

# Rate Coefficients for Vibrational Energy Transfer Involving the Hydrogen Halides

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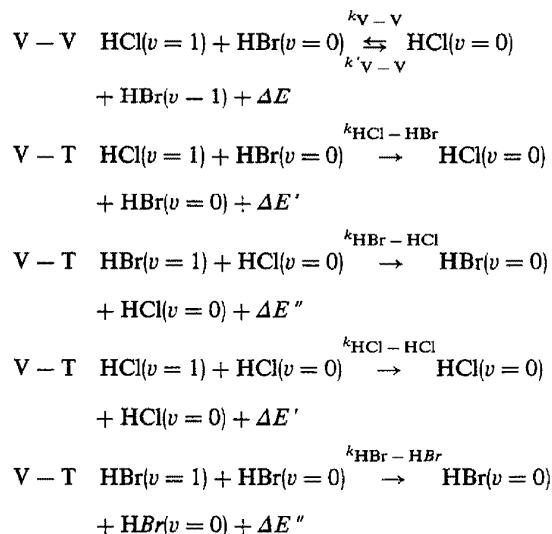
Theoretical papers were scanned for tables of experimental values that might have been missed. Technical reports and meeting abstracts were reviewed for unpublished data.

### 3. Arrangement of Table

The table lists each process under one of the main groupings, HF, HCl, HBr, HI, DF, DCI, 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 common chemical formulation (e.g., SF<sub>6</sub> instead of F<sub>6</sub>S). 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) → 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:



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:  $k_{\text{V}-\text{V}} + k'_{\text{V}-\text{V}}$ . This result taken together with detailed balancing,  $k_{\text{V}-\text{V}}/k'_{\text{V}-\text{V}} = e^{\Delta E/kT}$ , allows  $k_{\text{V}-\text{V}}$  to be deter-

mined. As written, the value of  $k_{\text{V}-\text{V}}$  is for the forward, exothermic direction (positive  $\Delta E$ ). 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 ( $k_{\text{V}-\text{V}}$ ) 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 HIF(v = 2) by HIF is listed as a V - V process in the exothermic direction as HF(v = 1) + HF(v = 1) → HF(v = 2) + HF(v = 0) + ΔE, but the relaxation of HF(v = 3) and higher levels is listed in the endothermic direction as HF(v = 3) + HF(v = 0) → HF(v = 2) + HF(v = 1) + ΔE. 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  $\Delta E$  is listed in  $\text{cm}^{-1}$ . The reader may find the value of  $\Delta E$  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,  $\Delta E$  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  $\Delta E$  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 uncer-

tainties 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  $V \leftrightarrow R$  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 <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
$\text{BCl}_3(v_4) + \text{DCl}(v=0) + \text{BCl}_3(0) + \text{DCl}(v=0)$	V-T	$5.1 \times 10^{-12}$ May be near resonant V-R transfer		243	295	DR	111 Houston...Steinfeld 1973
$\text{BCl}_3(v_4) + \text{HCl}(v=0) + \text{BCl}_3(0) + \text{HCl}(v=0)$	V-T	$8.2 \times 10^{-12}$ May be near resonant V-R transfer		243	295	DR	111 Houston...Steinfeld 1973
		$3.4 \times 10^{-12}$		243	300	DR	87 Frankel...Poulsen 1974
		$7.3 \times 10^{-12}$		243	220-	DR	87 Frankel...Poulsen 1974
		$3.6 \times 10^{-12}$			340		
$\text{CD}_4(v_4) + \text{DCl}(v=0) + \text{CD}_4(0) + \text{DCl}(v=0)$	V-T	$6.3 \times 10^{-14}$	$\pm 15$	996	295	LF	176 Zittel and Moore 1973
$\text{CD}_4(v_4) + \text{HCl}(v=0) + \text{CD}_4(0) + \text{HCl}(v=0)$	V-T	$4.2 \times 10^{-13}$	$\pm 20$	996	295	LF	176 Zittel and Moore 1973
$\text{CH}_4(v_4) + \text{DCl}(v=0) + \text{CH}_4(0) + \text{DCl}(v=0)$	V-T	$3.9 \times 10^{-14}$	$\pm 25$	1306	295	LF	176 Zittel and Moore 1973
$\text{CH}_4(v_4) + \text{HCl}(v=0) + \text{CH}_4(0) + \text{HCl}(v=0)$	V-T	$2.0 \times 10^{-13}$	$\pm 15$	1306	295	LF	176 Zittel and Moore 1973
$\text{Cl}_2(v=1) + \text{HCl}(v=0) + \text{Cl}_2(v=0) + \text{HCl}(v=0)$	V-T	$2.7 \times 10^{-12}$ $6.5 \times 10^{-12}$	$\pm 25$	595	400-	ST	48 Breshears and Bird 1969
					1100		
$\text{Cl}_2(v=1) + \text{DCl}(v=0) + \text{Cl}_2(v=0) + \text{DCl}(v=0)$	V-T	$4.2 \times 10^{-13}$ $2.5 \times 10^{-12}$	$\pm 25$	595	400-	ST	48 Breshears and Bird 1969
					1100		
$\text{CO}(v=1) + \text{DBr}(v=0) + \text{CO}(v=0) + \text{DBr}(v=1)$	V-V	$1.25 \times 10^{-13}$	$\pm 10$	303	295	LF	177 Zittel and Moore 1973
$\text{CO}(v=4) + \text{DBr}(v=0) + \text{CO}(v=3) + \text{DBr}(v=1)$	V-V & V-T	$8.8 \times 10^{-13}$		224	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=5) + \text{DBr}(v=0) + \text{CO}(v=4) + \text{DBr}(v=1)$	V-V & V-T	$1.7 \times 10^{-12}$		198	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=6) + \text{DBr}(v=0) + \text{CO}(v=5) + \text{DBr}(v=1)$	V-V & V-T	$2.4 \times 10^{-12}$		172	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=7) + \text{DBr}(v=0) + \text{CO}(v=6) + \text{DBr}(v=1)$	V-V & V-T	$3.1 \times 10^{-12}$		145	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=8) + \text{DBr}(v=0) + \text{CO}(v=7) + \text{DBr}(v=1)$	V-V & V-T	$5.0 \times 10^{-12}$		119	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=9) + \text{DBr}(v=0) + \text{CO}(v=8) + \text{DBr}(v=1)$	V-V & V-T	$8.2 \times 10^{-12}$		94	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=10) + \text{DBr}(v=0) + \text{CO}(v=9) + \text{DBr}(v=1)$	V-V & V-T	$1.0 \times 10^{-11}$		67	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=11) + \text{DBr}(v=0) + \text{CO}(v=10) + \text{DBr}(v=1)$	V-V & V-T	$1.4 \times 10^{-11}$		42	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=12) + \text{DBr}(v=0) + \text{CO}(v=11) + \text{DBr}(v=1)$	V-V & V-T	$1.7 \times 10^{-11}$		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							
$\text{CO}(v=1) + \text{DCl}(v=0) + \text{CO}(v=0) + \text{DCl}(v=1)$	V-V	$1.45 \times 10^{-12}$	$\pm 10$	52	295	LF	177 Zittel and Moore 1973
V-T contribution is less than 0.5%							
$^{13}\text{CO}(v=1) + \text{DCl}(v=0) + ^{13}\text{CO}(v=0) + \text{DCl}(v=1)$	V-V	$2.1 \times 10^{-12}$	$\pm 10$	5	295	LF	177 Zittel and Moore 1973
$\text{CO}(v=2) + \text{DCl}(v=0) + \text{CO}(v=1) + \text{DCl}(v=1)$	V-V	$3.7 \times 10^{-12}$	$\pm 10$	26	295	LF	73 Dasch and Moore 1980
Direct excitation to CO(v=2)							
$\text{CO}(v=4) + \text{DCl}(v=0) + \text{CO}(v=3) + \text{DCl}(v=1)$	V-V & V-T	$6.3 \times 10^{-12}$		-27	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=5) + \text{DCl}(v=0) + \text{CO}(v=4) + \text{DCl}(v=1)$	V-V & V-T	$7.5 \times 10^{-12}$		-53	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=6) + \text{DCl}(v=0) + \text{CO}(v=5) + \text{DCl}(v=1)$	V-V & V-T	$6.8 \times 10^{-12}$		-79	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=7) + \text{DCl}(v=0) + \text{CO}(v=6) + \text{DCl}(v=1)$	V-V & V-T	$8.1 \times 10^{-12}$		-106	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=8) + \text{DCl}(v=0) + \text{CO}(v=7) + \text{DCl}(v=1)$	V-V & V-T	$7.4 \times 10^{-12}$		-132	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=9) + \text{DCl}(v=0) + \text{CO}(v=8) + \text{DCl}(v=1)$	V-V & V-T	$6.6 \times 10^{-12}$		-157	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=10) + \text{DCl}(v=0) + \text{CO}(v=9) + \text{DCl}(v=1)$	V-V & V-T	$5.4 \times 10^{-12}$		-184	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=11) + \text{DCl}(v=0) + \text{CO}(v=10) + \text{DCl}(v=1)$	V-V & V-T	$3.9 \times 10^{-12}$		-209	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=12) + \text{DCl}(v=0) + \text{CO}(v=11) + \text{DCl}(v=1)$	V-V & V-T	$3.3 \times 10^{-12}$		-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							
$\text{CO}(v=1) + \text{DI}(v=0) + \text{CO}(v=0) + \text{DI}(v=1)$	V-V	$7.4 \times 10^{-15}$	$\pm 15$	548	295	LF	177 Zittel and Moore 1973
V-T contribution is less than 10%							
$\text{CO}(v=1) + \text{HBr}(v=0) + \text{CO}(v=0) + \text{HBr}(v=0)$	V-T	$<6.8 \times 10^{-16}$		2143	296	LF	61 Chen 1971
$\text{CO}(v=4) + \text{HBr}(v=0) + \text{CO}(v=3) + \text{HBr}(v=0)$	V-T	$5.3 \times 10^{-14}$		2064	298	FR	46 Braithwaite and Smith 1975
$\text{CO}(v=5) + \text{HBr}(v=0) + \text{CO}(v=4) + \text{HBr}(v=0)$	V-T	$6.8 \times 10^{-14}$		2038	298	FR	46 Braithwaite and Smith 1975

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E(\text{cm}^{-1})$ (+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	$1.2 \times 10^{-13}$			2012	298	FR 46 Braithwaite and Smith 1975
CO(v=7) + HBr(v=0) + CO(v=6) + HBr(v=0)	V-T	$1.5 \times 10^{-13}$			1985	298	FR 46 Braithwaite and Smith 1975
CO(v=8) + HBr(v=0) + CO(v=7) + HBr(v=0)	V-T	$2.7 \times 10^{-13}$			1959	298	FR 46 Braithwaite and Smith 1975
CO(v=9) + HBr(v=0) + CO(v=8) + HBr(v=0)	V-T	$3.5 \times 10^{-13}$			1934	298	FR 46 Braithwaite and Smith 1975
CO(v=10) + HBr(v=0) + CO(v=9) + HBr(v=0)	V-T	$5.0 \times 10^{-13}$			1907	298	FR 46 Braithwaite and Smith 1975
CO(v=11) + HBr(v=0) + CO(v=10) + HBr(v=0)	V-T	$6.6 \times 10^{-13}$			1882	298	FR 46 Braithwaite and Smith 1975
CO(v=12) + HBr(v=0) + CO(v=11) + HBr(v=0)	V-T	$8.2 \times 10^{-13}$			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	$2.0 \times 10^{-14}$			2064	298	FR 46 Braithwaite and Smith 1975
CO(v=5) + HCl(v=0) + CO(v=4) + HCl(v=0)	V-T	$2.8 \times 10^{-14}$			2038	298	FR 46 Braithwaite and Smith 1975
CO(v=6) + HCl(v=0) + CO(v=5) + HCl(v=0)	V-T	$3.9 \times 10^{-14}$			2012	298	FR 46 Braithwaite and Smith 1975
CO(v=7) + HCl(v=0) + CO(v=6) + HCl(v=0)	V-T	$3.8 \times 10^{-14}$			1985	298	FR 46 Braithwaite and Smith 1975
CO(v=8) + HCl(v=0) + CO(v=7) + HCl(v=0)	V-T	$4.7 \times 10^{-14}$			1959	298	FR 46 Braithwaite and Smith 1975
CO(v=9) + HCl(v=0) + CO(v=8) + HCl(v=0)	V-T	$5.6 \times 10^{-14}$			1934	298	FR 46 Braithwaite and Smith 1975
CO(v=10) + HCl(v=0) + CO(v=9) + HCl(v=0)	V-T	$6.9 \times 10^{-14}$			1907	298	FR 46 Braithwaite and Smith 1975
CO(v=11) + HCl(v=0) + CO(v=10) + HCl(v=0)	V-T	$6.8 \times 10^{-14}$			1002	298	FR 46 Braithwaite and Smith 1975
CO(v=12) + HCl(v=0) + CO(v=11) + HCl(v=0)	V-T	$9 \times 10^{-14}$			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) + Br(v=0) + CO(v=0) + HF(v=0)	V-T	$9.3 \times 10^{-15}$	$\pm 35$		2143	295	LF 37 Bott and Cohen 1973
	V-T	$1.5 \times 10^{-14}$	$\pm 5$		2143	295	LF 92 Green and Hancock 1973
CO <sub>2</sub> (001) + DBr(v=0) + CO <sub>2</sub> (000) + DBr(v=1)	V-V	$2.84 \times 10^{-13}$	$\pm 1$		540	295	LF 167 Stephenson...Moore 1972
CO <sub>2</sub> (001) + DBr(v=0) + CO <sub>2</sub> (nm0) + DBr(v=0)	V-T	$<2.8 \times 10^{-14}$			2349	295	LF 167 Stephenson...Moore 1972
CO <sub>2</sub> (001) + DCI(v=0) + CO <sub>2</sub> (000) + DCI(v=1)	V-V	$3.1 \times 10^{-12}$	$\pm 5$		258	295	LF 167 Stephenson...Moore 1972
		$3.1 \times 10^{-12}$	$\pm 5$		258	295-	
		$2.9 \times 10^{-12}$				510	LF 167 Stephenson...Moore 1972
CO <sub>2</sub> (001) + DCI(v=0) + CO <sub>2</sub> (nm0) + DCI(v=0)	V-T	$<1.4 \times 10^{-13}$			2349	295	LF 167 Stephenson...Moore 1972
CO <sub>2</sub> (001) + DF(v=0) + CO <sub>2</sub> (nm0) + DF(v=0)	V-T	$7.3 \times 10^{-13}$	$\pm 10$		2349	295	LF 38 Bott and Cohen 1973
		$8.0 \times 10^{-13}$	$\pm 20$		2349	295	LF 127 Lucht and Cool 1974
		$4.6 \times 10^{-13}$			2349	295	LF 102 Hinchen and Hobbs 1975
		$6.8 \times 10^{-13}$	$\pm 20$		2349	350	LF 166 Stephens and Cool 1972
		$6.7 \times 10^{-13}$			2349	348-	
		$8.3 \times 10^{-13}$				373	LF 58 Chang and Wolga 1972
		$5.1 \times 10^{-13}$	$\pm 10$		2349	470	LF-ST 38 Bott and Cohen 1973
		$8.0 \times 10^{-13}$	$\pm 20$		2349	295-	
		$5.5 \times 10^{-13}$				670	LF 127 Lucht and Cool 1974
CO <sub>2</sub> (001) + DI(v=0) + CO <sub>2</sub> (000) + DI(v=1)	V-V & V-T	$3.7 \times 10^{-14}$	$\pm 10$		737 (70,010)	295	LF 167 Stephenson...Moore 1972
CO <sub>2</sub> (001) + HBr(v=0) + CO <sub>2</sub> (nm0) + HBr(v=0)	V-T	$<7.4 \times 10^{-14}$			2349	295	LF 167 Stephenson...Moore 1972
CO <sub>2</sub> (001) + HCl(v=0) + CO <sub>2</sub> (nm0) + HCl(v=0)	V-T	$1.3 \times 10^{-13}$	$\pm 20$		2349	295	LF 167 Stephenson...Moore 1972
		$1.5 \times 10^{-13}$			2349	295	SP 161 Slobodskaya and Rityn 1975
Rate contains small V-T contribution of HCl(v=1) with CO <sub>2</sub>							
		$1.1 \times 10^{-13}$			2349	295	LF 80 Doyennette...Henry 1978
		$1.1 \times 10^{-13}$			2349	295-	
		$4.9 \times 10^{-13}$				900	LF 80 Doyennette...Henry 1978
CO <sub>2</sub> (010) + HCl(v=0) + CO <sub>2</sub> (000) + HCl(v=0)	V-T	$2.9 \times 10^{-12}$			667	295	SP 161 Slobodskaya and Rityn 1975

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, or First and Last Author, Year of Publication
CO <sub>2</sub> (001) + HF(v=0) + CO <sub>2</sub> (nm0) + HF(v=0)	V-T	1.63 × 10 <sup>-12</sup>	±5	2349	294	LF	94, 95 Hancock and Green 1972
		1.05 × 10 <sup>-12</sup>	±10	2349	295	LF	37 Bott and Cohen 1973
		1.5 × 10 <sup>-12</sup>	±20	2349	295	LF	127 Lucht and Cool 1974
		1.5 × 10 <sup>-12</sup>	±20	2349	205– 358	LF	129 Lucht and Cool 1974
		9.0 × 10 <sup>-13</sup>					
		1.3 × 10 <sup>-12</sup>	±10	2349	350	LF	166 Stephens and Cool 1972
		8.2 × 10 <sup>-13</sup>		2349	348– 373	LF	58 Chang... Wolga 1972
		8.5 × 10 <sup>-13</sup>					
		1.5 × 10 <sup>-12</sup>	±20	2349	295– 700	LF	127 Lucht and Cool 1974
		5.1 × 10 <sup>-13</sup>					
CO <sub>2</sub> (001) + HI(v=0) → CO <sub>2</sub> (000) + HI(v=1)	V-V	6.8 × 10 <sup>-12</sup>	±5	116	295	LF	64 Chen... Moore 1968
CO <sub>2</sub> (001) + HI(v=0) + CO <sub>2</sub> (nm0) + HI(v=0)	V-T	<7.1 × 10 <sup>-14</sup>		2349	295	LF	167 Stephenson... Moore 1972
DBr(v=1) + Br + DBr(v=0) + Br	V-T	4.1 × 10 <sup>-12</sup>	±20	1840	295	LF-DF	85 Fernando and Smith 1979
DBr + CO, see CO + DBr							
DBr(v=1) + CO <sub>2</sub> (000) + DBr(v=0) + CO <sub>2</sub> (nm0)	V-T	3.4 × 10 <sup>-14</sup>	±20	1840	295	LF	167 Stephenson... Moore 1972
DBr + CO <sub>2</sub> , see also CO <sub>2</sub> + DBr							
D <sup>79</sup> Br(v=1) + D <sup>81</sup> Br(v=0) + D <sup>79</sup> Br(v=0) + D <sup>81</sup> Br(v=1)	V-V	8.34 × 10 <sup>-12</sup>	±2	0.6	295	LF	109 Horwitz and Leone 1978
DBr(v=1) + DBr(v=0) + DBr(v=0) + DBr(v=0)	V-T	5.2 × 10 <sup>-15</sup>	±20	1840	295	LF	65 Chen and Chen 1972
		2.4 × 10 <sup>-14</sup>		1840	700– 2000	ST	49 Breshears and Bird 1970
		7.3 × 10 <sup>-15</sup>					
DBr(v=1) + DF(v=0) + DBr(v=0) + DF(v=0)	V-T	7.1 × 10 <sup>-13</sup>	±30	1840	295	LF	26 Bott 1974
DBr + DF, see also DF + DBr							
DBr(v=1) + HBr(v=0) + DBr(v=0) + HBr(v=0)	V-T	1.1 × 10 <sup>-14</sup>	±20	1840	295	LF	65 Chen and Chen 1972
DBr + HBr, see also HBr + DBr							
DBr + HCN, see HCN + DBr							
DBr + H <sub>2</sub> , see H <sub>2</sub> + DBr							
DBr(v=1) + O <sub>2</sub> (v=0) + DBr(v=0) + O <sub>2</sub> (v=1)	V-V	1.9 × 10 <sup>-13</sup>	±15	284	295	LF	85 Fernando and Smith 1979
DCI(v=1) + Ar + DCI(v=0) + Ar	V-T	<9.3 × 10 <sup>-18</sup>		2091	295	LF	177 Zittel and Moore 1973
		1.9 × 10 <sup>-18</sup>	±35	2091	295	LF	165 Steele and Moore 1974
		1.9 × 10 <sup>-18</sup>	±35	2091	295– 640	LF	165 Steele and Moore 1974
		9.6 × 10 <sup>-17</sup>					
DCI + BC <sub>l</sub> <sub>3</sub> , see BC <sub>l</sub> <sub>3</sub> + DCI							
DCI(v=1) + Br + DCI(v=0) + Br	V-T	9.4 × 10 <sup>-13</sup>	±20	2091	296	LF-DF	54 Brown... Van der Merwe 1976
		2.3 × 10 <sup>-13</sup>	±30	2091	294	LF-DF	130 Macdonald and Moore 1976
The authors state that results in Ref. 54 may be in error							
DCI(v=1) + CD <sub>4</sub> + DCI(v=0) + CD <sub>4</sub> <sup>†</sup>	V-V & V-T	1.5 × 10 <sup>-12</sup>	±10	-17(v <sub>2</sub> ) -168(v <sub>3</sub> ) 7(v <sub>2</sub> +v <sub>4</sub> )	295	LF	176 Zittel and Moore 1973
DCI + CD <sub>4</sub> , see also CD <sub>4</sub> + DCI							
DCI(v=1) + CH <sub>4</sub> + DCI(v=0) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	8.6 × 10 <sup>-13</sup>	±10	558(v <sub>3</sub> ) 785(v <sub>4</sub> )	295	LF	176 Zittel and Moore 1973
DCI + CH <sub>4</sub> , see also CH <sub>4</sub> + DCI							
DCI(v=1) + Cl + DCI(v=0) + Cl	V-T	~5.3 × 10 <sup>-12</sup>		2091	295	LF-DF	52 Brown... Smith 1975
		Preliminary estimate					
		6.4 × 10 <sup>-12</sup>	±25	2091	295	LF-DF	53 Brown... Smith 1975
		5.5 × 10 <sup>-12</sup>	±30	2091	294	LF-DF	130 Macdonald and Moore 1976

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

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

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+ = exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
DCI(v=1) + O + DCI(v=0) + O (cont'd.)		$8.1 \times 10^{-13}$ $1.6 \times 10^{-12}$	±40	2091	196- 400	LF-DF	55 Brown...Smith 1975
DCI(v=1) + O <sub>2</sub> (v=0) + DCI(v=0) + O <sub>2</sub> (v=1)	V-V	$1.9 \times 10^{-14}$	±10	535	295	LF	177 Zittel and Moore 1973
		V-T contribution is less than 1%					
DCI(v=1) + SF <sub>6</sub> + DCI(v=0) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	$1.1 \times 10^{-14}$	±10	2091 1126(v <sub>3</sub> )	295	LF	177 Zittel and Moore 1973
D <sub>2</sub> (v=1) + DF(v=0) + D <sub>2</sub> (v=0) + DF(v=1)	V-V	$9.3 \times 10^{-13}$ $8.6 \times 10^{-13}$ $6.2 \times 10^{-13}$ $9.6 \times 10^{-13}$ $1.0 \times 10^{-12}$ $9.6 \times 10^{-13}$ $8.7 \times 10^{-13}$ $9.7 \times 10^{-13}$	±20 ±10 ±40 ±10 200- 295 490- 732	83 83 83 83 295 LF-ST	295 295 298 295 200- 295 490- 732	LF LF	100 Hinchen 1973 26 Bott 1974 122 Kwok and Wilkins 1975 32 Bott 1979 33 Bott 1981 26 Bott 1974
D <sub>2</sub> (v=1) + DF(v=1) + D <sub>2</sub> (v=0) + DF(v=2)	V-V	$1.4 \times 10^{-12}$	±35	175	298	FT	122 Kwok and Wilkins 1975
	V-V	$1.3 \times 10^{-12}$		175	295	LF	32 Bott 1979
		Measured from deactivation of v=2 Sequential absorption to DF(v=2) followed by deactivation					
D <sub>2</sub> (v=1) + DF(v=0) + D <sub>2</sub> (v=0) + DF(v=0)	V-T	$8.9 \times 10^{-13}$	±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 <sub>DF-D<sub>2</sub></sub> + 0.667 k <sub>D<sub>2</sub>-DF</sub>					
		$\leq 3.8 \times 10^{-15}$	±25	2992	363- 436	LF-ST	27 Bott 1974
D <sub>2</sub> (v=1) + HBr(v=0) + D <sub>2</sub> (v=0) + HBr(v=1)	V-V	$1.2 \times 10^{-13}$	±10	435	296	LF	61 Chen 1971
D <sub>2</sub> (v=1) + HBr(v=0) + D <sub>2</sub> (v=0) + HBr(v=0)	V-T	$\leq 9.9 \times 10^{-15}$		2992	296	LF	61 Chen 1971
D <sub>2</sub> (v=1) + HCl(v=0) + D <sub>2</sub> (v=0) + HCl(v=1)	V-V	$2.8 \times 10^{-13}$	±10	108	296	LF	63 Chen and Moore 1971
		Erroneously reported as 10 <sup>-12</sup> in original publication					
		$2.8 \times 10^{-13}$	±10	108	296	LF	108 Hopkins...Sharma 1973
		$3.7 \times 10^{-13}$	±10	108	295	LF	4 Allé...Doyennette 1974
		$3.3 \times 10^{-13}$	±10	108	295	LF	40 Bott and Cohen 1975
		$3.9 \times 10^{-13}$ $2.3 \times 10^{-13}$	±10	108	196- 342	LF	108 Hopkins...Sharma 1973
		$3.2 \times 10^{-13}$ $3.3 \times 10^{-13}$	±10	108	469- 742	LF	40 Bott and Cohen 1975
		$3.7 \times 10^{-13}$ $6.6 \times 10^{-13}$	±10	108	295- 1000	LF	4 Allé...Doyennette 1974
DF(v=1) + Ar + DF(v=0) + Ar	V-T	$\leq 9.3 \times 10^{-16}$ $\leq 1.2 \times 10^{-15}$ $\leq 2.0 \times 10^{-16}$ $\leq 2.9 \times 10^{-16}$ $\leq 9.9 \times 10^{-16}$  $7.7 \times 10^{-16}$ $1.9 \times 10^{-14}$  $1.5 \times 10^{-14}$ $4.8 \times 10^{-13}$		2907	295	LF	100 Hinchen 1973
				2907	296	LF	97 Hancock and Saunders 1976
				2907	198	LF	97 Hancock and Saunders 1976
				2907	910- 1150	ST	29 Bott 1975
				2907	1700- 4000	ST	36 Bott and Cohen 1973
				2907	1500- 5000	ST	171 Vasil'ev...Tal'roze 1973
DF(v=1) + BF <sub>3</sub> + DF(v=0) + BF <sub>3</sub> <sup>†</sup>	V-V & V-T	$2.2 \times 10^{-13}$	±15	2907	295	LF	24 Bott 1977
DF(v=1) + CBrF <sub>3</sub> + DF(v=0) + CBrF <sub>3</sub> <sup>†</sup>	V-V & V-T	$1.7 \times 10^{-14}$	±10	2907	295	LF	24 Bott 1977
DF(v=1) + CF <sub>4</sub> + DF(v=0) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	$3.4 \times 10^{-14}$		2907	295	LF	173 Wendelken...Noetzel 1975

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
DF(v=1) + CF <sub>4</sub> + DF(v=0) + CF <sub>4</sub> <sup>†</sup> (cont'd.)		3.1 × 10 <sup>-14</sup>	±10	2907	295	LF	24 Bott 1977
		4.6 × 10 <sup>-14</sup>		2907	295-		172 Wendelken and Stout,
		3.3 × 10 <sup>-14</sup>			800		private communication in 24
		3.1 × 10 <sup>-14</sup>		2907	295-	LF-ST	24 Bott 1977
		~1.2 × 10 <sup>-14</sup>			800		
DF(v=1) + CF <sub>3</sub> H + DF(v=0) + CF <sub>3</sub> H <sup>†</sup>	V-V & V-T	6.0 × 10 <sup>-13</sup>	±15	2907	295	LF	24 Bott 1977
DF(v=1) + CH <sub>3</sub> F + DF(v=0) + CH <sub>3</sub> F <sup>†</sup>	V-V & V-T	1.1 × 10 <sup>-11</sup>	±10	2907	295	LF	24 Bott 1977
DF(v=1) + CH <sub>4</sub> + DF(v=0) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	6.8 × 10 <sup>-12</sup>	±15	2907	295	LF	24 Bott 1977
		6.8 × 10 <sup>-12</sup>	±20	2907	295-	LF-ST	24 Bott 1977
		4.6 × 10 <sup>-12</sup>			740		
DF(v=1) + C <sub>2</sub> H <sub>2</sub> + DF(v=0) + C <sub>2</sub> H <sub>2</sub> <sup>†</sup>	V-V & V-T	1.2 × 10 <sup>-12</sup>	±15	2907	295	LF	24 Bott 1977
DF(v=1) + C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> + DF(v=0) + C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> <sup>†</sup>	V-V & V-T	5.7 × 10 <sup>-13</sup>	±10	2907	295	LF	24 Bott 1977
DF(v=1) + C <sub>2</sub> H <sub>4</sub> + DF(v=0) + C <sub>2</sub> H <sub>4</sub> <sup>†</sup>	V-V & V-T	5.4 × 10 <sup>-12</sup>	±15	2907	295	LF	24 Bott 1977
DF(v=1) + C <sub>2</sub> H <sub>6</sub> + DF(v=0) + C <sub>2</sub> H <sub>6</sub> <sup>†</sup>	V-V & V-T	1.9 × 10 <sup>-11</sup>	±15	2907	295	LF	24 Bott 1977
DF(v=1) + C <sub>4</sub> H <sub>10</sub> + DF(v=0) + C <sub>4</sub> H <sub>10</sub> <sup>†</sup>	V-V & V-T	3.9 × 10 <sup>-11</sup>	±15	2907	295	LF	24 Bott 1977
DF(v=1) + Cl + DF(v=1) + Cl	V-T	2.0 × 10 <sup>-12</sup>	±15	2907	295	LF-DF	151 Quigley and Wolga 1975
		6.9 × 10 <sup>-12</sup>	±50	2907	1500-	ST	18 Blauer and Solomon 1973
		1.0 × 10 <sup>-12</sup>			3350		
DF(v=1) + Cl <sub>2</sub> + DF(v=0) + Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	<1.2 × 10 <sup>-14</sup>		2907	295	LF	151 Quigley and Wolga 1975
DF(v=1) + CO(v=0) + DF(v=0) + CO(v=1)	V-V & V-T	1.2 × 10 <sup>-13</sup>	±10	764	295	LF	26 Bott 1974
		8.6 × 10 <sup>-14</sup>	±10	764	473-	LF-ST	26 Bott 1974
		1.2 × 10 <sup>-13</sup>			725		
DF(v=3) + CO(v=0) + DF(v=2) + CO(v=1)	V-V & V-T	5.0 × 10 <sup>-13</sup>		582	295	FR	147 Poole and Smith 1977
DF(v=4) + CO(v=0) + DF(v=3) + CO(v=1)	V-V & V-T	1.2 × 10 <sup>-12</sup>		494	295	FR	147 Poole and Smith 1977
DF(v=5) + CO(v=0) + DF(v=4) + CO(v=1)	V-V & V-T	2.8 × 10 <sup>-12</sup>		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 <sub>2</sub> (000) + DF(v=0) + CO <sub>2</sub> (001)	V-V	1.5 × 10 <sup>-12</sup>	±35	557		LG	13 Basov...Oraevsky 1971
DF vibrational level not determined							
		4.0 × 10 <sup>-12</sup>		557	295	FR	3 Airey and Smith 1972
		4.7 × 10 <sup>-12</sup>		557	295	LF	38 Bott and Cohen 1973
May include small V-T contribution							
		7.0 × 10 <sup>-12</sup>	±40	557	295	LF	127 Lucht and Cool 1974
V-V contribution only							
		6.2 × 10 <sup>-12</sup>		557	295	LF	102 Hinchen and Hobbs 1975
		≤3.1 × 10 <sup>-12</sup>		557	295	LF	129 Lucht and Cool 1975
		4.8 × 10 <sup>-12</sup>		557	295	LF	32 Bott 1979
		≤6.0 × 10 <sup>-12</sup>	±50	557	208-	LF	129 Lucht and Cool 1975
		≤4.3 × 10 <sup>-12</sup>			359		
V-V contribution only							
		6.3 × 10 <sup>-12</sup>	±15	557	350	LF	166 Stephens and Cool 1972
May include small V-T contribution							
		~3.3 × 10 <sup>-13</sup>		557	400	FT	170 Vasil'ev...Tal'roze 1972
		7.0 × 10 <sup>-12</sup>	±40	557	295-	LF	127 Lucht and Cool 1974
		5.8 × 10 <sup>-12</sup>			670		
V-V contribution only							
		4.7 × 10 <sup>-12</sup>		557	295-	LF	38 Bott and Cohen 1973
		3.1 × 10 <sup>-12</sup>			720		
There is a minimum in the probability at 400 K							

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

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

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

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

# VIBRATIONAL ENERGY TRANSFER IN HYDROGEN HALIDES

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E(\text{cm}^{-1})$ (+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.)		$2.5 \times 10^{-11}$	$\pm 25$	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 <sub>2</sub> + DF(v=0) + F <sub>2</sub> <sup>†</sup>	V-V & V-T	$<8 \times 10^{-15}$		2907	295	LF	151 Quigley and Wolga 1975
DF(v=1) + H + DF(v=0) + H Exchange	V-T & Exchange	$1.1 \times 10^{-13}$	$\pm 30$	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	$2.2 \times 10^{-12}$	$\pm 10$	348	295	LF	26 Bott 1974
		Probably mainly V-V contribution					
		$1.2 \times 10^{-12}$	$\pm 10$	348	471- 739	LF-ST	26 Bott 1974
		$1.0 \times 10^{-12}$					
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	$1.2 \times 10^{-11}$	$\pm 10$	21	295	LF	26 Bott 1974
		V-T contribution is less than 5%					
		$5.2 \times 10^{-12}$	$\pm 10$	21	475- 745	LF-ST	26 Bott 1974
		$5.0 \times 10^{-12}$					
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
		$<3.5 \times 10^{-13}$		2907	475- 745	LF-ST	26 Bott 1974
		$<3 \times 10^{-13}$					
DF(v=1) + HCN + DF(v=0) + HCN <sup>†</sup>	V-V & V-T	$3.3 \times 10^{-12}$	$\pm 15$	2907 -405(v <sub>3</sub> )	298	LF	135 McGarvey...Cool 1977
		$5.1 \times 10^{-12}$		2907	240-	LF	135 McGarvey...Cool 1977
		$2.2 \times 10^{-12}$		-405(v <sub>3</sub> )	450		
DF(v=2) + HCN + DF(v=2) + HCN <sup>†</sup>	V-V & V-T	$8.6 \times 10^{-12}$		2726 -586(v <sub>3</sub> ) -74(v <sub>1</sub> +v <sub>2</sub> )	295	FR	147 Poole and Smith 1977
DF(v=4) + HCN + DF(v=3) + HCN <sup>†</sup>	V-V & V-T	$1.3 \times 10^{-11}$		2638	295	FR	147 Poole and Smith 1977
DF(v=5) + HCN + DF(v=4) + HCN <sup>†</sup>	V-V & V-T	$2.3 \times 10^{-11}$		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
		$6.4 \times 10^{-16}$		2907	900- 2600	ST	29 Bott 1975
		$1.0 \times 10^{-13}$					
		$1.5 \times 10^{-14}$		2907	1500- 3500	ST	169 Vasil'ev...Papin 1975
		$3.1 \times 10^{-13}$					
DF(v=1) + HF(v=0) + DF(v=0) + HF(v=0)	V-T	$2.2 \times 10^{-12}$		2907	295	FT	3 Airey and Smith 1972
		$1.4 \times 10^{-12}$	$\pm 15$	2907	300	LF	1 Ahl and Cool 1973
		$1.1 \times 10^{-12}$	$\pm 15$	2907	295	LF	37 Bott and Cohen 1973
		$1.0 \times 10^{-12}$	$\pm 10$	2907	295	LF	100 Hinchen 1973
		$9.9 \times 10^{-13}$	$\pm 10$	2907	295	LF	101 Hinchen 1973
		$1.6 \times 10^{-12}$	$\pm 45$	2907	295	FT	122 Kwolek and Wilkins 1975
		$1.1 \times 10^{-12}$		2907	295	LF	32 Bott 1979
		$1.7 \times 10^{-12}$	$\pm 20$	2907	210- 364	LF	129 Lucht and Cool 1975
		$7.3 \times 10^{-13}$					
		$1.2 \times 10^{-12}$	$\pm 15$	2907	350	LF	1 Ahl and Cool 1973
		$9.9 \times 10^{-13}$	$\pm 10$	2907	295- 573	LF-ST	101 Hinchen 1973

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

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

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+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	$6.5 \times 10^{-14}$ $2.9 \times 10^{-13}$		308	295	FR	147 Poole and Smith 1977	
$DF(v=5) + N_2(v=0) \rightarrow DF(v=4) + N_2(v=1)$	V-V & V-T	$1.0 \times 10^{-13}$		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	$2.5 \times 10^{-13}$ $1.8 \times 10^{-13}$ $2.1 \times 10^{-13}$	$\pm 10$	1031	295	LF	26 Bott 1974	
				1031	476- 725	LF-ST	26 Bott 1974	
				1031	1060- 2080	ST	20 Blaauw...Owens 1972	
$DF(v=1) + O \rightarrow DF(v=0) + O$	V-T	$7.8 \times 10^{-12}$	$\pm 30$	2907	295	LF	151 Quigley and Wolga 1975	
$DF(v=1) + O_2 \rightarrow DF(v=0) + O_2^\dagger$	V-V & V-T	$2.3 \times 10^{-15}$		$1351(v=1)$ $-205(v=2)$	295	LF	26 Bott 1974	
		$<1.6 \times 10^{-14}$		$1351(v=1)$ $-205(v=2)$	295	LF	151 Quigley and Wolga 1975	
		$3.5 \times 10^{-15}$ $8.5 \times 10^{-15}$		$1351(v=1)$ $-250(v=2)$	550- 870	LF-ST	26 Bott 1974	
		$1.2 \times 10^{-14}$ $1.9 \times 10^{-13}$		$1351(v=1)$ $-250(v=2)$	1200- 3500	ST	169 Vasil'ev...Papin 1975	
$DF(v=1) + SO_2 \rightarrow DF(v=0) + SO_2^\dagger$	V-T	$3.9 \times 10^{-13}$	$\pm 15$	2907	295	LF	24 Bott 1977	
$DI(v=1) + DI(v=0) \rightarrow DI(v=0) + DI(v=0)$	V-T	$2.5 \times 10^{-13}$ $5.6 \times 10^{-13}$		1600	700- 2000	ST	49 Breshears and Bird 1970	
DI + CO, see CO + DI								
DI + CO <sub>2</sub> , see CO <sub>2</sub> + DI								
DI + N <sub>2</sub> , see N <sub>2</sub> + DI								
HBr(v=1) + Ar → HBr(v=0) + Ar	V-T	$53.7 \times 10^{-18}$	$\pm 10$	2559	296	LF	60 Chen 1971	
HBr(v=1) + Br → HBr(v=0) + Br	V-T & V-E	$\sim 1.9 \times 10^{-12}$ $1.6 \times 10^{-12}$ $2.4 \times 10^{-13}$ V-T contribution only	$\pm 45$	2559	295	FP	74 Donovan...Stevenson 1970	
		$2.6 \times 10^{-12}$ V-T contribution only	$\pm 40$	2559	294	LF-DF	113 Karny and Katz 1976	
		$4.6 \times 10^{-12}$ V-T contribution only	$\pm 10$	2559	295	LF-DF	85 Fernando and Smith 1979	
		$\pm 1.5 \times 10^{-16}$ Contribution due to V-E transfer only		-1126	295	LF-DF	126 Leone and Wodarczyk 1974	
HBr(v=1) + Br <sub>2</sub> → HBr(v=0) + Br <sub>2</sub> <sup>†</sup>	V-V & V-T	$1.5 \times 10^{-12}$ Probably incorrect	$\pm 30$	2559	295	FP	75 Donovan...Stevenson 1970	
		$2.2 \times 10^{-14}$	$\pm 10$	2559	295	LF-DF	113 Karny and Katz 1976	
HBr(v=1) + CD <sub>4</sub> → HBr(v=0) + CD <sub>4</sub> <sup>†</sup>	V-V & V-T	$\geq 1.5 \times 10^{-12}$	$\pm 15$	$447(v_1)$ $297(v_3)$	295	LF	107 Hopkins and Chen 1973	
HBr(v=1) + CH <sub>4</sub> → HBr(v=0) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	$3.5 \times 10^{-13}$ $4.5 \times 10^{-13}$	$\pm 20$ $\pm 10$	$-352(v_1)$ $-445(v_3)$ $-352(v_1)$ $-445(v_2)$	295	FP	75 Donovan...Stevenson 1970	
HBr(v=1) + CO(v=0) → HBr(v=0) + CO(v=1)	V-V	$3.04 \times 10^{-13}$ $2.8 \times 10^{-13}$ $5.1 \times 10^{-13}$	$\pm 5$	416	296	LF	61 Chen 1971	
				416	295- 700	LF	160 Seoudi...Henry 1980	
HBr(v=1) + CO(v=0) → HBr(v=0) + CO(v=0)	V-T	$1.7 \times 10^{-13}$ Probably incorrect	$\pm 20$	2559	295	FP	75 Donovan...Stevenson 1970	

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+ = exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HBr(v=1) + CO(v=0) + HBr(v=0) + CO(v=0) (cont'd.)		<4.8 × 10 <sup>-15</sup>		2559	295	LF	60 Chen 1971
		3.3 × 10 <sup>-14</sup>	±5	2559	1200- 2000	ST	22 Borrell...Gutteridge 1974
1.6 × 10 <sup>-13</sup>							
HBr + CO, see also CO + HBr							
HBr(v=1) + CO <sub>2</sub> (000) + HBr(v=0) + CO <sub>2</sub> (001)	V-V	8.6 × 10 <sup>-12</sup>	±10	210	295	LF	167 Stephenson...Moore 1972
		1.1 × 10 <sup>-11</sup>		210	295	LF	159 Seoudi...Henry 1979
CO <sub>2</sub> excited directly, V-T contribution is less than 2%							
		1.1 × 10 <sup>-11</sup>		210	295-	LF	159 Seoudi...Henry 1979
		7.4 × 10 <sup>-12</sup>		900			
V-T contribution is less than 10% at 900 K							
HBr(v=1) + CO <sub>2</sub> (000) + HBr(v=0) + CO <sub>2</sub> (nm0)	V-T	<2.0 × 10 <sup>-13</sup>		2559	295	LF	167 Stephenson...Moore 1972
Value reported is for k <sub>CO<sub>2</sub>-HBr</sub> + 0.377 k <sub>HBr-CO<sub>2</sub></sub>							
HBr + CO <sub>2</sub> , see also CO <sub>2</sub> + HBr							
HBr(v=1) + DBr(v=0) + HBr(v=0) + DBr(v=1)	V-V	6.0 × 10 <sup>-14</sup>	±10	719	295	LF	65 Chen and Chen 1972
HBr(v=1) + DCN + HBr(v=0) + DCN <sup>†</sup>	V-V & V-T	1.7 × 10 <sup>-12</sup>	±10	-71(v <sub>3</sub> )	295	LF	7 Arnold...Smith 1980
HBr(v=1) + D <sub>2</sub> (v=0) + HBr(v=0) + D <sub>2</sub> (v=0)	V-T	≤1.2 × 10 <sup>-15</sup>	±15	2559	296	LF	61 Chen 1971
		1.2 × 10 <sup>-15</sup>	±15	2559	295	LF	107 Hopkins and Chen 1973
HBr + D <sub>2</sub> , see also D <sub>2</sub> + HBr							
HBr(v=1) + DF(v=0) + HBr(v=0) + DF(v=0)	V-T	~3 × 10 <sup>-13</sup>	±20	2559	295	LF	26 Bott 1974
H <sup>79</sup> Br(v=1) + H <sup>81</sup> Br(v=0) + H <sup>79</sup> Br(v=0) + H <sup>81</sup> Br(v=1)	V-V	1.50 × 10 <sup>-11</sup>	±4	0.4	295	LF	109 Horwitz and Leone 1978
HBr(v=1) + HBr(v=1) + HBr(v=2) + HBr(v=0)		4.6 × 10 <sup>-12</sup>	±20	90	296	LF	104 Hopkins and Chen 1972
		6.6 × 10 <sup>-12</sup>	±15	90	295	LF	56 Burak...Szöke 1972
		2.9 × 10 <sup>-12</sup>	±10	90	295	LF	72 Dasch and Moore 1980
Direct excitation to HBr(v=2)							
		6.9 × 10 <sup>-12</sup>	±10	90	320-	LF	140 Noter...Szöke 1973
		6.8 × 10 <sup>-12</sup>			640		
HBr(v=1) + HBr(v=0) + HBr(v=0) + HBr(v=0)	V-T	6.2 × 10 <sup>-14</sup>	±50	2559	295	FP	75 Donovan...Stevenson 1970
		1.8 × 10 <sup>-14</sup>	±10	2559	296	LF	60 Chen 1971
		1.8 × 10 <sup>-14</sup>	±10	2559	296	LF	65 Chen and Chen 1972
		1.9 × 10 <sup>-14</sup>	±35	2559	300	LF	1 Ahl and Cool 1973
		2.5 × 10 <sup>-14</sup>	±15	2559	295	LF	37 Bott and Cohen 1973
		3.0 × 10 <sup>-14</sup>	±10	2559	169-	LF	178 Zittel and Moore 1973
		3.2 × 10 <sup>-14</sup>			505		
Minimum in the rate at 374 K (1.9 × 10 <sup>-14</sup> )							
		2.2 × 10 <sup>-14</sup>	±33	2559	350	LF	1 Ahl and Cool 1973
				2559	460-	ST	21 Borrell 1966
					1370		
The results in Ref. 21 are orders of magnitude too large							
		7.2 × 10 <sup>-14</sup>	±20	2559	800-	ST	116 Kiefer...Bird 1969
		6.1 × 10 <sup>-13</sup>			1800		
HBr(v=2) + HBr(v=0) + HBr(v=1) + HBr(v=0)	V-T	<3.1 × 10 <sup>-13</sup>		2469	295	LF	72 Dasch and Moore 1980
Direct excitation to HBr(v=2)							
HBr(v=1) + HCl(v=0) + HBr(v=0) + HCl(v=0)	V-T	2.5 × 10 <sup>-13</sup>	±40	2559	295	FP	75 Donovan...Stevenson 1970
Probably incorrect							
		4.1 × 10 <sup>-14</sup>	±10	2559	296	LF	60 Chen 1971
HBr(v=1) + HCl(v=1) + HBr(v=2) + HCl(v=0)	V-V	2.3 × 10 <sup>-12</sup>	±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 <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HBr(v=1) + HCN + HBr(v=0) + HCN <sup>†</sup>	V-V & V-T	$1.40 \times 10^{-12}$ $-773(001)$	±4	2559	295	LF	7 Arnold...Smith 1980
<b>HBr + HCN, see also HCN + HBr</b>							
HBr(v=1) + HD(v=0) + HBr(v=0) + HD(v=0)	V-T	$2.0 \times 10^{-15}$	±5	2559	295	LF	107 Hopkins and Chen 1973
HBr(v=1) + <sup>3</sup> He + HBr(v=0) + <sup>3</sup> He	V-T	$4.7 \times 10^{-16}$	±5	2559	295	LF	107 Hopkins and Chen 1973
HBr(v=1) + He + HBr(v=0) + He	V-T	$<1 \times 10^{-16}$ $\leq 2.7 \times 10^{-17}$ $2.0 \times 10^{-16}$	±10	2559	295	FP	75 Donovan...Stevenson 1970 60 Chen 1971 107 Hopkins and Chen 1973
HBr(v=1) + HF(v=0) + HBr(v=0) + HF(v=0)	V-T	$4.9 \times 10^{-13}$ $2.8 \times 10^{-13}$ $4.0 \times 10^{-13}$	±20	2559	300	LF	1 Ahl and Cool 1973 37 Bott and Cohen 1973
HBr(v=1) + H <sub>2</sub> (v=0) + HBr(v=0) + H <sub>2</sub> (v=0)	V-T	$1.9 \times 10^{-14}$ $6.4 \times 10^{-15}$	±35	2559	295	FP	75 Donovan...Stevenson 1970 60 Chen 1971
The same rate is observed for both normal and para hydrogen							
<b>HBr + H<sub>2</sub>, see also H<sub>2</sub> + HBr</b>							
HBr(v=1) + H <sub>2</sub> O + HBr(v=0) + H <sub>2</sub> O <sup>†</sup>	V-V & V-T	$8.6 \times 10^{-14}$	±10	2559 964(v <sub>2</sub> )	295	LF	107 Hopkins and Chen 1973
HBr(v=1) + HI(v=0) + HBr(v=0) + HI(v=1)	V-V	$6.6 \times 10^{-13}$	±15	329	296	LF	60 Chen 1971
HBr(v=1) + Kr + HBr(v=0) + Kr	V-T	$<3 \times 10^{-17}$		2559	296	LF	104 Hopkins and Chen 1972
HBr(v=1) + Ne + 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) + HBr(v=0) + NO(v=1)	V-V	$2.3 \times 10^{-13}$ $4.7 \times 10^{-13}$		683	295- 700	LF	160 Seoudi...Henry 1980
HBr(v=1) + N <sub>2</sub> (v=0) + HBr(v=0) + N <sub>2</sub> (v=1)	V-V	$1.2 \times 10^{-14}$ Probably incorrect	±15	228	295	FP	75 Donovan...Stevenson 1970 61 Chen 1971
		$9.8 \times 10^{-14}$ $1.02 \times 10^{-13}$ $9.5 \times 10^{-14}$	±10	228	296	LF	160 Seoudi...Henry 1980
HBr(v=1) + N <sub>2</sub> (v=0) + HBr(v=0) + N <sub>2</sub> (v=0)	V-T	$<3.2 \times 10^{-15}$		2559	296	LF	61 Chen 1971
<b>HBr + N<sub>2</sub>, see also N<sub>2</sub> + HBr</b>							
HBr(v=1) + N <sub>2</sub> O(000) + HBr(v=0) + N <sub>2</sub> O(001)	V-V	$5.6 \times 10^{-12}$ Direct excitation to N <sub>2</sub> O(001)		336	295	LF	159 Seoudi...Henry 1979
		$5.6 \times 10^{-12}$ $6.7 \times 10^{-12}$		336	295- 900	LF	159 Seoudi...Henry 1979
HBr(v=1) + OCS + HBr(v=0) + OCS <sup>†</sup>	V-V & V-T	$5.6 \times 10^{-12}$	±10	497(v <sub>3</sub> ) -19(v <sub>2</sub> +v <sub>3</sub> )	296	LF	103 Hopkins and Chen 1973
<b>HBr + OCS, see also OCS + HBr</b>							
HBr(v=1) + O <sub>2</sub> (v=0) + HBr(v=0) + O <sub>2</sub> (v=1)	V-V & V-T	$4.9 \times 10^{-15}$ $5.1 \times 10^{-15}$ $3.5 \times 10^{-14}$	±5	1003(v=1)	296	LF	61 Chen 1971
				1003(v=1)	295- 700	LF	160 Seoudi...Henry 1980
HBr(v=1) + SF <sub>6</sub> + HBr(v=0) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	$2.5 \times 10^{-14}$	±15	2559	295	FP	75 Donovan...Stevenson 1970
HCl(v=1) + Ar + HCl(v=0) + Ar	V-T	$<6 \times 10^{-17}$ $3.4 \times 10^{-18}$ $3.4 \times 10^{-18}$ $1.4 \times 10^{-16}$ $8.2 \times 10^{-16}$ $1.8 \times 10^{-14}$	±20	2886	295	LF	62 Chen and Moore 1971 165 Steele and Moore 1974
				2886	295- 700	LF	165 Steele and Moore 1974
				2886	1166- 1950	ST	257 Seery 1973
				2886	1000- 2100	ST	45 Bowman and Seery 1969

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
<b>HCl + BCi<sub>3</sub>, see BCi<sub>3</sub> + HCl</b>							
HCl(v=1) + Br + HCl(v=0) + Br	V-T & V-E	29 × 10 <sup>-14</sup> V-E contribution only	±50	-799	295	LF	126 Leone and Wodarczyk 1974
		2.8 × 10 <sup>-13</sup> Mainly V-T contribution, total V-T and V-E would be ~3.7 × 10 <sup>-13</sup>	±20	2886	295	LF-DF	124 Leone...Moore 1975
		7.0 × 10 <sup>-13</sup> Total of V-T and V-E processes; V-T only is 4.15 × 10 <sup>-13</sup>	±25	2886	295	LF-DF	9 Arnoldi and Wolfrum 1976
		5.6 × 10 <sup>-13</sup> V-T contribution only	±15	2886	295	LF-DF	54 Brown...Van der Merwe 1976
		2.6 × 10 <sup>-13</sup> 4.1 × 10 <sup>-13</sup>	±20	2886	295	LF-DF	114 Karny and Katz 1976
		2.8 × 10 <sup>-13</sup> (2.6 × 10 <sup>-13</sup> for V-T contribution only)	±20	2886	210	LF-DF	54 Brown...Van der Merwe 1976
		9.5 × 10 <sup>-13</sup> (7.7 × 10 <sup>-13</sup> for V-T contribution only)	±15	2886	371	LF-DF	54 Brown...Van der Merwe 1976
		3.3 × 10 <sup>-13</sup> 3.8 × 10 <sup>-13</sup>	±55	2886	295	LF-DF	132 Macdonald and Moore 1980
		Not as accurate as earlier measurement in Ref. 124					
HCl(v=2) + Br + HCl(v=1) + Br	V-T, V-E & Rx	1.8 × 10 <sup>-12</sup>	±20	2782	298	LF-DF	124 Leone...Moore 1975
		1.5 × 10 <sup>-12</sup>	±65	2782	295	LF-DF	9 Arnoldi and Wolfrum 1976
		Thought to be mainly reaction					
		>5 × 10 <sup>-13</sup> <5 × 10 <sup>-12</sup>		2782	295	CD	79 Douglas...Sloan 1973
		Estimate for reactive contribution only					
		1.7 × 10 <sup>-12</sup>	±15	2782	295	LF-DF	132 Macdonald and Moore 1980
		Relaxation to vml observed to be dominant process; reaction contributes less than 17%					
		1.7 × 10 <sup>-12</sup> 3.3 × 10 <sup>-12</sup>	±15	2782	295	LF-DF	132 Macdonald and Moore 1980
		Reaction contributes less than 34% at 390 K					
HCl(v=3) + Br + HCl(v=2) + Br	V-T, V-E & Rx	>3.5 × 10 <sup>-12</sup> <3.5 × 10 <sup>-11</sup>		2678	295	CD	79 Douglas...Sloan 1973
		Estimate for the reactive contribution only					
HCl(v=4) + Br + HCl(v=3) + Br	V-T, V-E & Rx	>5 × 10 <sup>-12</sup> <5 × 10 <sup>-11</sup>		2575	295	CD	79 Douglas...Sloan 1973
		Estimate for the reactive contribution only					
HCl(v=1) + Br <sub>2</sub> + HCl(v=0) + Br <sub>2</sub> <sup>†</sup>	V-V & V-T	3.26 × 10 <sup>-14</sup>	±4	2886	295	LF	124 Leone...Moore 1975
HCl(v=1) + CD <sub>4</sub> + HCl(v=0) + CD <sub>4</sub> <sup>†</sup>	V-V & V-T	3.4 × 10 <sup>-13</sup>	±20	2886	295	LF	176 Zittel and Moore 1973
627(v <sub>1</sub> )							
<b>HCl + CD<sub>4</sub>, see also CD<sub>4</sub> + HCl</b>							
HCl(v=2) + CFCl <sub>3</sub> + HCl(v=1) + CFCl <sub>3</sub> <sup>†</sup>	V-V & V-T	~2 × 10 <sup>-13</sup>	±30	2762	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + CFCl <sub>3</sub> + HCl(v=2) + CFCl <sub>3</sub> <sup>†</sup>	V-V & V-T	2.8 × 10 <sup>-13</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982
HCl(v=4) + CFCl <sub>3</sub> + HCl(v=3) + CFCl <sub>3</sub> <sup>†</sup>	V-V & V-T	7.5 × 10 <sup>-13</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + CFCl <sub>3</sub> + HCl(v=4) + CFCl <sub>3</sub> <sup>†</sup>	V-V & V-T	2.4 × 10 <sup>-12</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + CFCl <sub>3</sub> + HCl(v=5) + CFCl <sub>3</sub> <sup>†</sup>	V-V & V-T	6.7 × 10 <sup>-12</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + CFCl <sub>3</sub> + HCl(v=6) + CFCl <sub>3</sub> <sup>†</sup>	V-V & V-T	1.5 × 10 <sup>-11</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + CF <sub>2</sub> Cl <sub>2</sub> + HCl(v=2) + CF <sub>2</sub> Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	<1 × 10 <sup>-13</sup>		2679	298	FT	14 Berquist...Kaufman 1982
HCl(v=4) + CF <sub>2</sub> Cl <sub>2</sub> + HCl(v=3) + CF <sub>2</sub> Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	3 × 10 <sup>-13</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + CF <sub>2</sub> Cl <sub>2</sub> + HCl(v=4) + CF <sub>2</sub> Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	1.6 × 10 <sup>-12</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + CF <sub>2</sub> Cl <sub>2</sub> + HCl(v=5) + CF <sub>2</sub> Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	3.2 × 10 <sup>-12</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + CF <sub>2</sub> Cl <sub>2</sub> + HCl(v=6) + CF <sub>2</sub> Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	4.9 × 10 <sup>-12</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + CF <sub>3</sub> Cl + HCl(v=2) + CF <sub>3</sub> Cl <sup>†</sup>	V-V & V-T	1.4 × 10 <sup>-13</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HCl(v=4) + CF <sub>3</sub> Cl + HCl(v=3) + CF <sub>3</sub> OCl <sup>†</sup>	V-V & V-T	3.4 × 10 <sup>-13</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + CF <sub>3</sub> Cl + HCl(v=4) + CF <sub>3</sub> OCl <sup>†</sup>	V-V & V-T	6.5 × 10 <sup>-13</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + CF <sub>3</sub> Cl + HCl(v=5) + CF <sub>3</sub> OCl <sup>†</sup>	V-V & V-T	9.5 × 10 <sup>-13</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + CF <sub>3</sub> Cl + HCl(v=6) + CF <sub>3</sub> OCl <sup>†</sup>	V-V & V-T	1.2 × 10 <sup>-12</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + CF <sub>4</sub> + HCl(v=2) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	1.8 × 10 <sup>-13</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982
HCl(v=4) + CF <sub>4</sub> + HCl(v=3) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	3.6 × 10 <sup>-13</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + CF <sub>4</sub> + HCl(v=4) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	2.7 × 10 <sup>-13</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + CF <sub>4</sub> + HCl(v=5) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	3.9 × 10 <sup>-13</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + CF <sub>4</sub> + HCl(v=6) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	4.7 × 10 <sup>-13</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + CF <sub>3</sub> OCl + HCl(v=0) + CF <sub>3</sub> OCl <sup>†</sup>	V-V & V-T	6.8 × 10 <sup>-14</sup>	±10	2886	295	LF	70 Coombe...Pilipovich 1975
HCl(v=2) + CH <sub>3</sub> Cl + HCl(v=1) + CH <sub>3</sub> Cl <sup>†</sup>	V-V & V-T	9.5 × 10 <sup>-12</sup>	±30	2762	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + CH <sub>3</sub> Cl + HCl(v=2) + CH <sub>3</sub> Cl <sup>†</sup>	V-V & V-T	3.0 × 10 <sup>-11</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982
HCl(v=4) + CH <sub>3</sub> Cl + HCl(v=3) + CH <sub>3</sub> Cl <sup>†</sup>	V-V & V-T	1.1 × 10 <sup>-10</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + CH <sub>3</sub> Cl + HCl(v=4) + CH <sub>3</sub> Cl <sup>†</sup>	V-V & V-T	1.7 × 10 <sup>-10</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + CH <sub>3</sub> Cl + HCl(v=5) + CH <sub>3</sub> Cl <sup>†</sup>	V-V & V-T	2.9 × 10 <sup>-10</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + CH <sub>3</sub> Cl + HCl(v=6) + CH <sub>3</sub> Cl <sup>†</sup>	V-V & V-T	3.3 × 10 <sup>-10</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + CH <sub>3</sub> F + HCl(v=0) + CH <sub>3</sub> F <sup>†</sup>	V-V & V-T	<9 × 10 <sup>-12</sup>		2886	298	FT	14 Berquist...Kaufman 1982
HCl(v=2) + CH <sub>3</sub> F + HCl(v=1) + CH <sub>3</sub> F <sup>†</sup>	V-V & V-T	1.1 × 10 <sup>-11</sup>	±30	2762	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + CH <sub>3</sub> F + HCl(v=2) + CH <sub>3</sub> F <sup>†</sup>	V-V & V-T	2.6 × 10 <sup>-11</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982
HCl(v=4) + CH <sub>3</sub> F + HCl(v=3) + CH <sub>3</sub> F <sup>†</sup>	V-V & V-T	3.5 × 10 <sup>-11</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + CH <sub>3</sub> F + HCl(v=4) + CH <sub>3</sub> F <sup>†</sup>	V-V & V-T	7.2 × 10 <sup>-11</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + CH <sub>3</sub> F + HCl(v=5) + CH <sub>3</sub> F <sup>†</sup>	V-V & V-T	9.8 × 10 <sup>-11</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + CH <sub>3</sub> F + HCl(v=6) + CH <sub>3</sub> F <sup>†</sup>	V-V & V-T	8.0 × 10 <sup>-11</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + CH <sub>4</sub> + HCl(v=0) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	2.6 × 10 <sup>-12</sup>	±10	-30(v <sub>1</sub> ) -133(v <sub>3</sub> )	295	LF	63 Chen and Moore 1971
		2.7 × 10 <sup>-12</sup>		-30(v <sub>1</sub> ) -133(v <sub>3</sub> )	296	LF	156 Schramm and Rapp 1980
		~3.8 × 10 <sup>-12</sup>	±30	-30(v <sub>1</sub> ) -133(v <sub>3</sub> )	298	FT	14 Berquist...Kaufman 1982
		3.6 × 10 <sup>-12</sup>		-30(v <sub>1</sub> )	194-	LF	156 Schramm and Rapp 1980
		2.7 × 10 <sup>-12</sup>		-133(v <sub>3</sub> )	296	LF	156 Schramm and Rapp 1980
HCl(v=2) + CH <sub>4</sub> + HCl(v=1) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	3.8 × 10 <sup>-12</sup>	±30	2762	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + CH <sub>4</sub> + HCl(v=2) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	4.2 × 10 <sup>-12</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982
HCl(v=4) + CH <sub>4</sub> + HCl(v=3) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	6.0 × 10 <sup>-12</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + CH <sub>4</sub> + HCl(v=4) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	1.2 × 10 <sup>-11</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + CH <sub>4</sub> + HCl(v=5) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	2.0 × 10 <sup>-11</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + CH <sub>4</sub> + HCl(v=6) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	2.5 × 10 <sup>-11</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl + CH <sub>4</sub> , see also CH <sub>4</sub> + HCl							
HCl(v=1) + 1,1-C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> + HCl(v=0) + 1,1-C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	3.1 × 10 <sup>-13</sup>	±20	2886	295	LF	70 Coombe...Pilipovich 1975
HCl(v=1) + trans-C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> + HCl(v=0) + trans-C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	3.1 × 10 <sup>-13</sup>	±20	2886	295	LF	70 Coombe...Pilipovich 1975
HCl(v=1) + C <sub>2</sub> H <sub>6</sub> + HCl(v=0) + C <sub>2</sub> H <sub>6</sub> <sup>†</sup>	V-V & V-T	2.0 × 10 <sup>-11</sup>	±30	2886	298	FT	14 Berquist...Kaufman 1982
HCl(v=2) + C <sub>2</sub> H <sub>6</sub> + HCl(v=1) + C <sub>2</sub> H <sub>6</sub> <sup>†</sup>	V-V & V-T	2.1 × 10 <sup>-11</sup>	±30	2762	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + C <sub>2</sub> H <sub>6</sub> + HCl(v=2) + C <sub>2</sub> H <sub>6</sub> <sup>†</sup>	V-V & V-T	2.0 × 10 <sup>-11</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta\tau$ (cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HCl(v=4) + C <sub>2</sub> H <sub>6</sub> + HCl(v=3) + C <sub>2</sub> H <sub>6</sub> †	V-V & V-T	2.3 × 10 <sup>-11</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + C <sub>2</sub> H <sub>6</sub> + HCl(v=4) + C <sub>2</sub> H <sub>6</sub> †	V-V & V-T	2.7 × 10 <sup>-11</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + C <sub>2</sub> H <sub>6</sub> + HCl(v=5) + C <sub>2</sub> H <sub>6</sub> †	V-V & V-T	4.3 × 10 <sup>-11</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + C <sub>2</sub> H <sub>6</sub> + HCl(v=6) + C <sub>2</sub> H <sub>6</sub> †	V-V & V-T	5.3 × 10 <sup>-11</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + C <sub>3</sub> H <sub>8</sub> + HCl(v=0) + C <sub>3</sub> H <sub>8</sub> †	V-V & V-T	4.7 × 10 <sup>-11</sup>	±30	2886	298	FT	14 Berquist...Kaufman 1982
HCl(v=2) + C <sub>3</sub> H <sub>8</sub> + HCl(v=1) + C <sub>3</sub> H <sub>8</sub> †	V-V & V-T	4.1 × 10 <sup>-11</sup>	±30	2762	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + C <sub>3</sub> H <sub>8</sub> + HCl(v=2) + C <sub>3</sub> H <sub>8</sub> †	V-V & V-T	3.8 × 10 <sup>-11</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982
nC <sub>3</sub> (v=-4) + C <sub>3</sub> H <sub>8</sub> + HCl(v=-3) + C <sub>3</sub> H <sub>8</sub> †	V-V & V-T	3.8 × 10 <sup>-11</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + C <sub>3</sub> H <sub>8</sub> + HCl(v=4) + C <sub>3</sub> H <sub>8</sub> †	V-V & V-T	5.3 × 10 <sup>-11</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + C <sub>3</sub> H <sub>8</sub> + HCl(v=5) + C <sub>3</sub> H <sub>8</sub> †	V-V & V-T	8.6 × 10 <sup>-11</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + C <sub>3</sub> H <sub>8</sub> + HCl(v=6) + C <sub>3</sub> H <sub>8</sub> †	V-V & V-T	9.6 × 10 <sup>-11</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + iso-C <sub>4</sub> H <sub>8</sub> + HCl(v=0) + iso-C <sub>4</sub> H <sub>8</sub> †	V-V & V-T	6.5 × 10 <sup>-11</sup>	±30	2886	298	FT	14 Berquist...Kaufman 1982
nC <sub>4</sub> (v=-2) + iso-C <sub>4</sub> H <sub>8</sub> + HCl(v=1) + iso-C <sub>4</sub> H <sub>8</sub> †	V-V & V-T	5.5 × 10 <sup>-11</sup>	±30	2762	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + iso-C <sub>4</sub> H <sub>8</sub> + HCl(v=2) + iso-C <sub>4</sub> H <sub>8</sub> †	V-V & V-T	5.6 × 10 <sup>-11</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982
HCl(v=4) + iso-C <sub>4</sub> H <sub>8</sub> + HCl(v=3) + iso-C <sub>4</sub> H <sub>8</sub> †	V-V & V-T	6.2 × 10 <sup>-11</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + iso-C <sub>4</sub> H <sub>8</sub> + HCl(v=4) + iso-C <sub>4</sub> H <sub>8</sub> †	V-V & V-T	7.5 × 10 <sup>-11</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + iso-C <sub>4</sub> H <sub>8</sub> + HCl(v=5) + iso-C <sub>4</sub> H <sub>8</sub> †	V-V & V-T	1.0 × 10 <sup>-10</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + iso-C <sub>4</sub> H <sub>8</sub> + HCl(v=6) + iso-C <sub>4</sub> H <sub>8</sub> †	V-V & V-T	1.2 × 10 <sup>-10</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + Cl + HCl(v=0) + Cl	V-T	1.1 × 10 <sup>-11</sup>	±60	2886	294	DR-LF	71 Craig and Moore 1971
		9.7 × 10 <sup>-13</sup>	±10	2886	295	FR	152 Ridley and Smith 1971
Probably incorrect							
		8.8 × 10 <sup>-12</sup>		2886	298	LF-DF	52 Brown...Smith 1975
		8.3 × 10 <sup>-12</sup>	±25	2886	295	LF-DF	53 Brown...Smith 1975
		8.8 × 10 <sup>-12</sup>	±30	2886	294	LF-DF	133 Macdonald...Wodarczyk 1975
		6 × 10 <sup>-12</sup>	±40	2886	294	DR-LF	133 Macdonald...Wodarczyk 1975
		5.8 × 10 <sup>-12</sup>	±15	2886	295	LF-DF	9 Arnoldi and Wolfrum 1976
		6.1 × 10 <sup>-12</sup>	±25	2886	295	LF-DF	117 Kneba and Wolfrum 1979
		7.4 × 10 <sup>-12</sup>	±10	2886	294	LF-DF	132 Macdonald and Moore 1980
		1.1 × 10 <sup>-11</sup>	0	295	LF-MS	117 Kneba and Wolfrum 1979	
The quoted rate is for isotopic exchange, <sup>37</sup> Cl + H <sup>35</sup> Cl(v=1), which is twice the deactivation rate							
		2.6 × 10 <sup>-12</sup>	±20	2886	195- 397	LF-DF	53 Brown...Smith 1975
		1.5 × 10 <sup>-11</sup>					
	V-T	6.7 × 10 <sup>-12</sup>		2886	263- 397	LF-DF	52 Brown...Smith 1975
		1.5 × 10 <sup>-11</sup>					
		7.4 × 10 <sup>-12</sup>	±10	2886	294- 459	LF-DF	132 Macdonald and Moore 1980
		6.1 × 10 <sup>-12</sup>					
HCl(v=2) + Cl + HCl(v=1) + Cl	V-T	3.1 × 10 <sup>-12</sup>	±35	2782	295	FR	152 Ridley and Smith 1971
		3.3 × 10 <sup>-11</sup>	±15	2782	294	LF-DF	132 Macdonald and Moore 1980
Probably incorrect							
Observed to be entirely relaxation to v=1							

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

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

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E(\text{cm}^{-1})$ (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HCl(v=4) + CO <sub>2</sub> (000) + HCl(v=3) + CO <sub>2</sub> (001)	V-V & V-T	$7.0 \times 10^{-11}$	±30	227	298	FT	15 Berquist...Kaufman 1982
HCl(v=5) + CO <sub>2</sub> (000) + HCl(v=4) + CO <sub>2</sub> (001)	V-V & V-T	$1.4 \times 10^{-10}$	±30	124	298	FT	15 Berquist...Kaufman 1982
HCl(v=6) + CO <sub>2</sub> (000) + HCl(v=5) + CO <sub>2</sub> (001)	V-V & V-T	$1.7 \times 10^{-10}$	±30	22	298	FT	15 Berquist...Kaufman 1982
HCl(v=7) + CO <sub>2</sub> (000) + HCl(v=6) + CO <sub>2</sub> (001)	V-V & V-T	$1.0 \times 10^{-10}$	±30	-80	298	FT	15 Berquist...Kaufman 1982
HCl(v=1) + CO <sub>2</sub> (000) + HCl(v=0) + CO <sub>2</sub> (000)	V-T	$1.1 \times 10^{-12}$ $2.9 \times 10^{-13}$ $2.9 \times 10^{-13}$ $3.4 \times 10^{-13}$	±30 2886 2886 295- 900	2886 2886 2886	295 295	LF LF LF	16/ Stephenson...Moore 1972 80 Doyennette...Henry 1978 80 Doyennette...Henry 1978
HCl + CO <sub>2</sub> , see also CO <sub>2</sub> + HCl							
HCl(v=1) + D + HCl(v=0) + D	V-T & Exchange & Rx	$8.3 \times 10^{-12}$ The exchange rate is 20 times slower than the relaxation	±30	2886	295	LF-MS	9 Arnoldi and Wolfrum 1976
HCl(v=1) + DCI(v=0) + HCl(v=0) + DCI(v=1)	V-V	$1.00 \times 10^{-13}$	±5	795	295	LF	64 Chen and Moore 1971
HCl(v=2) + DCI(v=0) + HCl(v=1) + DCI(v=1)	V-V	$4.0 \times 10^{-13}$	±15	691	295	LF	72 Dasch and Moore 1980
		Direct excitation to HCl(v=2)					
HCl(v=5) + DCI(v=0) + HCl(v=4) + DCI(v=1)	V-V & V-T	$3.3 \times 10^{-11}$	±30	432	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + DCI(v=0) + HCl(v=5) + DCI(v=1)	V-V & V-T	$5.9 \times 10^{-11}$	±30	330	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + DCI(v=0) + HCl(v=6) + DCI(v=1)	V-V & V-T	$1.1 \times 10^{-10}$	±30	228	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + DCN + HCl(v=0) + DCN <sup>+</sup>	V-V & V-T	$2.22 \times 10^{-12}$	±5	2886	296	LF	7 Arnold and Smith 1980
HCl(v=1) + D <sub>2</sub> (v=0) + HCl(v=0) + D <sub>2</sub> (v=0)	V-T	$1.5 \times 10^{-16}$	±15	2886	295	LF	105 Hopkins and Chen 1972
		Value reported is for k <sub>HCl-D<sub>2</sub></sub> + 0.60 k <sub>D<sub>2</sub>-HCl</sub>					
HCl + D <sub>2</sub> , see also D <sub>2</sub> + HCl							
HCl(v=1) + DF(v=0) + HCl(v=0) + DF(v=0)	V-T	$<5.3 \times 10^{-13}$ $<3.5 \times 10^{-13}$ $<3 \times 10^{-13}$		2886 2886 475- 745	295	LF	26 Bott 1974
HCl(v=1) + H + HCl(v=0) + H	V-T & Rx	$6.5 \times 10^{-12}$ $6.8 \times 10^{-12}$ $7.0 \times 10^{-12}$	±35 ±25 ±15	2886 2886 2886	295 295 295	LF-DF	10 Arnoldi and Wolfrum 1974
		The deactivation is 50 times faster than reaction					
		$7.6 \times 10^{-12}$ $3.4 \times 10^{-12}$	±30 ±15	2886 2886	295 296	LF-DF	41 Bott and Heidner 1976 132 Macdonald and Moore 1980
		The reactive channel may be as much as 50%					
HCl(v=2) + H + HCl(v=1) + H	V-T & Rx	$2.6 \times 10^{-11}$	±20	2782	296	LF-DF	132 Macdonald and Moore 1980
		Deactivation to v=1 is only 35% of total					
HCl(v=1) + HBr(v=0) + HCl(v=0) + HBr(v=1)	V-V	$1.2 \times 10^{-12}$ $1.1 \times 10^{-12}$	±35 ±10	327	295	FP	74 Donovan...Stevenson 1970
		V-T contribution is less than 3%					
		$1.1 \times 10^{-12}$ $8.4 \times 10^{-13}$	±10	327	295	LF	60 Chen 1971
		The rate constants in Ref. 153 are internally consistent, but their absolute magnitudes may be in error					
		$9.6 \times 10^{-13}$	±10	327	295	LF	40 Bott and Cohen 1975
HCl(v=2) + HBr(v=0) + HCl(v=1) + HBr(v=1)	V-V	$2.9 \times 10^{-12}$	±10	223	295	LF	72 Dasch and Moore 1980
		Direct excitation to HCl(v=2)					
HCl(v=2) + HBr(v=0) + HCl(v=0) + HBr(v=2)	V-V	$<3.1 \times 10^{-14}$		641	295	LF	72 Dasch and Moore 1980
HCl(v=1) + HCl(v=1) + HCl(v=2) + HCl(v=0)	V-V	$4.6 \times 10^{-12}$	±20	104	295	LF	57 Burak...Szöke 1972
		$4.6 \times 10^{-12}$	±15	104	295	LF	106 Hopkins and Chen 1972

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

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

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HCl(v=1) + HCl(v=0) + HCl(v=0) + HCl(v=0) (cont'd.)		9.5 × 10 <sup>-14</sup> 1.3 × 10 <sup>-12</sup>	±30	2886	700- 1900	ST	47 Breshears and Bird 1969
		1.5 × 10 <sup>-13</sup> 1.1 × 10 <sup>-12</sup>		2886	1100- 2000	ST	45 Bowman and Seery 1969
		8.8 × 10 <sup>-15</sup> 4.7 × 10 <sup>-14</sup>		2886	1300- 2200	ST	21 Borrell 1966
		Values are many times too small					
HCl(v=2) + HCl(v=0) + HCl(v=1) + HCl(v=0)	V-T	<3.1 × 10 <sup>-13</sup>		2782	295	LF	72 Dasch and Moore 1980
HCl(v=1) + HCN(000) + HCl(v=0) + HCN(rm0)	V-T	1.43 × 10 <sup>-12</sup>	±3	2886	296	LF	7 Arnold...Smith 1980
HC <sub>2</sub> + HCN, see also HCN + HC <sub>2</sub>							
HCl(v=1) + HD(v=0) → HCl(v=0) + HD(v=0)	V-T	2.5 × 10 <sup>-15</sup>	±15	2886	295	LF	105 Hopkins and Chen 1972
HC <sub>2</sub> + HD, see also HD + HC <sub>2</sub>							
HC <sub>2</sub> (v=1) + <sup>3</sup> He → HC <sub>2</sub> (v=0) + <sup>3</sup> He	V-T	1.2 × 10 <sup>-16</sup>	+20 -40	2886	295	LF	165 Steele and Moore 1974
HC <sub>2</sub> (v=1) + He → HC <sub>2</sub> (v=0) + He	V-T	<6 × 10 <sup>-17</sup>		2886	295	LF	62 Chen and Moore 1971
		5.6 × 10 <sup>-17</sup>	±10	2886	295	LF	165 Steele and Moore 1974
		4.1 × 10 <sup>-17</sup> 1.1 × 10 <sup>-16</sup>	±15	2886	196- 342	LF	108 Hopkins and Chen 1973
		5.6 × 10 <sup>-17</sup> 2.1 × 10 <sup>-15</sup>	±10	2886	295- 700	LF	165 Steele and Moore 1974
		3.9 × 10 <sup>-14</sup> 1.4 × 10 <sup>-13</sup>	±20	2886	1160- 1630	ST	157 Seery 1973
HCl(v=1) + HF(v=0) + HCl(v=0) + HF(v=0)	V-T	6.2 × 10 <sup>-13</sup>	±15	2886	300	LF	1 Ahl and Cool 1973
		4.6 × 10 <sup>-13</sup>	±15	2886	295	LF	37 Bott and Cohen 1973
		4.0 × 10 <sup>-13</sup>	±15	2886	295	LF	40 Bott and Cohen 1975
		4.9 × 10 <sup>-13</sup>	±25	2886	350	LF	1 Ahl and Cool 1973
		1.9 × 10 <sup>-13</sup>	±10	2886	470	LF	37 Bott and Cohen 1973
		4.2 × 10 <sup>-13</sup> 7.9 × 10 <sup>-13</sup>	±15	2886	468- 632	LF-ST	40 Bott and Cohen 1975
HCl(v=2) + HF(v=0) + HCl(v=1) + HF(v=0)	V-T	~5 × 10 <sup>-13</sup>	>±30	2762	298	FT	14 Berquist...Kaufman 1982
HCl(v=3) + HF(v=0) + HCl(v=2) + HF(v=0)	V-T	2.5 × 10 <sup>-12</sup>	±30	2679	298	FT	14 Berquist...Kaufman 1982
HCl(v=4) + HF(v=0) + HCl(v=3) + HF(v=0)	V-T	8 × 10 <sup>-12</sup>	±30	2576	298	FT	14 Berquist...Kaufman 1982
HCl(v=5) + HF(v=0) + HCl(v=4) + HF(v=0)	V-T	2.5 × 10 <sup>-11</sup>	±30	2473	298	FT	14 Berquist...Kaufman 1982
HCl(v=6) + HF(v=0) + HCl(v=5) + HF(v=0)	V-T	4.5 × 10 <sup>-11</sup>	±30	2371	298	FT	14 Berquist...Kaufman 1982
HCl(v=7) + HF(v=0) + HCl(v=6) + HF(v=0)	V-T	5.2 × 10 <sup>-11</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + H <sub>2</sub> (v=0) + HCl(v=0) + H <sub>2</sub> (v=0)	V-T	5.2 × 10 <sup>-15</sup>	±20	2886	295	LF	62 Chen and Moore 1971
Strictly V-T process, no double exponential observed for v-v contribution							
		5.5 × 10 <sup>-15</sup>	±10	2886	295	LF	40 Bott and Cohen 1975
		~4.8 × 10 <sup>-15</sup>		2886	295	LG	136 Menard-Bourcin...Henry 1975
		Crude estimate only					
		5.9 × 10 <sup>-15</sup>		2886	296	LF	156 Schramm and Rapp 1980
		4.3 × 10 <sup>-15</sup>		2886	143- 296	LF	156 Schramm and Rapp 1980
		5.9 × 10 <sup>-15</sup>					
		1.3 × 10 <sup>-14</sup> 9.1 × 10 <sup>-14</sup>	±10	2886	403- 770	LF-ST	40 Bott and Cohen 1975
		1.6 × 10 <sup>-13</sup> 7.5 × 10 <sup>-13</sup>		2886	1000- 2000	ST	155 Rosen...Taylor 1979
HCl(v=2) + H <sub>2</sub> (v=0) + HCl(v=1) + H <sub>2</sub> (v=0)	V-T	~9.7 × 10 <sup>-15</sup>		2782	295	LG	136 Menard-Bourcin...Henry 1975
Crude estimate only							

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

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

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, or First and Last Author, Year of Publication
HCl(v=1) + NO <sub>2</sub> + HCl(v=0) + NO <sub>2</sub> <sup>†</sup>	V-V & V-T	9.5 × 10 <sup>-13</sup>	±30	2886	298	PT	14 Berquist...Kaufman 1982
HCl(v=2) + NO <sub>2</sub> + HCl(v=1) + NO <sub>2</sub> <sup>†</sup>	V-V & V-T	~1.2 × 10 <sup>-12</sup>	>±30	2762	298	PT	14 Berquist...Kaufman 1982
HCl(v=3) + NO <sub>2</sub> + HCl(v=2) + NO <sub>2</sub> <sup>†</sup>	V-V & V-T	2.0 × 10 <sup>-12</sup>	±30	2679	298	PT	14 Berquist...Kaufman 1982
HCl(v=4) + NO <sub>2</sub> + HCl(v=3) + NO <sub>2</sub> <sup>†</sup>	V-V & V-T	4.0 × 10 <sup>-12</sup>	±30	2576	298	PT	14 Berquist...Kaufman 1982
		Reaction unlikely					
HCl(v=1) + N <sub>2</sub> O(000) + HCl(v=0) + N <sub>2</sub> O(001)	V-V	1.1 × 10 <sup>-12</sup>		662	295	LF	80 Doyennette...Henry 1978
		1.8 × 10 <sup>-12</sup>	±30	662	298	PT	15 Berquist...Kaufman 1982
		1.1 × 10 <sup>-12</sup>		662	295- 700	LF	80 Doyennette...Henry 1978
1.9 × 10 <sup>-12</sup>							
HCl(v=2) + N <sub>2</sub> O(000) + HCl(v=1) + N <sub>2</sub> O(001)	V-V & V-T	4.5 × 10 <sup>-12</sup>	±30	558	298	PT	15 Berquist...Kaufman 1982
HCl(v=3) + N <sub>2</sub> O(000) + HCl(v=2) + N <sub>2</sub> O(001)	V-V & V-T	1.2 × 10 <sup>-11</sup>	±30	455	298	PT	15 Berquist...Kaufman 1982
HCl(v=4) + N <sub>2</sub> O(000) + HCl(v=3) + N <sub>2</sub> O(001)	V-V & V-T	4.5 × 10 <sup>-11</sup>	±30	352	298	PT	15 Berquist...Kaufman 1982
HCl(v=5) + N <sub>2</sub> O(000) + HCl(v=4) + N <sub>2</sub> O(001)	V-V & V-T	9.6 × 10 <sup>-11</sup>	±30	249	298	PT	15 Berquist...Kaufman 1982
HCl(v=6) + N <sub>2</sub> O(000) + HCl(v=5) + N <sub>2</sub> O(001)	V-V & V-T	1.5 × 10 <sup>-10</sup>	±30	147	298	PT	15 Berquist...Kaufman 1982
HCl(v=7) + N <sub>2</sub> O(000) + HCl(v=6) + N <sub>2</sub> O(001)	V-V & V-T	1.5 × 10 <sup>-10</sup>	±30	45	298	PT	15 Berquist...Kaufman 1982
HCl(v=1) + N <sub>2</sub> O(000) + HCl(v=0) + N <sub>2</sub> O(nm0)	V-T	3.1 × 10 <sup>-13</sup>		2886	295	LF	80 Doyennette...Henry 1978
		3.1 × 10 <sup>-13</sup>		2886	295- 700	LF	80 Doyennette...Henry 1978
		3.6 × 10 <sup>-13</sup>					
HCl + N <sub>2</sub> O, see also N <sub>2</sub> O + HCl							
HCl(v=1) + O + HCl(v=0) + O	V-T & Rx	3.7 × 10 <sup>-12</sup>	±35	2886	298	LF-DF	10 Arnaldi and Wolfrum 1974
		It is thought that the reactive channel is dominant					
		9 × 10 <sup>-13</sup>		2886	298	LF-DF	52 Brown...Smith 1975
		1.0 × 10 <sup>-12</sup>	±20	2886	300	LF-DF	55 Brown...Smith 1975
		3.5 × 10 <sup>-13</sup>	±5	2886	295	LF-DF	115 Karny...Szöke 1975
		Reactive contribution is thought to be 1.8 × 10 <sup>-13</sup>					
		8.9 × 10 <sup>-13</sup>	±15	2886	296	LF-DF	131 Macdonald and Moore 1978
		4.3 × 10 <sup>-13</sup>	±20	2886	196- 400	LF-DF	55 Brown...Smith 1975
		2.8 × 10 <sup>-12</sup>					
HCl(v=2) + O + HCl(v=1) + O	V-T & Rx	5.2 × 10 <sup>-12</sup>	±10	2782	296	LF-DF	131 Macdonald and Moore 1978
		Reactive contribution is 1.5 × 10 <sup>-12</sup> (+90% error)					
HCl(v=1) + OCS + HCl(v=0) + OCS <sup>†</sup>	V-V & V-T	6.2 × 10 <sup>-13</sup>	±10	812(001) -32(101)	296	LF	103 Hopkins and Chen 1973
HCl(v=1) + O <sub>2</sub> (v=0) + HCl(v=0) + O <sub>2</sub> (v=1)	V-V	3.3 × 10 <sup>-15</sup>	±10	1330(v=1) -203(v=2)	295	LF	177 Zittel and Moore 1973
HCl(v=1) + <sup>18</sup> O <sub>2</sub> (v=0) + HCl(v=0) + <sup>18</sup> O <sub>2</sub> (v=1)		5.4 × 10 <sup>-15</sup>	±15	1417(v=1) -30(v=2)	295	LF	177 Zittel and Moore 1973
		Concluded that ΔV=2 changes in O <sub>2</sub> may be important					
HCl(v=2) + O <sub>2</sub> (v=0) + HCl(v=1) + O <sub>2</sub> (v=1)	V-V & V-T	7.6 × 10 <sup>-15</sup>	±20	1226(v=1)	295	PT	168 Thomas and Thrush 1977
HCl + O <sub>3</sub> , see O <sub>3</sub> + HCl							
HCl(v=1) + PF <sub>3</sub> H <sub>2</sub> + HCl(v=0) + PF <sub>3</sub> H <sub>2</sub> <sup>†</sup>	V-V & V-T	9.3 × 10 <sup>-13</sup>	±30	2886	295	LF	70 Coulibe...Filipovitch 1975
HCl(v=1) + SF <sub>6</sub> + HCl(v=0) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	3.0 × 10 <sup>-15</sup>	±10	2886	295	LF	177 Zittel and Moore 1973
		5.5 × 10 <sup>-13</sup>	±30	2886	298	PT	14 Berquist...Kaufman 1982
HCl(v=2) + SF <sub>6</sub> + HCl(v=1) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	~1 × 10 <sup>-13</sup>	>±30	2762	298	PT	14 Berquist...Kaufman 1982
HCl(v=3) + SF <sub>6</sub> + HCl(v=2) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	≤1 × 10 <sup>-13</sup>		2679	298	PT	14 Berquist...Kaufman 1982
HCl(v=4) + SF <sub>6</sub> + HCl(v=3) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	≤1 × 10 <sup>-13</sup>		2576	298	PT	14 Berquist...Kaufman 1982
HCl(v=5) + SF <sub>6</sub> + HCl(v=4) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	≤1 × 10 <sup>-13</sup>		2473	298	PT	14 Berquist...Kaufman 1982
HCl(v=6) + SF <sub>6</sub> + HCl(v=5) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	~1 × 10 <sup>-13</sup>	±30	2371	298	PT	14 Berquist...Kaufman 1982

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HCl(v=7) + SF <sub>6</sub> → HCl(v=6) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	~1.6 × 10 <sup>-13</sup>	±30	2269	298	FT	14 Berquist...Kaufman 1982
HCl(v=1) + SiHCl <sub>3</sub> → HCl(v=0) + SiHCl <sub>3</sub> <sup>†</sup>	V-V & V-T	1.3 × 10 <sup>-13</sup>	±5	2886	295	LF	70 Coombe...Pilipovitch 1975
HCl(v=1) + SiH <sub>2</sub> Cl <sub>2</sub> → HCl(v=0) + SiH <sub>2</sub> Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	4.3 × 10 <sup>-13</sup>	±10	2886	295	LF	70 Coombe...Pilipovitch 1975
HCl(v=1) + SOCl <sub>2</sub> → HCl(v=0) + SOCl <sub>2</sub> <sup>†</sup>	V-V & V-T	3.4 × 10 <sup>-13</sup>	±10	2886	295	LF	70 Coombe...Pilipovitch 1975
HCN(001) + DDCI(v=0) → HCN(nm0) + DDCI(v=0)	V-T	1.2 × 10 <sup>-13</sup>	±25	3312	296	LF	7 Arnold...Smith 1980
HCN(001) + DCI(v=0) → HCN(nm0) + DCI(v=0)	V-T	1.5 × 10 <sup>-13</sup>	±20	3312	296	LF	7 Arnold...Smith 1980
HCN(001) + DF(v=0) → HCN(000) + DF(v=1)	V-V & V-T	9.6 × 10 <sup>-13</sup>	±35	405	298	LF	135 McGarvey...Cool 1977
		1.4 × 10 <sup>-12</sup> 6.9 × 10 <sup>-13</sup>	±35	405	240-450	LF	135 McGarvey...Cool 1977
HCN(001) + HBr(v=0) → HCN(nm0) + HBr(v=0)	V-T	2.63 × 10 <sup>-13</sup>	±5	3312	296	LF	7 Arnold...Smith 1980
HCN(001) + HCl(v=0) → HCN(nm0) + HCl(v=0)	V-T	3.17 × 10 <sup>-13</sup>	±5	3312	296	LF	7 Arnold...Smith 1980
HCN(001) + HF(v=0) → HCN(nm0) + HF(v=0)	V-T	1.3 × 10 <sup>-12</sup>	±15	3312	298	LF	135 McGarvey...Cool 1977
		V-V contribution is less than 20%					
		1.4 × 10 <sup>-12</sup> 7.4 × 10 <sup>-13</sup>	±25	3312	240-449	LF	135 McGarvey...Cool 1977
HD(v=1) + HCl(v=0) → HD(v=0) + HCl(v=1)	V-V	1.05 × 10 <sup>-13</sup>	±10	741	295	LF	105 Hopkins and Chen 1972
HF(v=1) + Ar → HF(v=0) + Ar	V-T	<1.9 × 10 <sup>-15</sup>		3962	294	LF	95 Hancock and Green 1972
		<1.9 × 10 <sup>-15</sup>		3962	295	LF	94 Hancock and Green 1972
		<1.9 × 10 <sup>-15</sup>		3962	295	LF	100 Hinchen 1973
		<1.1 × 10 <sup>-14</sup>		3962	350	LF	2 Airey and Fried 1971
		<3.1 × 10 <sup>-15</sup>		3962	350	LF	89 Fried...Taylor 1973
		2.5 × 10 <sup>-15</sup> 6.2 × 10 <sup>-14</sup>	±20	3962	800-2400	LF-ST	16 Blair...Schott 1973
		8.3 × 10 <sup>-14</sup> 6 × 10 <sup>-13</sup>		3962	1350-4000	ST	34 Bott and Cohen 1971
		9.5 × 10 <sup>-15</sup> 4.2 × 10 <sup>-13</sup>		3962	1500-5000	ST	171 Vasil'ev...Tal'roze 1973
HF(v=3) + Ar → HF(v=2) + Ar	V-T	~1 × 10 <sup>-15</sup>		3622	296	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
		<1 × 10 <sup>-15</sup>		3622	295	LF	162 Wrigley and Smith 1981
HF(v=4) + Ar → HF(v=3) + Ar	V-T	<2 × 10 <sup>-15</sup>		3459	295	LF	162 Wrigley and Smith 1981
HF(v=6) + Ar → HF(v=5) + Ar	V-T	<6 × 10 <sup>-15</sup>		3143	295	LF	162 Wrigley and Smith 1981
HF(v=1) + BF <sub>3</sub> → HF(v=0) + BF <sub>3</sub> <sup>†</sup>	V-V & V-T	4.7 × 10 <sup>-4</sup>	±10	3962	295	LF	39 Bott and Cohen 1974
HF(v=1) + Br → HF(v=0) + Br(Br <sup>*</sup> )	V-T & V-E	>3.1 × 10 <sup>-11</sup>	±50	274(Br <sup>*</sup> )	295	LF-DF	150 Quigley and Wolga 1975
		The analysis states incorrectly that k <sub>e</sub> = k <sub>e'</sub> for V-E equilibrium, however the result matches a correct analysis of the data					
		6.3 × 10 <sup>-11</sup>	±20	274(Br <sup>*</sup> )	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 <sup>-10</sup> 3.2 × 10 <sup>-11</sup>		3962	1500-2600	ST	18 Blauer and Solomon 1973
HF(v=n) + Br → HF(v=n-1) + Br(Br <sup>*</sup> )	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 <sub>3</sub> → HF(v=0) + CBrF <sub>3</sub> <sup>+</sup>	V-V & V-T	≤1.2 × 10 <sup>-14</sup>	±15	3962	295	LF	39 Bott and Cohen 1974
HF(v=3) + CD <sub>4</sub> → HF(v=2) + CD <sub>4</sub> <sup>†</sup>	V-V & V-T	1.8 × 10 <sup>-12</sup>	±35	3622	295	LF	123 Lampert...Crim 1980
				1364(v <sub>3</sub> )			
		Direct excitation to HF(v=3)					
HF(v=4) + CD <sub>4</sub> → HF(v=3) + CD <sub>4</sub> <sup>†</sup>	V-V & V-T	5.5 × 10 <sup>-12</sup>	±15	3459	295	LF	123 Lampert...Crim 1980
				1201(v <sub>3</sub> )			
		Direct excitation to HF(v=4)					

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+=exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=1) + CF <sub>4</sub> + HF(v=0) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	≤1.3 × 10 <sup>-14</sup>	±15	3962	295	LF	39 Bott and Cohen 1974
		<1.2 × 10 <sup>-14</sup>	±30	3962	298	FT	119 Kwok and Cohen 1974
HF(v=2) + CF <sub>4</sub> + HF(v=1) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	2.2 × 10 <sup>-14</sup>	±50	3789	298	FT	119 Kwok and Cohen 1974
HF(v=3) + CF <sub>4</sub> + HF(v=2) + CF <sub>4</sub> <sup>†</sup>	V-V & V-T	6.3 × 10 <sup>-14</sup>	±50	3622	298	FT	119 Kwok and Cohen 1974
HF(v=1) + CH <sub>4</sub> + HF(v=0) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	2.1 × 10 <sup>-12</sup>		3962	320	FT	6 Anlauf...Herman 1973
		1.6 × 10 <sup>-12</sup>	±15	3962	295	LF	96 Hancock and Green 1973
		6.5 × 10 <sup>-13</sup>	±30	3962	298	FT	119 Kwok and Cohen 1974
		8.0 × 10 <sup>-13</sup>	±15	3962	295	LF	24 Bott 1977
		1.1 × 10 <sup>-12</sup>		3962	295	FT	8 Arnold and Kimbell 1978
HF(v=2) + CH <sub>4</sub> + HF(v=1) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	7.6 × 10 <sup>-12</sup>		3789	320	FT	6 Anlauf...Herman 1973
		2.2 × 10 <sup>-12</sup>	±50	3789	298	FT	119 Kwok and Cohen 1974
		1.8 × 10 <sup>-12</sup>		3789	295	FR	147 Poole and Smith 1977
HF(v=3) + CH <sub>4</sub> + HF(v=2) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	2.7 × 10 <sup>-12</sup>	±50	3622	298	FT	119 Kwok and Cohen 1974
		4.7 × 10 <sup>-12</sup>		3622	295	FR	147 Poole and Smith 1977
		1.8 × 10 <sup>-11</sup>	±25	3622	295	LF	123 Lampert...Crim 1980
		602(v <sub>3</sub> )					
		Direct excitation to HF(v=3)					
HF(v=4) + CH <sub>4</sub> + HF(v=3) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	1.3 × 10 <sup>-11</sup>		3459	295	FR	147 Poole and Smith 1977
		4.7 × 10 <sup>-11</sup>	±15	3459	295	LF	123 Lampert...Crim 1980
		439(v <sub>3</sub> )					
		Direct excitation to HF(v=4)					
HF(v=5) + CH <sub>4</sub> + HF(v=4) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	3.2 × 10 <sup>-11</sup>		3299	295	FR	147 Poole and Smith 1977
		1.0 × 10 <sup>-10</sup>	±30	3299	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=6) + CH <sub>4</sub> + HF(v=5) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	4.8 × 10 <sup>-11</sup>		3143	295	FR	147 Poole and Smith 1977
		1.4 × 10 <sup>-10</sup>	±30	3143	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=7) + CH <sub>4</sub> + HF(v=6) + CH <sub>4</sub> <sup>†</sup>	V-V & V-T	3.9 × 10 <sup>-11</sup>		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 <sup>-10</sup>	±30	2988	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=1) + C <sub>2</sub> F <sub>4</sub> + HF(v=0) + C <sub>2</sub> F <sub>4</sub> <sup>†</sup>	V-V & V-T	1.0 × 10 <sup>-13</sup>		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + C <sub>2</sub> F <sub>4</sub> + HF(v=1) + C <sub>2</sub> F <sub>4</sub> <sup>†</sup>	V-V & V-T	2.7 × 10 <sup>-13</sup>		3789	298	FT	8 Arnold and Kimbell 1978
HF(v=1) + C <sub>2</sub> F <sub>6</sub> + HF(v=0) + C <sub>2</sub> F <sub>6</sub> <sup>†</sup>	V-V & V-T	≤4.9 × 10 <sup>-15</sup>	±35	3962	295	LF	39 Bott and Cohen 1974
HF(v=1) + C <sub>2</sub> H <sub>3</sub> F + HF(v=0) + C <sub>2</sub> H <sub>3</sub> F <sup>†</sup>	V-V & V-T	5.9 × 10 <sup>-13</sup>		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + C <sub>2</sub> H <sub>3</sub> F + HF(v=1) + C <sub>2</sub> H <sub>3</sub> F <sup>†</sup>	V-V & V-T	1.3 × 10 <sup>-12</sup>		3789	298	FT	8 Arnold and Kimbell 1978
HF(v=1) + C <sub>2</sub> H <sub>2</sub> + HF(v=0) + C <sub>2</sub> H <sub>2</sub> <sup>†</sup>	V-V & V-T	1.9 × 10 <sup>-12</sup>		3962	320	FT	6 Anlauf...Herman 1973
HF(v=2) + C <sub>2</sub> H <sub>2</sub> + HF(v=1) + C <sub>2</sub> H <sub>2</sub> <sup>†</sup>	V-V & V-T	6.6 × 10 <sup>-12</sup>		3789	320	FT	6 Anlauf...Herman 1973
HF(v=1) + 1,1-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> + HF(v=0) + 1,1-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> <sup>†</sup>	V-V & V-T	8.3 × 10 <sup>-13</sup>		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + 1,1-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> + HF(v=1) + 1,1-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> <sup>†</sup>	V-V & V-T	2.0 × 10 <sup>-12</sup>		3789	298	FT	8 Arnold and Kimbell 1978

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=1) + cis-1,2-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> + HF(v=0) + cis-1,2-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> <sup>†</sup>	V-V & V-T	9.6 × 10 <sup>-13</sup>		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + cis-1,2-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> + HF(v=1) + cis-1,2-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> <sup>†</sup>	V-V & V-T	1.8 × 10 <sup>-12</sup>		3789	298	FT	8 Arnold and Kimbell 1978
HF(v=1) + trans-1,2-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> + HF(v=0) + trans-1,2-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> <sup>†</sup>	V-V & V-T	9.0 × 10 <sup>-13</sup>		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + trans-1,2-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> + HF(v=1) + trans-1,2-C <sub>2</sub> H <sub>2</sub> F <sub>2</sub> <sup>†</sup>	V-V & V-T	2.0 × 10 <sup>-12</sup>		3789	298	FT	8 Arnold and Kimbell 1978
HF(v=1) + C <sub>2</sub> H <sub>3</sub> F + HF(v=0) + C <sub>2</sub> H <sub>3</sub> F <sup>†</sup>	V-V & V-T	1.05 × 10 <sup>-12</sup>		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + C <sub>2</sub> H <sub>3</sub> F + HF(v=1) + C <sub>2</sub> H <sub>3</sub> F <sup>†</sup>	V-V & V-T	2.7 × 10 <sup>-12</sup>		3789	298	FT	8 Arnold and Kimbell 1978
HF(v=1) + C <sub>2</sub> H <sub>4</sub> + HF(v=0) + C <sub>2</sub> H <sub>4</sub> <sup>†</sup>	V-V & V-T	≤1.7 × 10 <sup>-12</sup>		3962	320	FT	6 Anlauf...Herman 1973
		1.5 × 10 <sup>-12</sup>		3962	298	FT	8 Arnold and Kimbell 1978
HF(v=2) + C <sub>2</sub> H <sub>4</sub> + HF(v=1) + C <sub>2</sub> H <sub>4</sub> <sup>†</sup>	V-V & V-T	≥7.3 × 10 <sup>-12</sup>		3789	320	FT	6 Anlauf...Herman 1973
		4.0 × 10 <sup>-12</sup>		3789	298	FT	8 Arnold and Kimbell 1978
HF(v=1) + C <sub>2</sub> H <sub>6</sub> + HF(v=0) + C <sub>2</sub> H <sub>6</sub> <sup>†</sup>	V-V & V-T	1.9 × 10 <sup>-12</sup>		3962	320	FT	6 Anlauf...Herman 1973
		3.4 × 10 <sup>-12</sup>	±15	3962	295	LF	96 Hancock and Green 1973
		1.8 × 10 <sup>-12</sup>	±10	3962	295	LF	24 Bott 1977
		3.9 × 10 <sup>-12</sup>		3962	290	FT	8 Arnold and Kimbell 1978
HF(v=2) + C <sub>2</sub> H <sub>6</sub> + HF(v=1) + C <sub>2</sub> H <sub>6</sub> <sup>†</sup>	V-V & V-T	9.3 × 10 <sup>-12</sup>		3789	320	FT	6 Anlauf...Herman 1973
HF(v=1) + C <sub>3</sub> H <sub>6</sub> + HF(v=0) + C <sub>3</sub> H <sub>6</sub> <sup>†</sup>	V-V & V-T	9.9 × 10 <sup>-12</sup>	±15	3962	295	LF	96 Hancock and Green 1973
HF(v=1) + C <sub>3</sub> H <sub>8</sub> + HF(v=0) + C <sub>3</sub> H <sub>8</sub> <sup>†</sup>	V-V & V-T	2.8 × 10 <sup>-12</sup>		3962	320	FT	6 Anlauf...Herman 1973
		4.2 × 10 <sup>-12</sup>	±15	3962	295	LF	96 Hancock and Green 1973
		2.6 × 10 <sup>-12</sup>	±10	3962	295	LF	24 Bott 1977
HF(v=2) + C <sub>3</sub> H <sub>8</sub> + HF(v=1) + C <sub>3</sub> H <sub>8</sub> <sup>†</sup>	V-V & V-T	9.9 × 10 <sup>-12</sup>		3789	320	FT	6 Anlauf...Herman 1973
HF(v=1) + C <sub>4</sub> F <sub>8</sub> + HF(v=0) + C <sub>4</sub> F <sub>8</sub> <sup>†</sup>	V-V & V-T	≤1.9 × 10 <sup>-14</sup>	±15	3962	295	LF	39 Bott and Cohen 1974
HF(v=1) + C <sub>4</sub> H <sub>10</sub> + HF(v=0) + C <sub>4</sub> H <sub>10</sub> <sup>†</sup>	V-V & V-T	5.3 × 10 <sup>-12</sup>	±15	3962	295	LF	96 Hancock and Green 1973
		4.0 × 10 <sup>-12</sup>	±10	3962	295	LF	24 Bott 1977
HF(v=1) + Cl + HF(v=0) + Cl	V-T	7.4 × 10 <sup>-13</sup>	±25	3962	295	LF-DF	151 Quigley and Wolga 1975
		3.8 × 10 <sup>-11</sup>		3962	3000	ST	19 Blauer...Owens 1972
		1.3 × 10 <sup>-12</sup>	±50	3962	1850-3200	ST	18 Blauer and Solomon 1973
HF(v=n) + Cl + HF(v=n-1) + Cl	V-T	n=1 1 2 10 30 50 50 6	Relative rate information only		295	CD	78 Douglas...Sloan 1976
HF(v=1) + Cl <sub>2</sub> + HF(v=0) + Cl <sub>2</sub> <sup>†</sup>	V-V & V-T	1.0 × 10 <sup>-14</sup>	±20	3962	295	LF	151 Quigley and Wolga 1975
HF(v=1) + ClF + HF(v=0) + ClF <sup>†</sup>	V-V & V-T	≤2.5 × 10 <sup>-14</sup>	±25	3962	295	LF	39 Bott and Cohen 1974
HF(v=1) + ClF <sub>3</sub> + HF(v=0) + ClF <sub>3</sub>	V-V & V-T	3.5 × 10 <sup>-12</sup>	±15	3962	295	LF	96 Hancock and Green 1973
		6.2 × 10 <sup>-12</sup>	±30	3962	295	LG	59 Chebotarev...Pshezhetskii 1976
HF(v=2) + ClF <sub>3</sub> + HF(v=1) + ClF <sub>3</sub> <sup>†</sup>	V-V & V-T	1.1 × 10 <sup>-13</sup>	±15	3789	295	LG	59 Chebotarev...Pshezhetskii 1976
HF(v=2) + ClF <sub>5</sub> + HF(v=1) + ClF <sub>5</sub> <sup>†</sup>	V-V & V-T	~5.6 × 10 <sup>-12</sup>	±35	3789	295	LG	59 Chebotarev...Pshezhetskii 1976
HF(v=1) + CO(v=0) + HF(v=0) + CO(v=1)	V-V & V-T	5.6 × 10 <sup>-14</sup>	±10	1816(v=1) -301(v=2)	295	LF	37 Bott and Cohen 1973
		7.7 × 10 <sup>-14</sup>	±20	1816(v=1) -301(v=2)	295	LF	92 Green and Hancock 1973
HF(v=2) + CO(v=0) + HF(v=1) + CO(v=1)	V-V & V-T	2.9 × 10 <sup>-13</sup>	1646(v=1)	295	FR	147 Poole and Smith 1977	

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

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

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, or First and Last Author, Year of Publication
HF(v=3) + CO <sub>2</sub> (000) + HF(v=2) + CO <sub>2</sub> (001) (cont'd.)		1.2 × 10 <sup>-11</sup>	±10	1273(001)	295	LF	31 Bott 1976
		1.2 × 10 <sup>-11</sup>		1273(001)	295	FT	118 Kwok, private communication in Ref. 31
		7.0 × 10 <sup>-12</sup>		1273(001)	295	FR	147 Poole and Smith 1977
		1.01 × 10 <sup>-11</sup>	±15	1273(001)	295	LF	77 Douglas and Moore 1979
		Direct excitation to HF(v=3)					
		1.04 × 10 <sup>-11</sup>	±15	1273(001)	296	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
HF(v=4) + CO <sub>2</sub> (000) + HF(v=3) + CO <sub>2</sub> (001)	V-V & V-T	1.2 × 10 <sup>-11</sup>		1109(001)	295	FT	3 Airey and Smith 1972
		Value given includes correction for radiative lifetime noted in 147					
		1.3 × 10 <sup>-11</sup>		1109(001)	295	FR	147 Poole and Smith 1977
		2.3 × 10 <sup>-11</sup>	±25	1109(001)	295	LF	77 Douglas and Moore 1979
		2.2 × 10 <sup>-11</sup>	±10	1109(001)	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
HF(v=5) + CO <sub>2</sub> (000) + HF(v=4) + CO <sub>2</sub> (001)	V-V & V-T	2.0 × 10 <sup>-11</sup>		949(001)	295	FT	3 Airey and Smith 1972
		Value given includes correction for radiative lifetime noted in 147					
		2.7 × 10 <sup>-11</sup>		949(001)	295	FR	147 Poole and Smith 1977
		8.1 × 10 <sup>-11</sup>	±30	949(001)	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=6) + CO <sub>2</sub> (000) + HF(v=5) + CO <sub>2</sub> (001)	V-V & V-T	3.5 × 10 <sup>-11</sup>		794(001)	295	FR	147 Poole and Smith 1977
		7.1 × 10 <sup>-11</sup>	±35	794(001)	295	LF	162 Smith and Wrigley 1981
		Deactivation of laser initiated reaction product					
		1.8 × 10 <sup>-10</sup>	±30	794(001)	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=7) + CO <sub>2</sub> (000) + HF(v=6) + CO <sub>2</sub> (001)	V-V & V-T	3.2 × 10 <sup>-11</sup>		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 <sup>-10</sup>	±30	640(001)	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=n) + CO <sub>2</sub> (000) + HF(v=n-1) + CO <sub>2</sub> (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 <sub>2</sub> + HF(v=0) + CS <sub>2</sub> <sup>+</sup>	V-V & V-T	4.9 × 10 <sup>-10</sup>		3962	295	LF	173 Wendelken...Noetzel 1975
HF(v=1) + D + HF(v=0) + D	V-T & Exchange	3 × 10 <sup>-14</sup>	±90	3962	295	LF-DF	99 Heidner and Bott 1975
HF(v=3) + D + HF(v=2) + D	V-T & Rx & Exchange	9.8 × 10 <sup>-11</sup>		3622	295	LF-DF	43 Bott and Heidner 1977
		Sequential absorption to HF(v=3)					
		1.3 × 10 <sup>-10</sup>		3622	200-	LF-DF	43 Bott and Heidner 1977
		9.8 × 10 <sup>-11</sup>		3622	295		
		Provides evidence that the v=3 relaxation is due mainly to reaction (HD) channel					
HF(v=1) + DBr(v=0) + HF(v=0) + DBr(v=1)	V-V & V-T	1.4 × 10 <sup>-13</sup>	±35	2119(v=1)	295	LF	39 Bott and Cohen 1974
				279(v=2)			
HF(v=1) + D <sub>2</sub> (v=0) + HF(v=0) + D <sub>2</sub> (v=1)	V-V & V-T	1.14 × 10 <sup>-13</sup>	±10	967	294	LF	95 Hancock and Green 1972
		9.6 × 10 <sup>-14</sup>	±20	967	295	LF	37 Bott and Cohen 1973
		9.0 × 10 <sup>-14</sup>	±10	967	295	LF	44 Bott and Heidner 1980
		8.2 × 10 <sup>-14</sup>	±10	967	200	LF	44 Bott and Heidner 1980
		1.2 × 10 <sup>-13</sup>	±20	967	450-	LF-ST	37 Bott and Cohen 1973
		1.0 × 10 <sup>-13</sup>		967	1000		
		8.5 × 10 <sup>-14</sup>		967	1500-	ST	34 Bott and Cohen 1971
		1.3 × 10 <sup>-12</sup>		967	3300		
HF(v=2) + D <sub>2</sub> (v=0) + HF(v=1) + D <sub>2</sub> (v=1)	V-V & V-T	2.6 × 10 <sup>-13</sup>		796	295	FR	146 Poole and Smith 1977
HF(v=3) + D <sub>2</sub> (v=0) + HF(v=2) + D <sub>2</sub> (v=1)	V-V & V-T	5.9 × 10 <sup>-13</sup>		628	295	FR	146 Poole and Smith 1977

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule-s)	Error (%)	$\Delta E(\text{cm}^{-1})$ (+/- exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=3) + D <sub>2</sub> (v=0) + HF(v=2) + D <sub>2</sub> (v=1) (cont'd.)		1.3 × 10 <sup>-12</sup>	±20	628	295	LF	77 Douglas and Moore 1979
	Direct excitation to HF(v=3)						
		1.5 × 10 <sup>-12</sup>	±15	628	295	LF	44 Bott and Heidner 1980
	Sequential absorption to HF(v=3)						
		1.5 × 10 <sup>-12</sup>	±15	628	200	LF	44 Bott and Heidner 1980
HF(v=4) + D <sub>2</sub> (v=0) + HF(v=3) + D <sub>2</sub> (v=1)	V-V & V-T	1.2 × 10 <sup>-12</sup>		466	295	FR	146 Poole and Smith 1977
		3.3 × 10 <sup>-12</sup>	±20	466	295	LF	77 Douglas and Moore 1979
	Direct excitation to HF(v=4)						
HF(v=5) + D <sub>2</sub> (v=0) + HF(v=4) + D <sub>2</sub> (v=1)	V-V & V-T	3.1 × 10 <sup>-12</sup>		304	295	FR	146 Poole and Smith 1977
		1.3 × 10 <sup>-11</sup>	±30	304	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=6) + D <sub>2</sub> (v=0) + HF(v=5) + D <sub>2</sub> (v=1)	V-V & V-T	8.2 × 10 <sup>-12</sup>		146	295	FR	146 Poole and Smith 1977
		4.2 × 10 <sup>-11</sup>	±30	146	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=7) + D <sub>2</sub> (v=0) + HF(v=6) + D <sub>2</sub> (v=1)	V-V & V-T	~6.1 × 10 <sup>-12</sup>		-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 <sup>-10</sup>	±30	-10	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=1) + D <sub>2</sub> O + HF(v=0) + D <sub>2</sub> O <sup>†</sup>	V-V & V-T	1.3 × 10 <sup>-10</sup>	±15	1176(v <sub>3</sub> )	294	LF	95 Hancock and Green 1972
		1.6 × 10 <sup>-11</sup>		1176(v <sub>3</sub> )	1200-	ST	20 Blaauw...Owens 1972
		1.1 × 10 <sup>-11</sup>			3300		
HF(v=2) + D <sub>2</sub> O + HF(v=1) + D <sub>2</sub> O <sup>†</sup>	V-V & V-T	4.0 × 10 <sup>-11</sup>		3789	295	FR	147 Poole and Smith 1977
HF(v=3) + D <sub>2</sub> O + HF(v=2) + D <sub>2</sub> O <sup>†</sup>	V-V & V-T	6.5 × 10 <sup>-11</sup>		3622	295	FR	147 Poole and Smith 1977
HF(v=4) + D <sub>2</sub> O + HF(v=3) + D <sub>2</sub> O <sup>†</sup>	V-V & V-T	8.0 × 10 <sup>-11</sup>		3459	295	FR	147 Poole and Smith 1977
HF(v=5) + D <sub>2</sub> O + HF(v=4) + D <sub>2</sub> O <sup>†</sup>	V-V & V-T	7.1 × 10 <sup>-11</sup>		3299	295	FR	147 Poole and Smith 1977
HF(v=6) + D <sub>2</sub> O + HF(v=5) + D <sub>2</sub> O <sup>†</sup>	V-V & V-T	4.8 × 10 <sup>-11</sup>		3143	295	FR	147 Poole and Smith 1977
HF(v=7) + D <sub>2</sub> O + HF(v=6) + D <sub>2</sub> O <sup>†</sup>	V-V & V-T	3.1 × 10 <sup>-11</sup>		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) + HF(v=0) + DF(v=1)	V-V & V-T	3.3 × 10 <sup>-12</sup>	±35	1055	300	LF	1 Ahl and Cool 1973
	V-V contribution only						
	2.4 × 10 <sup>-12</sup>	±5	1055	295	LF	37 Bott and Cohen 1973	
	May contain a small V-T contribution						
	2.1 × 10 <sup>-12</sup>	±10	1055	295	LF	100 Hinchen 1973	
	V-V contribution estimated to be 7.4 × 10 <sup>-13</sup>						
	4.2 × 10 <sup>-12</sup>	±20	1055	295	LF	93 Hancock and Green 1975	
	Contains V-T contribution						
	3.24 × 10 <sup>-12</sup>	±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 <sup>-12</sup>		1055	200	LF	93 Hancock and Green 1975	
	2.8 × 10 <sup>-12</sup>		1055	198	LF	97 Hancock and Saunders 1976	
	5.5 × 10 <sup>-12</sup>	±20	1055	210-	LF	128 Lucht and Cool 1975	
	2.4 × 10 <sup>-12</sup>			364			
	Polymer (DF) <sub>n</sub> quenching observed in Refs. 129 and 97						
	2.9 × 10 <sup>-12</sup>	±45	1055	350	LF	1 Ahl and Cool 1973	
	V-V contribution only						
	4.2 × 10 <sup>-12</sup>	±20	1055	297-	LF	128 Lucht and Cool 1974	
	2.2 × 10 <sup>-12</sup>			678			
	1.3 × 10 <sup>-12</sup>	±5	1055	450-	LF-ST	37 Bott and Cohen 1973	
	1.3 × 10 <sup>-12</sup>			1100			

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author, or First and Last Author, Year of Publication
HF(v=1) + DF(v=0) + HF(v=C) + DF(v=1) (cont'd.)		4.5 × 10 <sup>-13</sup> 3.1 × 10 <sup>-12</sup>	±50	1055 3300	1700– 3300	ST	19 Blauer...Owens 1972
HF(v=1) + DF(v=0) + HF(v=0) + DF(v=0)	V-T	<1.4 × 10 <sup>-12</sup>  <1.3 × 10 <sup>-12</sup>  <1.2 × 10 <sup>-12</sup>	±15 ±50 ±15	3962 3962 3962	300 295 350	LF LF LF	1 Ahl and Cool 1973  100 Hinchen 1973  1 Ahl and Cool 1973
HF(v=1) + (DF) <sub>n</sub> + HF(v=0) + (DF) <sub>n</sub> <sup>†</sup>	V-V & V-T			3962	198– 296	LF	97 Hancock and Saunders 1976
Strong rate enhancement over monomer							
HF(v=1) + F + HF(v=0) + F	V-T	2.8 × 10 <sup>-13</sup> 2.8 × 10 <sup>-13</sup> 4.5 × 10 <sup>-12</sup> 1.3 × 10 <sup>-11</sup> 5.0 × 10 <sup>-11</sup>	±25 ±25 ±20	3962 3962 3962 3962	295 295 1500– 2400 1800– 3300	LF-DF LF-DF LF-ST ST	149 Quigley and Wolga 1974 151 Quigley and Wolga 1975 16 Blair...Schott 1973 35 Bott and Cohen 1971
The rate constant is essentially constant over this temperature range							
		1.5 × 10 <sup>-12</sup> 1.5 × 10 <sup>-11</sup>		3962 3500	1700– 3500	ST	164 Solomon...Hnat 1971
Rates found to be seven times slower than reported in Ref. 164							
HF(v=2) + F + 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) <sub>5</sub> + HF(v=0) + Fe(CO) <sub>5</sub> <sup>†</sup>	V-V & V-T	~6.2 × 10 <sup>-12</sup> Estimate only		3962	295	LF	37 Bott and Cohen 1973
HF(v=1) + F <sub>2</sub> + HF(v=0) + F <sub>2</sub> <sup>†</sup>	V-V & V-T	<4.7 × 10 <sup>-13</sup>  <3 × 10 <sup>-15</sup>		3962 3962	350 350	LF LF	2 Airey and Fried 1971 89 Fried...Taylor 1973
HF(v=1) + H + HF(v=0) + H	V-T	<3.2 × 10 <sup>-12</sup>  <1.4 × 10 <sup>-14</sup>  2.3 × 10 <sup>-13</sup>		3962 3962 3962	295 295 295	FT LF-DF LF-DF	121 Kwok and Wilkins 1974 149 Quigley and Wolga 1974 99, 98 Heidner and Bott 1975, 1977
HF(v=2) + H + HF(v=1) + H	V-T	<1.8 × 10 <sup>-11</sup>  1.1 × 10 <sup>-12</sup>	±50	3789 3789	295 295	FT LF-DF	121 Kwok and Wilkins 1974 42 Bott and Heidner 1977
Sequential absorption to HF(v=2)							
		8.3 × 10 <sup>-13</sup>	±40	3789	295	LF-DF	98 Heidner and Bott 1977
HF(v=3) + H + HF(v=2) + H	V-T & RX	3.0 × 10 <sup>-11</sup>  1.05 × 10 <sup>-10</sup>		3622 3622	295 295	FT LF-DF	121 Kwok and Wilkins 1974 42 Bott and Heidner 1977 98 Heidner and Bott 1977
		1.66 × 10 <sup>-10</sup> 1.05 × 10 <sup>-10</sup>		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) + HF(v=0) + HBr(v=1)	V-V & V-T	2.2 × 10 <sup>-13</sup> V-V contribution only	±35	1400	300	LP	1 Ahl and Cool 1973
		2.3 × 10 <sup>-13</sup>	±15	1400	295	LP	37 Bott and Cohen 1973
Contains V-T contribution							
		1.5 × 10 <sup>-13</sup>	±35	1400	350	LF	1 Ahl and Cool 1973
HF(v=4) + HBr(v=0) + HF(v=3) + HBr(v=1)	V-V & V-T	2.2 × 10 <sup>-11</sup>	±10	900	295	LF	162 Smith and Wrigley 1981
Deactivation of laser initiated reaction product							
HF(v=1) + HBr(v=0) + HF(v=0) + HBr(v=0)	V-T	<1.5 × 10 <sup>-13</sup>  <1.0 × 10 <sup>-13</sup>		3962 3962	300 350	LF LF	1 Ahl and Cool 1973 1 Ahl and Cool 1973
HF(v=1) + HCl(v=0) + HF(v=0) + HCl(v=1)	V-V & V-T	5.3 × 10 <sup>-13</sup>	±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 <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+/- exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=1) + HCl(v=0) + HF(v=0) + HCl(v=1) (cont'd.)		$7.4 \times 10^{-13}$			1074	300	LF 1 Ahl and Cool 1973
		V-V contribution only					
		$6.7 \times 10^{-13}$			1074	350	LF 1 Ahl and Cool 1973
		$4.2 \times 10^{-13}$	$\pm 5$		1074	450- 1100	LF-ST 37 Bott and Cohen 1973
		$6 \times 10^{-13}$					
		$2.5 \times 10^{-14}$			1074	1420- 2900	ST 20 Blauer...Owens 1972
		$1.7 \times 10^{-13}$					
HF(v=3) + HCl(v=0) + HF(v=2) + HCl(v=1)	V-V & V-T	$1.2 \times 10^{-11}$	$\pm 10$	739	295	LF	31 Bott 1976
		Sequential absorption to HF(v=3)					
		$1.2 \times 10^{-11}$	$\pm 15$	739	296	LF	163 Smith and Wrigley 1980
		Deactivation of laser initiated reaction product					
HF(v=1) + HCl(v=0) + 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(COO) + HF(v=0) + HCN(001)	V-V & V-T	$5.3 \times 10^{-12}$	$\pm 25$	650(C01) -44(011)	298	LF	135 McGarvey...Cool 1977
		$7.2 \times 10^{-12}$	$\pm 20$	650(001)	240- 449	LF	135 McGarvey...Cool 1977
		$3.3 \times 10^{-12}$					
HF(v=2) + HCN + HF(v=1) + HCN <sup>†</sup>	V-V & V-T	$1.7 \times 10^{-11}$			3789	295	FR 147 Poole and Smith 1977
HF(v=3) + HCN + HF(v=2) + HCN <sup>†</sup>	V-V & V-T	$4.3 \times 10^{-11}$			3622	295	FR 147 Poole and Smith 1977
HF(v=4) + HCN + HF(v=3) + HCN <sup>†</sup>	V-V & V-T	$8.6 \times 10^{-11}$			3459	295	FR 147 Poole and Smith 1977
HF(v=5) + HCN + HF(v=4) + HCN <sup>†</sup>	V-V & V-T	$1.1 \times 10^{-10}$			3299	295	FR 147 Poole and Smith 1977
HF(v=6) + HCN + HF(v=5) + HCN <sup>†</sup>	V-V & V-T	$7.4 \times 10^{-11}$			3143	295	FR 147 Poole and Smith 1977
HF(v=7) + HCN + HF(v=6) + HCN <sup>†</sup>	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) + HF(v=1) + HD(v=1)	V-V & V-T	$1.2 \times 10^{-12}$			159	295	FR 146 Poole and Smith 1977
HF(v=3) + HD(v=0) + HF(v=2) + HD(v=1)	V-V & V-T	$5.1 \times 10^{-12}$			-8	295	FR 146 Poole and Smith 1977
HF(v=4) + HD(v=0) + HF(v=3) + HD(v=1)	V-V & V-T	$2.1 \times 10^{-12}$			-172	295	FR 146 Poole and Smith 1977
HF(v=5) + HD(v=0) + HF(v=4) + HD(v=1)	V-V & V-T	$1.3 \times 10^{-12}$			-333	295	FR 146 Poole and Smith 1977
HF(v=6) + HD(v=0) + HF(v=5) + HD(v=1)	V-V & V-T	$1.3 \times 10^{-12}$			-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 + 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
		$9.2 \times 10^{-15}$			3962	1500- 3500	ST 169 Vasil'ev...Papin 1975
		$2.7 \times 10^{-13}$					
		$3.6 \times 10^{-15}$			3962	1100- 3650	ST 34 Bott and Cohen 1974
		$5.2 \times 10^{-13}$					
HF(v=1) + HF(v=1) + HF(v=2) + HF(v=0)	V-V	$4.3 \times 10^{-11}$			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					
		$4.7 \times 10^{-11}$			173	295	LF 143 Osgood...Sackett 1972
		$1.7 \times 10^{-11}$			173	295	LG 25 Bott 1972
		Rate first described in Ref. 25 as $3.7 \times 10^{-11}$ , then corrected for faster V-T deactivation of HF(v=2) in Ref. 67 (Hinchen and Bott 1976)					
		$4.8 \times 10^{-11}$	$\pm 25$	173	295	LF	144 Osgood...Javan 1974
		Correction for faster V-T deactivation of HF(v=2) would give $3.1 \times 10^{-11}$ according to Ref. 67					
		$3.8 \times 10^{-11}$	$\pm 30$	173	298	FT	122 Kwok and Wilkins 1975

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

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

## Vibrational energy transfer (continued)

		Error (molecule·s)	Error (%)	$\Delta E(\text{cm}^{-1})$ (+ = exo)	Temp (K)	Method	Reference Number, Author, or First and Last Author, Year of Publication
HF(v=5) + HF(v=0) + HF(v=0) + HF(v=1)		$4.6 \times 10^{-11}$		-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							
		$5.8 \times 10^{-11}$		-662 3299	295	FT	120 Kwok and Cohen, private communication, in Ref. 174
		$1.51 \times 10^{-10}$	±4	-662 3299	295	LF	112 Jursich and Crim 1981
Direct excitation to HF(v=5)							
HF(v=6) + HF(v=0) + HF(v=5) + HF(v=1)	V-V & V-T	$1.6 \times 10^{-10}$	±30	-622 3299	298	FT	81 Dzelzkalns and Kaufman 1982
		$1.49 \times 10^{-10}$	±10	-662	295	LF	86 Foster and Crim 1981
		$8.1 \times 10^{-11}$	~1% at 295	3299	625		
V-T contribution thought to be substantial							
HF(v=7) + HF(v=0) + HF(v=0) + HF(v=1)	V-V & V-T	$4.3 \times 10^{-11}$		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							
		$4.6 \times 10^{-10}$	±30	2988	298	FT	81 Dzelzkalns and Kaufman 1982
V-T contribution thought to be substantial							
HF(v=1) + HF(v=0) + HF(v=0) + HF(v=0)	V-T	$1.8 \times 10^{-12}$	±10	3962	295	LF	25 Bott 1972
		$2.70 \times 10^{-12}$	±1	3962	294	LF	94 Hancock and Green 1972
		$2.7 \times 10^{-12}$	±10	3962	294	LF	95 Hancock and Green 1972
With Ar diluent							
		$1.4 \times 10^{-12}$	±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							
		$2.7 \times 10^{-12}$	±1	3962	295	LF	92 Green and Hancock 1973
		$2.25 \times 10^{-12}$	±1	3962	295	LF	28 Bott 1974
Corrected Green and Hancock result for error in partial pressure measurement							
		$2.6 \times 10^{-12}$	±10	3962	295	LF	89 Fried and Taylor 1973
		$1.9 \times 10^{-12}$	±10	3962	295	LF	100 Hinchen 1973
		$1.8 \times 10^{-12}$	±10	3962	295	LF	101 Hinchen 1973
		$2.2 \times 10^{-12}$	±15	3962	300	LF	1 Ahi and Cool 1973
		$1.81 \times 10^{-12}$	±15	3962	300	LF	28 Bott 1974
Corrected Ahi and Cool result for error in partial pressure measurement							
		$1.7 \times 10^{-12}$		3962	295	LF	37 Bott and Cohen 1973
		$2.6 \times 10^{-12}$	±20	3962	295	LF	127 Lucht and Cool 1974
		$2.6 \times 10^{-12}$	±25	3962	295	LF	128 Lucht and Cool 1974
Noted that without Ar diluent the rate is slower							
		$2.18 \times 10^{-12}$	±15	3962	295	LF	28 Bott 1974
Corrected Lucht and Cool result for error in partial pressure measurement							
		$1.7 \times 10^{-12}$		3962	295	LF	144 Osgood...Javan 1974
		$1.6 \times 10^{-12}$	±20	3962	298	FT	122 Kwok and Wilkins 1975
		$1.45 \times 10^{-12}$	±4	3962	295	LF	93 Hancock and Green 1975

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=1) + HF(v=0) + HF(v=0) + HF(v=0) (cont'd.)		$3 \times 10^{-12}$	±50	3962	200	LF	93 Hancock and Green 1975
		$2.2 \times 10^{-12}$	±10	3962	205-	LF	129 Lucht and Cool 1975
		$1.5 \times 10^{-12}$			358		
		$4.3 \times 10^{-12}$		3962	330	SP	154 Rityn...Slobodskaya 1974
Possibly some residual water vapor present							
		$3.4 \times 10^{-12}$		3962	360	LF	2 Airey and Fricd 1971
		$1.90 \times 10^{-12}$	±5	3962	350	LF	166 Stephens and Cool 1972
		$1.80 \times 10^{-12}$	±10	3962	350	LF	1 Ahl and Cool 1973
		$2.6 \times 10^{-12}$	±20	3962	300-	LF	127 Lucht and Cool 1974
		$1.4 \times 10^{-12}$			670		
		$2.6 \times 10^{-12}$	±15	3962	300-	LF	128 Lucht and Cool 1974
		$1.4 \times 10^{-12}$			678		
		$1.2 \times 10^{-12}$	±10	3962	295-	LF	89 Fried...Taylor 1973
		$1.3 \times 10^{-12}$			730		
		$1.8 \times 10^{-12}$	±10	3962	295-	LF-ST	101 Hinchen 1973
		$1.0 \times 10^{-12}$			900		
		$1.8 \times 10^{-12}$	±10	3962	295-	LF	25 Bott 1972
		$7.5 \times 10^{-13}$			1000		
		$1.4 \times 10^{-12}$	±20	3962	600-	LF-ST	16 Blair...Schott 1973
		$3.6 \times 10^{-12}$			2400		
		$8.3 \times 10^{-13}$		3962	1350-	ST	34 Bott and Cohen 1971
		$6.0 \times 10^{-12}$			4000		
		$9.5 \times 10^{-14}$	±30	3962	1400-	ST	164 Solomon...Hnat 1971
		$1.5 \times 10^{-11}$			4100		
		$8.9 \times 10^{-13}$		3962	1500-	ST	171 Vasil'ev...Tal'roze 1973
		$4.8 \times 10^{-11}$			5000		
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) + HF(v=1) + HF(v=0)	V-T	$\sim 1.2 \times 10^{-11}$		3789	295	LG	67 Cohen and Bott 1976
HF + H <sub>2</sub> , see also H <sub>2</sub> + HF, especially HF(v=1,2)							
HF(v=3) + H <sub>2</sub> (v=0) + HF(v=2) + H <sub>2</sub> (v=1)	V-V & V-T	$3.6 \times 10^{-13}$	±10	-535	295	LF	31 Bott 1976
Sequential absorption to HF(v=3)							
		$1.5 \times 10^{-13}$		-535	295	FR	146 Poole and Smith 1977
		$3.1 \times 10^{-13}$	±20	-535	295	LF	77 Douglas and Moore 1979
Direct excitation to HF(v=3)							
		$3.5 \times 10^{-13}$	±10	-535	295	LF	44 Bott and Heidner 1980
Sequential absorption to HF(v=3)							
		$1.8 \times 10^{-13}$	±15	-535	200	LF	44 Bott and Heidner 1980
HF(v=4) + H <sub>2</sub> (v=0) + HF(v=3) + H <sub>2</sub> (v=0)	V-T	$2.1 \times 10^{-13}$		3459	295	FR	146 Poole and Smith 1977
		$4.7 \times 10^{-13}$	±25	3459	295	LF	77 Douglas and Moore 1979
Thought to be mainly V-T							
HF(v=5) + H <sub>2</sub> (v=0) + HF(v=4) + H <sub>2</sub> (v=0)	V-T	$4.9 \times 10^{-13}$		3299	295	FR	146 Poole and Smith 1977
		$1.8 \times 10^{-12}$	±30	3299	298	PT	81 Dzelzkalns and Kaufman 1982
Thought to be mainly V-T							
HF(v=6) + H <sub>2</sub> (v=0) + HF(v=5) + H <sub>2</sub> (v=0)	V-T	$9.9 \times 10^{-13}$		3143	295	FR	146 Poole and Smith 1977
		$3.4 \times 10^{-12}$	±30	3143	298	PT	81 Dzelzkalns and Kaufman 1982
Thought to be mainly V-T							
HF(v=7) + H <sub>2</sub> (v=0) + HF(v=6) + H <sub>2</sub> (v=0)	V-T	$1.6 \times 10^{-12}$		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 <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+/- exo)	Temp (K)	Method	Reference Number, Author or First and Last Authors, Year of Publication
HF(v=7) + H <sub>2</sub> (v=0) + HF(v=6) + H <sub>2</sub> (v=0) (cont'd.)		$9.0 \times 10^{-12}$	$\pm 30$	2988	298	FT	81 Dzelzkalns and Kaufman 1982
		Thought to be mainly V-T					
HF(v=1) + H <sub>2</sub> (v=0) + HF(v=0) + H <sub>2</sub> (v=0)	V-T	$< 3 \times 10^{-14}$		3962	295	LF	95 Hancock and Green 1972
		$< 1.8 \times 10^{-14}$	$\pm 35$	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					
		$1.2 \times 10^{-14}$	$\pm 30$	3962	295	LF	27 Bott 1974
		$3.5 \times 10^{-14}$		3962	295	LF	141 Osgood, private communication in Ref. 27
		$\lesssim 3.1 \times 10^{-14}$	$\pm 30$	3962	457-611	LF-ST	27 Bott 1974
$\lesssim 3.1 \times 10^{-14}$							
HF + H <sub>2</sub> , see also H <sub>2</sub> + HF							
HF(v=1) + H <sub>2</sub> O + HF(v=0) + H <sub>2</sub> O <sup>†</sup>	V-V & V-T	$1.3 \times 10^{-10}$	$\pm 15$	206(001) 310(100)	294	LF	95 Hancock and Green 1972
		$1.0 \times 10^{-10}$		206(001)	1630-	ST	20 Blauer...Owens 1972
		$4.9 \times 10^{-11}$		310(100)	2920		
HF(v=2) + H <sub>2</sub> O + HF(v=1) + H <sub>2</sub> O <sup>†</sup>	V-V & V-T	$4.0 \times 10^{-10}$		3789	295	FR	147 Poole and Smith 1977
HF(v=3) + H <sub>2</sub> O + HF(v=2) + H <sub>2</sub> O <sup>†</sup>	V-V & V-T	$6.2 \times 10^{-10}$		3622	295	FR	147 Poole and Smith 1977
HF(v=4) + H <sub>2</sub> O + HF(v=3) + H <sub>2</sub> O <sup>†</sup>	V-V & V-T	$7.6 \times 10^{-10}$		3459	295	FR	147 Poole and Smith 1977
HF(v=5) + H <sub>2</sub> O + HF(v=4) + H <sub>2</sub> O <sup>†</sup>	V-V & V-T	$6.5 \times 10^{-10}$		3299	295	FR	147 Poole and Smith 1977
HF(v=6) + H <sub>2</sub> O + HF(v=5) + H <sub>2</sub> O <sup>†</sup>	V-V & V-T	$3.7 \times 10^{-10}$		3143	295	FR	147 Poole and Smith 1977
HF(v=7) + H <sub>2</sub> O + HF(v=6) + H <sub>2</sub> O <sup>†</sup>	V-V & V-T	$3.1 \times 10^{-10}$		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 <sub>2</sub> S + HF(v=0) + H <sub>2</sub> S <sup>†</sup>	V-V & V-T	$1.0 \times 10^{-12}$	$\pm 10$	3962	295	LF	39 Bott and Cohen 1974
		$2.3 \times 10^{-12}$	$\pm 30$	3962	298	FT	119 Kwok and Wilkins 1974
HF(v=2) + H <sub>2</sub> S + HF(v=1) + H <sub>2</sub> S <sup>†</sup>	V-V & V-T	$8.6 \times 10^{-12}$	$\pm 50$	3789	298	FT	119 Kwok and Wilkins 1974
HF(v=3) + H <sub>2</sub> S + HF(v=2) + H <sub>2</sub> S <sup>†</sup>	V-V & V-T	$1.0 \times 10^{-11}$	$\pm 50$	3622	298	FT	119 Kwok and Wilkins 1974
HF(v=1) + HI(v=0) + HF(v=0) + HI(v=1)	V-V & V-T	$1.1 \times 10^{-13}$	$\pm 60$	1950(v=1) -418(v=2)	300	LF	1 Ahl and Cool 1973
		$7.2 \times 10^{-14}$	$\pm 75$	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	$2.0 \times 10^{-10}$	$\pm 10$		295	LF	162 Wrigley and Smith 1981
		Deactivation of laser initiated reaction product					
HF(v=1) + I + HF(v=0) + I	V-T	$3.8 \times 10^{-12}$	$\pm 50$	3962	1600-3000	ST	18 Blauer and Solomon 1973
		$3.6 \times 10^{-11}$					
HF(v=2) + I + HF(v=0) + I(I <sup>*</sup> )	V-T & V-E	$\lesssim 3 \times 10^{-12}$	$\pm 35$	7751 147(I <sup>*</sup> )	295	LF	148 Pritt and Coombe 1976
		V-E contribution to the total deactivation from reverse process					
		$59.4 \times 10^{-13}$		7751 147(I <sup>*</sup> )		LF	69 Coombe and Pritt 1977
		Value obtained from V-E contribution to the total deactivation, z-v channel established to be 35%					
HF(v=1) + NF <sub>3</sub> + HF(v=0) + NF <sub>3</sub> <sup>†</sup>	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 <sub>3</sub> + HF(v=1) + NH <sub>3</sub> <sup>†</sup>	V-V & V-T	$1.9 \times 10^{-10}$		3789	295	FR	147 Poole and Smith 1977
HF(v=3) + NH <sub>3</sub> + HF(v=2) + NH <sub>3</sub> <sup>†</sup>	V-V & V-T	$1.9 \times 10^{-10}$		3622	295	FR	147 Poole and Smith 1977
HF(v=4) + NH <sub>3</sub> + HF(v=3) + NH <sub>3</sub> <sup>†</sup>	V-V & V-T	$2.3 \times 10^{-10}$		3459	295	FR	147 Poole and Smith 1977
HF(v=5) + NH <sub>3</sub> + HF(v=4) + NH <sub>3</sub> <sup>†</sup>	V-V & V-T	$4.0 \times 10^{-10}$		3299	295	FR	147 Poole and Smith 1977

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=6) + NH <sub>3</sub> + HF(v=5) + NH <sub>3</sub> <sup>†</sup>	V-V & V-T	$2.8 \times 10^{-10}$		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 <sub>2</sub> (v=0) + HF(v=0) + N <sub>2</sub> (v=1)	V-V & V-T	$4.0 \times 10^{-15}$	$\pm 50$	1630	294	LF	94 Hancock and Green 1972
		$3.9 \times 10^{-15}$	$\pm 50$	1630	294	LF	95 Hancock and Green 1972
		$4.7 \times 10^{-15}$	$\pm 10$	1630	295	LF	37 Bott and Cohen 1973
May contain large V-T contribution							
		$4.5 \times 10^{-15}$	$\pm 15$	1630	295	LF	31 Bott 1976
		$4.3 \times 10^{-15}$	$\pm 15$	1630	295	LF	44 Bott and Heidner 1980
		$6.2 \times 10^{-15}$	$\pm 10$	1630	200	LF	44 Bott and Heidner 1980
		$<1.2 \times 10^{-14}$		1630	350	LF	2 Airey and Fried 1971
		$6.2 \times 10^{-15}$	$\pm 50$	1630	350	LF	89 Fried...Taylor 1973
		$6.2 \times 10^{-15}$	$\pm 10$	1630	450- 1700	LF-ST	37 Bott and Cohen 1973
		$5.2 \times 10^{-14}$		1630	1600- 3200	ST	34 Bott and Cohen 1971
		$4.3 \times 10^{-13}$					
		$9.5 \times 10^{-14}$	$\pm 60$	1630	1400- 3200	ST	19 Blauer...Owens 1972
HF(v=2) + N <sub>2</sub> (v=0) + HF(v=1) + N <sub>2</sub> (v=1)	V-V & V-T	$2.5 \times 10^{-14}$	$\pm 15$	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 <sub>2</sub> (v=0) + HF(v=2) + N <sub>2</sub> (v=1)	V-V & V-T	$9.0 \times 10^{-14}$	$\pm 15$	1295	295	LF	31 Bott 1976
Sequential absorption to HF(v=3)							
		$2.8 \times 10^{-14}$		1295	295	FR	147 Poole and Smith 1977
		$7.1 \times 10^{-14}$		1295	295	LF	163 Smith and Wrigley 1980
Deactivation of laser initiated reaction product							
HF(v=4) + N <sub>2</sub> (v=0) + HF(v=3) + N <sub>2</sub> (v=1)	V-V & V-T	$6.1 \times 10^{-14}$		1128	295	FR	147 Poole and Smith 1977
Deactivation of laser initiated reaction product							
		$3.5 \times 10^{-13}$	$\pm 10$	1128	295	LF	162 Smith and Wrigley 1981
HF(v=5) + N <sub>2</sub> (v=0) + HF(v=4) + N <sub>2</sub> (v=1)	V-V & V-T	$2.5 \times 10^{-13}$		967	295	FR	147 Poole and Smith 1977
HF(v=6) + N <sub>2</sub> (v=0) + HF(v=5) + N <sub>2</sub> (v=1)	V-V & V-T	$7.0 \times 10^{-13}$		809	295	FR	147 Poole and Smith 1977
		$1.2 \times 10^{-12}$	$\pm 35$	809	295	LF	162 Smith and Wrigley 1981
HF(v=7) + N <sub>2</sub> (v=0) + HF(v=6) + N <sub>2</sub> (v=1)	V-V & V-T	$1.4 \times 10^{-12}$		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 <sub>2</sub> O + HF(v=0) + N <sub>2</sub> O <sup>†</sup>	V-V & V-T	$1.0 \times 10^{-12}$	$\pm 10$	3962	295	LF	39 Bott and Cohen 1974
		$3.8 \times 10^{-13}$	$\pm 30$	3962	298	FT	119 Kwok and Cohen 1974
HF(v=2) + N <sub>2</sub> O + HF(v=1) + N <sub>2</sub> O <sup>†</sup>	V-V & V-T	$6.8 \times 10^{-13}$	$\pm 50$	3789	298	FT	119 Kwok and Cohen 1974
		$1.0 \times 10^{-11}$		3789	295	FR	147 Poole and Smith 1977
HF(v=3) + N <sub>2</sub> O + HF(v=2) + N <sub>2</sub> O <sup>†</sup>	V-V & V-T	$2.5 \times 10^{-11}$		3622	295	FR	147 Poole and Smith 1977
		$1.4 \times 10^{-11}$	$\pm 10$	3622	296	LF	163 Smith and Wrigley 1980
Deactivation of laser initiated reaction product							
HF(v=4) + N <sub>2</sub> O + HF(v=3) + N <sub>2</sub> O <sup>†</sup>	V-V & V-T	$3.0 \times 10^{-11}$		3459	295	FR	147 Poole and Smith 1977
		$5.9 \times 10^{-11}$	$\pm 15$		295	LF	162 Smith and Wrigley 1981
Deactivation of laser initiated reaction product							
HF(v=5) + N <sub>2</sub> O + HF(v=4) + N <sub>2</sub> O <sup>†</sup>	V-V & V-T	$5.2 \times 10^{-11}$		3299	295	FR	147 Poole and Smith 1977
		$1.2 \times 10^{-10}$	$\pm 30$	3299	298	FT	81 Dzelzkalns and Kaufman 1982

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

process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E$ (cm <sup>-1</sup> ) (+ = exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=6) + N <sub>2</sub> O + HF(v=5) + N <sub>2</sub> O <sup>†</sup>	V-V & V-T	$7.4 \times 10^{-11}$		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							
		$1.2 \times 10^{-10}$	$\pm 35$	3143	295	LF	162 Smith and Wrigley 1981
		$1.8 \times 10^{-10}$	$\pm 30$	3143	298	FT	81 Dzelzkalns and Kaufman 1982
HF(v=7) + N <sub>2</sub> O + HF(v=6) + N <sub>2</sub> O <sup>†</sup>	V-V & V-T	$3.1 \times 10^{-10}$	$\pm 30$	2988	298	FT	81 Dzelzkalns and Kaufman 1982
HF + N <sub>2</sub> O, see also N <sub>2</sub> O + HF							
HF(v=1) + NO(v=0) + HF(v=0) + NO(v=1)	V-V & V-T	$1.9 \times 10^{-13}$	$\pm 20$	2083(v=1) 235(v=2)	295	LF	37 Bott and Cohen 1973
		$1.9 \times 10^{-13}$	$\pm 20$	2083(v=1) 235(v=2)	295	LF	92 Green and Hancock 1973
		$3.4 \times 10^{-13}$		2083(v=1)	1060-	ST	20 Blauer...Owens 1972
		$1.5 \times 10^{-12}$		235(v=2)	2680		
HF + NO, see also NO + HF							
HF(v=1) + O + HF(v=0) + O	V-T	$3.1 \times 10^{-12}$	$\pm 20$	3962	295	LF	149 Quigley and Wolga 1974
		$3.1 \times 10^{-12}$	$\pm 20$	3962	295	LF	151 Quigley and Wolga 1975
		$1.1 \times 10^{-11}$		3962	1400-	ST	18 Blauer and Solomon 1973
		$2.5 \times 10^{-12}$			2500		
HF(v=1) + O <sub>2</sub> (v=0) + HF(v=0) + O <sub>2</sub> (v=1)	V-V & V-T	$1.4 \times 10^{-15}$	$\pm 15$	2403(v=1) 871(v=2)	295	LF	37 Bott and Cohen 1973
V-T contribution may be large							
		$1.1 \times 10^{-14}$	$\pm 10$	2403(v=1) 871(v=2)	295	LF	37 Hancock and Green 1973
		$1.4 \times 10^{-15}$	$\pm 10$	2403(v=1)	295-	LF-ST	37 Bott and Cohen 1973
		$1.3 \times 10^{-14}$		871(v=2)	900		
		$4.1 \times 10^{-14}$	$\pm 50$	2403(v=1) 871(v=2)	1400-	ST	19 Blauer...Owens 1972
		$1.7 \times 10^{-13}$			3000		
		$2.0 \times 10^{-14}$		2403(v=1)	1200-	ST	169 Vasil'ev...Papin 1975
		$2.2 \times 10^{-13}$		871(v=2)	3500		
HF(v=2) + O <sub>2</sub> (v=0) + HF(v=1) + O <sub>2</sub> (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 <sub>2</sub> (v=0) + HF(v=2) + O <sub>2</sub> (v=1)	V-V & V-T	$2.3 \times 10^{-14}$	$\pm 15$	2066(v=1)	295	LF	31 Bott 1976
Sequential absorption to HF(v=3)							
		$3.4 \times 10^{-14}$		2066(v=1)	295	FR	147 Poole and Smith 1977
		O <sub>2</sub> ( <sup>1</sup> A <sub>1</sub> ) presumed to be unimportant					
		$1.9 \times 10^{-14}$	$\pm 35$	2066(v=1)	296	LF	163 Smith and Wrigley 1980
Deactivation of laser initiated reaction product							
HF(v=4) + O <sub>2</sub> (v=0) + HF(v=3) + O <sub>2</sub> (v=1)	V-V & V-T	$8.4 \times 10^{-14}$		1902(v=1)	295	FR	147 Poole and Smith 1977
		$1.01 \times 10^{-13}$	$\pm 20$	1902(v=1)	295	LF	162 Smith and Wrigley 1981
Deactivation of laser initiated reaction product							
HF(v=5) + O <sub>2</sub> (v=0) + HF(v=4) + O <sub>2</sub> (v=1)	V-V & V-T	$2.1 \times 10^{-13}$		1741(v=1)	295	FR	147 Poole and Smith 1977
HF(v=6) + O <sub>2</sub> (v=0) + HF(v=5) + O <sub>2</sub> (v=1)	V-V & V-T	$4.7 \times 10^{-13}$		1584(v=1)	295	FR	147 Poole and Smith 1977
		$2.7 \times 10^{-13}$	$\pm 40$	1584(v=1)	295	LF	162 Smith and Wrigley 1981
HF(v=7) + O <sub>2</sub> (v=0) + HF(v=6) + O <sub>2</sub> (v=1)	V-V & V-T	$7.2 \times 10^{-13}$		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 <sub>5</sub> + HF(v=0) + PF <sub>5</sub> <sup>†</sup>	V-V & V-T	$2.3 \times 10^{-13}$	$\pm 15$	3962	295	LF	39 Bott and Cohen 1974
HF(v=1) + SF <sub>6</sub> + HF(v=0) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	$2.8 \times 10^{-15}$	$\pm 85$	3962	295	LF	89 Fried...Taylor 1973
		$< 1.5 \times 10^{-15}$		3962	295	LF	39 Bott and Cohen 1974
HF(v=2) + SF <sub>6</sub> + HF(v=1) + SF <sub>6</sub> <sup>†</sup>	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 <sup>3</sup> /molecule·s)	Error (%)	ΔE(cm <sup>-1</sup> ) (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
HF(v=3) + SF <sub>6</sub> + HF(v=2) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	2.8 × 10 <sup>-14</sup> 1.6 × 10 <sup>-14</sup>	±50 ±50	3622 3622	298 295	FT FR	119 Kwok and Cohen 1974 147 Poole and Smith 1977
HF(v=4) + SF <sub>6</sub> + HF(v=3) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	3.6 × 10 <sup>-14</sup>		3459	295	FR	147 Poole and Smith 1977
HF(v=5) + SF <sub>6</sub> + HF(v=4) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	7.0 × 10 <sup>-14</sup>		3299	295	FR	147 Poole and Smith 1977
HF(v=6) + SF <sub>6</sub> + HF(v=5) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	1.5 × 10 <sup>-13</sup>		3143	295	FR	147 Poole and Smith 1977
HF(v=7) + SF <sub>6</sub> + HF(v=6) + SF <sub>6</sub> <sup>†</sup>	V-V & V-T	3.5 × 10 <sup>-13</sup>		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 <sub>4</sub> + HF(v=0) + SiF <sub>4</sub> <sup>†</sup>	V-V & V-T	≤1.0 × 10 <sup>-14</sup>	±15	3962	295	LF	39 Bott and Cohen 1974
HF(v=1) + SO <sub>2</sub> + HF(v=0) + SO <sub>2</sub> <sup>†</sup>	V-V & V-T	7.4 × 10 <sup>-13</sup>	±15	3962	295	LF	39 Bott and Cohen 1974
HF(v=1) + SO <sub>2</sub> F <sub>2</sub> + HF(v=0) + SO <sub>2</sub> F <sub>2</sub> <sup>†</sup>	V-V & V-T	4.4 × 10 <sup>-13</sup>	±10	3962	295	LF	39 Bott and Cohen 1974
H <sub>2</sub> (v=1) + DBr(v=0) + H <sub>2</sub> (v=0) + DBr(v=1)	V-V & V-T	6.5 × 10 <sup>-15</sup>	±20	2321(v=1) 527(v=2)	296	LF	137,138 Miller and Hancock 1976,1977
Laser Raman excitation of H <sub>2</sub>							
H <sub>2</sub> (v=1) + DCI(v=0) + H <sub>2</sub> (v=0) + DCI(v=1)	V-V & V-T	2.13 × 10 <sup>-14</sup>	±5	2059(v=1) 34(v=2)	296	LF	137,138 Miller and Hancock 1976,1977
H <sub>2</sub> (v=1) + HBr(v=0) + H <sub>2</sub> (v=0) + HBr(v=1)	V-V & V-T	6.9 × 10 <sup>-15</sup>	±10	1604	296	LF	137,138 Miller and Hancock 1976,1977
H <sub>2</sub> (v=1) + HCl(v=0) + H <sub>2</sub> (v=0) + HCl(v=1)	V-V & V-T	5.0 × 10 <sup>-14</sup> 3.9 × 10 <sup>-14</sup> 4.7 × 10 <sup>-14</sup>	±15 ±15 ±15	1274 1274 1274	299 295 296	LF	145 Pirkle and Cool 1976 137,138 Miller and Hancock 1976,1977
		Laser Raman excitation of H <sub>2</sub>					
		3.8 × 10 <sup>-14</sup> 4.6 × 10 <sup>-14</sup>	±30	1274	215- 448	LF	145 Pirkle and Cool 1976
		3.7 × 10 <sup>-13</sup> 1.6 × 10 <sup>-12</sup>	±50	1274	800- 2000	ST	155 Rosen...Taylor 1979
H <sub>2</sub> (v=1) + HF(v=0) + H <sub>2</sub> (v=0) + HF(v=1)	V-V	1.9 × 10 <sup>-12</sup> 1.94 × 10 <sup>-12</sup> 1.95 × 10 <sup>-12</sup> 1.34 × 10 <sup>-12</sup>	±15 ±5 201 ±5	201 201 201 201	294 294 320 295	LF	94 Hancock and Green 1972 95 Hancock and Green 1972 6 Anlauf...Herman 1973 37 Bott and Cohen 1973
		May contain a small V-T contribution					
		1.9 × 10 <sup>-12</sup> 1.3 × 10 <sup>-12</sup>	±25	201	295	LF	100 Hinchen 1973
		1.5 × 10 <sup>-12</sup>	±5	201	295	LF	142 Osgood, private communication in Ref. 37
		1.2 × 10 <sup>-12</sup> 1.32 × 10 <sup>-12</sup>	±10 ±10	201	295	LF	31 Bott 1976
		9.27 × 10 <sup>-13</sup>	±10	201	200	LF	44 Bott and Heidner 1980
		1.3 × 10 <sup>-12</sup> 1.6 × 10 <sup>-12</sup>	±5	201	450- 1100	LF-ST	37 Bott and Cohen 1973
H <sub>2</sub> (v=1) + HF(v=1) + H <sub>2</sub> (v=0) + HF(v=2)	V-V	7.8 × 10 <sup>-12</sup> 2.2 × 10 <sup>-12</sup>		367 367	320 295	FT LF	6 Anlauf...Herman 1973 31 Bott 1976
H <sub>2</sub> (v=1) + HF(v=0) + H <sub>2</sub> (v=0) + HF(v=0)	V-T	<5.1 × 10 <sup>-14</sup> 9.0 × 10 <sup>-13</sup> 1.2 × 10 <sup>-14</sup> 3.5 × 10 <sup>-14</sup>	±30 ±65 ±30 ±50	4160 4160 4160 4160	295 295 295 295	LF	37 Bott and Cohen 1973 100 Hinchen 1973 44 Bott and Heidner 1980 27 Bott 1974
		Value given is k <sub>HF-H<sub>2</sub></sub> : 0.376 k <sub>H<sub>2</sub>-HF</sub>					

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

Process	Type	Rate Constant (cm <sup>3</sup> /molecule·s)	Error (%)	$\Delta E(\text{cm}^{-1})$ (+exo)	Temp (K)	Method	Reference Number, Author or First and Last Author, Year of Publication
H <sub>2</sub> (v=1) + HF(v=0) + H <sub>2</sub> (v=0) + HF(v=0) (cont'd.)		3.1 × 10 <sup>-14</sup> 3.1 × 10 <sup>-14</sup>	±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 <sup>-13</sup> 3.9 × 10 <sup>-13</sup>	±10	2230	1400- 2000	ST	22 Borrell...Gutteridge 1975
HI(v=1) + CO <sub>2</sub> (000) + HI(v=0) + CO <sub>2</sub> (nm0)	V-T	<4.1 × 10 <sup>-14</sup>		2230	295	LF	167 Stephenson...Moore 1972
HF(v=2) + HF(v=0) + HI(v=0) + HF(v=1)	V-V	6.0 × 10 <sup>-13</sup>	±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 <sup>-13</sup>		418	350	LP	1 Ahl and Cool 1973
HI(v=1) + HF(v=1) + HI(v=?) + HI(v=0)	V-V	3.2 × 10 <sup>-13</sup>	±20	81	300	LF	1 Ahl and Cool 1973
		1.2 × 10 <sup>-12</sup>	±30	81	350	LF	1 Ahl and Cool 1973
HI(v=1) + HI(v=0) + HI(v=0) + HI(v=0)	V-T	~1.2 × 10 <sup>-14</sup>	±15	2230	295	LF	64 Chen...Moore 1968
		8.3 × 10 <sup>-14</sup> 9.4 × 10 <sup>-13</sup>	±20	2230	800- 1800	ST	116 Kiefer...Bird 1969
		~1 × 10 <sup>-13</sup>		2230	1400- 2300	ST	66 Chow...Greene 1965
		Some data for v = 2,3 also					
HI + N <sub>2</sub> , see N <sub>2</sub> + HI							
NaF(v) + HF(v=0) + NaF(v-n) + HF(v')	V-V	~1.4 × 10 <sup>-10</sup>				CB	82 Engelke 1979
		Crossed beam fluorescence, results also for MgF(v)					
N <sub>2</sub> (v=1) + DCI(v=0) + N <sub>2</sub> (v=0) + DCI(v=1)	V-V	5.2 × 10 <sup>-14</sup>	±15	240	295	LF	177 Zittel and Moore 1973
		V-T contribution is less than 1%					
N <sub>2</sub> (v=1) + DI(v=0) + N <sub>2</sub> (v=0) + DI(v=1)	V-V	1.6 × 10 <sup>-14</sup> 3.9 × 10 <sup>-14</sup>	±10	730	1200- 2000	ST	50 Dreshears and Bird 1971
N <sub>2</sub> (v=1) + HBr(v=0) + N <sub>2</sub> (v=0) + HBr(v=0)	V-T	<1.1 × 10 <sup>-15</sup>		2330	296	LF	61 Chen 1971
N <sub>2</sub> (v=1) + HI(v=0) + N <sub>2</sub> (v=0) + HI(v=1)	V-V	1.7 × 10 <sup>-13</sup> 1.8 × 10 <sup>-13</sup>	±15	100	1000- 2700	ST	50 Dreshears and Bird 1971
N <sub>2</sub> O(001) + HCl(v=0) + N <sub>2</sub> O(nm0) + HCl(v=0)	V-T	3.9 × 10 <sup>-13</sup> 6.4 × 10 <sup>-13</sup>		2224	300- 700	LF	80 Doyennette...Henry 1978
N <sub>2</sub> O(001) + HF(v=0) + N <sub>2</sub> O(nm0) + HF(v=0)	V-T	2.2 × 10 <sup>-12</sup>	±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 <sup>-14</sup>	±35	1876	295	LF	37 Bott and Cohen 1973
OCS(001) + HBr(v=0) + OCS(nm0) + HBr(v=0)	V-T	1.0 × 10 <sup>-13</sup>	±10	2062	296	LF	103 Hopkins and Chen 1973
O <sub>3</sub> (001) + HCl(v=0) + O <sub>3</sub> (nm0) + HCl(v=0)	V-T	1.6 × 10 <sup>-12</sup> 1.2 × 10 <sup>-12</sup>	±30	1740	173- 419	PT	90 Gordon...Moy 1978
TF(v=1) + CO <sub>2</sub> (000) + TF(v=0) + CO <sub>2</sub> (001)		≤5.2 × 10 <sup>-11</sup>		95			139 Nikitin and Oraevskii 1976

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