owens 1972
$HF(v=2) + N_2(v=0) \rightarrow HF(v=1) + N_2(v=1)$	V-V & V-T	2.5×10^{-14}	±15	1462	295	LF	31 Bott 1976
		Sequential absorption to HF(v=2)					
		$\sim 1.1 \times 10^{-14}$		1462	295	FR	147 Poole and Smith 1977
$HF(v=3) + N_2(v=0) \rightarrow HF(v=2) + N_2(v=1)$	V-V & V-T	9.0×10^{-14}	±15	1295	295	LF	31 Bott 1976
		Sequential absorption to HF(v=3)					
		2.8×10^{-14}		1295	295	FR	147 Poole and Smith 1977
		7.1×10^{-14}		1295	295	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
$HF(v=4) + N_2(v=0) \rightarrow HF(v=3) + N_2(v=1)$	V-V & V-T	6.1×10^{-14}		1128	295	FR	147 Poole and Smith 1977
		3.5×10^{-13}	±10	1128	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
$HF(v=5) + N_2(v=0) \rightarrow HF(v=4) + N_2(v=1)$	V-V & V-T	2.5×10^{-13}		967	295	FR	147 Poole and Smith 1977
$HF(v=6) + N_2(v=0) \rightarrow HF(v=5) + N_2(v=1)$	V-V & V-T	7.0×10^{-13}		809	295	FR	147 Poole and Smith 1977
		1.2×10^{-12}	±35	809	295	LF	162 Smith and Wrigley 1981
$HF(v=7) + N_2(v=0) \rightarrow HF(v=6) + N_2(v=1)$	V-V & V-T	1.4×10^{-12}		654	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$HF(v=1) + N_2O \rightarrow HF(v=0) + N_2O^{\dagger}$	V-V & V-T	1.0×10^{-12}	±10	3962	295	LF	39 Bott and Cohen 1974
		3.8×10^{-13}	±30	3962	298	FT	119 Kwok and Cohen 1974
$HF(v=2) + N_2O \rightarrow HF(v=1) + N_2O^{\dagger}$	V-V & V-T	6.8×10^{-13}	±50	3789	298	FT	119 Kwok and Cohen 1974
		1.0×10^{-11}		3789	295	FR	147 Poole and Smith 1977
$HF(v=3) + N_2O \rightarrow HF(v=2) + N_2O^{\dagger}$	V-V & V-T	2.5×10^{-11}		3622	295	FR	147 Poole and Smith 1977
		1.4×10^{-11}	±10	3622	296	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
$HF(v=4) + N_2O \rightarrow HF(v=3) + N_2O^{\dagger}$	V-V & V-T	3.0×10^{-11}		3459	295	FR	147 Poole and Smith 1977
		5.9×10^{-11}	±15		295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
$HF(v=5) + N_2O \rightarrow HF(v=4) + N_2O^{\dagger}$	V-V & V-T	5.2×10^{-11}		3299	295	FR	147 Poole and Smith 1977
		1.2×10^{-10}	±30	3299	298	FT	81 Dzelzkalns and Kaufman 1982

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	$\Delta E(cm^{-1})$ (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=6) + N_2O \rightarrow HF(v=5) + N_2O^\dagger$	V-V & V-T	7.4×10^{-11}		3143	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
		1.2×10^{-10}	±35	3143	295	LF	162 Smith and Wrigley 1981
		1.8×10^{-10}	±30	3143	298	FT	81 Dzelzkalns and Kaufman 1982
$HF(v=7) + N_2O \rightarrow HF(v=6) + N_2O^\dagger$	V-V & V-T	3.1×10^{-10}	±30	2988	298	FT	81 Dzelzkalns and Kaufman 1982
$HF + N_2O$, see also $N_2O + HF$							
$HF(v=1) + NO(v=0) \rightarrow HF(v=0) + NO(v=1)$	V-V & V-T	1.9×10^{-13}	±20	2083(v=1) 235(v=2)	295	LF	37 Bott and Cohen 1973
		1.9×10^{-13}	±20	2083(v=1) 235(v=2)	295	LF	92 Green and Hancock 1973
		3.4×10^{-13} 1.5×10^{-12}		2083(v=1) 235(v=2)	1060- 2680	ST	20 Blauer...Owens 1972
$HF + NO$, see also $NO + HF$							
$HF(v=1) + O \rightarrow HF(v=0) + O$	V-T	3.1×10^{-12}	±20	3962	295	LF	149 Quigley and Wolga 1974
		3.1×10^{-12}	±20	3962	295	LF	151 Quigley and Wolga 1975
		1.1×10^{-11} 2.5×10^{-12}		3962	1400- 2500	ST	18 Blauer and Solomon 1973
$HF(v=1) + O_2(v=0) \rightarrow HF(v=0) + O_2(v=1)$	V-V & V-T	1.4×10^{-15}	±15	2403(v=1) 871(v=2)	295	LF	37 Bott and Cohen 1973
		V-T contribution may be large					
		1.1×10^{-14}	±10	2403(v=1) 871(v=2)	295	LF	37 Hancock and Green 1973
		1.4×10^{-15} 1.3×10^{-14}	±10	2403(v=1) 871(v=2)	295- 900	LF-ST	37 Bott and Cohen 1973
		4.1×10^{-14} 1.7×10^{-13}	±50	2403(v=1) 871(v=2)	1400- 3000	ST	19 Blauer...Owens 1972
		2.0×10^{-14} 2.2×10^{-13}		2403(v=1) 871(v=2)	1200- 3500	ST	169 Vasil'ev...Papin 1975
$HF(v=2) + O_2(v=0) \rightarrow HF(v=1) + O_2(v=1)$	V-V & V-T	$<1.4 \times 10^{-14}$		2233(v=1)	295	FR	147 Poole and Smith 1977
$HF(v=3) + O_2(v=0) \rightarrow HF(v=2) + O_2(v=1)$	V-V & V-T	2.3×10^{-14}	±15	2066(v=1)	295	LF	31 Bott 1976
		Sequential absorption to HF(v=3)					
		3.4×10^{-14}		2066(v=1)	295	FR	147 Poole and Smith 1977
		$O_2(^1\Delta)$ presumed to be unimportant					
		1.9×10^{-14}	±35	2066(v=1)	296	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
$HF(v=4) + O_2(v=0) \rightarrow HF(v=3) + O_2(v=1)$	V-V & V-T	8.4×10^{-14}		1902(v=1)	295	FR	147 Poole and Smith 1977
		1.01×10^{-13}	±20	1902(v=1)	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initated reaction product					
$HF(v=5) + O_2(v=0) \rightarrow HF(v=4) + O_2(v=1)$	V-V & V-T	2.1×10^{-13}		1741(v=1)	295	FR	147 Poole and Smith 1977
$HF(v=6) + O_2(v=0) \rightarrow HF(v=5) + O_2(v=1)$	V-V & V-T	4.7×10^{-13}		1584(v=1)	295	FR	147 Poole and Smith 1977
		2.7×10^{-13}	±40	1584(v=1)	295	LF	162 Smith and Wrigley 1981
$HF(v=7) + O_2(v=0) \rightarrow HF(v=6) + O_2(v=1)$	V-V & V-T	7.2×10^{-13}		1428(v=1)	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$HF(v=1) + PF_5 \rightarrow HF(v=0) + PF_5^\dagger$	V-V & V-T	2.3×10^{-13}	±15	3962	295	LF	39 Bott and Cohen 1974
$HF(v=1) + SF_6 \rightarrow HF(v=0) + SF_6^\dagger$	V-V & V-T	2.8×10^{-15}	±85	3962	295	LF	89 Fried...Taylor 1973
		$<1.5 \times 10^{-15}$		3962	295	LF	39 Bott and Cohen 1974
$HF(v=2) + SF_6 \rightarrow HF(v=1) + SF_6^\dagger$	V-V & V-T	$<5 \times 10^{-15}$		3789	298	FT	119 Kwok and Cohen 1974
		$\sim 6 \times 10^{-15}$		3789	295	FR	147 Poole and Smith 1977

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$HF(v=3) + SF_6 \rightarrow HF(v=2) + SF_6^{\dagger}$	V-V & V-T	2.8×10^{-14}	±50	3622	298	FT	119 Kwok and Cohen 1974
		1.6×10^{-14}		3622	295	FR	147 Poole and Smith 1977
$HF(v=4) + SF_6 \rightarrow HF(v=3) + SF_6^{\dagger}$	V-V & V-T	3.6×10^{-14}		3459	295	FR	147 Poole and Smith 1977
$HF(v=5) + SF_6 \rightarrow HF(v=4) + SF_6^{\dagger}$	V-V & V-T	7.0×10^{-14}		3299	295	FR	147 Poole and Smith 1977
$HF(v=6) + SF_6 \rightarrow HF(v=5) + SF_6^{\dagger}$	V-V & V-T	1.5×10^{-13}		3143	295	FR	147 Poole and Smith 1977
$HF(v=7) + SF_6 \rightarrow HF(v=6) + SF_6^{\dagger}$	V-V & V-T	3.5×10^{-13}		2988	295	FR	147 Poole and Smith 1977
		The rate constants in Ref. 147 are internally consistent, but their absolute magnitudes may be in error					
$HF(v=1) + SiF_4 \rightarrow HF(v=0) + SiF_4^{\dagger}$	V-V & V-T	$\leq 1.0 \times 10^{-14}$	±15	3962	295	LF	39 Bott and Cohen 1974
$HF(v=1) + SO_2 \rightarrow HF(v=0) + SO_2^{\dagger}$	V-V & V-T	7.4×10^{-13}	±15	3962	295	LF	39 Bott and Cohen 1974
$HF(v=1) + SO_2F_2 \rightarrow HF(v=0) + SO_2F_2^{\dagger}$	V-V & V-T	4.4×10^{-13}	±10	3962	295	LF	39 Bott and Cohen 1974
$H_2(v=1) + DBr(v=0) \rightarrow H_2(v=0) + DBr(v=1)$	V-V & V-T	6.5×10^{-15}	±20	2321(v=1) 527(v=2)	296	LF	137,138 Miller and Hancock 1976,1977
		Laser Raman excitation of H_2					
$H_2(v=1) + DC\ell(v=0) \rightarrow H_2(v=0) + DC\ell(v=1)$	V-V & V-T	2.13×10^{-14}	±5	2069(v=1) 34(v=2)	296	LF	137,138 Miller and Hancock 1976,1977
$H_2(v=1) + HBr(v=0) \rightarrow H_2(v=0) + HBr(v=1)$	V-V & V-T	6.9×10^{-15}	±10	1604	296	LF	137,138 Miller and Hancock 1976,1977
$H_2(v=1) + HC\ell(v=0) \rightarrow H_2(v=0) + HC\ell(v=1)$	V-V & V-T	5.0×10^{-14}	±15	1274	299	LF	145 Pirkle and Cool 1976
		3.9×10^{-14}	±15	1274	295	LF	30 Bott 1976
		4.7×10^{-14}	±15	1274	296	LF	137,138 Miller and Hancock 1976,1977
		Laser Raman excitation of H_2					
		3.8×10^{-14} 4.6×10^{-14}	±30	1274	215-448	LF	145 Pirkle and Cool 1976
		3.7×10^{-13} 1.6×10^{-12}	±50	1274	800-2000	ST	155 Rosen...Taylor 1979
$H_2(v=1) + HF(v=0) \rightarrow H_2(v=0) + HF(v=1)$	V-V	1.9×10^{-12}	±15	201	294	LF	94 Hancock and Green 1972
		1.94×10^{-12}	±5	201	294	LF	95 Hancock and Green 1972
		1.95×10^{-12}		201	320	FT	6 Anlauf...Herman 1973
		1.34×10^{-12}	±5	201	295	LF	37 Bott and Cohen 1973
		May contain a small V-T contribution					
		1.9×10^{-12}	±25	201	295	LF	100 Hinchen 1973
		1.3×10^{-12}		201	295	LF	142 Osgood, private communication in Ref. 37
		1.5×10^{-12}	±5	201	295	LF	88 Fried, private communication in Ref. 37
		1.2×10^{-12}	±10	201	295	LF	31 Bott 1976
		1.32×10^{-12}	±10	201	295	LF	44 Bott and Heidner 1980
		9.27×10^{-13}	±10	201	200	LF	44 Bott and Heidner 1980
		1.3×10^{-12} 1.6×10^{-12}	±5	201	450-1100	LF-ST	37 Bott and Cohen 1973
$H_2(v=1) + HF(v=1) \rightarrow H_2(v=0) + HF(v=2)$	V-V	7.8×10^{-12}		367	320	FT	6 Anlauf...Herman 1973
		2.2×10^{-12}	±10	367	295	LF	31 Bott 1976
$H_2(v=1) + HF(v=0) \rightarrow H_2(v=0) + HF(v=0)$	V-T	$<5.1 \times 10^{-14}$	±30	4160	295	LF	37 Bott and Cohen 1973
		9.0×10^{-13}	±65	4160	295	LF	100 Hinchen 1973
		1.2×10^{-14}	±30	4160	295	LF	27 Bott 1974
		Value given is $k_{HF-H_2} + 0.376\ k_{H_2-HF}$					
		3.5×10^{-14}		4160	295	LF	141 Osgood 1974

Table 1. Rate coefficients for vibrational energy transfer (continued)

Process	Type	Rate Constant (cm^3/molecule·s)	Error (%)	ΔE(cm^{-1}) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
H_2(v=1) + HF(v=0) → H_2(v=0) + HF(v=0) (cont'd.)		3.1×10^{-14} 3.1×10^{-14}	±30	4160	457– 611	LF-ST	27 Bott 1974
HI(v=1) + CO(v=0) → HI(v=0) + CO(v=0)	V-T	1.4×10^{-13} 3.9×10^{-13}	±10	2230	1400– 2000	ST	22 Borrell...Gutteridge 1975
HI(v=1) + CO_2(000) → HI(v=0) + CO_2(nm0)	V-T	$<4.1 \times 10^{-14}$		2230	295	LF	167 Stephenson...Moore 1972
HI(v=2) + HF(v=0) → HI(v=0) + HF(v=1)	V-V	6.0×10^{-13}	±15	418	300	LF	1 Ahl and Cool 1973
		Deactivation of HF(v=2) appears to occur via double quantum transfer to HI					
		4.5×10^{-13}		418	350	LF	1 Ahl and Cool 1973
HI(v=1) + HI(v=1) → HI(v=2) + HI(v=0)	V-V	2.2×10^{-13}	±20	81	300	LF	1 Ahl and Cool 1973
		1.2×10^{-12}	±30	81	350	LF	1 Ahl and Cool 1973
HI(v=1) + HI(v=0) → HI(v=0) + HI(v=0)	V-T	$\sim 1.2 \times 10^{-14}$	±15	2230	295	LF	64 Chen...Moore 1968
		8.3×10^{-14} 9.4×10^{-13}	±20	2230	800– 1800	ST	116 Kiefer...Bird 1969
		$\sim 1 \times 10^{-13}$		2230	1400– 2300	ST	66 Chow...Greene 1965
		Some data for v = 2,3 also					
HI + N_2, see N_2 + HI							
NaF(v) + HF(v=0) → NaF(v-n) + HF(v')	V-V	$\sim 1.4 \times 10^{-10}$				CB	82 Engelke 1979
		Crossed beam fluorescence, results also for MgF(v)					
N_2(v=1) + DCℓ(v=0) → N_2(v=0) + DCℓ(v=1)	V-V	5.2×10^{-14}	±15	240	295	LF	177 Zittel and Moore 1973
		V-T contribution is less than 1%					
N_2(v=1) + DI(v=0) → N_2(v=0) + DI(v=1)	V-V	1.6×10^{-14} 3.9×10^{-14}	±10	730	1200– 2000	ST	50 Breshears and Bird 1971
N_2(v=1) + HBr(v=0) → N_2(v=0) + HBr(v=0)	V-T	$<1.1 \times 10^{-15}$		2330	296	LF	61 Chen 1971
N_2(v=1) + HI(v=0) → N_2(v=0) + HI(v=1)	V-V	1.7×10^{-13} 1.8×10^{-13}	±15	100	1000– 2700	ST	50 Breshears and Bird 1971
N_2O(001) + HCℓ(v=0) → N_2O(nm0) + HCℓ(v=0)	V-T	3.9×10^{-13} 6.4×10^{-13}		2224	300– 700	LF	80 Doyennette...Henry 1978
N_2O(001) + HF(v=0) → N_2O(nm0) + HF(v=0)	V-T	2.2×10^{-12}	±10	2224	295	LF	39 Bott and Cohen 1974
NO(v=1) + HF(v=0) → NO(v=0) + HF(v=0)	V-T	9.3×10^{-14}	±35	1876	295	LF	37 Bott and Cohen 1973
OCS(001) + HBr(v=0) → OCS(nm0) + HBr(v=0)	V-T	1.0×10^{-13}	±10	2062	296	LF	103 Hopkins and Chen 1973
O_3(001) + HCℓ(v=0) → O_3(nm0) + HCℓ(v=0)	V-T	1.6×10^{-12} 1.2×10^{-12}	±30	1740	173– 419	FT	90 Gordon...Moy 1978
TF(v=1) + CO_2(000) → TF(v=0) + CO_2(001)		$\leq 5.2 \times 10^{-11}$		95			139 Nikitin and Oraevskii 1976

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