Rate Coefficients for Ion-Molecule Reactions. I. Ions Containing C and H

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A compilation is presented of experimentally determined bimolecular and third order rate coefficients for the reactions of hydrocarbon ions with neutral molecules in the vapor phase. The literature covered is from 1960 to the present, and both positive and negative ions are considered. Four hundred and fifty-eight separate reaction-pairs are tabulated, and the ionic reaction products and experimental conditions are specified wherever possible. Preferred values are suggested for a number of these processes.

Key words: Chemical kinetics; data evaluation; gas phase; hydrocarbons; ion-molecule reactions; mass spectrometry; rate coefficients.

1. Introduction

During the past decade, the detailed investigation of the dynamics, rates, and mechanisms associated with the interactions of ions with molecules in the vapor phase has been characterized by an almost exponential growth. The current widespread interest in these processes can be attributed to their recognized role in the upper atmosphere, combustion systems, in materials exposed to high energy radiation, and their application in organic and inorganic trace analysis, especially in the area of air and water pollution. Recent reviews of kinetic data [1,2][1] have been restricted to those reactions relevant to the chemical physics of planetary atmospheres, which involves principally the interactions of atomic, diatomic, and triatomic inorganic ions. Although the literature concerned with specific aspects of the instrumentation, thermochemistry, kinematics, rates, and mechanisms associated with vapor phase processes involving complex ions, particularly those of organic origin, is quite extensive [3–6], the available bibliographies incorporating rate data [7, 8] are more than five years out of date as of this writing and no critical review has ever been attempted. Furthermore, the overall quality of the data cited therein necessarily reflects the instrumental state-of-the-art characteristic of the late 1960's, which has vastly improved recently both in the variety of techniques and the overall accuracy and precision with which rate parameters have been measured.

Our goal in preparing these articles is two-fold. First, we wish to provide a comprehensive, up-to-date compilation of those bimolecular and third-order ion-molecule reactions and the associated rate constants (coefficients) recorded under reasonable well-specified experimental conditions at ion kinetic energies ≤ 0.5 eV. We have restricted our entries to those data expressed in units of cm^3 $molecule^{-1}$ s^{-1} or cm^6 $molecule^{-2}$ s, which encompass more than 95% of the recent measurements carried out at thermal or nearly thermal energies. Second, since rate coefficients for many reactions have now been determined under a variety of experimental conditions, it is possible, in many cases, to subject the combined literature to critical evaluation and to suggest a preferred value. We feel that this objective is of prime importance since many investigators use reference reactions for instrumental calibration purposes. Unfortunately, depending upon the particular laboratory, different values have been assumed in many cases for the same calibration reaction, and in several instances the value chosen by a given laboratory has changed with time. One would hope that the assignment of a preferred value with appropriate error limits would provide a common reference base for use by the various research groups.

This compilation and evaluation deals with the reactions of ions containing carbon and hydrogen only (including C^+ and C_2^+). The following journals were searched for entries from 1960 to the cut-off date, approximately 1 September, 1975.

- Journal of Chemical Physics
- Journal of Physical Chemistry
- Journal of the American Chemical Society
- Journal of Research of the National Bureau of Standards
- The International Journal of Mass Spectrometry and Ion Physics
- International Journal of Chemical Kinetics
- Canadian Journal of Chemistry
- Chemical Physics Letters
- Transactions of the Faraday Society

Other pertinent entries were found by scanning Current Contents, Advances in Mass Spectrometry, and the published proceedings of various symposia and meetings dealing with this subject. Unpublished results are not included.

[1] Figures in brackets indicate literature references at the end of this paper.

1.1. Evaluation of Data

With respect to error limits and the reliability of data, it is often difficult to make an objective judgment concerning the validity of a particular rate coefficient. However, it is our feeling that greater than 98 percent of the tabulated values are most certainly correct to within a factor of two of the true value at the stated temperature and/or kinetic energy. Difficulties often arise in assigning more stringent limits. For example, one of the perplexing aspects of the chemistry associated with complex ions is the fact that the reactivity of these species may depend critically upon the internal energy content of the reactant ion. Whenever specific reactions have been shown to exhibit such effects it is so stated in the compilation. Secondly, many of the older values reflect the reactivities of ions which were translationally excited due to the presence of electric fields within the reaction zone. Although this condition would not necessarily affect the total reactivity of any given ion, it is well established that resultant product distributions are often seriously affected. Moreover, in many cases the original authors did not properly state their experimental conditions, particularly with respect to the temperature of the bulk gas. Even when the temperature was stated it is unlikely that the neutral flow component had achieved equilibrium, especially in measurements carried out at reduced pressures. Taken together, these complications, as well as others discussed elsewhere [9, 10], introduce a large and often undefinable uncertainty in a number of the tabulated values.

When the accuracy limits given by the original authors seem appropriate within the framework of the possible sources of error, the original error limits are cited. Otherwise, either a reasonable estimate is applied or limits are simply not stated. In general, the most recent values tend to be the most accurate for any given reaction-pair.

2. Reaction Rate Tables

Two tables are presented, table 1 covering positive ion reactions and table 2, negative ion reactions. The entries in the various columns are described as follows:

2.1. Reaction

The reactions are listed sequentially according to the molecular weight (atomic number) of the reactant ion except in those cases where certain ions should be grouped together, as when deuterium is substituted for hydrogen, for example. In order to conserve space, the following abbreviations are used to define the structures of ionic and neutral reactants in those cases when more than one isomer may exist; n = normal, i = iso, t = tertiary, c = cyclo, tr = trans, o = ortho, p = para, and m = meta.

More than one product ion is obtained for many of the reactions which are cited. In some cases the ionic product distributions (branching ratios) are given as the percentage contribution of each product to the total secondary ion spectrum. However, for most reactions the branching ratios critically depend on the temperature and pressure. In these cases, the various product ions observed in a given determination are simply listed. Neutral products are not specified.

2.2. Rate Coefficient (*k*)

Rate coefficients are given in units of cm^3 $molecule^{-1}$ s^{-1} for bimolecular reactions and cm^6 $molecule^{-2}$ s^{-1} for third order processes. Unless otherwise stated, the error limits given are those imposed by the original authors (see Introduction for discussion). The most recent experimental determination is listed first, the others following in reverse chronological order. Preferred values and the associated uncertainties are indicated by an asterisk.

2.3. Temperature (*T*)

When the system temperature was specified, then that value is given in kelvins. All ion cyclotron resonance measurements may be assumed to have been carried out at ambient laboratory temperatures (295 ± 5 K).

2.4. Method

The nomenclature used to described the various measurement techniques is similar to that used by Ferguson [1].

Method	See below for short description
DT	Drift Tube
FA	Flowing Afterglow
ICR	Ion Cyclotron Resonance
MS	Mass Spectrometer Ion Source
B	Beam Apparatus
TI	Ion Trap
R	Radiolysis

a. Drift Tube (DT)

This is a relatively new technique which yields rate coefficients from thermal to several electron volts kinetic energy. It has been mainly applied to the reactions of inorganic ions of aeronomic interest.

b. Flowing Afterflow (FA)

This versatile method, which utilizes a buffer gas at relatively high pressures, assures that the reactant ions are essentially always in thermodynamic equilibrium prior to reaction. The gas temperature is variable over a considerable range (up to 900 K). FA has been especially useful for the determination of equilibrium constants and other thermodynamic quantities pertinent to ionic association and particle transfer reactions.

c. Ion Cyclotron Resonance (ICR)

Ion Cyclotron Resonance mass spectrometry is a low pressure technique (10^{-7} to 10^{-3} N m^{-2}) in which the reaction time is usually the variable experimental parameter. Most of the rate data have been obtained at nearly thermal kinetic energies and at ambient room temperature.

d. Mass Spectrometer Ion Source (MS)

This is a catch-all category used to denote measurements involving a single reaction chamber associated with a mass analysis system. The application of this popular technique varies considerably from laboratory to laboratory. Some groups work in the pressure range 10^{-3} to 10^{-1} N m^{-2}, with or without pulsed chambers, while others have extended the pressure range up to nearly one atmosphere. Both photoionization and electron impact have been utilized to produce reactant ions. Many of the earlier low pressure studies involved the application of a electric field across the reaction zone for the purposes of ion extraction. In these cases the reactant ions were continuously accelerated, giving an epithermal kinetic energy distribution.

e. Beam (B)

Beam experiments involve the generation of a mass and energy selected ion beam which is impacted on a neutral target in a collision chamber coupled with a second mass analyzer. The kinetic energy may be varied from nearly thermal values up to tens of kilovolts.

f. Ion Trap (TI)

This relatively new technique usually involves the trapping of ions for a variable period of time in the negative space charge of a continuous low energy electron beam. The reactant ions may have kinetic energies in excess of thermal values, in some cases up to several tenths of an electron volt.

g. Radiolysis (R)

Normally experiments carried out at pressures greater than 100 N m^{-2}, and at ambient room temperature. Rate coefficients are derived from product distributions obtained from end-product analysis.

In many cases characterization of an experiment as being of the Beam type, Mass Spectrometer ion source type, etc., is not sufficient for defining the exact measurement technique. To provide more information we have also included a reference under Methods which best describes the original instrument. The reader should always refer to the specific literature citation associated with the quoted rate coefficient for details of the variation used to generate any particular value.

h. Comments

This column is used to provide descriptive information pertinent to the measurement such as "k varies with temperature, 0.3 eV ions," etc. When the quoted value of k for any particular reaction was determined relative to an assumed value for a calibration reaction, then the assumed value for the calibration reaction is given. For ions containing three or more C atoms, one or more structural isomers may be present in any given experiment. In those cases where the identity of the reactant ions is not uniquely defined by the particular preparation technique, we have listed the neutral from which the ion is derived. Comments pertinent to our choice of a preferred value are also given in this column. Preferred values are suggested only for the reactivity of low kinetic energy ions (thermal or nearly thermal). Although coefficients obtained at high kinetic energies are included for completeness, these values were not considered in our determination.

Table 1. Rate coefficients for reactions of hydrocarbon cations

Reaction	T	k	Method	Comments	Ref.
$C^+ + CH_4 \rightarrow$	373	1.43×10^{-9}	MS, 11	Assumes $k(CH_4^+ + CH_4) = 1.20 \times 10^{-9}$	12
		8.1×10^{-10}	MS, 13		13
		$\sim 1.5 \times 10^{-9}$	TI, 14		14
		$1.0 \pm 0.2 \times 10^{-9}$	FA, 15		15
$C^+ + n\text{-}C_4H_{10} \rightarrow$		$1.0 \pm 0.2 \times 10^{-9}$	FA, 15		15
$C^+ + CH_3Cl \rightarrow$	373	2.1×10^{-9}	MS, 16	0.21 eV ion exit energy	17
	373	2.7×10^{-9}	MS, 16	0.46 eV ion exit energy	17
	373	3.1×10^{-9}	MS, 16	0.65 eV ion exit energy	17
	373	3.0×10^{-9}	MS, 16	1.1 eV ion exit energy	17
$C^+ + CH_3F \rightarrow$	373	1.77×10^{-9}	MS, 16	0.24 eV ion exit energy	17
	373	2.95×10^{-9}	MS, 16	0.65 eV ion exit energy	17
$C^+ + CH_3NH_2 \rightarrow$	373	3.8×10^{-9}	MS, 16	3.4 eV ion exit energy	18
$C^+ + CH_2O \rightarrow CH_2^+$		8.2×10^{-10}	ICR, 19	Assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	19
$C^+ + CO_2 \rightarrow$	300	$1.9 \pm 0.6 \times 10^{-9}$	FA, 20		21
	300	$1.46 \pm 0.15 \times 10^{-9}$	MS, 22		23
$C^+ + CO_2 \rightarrow CO^+$		1.6×10^{-9}	MS, 22	RF discharge in CO_2	24
$C^+ + H_2O \rightarrow COH^+$	300	$2.0 \pm 0.6 \times 10^{-9}$	FA, 25		25
$C^+ + O_2 \rightarrow$		$9.0 \pm 2.7 \times 10^{-10}$	MS, 26		27
	300	$1.1 \pm 0.3 \times 10^{-9}$	FA, 20		21
$C^+ + SiH_4 \rightarrow Si^+, SiH^+, SiH_2^+, SiH_3^+, SiCH^+, SiCH_2^+$	340	$4.36 \pm 0.9 \times 10^{-9}$	MS,B,28,29	2.1 eV ion exit energy, 6.25 V cm^{-1}	30
$C^+ + SF_6 \rightarrow SF_5^+$	300	1.3×10^{-9}	FA, 20		31
$C^+ + Xe \rightarrow$		$< 5 \times 10^{-13}$	FA, 15		15
$CH^+ + CH_4 \rightarrow$	373	1.64×10^{-9}	MS, 11		12
		$1.29 \pm 0.06 \times 10^{-9}$	ICR, 32		33
		$1.7 \pm 0.1 \times 10^{-9}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.20 \times 10^{-9}$	14
$CD^+ + CD_4 \rightarrow$		1.21×10^{-9}	MS, 13		13
$CH^+ + C_2H_2 \rightarrow C_2H_3^+$		8×10^{-10}	B, 34		34
$CH^+ + C_2H_6 \rightarrow$		$2.6 \pm 0.5 \times 10^{-9}$	MS, 26		35
$CH^+ + CH_3Cl \rightarrow$	373	1.8×10^{-9}	MS, 16	0.21 eV ion exit energy	17
	373	2.2×10^{-9}	MS, 16	0.46 eV ion exit energy	17
	373	2.4×10^{-9}	MS, 16	0.65 eV ion exit energy	17
	373	2.1×10^{-9}	MS, 16	1.1 eV ion exit energy	17
$CH^+ + CH_3F \rightarrow$	373	1.72×10^{-9}	MS, 16	0.24 eV ion exit energy	17
	373	2.71×10^{-9}	MS, 16	0.65 eV ion exit energy	17
$CH^+ + CH_3NH_2 \rightarrow$	373	3.0×10^{-9}	MS, 16	3.4 eV ion exit energy	18
$CH^+ + CH_2O \rightarrow CH_3^+$		3.2×10^{-10}	ICR, 19	Assumes $k(CH_4^+ + CH_4) = 1.20 \times 10^{-9}$	19
$CH^+ + H_2 \rightarrow CH_2^+$	295	$1.01 \pm 0.4 \times 10^{-9}$	ICR, 32		36
$CH^+ + H_2S \rightarrow CHS^+$		$6.6 \pm 0.6 \times 10^{-10}$	ICR, 32	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	37
$CH^+ + SiH_4 \rightarrow Si^+, SiH^+, SiH_2^+, SiH_3^+, SiCH_2^+, SiCH_3^+$		$4.56 \pm 0.86 \times 10^{-9}$	MS,B,28,29	2.1 eV ion exit energy	30
$CH^+ + SiH_4 \rightarrow SiCH_2^+$		$1.56 \pm 0.4 \times 10^{-10}$	ICR, 38		38
$CH_2^+ + CH_4 \rightarrow$	323	$1.21 \pm 0.12 \times 10^{-9}$	MS, 39	15 V cm^{-1}	39
		$1.20 \pm 0.06 \times 10^{-9}$	ICR, 32		33
	373	1.33×10^{-9}	MS, 11	Thermal ions	12
	373	1.55×10^{-9}	MS, 11	20 eV ions	12
		$1.53 \pm 0.1 \times 10^{-9}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.20 \times 10^{-9}$	14
		$1.31 \pm 0.13 \times 10^{-9}$(*)	Preferred Value	Error is one standard deviation	
$CD_2^+ + CD_4 \rightarrow$		1.3×10^{-9}	MS, 13		13
$CH_2^+ + C_2H_6 \rightarrow$		$2.6 \pm 0.7 \times 10^{-9}$	MS, 26		35
$CH_2^+ + CH_3Cl \rightarrow$	373	1.3×10^{-9}	MS, 16	0.21 eV ion exit energy	17
	373	1.4×10^{-9}	MS, 16	0.46 eV ion exit energy	17
	373	1.6×10^{-9}	MS, 16	0.65 eV ion exit energy	17
	373	9.7×10^{-10}	MS, 16	1.1 eV ion exit energy	17
$CH_2^+ + CH_3F \rightarrow$	373	1.21×10^{-9}	MS, 16	0.24 eV ion exit energy	17
	373	1.74×10^{-9}	MS, 16	0.65 eV ion exit energy	17
$CH_2^+ + CH_3NH_2 \rightarrow$	373	3.6×10^{-9}	MS, 16	3.4 eV ion exit energy	18

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$CH_2^+ + CH_3CN \rightarrow$	300	1.76×10^{-9}	MS, 22	Pressure varied	22
	300	3.4×10^{-9}	MS, 22	Time varied	22
$CD_2^+ + CD_3CN \rightarrow$	300	1.76×10^{-9}	MS, 22	Pressure varied	22
$CH_2^+ + C_2H_5CN \rightarrow$	300	3.12×10^{-9}	MS, 22	Pressure varied	22
$CH_2^+ + CH_2O \rightarrow CH_3^+$		6.4×10^{-10}	ICR, 19	Assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	19
$CH_2^+ + CH_3SH \rightarrow$	500	$3.4 \pm 0.51 \times 10^{-9}$	MS, 40	10 V cm^{-1}	41
$CH_2^+ + CH_3SOCH_3 \rightarrow$	408	$4.4 \pm 0.4 \times 10^{-9}$	MS, 11	0.71 eV ion exit energy	42
	408	4.0×10^{-9}	MS, 11	1.07 eV ion exit energy	42
$CH_2^+ + H_2 \rightarrow CH_3^+$	295	$7.2 \pm 0.4 \times 10^{-10}$	ICR, 32		36
$CH_2^+ + D_2 \rightarrow CHD^+, CD_2^+$	83	3.1×10^{-10}	MS, 43	Varies with T	44
$CH_2^+ + NH_3 \rightarrow CH_2NH_2^+$		$2.0 \pm 0.8 \times 10^{-9}$	MS, 26		15
$CH_2^+ + {}^{15}NH_3 \rightarrow$		$1.51 \pm 0.29 \times 10^{-9}$	ICR, 32		37
$CH_2^+ + NH_3 \rightarrow CH_2NH_2^+$		1.2×10^{-9}	ICR, 38		46
$CH_2^+ + H_2O \rightarrow CH_2OH^+$		$5.2 \pm 0.9 \times 10^{-10}$	ICR, 32	Assumes $k(CH_4^+ + CH_4) = 1.10 \times 10^{-9}$	37
		5.2×10^{-10}	ICR, 38		46
$CH_2^+ + H_2S \rightarrow CH_2SH^+, CHS^+$		$5.9 \pm 1.2 \times 10^{-10}$	ICR, 32	Assumes $k(CH_4^+ + CH_4) = 1.10 \times 10^{-9}$	37
		6.0×10^{-10}	ICR, 38		46
$CH_2^+ + SiH_4 \rightarrow Si^+, SiH^+, SiH_2^+, SiH_3^+, SiCH_2^+, SiCH_3^+$		$3.49 \pm 0.89 \times 10^{-9}$	MS,B,28,29		30
$CH_2^+ + SiH_4 \rightarrow SiCH_3^+$		$2.91 \pm 0.53 \times 10^{-10}$	ICR, 38		38
$CH_3^+ + CF_4 \rightarrow$	323	$5.45 \pm 0.55 \times 10^{-10}$	MS, 39	15 V cm^{-1}	39
$CH_3^+ + CH_4 \rightarrow C_2H_5^+$	323	$8.6 \pm 0.9 \times 10^{-10}$	MS, 39	15 V cm^{-1}	39
	300	$9.5 \pm 1.5 \times 10^{-10}$	TI, 47	Kinetic energy ≤ 1 eV	47
		$9.6 \pm 0.4 \times 10^{-10}$	ICR, 32		33
	340	$1.31 \pm 0.04 \times 10^{-9}$	TI, 48		49
		$9.0 \pm 0.08 \times 10^{-10}$	ICR, 32	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	37
		$8.9 \pm 0.3 \times 10^{-10}$	ICR, 32	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	32
		$1.2 \pm 0.1 \times 10^{-9}$	ICR, 50	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	50
		$1.15 \pm 0.05 \times 10^{-9}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	14
		$1.0 \pm 0.1 \times 10^{-9}$	ICR, 51		51
	298	$9.-10. \times 10^{-10}$	MS, 52		53
		$1.3 \pm 0.1 \times 10^{-9}$	MS, 54		54
	310	8.6×10^{-10}	MS, 16		55
	300	7.0×10^{-10}	MS, 22		22
		8.2×10^{-10}	MS, 26		35
		9.67×10^{-10}	MS, 26		56
		$9.87 \pm 1.80 \times 10^{-10}$(*)		Least squares, all values	
$CD_3^+ + CD_4 \rightarrow C_2D_5^+$		$1.08 \pm 0.03 \times 10^{-9}$	TI, 14		57
		1.2×10^{-9}	ICR, 58		59
		$7.6 \pm 0.5 \times 10^{10}$	ICR, 32		32
		9.3×10^{-10}	MS, 13		13
		6.1×10^{-10}	MS, 16		55
		$9.16 \pm 2.37 \times 10^{-10}$(*)		Mean of all	
$CH_3^+ + C_2H_2 \rightarrow C_3H_3^+$	310	2.12×10^{-9}	MS, 16	3.7 eV ion exit energy; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	60
	310	1.54×10^{-9}	MS, 16	1.7 eV ion exit energy	60
$CH_3^+ + C_2H_6 \rightarrow$		$1.7 \pm 0.3 \times 10^{-9}$	MS, 26		35
$CD_3^+ + CH_3Br \rightarrow CH_3^+, CD_3^+, CH_2Br^+, CD_2Br^+$		$3.9 \pm 0.42 \times 10^{-9}$	ICR, 38		61
$CH_3^+ + CH_3Cl \rightarrow$		9.7×10^{-10}	MS, 16	0.21 eV ion exit energy	17
		4.2×10^{-10}	MS, 16	0.46 eV ion exit energy	17
		4.0×10^{-10}	MS, 16	0.65 eV ion exit energy	17
		8.6×10^{-10}	MS, 16	0.45 eV ion exit energy	17
$CD_3^+ + CH_3Cl \rightarrow CH_3^+, CD_3^+, CH_2Br^+, CD_2Br^+$		$2.62 \pm 0.22 \times 10^{-9}$	ICR, 38		61
$CH_3^+ + CH_3F \rightarrow CH_2F^+$		1.02×10^{-9}	ICR, 62		63
$CD_3^+ + CH_3F \rightarrow CH_3^+, CD_3^+, CH_2F^+, CD_2F^+$		$1.86 \pm 0.24 \times 10^{-9}$	ICR, 38		61
$CH_3^+ + CH_2F_2 \rightarrow CH_2F^+$		6.4×10^{-10}	ICR, 62		63
$CH_3^+ + CHF_3 \rightarrow$		7.6×10^{-10}	ICR, 62		63
$CD_3^+ + CH_3I \rightarrow CH_3^+, CD_3^+, CH_2I^+, CD_2I^+$		$2.2 \pm 1.0 \times 10^{-10}$	ICR, 38		61
$CH_3^+ + CH_3NH_2 \rightarrow$		1.2×10^{-9}	MS, 26		64
$CH_3^+ + CH_3CN \rightarrow$		$1.63 \pm 0.05 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$CH_3^+ + (CH_3)_2NH \rightarrow$		9×10^{-10}	MS, 26		64
$CH_3^+ + C_2H_5CN \rightarrow$	300	2.2×10^{-9}	MS, 22	Pressure varied	22
	300	2.9×10^{-9}	MS, 22	Time varied	22
$CD_3^+ + C_2D_5CN \rightarrow$	300	2.4×10^{-9}	MS, 22	Pressure varied	22
	300	2.3×10^{-9}	MS, 22	Time varied	22
$CH_3^+ + (CH_3)_3N \rightarrow$	300	6.3×10^{-10}	MS, 26		64
$CH_3^+ + CH_3OH \rightarrow$	373	$1.40 \pm 0.2 \times 10^{-9}$	MS, 16	3.4 eV ion exit energy	16
$CH_3^+ + CH_3CHO \rightarrow$		$2.49 \pm 0.05 \times 10^{-9}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	66
$CH_3^+ + CD_3CDO \rightarrow$		$3.10 \pm 0.3 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_3^+ + c\text{-}CD_2CD_2O \rightarrow$		$1.68 \pm 0.13 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_3^+ + CH_3OCH_3 \rightarrow$		$2.0 \pm 0.3 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	66
$CH_3^+ + CD_3OCD_3 \rightarrow$		$2.58 \pm 0.31 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_3^+ + CH_3COCH_3 \rightarrow CH_3CO^+(46\%), CH_3COCH_3^+ (10\%), (CH_3COCH_3)H^+(10\%)$	473	$2.0 \pm 0.1 \times 10^{-9}$	ICR, 51	Remaining 34% of reaction products are unspecified	67
		2.4×10^{-9}	MS, 67		67
$CH_3^+ + CH_3SH \rightarrow$	520	$3.6 \pm 0.54 \times 10^{-9}$	MS, 40	10 V cm^{-1}	41
$CH_3^+ + (CH_3)_2S \rightarrow C_2H_6S^+$	520	$2.0 \pm 0.3 \times 10^{-9}$	MS, 40	10 V cm^{-1}	41
$CH_3^+ + CH_3SOCH_3 \rightarrow$	408	$4.8 \pm 0.5 \times 10^{-9}$	MS, 11	0.71 eV ion exit energy	42
	408	$4.6 \pm 0.5 \times 10^{-9}$	MS, 11	1.07 eV ion exit energy	42
$CH_3^+ + COS \rightarrow CH_3S^+(78\%), CH_2S^+(11\%), CHS^+(11\%)$	300	6.45×10^{-10}	MS, 53		68
$CH_3^+ + CS_2 \rightarrow CH_3S^+, CH_3CS^+$		$<10^{-10}$	ICR, 69		69
$CH_3^+ + H_2 \rightarrow CH_4^+$	295	5×10^{-13}	ICR, 32		36
$CH_3^+ + D_2 \rightarrow CH_2D^+, CHD_2^+$	83	1.7×10^{-10}	MS, 43		44
	373	$6.1 \pm 0.1 \times 10^{-10}$	MS, 16		70
$CD_3^+ + H_2 \rightarrow CD_2H^+, CDH_2^+$	295	$5.1 \pm 0.5 \times 10^{-10}$	ICR, 32		36
$CH_3^+ + NH_3 \rightarrow CH_2NH_2^+$		6.6×10^{-10}	ICR, 38		46
$CH_3^+ + NH_3 \rightarrow NH_4^+(20\%), CH_2NH_2^+(80\%)$		$8.3 \pm 0.8 \times 10^{-10}$	ICR, 32		37
$CH_3^+ + NH_3 \rightarrow$		$2.0 \pm 0.5 \times 10^{-9}$	ICR, 50	Assumes $k(CH_3^+ + CH_4) = 1.1 \times 10^{-9}$	50
$CH_3^+ + NH_3 \rightarrow NH_4^+, CH_2NH_2^+$		$1.3 \pm 0.2 \times 10^{-9}$	MS, 26		45
		$8.3 \pm 1.0 \times 10^{-10}$(*)		Correcting data of ref. 46 for NH_4^+ production gives same value as ref. 37.	
$CH_3^+ + H_2O \rightarrow CH_2OH^+$		$<1 \times 10^{-11}$	ICR, 32	k refers to specified channel only	37
$CH_3^+ + D_2O \rightarrow$		$4.2 \pm 0.9 \times 10^{-10}$	MS, 71		72
$CH_3^+ + PH_3 \rightarrow PCH_2^+(63\%), PCH_4^+(37\%)$	300	$1.11 \pm 0.1 \times 10^{-9}$	ICR, 73		73
$CH_3^+ + H_2S \rightarrow CH_2SH^+$		$5.0 \pm 0.3 \times 10^{-10}$	ICR, 32		37
$CH_3^+ + SiH_4 \rightarrow SiH_3^+, SiCH_3^+, SiCH_5^+$	343	$2.39 \pm 0.73 \times 10^{-9}$	MS,B,28,29	2.1 eV exit energy, 6.25 V cm^{-1}	30
$\rightarrow SiH_3^+$		$1.11 \pm 0.18 \times 10^{-9}$	ICR, 38		38
$CH_3^+ + NO \rightarrow NO^+$		$1.1 \pm 0.1 \times 10^{-9}$	B, 74	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	75
$CH_3^+ + N_2O \rightarrow$	340	$5.3 \pm 0.1 \times 10^{-10}$	TI, 48	Electron energy = 20 eV	49
	340	$5.0 \pm 0.2 \times 10^{-10}$	TI, 48	Electron energy = 18 eV	49
	340	$4.3 \pm 0.2 \times 10^{-10}$	TI, 48	Electron energy = 16 eV	49
	340	$3.4 \pm 0.2 \times 10^{-10}$	TI, 48	Electron energy = 15 eV	49
	340	No reaction	TI, 48	Electron energy = 14 eV	49
$CH_4^+ + CH_4 \rightarrow CH_5^+$	323	$1.01 \pm 0.10 \times 10^{-9}$	MS, 39	10 V cm^{-1}	39
		$1.05 \pm 0.15 \times 10^{-9}$	TI, 47	K.E. less than 1 eV	47
	300	$1.14 \pm 0.03 \times 10^{-9}$	ICR, 32		33
		$1.22 \pm 0.02 \times 10^{-9}$	TI, 48		49
		1.10×10^{-9}	ICR, 50		37
	296	$11.8 \pm 0.8 \times 10^{-10}$	ICR, 76		76
		$1.11 \pm 0.04 \times 10^{-9}$	ICR, 32		32
		$1.22 \pm 0.02 \times 10^{-9}$	TI, 48		48
	455	$1.0 \pm 0.04 \times 10^{-9}$	MS, 77		77
		$1.1 \pm 0.4 \times 10^{-9}$	TI, 78		78
	373	1.0×10^{-9}	ICR, 51		58
		1.05×10^{-9}	MS, 79		79
		$1.2 \pm 0.1 \times 10^{-9}$	ICR, 80		80

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$CH_4^+ + CH_4 \rightarrow CH_5^+$		1.23×10^{-9}	MS, 16		81
		$1.2 \pm 0.1 \times 10^{-9}$	ICR, 51		51
	300	$1.1 \pm 0.1 \times 10^{-9}$	ICR, 73		73
		1.39×10^{-9}	MS, 82		83
		$0.95(1.15) \times 10^{-9}$	ICR, 84	Upward revision to 1.15×10^{-9} mentioned in ref. 10.	84
		3.1×10^{-10}	ICR, 85		86
		$1.2 \pm 0.1 \times 10^{-9}$	MS, 54		54
	298	$1.0 \pm 0.1 \times 10^{-9}$	MS, 53		53
	520	$1.12 \pm 0.04 \times 10^{-9}$	MS, 40	10 V cm^{-1}	40
		$1.25 \pm 0.02 \times 10^{-9}$	MS, 87	0.7-1.5 eV ions, k invariant	87
	310	1.20×10^{-9}	MS, 16		60
		1.13×10^{-9}	MS, 88		89
	373	1.22×10^{-9}	MS, 16		16
	300	1.25×10^{-9}	MS, 22		22
	450	8.8×10^{-10}	MS, 88	9.1 V cm^{-1}, 0.9 eV exit energy	90
		1.07×10^{-9}	MS, 91		92
		1.11×10^{-9}	MS, 93		93
		1.26×10^{-9}	MS, 93		94
		1.03×10^{-9}	MS, 26		35
	450	1.07×10^{-9}	MS, 95	0.86 V/cm^{-1}	96
		1.16×10^{-9}	MS, 97		97
		8.93×10^{-10}	MS, 26		56
		$1.13 \pm 0.08 \times 10^{-9}$		Mean of all values	
		$1.15 \pm 0.04 \times 10^{-9}$		Mean of all ICR values	
		$1.11 \pm 0.04 \times 10^{-9}$		Mean of all MS, TI values	
		$1.14 \pm 0.06 \times 10^{-9}$(*)		Error is 95% confidence limit.	
$CD_4^+ + CD_4 \rightarrow CD_5^+$		$9.8 \pm 0.2 \times 10^{-10}$	TI, 14		57
		1.1×10^{-9}	ICR, 58		59
		$8.0 \pm 0.7 \times 10^{-10}$	ICR, 32		37
		$7.9 \pm 0.3 \times 10^{-10}$	ICR, 32		32
		7.3×10^{-10}	MS, 13		13
	373	8.2×10^{-10}	MS, 16		16
		4.65×10^{-10}	MS, 16	10.5 V cm^{-1}, 3.7 eV exit energy	98
		$9.2 \pm 1.4 \times 10^{-10}$(*)		Mean of all, neglect value of ref. 98	
$CH_2D_2^+ + CH_2D_2 \rightarrow CH_3D_2^+(55\%), CH_2D_3^+(45\%)$		9.2×10^{-10}	ICR, 84		84
	373	8.5×10^{-10}	MS, 16		16
$CH_3D^+ + CH_3D \rightarrow CH_4D^+(77\%), CH_3D_2^+(23\%)$	373	1.01×10^{-9}	MS, 16		16
$CHD_3^+ + CHD_3 \rightarrow CH_2D_3^+(33\%), CHD_4^+(67\%)$	373	8.8×10^{-10}	MS, 16		16
$CH_4^+ + C_2H_2 \rightarrow$		5.4×10^{-10}	MS, 60	3.7 eV ion exit energy	60
		1.7×10^{-10}	MS, 16	1.7 eV ion exit energy	60
$CH_4^+ + C_2H_2 \rightarrow C_2H_3^+(30\text{-}40\%), C_2H_2^+(57\text{-}70\%)$		2.9×10^{-9}	MS, 79	Photoionization	79
$CH_4^+ + C_2H_4 \rightarrow C_2H_5^+, C_2H_4^+, C_3H_6^+, C_3H_7^+$		2.9×10^{-9}	MS, 79	Photoionization	79
$CH_4^+ + CH_3CN \rightarrow$		$3.92 \pm 0.15 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_4^+ + CD_3CDO \rightarrow$		$3.68 \pm 0.46 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	65
$CH_4^+ + c\text{-}CD_2CD_2O \rightarrow$		$2.29 \pm 0.27 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	65
$CH_4^+ + CD_3OCD_3 \rightarrow$		$2.24 \pm 0.32 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	65
$CH_4^+ + CH_3COCH_3 \rightarrow$		$4.08 \pm 0.45 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	65
$CH_4^+ + CH_3COCH_2CH_2CH_3 \rightarrow C_5H_{10}O^+$		3.5×10^{-10}	B, 74	0.3 ± 0.3 eV ions	99
$CD_4^+ + CH_3SH \rightarrow CH_3SHD^+, CH_3SH^+, CSH_3^+$		$2.86 \pm 0.18 \times 10^{-9}$	TI, 14	0.4 eV ions	100
$CD_4^+ + CO \rightarrow$		$7 \pm 1 \times 10^{-10}$	TI, 14		57
$CD_4^+ + CO \rightarrow COD^+$		5.22×10^{-10}	MS, 98	10.5 V cm^{-1}, 3.7 eV exit energy	98
$CH_4^+ + CO_2 \rightarrow$	340	$8 \pm 1 \times 10^{-10}$	TI, 48		49
		6×10^{-10}	TI, 14		57
$CD_4^+ + CO_2 \rightarrow CO_2D^+$		4.86×10^{-10}	MS, 98		98
$CH_4^+ + CS_2 \rightarrow CS_2H^+$		$3.4 \pm 1.7 \times 10^{-10}$	ICR, 69		69
$CH_4^+ + H_2 \rightarrow CH_5^+$	295	$4.1 \pm 0.2 \times 10^{-11}$	ICR, 32		36
$CH_4^+ + D_2 \rightarrow CH_4D^+$		9×10^{-12}	ICR, 85		86
$CH_4^+ + {}^{15}NH_3 \rightarrow {}^{15}NH_4^+(49\%), {}^{15}NH_3^+(51\%)$		$1.35 \pm 0.16 \times 10^{-9}$	ICR, 32		37
$CD_4^+ + NH_3 \rightarrow$		1.2×10^{-10}	MS, 101	10.5 V cm^{-1}, 3.7 eV ion exit energy	101
					45

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$CH_4^+ + NH_3 \rightarrow NH_3^+, NH_4^+$		$2.2\pm0.7 \times 10^{-9}$	MS, 26		45
$CD_4^+ + NH_3 \rightarrow CD_4H^+$		$3\pm0.7 \times 10^{-11}$	ICR, 32	Rate constant refers to one channel only	37
$CH_4^+ + H_2O \rightarrow H_3O^+$		$2.4\pm0.5 \times 10^{-9}$	ICR, 32		37
$CH_4^+ + H_2O \rightarrow$		5.7×10^{-10}	MS, 16		101
$CH_4^+ + D_2O \rightarrow$		$1.6\pm0.5 \times 10^{-9}$	MS, 71		72
$CH_4^+ + H_2S \rightarrow H_3S^+(55\%), H_2S^+(45\%)$		$1.31\pm.17 \times 10^{-9}$	ICR, 32		37
$CD_4^+ + H_2S \rightarrow CD_4H^+$		9×10^{-11}	ICR, 32		37
		1.5×10^{-10}	MS, 26		102
$CH_4^+ + SiH_4 \rightarrow SiH_2^+, SiH_3^+, SiCH_4^+, SiCH_5^+$		$2.04\pm0.48 \times 10^{-9}$	MS,B,28,29		30
$CH_4^+ + SiH_4 \rightarrow SiH_3^+, SiCH_4^+, SiCH_5^+$		$2.56\pm1.04 \times 10^{-9}$	ICR, 38		38
$CD_4^+ + N_2 \rightarrow N_2D^+$		5.1×10^{-11}	MS, 98	10.5 V cm^{-1}, 3.7 eV exit	98
$CH_4^+ + NO \rightarrow NO^+$		2.8×10^{-10}	B, 74	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	75
$CH_4^+ + N_2O \rightarrow N_2OH^+(97\%), NOH^+(3\%)$		1.04×10^{-9}	ICR, 103	Assumes $k(CH_4^+ + CH_4) = 1.0 \times 10^{-9}$	103
$CH_5^+ + B_5H_9 \rightarrow B_5H_{10}^+$	373	1.93×10^{-9}	MS, 43		104
$CH_5^+ + CF_4 \rightarrow CF_3^+$	323	$2.3\pm0.3 \times 10^{-10}$	MS, 39	15 V cm^{-1}	39
$CH_5^+ + CH_4 \rightarrow$ Products other than CH_5^+		$<10^{-12}$	MS, 26		105
$CH_4D^+ + CH_4 \rightarrow CH_5^+$	83	$2.7\pm0.2 \times 10^{-9}$	MS, 43		44
	83	$3.7\pm1.0 \times 10^{-9}$	MS, 43		44
$CD_5^+ + CH_4 \rightarrow CH_4D^+$	300	3.3×10^{-11}	B, 74	0.3±0.3 eV ions	106
$CH_5^+ + C_2H_2 \rightarrow$	295	$1.4\pm0.3 \times 10^{-9}$	B, 107	Less than 0.1 eV ions	108
$CH_5^+ + C_2H_4 \rightarrow$		1.5×10^{-9}	B, 107	Less than 0.1 eV ions	108
$CH_5^+ + C_2H_4 \rightarrow C_2H_5^+$		10^{-9}	MS, 26		109
$CD_5^+ + C_2H_4 \rightarrow C_2H_4D^+$		$1.51\pm0.08 \times 10^{-9}$	TI, 14		110
$CD_5^+ + C_2H_6 \rightarrow$		$1.07\pm0.04 \times 10^{-9}$	TI, 14		111
$CH_5^+ + CH_3CHCH_2 \rightarrow$		2.0×10^{-9}	B, 107		108
$CH_5^+ + c\text{-}C_3H_6 \rightarrow$		1.7×10^{-9}	B, 107		108
$CH_5^+ + CH_3CD_2CH_3 \rightarrow$		$1.71\pm0.1 \times 10^{-9}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.20 \times 10^{-9}$	112
$CH_5^+ + CD_3CH_2CD_3 \rightarrow$		$1.51\pm0.2 \times 10^{-9}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.20 \times 10^{-9}$	112
$CH_5^+ + C_3D_8 \rightarrow$		$1.54\pm0.15 \times 10^{-9}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.20 \times 10^{-9}$	112
$CD_5^+ + C_3H_8 \rightarrow$		$1.53\pm0.2 \times 10^{-9}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.20 \times 10^{-9}$	112
$CH_5^+ + CH_3Cl \rightarrow CH_3ClH^+$	300	$2.60\pm0.39 \times 10^{-9}$	ICR, 76		113
$CH_5^+ + C_2H_5Cl \rightarrow C_2H_5ClH^+$	300	$3.02\pm0.45 \times 10^{-9}$	ICR, 76		113
$CH_5^+ + CCl_2CH_2 \rightarrow$	300	$1.97\pm0.29 \times 10^{-9}$	ICR, 76		114
$CD_5^+ + CCl_2CH_2 \rightarrow$	300	$1.69\pm0.25 \times 10^{-9}$	ICR, 76		114
CH_5^+ + tr-CHClCHCl $\rightarrow$	300	$1.78\pm0.27 \times 10^{-9}$	ICR, 76		114
CD_5^+ + tr-CHClCHCl $\rightarrow$	300	$1.54\pm0.23 \times 10^{-10}$	ICR, 76		114
CH_5^+ + cis-CHClCHCl $\rightarrow$	300	$2.09\pm0.31 \times 10^{-9}$	ICR, 76		114
CD_5^+ + cis-CHClCHCl $\rightarrow$	300	$1.80\pm0.27 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + CF_2CH_2 \rightarrow$	300	$1.27\pm0.19 \times 10^{-9}$	ICR, 76		114
$CD_5^+ + CF_2CH_2 \rightarrow$	300	$1.14\pm0.17 \times 10^{-9}$	ICR, 76		114
CH_5^+ + tr-CHFCHF $\rightarrow$	300	$1.02\pm.15 \times 10^{-9}$	ICR, 76		114
CD_5^+ + tr-CHFCHF $\rightarrow$	300	$9.5\pm1.4 \times 10^{-10}$	ICR, 76		114
CH_5^+ + cis-CHFCHF $\rightarrow$	300	$1.57\pm0.23 \times 10^{-9}$	ICR, 76		114
CD_5^+ + cis-CHFCHF $\rightarrow$	300	$1.35\pm0.20 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + n\text{-}C_3H_7Cl \rightarrow C_3H_7ClH^+$	300	$3.11\pm0.47 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + CH_3CHClCH_3 \rightarrow C_3H_7ClH^+$	300	$3.10\pm0.47 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + n\text{-}C_4H_9Cl \rightarrow C_4H_9ClH^+$	300	$3.20\pm0.48 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + sec\text{-}C_4H_9Cl \rightarrow C_4H_9ClH^+$	300	$3.14\pm0.47 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + t\text{-}C_4H_9Cl \rightarrow C_4H_9ClH^+$	300	$3.28\pm0.49 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + n\text{-}C_5H_{11}Cl \rightarrow C_5H_{11}ClH^+$	300	$3.29\pm0.49 \times 10^{-9}$	ICR, 76		113
$CH_5^+ + t\text{-}C_5H_{11}Cl \rightarrow C_5H_{11}ClH^+$	300	$3.29\pm0.49 \times 10^{-9}$	ICR, 76		113
$CH_5^+ + p\text{-}C_6H_4F_2 \rightarrow$	300	$1.91\pm0.29 \times 10^{-9}$	ICR, 76		114
$CD_5^+ + p\text{-}C_6H_4F_2 \rightarrow$	300	$1.50\pm0.22 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + m\text{-}C_6H_4F_2 \rightarrow$	300	$2.12\pm0.32 \times 10^{-9}$	ICR, 76		114
$CD_5^+ + m\text{-}C_6H_4F_2 \rightarrow$	300	$1.65\pm0.25 \times 10^{-9}$	ICR, 76		114

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref
$CH_5^+ + o\text{-}C_6H_4F_2 \rightarrow$	300	$2.38\pm0.36 \times 10^{-9}$	ICR, 76		114
$CD_5^+ + o\text{-}C_6H_4F_2 \rightarrow$	300	$1.91\pm0.29 \times 10^{-9}$	ICR, 76		114
$CH_5^+ + CH_3NH_2 \rightarrow$	300	2.25×10^{-9}	ICR, 76		115
$CH_5^+ + CH_3CN \rightarrow$		$4.90\pm0.24 \times 10^{-9}$	TI, 14	0.4 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_5^+ + (CH_3)_2NH \rightarrow$	300	2.15×10^{-9}	ICR, 76		115
$CH_5^+ + CD_3CDO \rightarrow$		$4.20\pm0.35 \times 10^{-9}$	TI, 14	0.4 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_5^+ + c\text{-}CD_2CD_2O \rightarrow$		$3.11\pm0.13 \times 10^{-9}$	TI, 14	0.4 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_5^+ + CD_3OCD_3 \rightarrow$		$2.97\pm0.24 \times 10^{-9}$	TI, 14	0.4 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_5^+ + CH_3COCH_3 \rightarrow$		$5.26\pm0.18 \times 10^{-9}$	TI, 14	0.4 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	65
$CH_5^+ + C_6H_5CH_2OCOCH_3 \rightarrow$		$2.9\pm0.3 \times 10^{-9}$	MS, 16		116
$CH_5^+ + CO \rightarrow$		$3.7\pm0.2 \times 10^{-10}$	TI, 14		57
$CH_5^+ + CO \rightarrow HCO^+$	340	5.54×10^{-10}	MS, 22	11.5 V cm^{-1}	117
$CH_5^+ + CO \rightarrow$	300	$>1.0 \times 10^{-10}$	FA, 118		119
$CD_5^+ + CO \rightarrow$		$3.0\pm0.3 \times 10^{-10}$	TI, 14		57
$CH_5^+ + CO_2 \rightarrow CO_2H^+$	296	$3.6\pm1.0 \times 10^{-11}$	ICR, 62		76
	300	$3.2\pm0.2 \times 10^{-11}$	FA, 118		120
$CH_5^+ + NH_3 \rightarrow$	300	2.3×10^{-9}	DT, 20		121
	300	2.33×10^{-9}	ICR, 76		115
$CH_5^+ + H_2O \rightarrow$		10^{-8}	MS, 26		45
$CH_5^+ + SiH_4 \rightarrow SiH_3^+$		$1.99\pm0.40 \times 10^{-9}$	MS,B,28,29		30
		$1.78\pm0.25 \times 10^{-9}$	ICR, 38		38
		$1.90\pm0.30 \times 10^{-9}$(*)		Error is 90% confidence limit	122
$CH_5^+ + SiD_4 \rightarrow$		$9\pm3 \times 10^{-11}$	ICR, 38		
$CH_5^+ + N_2O \rightarrow N_2OH^+$	340	$7.9\pm1.0 \times 10^{-10}$	TI, 48		49
$CH_5^+ + N_2O \rightarrow$	300	$\geq1.0 \times 10^{-10}$	FA, 118		119
$C_2^+ + C_2H_2 \rightarrow$		$2.65\pm0.1 \times 10^{-9}$	TI, 14	0.3-0.5 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
$C_2^+ + C_2H_2 \rightarrow C_4H^+$		3×10^{-9}	B, 34		34
$C_2^+ + C_2H_4 \rightarrow$		1.02×10^{-9}	MS, 26		56
		1.9×10^{-9}	TI, 14	0.3-0.5 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
$C_2^+ + H_2 \rightarrow C_2H^+$	295	$1.12\pm0.11 \times 10^{-9}$	ICR, 32		36
$C_2H^+ + C_2H_2 \rightarrow$		$1.47\pm0.15 \times 10^{-9}$	TI, 47	Less than 1 eV ions	47
$C_2H^+ + C_2H_2 \rightarrow$		$1.3\pm0.3 \times 10^{-9}$	MS, 26		123
		$2.45\pm0.1 \times 10^{-9}$	TI, 14	0.3-0.5 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
$C_2H^+ + C_2H_2 \rightarrow C_2H_3^+, C_4H_2^+$		2.4×10^{-9}	B, 34	0.3-0.5 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	34
$C_2H^+ + C_2H_4 \rightarrow C_4H_3^+$		5.8×10^{-10}	MS, 26		56
		$1.71\pm0.1 \times 10^{-9}$	TI, 14	0.3-0.5 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
$C_2H^+ + C_2H_6 \rightarrow$		$2.9\pm0.6 \times 10^{-9}$	MS, 26		35
$C_2H^+ + C_3H_8 \rightarrow$		$4.0\pm0.8 \times 10^{-9}$	MS, 26		35
$C_2H^+ + CH_3CN \rightarrow$	300	3.64×10^{-9}	MS, 22		22
$C_2D^+ + CD_3CN \rightarrow$	300	4.8×10^{-9}	MS, 22		22
$C_2H^+ + H_2 \rightarrow$	295	$7.8\pm0.5 \times 10^{-10}$	ICR, 32		36
$C_2H_2^+ + CH_4 \rightarrow C_3H_6^+, C_3H_5^+, C_3H_4^+, C_2H_3^+$		9.1×10^{-10}	MS, 79	Photoionization	79
$\rightarrow C_3H_5^+$	310	3.8×10^{-10}	MS, 16		60
	310	1.64×10^{-10}	MS, 16		55
		$4.6\pm0.7 \times 10^{-10}$	MS, 26		105
$C_2H_2^+ + C_2H_2 \rightarrow C_4H_3^+, C_4H_2^+$		$1.15\pm0.15 \times 10^{-9}$	TI, 47	$\leq$1 eV ions	47
		$1.52\pm0.10 \times 10^{-9}$	ICR, 124		124
$\rightarrow C_4H_4^+, C_4H_3^+, C_4H_2^+$		1.39×10^{-9}	MS, 79	11.4 eV photons	79

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$C_2H_2^+ + C_2H_2 \rightarrow$		1.38×10^{-9}	MS, 79	13.4 eV photons	79
$\rightarrow C_4H_4^+, C_4H_3^+, C_4H_2^+, C_2H_3^+$		1.25×10^{-9}	MS, 79	16.2 eV photons	79
$\rightarrow C_4H_3^+, C_4H_2^+, C_2H_3^+$		1.94×10^{-9}	B, 34		34
		$1.41 \pm 0.7 \times 10^{-9}$	TI, 14	0.3-0.5 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
$\rightarrow C_4H_3^+, C_4H_2^+$		1.22×10^{-9}	ICR, 84		84
		9.0×10^{-10}	MS, 16	3.7 eV ion exit energy	60
		7.9×10^{-10}	MS, 16	3.4 eV ion exit energy	125
		3.3×10^{-10}	MS, 60	1.7 eV ion exit energy	60
$\rightarrow C_3H_5^+, C_4H_2^+$		7.51×10^{-10}	MS, 55		55
		8.5×10^{-10}	MS, 26		123
$C_2H_2^+ + C_2H_4 \rightarrow C_3H_3^+, C_4H_5^+, C_2H_4^+$		1.35×10^{-9}	MS, 79	11.4 eV photons	79
$\rightarrow C_3H_3^+, C_4H_5^+$		1.30×10^{-9}	MS, 79	13.4 eV photons	79
		$1.58 \pm 0.1 \times 10^{-9}$	TI, 14	0.3-0.5 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	
$\rightarrow C_3H_3^+$		2.5×10^{-10}	MS, 126		126
$\rightarrow C_3H_3^+, C_4H_5^+$		4.1×10^{-10}	MS, 26		56
$C_2H_2^+ + C_2H_6 \rightarrow$	323	$5.82 \pm 0.6 \times 10^{-10}$	MS, 39	15 V cm^{-1}	39
		$1.3 \pm 0.2 \times 10^{-9}$	TI, 14		111
		$2.1 \pm 0.4 \times 10^{-9}$	MS, 26		35
$C_2H_2^+ + C_2H_3Cl \rightarrow C_2H_3Cl^+$	373	1.9×10^{-9}	MS, 16		127
$C_2H_2^+ + C_2H_3F \rightarrow C_2H_3F^+(97\%), C_3H_3^+(3\%)$	373	1.95×10^{-9}	MS, 16		128
$C_2H_2^+ + C_2H_5CN \rightarrow$		2.7×10^{-9}	MS, 22	Pressure varied	22
		2.2×10^{-9}	MS, 22	Time varied	22
$C_2D_2^+ + C_2D_5CN \rightarrow$		2.5×10^{-9}	MS, 22	Pressure varied	22
		2.9×10^{-9}	MS, 22	Time varied	22
$C_2H_2^+ + CH_3COCH_2CH_2CH_3 \rightarrow C_5H_{10}O^+$		6.5×10^{-10}	B, 74	0.3 ± 0.3 eV ions	99
$C_2H_2^+ + COS \rightarrow C_2H_2S^+$	300	4.7×10^{-11}	MS, 53		68
$C_2H_2^+ + H_2 \rightarrow C_2H_3^+$		$<2 \times 10^{-12}$	ICR, 124	k varies with vibrational energy of $C_2H_2^+$	124
		$6.3 \pm 1.8 \times 10^{-11}$	ICR, 124		124
$C_2H_2^+ + NO \rightarrow NO^+$		3×10^{-11}	B, 74	$C_2H_2^+$ generated in C_2H_4, C_3H_8	75
$C_2D_2^+ + NO \rightarrow NO^+$		6×10^{-11}	B, 74	$C_2D_2^+$ generated in C_2D_2	75
$C_2H_2^+ + SiH_4 \rightarrow Si^+, SiH^+, SiH_2^+, SiH_3^+, SiCH_3^+, SiC_2H^+, SiC_2H_3^+, SiC_2H_5^+$		$1.11 \pm 0.34 \times 10^{-9}$	MS,B,28,29		129
		$1.79 \pm 0.71 \times 10^{-9}$	MS,B,28,29	1.4 eV ions	130
$C_2H_3^+ + CH_4 \rightarrow$		$9 \pm 1 \times 10^{-11}$	MS, 26		105
$C_2H_3^+ + C_2H_2 \rightarrow$		$7.1 \pm 0.8 \times 10^{-10}$	ICR, 124		124
		8.5×10^{-11}	TI, 47	≤ 1 eV ions	47
		$3.1 \pm 0.2 \times 10^{-10}$	TI, 14		111
$C_2H_3^+ + C_2H_4 \rightarrow$		$8.4 \pm 0.5 \times 10^{-10}$	TI, 14	0.3-0.5 eV ions; assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
		6.5×10^{-10}	MS, 91		92
$C_2H_3^+ + C_2H_4 \rightarrow C_2H_5^+$		3.8×10^{-10}	MS, 126		126
		3.82×10^{-10}	MS, 26		56
$C_2H_3^+ + C_2H_6 \rightarrow C_2H_5^+$	323	$5.71 \pm 0.6 \times 10^{-10}$	MS, 39	15 V cm^{-1}	39
		$3.7 \pm 0.1 \times 10^{-10}$	TI, 14		111
		$4.8 \pm 0.9 \times 10^{-10}$	MS, 26		35
$C_2H_3^+ + C_3H_8 \rightarrow$		$6.7 \pm 1.6 \times 10^{-10}$	MS, 26		35
$C_2H_3^+ + i\text{-}C_4H_8 \rightarrow$		$1.59 \pm 0.06 \times 10^{-9}$	MS, 16		131
$C_2H_3^+ + c\text{-}C_4H_8 \rightarrow$	520	1.44×10^{-9}	MS, 40	10 V cm^{-1}	132
$C_2H_3^+ + n\text{-}C_4H_{10} \rightarrow$		$8.5 \pm 1.0 \times 10^{-10}$	MS, 26		133
$C_2H_3^+ + i\text{-}C_4H_{10} \rightarrow$		$1.14 \pm 0.13 \times 10^{-9}$	MS, 26		133
$C_2H_3^+ + C_6H_6 \rightarrow C_8H_7^+$		3.55×10^{-10}	MS, 82		83
$C_2H_3^+ + C_2H_5CN \rightarrow$		7×10^{-10}	MS, 22	Pressure varied	22
		1.6×10^{-9}	MS, 22	Time varied	22
$C_2D_3^+ + C_2D_5CN \rightarrow$		1.2×10^{-9}	MS, 22	Pressure varied	22
		2.3×10^{-9}	MS, 22	Time varied	22
$C_2H_3^+ + C_2H_3Cl \rightarrow C_2H_4Cl^+(21\%), C_4H_5^+(79\%)$		7.1×10^{-10}	MS, 16		127
$C_2H_3^+ + C_2H_3F \rightarrow C_2H_4F^+$		$3.0 \pm 0.5 \times 10^{-10}$	MS, 16	Rate refers to one channel only	128

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$C_2H_3^+ + CD_3OCD_3 \rightarrow (CD_3OCD_3)H^+$		$4.0\pm0.5 \times 10^{-9}$	TI, 14	Rate refers to one channel only	110
$C_2H_3^+ + CH_3SCH_3 \rightarrow C_2H_7S^+$	500	$2.3\pm0.35 \times 10^{-9}$	MS, 40	10 V cm^{-1}	41
$C_2H_3^+ + COS \rightarrow C_2H_3S^+$		1.8×10^{-10}	MS, 53		68
$C_2H_3^+ + H_2 \rightarrow C_2H_4^+$		$<1 \times 10^{12}$	ICR, 124		124
$C_2H_3^+ + SiH_4 \rightarrow SiH_3^+(89\%), SiH_5^+(11\%)$		$2.8\pm0.9 \times 10^{-10}$	MS,B,28,29		129
$C_2H_4^+ + CH_4 \rightarrow$		$<3 \times 10^{-12}$	MS, 26		105
$C_2H_4^+ + C_2H_4 \rightarrow$	295	$8.0\pm0.1 \times 10^{-10}$	ICR, 124	k varies with internal energy	134
$C_2H_4^+ + C_2D_4 \rightarrow C_4H_4D_4^+, C_2D_4^+$		$1.6\pm0.2 \times 10^{-9}$	ICR, 76		135
$C_2H_4^+ + C_2H_4 \rightarrow (C_4H_8^+)$		1.13×10^{-9}	ICR, 76		76
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+, C_4H_7^+, C_4H_8^+$		1.24×10^{-9}	MS, 79	11.4 eV photons	79
$\rightarrow C_3H_5^+, C_4H_7^+, C_2H_5^+$		8.8×10^{-10}	MS, 79	13.4 eV photons	79
$C_2H_4^+ + C_2H_4 \rightarrow$		$8.3\pm0.2 \times 10^{-10}$	TI, 14		111
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+, C_4H_7^+, C_3H_4^+$		$9.6\pm0.2 \times 10^{-10}$	MS, 136	10.6 eV photons	137
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+, C_4H_7^+, C_3H_4^+$		$8.5+0.2 \times 10^{-10}$	MS, 136	11.7 eV photons	137
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+$		$3.7\pm1.0 \times 10^{-10}$	TI, 78		78
$C_2H_4^+ + C_2H_4 \rightarrow C_4H_8^+, C_4H_7^+, C_3H_5^+$		7.3×10^{-10}	MS, 138	Error: "Within factor of 2.5", photo-ionization	138
$C_2H_4^+ + C_2H_4 \rightarrow$		$8.5\pm0.4 \times 10^{-10}$	TI, 14	0.3-0.5 eV ions, assumes $K(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+$		$4.3\pm1.5 \times 10^{-10}$	ICR, 139		140
$C_2H_4^+ + C_2H_4 \rightarrow$	300	4.4×10^{-10}	ICR, 141		142
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+, C_4H_8^+, C_4H_7^+$		8.3×10^{-10}	MS, 16	0.85 eV ion exit energy	143
$C_2H_4^+ + C_2H_4 \rightarrow$		5.7×10^{-10}	MS, 16	3.5 eV ion exit energy	143
		1.0×10^{-9}	MS, 52		144
		8.3×10^{-10}	MS, 145		145
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+$		2.8×10^{-10}	MS, 26		146
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+$		4.1×10^{-10}	MS, 126		126
$C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+, C_4H_8^+, C_4H_7^+$		6.3×10^{-10}	MS, 26		56
$C_2H_4^+ + C_2H_6 \rightarrow$ Products other than $C_2H_4^+$	189	2.5×10^{-10}	MS, 147		148
	410	1×10^{-11}	MS, 147		148
		5×10^{-12}	TI, 14		111
$\rightarrow C_2H_5^+, C_3H_5^+, C_3H_3^+, C_4H_8^+$		4.3×10^{-11}	ICR, 149	Assumes $k(C_2H_6^+ + C_2H_6) = 1 \times 10^{-10}$	149
$C_2H_4^+ + C_2D_4 \rightarrow C_2D_4^+$	295	1.1×10^{-10}	MS, 136	Photoionization	150
$C_2H_4^+ + C_2H_6 \rightarrow$		$3.5\pm1.2 \times 10^{-10}$	MS, 26		35
$C_2H_4^+ + C_3H_8 \rightarrow$		$8.5\pm0.5 \times 10^{-10}$	TI, 14		112
$C_2H_4^+ + C_3H_8 \rightarrow$		$6.3\pm1.0 \times 10^{-10}$	MS, 26		35
$C_2H_3D^+ + CH_3CD_2CH_3 \rightarrow$		$7.9\pm0.5 \times 10^{-10}$	TI, 14		112
$C_2H_2D_2^+ + CH_3CD_2CH_3 \rightarrow$		$8.5\pm1.0 \times 10^{-10}$	TI, 14		112
$C_2H_2D_2^+ + CD_3CH_2CD_3 \rightarrow$		$8.9\pm0.3 \times 10^{-10}$	TI, 14		112
$C_2H_4^+ + CD_3CH_2CD_3 \rightarrow$		$8.4\pm0.2 \times 10^{-10}$	TI, 14		112
$C_2H_4^+ + i\text{-}C_4H_8 \rightarrow$		$2.05\pm0.12 \times 10^{-9}$	MS, 16		131
$C_2H_4^+ + c\text{-}C_4H_8 \rightarrow$		3.01×10^{-9}	MS, 40		132
$C_2H_4^+ + n\text{-}C_4H_{10} \rightarrow$		$1.14\pm0.13 \times 10^{-9}$	MS, 26		133
$C_2H_4^+ + C_2H_5Cl \rightarrow C_2H_3Cl^+(51\%), C_4H_9^+(24\%), C_4H_8^+(16\%), C_2H_4Cl^+(9\%)$	300	5.25×10^{-10}	ICR, 62		151
$C_2H_4^+ + C_2H_3F \rightarrow$		$1.9\pm0.2 \times 10^{-9}$	ICR, 76	Total rate	135
$C_2H_4^+ + C_2H_3F \rightarrow C_2H_3F^+$		5.3×10^{-10}	ICR, 139	Assumes $k(C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+) = 8 \times 10^{-10}$	152
$C_2H_4^+ + CH_2CF_2 \rightarrow$		1.8×10^{-9}	ICR, 76	Total rate	135
$C_2H_4^+ + CH_2CF_2 \rightarrow CH_2CF_2^+$		1.0×10^{-9}	ICR, 139	Assumes $k(C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+) = 8 \times 10^{-10}$	152
$C_2H_4^+$ + cis-CHFCHF $\rightarrow$		1.8×10^{-9}	ICR, 76	Total rate	135
$C_2H_4^+$ + cis-CHFCHF $\rightarrow$ $CHFCHF^+$		5.2×10^{-10}	ICR, 139	Assumes $k(C_2H_9^+ + C_2H_4 \rightarrow C_3H_5^+) = 8 \times 10^{-10}$	152
$C_2H_4^+ + CHFCF_2 \rightarrow$		2.2×10^{-9}	ICR, 76	Total rate	135
$C_2H_4^+ + CHFCF_2 \rightarrow$		7.3×10^{-10}	ICR, 139	Assumes $k(C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+) = 8 \times 10^{-10}$	152

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$C_2H_4^+ + C_2H_5CN \rightarrow$	300	5×10^{-10}	MS, 22	Pressure varied	22
	300	1.76×10^{-9}	MS, 22	Time varied	22
$C_2D_4^+ + C_2H_5CN \rightarrow$	300	1.5×10^{-9}	MS, 22	Pressure varied	22
	300	2.0×10^{-9}	MS, 22	Time varied	22
$C_2H_4^+ + CD_3OCD_3 \rightarrow CD_3OCD_2^+$		$2.68 \pm 0.25 \times 10^{-9}$	TI, 14		110
		$3.1 \pm 0.3 \times 10^{-9}$			
$C_2H_4^+ + CH_3COCH_2CH_2CH_3 \rightarrow C_5H_{10}O^+$		2.6×10^{-9}	B, 74	0.3 ± 0.3 eV ions	99
$C_2H_4^+ + SiH_4 \rightarrow SiH_2^+, C_2H_5^+, SiH_3^+, SiC_2H_4^+, SiC_2H_5^+, SiC_2H_6^+$		$1.41 \pm 0.44 \times 10^{-9}$	MS,B,28,29		129
$C_2H_4^+ + NO \rightarrow NO^+$		$3.6 \pm 0.4 \times 10^{-10}$	B, 74	0.3 ± 0.3 eV ions; assume $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	75
$C_2H_4^+ + C_2F_4 \rightarrow$		1.4×10^{-9}	ICR, 76		135
		$3.5 \pm 0.5 \times 10^{-10}$	ICR, 139	Assumes $k(C_2H_4^+ + C_2H_4 \rightarrow C_3H_5^+) = 8 \times 10^{-10}$	152
$C_2H_5^+ + CH_4 \rightarrow$		$<10^{-12}$	MS, 26		105
$C_2H_5^+ + CH_4 \rightarrow C_3H_7^+$	86	1×10^{-14}	MS, 53		153
$C_2H_5^+ + C_2H_2 \rightarrow$		$1.0 \pm 0.1 \times 10^{-10}$	TI, 14		111
$C_2H_5^+ + C_2H_4 \rightarrow$		$2.9 \pm 0.5 \times 10^{-10}$	TI, 14	$C_2H_5^+$ formed from $(CH_3^+ + CH_4)$	110
		$3.2 \pm 0.2 \times 10^{-10}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
$C_2D_5^+ + C_2H_4 \rightarrow C_2H_4D^+$		$6.2 \pm 0.9 \times 10^{-10}$	TI, 14		110
$C_2H_4D^+ + C_2H_4 \rightarrow C_2H_5^+$		$5.6 \pm 0.4 \times 10^{-10}$	TI, 14		110
$C_2H_5^+ + C_2H_6 \rightarrow C_3H_7^+, C_4H_9^+$	323	$1.6 \pm 0.2 \times 10^{-10}$	MS, 39	15 V cm^{-1}	39
	189	2.5×10^{-10}	MS, 147		148
	400	5×10^{-11}	MS, 147		148
$C_2H_5^+ + C_2H_6 \rightarrow C_4H_9^+$	300	4×10^{-11}	ICR, 149	Assumes $k(C_2H_6^+ + C_2H_6) = 1 \times 10^{-10}$	149
$C_2H_5^+ + C_2H_6 \rightarrow$	300	1×10^{-10}	MS, 136	Photoionization	150
$C_2D_5^+ + C_2H_6 \rightarrow$		$2.8 \pm 0.1 \times 10^{-10}$	TI, 14		111
$C_2H_5^+ + C_3H_8 \rightarrow$	300	$6.3 \pm 0.1 \times 10^{-10}$(*)	ICR, 154	Collisionally deactivated	154
	300	$5.6 \pm 0.6 \times 10^{-10}$	TI, 14		112
	300	$6.2 \pm 0.5 \times 10^{-10}$(*)	TI, 14	Methane added; collisionally deactivated	112
	300	$5.4 \pm 0.5 \times 10^{-10}$	TI, 14	$C_2H_5^+$ generated in excess CH_4	112
		$6.2 \pm 1.3 \times 10^{-10}$	MS, 26		35
$C_2H_5^+ + CH_3CD_2CH_3 \rightarrow$	300	$6.4 \pm 0.3 \times 10^{-10}$	TI, 14		112
$C_2H_5^+ + C_3D_8 \rightarrow$	300	$5.3 \pm 0.6 \times 10^{-10}$	TI, 14	$C_2H_5^+$ generated in excess CH_4	112
$C_2H_3D_2^+ + CH_3CD_2CH_3 \rightarrow$	300	$5.0 \pm 0.5 \times 10^{-10}$	TI, 14		112
	300	$5.8 \pm 0.7 \times 10^{-10}$(*)	TI, 14	Methane added; collisionally deactivated	112
$C_2D_3H_2^+ + CD_3CH_2CD_3 \rightarrow$	300	$8.4 \pm 0.2 \times 10^{-10}$	TI, 14		112
	300	$5.6 \pm 0.5 \times 10^{-10}$(*)	TI, 14	Methane added	112
$C_2D_4H^+ + CD_3CH_2CD_3 \rightarrow$	300	$4.7 \pm 0.5 \times 10^{-10}$	TI, 14		112
$C_2D_5^+ + C_3H_8 \rightarrow$	300	$6.3 \pm 0.5 \times 10^{-10}$(*)	TI, 14	$C_2D_5^+$ generated in excess CD_4	112
$C_2D_5^+ + C_3D_8 \rightarrow$	300	$4.7 \pm 0.5 \times 10^{-10}$(*)	TI, 14	Methane added	112
$C_2H_5^+ + i\text{-}C_4H_8 \rightarrow$		$1.20 \pm 0.08 \times 10^{-9}$	MS, 16		131
$C_2H_5^+ + n\text{-}C_4H_{10} \rightarrow$	300	$8.4 \pm 0.2 \times 10^{-10}$	ICR, 154		154
		$7.5 \pm 0.9 \times 10^{-10}$	MS, 26		133
		6×10^{-10}	MS, 26		155
$C_2H_5^+ + i\text{-}C_4H_{10} \rightarrow$		$1.01 \pm 0.13 \times 10^{-9}$	MS, 26		133
		6×10^{-10}	MS, 26		155
$C_2H_5^+ + n\text{-}C_5H_{12} \rightarrow$	300	$1.09 \pm 0.01 \times 10^{-9}$	ICR, 154		154
$C_2H_5^+ + n\text{-}C_6H_{14} \rightarrow C_6H_{13}^+$	300	$1.31 \pm 0.03 \times 10^{-9}$	ICR, 154		154
$C_2H_5^+ + C_2D_5CD(CD_3)C_2D_5 \rightarrow C_6D_{13}^+$	300	2.2×10^{-9}	R, 150		150
$C_2H_5^+ + n\text{-}C_8H_{18} \rightarrow$	300	$1.72 \pm 0.02 \times 10^{-9}$	ICR, 154		154
$C_2H_5^+ + C_2H_5I \rightarrow C_2H_5IH^+$	300	$1.0 \pm 0.2 \times 10^{-9}$	MS, 136	Photoionization	156
$C_2H_5^+ + CH_3NH_2 \rightarrow$	300	1.87×10^{-9}	ICR, 76		115
$C_2H_5^+ + CH_3CN \rightarrow$		$3.46 \pm 0.12 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	65
$C_2H_5^+ + (CH_3)_2NH \rightarrow$		1.88×10^{-9}	ICR, 76		115
$C_2H_5^+ + CD_3CDO \rightarrow$		$3.37 \pm 0.42 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	65
$C_2H_5^+ + c\text{-}CD_2CD_2O \rightarrow$		$1.98 \pm 0.14 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	65
$C_2H_5^+ + CD_3OCD_3 \rightarrow$		$2.14 \pm 0.19 \times 10^{-9}$	TI, 14	0.4 eV ion exit energy	65

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref
$C_2H_5^+ + CD_3OCD_3 \rightarrow (CD_3OCD_3)H^+$		$1.87\pm0.30 \times 10^{-9}$	TI, 14	$C_2H_5^+$ from propane	110
		$2.35\pm0.25 \times 10^{-9}$	TI, 14	$C_2H_5^+$ from H^+ transfer to C_2H_4	110
$C_2H_5^+ + CH_3COCH_3 \rightarrow$		$1.99\pm0.18 \times 10^{-9}$	TI, 14	$C_2H_5^+$ from H^+ transfer to C_2H_4	65
$C_2H_5^+ + CH_3SOCH_3 \rightarrow$	408	$4.3\pm0.4 \times 10^{-9}$	MS, 11	0.71 eV ion exit energy	42
	408	$4.1\pm0.4 \times 10^{-9}$	MS, 11	1.07 eV ion exit energy	42
$C_2H_5^+ + NH_3 \rightarrow$		2.00×10^{-9}	ICR, 76		115
$C_2H_5^+ + D_2O \rightarrow$		$4.0\pm0.8 \times 10^{-10}$	MS, 71		72
$C_2H_5^+ + H_2O \rightarrow$		6×10^{-9}	MS, 26		45
$C_2H_6^+ + C_2H_2 \rightarrow$		$1.4\pm0.1 \times 10^{-9}$	TI, 14		111
$C_2H_6^+ + C_2H_6 \rightarrow$	189	2×10^{-10}	MS, 147	Branching ratios depend on pressure, energy, temperature	149
	400	5×10^{-11}	MS, 147	Branching ratios depend on pressure, energy, temperature	148
$C_2H_6^+ + C_2H_6 \rightarrow C_3H_8^+, C_4H_9^+, C_3H_9^+, C_2H_5^+, C_3H_7^+$		1.01×10^{-10}	ICR, 149	Branching ratios depend on pressure, energy, temperature	149
$C_2H_6^+ + C_2H_6 \rightarrow$		$1.85\pm0.05 \times 10^{-10}$		Branching ratios depend on pressure, energy, temperature	
		$0.7\text{-}1.8 \times 10^{-10}$	MS, 26	Branching ratios depend on pressure, energy, temperature	35
$C_2D_6^+ + C_2D_6 \rightarrow$	295	1×10^{-10}	MS, 136	Photoionization	157
$C_2H_6^+ + CH_3COCH_2CH_2CH_3 \rightarrow C_5H_{10}O^+$		1.7×10^{-9}	B, 74	0.3 ± 0.3 eV ions	99
$C_2H_6^+ + H_2O \rightarrow H_3O^+$	295	1.2×10^{-9}	MS, 136	Photoionization	158
$C_2H_6^+ + D_2O \rightarrow$		$1.2\pm0.4 \times 10^{-9}$	MS, 71	Excess K.E. ions	23
$C_2H_7^+ + CH_4 \rightarrow C_2H_5^+$		$k = 8.3 \times 10^{-8} \exp(-10.5\ kcal/RT)$	MS, 53		153
$C_3H^+ + C_3H_8 \rightarrow$		$1.6\pm0.6 \times 10^{-9}$	MS, 26		35
$C_3H_2^+ + CH_2CCH_2 \rightarrow C_4H_3^+$	310	5.48×10^{-10}	MS, 16	$C_3H_2^+$ from CH_2CCH_2	55
$C_3H_2^+ + C_3H_8 \rightarrow$		$1.1\pm0.2 \times 10^{-9}$	MS, 16	$C_3H_2^+$ from C_3H_8	35
$C_3H_2^+ + NO \rightarrow NO^+$		$6.0\pm0.6 \times 10^{-11}$	B, 74	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	75
$C_3H_3^+ + i\text{-}C_4H_8 \rightarrow$		$4\pm2 \times 10^{-11}$	MS, 16	$C_3H_3^+$ from $i\text{-}C_4H_{10}$	131
$C_3H_4^+ + C_2H_4 \rightarrow$		2.5×10^{-9}	TI, 14		14
$C_3H_4^+ + HCCCH_3 \rightarrow$		1.55×10^{-9}	MS, 16	$C_3H_4^+$ from $HCCCH_3$	125
$C_3H_4^+ + HCCCH_3 \rightarrow C_3H_5^+$	310	2.0×10^{-10}	MS, 16	$C_3H_4^+$ from $HCCCH_3$	55
$C_3D_4^+ + DCCCD_3 \rightarrow C_6D_7^+$	310	4.73×10^{-10}	MS, 16	$C_3D_4^+$ from $DCCCD_3$	55
$C_3H_4^+ + H_2CCCH_2 \rightarrow$		5.9×10^{-10}	MS, 16	$C_3H_4^+$ from H_2CCCH_2	125
$C_3H_4^+ + H_2CCCH_2 \rightarrow C_6H_7^+$	310	3.73×10^{-10}	MS, 16	$C_3H_4^+$ from H_2CCCH_2	55
$C_3H_4^+ + C_3H_8 \rightarrow$		$1.2\pm0.2 \times 10^{-10}$	MS, 26	$C_3H_4^+$ from C_3H_8	35
$C_3H_4^+ + i\text{-}C_4H_8 \rightarrow$		$1.80\pm0.10 \times 10^{-10}$	MS, 16	$C_3H_4^+$ from $i\text{-}C_4H_8$	131
$C_3H_4^+ + NO \rightarrow NO^+$		1.8×10^{-10}	B, 74	$C_3H_4^+$ generated in both C_3H_8, $c\text{-}C_3H_6$	75
		2.8×10^{-10}	B, 74	$C_3H_4^+$ generated in CH_3CHCH_2	75
$C_3H_5^+ + c\text{-}C_3H_6 \rightarrow$		$3.0\pm0.3 \times 10^{-10}$	TI, 14	$C_3H_5^+$ from $c\text{-}C_3H_6$	159
$C_3H_5^+ + 2C_2D_4 \rightarrow C_5H_5D_4^+$	373	8.4×10^{-25}	MS, 16	0.64 eV ion exit energy; $C_3H_5^+$ from $c\text{-}C_3H_5Br$	160
	373	4.6×10^{-25}	MS, 16	0.96 eV ion exit energy; $C_3H_5^+$ from $c\text{-}C_3H_5Br$	160
	373	2.35×10^{-25}	MS, 16	1.60 eV ion exit energy; $C_3H_5^+$ from $c\text{-}C_3H_5Br$	160
$C_3H_5^+ + 2C_2D_4 \rightarrow C_5H_5D_4^+$	373	14.1×10^{-25}	MS, 16	0.64 eV ion exit energy; $C_3H_5^+$ from CH_2CHCH_2Br	160
	373	7.1×10^{-25}	MS, 16	0.96 eV ion exit energy; $C_3H_5^+$ from CH_2CHCH_2Br	160
	373	3.4×10^{-25}	MS, 16	1.60 eV ion exit energy; $C_3H_5^+$ from CH_2CHCH_2Br	160
$C_3H_5^+ + 2C_2D_4 \rightarrow C_5H_5D_4^+$	373	6.2×10^{-25}	MS, 16	0.64 eV ion exit energy; $C_3H_5^+$ from CH_2CBrCH_3	160
	373	2.45×10^{-25}	MS, 16	0.96 eV ion exit energy; $C_3H_5^+$ from CH_2CBrCH_3	160
	373	0.93×10^{-25}	MS, 16	1.60 eV ion exit energy; $C_3H_5^+$ from CH_2CBrCH_3	160
$C_3H_5^+ + 2C_2D_4 \rightarrow C_5H_5D_4^+$	373	3.6×10^{-25}	MS, 16	0.64 eV ion exit energy; $C_3H_5^+$ from $CHBrCHCH_3$	160

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$C_3H_5^+ + 2C_2D_4 \rightarrow C_5H_5D_4^+$	373	2.1×10^{-25}	MS, 16	0.96 eV ion exit energy; $C_3H_5^+$ from $CHBrCHCH_3$	160
	373	0.10×10^{-25}	MS, 16	1.60 eV ion exit energy; $C_3H_5^+$ from $CHBrCHCH_3$	160
$C_3H_5^+ + C_3H_8 \rightarrow$		$1.8 \pm 0.5 \times 10^{-10}$	MS, 26	$C_3H_5^+$ from C_3H_8	35
$C_3H_5^+ + c\text{-}C_4H_8 \rightarrow$		1.13×10^{-9}	MS, 40	$C_3H_5^+$ from $c\text{-}C_4H_8$	132
$C_3H_5^+ + i\text{-}C_4H_8 \rightarrow$		$1.05 \pm 0.08 \times 10^{-10}$	MS, 16	$C_3H_5^+$ from $i\text{-}C_4H_8$	131
$C_3H_5^+ + n\text{-}C_4H_{10} \rightarrow$		$5.0 \pm 0.6 \times 10^{-10}$	MS, 26	$C_3H_5^+$ from $n\text{-}C_4H_{10}$	133
$C_3H_5^+ + i\text{-}C_4H_{10} \rightarrow$		$5.8 \pm 0.4 \times 10^{-10}$	MS, 26	$C_3H_5^+$ from $i\text{-}C_4H_{10}$	133
$C_3H_5^+ + CD_3OCD_3 \rightarrow CD_3OCD_2^+$		$5.3 \pm 0.3 \times 10^{-10}$	TI, 14	$C_3H_5^+$ from C_3H_8	110
$C_3H_6^+ + C_2H_6 \rightarrow C_4H_8^+$	300	3×10^{-11}	ICR, 149	$C_3H_6^+$ from C_3H_6	149
$C_3H_6^+ + C_3H_6 \rightarrow C_3H_7^+, C_4H_7^+, C_4H_8^+, C_5H_9^+$		$8.0 \pm 0.5 \times 10^{-10}$	MS, 16		159
	300	$8.4 \pm 0.4 \times 10^{-10}$	MS, 136	10.0 eV photoionization	132
	300	$6.8 \pm 0.3 \times 10^{-10}$	MS, 136	11.7 eV photoionization	137
$C_3H_6^+ + C_3H_6 \rightarrow C_3H_7^+, C_4H_7^+, C_4H_8^+, C_5H_9^+, C_6H_{12}^+$		7.89×10^{-10}	MS, 138	Error: "Within factor of 2.5"	138
		1.02×10^{-9}	MS, 161		161
$C_3H_6^+ + C_3H_6 \rightarrow C_3H_7^+, C_4H_7^+, C_4H_8^+, C_5H_9^+$		7.56×10^{-10}	MS, 95	$C_3H_6^+$ from C_3H_6	162
$C_3D_6^+ + C_3D_6 \rightarrow C_3D_7^+, C_4D_7^+, C_4D_8^+, C_5D_9^+, C_6D_{12}^+$	300	$7.8 \pm 0.4 \times 10^{-10}$	MS, 136	10.0 eV photoionization	137
	300	$6.1 \pm 0.3 \times 10^{-10}$	MS, 136	11.7 eV photoionization	137
$C_3D_6^+ + C_3D_6 \rightarrow C_3D_7^+, C_4D_7^+, C_4D_8^+, C_5D_9^+$		$8.1 \pm 0.2 \times 10^{-10}$	TI, 14	Assumes $k(CH_4^+ + CH_4) = 1.2 \times 10^{-9}$	14
		6.28×10^{-10}	MS, 95	$C_3D_6^+$ from C_3D_6	162
$C_3H_6^+ + C_3D_8 \rightarrow C_3D_6^+, C_3D_7^+$		3.35×10^{-11}	MS, 95	$C_3H_6^+$ from C_3H_6	161
$C_3H_6^+ + n\text{-}C_4H_{10} \rightarrow$		$4.9 \pm 0.5 \times 10^{-10}$	MS, 136	$C_3H_6^+$ from $n\text{-}C_4H_{10}$	163
		$5.1 \pm 1.1 \times 10^{-10}$	MS, 26	$C_3H_6^+$ from $n\text{-}C_4H_{10}$	133
$C_3H_6^+ + CD_3CD_2CH_2CH_3 \rightarrow C_4D_4H_4^+$		4.09×10^{-10}	MS, 95	$C_3H_6^+$ from C_3H_6	162
$C_3H_6^+ + CD_3CH_2CH_2CD_3 \rightarrow C_4D_5H_3^+$		4.04×10^{-10}	MS, 95	$C_3H_6^+$ from C_3H_6	162
$C_3H_6^+ + n\text{-}C_4D_{10} \rightarrow C_4D_8^+(90\%), C_4D_9^+(10\%)$		3.2×10^{-10}	MS, 95	$C_3H_6^+$ from C_3H_6	162
$C_3D_6^+ + n\text{-}C_4D_{10} \rightarrow C_4D_8^+(100\%)$	295	$4.4 \pm 0.5 \times 10^{-10}$	MS, 136	$C_3D_6^+$ from C_3D_6	136
$C_3D_6^+ + n\text{-}C_4H_{10} \rightarrow C_4H_8^+(88\%), C_4H_9^+(12\%)$		4.45×10^{-10}	MS, 95	$C_3D_6^+$ from C_3D_6	162
$C_3H_6^+ + i\text{-}C_4H_{10} \rightarrow$	295	$4.9 \pm 0.5 \times 10^{-10}$	MS, 136	$C_3H_6^+$ from $i\text{-}C_4H_{10}$	163
		$6.7 \pm 1.0 \times 10^{-10}$	MS, 26	$C_3H_6^+$ from $i\text{-}C_4H_{10}$	133
$C_3H_6^+ + i\text{-}C_4H_{10} \rightarrow C_4H_8^+(31\%), C_4H_9^+(69\%)$		3.97×10^{-10}	MS, 95	$C_3H_6^+$ from C_3H_6	162
$C_3H_6^+ + i\text{-}C_4D_{10} \rightarrow C_4D_8^+, C_4D_9^+$	295	$4.6 \pm 0.5 \times 10^{-10}$	MS, 136	$C_3H_6^+$ from C_3H_6	136
$C_3H_6^+ + i\text{-}C_4D_{10} \rightarrow C_4D_8^+(33\%), C_4D_9^+(67\%)$		4.3×10^{-10}	MS, 95	$C_3H_6^+$ from C_3H_6	162
$C_3D_6^+ + i\text{-}C_4H_{10} \rightarrow C_4H_8^+(43\%), C_4H_9^+(57\%)$	295	$4.2 \pm 0.4 \times 10^{-10}$	MS, 136	$C_3D_6^+$ from C_3D_6	136
$C_3D_6^+ + i\text{-}C_4H_{10} \rightarrow C_4H_8^+(31\%), C_4H_9^+(69\%)$		4.56×10^{-10}	MS, 95	$C_3D_6^+$ from C_3D_6	162
$C_3D_6^+ + c\text{-}C_5H_{10} \rightarrow C_5H_8^+(97\%), C_5H_9^+(3\%)$	300	$9.1 \pm 0.9 \times 10^{-10}$	MS, 136	$C_3D_6^+$ from C_3D_6	136
$C_3H_6^+ + n\text{-}C_5H_{12} \rightarrow$	300	$7.9 \pm 0.8 \times 10^{-10}$	MS, 136	$C_3H_6^+$ from $n\text{-}C_5H_{12}$	163
$C_3D_6^+ + n\text{-}C_5H_{12} \rightarrow C_5H_{10}^+(96\%), C_5H_{11}^+(4\%)$	300	$8.2 \pm 0.8 \times 10^{-10}$	MS, 136	$C_3D_6^+$ from C_3D_6	136
$C_3H_6^+ + i\text{-}C_5H_{12} \rightarrow$	300	$7.6 \pm 0.8 \times 10^{-10}$	MS, 136	$C_3H_6^+$ from $i\text{-}C_5H_{12}$	163
$C_3D_6^+ + i\text{-}C_5H_{12} \rightarrow C_5H_{10}^+(61\%), C_5H_{11}^+(39\%)$	300	$7.9 \pm 0.8 \times 10^{-10}$	MS, 136	$C_3D_6^+$ from C_3D_6	136
$C_3D_6^+ + CH_3OH \rightarrow CH_3OHD^+$	300	$1.0 \pm 0.4 \times 10^{-9}$	MS, 136	$C_3D_6^+$ from C_3D_6	164
$C_3H_6^+ + CD_3OCD_3 \rightarrow (CD_3OCD_3)H^+$		$1.33 \pm 0.05 \times 10^{-9}$	TI, 14	$C_3H_6^+$ from C_3H_6	110
$C_3D_6^+ + NH_3 \rightarrow NH_3D^+$	300	$9.4 \pm 0.4 \times 10^{-10}$	MS, 136	$C_3D_6^+$ from C_3D_6	164
$C_3H_6^+ + NO \rightarrow NO^+$		$3.85 \pm 0.4 \times 10^{-10}$	B, 74	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	
$C_3D_6^+ + NO \rightarrow NO^+$		$4.0 \pm 0.4 \times 10^{-10}$	B, 74	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	
$c\text{-}C_3H_6^+ + c\text{-}C_3H_6 \rightarrow$	300	$2.2 \pm 0.2 \times 10^{-10}$	MS, 136	10.0 eV photoionization of $c\text{-}C_3H_6$	137
	300	$2.2 \pm 0.2 \times 10^{-10}$	MS, 136	11.7 eV photoionization of $c\text{-}C_3H_6$	137
	300	$1.5 \pm 0.5 \times 10^{-10}$	TI, 14	$c\text{-}C_3H_6^+$ from $c\text{-}C_3H_6$	159
		$1.14 \pm 0.24 \times 10^{-9}$	MS, 138	$c\text{-}C_3H_6^+$ from $c\text{-}C_3H_6$	138
		1.1×10^{-10}	MS, 95	$c\text{-}C_3H_6^+$ from $c\text{-}C_3H_6$	162
$c\text{-}C_3H_6^+ + n\text{-}C_4D_{10} \rightarrow C_4D_9^+(68\%), C_4D_8^+(32\%)$		$>1.87 \times 10^{-10}$	MS, 95	$c\text{-}C_3H_6^+$ from $c\text{-}C_3H_6$	162
$c\text{-}C_3H_6^+ + i\text{-}C_4D_{10} \rightarrow C_4D_9^+(\geq 97\%)$		1.46×10^{-10}	MS, 95	$c\text{-}C_3H_6^+$ from $c\text{-}C_3H_6$	162
$c\text{-}C_3D_6^+ + NH_3 \rightarrow NH_3D^+, CD_2H_2N^+, CD_2NH_3^+$	295	$9.4 \pm 0.4 \times 10^{-10}$	MS, 136	10.6 eV photoionization of $c\text{-}C_3D_6$	164
$\rightarrow NH_3D^+, CD_2H_2N^+, CD_2NH_3^+$	295	$9.3 \pm 0.3 \times 10^{-10}$		11.6-11.8 eV photoionization of $c\text{-}C_3D_6$	164
$c\text{-}C_3H_6^+ + NO \rightarrow NO^+$		3.0×10^{10}	B, 74	$c\text{-}C_3H_6^+$ from $c\text{-}C_3H_6$	75

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
sec-$C_3D_5H_2^+$ + $CD_3CH_2CD_3$ →		$3\pm1 \times 10^{-11}$	TI, 14	$C_3D_5H_2^+$ from $CD_3CH_6CD_3$	112
	300	$1.2\pm0.1 \times 10^{-10}$	ICR, 154	sec-$C_3D_5H_2^+$ collisionally deactivated	154
sec-$C_3H_7^+$ + i-C_4H_8 →		$5.8\pm0.2 \times 10^{-10}$	MS, 16	sec-$C_3H_7^+$ from i-C_4H_8	131
		4.6×10^{-10}	MS, 40	calculated from cross section (ref. 131)	165
sec-$C_3H_7^+$ + n-C_4H_{10} → $C_4H_9^+$	300	$5.6\pm0.2 \times 10^{-10}$(*)	ICR, 154	sec-$C_3H_7^+$, collisionally deactivated	154
	300	4.4×10^{-10}	MS, 136	sec-$C_3H_7^+$ from n-C_4H_{10}	163
	450	4.0×10^{-10}	MS, 26	sec-$C_3H_7^+$ from n-C_4H_{10}	166
	450	$3.9\pm0.3 \times 10^{-10}$	MS, 26	sec-$C_3H_7^+$ from n-C_4H_{10}	133
sec-$C_3H_7^+$ + i-C_4H_{10} → $C_4H_9^+$	300	$4.2\pm0.2 \times 10^{-10}$(*)	ICR, 154	sec-$C_3H_7^+$ collisionally deactivated	154
	300	3.3×10^{-10}	MS, 136	sec-$C_3H_7^+$ from i-C_4H_{10}	163
	450	4.0×10^{-10}	MS, 26	sec-$C_3H_7^+$ from i-C_4H_{10}	166
	450	$4.0\pm0.3 \times 10^{-10}$	MS, 26	sec-$C_3H_7^+$ from i-C_4H_{10}	133
sec-$C_3H_7^+$ + n-C_5H_{12} → $C_5H_{11}^+$	300	$8.3\pm0.3 \times 10^{-10}$	ICR, 154	sec-$C_3H_7^+$ collisionally deactivated	154
	300	5.2×10^{-10}	MS, 136	sec-$C_3H_7^+$ from n-C_5H_{12}	163
sec-$C_3H_7^+$ + i-C_5H_{12} → $C_5H_{11}^+$	300	4.7×10^{-10}	MS, 136	sec-$C_3H_7^+$ from i-C_5H_{12}	163
sec-$C_3H_7^+$ + neo-C_5H_{12} → $C_5H_{11}^+$	300	$2.6\pm0.2 \times 10^{-10}$	ICR, 154	sec-$C_3H_7^+$ collisionally deactivated	154
sec-$C_3H_7^+$ + n-C_6H_{14} → $C_6H_{13}^+$	300	$1.10\pm0.02 \times 10^{-9}$	ICR, 154	sec-$C_3H_7^+$ collisionally deactivated	154
sec-$C_3H_7^+$ + n-C_8H_{18} → $C_8H_{17}^+$	300	$1.48\pm0.05 \times 10^{-9}$	ICR, 154	sec-$C_3H_7^+$ collisionally deactivated	154
sec-$C_3H_7^+$ + $(CH_3)_2CHCH(CH_3)CH(CH_3)_2$ → $C_8H_{17}^+$		$1.45\pm0.12 \times 10^{-9}$	ICR, 154	sec-$C_3H_7^+$ collisionally deactivated	154
sec-$C_3H_7^+$ + CH_3NH_2 →	300	2.25×10^{-9}	ICR, 154	sec-$C_3H_7^+$ from n-C_4H_{10}	115
sec-$C_3H_7^+$ + $(CH_3)_2NH$ →	300	1.64×10^{-9}	ICR, 154	sec-$C_3H_7^+$ from n-C_4H_{10}	115
sec-$C_3H_7^+$ + CD_3OCD_3 → $(CD_3OCD_3)H^+$		$1.24\pm0.15 \times 10^{-9}$	TI, 14	sec-$C_3H_7^+$ from C_3H_8	110
sec-$C_3H_7^+$ + NH_3 →	300	1.95×10^{-9}	ICR, 154	sec-$C_3H_7^+$ from n-C_4H_{10}	115
sec-$C_3H_7^+$ + D_2O →		$3.7\pm0.8 \times 10^{-10}$	MS, 71	Reactant ions translationally excited	72
$C_3H_8^+$ + $2C_3H_8$ → $(C_3H_8)_2^+$	300	$3.6\pm1.0 \times 10^{-26}$	MS, 136	Photoionization	167
$C_3H_8^+$ + n-C_4H_{10} → $C_4H_{10}^+$	300	$1.17\pm0.10 \times 10^{-9}$	ICR, 154	$C_3H_8^+$ from C_3H_8	168
$C_3H_8^+$ + i-C_4H_{10} → $C_4H_{10}^+$	300	$1.29\pm0.10 \times 10^{-9}$	ICR, 154	$C_3H_8^+$ from C_3H_8	168
$C_3H_8^+$ + CD_3OCD_3 → $(CD_3OCD_3)H^+$		$1.85\pm0.08 \times 10^{-9}$	TI, 14	$C_3H_8^+$ from C_3H_8	110
$C_3H_8^+$ + H_2O → H_3O^+	300	1.4×10^{-9}	MS, 136	Photoionization	158
$C_3H_8^+$ + D_2O →		$1.3\pm0.3 \times 10^{-9}$	MS, 71	$C_3H_8^+$ translationally excited	72
$C_3H_8^+$ + NO → NO^+		3.9×10^{-10}	B, 74	Assumes k(CH_4^+ + CH_4) = 1.1×10^{-9}	75
$C_3D_8^+$ + NO →		3.8×10^{-10}	B, 74	Assumes k(CH_4^+ + CH_4) = 1.1×10^{-9}	75
$C_3H_9^+$ + C_2H_6 → $C_4H_9^+$	300	1.0×10^{-10}	ICR, 149	$C_3H_9^+$ from $C_2H_6^+$ + C_2H_6	149
$C_4H_2^+$ + C_2H_2 →		1×10^{-10}	TI, 14	$C_4H_2^+$ from $C_2H_2^+$ + C_2H_2	14
$C_4H_2^+$ + C_2H_2 → $C_6H_4^+$	295	$2.3\pm0.3 \times 10^{-10}$	TI, 47	$C_4H_2^+$ from $C_2H_2^+$ + C_2H_2	47
$C_4H_2^+$ + C_2H_4 →		7.0×10^{-10}	TI, 47	$C_4H_2^+$ from fragment ion reactions in C_2H_4	14
$C_4H_2^+$ + C_6H_6 → $C_{10}H_7^+$		4.73×10^{-10}	MS, 82	$C_4H_2^+$ from C_6H_6	83
$C_4H_3^+$ + C_2H_2 → $C_6H_5^+$	295	3.6×10^{-11}	TI, 47	$C_4H_3^+$ from $C_2H_2^+$ + C_2H_2	47
$C_4H_3^+$ + C_2H_4 →		2.6×10^{-10}	TI, 14	$C_4H_3^+$ from fragment ion reactions in C_2H_4	14
$C_4H_3^+$ + i-C_4H_8 →		$9.3\pm0.6 \times 10^{-10}$	MS, 16	$C_4H_3^+$ from i-C_4H_8	131
$C_4H_3^+$ + C_6H_6 → $C_{10}H_8^+$		1.93×10^{-10}	MS, 82	$C_4H_3^+$ from C_6H_6	83
$C_4H_4^+$ + i-C_4H_8 →		$6.7\pm0.4 \times 10^{-10}$	MS, 16	$C_4H_4^+$ from i-C_4H_8	131
$C_4H_4^+$ + C_6H_6 → $C_9H_7^+$		3.62×10^{-11}	MS, 82	$C_4H_4^+$ from C_6H_6	83
$C_4H_4^+$ + C_6H_6 → $C_6H_6^+$	440	5×10^{-9}	MS, 26	$C_4H_4^+$ from C_6H_6	169
$C_4H_5^+$ + i-C_4H_8 →		$1.2\pm0.2 \times 10^{-10}$	MS, 16	$C_4H_5^+$ from i-C_4H_8	131
$C_4H_6^+$ + i-C_4H_8 →		$7.5\pm0.4 \times 10^{-10}$	MS, 16	$C_4H_6^+$ from i-C_4H_8	131
$C_4H_7^+$ + 1-C_4H_8 →	450	6×10^{-10}	MS, 26	$C_4H_7^+$ from 1-C_4H_8	166
$C_4H_7^+$ + 2-C_4H_8 →	450	3×10^{-10}	MS, 26	$C_4H_7^+$ from 2-C_4H_8	166
$C_4H_7^+$ + i-C_4H_8 →		$3.7\pm0.2 \times 10^{-10}$	MS, 16	$C_4H_7^+$ from i-C_4H_8	131
		$3.6\pm0.2 \times 10^{-10}$	B, 74	$C_4H_7^+$ from i-C_4H_8	165
$C_4H_8^+$ + C_2H_4 → $C_6H_{12}^+$		2×10^{-12}	MS, 52	$C_4H_8^+$ from $C_2H_4^+$ + C_2H_4	144
$C_4H_8^+$ + n-C_4H_{10} → Products other than $C_4H_8^+$		$<1 \times 10^{-12}$	MS, 26	$C_4H_8^+$ from n-C_4H_{10}	133
$C_4H_8^+$ + i-C_4H_{10} → Products other than $C_4H_8^+$		$2.1\pm0.3 \times 10^{-10}$	MS, 26	$C_4H_8^+$ from i-C_4H_{10}	133
$C_4H_8^+$ + n-C_5H_{12} →		4×10^{-11}	MS, 136	$C_4H_8^+$ from n-C_5H_{12}	163

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$C_4H_8^+ + i\text{-}C_5H_{12} \rightarrow$		$<5 \times 10^{-11}$	MS, 136	$C_4H_8^+$ from $i\text{-}C_5H_{12}$	163
$C_4H_8^+ + c\text{-}C_6H_{12} \rightarrow$		7×10^{-11}	MS, 136	$C_4H_8^+$ from $c\text{-}C_6H_{12} + c\text{-}C_4H_8$	170
$C_4H_8^+ + NO \rightarrow NO^+$		1×10^{-9}	MS, 136	$C_4H_8^+$ from $c\text{-}C_6H_{12}^+ + c\text{-}C_4H_8$	170
$1\text{-}C_4H_8^+ + 1\text{-}C_4H_8 \rightarrow$	300	$6.0 \pm 0.5 \times 10^{-10}$	MS, 136	Photoionization	171
$1\text{-}C_4H_8^+ + NO \rightarrow NO^+$		1.9×10^{-10}	B, 74	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	75
$2\text{-}C_4H_8^+ + cis\text{-}2\text{-}C_4H_8 \rightarrow$		$3.7 \pm 1 \times 10^{-11}$	MS, 136	Photoionization	171
$2\text{-}C_4H_8^+ + c\text{-}C_5H_{10} \rightarrow$	300	$<4 \times 10^{-12}$	MS, 136	Photoionization of $2\text{-}C_4H_8$	136
$2\text{-}C_4H_8^+ + c\text{-}C_5H_9CH_3 \rightarrow C_6H_{10}^+(100\%)$	300	3.9×10^{-10}	MS, 136	Photoionization of $2\text{-}C_4H_8$	136
$2\text{-}C_4H_8^+ + c\text{-}C_5H_9CH_3 \rightarrow$	300	5×10^{-10}	MS, 136	Photoionization of $2\text{-}C_4H_8$	170
$2\text{-}C_4H_8^+ + NO \rightarrow NO^+$		1.0×10^{-11}	B, 74	$2\text{-}C_4H_8^+$ from $trans\text{-}2\text{-}C_4H_8$	75
$2\text{-}C_4H_8^+ + NO \rightarrow NO^+$		1.3×10^{-11}	B, 74	$2\text{-}C_4H_8^+$ from $cis\text{-}2\text{-}C_4H_8$	75
$i\text{-}C_4H_8^+ + i\text{-}C_4H_8 \rightarrow$		$5.2 \pm 0.4 \times 10^{-10}$	MS, 16	$i\text{-}C_4H_8^+$ from $i\text{-}C_4H_8$	131
	300	$5.4 \pm 0.4 \times 10^{-10}$	MS, 136	Photoionization of $i\text{-}C_4H_8$	171
$i\text{-}C_4D_8^+ + i\text{-}C_4D_8 \rightarrow$	300	$5.4 \pm 0.4 \times 10^{-10}$	MS, 136	Photoionization of $i\text{-}C_4D_8$	171
$i\text{-}C_4H_8^+ + c\text{-}C_5H_9CH_3 \rightarrow C_6H_{10}^+, C_6H_{11}^+$	300	$7.9 \pm 0.8 \times 10^{-10}$	MS, 136	Photoionization of $i\text{-}C_4H_8$	136
$i\text{-}C_4H_8^+ + NO \rightarrow NO^+$		2.3×10^{-11}	B, 74	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	75
$c\text{-}C_3H_5CH_3^+ + c\text{-}C_3H_5CH_3 \rightarrow$	300	$6.0 \pm 1 \times 10^{-11}$	MS, 136	Photoionization	171
$c\text{-}C_4H_8^+ + c\text{-}C_5H_9CH_3 \rightarrow$	300	$6.3 \pm 0.7 \times 10^{-10}$	MS, 136	$c\text{-}C_4H_8^+$ from $c\text{-}C_4H_8$	170
$c\text{-}C_4H_8^+ + (CH_3)_2CHCH_2CH_2CH_3 \rightarrow$	300	$3.6 \pm 0.4 \times 10^{-10}$	MS, 136	$c\text{-}C_4H_8^+$ from $c\text{-}C_4H_8$	170
$c\text{-}C_4H_8^+ + (CH_3)_3N \rightarrow (CH_3)_3N^+$	300	$3.2 \pm 0.4 \times 10^{-9}$	MS, 136	$c\text{-}C_4H_8^+$ from $c\text{-}C_4H_8$	170
$c\text{-}C_4H_8^+ + NO \rightarrow NO^+$	300	$1.07 \pm 0.1 \times 10^{-9}$	MS, 136	$c\text{-}C_4H_8^+$ from $c\text{-}C_4H_8$	170
$c\text{-}C_4H_8^+ + NO + c\text{-}C_4H_8 \rightarrow C_4H_8NO^+$	300	$2.5 \pm 0.8 \times 10^{-25}$	MS, 136	$c\text{-}C_4H_8^+$ from $c\text{-}C_4H_8$	170
$C_4H_9^+ + C_3H_6 \rightarrow$	450	3.2×10^{-10}	MS, 26	$C_4H_9^+$ from $n\text{-}C_4H_{10}$	166
$C_4H_9^+ + 1\text{-}C_4H_8 \rightarrow$	450	5.7×10^{-10}	MS, 26	$C_4H_9^+$ from $n\text{-}C_4H_{10}$	166
$C_4H_9^+ + i\text{-}C_4H_8 \rightarrow$	450	5×10^{-11}	MS, 26	$C_4H_9^+$ from $n\text{-}C_4H_{10}$	166
$C_4H_9^+ + n\text{-}C_4H_{10} \rightarrow$	450	$<7 \times 10^{-13}$	MS, 26	$C_4H_9^+$ from $n\text{-}C_4H_{10}$	133
$C_4H_9^+ + 1\text{-}C_5H_{10} \rightarrow$	450	7.0×10^{-10}	MS, 26	$C_4H_9^+$ from $n\text{-}C_4H_{10}$	166
$sec\text{-}C_4H_9^+ + n\text{-}C_5H_{12} \rightarrow C_5H_{11}^+$	300	$3.7 \pm 0.4 \times 10^{-10}$	MS, 136	$C_4H_9^+$ from $n\text{-}C_5H_{12}$	163
$sec\text{-}C_4H_9^+ + i\text{-}C_5H_{12} \rightarrow C_5H_{11}^+$	300	$3.8 \pm 0.4 \times 10^{-10}$	MS, 136	$C_4H_9^+$ from $i\text{-}C_5H_{12}$	163
$sec\text{-}C_4H_9^+ + c\text{-}C_6H_{12} \rightarrow C_6H_{11}^+$	300	1.0×10^{-9}	R, 172	Radiolysis	172
$sec\text{-}C_4H_9^+ + n\text{-}C_6H_{14} \rightarrow C_6H_{13}^+$	300	7×10^{-10}	R, 172	Radiolysis	172
$t\text{-}C_4H_9^+ + C_3H_6 \rightarrow$	450	1.4×10^{-10}	MS, 26	$C_4H_9^+$ from $i\text{-}C_4H_{10}$	166
$t\text{-}C_4H_9^+ + 1\text{-}C_4H_8 \rightarrow$	450	2.7×10^{-10}	MS, 26	$C_4H_9^+$ from $i\text{-}C_4H_{10}$	166
$t\text{-}C_4H_9^+ + tr\text{-}2\text{-}C_4H_8 \rightarrow$	450	4×10^{-9}	MS, 26	$C_4H_9^+$ from $i\text{-}C_4H_{10}$	166
$t\text{-}C_4H_9^+ + i\text{-}C_4H_8 \rightarrow C_8H_{17}^+$	450	7×10^{-9}	MS, 26	$C_4H_9^+$ from $i\text{-}C_4H_{10}$	166
$t\text{-}C_4H_9^+ + i\text{-}C_4H_{10} \rightarrow$	450	$<1 \times 10^{-13}$	MS, 26	$C_4H_9^+$ from $i\text{-}C_4H_{10}$	133
$t\text{-}C_4H_9^+ + (CH_3)_2CHC_2H_5 \rightarrow t\text{-}C_5H_{11}^+$	190	5.21×10^{-11}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	262	2.75×10^{-11}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	320	1.4×10^{-11}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	173
	328	1.56×10^{-11}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	358	1.27×10^{-11}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	385	8.5×10^{-12}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	388	7.8×10^{-12}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	389	7.3×10^{-12}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	470	3.6×10^{-12}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	520	4.0×10^{-12}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	570	2.3×10^{-12}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	147
	640	1.7×10^{-12}	MS, 147	$t\text{-}C_4H_9^+$ collisionally deactivated	173
$t\text{-}C_4H_9^+ + c\text{-}C_5H_9CH_3 \rightarrow$	300	2.3×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ + \text{2-methylheptane}) = 5.3 \times 10^{-11}$	174
	300	2.7×10^{-11}	R, 175	Assumes $k(t\text{-}C_4H_9^+ + \text{2-methylheptane}) = 5.3 \times 10^{-11}$	175
$t\text{-}C_4H_9^+ + n\text{-}C_6H_{14} \rightarrow C_6H_{13}^+$	300	3×10^{-13}	R. 174	Assumes $k(t\text{-}C_4H_9^+ + \text{2-methylheptane}) = 5.3 \times 10^{-11}$	174

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$t\text{-}C_4H_9^+ + t\text{-}C_4H_9OH \rightarrow$	300	8.9×10^{-10}	ICR, 62	$t\text{-}C_4H_9^+$ from $t\text{-}C_4H_9OH$	178
$t\text{-}C_4H_9^+ + C_6H_5CH_2OCOCH_3 \rightarrow$	300-400	1.1×10^{-9}	MS, 116	k independent of T(300-400 K)	116
$t\text{-}C_4H_9^+ + NH_3 \rightarrow$	300	1.16×10^{-9}	ICR, 76	$t\text{-}C_4H_9^+$ from neopentane	115
	300	9.1×10^{-10}	ICR, 76	$t\text{-}C_4H_9^+$ from neopentane	176
	300	9.7×10^{-10}	ICR, 76	$t\text{-}C_4H_9^+$ from $n\text{-}C_4H_9Cl$	176
	300	1.40×10^{-9}	ICR, 76	$t\text{-}C_4H_9^+$ from $(i\text{-}C_4H_8^+ + i\text{-}C_4H_8)$	176
$CD_3CD_2CD_2CH_3^+ + c\text{-}C_4H_8 \rightarrow C_4H_8^+$	300	$7.0 \pm 0.2 \times 10^{-10}$	ICR, 154	$CD_3CD_2CD_2CH_3^+$ from $n\text{-}CD_3CD_2CD_2CH_3$	168
$CD_3CD_2CD_2CH_3^+ + c\text{-}C_5H_{10} \rightarrow C_5H_{10}^+$	300	$5.8 \pm 1.0 \times 10^{-10}$	ICR, 154	$CD_3CD_2CD_2CH_3^+$ from $n\text{-}CD_3CD_2CD_2CH_3$	168
$CD_3CD_2CD_2CH_3^+ + n\text{-}C_5H_{12} \rightarrow C_5H_{12}^+$	300	$7.1 \pm 0.5 \times 10^{-10}$	ICR, 154	$CD_3CD_2CD_2CH_3^+$ from $n\text{-}CD_3CD_2CD_2CH_3$	168
$CD_3CD_2CD_2CH_3^+ + n\text{-}C_6H_{14} \rightarrow C_6H_{14}^+$	300	$9.4 \pm 0.8 \times 10^{-10}$	ICR, 154	$CD_3CD_2CD_2CH_3^+$ from $n\text{-}CD_3CD_2CD_2CH_3$	168
$CD_3CD_2CD_2CH_3^+ + n\text{-}C_7H_{16} \rightarrow C_7H_{16}^+$	300	$10.5 \pm 0.7 \times 10^{-10}$	ICR, 154	$CD_3CD_2CD_2CH_3^+$ from $n\text{-}CD_3CD_2CD_2CH_3$	168
$CD_3CD_2CD_2CH_3^+ + n\text{-}C_8H_{18} \rightarrow C_8H_{18}^+$	300	$13.5 \pm 0.5 \times 10^{-10}$	ICR, 154	$CD_3CD_2CD_2CH_3^+$ from $n\text{-}CD_3CD_2CD_2CH_3$	168
$CD_3CD_2CD_2CH_3^+ + n\text{-}C_9H_{20} \rightarrow C_9H_{20}^+$	300	$13.1 \pm 0.5 \times 10^{-10}$	ICR, 154	$CD_3CD_2CD_2CH_3^+$ from $n\text{-}CD_3CD_2CD_2CH_3$	168
$n\text{-}C_4H_{10}^+ + 2H_2O \rightarrow H^+(H_2O)_2$	300	$4 \pm 1 \times 10^{-25}$	MS, 136	$n\text{-}C_4H_{10}^+$ from $n\text{-}C_4H_{10}$	158
$n\text{-}C_4H_{10}^+ + H_2O \rightarrow$	300	3.9×10^{-10}	MS, 179	Pressure of H_2O varied	179
	300	4.1×10^{-10}	MS, 179	Temperature varied	179
$n\text{-}C_4H_{10}^+ + D_2O \rightarrow$		$1.6 \pm 0.5 \times 10^{-9}$	MS, 71	Ions translationally excited	72
$n\text{-}C_4H_{10}^+ + NO \rightarrow NO^+$		3.6×10^{-10}	B, 74	Assumes $k(CH_4^+ + CH_4) = 1.1 \times 10^{-9}$	75
$i\text{-}C_4H_{10}^+ + 2H_2O \rightarrow H^+(H_2O)_2$	300	$1.2 \pm 0.2 \times 10^{-25}$	MS, 136	$i\text{-}C_4H_{10}^+$ from $i\text{-}C_4H_{10}$	158
$i\text{-}C_4H_{10}^+ + H_2O \rightarrow$	300	3.0×10^{-10}	MS, 179	Pressure of H_2O varied	179
	300	4.4×10^{-10}	MS, 179	Time varied	179
$C_5H_3^+ + c\text{-}C_6H_6 \rightarrow C_{11}H_7^+$		5.83×10^{-11}	MS, 82	$C_5H_3^+$ from C_6H_6	83
$C_5H_7^+ + c\text{-}C_6H_{10} \rightarrow C_{11}H_{17}^+$	300	$2.5 \pm 0.3 \times 10^{-10}$	MS, 136	$C_5H_7^+$ from $c\text{-}C_6H_{10}$	180
$C_5H_8^+ + c\text{-}C_5H_8 \rightarrow C_5H_6^+(55\%), C_{10}H_{16}^+(45\%)$	300	6.0×10^{-10}	MS, 136	$C_5H_8^+$ from $c\text{-}C_5H_8$	181
$c\text{-}C_5H_{10}^+ + H_2O \rightarrow$	300	9.5×10^{-11}	MS, 179	Pressure varied	179
	300	5.0×10^{-11}	MS, 179	Time varied	179
$c\text{-}C_5H_{10}^+ + 2H_2O \rightarrow H^+(H_2O)_n$	295	$5 \pm 1 \times 10^{-26}$	MS, 136	$c\text{-}C_5H_8^+$ from $c\text{-}C_5H_8$	158
$t\text{-}C_5H_{11}^+ + i\text{-}C_4H_{10} \rightarrow$	190	0.3×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	262	1.8×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	328	3.8×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	358	4.4×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	385	4.6×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	388	4.1×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	389	3.9×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	470	3.9×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	520	6.1×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
	570	5.0×10^{-13}	MS, 147	$t\text{-}C_5H_{11}^+$ from isopentane	147
$t\text{-}C_5H_{11}^+ + CH_3NH_2 \rightarrow CH_3NH_3^+$	300	$9.1 \pm 1.4 \times 10^{-10}$	ICR, 46	$C_5H_{11}^+$ from $n\text{-}C_5H_{11}Cl$	176
$t\text{-}C_5H_{11}^+ + NH_3 \rightarrow NH_4^+$	300	$6.5 \pm 1.0 \times 10^{-10}$	ICR, 46	$C_5H_{11}^+$ from $n\text{-}C_5H_{11}Cl$	176
$n\text{-}C_5H_{12}^+ + C_3D_6 \rightarrow C_5H_{10}^+$	300	$1.5 \pm 0.2 \times 10^{-9}$	MS, 136		136
$n\text{-}C_5H_{12}^+ + 2H_2O \rightarrow H^+(H_2O)_2$	300	$4.6 \pm 0.5 \times 10^{-26}$	MS, 136		158
$n\text{-}C_5H_{12}^+ + D_2O \rightarrow$		$2.0 \pm 0.6 \times 10^{-9}$	MS, 71	Ions translationally heated	72
$i\text{-}C_5H_{12}^+ + C_3H_6 \rightarrow C_5H_{10}^+(50\%), C_5H_9^+(50\%)$	300	$1.9 \pm 0.2 \times 10^{-9}$	MS, 136	$i\text{-}C_5H_{12}^+$ from isopentane	136
$i\text{-}C_5H_{12}^+ + c\text{-}C_3H_6 \rightarrow C_5H_{10}^+(10\%), C_5H_9^+(90\%)$	300	$6.0 \pm 2 \times 10^{-10}$	MS, 136	$i\text{-}C_5H_{12}^+$ from isopentane	136
$i\text{-}C_5H_{12}^+ + 2H_2O \rightarrow H^+(H_2O)_2$	300	1.5×10^{-26}	MS, 136	$i\text{-}C_5H_{12}^+$ from isopentane	158
$C_6H_4^+ + C_6H_6 \rightarrow C_{12}H_{10}^+, C_{12}H_8^+$		1.41×10^{-10}	MS, 82	$C_6H_4^+$ from $c\text{-}C_6H_6$	83
$\rightarrow C_{12}H_{10}^+$		1.27×10^{-10}	MS, 82	$C_6H_4^+$ from $c\text{-}C_6H_6$	182
$C_6H_4^+ + C_6H_6 \rightarrow C_{12}H_{10}^+, C_{12}H_8^+$	295	$5.5 \pm 1.6 \times 10^{-10}$	MS, 183	$C_6H_4^+$ from C_6H_6, 30 eV electrons	183
	295	$4.5 \pm 1.3 \times 10^{-10}$	MS, 183	$C_6H_4^+$ from C_6H_6, 50 eV electrons	183
$C_6H_5^+ + C_6H_6 \rightarrow C_{12}H_{11}^+, C_{12}H_9^+, C_{10}H_9^+$		1.97×10^{-10}	MS, 82	$C_6H_5^+$ from C_6H_6	83
		3.66×10^{-10}	MS, 82	$C_6H_5^+$ from C_6H_6	182
$C_6H_5^+ + C_6H_6 \rightarrow C_{12}H_{11}^+, C_{12}H_9^+, C_{10}H_9^+$	295	$5.03 \pm 1.5 \times 10^{-10}$	MS, 183	$C_6H_5^+$ from C_6H_6, 20 eV electrons	183
	295	$5.07 \pm 1.5 \times 10^{-10}$	MS, 183	$C_6H_5^+$ from C_6H_6, 30 eV electrons	183
	295	$7.09 \pm 2.0 \times 10^{-10}$	MS, 183	$C_6H_5^+$ from C_6H_6, 50 eV electrons	183
$C_6H_6^+ + C_6H_6 \rightarrow C_{12}H_{12}^+$	295	$7 \pm 2 \times 10^{-12}$	MS, 183	$C_6H_6^+$ from C_6H_6, 20 eV electrons	183
	295	$1.2 \pm 0.4 \times 10^{-11}$	MS, 183	$C_6H_6^+$ from C_6H_6, 30 eV electrons	183
	295	$1.3 \pm 0.4 \times 10^{-11}$	MS, 183	$C_6H_6^+$ from C_6H_6, 50 eV electrons	183

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH_2CH_2CH_3 \rightarrow C_6H_{13}^+$	300	1.7×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
	300	1.5×10^{-11}	R, 175	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	175
$t\text{-}C_4H_9^+ + C_2H_5CH(CH_3)C_2H_5 \rightarrow C_6H_{13}^+$	300	1.1×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH(CH_3)_2 \rightarrow$	300	2.3×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
	300	2.1×10^{-11}	R, 175	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	175
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH_2CH_2CH_2CH_2CH_3 \rightarrow C_7H_{15}^+$	300	2.8×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + CH_3CH_2CH(CH_3)CH_2CH_2CH_3 \rightarrow C_7H_{15}^+$	300	1.95×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH_2CH(CH_3)_2 \rightarrow C_7H_{15}^+$	300	8.9×10^{-12}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $CH_3) = 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ (C_2H_5)_3CH \rightarrow C_7H_{15}^+$	300	1.1×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + (CH_3)_2CHC(CH_3)_3 \rightarrow C_7H_{15}^+$	300	1.4×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + CH_2 = C(CH_3)CH_2C(CH_3)_3 \rightarrow$	450	1.3×10^{-9}	MS, 26	$C_4H_9^+$ from $n\text{-}C_4H_{10}$	166
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH_2CH_2CH_2CH_2CH_3 \rightarrow C_8H_{17}^+$	300	$5.3 \pm 0.3 \times 10^{-11}$	ICR, 154	$t\text{-}C_4H_9^+$ from neopentane	154
$t\text{-}C_4H_9^+ + CH_3CH_2CH(CH_3)CH_2CH_2CH_2CH_3 \rightarrow C_8H_{17}^+$		$3.9 \pm 0.5 \times 10^{-11}$	ICR, 154		154
	300	3.6×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH(CH_3)CH_2CH_2CH_3 \rightarrow C_8H_{17}^+$	300	$5.5 \pm 0.6 \times 10^{-11}$	ICR, 154	$t\text{-}C_4H_9^+$ from neopentane	154
	300	4.6×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH_2CH(CH_3)CH_2CH_3 \rightarrow C_8H_{17}^+$	300	$1.9 \pm 0.3 \times 10^{-11}$	ICR, 154	$t\text{-}C_4H_9^+$ from neopentane	154
	300	1.4×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH_2CH_2CH(CH_3)_2 \rightarrow C_8H_{17}^+$	300	$1.0 \pm 0.1 \times 10^{-11}$	ICR, 154	$t\text{-}C_4H_9^+$ from neopentane	154
	300	4.7×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + CH_3CH_2CH(CH_3)CH(CH_3)CH_2CH_3 \rightarrow C_8H_{17}^+$		2.6×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + (CH_3)_3CCH_2CH(CH_3)_2 \rightarrow C_8H_{17}^+$	300	2.5×10^{-12}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{11}$	174
$t\text{-}C_4H_9^+ + (CH_3)_2CHCH(CH_3)CH(CH_3)_2 \rightarrow C_8H_{17}^+$	300	$1.3 \pm 0.2 \times 10^{-11}$	ICR, 154	$t\text{-}C_4H_9^+$ from neopentane	154
	300	1.1×10^{-11}	R, 174	Assumes $k(t\text{-}C_4H_9^+ +$ 2-methylheptane) $= 5.3 \times 10^{-11}$	174
$t\text{-}C_4H_9^+ + CH_3NH_2 \rightarrow$	300	$1.31 \pm 0.20 \times 10^{-9}$	ICR, 76	$t\text{-}C_4H_9^+$ from neopentane	176
	300	$1.20 \pm 0.18 \times 10^{-9}$	ICR, 76	$t\text{-}C_4H_9^+$ from $n\text{-}C_4H_9Cl$	176
	300	$1.43 \pm 0.21 \times 10^{-9}$	ICR, 76	$t\text{-}C_4H_9^+$ from $i\text{-}C_4H_8^+ + i\text{-}C_4H_8$	176
	300	$1.3 \pm 0.1 \times 10^{-9}$	MS, 136	$t\text{-}C_4H_9^+$ from neopentane	177
	300	1.31×10^{-9}	ICR, 76	$t\text{-}C_4H_9^+$ from neopentane	115
		$1.30 \pm 0.15 \times 10^{-9}$(*)		$t\text{-}C_4H_9^+$ from neopentane	
$t\text{-}C_4H_9^+ + (CH_3)_2NH \rightarrow$	300	$1.2 \pm 0.05 \times 10^{-9}$	MS, 136	$t\text{-}C_4H_9^+$ from neopentane	177
	300	1.09×10^{-9}	ICR, 76	$t\text{-}C_4H_9^+$ from neopentane	115
$t\text{-}C_4H_9^+ + (CH_3)_3N \rightarrow$	300	$1.2 \pm 0.1 \times 10^{-9}$	MS, 136	$t\text{-}C_4H_9^+$ from neopentane	177
$t\text{-}C_4H_9^+ + (C_2H_5)_2NH \rightarrow$	300	$1.18 \pm .18, 1.23 \pm .18 \times 10^{-9}$	ICR, 76	$t\text{-}C_4H_9^+$ from neopentane	176
	300	$1.38 \pm 0.21 \times 10^{-9}$	ICR, 76	$t\text{-}C_4H_9^+$ from $(i\text{-}C_4H_8^+ + i\text{-}C_4H_8)$	176
$t\text{-}C_4H_9^+ + (C_2H_5)_3N \rightarrow (C_2H_5)_3NH^+$	320	1.6×10^{-9}	MS, 147		173
	640	1.6×10^{-9}	MS, 147		173
$t\text{-}C_4H_9^+ + 2CH_3OH \rightarrow H^+(CH_3OH)_2$	300	$3.6 \pm 1.5 \times 10^{-26}$	MS, 136	$t\text{-}C_4H_9^+$ from neopentane	177
$t\text{-}C_4H_9^+ + CH_3CHO \rightarrow C_4H_9CH_3CHO^+$	300	$4.2 \pm 0.5 \times 10^{-11}$	MS, 136	$t\text{-}C_4H_9^+$ from neopentane	177
$t\text{-}C_4H_9^+ + CH_3COCH_3 \rightarrow H^+(CH_3COCH_3)$	300	$1.1 \pm 0.1 \times 10^{-9}$	MS, 136	$t\text{-}C_4H_9^+$ from neopentane	177

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$C_6H_6^+ + C_6H_6 \rightarrow C_{12}H_{12}^+$	440	7×10^{-12}	MS, 26	$C_6H_6^+$ from C_6H_6	169
$C_6H_6^+ + C_6D_6 \rightarrow C_6D_6^+$	300	4.8×10^{-10}	B, 74	$C_6H_6^+$ from C_6H_6	184
$C_6H_6^+ + 2C_6H_6 \rightarrow (C_6H_6)_2^+$	300	$1.2 \pm 0.25 \times 10^{-25}$	ICR, 76	$C_6H_6^+$ from C_6H_6	185
$C_6H_6^+ + 2C_6H_6 \rightarrow (C_6H_6)_2^+$	295	$1.9 \pm 0.3 \times 10^{-25}$	MS, 136	$C_6H_6^+$ from C_6H_6	186
$C_6H_6^+ + C_6H_6 + He \rightarrow (C_6H_6)_2^+$	300	$0.4 \pm 0.2 \times 10^{-26}$	ICR, 76	$C_6H_6^+$ from C_6H_6	185
$+ Ne \rightarrow (C_6H_6)_2^+$	300	$0.0 \pm 0.6 \times 10^{-26}$	ICR, 76	$C_6H_6^+$ from C_6H_6	185
$+ Ar \rightarrow (C_6H_6)_2^+$	300	$0.7 \pm 0.6 \times 10^{-26}$	ICR, 76	$C_6H_6^+$ from C_6H_6	185
$+ Kr \rightarrow (C_6H_6)_2^+$	300	$1.1 \pm 0.3 \times 10^{-26}$	ICR, 76	$C_6H_6^+$ from C_6H_6	185
$+ Xe \rightarrow (C_6H_6)_2^+$	300	$1.6 \pm 0.6 \times 10^{-26}$	ICR, 76	$C_6H_6^+$ from C_6H_6	185
$C_6D_6^+ + 2C_6D_6 \rightarrow (C_6D_6)_2^+$	295	$5.26 \pm 1.5 \times 10^{-25}$	MS, 136	k varies with T	186
$c\text{-}C_6H_9^+ + c\text{-}C_6H_{10} \rightarrow$	300	3×10^{-11}	MS, 136	$c\text{-}C_6H_9^+$ from $c\text{-}C_6H_{10}$	180
$c\text{-}C_6H_{10}^+ + c\text{-}C_6H_{10} \rightarrow C_{12}H_{20}^+(85\%), C_6H_8^+$	300	4.8×10^{-10}	MS, 136	$c\text{-}C_6H_{10}^+$ from $c\text{-}C_6H_{10}$	180
$C_5H_7CH_3^+$ + 1-methylcyclopentene $\rightarrow C_6H_8^+, C_6H_9^+$	300	$5.2 \pm 0.6 \times 10^{-10}$	MS, 136	$C_5H_7CH_3^+$ from 1-methylcyclopentene	181
$C_5H_7CH_3^+$ + 3-methylcyclopentene $\rightarrow C_6H_8^+, C_6H_9^+$	300	$4.6 \pm 0.5 \times 10^{-10}$	MS, 136	$C_5H_7CH_3^+$ from 3-methylcyclopentene	181
$C_5H_7CH_3^+$ + 4-methylcyclopentene $\rightarrow C_6H_8^+, C_6H_9^+$	300	$5.2 \pm 0.6 \times 10^{-10}$	MS, 136	$C_5H_7CH_3^+$ from 4-methylcyclopentene	181
$c\text{-}C_6H_{11}^+ + NO \rightarrow C_6H_{11}NO^+$	300	1×10^{-10}	MS, 136	$c\text{-}C_6H_{11}^+$ from $c\text{-}C_6H_{12}$	187
$c\text{-}C_6H_{12}^+ + C_2D_2 \rightarrow$	300	$8.4 \pm 2.0 \times 10^{-10}$	MS, 136	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	136
$c\text{-}C_6H_{12}^+ + C_2H_4 \rightarrow C_6H_{11}^+(67\%), C_6H_{10}^+(33\%)$	300	$1 \pm 0.2 \times 10^{-9}$	MS, 136	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	136
$c\text{-}C_6H_{12}^+ + C_2H_4 \rightarrow C_8H_{16}^+$		8×10^{-13}	MS, 52	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	144
$c\text{-}C_6H_{12}^+ + C_3H_6 \rightarrow C_9H_{18}^+$		1.3×10^{-10}	MS, 138	Error: "Within a factor of 2.5"	138
$c\text{-}C_6H_{12}^+ + C_3D_6 \rightarrow C_6H_{11}^+(10\%), C_6H_{10}^+(90\%)$	300	2.7×10^{-9}	MS, 136	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	136
$c\text{-}C_6H_{12}^+ + c\text{-}C_3H_6 \rightarrow C_6H_{11}^+(85\%), C_6H_{10}^+(15\%)$		1.2×10^{-9}	MS, 136	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	136
$c\text{-}C_6H_{12}^+ + 1\text{-}C_4H_8 \rightarrow C_6H_{10}^+(\geq 95\%)$	300	2.1×10^{-9}	MS, 136	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	136
$c\text{-}C_6H_{12}^+ + c\text{-}C_4H_8 \rightarrow C_4H_8^+$	300	7.7×10^{-10}	MS, 136	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	170
$c\text{-}C_6H_{12}^+ + c\text{-}C_4H_8 \rightarrow C_4H_8^+$	300	$6.1 \pm 0.7 \times 10^{-10}$	ICR, 154	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	168
$c\text{-}C_6H_{12}^+ + c\text{-}C_6D_{12} \rightarrow C_6D_{12}^+$	300	1.5×10^{-10}	ICR, 154	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	168
$c\text{-}C_6H_{12}^+ + (CH_3)_3CC_2H_5 \rightarrow C_6H_{14}^+$	300	$2.3 \pm 0.2 \times 10^{-10}$	ICR, 154	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	168
$c\text{-}C_6H_{12}^+ + 2H_2O \rightarrow H^+(H_2O)_2$	300	$5 \pm 1 \times 10^{-27}$	MS, 136	$c\text{-}C_6H_{12}^+$ from $c\text{-}C_6H_{12}$	158
$c\text{-}C_6D_{12}^+ + c\text{-}C_6H_{12} \rightarrow C_6H_{12}^+$	300	$3.8 \pm 0.3 \times 10^{-10}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_6D_{12}^+ + c\text{-}C_5H_9CH_3 \rightarrow C_6H_{12}^+$	300	$2.4 \pm 0.3 \times 10^{-10}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_6D_{12}^+ + C_2H_5CH(CH_3)C_2H_5 \rightarrow C_6H_{13}^+$	300	$3.3 \pm 0.3 \times 10^{-10}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_6D_{12}^+ + (CH_3)_3CC_2H_5 \rightarrow C_6H_{14}^+$	300	$4.0 \pm 0.3 \times 10^{-10}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_6D_{12}^+ + (CH_3)_2CHCH(CH_3)_2 \rightarrow C_6H_{14}^+$	300	$6.5 \pm 0.5 \times 10^{-10}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_6D_{12}^+ + c\text{-}C_6H_{11}CH_3 \rightarrow C_7H_{14}^+$	300	$1.37 \pm 0.07 \times 10^{-9}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_6D_{12}^+ + n\text{-}C_7H_{16} \rightarrow C_7H_{16}^+$	300	$1.1 \pm 0.3 \times 10^{-10}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_6D_{12}^+ + n\text{-}C_8H_{18} \rightarrow C_8H_{18}^+$	300	$4.6 \pm 0.4 \times 10^{-10}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_6D_{12}^+ + n\text{-}C_9H_{20} \rightarrow C_9H_{20}^+$	300	$1.04 \pm 0.10 \times 10^{-9}$	ICR, 154	$c\text{-}C_6D_{12}^+$ from $c\text{-}C_6D_{12}$	168
$c\text{-}C_5H_9CH_3^+ + 1\text{-}C_4H_8 \rightarrow C_6H_{11}^+, C_6H_{10}^+$	300	$1.2 \pm 0.2 \times 10^{-9}$	MS, 136	$c\text{-}C_5H_9CH_3^+$ from methylcyclopentane	136
$c\text{-}C_5H_9CH_3^+ + c\text{-}C_6D_{12} \rightarrow C_6D_{12}^+$	300	5.9×10^{-11}	ICR, 154	$c\text{-}C_5H_9CH_3^+$ from methylcyclopentane	168
$c\text{-}C_5H_9CH_3^+ + n\text{-}C_7H_{16} \rightarrow C_7H_{16}^+$	300	7×10^{-12}	ICR, 154	$c\text{-}C_5H_9CH_3^+$ from methylcyclopentane	168
$n\text{-}C_6H_{14}^+ + n\text{-}C_6D_{14} \rightarrow C_6D_{14}^+$	300	4.4×10^{-11}	ICR, 154	$n\text{-}C_6H_{14}^+$ from $n\text{-}C_6H_{14}$	168
$n\text{-}C_6H_{14}^+ + H_2O \rightarrow$	300	5.6×10^{-11}	MS, 179	Pressure of H_2O varied	179
	300	1.5×10^{-11}	MS, 179	Time varied	179
$n\text{-}C_6H_{14}^+ + 2H_2O \rightarrow H^+(H_2O)_2$	300	$3.6 \pm 0.8 \times 10^{-26}$	MS, 136		158
$n\text{-}C_6H_{14}^+ + D_2O \rightarrow$		$2.5 \pm 0.8 \times 10^{-9}$	MS, 71	Ions translationally heated	72
$n\text{-}C_6D_{14}^+ + c\text{-}C_6H_{12} \rightarrow C_6H_{12}^+$	300	$7.9 \pm 0.4 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from $n\text{-}C_6D_{14}$	168
$n\text{-}C_6D_{14}^+ + c\text{-}C_5H_9CH_3 \rightarrow C_6H_{12}^+$	300	$4.5 \pm 0.1 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from $n\text{-}C_6D_{14}$	168
$n\text{-}C_6D_{14}^+ + n\text{-}C_6H_{14} \rightarrow C_6H_{14}^+$	300	$8.4 \pm 2 \times 10^{-11}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from $n\text{-}C_6D_{14}$	168
$n\text{-}C_6D_{14}^+ + C_2H_5CH(CH_3)C_2H_5 \rightarrow C_6H_{14}^+$	300	$4.6 \pm 0.4 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from $n\text{-}C_6D_{14}$	168
$n\text{-}C_6D_{14}^+ + (CH_3)_3CC_2H_5 \rightarrow C_6H_{14}^+$	300	$4.3 \pm 0.5 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from $n\text{-}C_6D_{14}$	168
$n\text{-}C_6D_{14}^+ + (CH_3)_2CHCH(CH_3)_2 \rightarrow C_6H_{14}^+$	300	$6.1 \pm 0.5 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from $n\text{-}C_6D_{14}$	168

Table 1. Rate coefficients for reactions of hydrocarbon cations--Continued

Reaction	T	k	Method	Comments	Ref.
$n\text{-}C_6D_{14}^+ + c\text{-}C_6H_{11}CH_3 \rightarrow C_7H_{14}^+$	300	$9.8 \pm 0.8 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from $n\text{-}C_6D_{14}$	168
$n\text{-}C_6D_{14}^+ + n\text{-}C_7H_{16} \rightarrow C_7H_{16}^+$	300	$2.7 \pm 0.4 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from $n\text{-}C_6D_{14}$	168
$n\text{-}C_6D_{14}^+$ + n-octane $\rightarrow C_8H_{18}^+$	300	$5.3 \pm 0.5 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from n-hexane-d_{14}	168
$n\text{-}C_6D_{14}^+$ + n-nonane $\rightarrow C_9H_{20}^+$	300	$6.8 \pm 1.1 \times 10^{-10}$	ICR, 154	$n\text{-}C_6D_{14}^+$ from n-hexane-d_{14}	168
$(CH_3)_3CC_2H_5^+ + c\text{-}C_6D_{12} \rightarrow C_6D_{12}^+$	300	9×10^{-12}	ICR, 154	$(CH_3)_3CC_2H_5^+$ from 2,2-dimethylbutane	168
$c\text{-}C_6H_5CH_3 + 2(c\text{-}C_6H_5CH_3) \rightarrow (C_6H_5CH_3)_2^+$	295	$1.88 \pm 0.54 \times 10^{-25}$	MS, 136	$c\text{-}C_6H_5CH_3$ from toluene	186
$c\text{-}C_6H_{11}CH_3^+$ + n-nonane $\rightarrow C_9H_{20}^+$	300	7×10^{-11}	ICR, 154	$c\text{-}C_6H_{11}CH_3^+$ from methylcyclohexane	168
$n\text{-}C_7H_{16}^+ + c\text{-}C_6H_{12} \rightarrow C_6H_{12}^+$	300	$5.3 \pm 0.3 \times 10^{-10}$	ICR, 154	$n\text{-}C_7H_{16}^+$ from n-heptane	168
$n\text{-}C_7H_{16}^+$ + methylcyclopentane $\rightarrow C_6H_{12}^+$	300	$1.2 \pm 0.2 \times 10^{-10}$	ICR, 154	$n\text{-}C_7H_{16}^+$ from n-heptane	168
$n\text{-}C_7H_{16}^+$ + 3-methylpentane $\rightarrow C_6H_{14}^+$	300	$1.8 \pm 0.5 \times 10^{-10}$	ICR, 154	$n\text{-}C_7H_{16}^+$ from n-heptane	168
$n\text{-}C_7H_{16}^+$ + 2,2-dimethylbutane $\rightarrow C_6H_{14}^+$	300	$1.7 \pm 0.2 \times 10^{-10}$	ICR, 154	$n\text{-}C_7H_{16}^+$ from n-heptane	168
$n\text{-}C_7H_{16}^+$ + 2,3-dimethylbutane $\rightarrow C_6H_{14}^+$	300	$3.3 \pm 0.2 \times 10^{-10}$	ICR, 154	$n\text{-}C_7H_{16}^+$ from n-heptane	168
$n\text{-}C_7H_{16}^+$ + methylcyclohexane $\rightarrow C_7H_{14}^+$	300	$9.2 \pm 0.5 \times 10^{-10}$	ICR, 154	$n\text{-}C_7H_{16}^+$ from n-heptane	168
$n\text{-}C_7H_{16}^+$ + n-octane $\rightarrow C_8H_{18}^+$	300	$2.4 \pm 0.4 \times 10^{-10}$	ICR, 154	$n\text{-}C_7H_{16}^+$ from n-heptane	168
$n\text{-}C_7H_{16}^+$ + 2,2,4-trimethylpentane $\rightarrow C_8H_{18}^+$	300	$8.8 \pm 1.0 \times 10^{-10}$	ICR, 154	$n\text{-}C_7H_{16}^+$ from n-heptane	168
$o\text{-}(CH_3)_2C_6H_4^+$ + 2(o-xylene) $\rightarrow C_{16}H_{20}^+$	295	$3.4 \pm 1.0 \times 10^{-25}$	MS, 136	$o\text{-}(CH_3)_2C_6H_4^+$ from o-xylene	186
$m\text{-}(CH_3)_2C_6H_4^+$ + 2(m-xylene) $\rightarrow C_{16}H_{20}^+$	295	$3.4 \pm 1.0 \times 10^{-25}$	MS, 136	$m\text{-}(CH_3)_2C_6H_4^+$ from m-xylene	186
$p\text{-}(CH_3)_2C_6H_4^+$ + 2(p-xylene) $\rightarrow C_{16}H_{20}^+$	295	$1.4 \pm 0.4 \times 10^{-25}$	MS, 136	$p\text{-}(CH_3)_2C_6H_4^+$ from p-xylene	186
$n\text{-}C_8H_{18}^+$ + 2,2,4-trimethylpentane $\rightarrow C_8H_{18}^+$	300	$3.4 \pm 0.3 \times 10^{-10}$	ICR, 154	$n\text{-}C_8H_{18}^+$ from n-octane	168
$n\text{-}C_8H_{18}^+$ + n-nonane $\rightarrow C_9H_{20}^+$	300	$1.3 \pm 0.2 \times 10^{-10}$	ICR, 154	$n\text{-}C_8H_{18}^+$ from n-octane	168
$1,3,5\text{-}(CH_3)_3C_6H_3^+$ + 2(mesitylene) $\rightarrow C_{18}H_{24}^+$	295	$6.73 \pm 2.0 \times 10^{-25}$	MS, 136	$1,3,5\text{-}(CH_3)_3C_6H_3^+$ from mesitylene	186
$n\text{-}C_9H_{20}^+$ + methylcyclohexane $\rightarrow C_7H_{14}^+$	300	6×10^{-10}	ICR, 154	$n\text{-}C_9H_{20}^+$ from n-nonane	168

Table 2. Rate coefficients for reactions of hydrocarbon anions

Reaction	T	k	Method	Comments	Ref.
C_2H^- + allene $\rightarrow C_3H_3^-$	300	$<1 \times 10^{-12}$	FA, 20	C_2H^- from C_2H_2	188
$C_2H^- + C_6H_5CH_3 \rightarrow C_6H_5CH_2^-$	300	$\sim 5 \times 10^{-11}$	FA, 20	C_2H^- from C_2H_2	188
$C_2H^- + CH_3OH \rightarrow CH_3O^-$	300	$\sim 5 \times 10^{-11}$	FA, 20	C_2H^- from C_2H_2	188
$C_2H^- + C_2H_5OH \rightarrow C_2H_5O^-$	300	$\sim 1 \times 10^{-10}$	FA, 20	C_2H^- from C_2H_2	188
$C_2H^- + i\text{-}C_3H_7OH \rightarrow i\text{-}C_3H_7O^-$	300	$\sim 5 \times 10^{-10}$	FA, 20	C_2H^- from C_2H_2	188
$C_2H^- + t\text{-}C_4H_9OH \rightarrow t\text{-}C_4H_9O$	300	$\geq 5 \times 10^{-11}$	FA, 20	C_2H^- from C_2H_2	188
$C_2H^- + CH_3Cl \rightarrow Cl^-$	300	$1.2 \pm 0.24 \times 10^{-9}$	FA, 118	C_2H^- from C_2H_2	189
$C_2H^- + CH_2Cl_2 \rightarrow CHCl_2^-$	300	$\geq 2 \times 10^{-10}$	FA, 118	C_2H^- from C_2H_2	189
$C_2H^- + CH_3F \rightarrow F^-$	300	$<3 \times 10^{13}$	FA, 118	C_2H^- from C_2H_2	189
$C_2H^- + CH_3CN \rightarrow CH_2CN^-$	300	$\geq 1 \times 10^{-10}$	FA, 20	C_2H^- from C_2H_2	188
$C_2H^- + CH_3SOCH_3 \rightarrow CH_3SOCH_2^-$	300	$\geq 1 \times 10^{-11}$	FA, 20	C_2H^- from C_2H_2	188
$C_2H^- + H_2O \rightarrow C_2H_2 + OH^-$	300	$9.3 \pm 3.7 \times 10^{-15}$	FA, 118	C_2H^- from C_2H_2	95
$C_3H_3^- + C_6H_5CH_3 \rightarrow C_6H_5CH_2^-$	300	$\leq 5 \times 10^{-12}$	FA, 20	$C_3H_3^-$ from allene	188
$C_3H_3^- + CHCl_3 \rightarrow CCl_3^-$	300	$\geq 2 \times 10^{-10}$	FA, 20	$C_3H_3^-$ from allene	188
$C_3H_3^- + CH_3CN \rightarrow CH_2CN^-$	300	$\geq 5 \times 10^{-11}$	FA, 20	$C_3H_3^-$ from allene	188
$C_3H_3^- + CH_3OH \rightarrow CH_3O^-$	300	$\geq 1 \times 10^{-11}$	FA, 20	$C_3H_3^-$ from allene	188
$C_3H_5^- + C_6H_5CH_3 \rightarrow C_6H_5CH_2^-$		$7.5 \pm 0.7 \times 10^{-11}$	ICR, 190	$C_3H_5^-$ from propylene	190
	300	1×10^{-11}	FA, 20	$C_3H_5^-$ from propylene	191
$C_3H_5^- + CH_3OH \rightarrow CH_3O^-$		$2.5 \pm 0.3 \times 10^{-10}$	ICR, 190	$C_3H_5^-$ from propylene	190
	300	$\geq 5 \times 10^{-11}$	FA, 20	$C_3H_5^-$ from propylene	188
$C_5H_5^- + CHCl_3 \rightarrow CCl_3^-$	300	$<2 \times 10^{-11}$	FA, 20	Origin of $C_5H_5^-$ uncertain	188
$C_5H_5^- + CH_3NO_2 \rightarrow CH_2NO_2^-$	300	$<1 \times 10^{-11}$	FA, 20	Origin of $C_5H_5^-$ uncertain	188
$C_6H_5^- + CH_4 \rightarrow CH_3^-$	300	$\leq 5 \times 10^{-12}$	FA, 20	$C_6H_5^-$ from benzene	188
$C_6H_5^- + C_6H_5CH_3 \rightarrow C_6H_5CH_2^-$	300	$\geq 5 \times 10^{-11}$	FA, 20	$C_6H_5^-$ from benzene	188

Table 2. Rate coefficients for reactions of hydrocarbon anions--Continued

Reaction	T	k	Method	Comments	Ref.
$C_6H_5^-$ + isopropylbenzene → $C_6H_5C(CH_3)_2^-$	300	~1 x 10^{-11}	FA, 20	$C_6H_5^-$ from benzene	188
$C_6H_5^-$ + H_2 → H^-	300	<5 x 10^{-12}	FA, 20	$C_6H_5^-$ from benzene	188
$C_6H_5^-$ + H_2O → OH^-	300	≥5 x 10^{-11}	FA, 20	$C_6H_5^-$ from benzene	191
$C_6H_5^-$ + NH_3 → NH_2^-	300	≤5 x 10^{-12}	FA, 20	$C_6H_5^-$ from benzene	188
$C_6H_5CH_2^-$ + C_2H_2 → C_2H^-	300	~5 x 10^{-11}	FA, 20	$C_6H_5CH_2^-$ from toluene	188
$C_6H_5CH_2^-$ + allene → $C_3H_3^-$	300	~6 x 10^{-12}	FA, 20	$C_6H_5CH_2^-$ from toluene	188
$C_6H_5CH_2^-$ + C_3H_6 →	300	<1 x 10^{-12}	FA, 20	$C_6H_5CH_2^-$ from toluene	191
$C_6H_5CH_2^-$ + isopropylbenzene → $C_6H_5C(CH_3)_2^-$	300	~1 x 10^{-12}	FA, 20	$C_6H_5CH_2^-$ from toluene	188
$C_6H_5CH_2^-$ + p-t-butyltoluene → $(CH_3)_3CC_6H_4CH_2^-$	300	<5 x 10^{-12}	FA, 20	$C_6H_5CH_2^-$ from toluene	188
$C_6H_5CH_2^-$ + CH_3OH → CH_3O^-	300	≥5 x 10^{-11}	FA, 20	$C_6H_5CH_2^-$ from toluene	188
$C_6H_5CH_2^-$ + C_2H_5OH → $C_2H_5O^-$	300	≥1 x 10^{-10}	FA, 20	$C_6H_5CH_2^-$ from toluene	191
$C_6H_5CH_2^-$ + CH_3SOCH_3 → $CH_3SOCH_2^-$	300	>5 x 10^{-12}	FA, 20	$C_6H_5CH_2^-$ from toluene	188
$C_6H_5C(CH_3)_2^-$ + C_6H_6 → $C_6H_5^-$	300	≤1 x 10^{-13}	FA, 20	$C_6H_5C(CH_3)_2^-$ from isopropylbenzene	188
$C_6H_5C(CH_3)_2^-$ + $C_6H_5CH_3$ → $C_6H_5CH_2^-$	300	~5 x 10^{-13}	FA, 20	$C_6H_5C(CH_3)_2^-$ from isopropylbenzene	188
$C_6H_5C(CH_3)_2^-$ + CH_3OH → CH_3O^-	300	≥5 x 10^{-11}	FA, 20	$C_6H_5C(CH_3)_2^-$ from isopropylbenzene	188
$C_6H_5C(CH_3)_2^-$ + C_2H_5OH → $C_2H_5O^-$	300	≥5 x 10^{-11}	FA, 20	$C_6H_5C(CH_3)_2^-$ from isopropylbenzene	188
p-$(CH_3)_3CC_6H_4CH_3^-$ + $C_6H_5CH_3$ → $C_6H_5CH_2^-$	300	≤5 x 10^{-11}	FA, 20	p-$(CH_3)_3CC_6H_4CH_3^-$ from p-t-butyltoluene	188

Acknowledgment

The authors would like to express their gratitude to Pierre Ausloos for his advice, encouragement, and critique during the formulation of this manuscript, and to Pam Davis for her patience and accuracy in preparing the tabular matter. This work is supported by the Office of Standard Reference Data, NBS.

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