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E-mail: bunken@nifs.ac.jp

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# Elastic Differential Cross Sections for Electron Collisions with Polyatomic Molecules

M. Hoshino[1], H. Kato[1], C. Makochekanwa[1, 2], S.J. Buckman[2], M. J. Brunger[3],
H. Cho[4], M. Kimura[5], D. Kato[6], I. Murakami[6], T. Kato[6], and H. Tanaka[1]

[1]Department of Physics, Sophia University, Tokyo 102-8554, Japan
[2]Center for Antimatter-Matter Studies, Australian National University, Canberra ACT 0200, Australia
[3]Center for Antimatter-Matter Studies, Flinders University, Adelaide SA 5001, Australia
[4]Department of Physics, Chungnam National University, Daejeon 305-764, Korea
[5]Graduate School of Sciences, Kyushu University, Fukuoka 812-8581, Japan
[6]National Institute of Fusion Science, Toki 509-5292, Japan



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## Abstract

Experimental data for electron-polyatomic molecule collisions are reviewed in connection with fusion and processing plasmas, as well as with the associated environmental issues. The electron scattering experiments for differential cross section (DCS) measurements for various processes, such as elastic scattering, have been performed across a broad range of energies (1-100 eV), mainly, at Sophia University since 1978, and some done under the collaborations with the Australian National University, Flinders University, and the Chungnam National University. As a benchmark cross section, elastic DCS are essential for the absolute scale conversion of inelastic DCS, as well as for testing computational methods. The need for cross-section data for a wide variety of molecular

species is also discussed, because there is an urgent need to develop an international program to provide the scientific and technological communities with authoritative cross sections for electron-molecule interactions. Note that the detailed comparison with other data available is not given here. Ruther, other available data can be found in the references we cite. This course of action was adopted to keep this report to a sensible length, so that only our numerical data is provided here.

**Keywords**
electron-molecule collision, differential cross section, polyatomic molecule, elastic scattering, excitation process, resonant electron scattering

## 1 Introduction

The interaction of electrons with atoms and molecules is an essential process in many areas of modern science and technology, recently referred to as "nano-technology", and is pivotal for a greater understanding of aeronomy, astrophysics, gas and laser discharges, plasma processing, fusion plasmas, medical radiation studies and cellular biology. An example of its application is to the technology of plasma processing, which includes chemical vapor deposition (CVD) and plasma etching (Tanaka and Inokuti 1999, Makabe and Petrovic 2006). Similarly a detailed understanding of electron molecule collisions is fundamental in environmental processes, i.e., the chemistry of dissociated fluorocarbons, in order to develop their use as replacements for the environmentally damaging chloro- and bromo-halocarbons, which are also notable as global warming gases (Samukawa and Mukai 1999). The current techniques of plasma diagnosis and modeling potentially elucidate plasma characteristics from the point of view of atomic, molecular, and optical physics, i.e., from much more fundamentally scientific bases rather than the empiricism and intuition relied on so far. For discharges utilized in industrial plasma processes, the most significant electron collisions occur in the electron energy range less than 100 eV. The generic primary processes are elastic and inelastic electron scattering, electron impact ionization, electron-impact dissociation, and attachment. However, the many possible excitation processes arising from the many degrees of freedom available within molecules make the study of electron-molecule collisions extremely complex. Comprehensive sets of electron-molecule collision cross section data are, therefore, only limited to the simplest of diatomics (e.g. $H_2$, $N_2$, $O_2$) (Brunger and Buckman 2002) and a few polyatomics (e.g. $CH_4$, $CF_4$, $SiH_4$ and $SF_6$) (Brunger et al 2003). Electron collision data, however, have provided the most stringent test of the theoretical methods.

As pointed out above, electron collisions with atoms and molecules are of general importance in the initiation of discharges and plasmas. In particular, a newer trend in etching technology is to use lower pressures, so that reactive species readily reach the base surface after a minimal number of collisions with gaseous molecules on the way. Therefore, the control of electron collision processes becomes even more important.

Our research program is based on three major objectives, achieved experimentally by studies of electron-molecule collision mechanisms under: (1) Elastic Scattering, (2) Excitation Processes (vibrational and electronic), and (3) Resonant Electron Scattering. Three broad classes of polyatomic molecular targets have been studied (see Table 1): Hydrocarbons, Fluorocarbons, and Linear Tri-atomic Molecules. A *systematic* measurement of Absolute Differential Cross Sections (DCSs) for electron scattering by these molecules has been performed within an impact energy range from 1.5 to 100 eV and scattering angles between 10°and normally around 130°, but for a few molecules even up to 180°.

In this report, illustrative examples of elastic DCSs will be reviewed, not particularly because of any special relevance to applications, but because it is possible in these cases to compare recent experimental results obtained by different groups and with available theoretical data. Elastic DCSs are important since they usually contribute the largest portion to the total cross sections (TCSs), especially in the low impact-energy region below a few tens of eV. TCSs are determined with uncertainties not more than 5 % for most cases, and therefore, precise measurements of elastic DCSs are the basis for better estimation of other cross sections which are otherwise normally difficult to measure.

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M.J. Brunger and S.J. Buckman et al, *Photon and Electron Interactions with Atoms, Molecules, and Ions*, Vol. 17, Ed. Y. Itikawa, (Landolt-Börnstein, Springer Berlin Heidelberg 2003)

## 2 Definition of Cross Sections

In what follows we shall concentrate first on a single collision between an electron and an atom or molecule. We first classify collisions into two kinds, namely, elastic and inelastic. In an elastic collision, the internal energy of an atom or molecule is unchanged. However a part ($\Delta E$) of the electron energy $E_0$ is transferred to the atom or a molecule as given by $\Delta E / E_0 \approx m/M \approx 10^{-4}$ , where $m$ is the electron mass and $M$ is the mass of the atom or molecule. In an inelastic collision, there is a change in the internal energy, which leads to one or more of rotational, vibrational, or electronic excitation, dissociation, ionization, or attachment of an electron to a molecule. For an atom, electronic excitation and ionization are the only possibilities. The energy transfer to rotational, vibrational, and electronic degrees of freedom is roughly in order of the ratios $(m/M)^{1/2} : (m/M)^{1/4} : 1 \approx 10^{-3} : 10^{-1} : 10$.

The probability of an inelastic collision is expressed in terms of the cross section defined as follows. Suppose that $I_0$ electrons per unit area of energy $E_0$ per unit area are incident on a gas consisting of $N$ atoms or molecules per unit volume. The number of electrons scattered into the solid angular element $d\Omega$ in the direction $\Omega\,(\theta, \phi)$, measured from the polar axis taken along the direction of electron incidence, can be written as:

$$I_{0n}\,(\Omega) = N\, I_0\, d\sigma_{0n}(E_0\,,\,\Omega)/d\Omega. \tag{1}$$

The subscript $0n$ indicates a transition from the ground state $0$ to an excited or ionized state $n$. One calls the quantity $d\sigma_{0n}\,(E_0,\Omega)/d\Omega$ the differential cross section for the excitation $0 \rightarrow n$.

Theoretically, the differential cross section is expressed in terms of the scattering amplitude $f_{0n}(E_0, \Omega)$, which is determined from the asymptotic behavior of the electron wave function, in the form:

$$d\sigma_{0n}(E_0\,,\,\Omega)/d\Omega = (k_n/k_0)\ /f_{0n}(E_0\,,\,\Omega)|^2, \tag{2}$$

where $k_0$ is the magnitude of the electron momentum before the collision, and $k_n$ the same after the collision.

The integral of the differential cross section over all scattering angles, viz. ,:

$$q_{0n}(E_0) = \int\int d\sigma_{0n}(E_0\,,\,\Omega)/d\Omega.\ \sin\,\theta\, d\theta\, d\phi \tag{3}$$

is called the (integral) cross section for the excitation $0 \rightarrow n$.

The elastic-scattering cross section $q_0\,(E_0\,)$ is defined similarly, by replacing the final state n by the ground state $0$ in Eqs. (1) - (3). To discuss effects of elastic scattering on electron transport phenomena, it is more important to use the momentum-transfer cross section defined by:

$$q_0^{\,M}(E_0) = \int\int d\sigma_0\,(E_0\,,\,\Omega)/d\Omega.\ (\,1 - \cos\,\theta)\sin\,\theta\, d\theta\, d\phi\,. \tag{4}$$

The sum of the cross sections given by Eq. (3) over all possible kinds of excitation (including the elastic-scattering cross section), viz.,

$$Q\ (E_0) = q_0(E_0) + \Sigma_n\, q_{0n}(E_0) \qquad (5)$$

is called the total cross section.

If the distribution of particle speeds $v$ is given by $F(v)$, then the reaction rate constant for a process with cross section $q_n$ is calculated as:

$$\kappa_n = \int q_n \; F(v)\, v\, dv \qquad (6)$$

## 3 Experimental Techniques for Precision Measurement of Elastic DCS

### 3.1 Instrumentation:

A typical electron spectrometer [eg. Tanaka *et al* 1988 as shown in Figure1] consists of an electron gun with a hemispherical monochromator, a molecular beam, and a rotatable detector ($\theta$ : 10° to around 130°) with a hemispherical analyzer, all contained in a vacuum chamber. A beam of molecules is produced by effusing the target through a nozzle with an internal diameter of, for example 0.3 mm, and a long length to ensure a high aspect ratio. The spectrometer and the nozzle can be heated to a temperature of about 50°C to reduce the possibility of contamination during the measurements. The molecular beam is crossed with a monoenergetic beam of electrons of fixed incident energy. At a particular scattering angle, scattered electrons are detected. A number of lenses in the spectrometer are used for imaging and energy control of the electron beam, whose characteristics are carefully modeled by electron trajectory calculations. The ideal molecular beam has a small size and a uniform high density. As far as this molecular beam remains within the view cone angle of the electron analyzer, the detection probability for scattered electrons should be uniform and measured scattering intensities are directly proportional to the scattering cross sections.

In some systems, both the monochromator and analyzer are enclosed in differentially pumped boxes in order to reduce the effect of background gases and to minimize any stray electron background. The magnetic field in the chamber has to be kept as low as a few milli-gauss. Overall energy resolution varies typically from around 20 to 80 meV (FWHM). The angular scale is accurate to about ±1.5° , as determined by noting the symmetry of elastic scattering about the true zero-degree point.

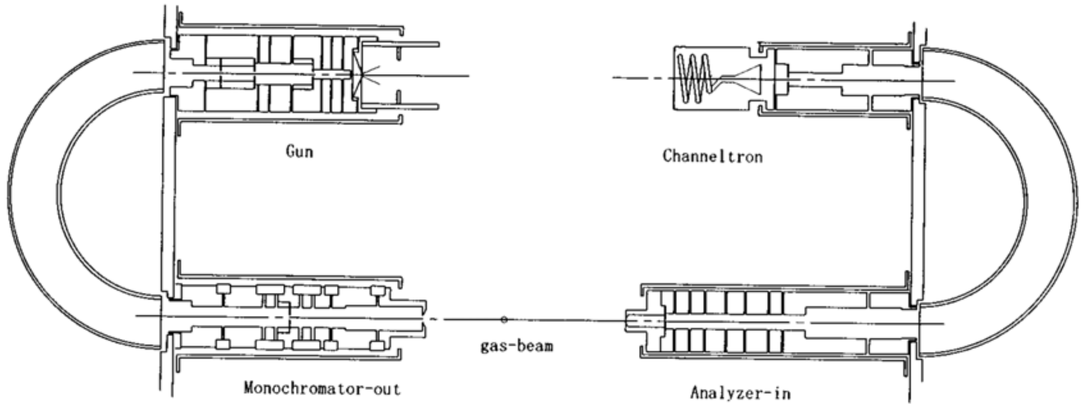


Figure 1. Schematic diagram of electron spectrometer at Sophia University

However, this conventional spectrometer is only capable of differential scattering measurements over an angular range typically ranging from 10° to around 130°. This is because of the mechanical restriction imposed by the size of some of the elements in the electron spectrometer. To overcome this limitation, an electron spectrometer with a magnetic-angle changing device has been developed to measure electron scattering cross sections at backward angles up to 180° (Read and Channing 1996). This technique involves the production of a magnetic field, localized in the vicinity of the interaction region, to change the trajectories of the incident and scattered electrons, such that one can effectively rotate the scattering geometry. The use of two concentric coils, producing opposed but coaxial magnetic fields, ensures that the electron beam passes through the common centres of the coils and thus crosses with the target molecular beam. The arrangement of the coils and their currents is such as to cancel the dipole and the octupole moments of the magnetic field outside the solenoids and so have a minimal effect on the effective operation of the electrostatic spectrometer. This technique has been used in measuring some of the elastic differential cross sections presented later, with detailed descriptions being found in earlier publications (Cho et al 2000, 2003).

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## 3.2 Normalization and Energy Calibration:

Relative measurements of the angular distribution are placed on an absolute scale by use of the relative flow technique (Srivastava *et al* 1975). This technique relies on measurements of the ratio of scattered electron intensities for the gas of interest relative to that for a standard gas. To establish the correct flow conditions, in particular that the mean-free-paths for the two gases are identical in the capillary needle, the driving pressures for the two gases must be set very carefully. In other words, the densities of the two gases are set to be identical by adjusting the pressure behind the nozzle so as to maintain approximately equal gas Knudsen numbers. The ratio of the driving pressures is determined from values of the molecular diameters of the standard gas and the target molecules. The conditions that need to be fulfilled to properly conduct a relative flow experiment have been discussed in detail by Gibson *et al* (1999), and references therein.

Providing the above conditions are satisfied, the ratio of the two cross sections $\sigma_x$ and $\sigma_h$ (*x* for the target gas of interest, *h* for the helium standard) can be determined from the following equation:

$$\frac{\sigma_x}{\sigma_h} = \frac{I_x P_h}{I_h P_x},$$

where $I_x$ and $I_h$ are the scattered electron intensities, and $P_x$ and $P_h$ are the corresponding driving pressures for the two gases respectively.

For most elastic differential cross section measurements presented here, the following helium cross sections were used: Boesten and Tanaka (1992), or Nesbet (1979) for energies below 20 eV, and Brunger *et al* (1992) at higher energies. Boesten and Tanaka (1992) have accumulated a large data base and calculated rational function fits for a representative set of elastic, non-resonant *e* + He differential cross sections (DCS) comprising (1) the variational DCS of Nesbet (1979), (2) the eikonal DCS of Byron and Joachain (1977), and the experimental data of Wagenaar et al(1986), Register et al (1980), Bromberg (1974), and Jansen et al (1976), with the priorities in the order given. The fits, expressed as functions of the scattering angle with the impact energy as the parameter, form smooth functions at sufficiently closely spaced intervals to allow for easy first- or second-order interpolation over angles $\theta$ from 0° to 180° and energies $E_0$ from 0.1 to 1000 eV. Maximum deviation from the data set is 10.4% for experiments and 20% for theory at low angles smaller or equal to 10°, where theory deviates from the experiments.

The absolute electron energy scale is calibrated by observing either the position of the second quasi-vibrational resonance peak of the $N_2^-$ $^2\Pi_g$ resonance, at the energy of 2.198 eV for a scattering angle of 60° (Rohr 1977), or the position of the $He^-$ $1s2s^2$ $^2S$ resonance at 19.367 eV (Brunt *et al* 1977).

## 3.3 Extrapolation procedures for DCS to derive Integral cross sections

The new technique, discussed above in section 3.1, for measuring DCS over a wide angular range has been implemented by several groups and some of the data which has resulted is presented in later sections. This technique helps to remove much of the uncertainty involved in the derivation of integral cross sections as it is only necessary to extrapolate the measured data in the forward angular region. However, in general, extrapolation procedures are necessary as most DCS measurements are over a finite angular range and do not cover the full range from $0^0$ to $180^0$. A number of techniques are used including, in many cases, the simple 'by eye' procedure, although this remains a rather subjective process. A somewhat more physically sound process which has been developed in recent years is to use a form of molecular phase shift analysis. In this technique, the measured DCS is fitted by an expression for the cross section which is expanded in terms of the scattering phase shifts. The phase shifts (usually less than 10 are needed) are free parameters and other molecular properties such as the dipole polarizability and dipole moment are required. Details of this technique can be found in the papers of Boesten and Tanaka (1991) and Panajotovic *et al.* (2003).

## 3.4 Error estimation:

Typical experimental errors for elastic scattering cross sections are estimated to be between 10 and 20%. They arise from a combination, in quadrature, of the statistical uncertainties on the scattered electron count rates together with those arising from measurements of parameters such as the electron current, gas pressure and the determination of relative flow rates and the uncertainties on the helium cross section. Each of these contributions varies typically from 2% to 5%.

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## 4 Benchmark Cross Sections for Elastic DCS

In Table1 below we summarize the broad classes of polyatomic molecules, and specific molecules within those classes, that we will consider in this report.

Table 1: List of molecules tabled in this report

A. Fusion Plasma-Related Gases

$CH_4$, $C_2H_6$, $C_3H_8$, $C_2H_4$, $C_3H_6$, *isomers*-$C_3H_4$

B. Processing Plasma-Related Gases

$CF_4$, $C_2F_6$, $C_3F_8$, C3F6, *cyclo*-$C_4F_8$, $C_2F_4$, $C_6F_6$,

$CH_3F$, $CH_2F_2$, $CHF_3$

$NF_3$, $SF_6$

$SiH_4$, $Si_2H_6$, $GeH_4$

C. Environmental Issues -Related Gases

$CF_3Cl$, $CF_3Br$, $CF_3I$

$H_2O$, $CO_2$, $N_2O$

We now consider each of these sequentially and present the available data.

### A. Fusion Plasma-Related Gases

#### <u>$CH_4$</u>

Absolute cross sections for elastic scattering of electrons from $CH_4$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°.The DCS were analyzed using a molecular phase-shift approach, in order to extrapolate them to lower and higher angles, i.e., $\theta <$ 10° and $\theta >$ 130°, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 2.

**Reference:**

L. Boesten, H. Tanaka, *J. Phys. B: At. Mol. Opt. Phys.* **24** 821 (1991).

Table 2. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $CH_4$. The estimated uncertainty in the DCS data is 15%, whilst the uncertainty on the ICS and MTCS is 25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.5 | 8.0 |
| 10 | - | - | - | - | - | 5.101 | 7.360 | 8.127 |
| 15 | - | 0.250 | 0.562 | 1.753 | 2.810 | 4.909 | 6.862 | 7.517 |
| 20 | 0.151 | 0.194 | 0.419 | 1.604 | 2.532 | 4.390 | 6.000 | 6.432 |
| 25 | 0.102 | 0.152 | 0.368 | 1.158 | 2.247 | 3.765 | 4.942 | 5.407 |
| 30 | 0.064 | 0.136 | 0.347 | 1.014 | 1.734 | 3.009 | 4.078 | 4.431 |
| 35 | 0.070 | 0.147 | 0.364 | 0.948 | 1.383 | 2.546 | 3.396 | 3.622 |
| 40 | 0.089 | 0.195 | 0.480 | 0.895 | 1.262 | 2.139 | 2.859 | 3.016 |
| 45 | 0.126 | 0.266 | 0.635 | 0.992 | 1.232 | 1.889 | 2.315 | 2.466 |
| 50 | 0.181 | 0.367 | 0.722 | 1.102 | 1.283 | 1.661 | 1.879 | 2.076 |
| 55 | - | 0.465 | 0.953 | 1.217 | 1.416 | - | 1.706 | 1.765 |
| 60 | 0.312 | 0.555 | 1.092 | 1.357 | 1.540 | 1.653 | 1.609 | 1.643 |
| 65 | - | 0.645 | - | - | - | - | 1.591 | 1.517 |
| 70 | 0.412 | 0.718 | 1.306 | 1.595 | 1.588 | 1.725 | 1.574 | 1.409 |
| 75 | - | 0.758 | - | - | - | - | 1.484 | 1.382 |
| 80 | 0.471 | 0.771 | 1.246 | 1.673 | 1.737 | 1.733 | 1.528 | 1.403 |
| 85 | - | 0.748 | - | - | - | - | 1.387 | 1.271 |
| 90 | 0.505 | 0.722 | 1.082 | 1.313 | 1.530 | 1.421 | 1.255 | 1.153 |
| 95 | - | 0.677 | - | - | - | 1.190 | 1.050 | 0.879 |
| 100 | 0.458 | 0.625 | 0.804 | 1.016 | 1.001 | 0.945 | 0.816 | 0.773 |
| 105 | - | 0.528 | 0.640 | 0.738 | 0.734 | 0.680 | 0.612 | 0.568 |
| 110 | 0.363 | 0.451 | 0.492 | 0.543 | 0.444 | 0.419 | 0.435 | 0.387 |
| 115 | - | 0.380 | 0.332 | 0.323 | 0.282 | 0.257 | 0.262 | 0.273 |
| 120 | 0.272 | 0.302 | 0.206 | 0.183 | 0.153 | 0.189 | 0.209 | 0.227 |
| 125 | - | 0.239 | 0.126 | 0.160 | 0.192 | 0.249 | 0.245 | 0.303 |
| 130 | 0.175 | 0.167 | 0.115 | 0.179 | 0.281 | 0.356 | 0.414 | 0.474 |
| ICS | 3.61 | 5.61 | 9.25 | 14.41 | 18.04 | 22.97 | 26.49 | 26.30 |
| MTCS | 3.49 | 5.40 | 8.43 | 13.71 | 17.55 | 21.79 | 25.07 | 23.76 |

(continued)

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 9.0 | 10 | 12 | 15 | 20 | 30 | 50 | 100 |
| 10 | 8.991 | 7.237 | 9.287 | 8.143 | 8.612 | 9.858 | 11.046 | 6.316 |
| 15 | 8.225 | 6.485 | 8.308 | - | - | - | - | - |
| 20 | 6.861 | 5.646 | 6.764 | 6.659 | 6.905 | 5.596 | 4.024 | 1.623 |
| 25 | 5.853 | 4.885 | 5.789 | - | - | - | - | - |
| 30 | 4.713 | 4.107 | 4.784 | 4.555 | 3.956 | 2.600 | 1.274 | 0.439 |
| 35 | 3.786 | 3.361 | 3.937 | - | - | - | - | - |
| 40 | 3.045 | 2.741 | 3.122 | 2.866 | 2.213 | 1.153 | 0.492 | 0.205 |
| 45 | 2.609 | 2.206 | 2.395 | - | - | - | - | 0.166 |
| 50 | 2.126 | 2.142 | 2.021 | 1.803 | 1.206 | 0.606 | 0.290 | 0.130 |
| 55 | 1.771 | - | - | - | - | - | - | 0.097 |
| 60 | 1.566 | 1.570 | 1.364 | 1.176 | 0.768 | 0.415 | 0.217 | 0.062 |
| 65 | 1.430 | - | - | - | - | - | 0.170 | 0.046 |
| 70 | 1.308 | 1.254 | 1.034 | 0.879 | 0.586 | 0.317 | 0.139 | 0.039 |
| 75 | 1.273 | 1.201 | - | - | - | - | 0.114 | 0.031 |
| 80 | 1.210 | 1.089 | 0.862 | 0.704 | 0.462 | 0.246 | 0.082 | 0.030 |
| 85 | 1.094 | 0.986 | - | - | - | - | 0.069 | 0.027 |
| 90 | 0.972 | 0.852 | 0.656 | 0.525 | 0.351 | 0.183 | 0.053 | 0.027 |
| 95 | 0.843 | 0.736 | - | - | - | - | 0.048 | 0.028 |
| 100 | 0.658 | 0.588 | 0.472 | 0.389 | 0.263 | 0.130 | 0.046 | 0.033 |
| 105 | 0.516 | 0.441 | - | - | - | - | 0.048 | 0.037 |
| 110 | 0.348 | 0.336 | 0.313 | 0.306 | 0.231 | 0.131 | 0.062 | 0.039 |
| 115 | 0.272 | 0.271 | - | - | - | - | 0.072 | 0.043 |
| 120 | 0.228 | 0.268 | 0.294 | 0.329 | 0.274 | 0.162 | 0.086 | 0.043 |
| 125 | 0.293 | 0.347 | - | - | - | - | 0.103 | 0.043 |
| 130 | 0.456 | 0.502 | 0.475 | 0.465 | 0.355 | 0.215 | 0.116 | 0.049 |
| ICS | 25.55 | 23.02 | 20.74 | 18.27 | 14.41 | 9.49 | 6.57 | 3.20 |
| MTCS | 21.77 | 20.21 | 14.63 | 11.78 | 6.95 | 3.87 | 2.22 | 1.08 |

## $C_2H_6$

Absolute cross sections for elastic scattering of electrons from $C_2H_6$ have been determined in the energy range of 2–100 eV and over the scattering angles of 10–130°. These DCS were analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, i.e., $\theta < 10°$ and $\theta > 130°$, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 3.

**Reference:**

H. Tanaka, L. Boesten, D. Matsunaga and T. Kubo, *J. Phys. B: At. Mol. Opt. Phys.* **21** 1255 (1988).

Table 3. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $C_2H_6$. The estimated uncertainty in the DCS data is 15%–22%, whilst the uncertainty on the integral and momentum transfer cross sections is 25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.5 | 8.5 | 10 |
| 10 | - | - | - | - | - | - | - | - |
| 15 | - | - | - | - | - | 12.900 | 12.020 | 13.360 |
| 20 | 1.235 | 1.543 | 2.809 | 5.217 | 6.223 | 9.555 | 10.490 | 12.770 |
| 30 | 0.795 | 1.166 | 1.878 | 3.249 | 4.048 | 5.732 | 6.163 | 6.686 |
| 40 | 0.487 | 0.871 | 1.335 | 2.270 | 2.460 | 3.260 | 3.507 | 3.575 |
| 50 | 0.493 | 1.060 | 1.485 | 2.129 | 1.921 | 2.359 | 2.361 | 1.964 |
| 60 | 0.678 | 1.450 | 1.734 | 2.083 | 1.950 | 2.011 | 2.103 | 1.416 |
| 70 | 0.929 | 1.696 | 1.956 | 1.950 | 1.792 | 1.831 | 1.787 | 1.252 |
| 80 | 1.173 | 1.728 | 1.828 | 1.738 | 1.417 | 1.321 | 1.212 | 0.963 |
| 90 | 1.242 | 1.652 | 1.422 | 1.453 | 1.113 | 0.924 | 0.834 | 0.699 |
| 100 | 1.240 | 1.340 | 1.015 | 1.181 | 0.924 | 0.893 | 0.941 | 0.645 |
| 110 | 1.048 | 0.947 | 0.794 | 1.063 | 1.055 | 1.132 | 1.452 | 0.871 |
| 120 | 0.754 | 0.666 | 0.672 | 1.087 | 1.488 | 1.660 | 1.726 | 1.119 |
| 130 | 0.655 | 0.585 | 0.788 | 1.309 | 1.636 | 1.852 | 1.835 | 1.240 |
| ICS | 10.82 | 14.71 | 19.13 | 24.34 | 26.76 | 31.68 | 30.11 | 28.75 |
| MTCS | 9.74 | 12.10 | 15.78 | 19.82 | 22.20 | 23.48 | 20.10 | 16.25 |

(continued)

| Angle | Energy (eV) | | | |
|---|---|---|---|---|
| (deg) | 15 | 20 | 40 | 100 |
| 10 | - | - | 25.120 | 17.870 |
| 15 | 15.460 | 15.900 | - | - |
| 20 | 11.020 | 11.350 | 7.910 | 2.158 |
| 30 | 5.668 | 4.936 | 2.001 | 0.652 |
| 40 | 2.898 | 2.108 | 0.806 | 0.337 |
| 50 | 1.730 | 1.259 | 0.638 | 0.220 |
| 60 | 1.291 | 0.995 | 0.370 | 0.144 |
| 70 | 1.026 | 0.731 | 0.236 | 0.079 |
| 80 | 0.801 | 0.482 | 0.199 | 0.051 |
| 90 | 0.591 | 0.380 | 0.169 | 0.061 |
| 100 | 0.577 | 0.358 | 0.147 | 0.067 |
| 110 | 0.650 | 0.404 | 0.142 | 0.079 |
| 120 | 0.740 | 0.448 | 0.172 | 0.088 |
| 130 | 0.909 | 0.480 | 0.193 | 0.090 |
| ICS | 25.26 | 21.82 | 14.10 | 6.60 |
| MTCS | 10.88 | 6.99 | 3.76 | 1.41 |

## $C_3H_8$

Absolute cross sections for elastic scattering of electrons from $C_3H_8$ have been determined in the energy range of 2–100 eV and over the scattering angles of 5–130°. The DCS were, again, analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 4.

**Reference:**

L. Boesten, M. A. Dillon, H. Tanaka, M. Kimura and H. Sato, *J. Phys. B: At. Mol. Opt. Phys.* **27** 1845 (1994).

Table 4. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $C_3H_8$. The estimated uncertainty in the DCS data is 15%–20%, whilst the uncertainty on the integral and momentum transfer cross sections is 30%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.5 | 8.5 | 10 |
| 20 | - | 2.466 | 3.240 | 5.628 | 7.195 | 14.159 | 13.466 | 13.471 |
| 25 | 2.277 | - | - | - | - | - | - | - |
| 30 | 1.668 | 1.543 | 2.359 | 3.638 | 5.002 | 7.713 | 7.544 | 7.177 |
| 40 | 0.933 | 1.074 | 1.809 | 2.298 | 2.840 | 3.891 | 3.595 | 3.340 |
| 50 | 0.752 | 1.252 | 1.983 | 2.306 | 2.358 | 2.713 | 2.441 | 2.237 |
| 60 | 0.999 | 1.657 | 2.371 | 2.503 | 2.416 | 2.662 | 2.211 | 1.994 |
| 70 | 1.450 | 1.992 | 2.463 | 2.525 | 2.225 | 2.261 | 1.916 | 1.684 |
| 80 | 1.623 | 1.859 | 2.274 | 1.968 | 1.710 | 1.813 | 1.470 | 1.352 |
| 90 | 1.568 | 1.264 | 1.417 | 1.638 | 1.480 | 1.443 | 1.235 | 1.155 |
| 100 | 1.430 | 1.117 | 1.144 | 1.292 | 1.257 | 1.526 | 1.384 | 1.199 |
| 110 | 1.271 | 0.922 | 1.025 | 1.344 | 1.639 | 1.689 | 1.510 | 1.289 |
| 120 | 1.044 | 0.804 | 0.888 | 1.495 | 1.639 | 1.911 | 1.627 | 1.340 |
| 130 | 0.837 | 0.784 | 0.981 | 1.600 | 1.737 | 1.967 | 1.689 | 1.486 |
| ICS | 17.04 | 19.82 | 26.97 | 34.09 | 39.95 | 44.46 | 41.54 | 38.36 |
| MTCS | 14.41 | 17.65 | 21.97 | 25.40 | 27.68 | 29.98 | 25.98 | 23.13 |

(continued)

| Angle | Energy (eV) | | | |
|---|---|---|---|---|
| (deg) | 15 | 20 | 40 | 100 |
| 5 | - | - | - | 34.452 |
| 10 | 23.396 | 25.685 | 30.073 | 19.275 |
| 20 | 13.438 | 10.063 | 7.500 | 1.992 |
| 25 | - | - | - | - |
| 30 | 6.036 | 4.754 | 1.769 | 0.800 |
| 40 | 2.823 | 2.212 | 1.000 | 0.383 |
| 50 | 1.955 | 1.638 | 0.725 | 0.222 |

| | | | | |
|---|---|---|---|---|
| 60 | 1.619 | 1.388 | 0.490 | 0.1693 |
| 70 | 1.295 | 0.974 | 0.291 | 0.0829 |
| 80 | 1.006 | 0.762 | 0.232 | 0.0525 |
| 90 | 0.822 | 0.547 | 0.208 | 0.0616 |
| 100 | 0.789 | 0.557 | 0.188 | 0.0798 |
| 110 | 0.781 | 0.587 | 0.192 | 0.0848 |
| 120 | 0.840 | 0.666 | 0.219 | 0.0915 |
| 130 | 1.056 | 0.731 | 0.266 | 0.0972 |
| ICS | 30.86 | 24.32 | 15.92 | 8.21 |
| MTCS | 16.73 | 13.73 | 6.34 | 2.88 |

## $C_2H_4$

Absolute cross sections for elastic scattering of electrons from $C_2H_4$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°. As before, the DCS were analyzed using a molecular phase-shift approach in order to extrapolate the DCS to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 5.

**Reference:**

R. Panajotovic, M. Kitajima, H. Tanaka, M. Jelisavcic, J. Lower, L. Campbell, M. J. Brunger and S. J. Buckman, *J. Phys. B: At. Mol. Opt. Phys.* **36** 1615 (2003).

Table 5. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $C_2H_4$. The estimated uncertainty in the DCS data is 15%, whilst the uncertainty on the integral and momentum transfer cross sections is 20%–25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 1.8 | 2.0 | 2.2 | 2.5 | 3.1 | 4.1 | 4.6 |
| 15 | - | - | - | - | - | 1.79 | 2.59 | 3.26 |
| 20 | 0.581 | 1.26 | 1.66 | 1.34 | 1.11 | 1.77 | 2.44 | 2.95 |
| 30 | 0.705 | 1.42 | 1.62 | 1.40 | 1.32 | 1.82 | 2.01 | 2.31 |
| 40 | 0.667 | 1.30 | 1.55 | 1.45 | 1.65 | 1.94 | 1.94 | 2.28 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 45 | - | - | - | - | - | 2.12 | - | 2.36 |
| 50 | 0.787 | 1.29 | 1.72 | 1.56 | 1.78 | 2.24 | 2.09 | 2.39 |
| 55 | - | - | - | - | - | 2.18 | - | 2.34 |
| 60 | 1.04 | 1.28 | 1.79 | 1.55 | 1.81 | 2.09 | 2.18 | 2.23 |
| 70 | 1.60 | 1.68 | 1.82 | 1.57 | 1.90 | 1.87 | 1.97 | 1.96 |
| 80 | 1.92 | 1.99 | 1.88 | 1.86 | 1.72 | 1.81 | 1.75 | 1.56 |
| 90 | 2.04 | 1.95 | 1.94 | 1.68 | 1.59 | 1.55 | 1.38 | 1.35 |
| 100 | 1.90 | 1.83 | 1.82 | 1.57 | 1.49 | 1.33 | 1.15 | 1.15 |
| 110 | 1.73 | 1.41 | 1.69 | 1.42 | 1.46 | 1.20 | 1.17 | 1.19 |
| 120 | 1.39 | 1.36 | 1.52 | 1.37 | 1.31 | 1.09 | 1.04 | 1.24 |
| 130 | 1.12 | 1.25 | 1.51 | 1.47 | 1.36 | 1.11 | 1.06 | 1.30 |
| ICS | 16.3 | 18.4 | 21.3 | 19.4 | 18.6 | 19.5 | 18.2 | 20.1 |
| MTCS | 16.8 | 17.9 | 20.8 | 19.3 | 17.6 | 17.3 | 14.6 | 16.3 |

(continued)

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 5.1 | 8.1 | 10.1 | 15 | 20 | 30 | 60 | 100 |
| 15 | 6.05 | 9.95 | 12.16 | - | - | - | - | - |
| 20 | 4.54 | 8.39 | 9.47 | 9.98 | 9.47 | 7.40 | 3.20 | 2.02 |
| 30 | 2.90 | 4.87 | 5.63 | 5.40 | 4.22 | 2.90 | 0.95 | 0.662 |
| 40 | 2.36 | 3.09 | 3.26 | 2.45 | 1.95 | 1.20 | 0.525 | 0.31 |
| 45 | - | - | - | - | - | - | - | - |
| 50 | 2.28 | 2.23 | 2.04 | 1.32 | 1.05 | 0.773 | 0.274 | 0.197 |
| 55 | - | - | - | - | - | - | - | - |
| 60 | 2.27 | 1.70 | 1.48 | 0.914 | 0.713 | 0.531 | 0.197 | 0.153 |
| 70 | 2.05 | 1.29 | 1.09 | 0.707 | 0.597 | 0.351 | 0.158 | 0.099 |
| 80 | 1.51 | 1.01 | 0.849 | 0.567 | 0.438 | 0.277 | 0.118 | 0.074 |
| 90 | 1.21 | 0.898 | 0.677 | 0.544 | 0.426 | 0.256 | 0.108 | 0.069 |
| 100 | 1.11 | 0.986 | 0.898 | 0.648 | 0.454 | 0.264 | 0.113 | 0.070 |
| 110 | 1.14 | 1.17 | 1.02 | 0.769 | 0.477 | 0.311 | 0.114 | 0.079 |
| 120 | 1.18 | 1.42 | 1.08 | 0.908 | 0.559 | 0.332 | 0.131 | 0.086 |
| 130 | 1.35 | 1.35 | 1.04 | 0.913 | 0.563 | 0.392 | 0.178 | 0.103 |
| ICS | 22.9 | 25.6 | 24.5 | 22.8 | 18.5 | 12.3 | 6.14 | 3.73 |
| MTCS | 18.5 | 19.6 | 15.8 | 13.8 | 9.8 0 | 5.3 0 | 2.5 0 | 1.50 |

## $C_3H_6$ (propene and cyclopropane)

Absolute cross sections for elastic scattering of electrons from $C_3H_6$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°. The DCS were analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, i.e., $\theta < 20°$ and $\theta > 130°$, to facilitate derivation of the integral cross sections.

The propene data are recommended in Table 6, while the cyclopropane data are recommended in Table 7.

**Reference:**

C. Makochekanwa, H. Kato, M. Hoshino, H. Tanaka, H. Kubo, M. H. F. Bettega, A. R. Lopes, M. A. P. Lima and L. G. Ferreira, *J. Chem. Phys.* **124** 024323 (2006).

Table 6. Differential cross sections ($10^{-16}$ $cm^2/sr$) for elastic scattering from propene ($C_3H_6$). Their absolute uncertainties are 15%. The experimental integral cross section (ICS) and momentum-transfer cross section (MTCS) have units of $10^{-16}$ $cm^2$ and are estimated to have experimental uncertainties of between 20% and 25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 1.8 | 2.0 | 2.3 | 2.6 | 3.0 | 5.0 | 8.0 |
| 15 | - | - | - | - | - | 2.806 | 20.354 | 9.643 |
| 20 | 10.691 | 2.093 | 3.001 | 2.939 | 2.628 | 2.577 | 10.916 | 10.192 |
| 30 | 2.279 | 1.505 | 2.416 | 2.61 | 2.685 | 2.307 | 3.979 | 6.888 |
| 40 | 1.507 | 1.338 | 1.953 | 2.434 | 2.626 | 2.393 | 2.949 | 4.202 |
| 50 | 1.261 | 1.349 | 1.823 | 2.501 | 2.688 | 2.456 | 2.968 | 2.537 |
| 60 | 1.605 | 1.676 | 1.914 | 2.619 | 2.722 | 2.539 | 2.803 | 2.267 |
| 70 | 1.925 | 2.151 | 2.126 | 2.365 | 2.497 | 2.307 | 2.350 | 1.799 |
| 80 | 2.729 | 2.496 | 2.293 | 2.038 | 2.122 | 1.854 | 1.969 | — |
| 90 | 2.730 | 2.385 | 2.047 | 1.972 | 1.858 | 1.620 | 1.627 | 1.458 |
| 100 | 2.536 | 2.074 | 1.791 | 1.526 | 1.712 | 1.363 | 1.442 | 1.539 |
| 110 | 2.231 | 1.773 | 1.414 | 1.520 | 1.504 | 1.192 | 1.570 | 1.512 |
| 120 | 2.005 | 1.460 | 1.299 | 1.464 | 1.447 | 1.095 | 1.601 | 1.413 |
| 130 | 1.649 | 1.355 | 1.354 | 1.544 | 1.483 | 1.101 | 1.356 | 1.472 |
| ICS | 20.9 | 22.8 | 28.8 | 25.7 | 26.8 | 20.9 | 25.6 | 28.6 |
| MTCS | 21.5 | 21.8 | 25.8 | 22.4 | 24.4 | 18.9 | 20.4 | 19.9 |

(continued)

| Angle | Energy (eV) | | | | |
|---|---|---|---|---|---|
| (deg) | 10 | 20 | 30 | 60 | 100 |
| 15 | 19.854 | 19.754 | 18.77 | 9.366 | 4.33 |
| 20 | 13.958 | 12.637 | 9.885 | 3.622 | 2.054 |
| 30 | 8.342 | 4.756 | 2.921 | 1.476 | 0.843 |
| 40 | 3.654 | 2.037 | 1.481 | 0.699 | 0.377 |
| 50 | 2.476 | 1.389 | 1.098 | 0.422 | 0.225 |
| 60 | 1.888 | 1.049 | 0.697 | 0.302 | 0.193 |
| 70 | 1.211 | 0.686 | 0.330 | 0.181 | 0.088 |
| 80 | - | - | - | - | - |
| 90 | 1.244 | 0.604 | 0.274 | 0.181 | 0.083 |
| 100 | 1.218 | 0.558 | 0.247 | 0.157 | 0.098 |
| 110 | 1.405 | 0.511 | 0.277 | 0.169 | 0.097 |
| 120 | 1.103 | 0.599 | 0.438 | 0.185 | 0.098 |
| 130 | 1.298 | 0.723 | 0.452 | 0.235 | 0.101 |
| ICS | 33.5 | 25.1 | 19.8 | 11.6 | 6.1 |
| MTCS | 19.1 | 13.7 | 8.9 | 8.1 | 4.3 |

Table 7. Differential cross sections ($10^{-16}$ $cm^2/sr$) for elastic scattering from cyclopropane (c-$C_3H_6$). Their absolute uncertainties are 15%. The experimental integral cross section (ICS) and momentum-transfer cross section (MTCS) have units of $10^{-16}$ $cm^2$ and are estimated to have experimental uncertainties of between 20% and 25%

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 7.0 | 10 | 12 |
| 15 | - | - | - | - | - | - | - | 15.74 |
| 20 | 1.92 | 2.233 | 3.132 | 4.859 | 8.545 | 9.555 | 11.57 | 11.73 |
| 30 | 1.206 | 1.214 | 1.513 | 2.331 | 4.287 | 4.874 | 5.81 | 5.784 |
| 40 | 0.729 | 0.944 | 1.243 | 1.784 | 2.538 | 2.854 | 2.806 | 2.581 |
| 50 | 0.727 | 0.927 | 1.124 | 1.746 | 2.221 | 2.348 | 1.949 | 1.661 |
| 60 | 0.878 | 1.068 | 1.148 | 1.681 | 2.145 | 2.131 | 1.722 | 1.587 |
| 70 | 1.084 | 1.220 | 1.195 | 1.495 | 1.723 | 1.688 | 1.398 | 1.411 |
| 80 | 1.353 | 1.394 | 1.234 | 1.094 | 0.978 | 0.993 | 0.973 | 1.051 |
| 90 | 1.479 | 1.487 | 1.121 | 0.827 | 0.732 | 0.851 | 0.924 | 0.934 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 100 | 1.601 | 1.481 | 1.036 | 0.863 | 1.145 | 1.283 | 1.386 | 1.22 |
| 110 | 1.645 | 1.258 | 1.032 | 1.096 | 1.837 | 2.099 | 1.964 | 1.52 |
| 120 | 1.621 | 1.201 | 1.216 | 1.312 | 2.279 | 2.374 | 2.085 | 1.634 |
| 130 | 1.622 | 1.203 | 1.361 | 1.465 | 2.645 | 2.145 | 1.682 | 1.334 |
| ICS | 17.7 | 17.2 | 17.8 | 19.5 | 28.9 | 30.8 | 30.0 | 28.0 |
| MTCS | 19.1 | 17.6 | 17.1 | 18.5 | 26.4 | 24.7 | 21.3 | 17.7 |

(continued)

| Angle | Energy (eV) | | | | | |
|---|---|---|---|---|---|---|
| (deg) | 15 | 20 | 25 | 30 | 60 | 100 |
| 15 | 16.853 | 18.37 | 20.086 | 22.44 | 15.34 | 9.10 |
| 20 | 12.453 | 12.98 | 12.407 | 12.27 | 6.46 | 3.068 |
| 30 | 5.898 | 4.963 | 4.026 | 3.50 | 1.22 | 0.774 |
| 40 | 2.355 | 1.908 | 1.645 | 1.444 | 0.673 | 0.358 |
| 50 | 1.530 | 1.354 | 1.277 | 1.061 | 0.368 | 0.252 |
| 60 | 1.451 | 1.243 | 0.971 | 0.736 | 0.258 | 0.189 |
| 70 | 1.275 | 0.924 | 0.644 | 0.442 | 0.223 | 0.103 |
| 80 | 0.944 | 0.644 | 0.457 | 0.357 | 0.1469 | 0.063 |
| 90 | 0.858 | 0.581 | 0.458 | 0.391 | 0.094 | 0.056 |
| 100 | 0.95 | 0.663 | 0.518 | 0.484 | 0.0846 | 0.074 |
| 110 | 1.09 | 0.718 | 0.53 | 0.522 | 0.106 | 0.076 |
| 120 | 1.13 | 0.812 | 0.61 | 0.644 | 0.142 | 0.094 |
| 130 | 1.035 | 0.851 | 0.674 | 0.863 | 0.18 | 0.115 |
| ICS | 27.2 | 25.5 | 23.8 | 22.6 | 11.8 | 6.4 |
| MTCS | 15.4 | 11.5 | 10.6 | 9.8 | 8.6 | 4.7 |

## $C_3H_4$ (allene and propyne)

Absolute cross sections for elastic scattering of electrons from $C_3H_4$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°.

The allene data are recommended in Table 8, with the propyne data being recommended in Table 9.

**Reference:**

Y. Nakano, M. Hoshino, M. Kitajima, H. Tanaka and M. Kimura, *Phys. Rev. A* **66** 032714 (2002).

Table 8. Differential cross sections ($10^{-16}$ $cm^2/sr$) for elastic scattering from allene. Their absolute uncertainties are 15%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 2.0 | 3.0 | 4.0 | 5.0 | 7.0 | 10 | 12 | 15 |
| 15 | - | - | - | - | - | 15.809 | 16.973 | 16.998 |
| 20 | 4.97 | 2.685 | 2.786 | 3.609 | 6.844 | 11.646 | 13.088 | 12.808 |
| 30 | 3.096 | 2.432 | 2.959 | 2.729 | 4.396 | 6.046 | 6.651 | 6.230 |
| 40 | 2.333 | 2.506 | 2.943 | 2.603 | 3.507 | 4.062 | 3.772 | 3.089 |
| 50 | 2.063 | 2.275 | 2.939 | 2.462 | 2.743 | 2.574 | 2.686 | 2.068 |
| 60 | 1.868 | 2.213 | 2.694 | 2.211 | 2.186 | 1.711 | 1.602 | 1.332 |
| 70 | 1.714 | 2.101 | 2.302 | 1.947 | 1.761 | 1.182 | 1.159 | 0.848 |
| 80 | 1.651 | 1.796 | 1.966 | 1.808 | 1.459 | 1.166 | 0.985 | 0.771 |
| 90 | 1.372 | 1.517 | 1.551 | 1.428 | 1.310 | 1.079 | 0.971 | 0.769 |
| 100 | 1.197 | 1.136 | 1.306 | 1.267 | 1.131 | 0.998 | 0.865 | 0.669 |
| 110 | 1.029 | 1.070 | 1.096 | 0.996 | 1.080 | 1.014 | 0.802 | 0.656 |
| 120 | 1.070 | 0.858 | 0.970 | 0.973 | 1.055 | 0.980 | 0.747 | 0.710 |
| 130 | 1.120 | 0.911 | 0.961 | 1.077 | 1.120 | 1.154 | 1.063 | 0.883 |

(continued)

| Angle | Energy (eV) | | | |
|---|---|---|---|---|
| (deg) | 20 | 30 | 60 | 100 |
| 15 | 16.956 | 18.769 | 9.835 | 6.581 |
| 20 | 11.514 | 11.156 | 4.336 | 3.176 |
| 30 | 4.755 | 3.943 | 1.351 | 0.858 |
| 40 | 2.592 | 1.941 | 0.603 | 0.309 |
| 50 | 1.722 | 0.886 | 0.294 | 0.220 |
| 60 | 0.937 | 0.458 | 0.208 | 0.187 |
| 70 | 0.585 | 0.369 | 0.159 | 0.117 |
| 80 | 0.613 | 0.358 | 0.142 | 0.0796 |
| 90 | 0.613 | 0.369 | 0.126 | 0.0823 |
| 100 | 0.558 | 0.274 | 0.102 | 0.0791 |
| 110 | 0.541 | 0.281 | 0.131 | 0.0866 |
| 120 | 0.547 | 0.357 | 0.162 | 0.0801 |
| 130 | 0.746 | 0.479 | 0.199 | 0.0751 |

Table 9. Differential cross sections ($10^{-16}$ $cm^2/sr$) for elastic scattering from propyne. Their absolute uncertainties are 15%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 3.2 | 4.0 | 5.0 | 7.0 | 10 |
| 15 | - | - | - | - | - | - | - | 15.403 |
| 20 | 2.93 | 3.253 | 5.01 | 7.102 | 4.702 | 5.158 | 9.546 | 11.036 |
| 30 | 1.771 | 1.537 | 3.772 | 4.847 | 3.696 | 4.424 | 6.463 | 6.941 |
| 40 | 1.441 | 1.189 | 2.722 | 3.559 | 2.931 | 3.319 | 4.527 | 4.173 |
| 50 | 1.543 | 1.275 | 2.486 | 3.066 | 2.486 | 2.768 | 3.166 | 2.819 |
| 60 | 1.798 | 1.526 | 2.449 | 3.173 | 2.211 | 2.380 | 2.300 | 2.133 |
| 70 | 1.836 | 1.490 | 2.155 | 2.691 | 1.893 | 2.096 | 1.926 | 1.611 |
| 80 | 2.365 | 1.407 | 1.877 | 2.191 | 1.621 | 1.901 | 1.943 | 1.490 |
| 90 | 1.920 | 1.256 | 1.622 | 1.557 | 1.505 | 1.786 | 1.783 | 1.256 |
| 100 | 1.492 | 1.183 | 1.377 | 1.501 | 1.218 | 1.528 | 1.550 | 1.184 |
| 110 | 1.225 | 0.942 | 1.468 | 1.566 | 1.302 | 1.378 | 1.233 | 0.949 |
| 120 | 1.010 | 0.841 | 1.501 | 1.870 | 1.330 | 1.306 | 1.127 | 1.074 |
| 130 | 0.918 | 0.847 | 1.832 | 2.072 | 1.354 | 1.286 | 1.149 | 1.286 |

(continued)

| Angle | Energy (eV) | | | | | |
|---|---|---|---|---|---|---|
| (deg) | 12 | 15 | 20 | 25 | 60 | 100 |
| 15 | 13.371 | 17.924 | 19.579 | 19.194 | 14.385 | 9.227 |
| 20 | 9.009 | 13.895 | 13.822 | 12.666 | 6.783 | 4.718 |
| 30 | 5.502 | 6.414 | 5.681 | 4.418 | 1.936 | 1.258 |
| 40 | 3.082 | 3.486 | 2.623 | 2.141 | 1.013 | 0.644 |
| 50 | 2.065 | 2.348 | 1.612 | 1.252 | 0.503 | 0.341 |
| 60 | 1.378 | 1.565 | 1.131 | 0.823 | 0.314 | 0.239 |
| 70 | 0.921 | 1.209 | 0.832 | 0.607 | 0.233 | 0.142 |
| 80 | 0.800 | 0.965 | 0.752 | 0.569 | 0.182 | 0.119 |
| 90 | 0.813 | 0.909 | 0.660 | 0.448 | 0.147 | 0.104 |
| 100 | 0.736 | 0.842 | 0.617 | 0.410 | 0.135 | 0.096 |
| 110 | 0.686 | 0.875 | 0.617 | 0.358 | 0.140 | 0.089 |
| 120 | 0.760 | 0.907 | 0.605 | 0.360 | 0.165 | 0.0936 |
| 130 | 0.988 | 1.078 | 0.725 | 0.529 | 0.212 | 0.0903 |

## B. Processing Plasma-Related Gases

### <u>$CF_4$</u>

Absolute cross sections for elastic scattering of electrons from $CF_4$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°. The DCS were again analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 10.

**Reference:**

L. Boesten, H. Tanaka, A. Kobayashi, M. A. Dillon and M. Kimura, *J. Phys. B: At. Mol. Opt. Phys.* **25** 1607 (1992).

Table 10. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$) from $CF_4$. The estimated uncertainty in the DCS data is 15%–20%, whilst the uncertainty on the integral and momentum transfer cross sections is 25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 |
| 15 | - | 0.1189 | 0.3408 | 0.9647 | 1.5526 | 2.5565 | 3.7041 | 4.7153 |
| 20 | 0.1156 | 0.2107 | 0.5437 | 1.1780 | 1.6739 | 2.4716 | 3.5055 | 4.0973 |
| 30 | 0.2929 | 0.5174 | 0.9571 | 1.7782 | 2.0409 | 2.3776 | 2.9866 | 3.5126 |
| 40 | 0.4775 | 0.7532 | 1.2560 | 2.1309 | 2.3629 | 2.4221 | 2.4890 | 2.6564 |
| 50 | 0.8106 | 1.1179 | 1.5905 | 2.3340 | 2.4184 | 2.0523 | 1.7570 | 1.7135 |
| 60 | 0.9146 | 1.3994 | 1.6028 | 2.0814 | 1.9375 | 1.7795 | 1.1971 | 1.1146 |
| 70 | 1.0264 | 1.2575 | 1.5126 | 1.4717 | 1.4875 | 1.1095 | 0.7749 | 0.7199 |
| 80 | 0.9225 | 1.0442 | 1.1786 | 1.0226 | 0.9028 | 0.6573 | 0.5520 | 0.6045 |
| 90 | 0.8779 | 0.8065 | 0.8906 | 0.6066 | 0.5430 | 0.4349 | 0.4953 | 0.6814 |
| 100 | 0.8154 | 0.7264 | 0.5381 | 0.4080 | 0.3774 | 0.4683 | 0.5924 | 0.7671 |
| 110 | 0.6146 | 0.4861 | 0.4399 | 0.3552 | 0.4347 | 0.5385 | 0.6781 | 0.7541 |
| 120 | 0.4576 | 0.4031 | 0.3167 | 0.3363 | 0.4473 | 0.5927 | 0.6703 | 0.7307 |
| 130 | 0.3618 | 0.2978 | 0.2637 | 0.3782 | 0.4503 | 0.5735 | 0.6118 | 0.6584 |
| ICS | 7.738 | 8.555 | 10.46 | 12.72 | 13.4 | 13.36 | 13.91 | 15.4 |

| MTCS | 6.963 | 7.136 | 7.645 | 8.243 | 8.62 | 8.781 | 9.124 | 10.24 |
|---|---|---|---|---|---|---|---|---|

(continued)

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 10 | 15 | 20 | 35 | 50 | 60 | 100 |
| 15 | 4.4007 | 5.4326 | 6.7566 | 14.1044 | 13.3217 | 12.1904 | 9.9255 |
| 20 | 4.7677 | 4.8219 | 5.1461 | 7.8265 | 6.9383 | 5.8892 | 3.4611 |
| 30 | 4.1163 | 3.4725 | 3.1666 | 2.6912 | 1.4085 | 1.0154 | 1.0555 |
| 40 | 2.8836 | 2.4642 | 1.7198 | 0.8776 | 0.7378 | 0.7464 | 0.7534 |
| 50 | 1.6848 | 1.3828 | 0.9118 | 0.8609 | 0.8566 | 0.7594 | 0.3187 |
| 60 | 0.9990 | 0.9010 | 0.7949 | 0.9268 | 0.6723 | 0.4286 | 0.2172 |
| 70 | 0.7302 | 0.8689 | 1.0042 | 0.8090 | 0.3603 | 0.2190 | 0.2153 |
| 80 | 0.7817 | 1.0580 | 1.0952 | 0.4353 | 0.1696 | 0.1289 | 0.1571 |
| 90 | 0.7996 | 1.0762 | 0.9876 | 0.2011 | 0.1364 | 0.1275 | 0.0995 |
| 100 | 0.7938 | 0.9311 | 0.6900 | 0.1760 | 0.1331 | 0.1237 | 0.0948 |
| 110 | 0.7272 | 0.6981 | 0.5303 | 0.2550 | 0.2002 | 0.1851 | 0.1223 |
| 120 | 0.6215 | 0.5948 | 0.5540 | 0.4546 | 0.4086 | 0.3220 | 0.1917 |
| 130 | 0.6514 | 0.6907 | 0.8226 | 0.6906 | 0.6573 | 0.4328 | 0.2619 |
| ICS | 16.63 | 16.92 | 17.63 | 16.72 | 14.24 | 13.06 | 9.844 |
| MTCS | 11.38 | 13.49 | 14.11 | 8.757 | 6.722 | 5.836 | 3.848 |

## $C_2F_6$

Absolute cross sections for elastic scattering of electrons from $C_2F_6$ have been determined in the energy range of 2–100 eV and over the scattering angles of 10–130°. These DCS were also analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 11.

**Reference:**

T. Takagi, L. Boesten, H. Tanaka and M. A. Dillon, *J. Phys. B: At. Mol. Opt. Phys.* **27** 5389 (1994).

Table 11. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $C_2F_6$. The estimated uncertainty in the DCS data is 15%–20%, whilst the uncertainty on the integral and momentum transfer cross sections is 25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 2.0 | 3.0 | 4.0 | 5.0 | 7.0 | 8.0 | 10 | 15 |
| 10 | - | - | - | - | - | - | - | - |
| 15 | - | - | - | - | 5.304 | 7.05 | 8.261 | 11.28 |
| 20 | 0.4578 | 1.042 | 2.113 | 3.963 | 5.536 | 6.882 | 7.803 | 8.700 |
| 25 | - | - | - | - | - | - | - | - |
| 30 | 0.9265 | 1.758 | 2.562 | 4.269 | 5.332 | 5.772 | 5.676 | 5.326 |
| 40 | 1.368 | 2.496 | 2.805 | 4.089 | 4.127 | 4.094 | 3.322 | 2.269 |
| 50 | 1.837 | 2.772 | 2.660 | 3.365 | 2.797 | 2.370 | 1.487 | 1.146 |
| 60 | 1.952 | 2.439 | 2.160 | 2.191 | 1.549 | 1.228 | 0.9494 | 1.230 |
| 70 | 1.960 | 2.018 | 1.650 | 1.471 | 0.9424 | 0.876 | 1.033 | 1.633 |
| 80 | 1.838 | 1.591 | 1.109 | 1.190 | 0.839 | 0.9448 | 1.243 | 1.813 |
| 90 | 1.394 | 1.168 | 0.9805 | 1.058 | 1.060 | 1.107 | 1.328 | 1.551 |
| 100 | 1.132 | 0.8898 | 0.8343 | 0.9543 | 1.047 | 1.125 | 1.187 | 1.365 |
| 110 | 1.066 | 0.8162 | 0.7842 | 0.8861 | 0.9339 | 0.9334 | 1.034 | 1.114 |
| 120 | 0.8144 | 0.6880 | 0.6748 | 0.8246 | 0.7572 | 0.8326 | 1.010 | 1.124 |
| 130 | 0.7224 | 0.7152 | 0.5981 | 0.6253 | 0.7671 | 0.9042 | 0.8516 | 1.209 |
| ICS | 15.53 | 17.61 | 19.11 | 21.19 | 22.66 | 24.26 | 24.88 | 28.04 |
| MTCS | 12.98 | 13.18 | 14.11 | 14.56 | 16.43 | 17.85 | 18.81 | 22.73 |

(continued)

| Angle | Energy (eV) | | | |
|---|---|---|---|---|
| (deg) | 20 | 30 | 60 | 100 |
| 10 | - | 23.54 | 41.13 | 37.91 |
| 15 | 15.45 | - | 19.31 | 11.26 |
| 20 | 10.09 | 14.07 | 6.473 | 2.772 |
| 25 | - | - | 2.092 | 1.859 |
| 30 | 4.126 | 3.220 | 1.373 | 1.607 |
| 40 | 1.174 | 1.154 | 1.428 | 0.8559 |
| 50 | 1.015 | 1.694 | 0.9475 | 0.3984 |

| | | | | |
|---|---|---|---|---|
| 60 | 1.477 | 1.681 | 0.5767 | 0.3622 |
| 70 | 1.598 | 1.239 | 0.4094 | 0.3113 |
| 80 | 1.405 | 0.8628 | 0.2396 | 0.1880 |
| 90 | 1.172 | 0.7576 | 0.2132 | 0.1566 |
| 100 | 0.9623 | 0.5131 | 0.2386 | 0.1387 |
| 110 | 0.7965 | 0.5407 | 0.2924 | 0.1694 |
| 120 | 0.9013 | 0.7836 | 0.4476 | 0.2530 |
| 130 | 1.227 | 1.148 | 0.5915 | 0.3439 |
| ICS | 28.09 | 25.33 | 21.51 | 16.12 |
| MTCS | 22.45 | 18.93 | 10.62 | 5.86 |

## $C_3F_8$

Absolute cross sections for elastic scattering of electrons from $C_3F_8$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°. The DCS were analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 12.

**Reference:**

H. Tanaka, Y. Tachibana, M. Kitajima, O. Sueoka, H. Takaki, A. Hamada and M. Kimura, *Phys. Rev. A* **59** 2006 (1999).

Table 12. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ cm$^2$/sr) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ cm$^2$), from $C_3F_8$. The estimated uncertainty in the DCS data is 15%–20%, whilst the uncertainty on the integral and momentum transfer cross sections is 30%.

| Angle | Energy (eV) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.5 | 7.0 | 8.0 | 9.0 |
| 15 | - | - | - | - | - | - | - | - | - |
| 20 | 1.224 | 1.185 | 3.270 | 5.757 | 7.099 | 9.769 | 10.830 | 12.417 | 14.415 |
| 30 | 0.883 | 1.624 | 4.100 | 6.171 | 6.284 | 9.395 | 9.306 | 9.099 | 9.232 |
| 40 | 1.309 | 2.258 | 4.143 | 6.085 | 5.510 | 5.981 | 5.916 | 4.958 | 4.154 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 50 | 1.792 | 2.632 | 3.811 | 4.941 | 4.940 | 3.409 | 3.048 | 2.313 | 1.595 |
| 60 | 2.033 | 2.718 | 3.250 | 3.739 | 2.946 | 1.900 | 1.642 | 1.280 | 1.253 |
| 70 | 2.232 | 2.418 | 2.618 | 2.436 | 1.889 | 1.356 | 1.303 | 1.429 | 1.612 |
| 80 | 2.290 | 2.034 | 1.811 | 1.773 | 1.474 | 1.375 | 1.516 | 1.603 | 1.669 |
| 90 | 2.038 | 1.752 | 1.323 | 1.315 | 1.391 | 1.435 | 1.613 | 1.777 | 1.650 |
| 100 | 1.640 | 1.369 | 1.075 | 1.179 | 1.178 | 1.315 | 1.465 | 1.457 | 1.535 |
| 110 | 1.355 | 1.078 | 0.890 | 1.010 | 1.038 | 1.138 | 1.340 | 1.328 | 1.422 |
| 120 | 1.176 | 0.939 | 0.767 | 0.870 | 0.942 | 1.053 | 1.122 | 1.295 | 1.382 |
| 130 | 1.115 | 0.916 | 0.734 | 0.872 | 0.908 | 1.081 | 1.199 | 1.334 | 1.580 |
| ICS | 19.800 | 20.817 | 27.401 | 35.317 | 37.503 | 42.877 | 44.365 | 44.513 | 44.942 |
| MTCS | 18.244 | 17.524 | 21.909 | 26.542 | 32.918 | 35.031 | 33.888 | 38.513 | 41.088 |

(continued)

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 10 | 12 | 15 | 20 | 25 | 30 | 60 | 100 |
| 15 | 16.748 | 15.202 | 14.168 | 22.021 | 26.080 | 28.094 | 17.724 | 7.253 |
| 20 | 14.339 | 12.969 | 12.032 | 13.724 | 14.267 | 13.322 | 4.860 | 3.174 |
| 30 | 9.051 | 7.671 | 5.932 | 3.473 | 2.665 | 2.098 | 2.683 | 2.436 |
| 40 | 3.662 | 3.083 | 1.866 | 1.161 | 1.565 | 1.551 | 2.007 | 1.251 |
| 50 | 1.608 | 1.417 | 1.217 | 1.689 | 2.010 | 1.844 | 1.276 | 0.596 |
| 60 | 1.289 | 1.481 | 1.628 | 1.978 | 2.132 | 1.776 | 0.751 | 0.525 |
| 70 | 1.549 | 1.767 | 2.046 | 1.945 | 1.908 | 1.328 | 0.571 | 0.442 |
| 80 | 1.751 | 1.906 | 2.204 | 1.684 | 1.225 | 0.825 | 0.397 | 0.263 |
| 90 | 1.716 | 1.959 | 2.168 | 1.418 | 0.813 | 0.640 | 0.334 | 0.207 |
| 100 | 1.624 | 1.791 | 1.972 | 1.166 | 0.762 | 0.570 | 0.354 | 0.222 |
| 110 | 1.586 | 1.609 | 1.591 | 1.150 | 0.852 | 0.656 | 0.472 | 0.299 |
| 120 | 1.508 | 1.537 | 1.382 | 1.315 | 1.221 | 0.813 | 0.530 | 0.449 |
| 130 | 1.623 | 1.590 | 1.569 | 1.929 | 1.645 | 1.283 | 0.942 | 0.632 |
| ICS | 44.335 | 42.379 | 39.150 | 37.631 | 36.324 | 32.869 | 18.784 | 13.001 |
| MTCS | 40.784 | 38.193 | 35.610 | 31.745 | 26.921 | 23.625 | 16.713 | 10.376 |

## ***cyclo*-$C_4F_8$**

Absolute cross sections for elastic scattering of electrons from cyclo-$C_4F_8$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 10–130°. The DCS were also analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 13.

**Reference:**

M. Jelisavcic, R. Panajotovic, M. Kitajima, M. Hoshino, H. Tanaka and S. J. Buckman, *J. Chem. Phys.* **121** 5272 (2004).

Table 13. Differential cross sections in units of $10^{-16}$ $cm^2/sr$, for elastic electron scattering from cyclo-$C_4F_8$. The ANU results are designated (A) and the Sophia results (S). For the ANU results the figures in parentheses represent the absolute error, expressed as a percentage, while for the Sophia data the estimated uncertainty is 15%. The figures at the base of each column are the integral elastic and elastic momentum transfer cross sections, for which the estimated uncertainties are 20%–25%.

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 1.5 (A) | 1.5 (S) | 2.0 (A) | 2.0 (S) | 2.6 (S) | 3.0 (S) | 4.0 (S) |
| 10 | - | - | - | - | - | - | - |
| 15 | - | - | - | - | - | - | - |
| 20 | 0.604(46) | 1.534 | 1.266(39) | 1.413 | 1.424 | 1.802 | 3.050 |
| 30 | 1.816(24) | 1.623 | 0.823(17) | 2.020 | 2.712 | 2.977 | 3.704 |
| 40 | 2.083(24) | 2.455 | 2.511(17) | 3.077 | 3.594 | 3.516 | 4.011 |
| 50 | 2.669(11) | 2.705 | 3.682(9) | 3.638 | 4.061 | 3.951 | 3.293 |
| 60 | 2.528(9) | 2.838 | 2.668(7) | 3.149 | 3.378 | 2.889 | 2.137 |
| 70 | 2.288(7) | 2.398 | 2.021(7) | 2.694 | 1.963 | 1.522 | 0.960 |
| 80 | 1.575(7) | 2.009 | 1.238(7) | 1.574 | 1.194 | 0.821 | 0.525 |
| 90 | 1.105(7) | 1.338 | 0.662(7) | 0.909 | 0.556 | 0.414 | 0.691 |
| 100 | 0.700(7) | 0.914 | 0.365(7) | 0.559 | 0.332 | 0.397 | 0.949 |
| 110 | 0.510(7) | 0.642 | 0.295(7) | 0.410 | 0.378 | 0.684 | 1.248 |
| 120 | 0.477(7) | 0.593 | 0.389(7) | 0.466 | 0.613 | 0.941 | 1.580 |
| 130 | 0.571(7) | 0.693 | 0.605(6) | 0.708 | 0.905 | 1.213 | 1.769 |
| ICS | 16.9 | 18.8 | 16.8 | 18.5 | 18.1 | 18.7 | 21.4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MTCS | 12.5 | 14.0 | 10.8 | 12.1 | 11.0 | 12.9 | 16.6 |

(continued)

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 5.0 (A) | 5.0 (S) | 6.0 (A) | 7.0 (A) | 8.0 (S) | 10 (A) | 10 (S) |
| 10 | - | - | - | - | - | - | - |
| 15 | - | - | 8.451(36) | - | - | - | - |
| 20 | 5.870(8) | 5.703 | 8.305(8) | 11.574(8) | 12.021 | 15.486(13) | 15.035 |
| 30 | 4.769(7) | 4.480 | 6.891(7) | 8.000(7) | 9.142 | 8.782(12) | 9.273 |
| 40 | 3.893(7) | 3.947 | 4.669(7) | 4.783(7) | 4.826 | 3.465(12) | 4.004 |
| 50 | 2.342(8) | 2.454 | 2.679(7) | 2.273(7) | 2.068 | 1.330(8) | 1.344 |
| 60 | 1.025(8) | 1.212 | 1.146(7) | 0.983(7) | 0.995 | 1.360(6) | 1.428 |
| 70 | 0.600(7) | 0.701 | 0.829(6) | 0.844(7) | 1.344 | 1.840(6) | 1.980 |
| 80 | 0.676(7) | 0.803 | 0.920(6) | 1.032(6) | 1.511 | 1.885(7) | 1.989 |
| 90 | 0.906(8) | 0.936 | 1.020(6) | 1.048(7) | 1.542 | 1.558(6) | 1.796 |
| 100 | 1.032(8) | 1.111 | 0.966(7) | 0.913(8) | 1.218 | 1.316(7) | 1.799 |
| 110 | 1.027(8) | 1.301 | 0.883(7) | 0.810(7) | 1.267 | 1.295(7) | 1.630 |
| 120 | 1.030(7) | 1.182 | 0.879(8) | 0.808(7) | 1.262 | 1.363(8) | 1.711 |
| 130 | 1.110(6) | 1.311 | 0.948(6) | 0.919(7) | 1.430 | 1.540(7) | 2.108 |
| ICS | 22.5 | 21.3 | 22.8 | 24.9 | 30.5 | 34.9 | 35.6 |
| MTCS | 14.2 | 16.2 | 11.9 | 13.3 | 18.5 | 21.5 | 22.3 |

(continued)

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 15 (A) | 15 (S) | 20 (A) | 20 (S) | 30 (S) | 60 (S) | 100 (S) |
| 10 | 37.581(35) | - | 47.398(7) | - | - | - | - |
| 15 | - | - | - | - | - | - | - |
| 20 | 15.553(8) | 15.908 | 15.956(7) | 17.773 | 14.627 | 5.112 | 3.822 |
| 30 | 5.632(8) | 6.280 | 2.880(7) | 3.890 | 1.554 | 3.479 | 3.045 |
| 40 | 1.299(8) | 1.568 | 0.990(7) | 1.160 | 2.500 | 2.142 | 1.557 |
| 50 | 1.166(8) | 1.279 | 1.812(6) | 2.448 | 2.530 | 1.403 | 0.769 |
| 60 | 1.834(6) | 2.045 | 2.016(8) | 2.776 | 1.890 | 0.842 | 0.538 |
| 70 | 1.961(7) | 2.663 | 1.725(7) | 2.390 | 1.543 | 0.616 | 0.489 |
| 80 | 1.848(6) | 2.290 | 1.452(7) | 1.929 | 1.073 | 0.423 | 0.275 |
| 90 | 1.687(6) | 2.112 | 1.167(7) | 1.595 | 0.827 | 0.363 | 0.200 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 | 1.401(6) | 1.865 | 1.020(6) | 1.376 | 0.921 | 0.352 | 0.244 |
| 110 | 1.266(6) | 1.758 | 1.088(7) | 1.381 | 0.872 | 0.472 | 0.300 |
| 120 | 1.309(6) | 1.600 | 1.302(7) | 1.599 | 1.270 | 0.666 | 0.373 |
| 130 | 1.621(7) | 2.022 | 1.780(7) | 2.117 | 1.700 | 0.935 | 0.674 |
| ICS | 34.2 | 35.2 | 32.9 | 37.8 | 31.3 | 16.1 | 11.0 |
| MTCS | 19.0 | 21.6 | 17.2 | 20.4 | 15.6 | 6.21 | 3.68 |

## $C_2F_4$

Absolute cross sections for elastic scattering of electrons from $C_2F_4$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 20–130°. The DCS were analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 14.

**Reference:**

R. Panajotovic, M. Jelisavcic, R. Kajita, T. Tanaka, M. Kitajima, H. Cho, H. Tanaka and S. J. Buckman, *J. Chem. Phys.* **121** 4559 (2004).

Table 14. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $C_2F_4$. The estimated uncertainty in the DCS data is 15%, whilst the uncertainty on the integral and momentum transfer cross sections is 20%–25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 |
| 20 | 0.596 | 0.539 | 0.781 | 0.842 | 1.487 | 2.455 | 2.388 | 3.149 |
| 30 | 0.399 | 0.356 | 0.627 | 0.950 | 1.587 | 2.477 | 2.301 | 2.698 |
| 40 | 0.250 | 0.287 | 0.701 | 0.969 | 1.621 | 2.263 | 1.965 | 2.058 |
| 50 | 0.247 | 0.346 | 0.802 | 1.091 | 1.555 | 1.880 | 1.521 | 1.572 |
| 60 | 0.330 | 0.392 | 0.756 | 0.954 | 1.211 | 1.323 | 1.083 | 1.048 |
| 70 | 0.352 | 0.417 | 0.719 | 0.755 | 0.911 | 0.928 | 0.873 | 0.966 |
| 80 | 0.393 | 0.435 | 0.589 | 0.537 | 0.652 | 0.725 | 0.700 | 0.867 |
| 90 | 0.412 | 0.367 | 0.563 | 0.480 | 0.579 | 0.672 | 0.683 | 0.882 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 100 | 0.433 | 0.343 | 0.501 | 0.409 | 0.529 | 0.580 | 0.607 | 0.809 |
| 110 | 0.410 | 0.320 | 0.440 | 0.385 | 0.479 | 0.528 | 0.594 | 0.788 |
| 120 | 0.413 | 0.306 | 0.402 | 0.348 | 0.427 | 0.531 | 0.661 | 0.845 |
| 130 | 0.366 | 0.286 | 0.410 | 0.349 | 0.511 | 0.621 | 0.803 | 0.955 |
| ICS | 4.55 | 4.34 | 7.13 | 7.73 | 10.1 | 13.1 | 10.5 | 14.4 |
| MTCS | 4.13 | 3.7 | 5.84 | 5.9 | 7.38 | 8.37 | 7.62 | 11.6 |

(continued)

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 9.0 | 10 | 15 | 20 | 30 | 60 | 100 |
| 20 | 3.427 | 4.594 | 7.896 | 8.781 | 9.537 | 6.75 | 2.800 |
| 30 | 2.981 | 3.312 | 4.233 | 3.866 | 2.970 | 1.440 | 1.290 |
| 40 | 2.168 | 2.428 | 2.373 | 1.815 | 1.298 | 0.940 | 0.645 |
| 50 | 1.600 | 1.605 | 1.365 | 1.173 | 1.064 | 0.642 | 0.332 |
| 60 | 1.166 | 1.222 | 1.085 | 1.101 | 0.911 | 0.437 | 0.229 |
| 70 | 1.049 | 1.022 | 0.981 | 0.934 | 0.753 | 0.245 | 0.185 |
| 80 | 0.922 | 0.979 | 0.830 | 0.861 | 0.543 | 0.202 | 0.157 |
| 90 | 1.014 | 0.896 | 0.808 | 0.660 | 0.387 | 0.177 | 0.114 |
| 100 | 0.913 | 0.869 | 0.711 | 0.54 | 0.332 | 0.172 | 0.106 |
| 110 | 0.840 | 0.852 | 0.711 | 0.578 | 0.446 | 0.221 | 0.140 |
| 120 | 0.935 | 0.896 | 0.771 | 0.795 | 0.558 | 0.328 | 0.205 |
| 130 | 1.104 | 1.053 | 0.983 | 1.034 | 0.773 | 0.441 | 0.288 |
| ICS | 16.8 | 19.4 | 18.7 | 20.8 | 16.9 | 12.2 | 5.43 |
| MTCS | 12.5 | 15.8 | 12.7 | 16.1 | 9.64 | 4.66 | 2.72 |

## $C_3F_6$

Absolute cross sections for elastic scattering of electrons from $C_3F_6$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°. As before the DCS were analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 15.

**Reference:**

H. Cho, R. J. Gulley, K. Sunohara, M. Kitajima, L. J. Uhlmann, H. Tanaka and S. J. Buckman, *J. Phys. B: At. Mol. Opt. Phys.* **34** 1019 (2001).

Table 15. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2$/sr) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$),from $C_3F_6$. The estimated uncertainty in the DCS data is 15%, whilst the uncertainty on the integral and momentum transfer cross sections is 20%–25%.

| angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 |
| 15 | 4.204 | 4.777 | 3.995 | 4.880 | 5.137 | 7.582 | 8.857 | 9.234 |
| 20 | 3.725 | 3.909 | 3.513 | 4.496 | 4.560 | 6.428 | 7.000 | 7.548 |
| 30 | 2.328 | 2.647 | 2.755 | 4.259 | 4.304 | 4.606 | 5.152 | 4.966 |
| 40 | 1.509 | 2.091 | 2.583 | 4.164 | 4.108 | 3.702 | 3.259 | 3.246 |
| 50 | 1.404 | 1.932 | 2.694 | 3.539 | 3.255 | 2.603 | 1.825 | 1.773 |
| 60 | 1.348 | 1.988 | 2.449 | 2.533 | 2.088 | 1.827 | 1.367 | 1.178 |
| 70 | 1.344 | 1.720 | 1.870 | 1.862 | 1.645 | 1.189 | 1.049 | 1.088 |
| 80 | 1.249 | 1.429 | 1.498 | 1.418 | 1.337 | 0.961 | 0.984 | 1.103 |
| 90 | 0.938 | 1.329 | 1.275 | 1.274 | 1.080 | 1.019 | 0.955 | 1.096 |
| 100 | 0.894 | 1.006 | 1.078 | 1.151 | 0.913 | 1.051 | 0.952 | 1.114 |
| 110 | 0.882 | 0.914 | 0.943 | 1.068 | 0.935 | 0.931 | 1.019 | 1.151 |
| 120 | 0.781 | 0.812 | 0.947 | 1.005 | 0.941 | 0.923 | 1.075 | 1.204 |
| 130 | 0.682 | 0.728 | 0.951 | 1.061 | 0.955 | 1.047 | 1.149 | 1.173 |
| ICS | 20.0 | 20.9 | 22.9 | 23.9 | 25.4 | 26.2 | 27.1 | 26.1 |
| MTCS | 18.4 | 19.6 | 20.2 | 21.5 | 22.4 | 24.4 | 25.2 | 24.9 |

(continued)

| angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 9.0 | 10 | 15 | 20 | 30 | 60 | 100 |
| 15 | 12.060 | 13.570 | 17.965 | 20.224 | 25.496 | 15.944 | 9.357 |
| 20 | 9.358 | 10.923 | 13.295 | 12.190 | 12.480 | 5.249 | 3.750 |
| 30 | 6.080 | 6.483 | 5.788 | 4.181 | 2.704 | 2.068 | 2.095 |
| 40 | 3.305 | 3.288 | 2.542 | 1.832 | 1.662 | 1.462 | 1.171 |
| 50 | 1.704 | 1.830 | 1.588 | 1.602 | 1.556 | 0.986 | 0.476 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 60 | 1.454 | 1.460 | 1.551 | 1.581 | 1.578 | 0.589 | 0.387 |
| 70 | 1.305 | 1.634 | 1.561 | 1.472 | 1.202 | 0.393 | 0.319 |
| 80 | 1.469 | 1.644 | 1.462 | 1.376 | 0.722 | 0.311 | 0.185 |
| 90 | 1.367 | 1.481 | 1.284 | 1.093 | 0.516 | 0.271 | 0.142 |
| 100 | 1.280 | 1.452 | 1.153 | 0.830 | 0.560 | 0.237 | 0.157 |
| 110 | 1.267 | 1.351 | 1.042 | 0.966 | 0.666 | 0.321 | 0.214 |
| 120 | 1.300 | 1.313 | 1.120 | 1.214 | 0.848 | 0.543 | 0.305 |
| 130 | 1.290 | 1.560 | 1.588 | 1.558 | 1.175 | 0.704 | 0.394 |
| ICS | 29.1 | 29.7 | 28.3 | 28.9 | 28.3 | 14.1 | 10.4 |
| MTCS | 23.7 | 22.9 | 20.9 | 18.7 | 15.4 | 6.9 | 3.5 |

## $C_6F_6$

Absolute cross sections for elastic scattering of electrons from $C_6F_6$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 20–130°. As before the DCS were analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 16.

**Reference:**

H. Cho, R. J. Gulley, K. Sunohara, M. Kitajima, L. J. Uhlmann, H. Tanaka and S. J. Buckman, *J. Phys. B: At. Mol. Opt. Phys.* **34** 1019 (2001).

Table 16. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$),from hexafluorobenzene. The estimated uncertainty in the DCS data is 15%, whilst the uncertainty on the integral and momentum transfer cross sections is 25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 3.0 | 5.0 | 8.0 | 10 | 15 | 20 | 30 |
| 20 | 9.534 | 5.695 | 6.330 | 17.310 | 17.990 | 27.230 | 23.960 | 13.140 |
| 30 | 5.130 | 3.103 | 3.731 | 5.023 | 8.583 | 8.649 | 6.193 | 2.601 |
| 40 | 2.706 | 1.917 | 2.382 | 2.208 | 3.201 | 2.941 | 2.553 | 1.290 |
| 50 | 1.612 | 1.412 | 1.498 | 1.024 | 1.915 | 1.480 | 1.585 | 1.230 |
| 60 | 1.123 | 1.174 | 1.047 | 0.851 | 1.713 | 1.422 | 1.932 | 1.502 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 70 | 0.840 | 0.904 | 0.760 | 1.059 | 1.346 | 1.993 | 2.217 | 1.185 |
| 80 | 0.690 | 0.736 | 0.727 | 0.927 | 1.391 | 2.276 | 1.984 | 0.655 |
| 90 | 0.588 | 0.685 | 0.733 | 0.931 | 1.554 | 1.828 | 1.288 | 0.525 |
| 100 | 0.472 | 0.608 | 0.856 | 1.125 | 1.708 | 1.519 | 1.104 | 0.602 |
| 110 | 0.515 | 0.643 | 0.908 | 1.378 | 1.820 | 1.628 | 1.570 | 0.695 |
| 120 | 0.602 | 0.694 | 0.967 | 1.463 | 1.824 | 2.308 | 2.108 | 0.841 |
| 130 | 0.762 | 1.129 | 1.185 | 1.646 | 1.938 | 2.371 | 2.128 | 1.286 |
| ICS | 21.75 | 18.60 | 21.51 | 30.98 | 41.09 | 51.62 | 48.01 | 32.65 |
| MTCS | 11.49 | 14.25 | 16.54 | 18.50 | 24.40 | 29.93 | 26.35 | 16.86 |

(continued)

| Angle | Energy (eV) | |
|---|---|---|
| (deg) | 60 | 100 |
| 20 | 6.583 | 2.594 |
| 30 | 2.374 | 1.918 |
| 40 | 2.065 | 1.095 |
| 50 | 1.416 | 0.418 |
| 60 | 0.658 | 0.464 |
| 70 | 0.386 | 0.379 |
| 80 | 0.428 | 0.218 |
| 90 | 0.425 | 0.179 |
| 100 | 0.367 | 0.189 |
| 110 | 0.364 | 0.217 |
| 120 | 0.493 | 0.319 |
| 130 | 0.779 | 0.402 |
| ICS | 24.26 | 9.04 |
| MTCS | 11.58 | 5.63 |

## $CH_3F$

Absolute cross sections for elastic scattering of electrons from $CH_3F$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°.

All these data are recommended in Table 17.

**Reference:**

Márcio T., N. Varella, C. Winstead, V. Mckoy, M. Kitajima and H. Tanaka, *Phys. Rev. A* **65** 022702 (2002).

Table 17. Differential cross sections ($10^{-16}$ $cm^2$/sr) for elastic scattering from $CH_3F$. Their absolute uncertainties are 15%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.5 | 7.0 | 8.0 |
| 15 | - | - | - | - | - | - | - | - |
| 20 | 14.1540 | 9.8276 | 7.4441 | 6.0525 | 7.0843 | 7.7898 | 8.0992 | 7.8911 |
| 30 | 7.1874 | 5.6562 | 4.0018 | 3.4945 | 4.1983 | 4.4785 | 4.6517 | 5.0518 |
| 40 | 3.8364 | 3.1210 | 2.1882 | 2.1424 | 2.3673 | 2.9357 | 2.8488 | 3.0756 |
| 50 | 2.2522 | 2.1132 | 1.3786 | 1.5485 | 1.6474 | 1.8061 | 1.7177 | 1.8000 |
| 60 | 1.6898 | 1.4086 | 1.1454 | 1.2539 | 1.4041 | 1.2465 | 1.3696 | 1.2924 |
| 70 | 1.0707 | 1.0683 | 1.1635 | 1.2975 | 1.2625 | 1.1107 | 1.1556 | 1.0046 |
| 80 | 0.9570 | 1.0478 | 1.1553 | 1.3416 | 1.3097 | 1.2281 | 1.1426 | 1.0010 |
| 90 | 0.8825 | 0.8323 | 1.1215 | 1.2426 | 1.4064 | 1.4072 | 1.2777 | 1.1234 |
| 100 | 0.7660 | 0.8923 | 1.0984 | 1.2070 | 1.3022 | 1.3379 | 1.2877 | 1.2020 |
| 110 | 0.7705 | 0.8579 | 1.0003 | 1.0502 | 1.2825 | 1.2004 | 1.3155 | 1.2724 |
| 120 | 0.7196 | 0.7659 | 0.9292 | 0.8941 | 1.1856 | 1.1851 | 1.2422 | 1.1599 |
| 130 | 0.6702 | 0.6979 | 0.7637 | 0.9579 | 1.0813 | 1.1207 | 1.2399 | 1.2863 |

(continued)

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 9.0 | 10 | 15 | 20 | 30 | 60 | 100 |
| 15 | - | 9.9915 | 9.7406 | 10.363 | 10.201 | 7.2117 | 2.5456 |
| 20 | 3.3488 | 8.2624 | 8.5840 | 7.6735 | 7.9241 | 4.0624 | 1.0977 |
| 30 | 5.0519 | 5.1938 | 4.7734 | 4.1405 | 3.1670 | 0.9253 | 0.2859 |
| 40 | 2.9920 | 1.3046 | 2.5443 | 2.1341 | 1.3697 | 0.4905 | 0.2521 |
| 50 | 1.8140 | 1.8203 | 1.5009 | 1.1827 | 0.6134 | 0.3519 | 0.2197 |
| 60 | 1.1114 | 1.0767 | 0.9337 | 0.7440 | 0.4983 | 0.2501 | 0.1489 |
| 70 | 0.8962 | 0.8114 | 0.6601 | 0.6409 | 0.4755 | 0.1414 | 0.0878 |
| 80 | 0.8893 | 0.7719 | 0.6260 | 0.5804 | 0.3436 | 0.1150 | 0.0629 |
| 90 | 0.8997 | 0.9428 | 0.6139 | 0.5165 | 0.2329 | 0.0744 | 0.0505 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 | 1.0631 | 1.0123 | 0.6384 | 0.3976 | 0.1874 | 0.0663 | 0.0552 |
| 110 | 1.1124 | 1.0556 | 0.6392 | 0.4287 | 0.2004 | 0.0799 | 0.0731 |
| 120 | 1.2329 | 1.0469 | 0.6743 | 0.4397 | 0.2955 | 0.1354 | 0.1071 |
| 130 | 1.1841 | 1.1701 | 0.7566 | 0.5727 | 0.3968 | 0.1906 | 0.1114 |

## $CH_2F_2$

Absolute cross sections for elastic scattering of electrons from $CH_2F_2$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°.

All these data are recommended in Table 18.

**Reference:**

Márcio T., N. Varella, C. Winstead, V. Mckoy, M. Kitajima and H. Tanaka, *Phys. Rev. A* **65** 022702 (2002).

Table 18. Differential cross sections ($10^{-16}$ $cm^2$/sr) for elastic scattering from $CH_2F_2$. Their absolute uncertainties are 15%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.5 | 7.0 | 8.0 |
| 15 | - | - | - | - | - | - | - | - |
| 20 | 21.3310 | 16.2830 | 11.5580 | 9.0750 | 9.7206 | 8.8760 | 8.4820 | 8.3492 |
| 30 | 8.5640 | 6.8560 | 5.6684 | 4.8670 | 4.4180 | 4.4710 | 4.9131 | 5.1217 |
| 40 | 4.6070 | 4.1600 | 3.6126 | 2.8320 | 3.0815 | 2.8070 | 3.5260 | 3.1706 |
| 50 | 2.8370 | 2.5047 | 2.2076 | 1.9440 | 2.0835 | 2.0618 | 2.1745 | 2.0621 |
| 60 | 1.9590 | 1.7140 | 1.8537 | 1.4480 | 1.4515 | 1.3635 | 1.3946 | 1.4373 |
| 70 | 1.6460 | 1.2980 | 1.3511 | 1.0850 | 0.9725 | 0.8670 | 0.8886 | 0.9045 |
| 80 | 1.2560 | 1.0820 | 0.9557 | 0.8350 | 0.7247 | 0.6164 | 0.6223 | 0.5381 |
| 90 | 1.1860 | 1.0637 | 0.9048 | 0.7271 | 0.6829 | 0.6441 | 0.6435 | 0.6352 |
| 100 | 0.9826 | 0.9339 | 0.7467 | 0.6775 | 0.6159 | 0.6132 | 0.6592 | 0.7877 |
| 110 | 0.9461 | 0.9448 | 0.7187 | 0.7262 | 0.6490 | 0.7416 | 0.8139 | 0.9840 |
| 120 | 0.9439 | 0.8562 | 0.7729 | 0.7282 | 0.8211 | 0.9898 | 0.9314 | 0.9863 |
| 130 | 0.9639 | 0.8741 | 0.8330 | 0.8820 | 0.9830 | 1.0857 | 1.0451 | 1.2380 |

(continued)

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 9.0 | 10 | 15 | 20 | 30 | 60 | 100 |
| 15 | - | 13.0880 | 11.872 | - | 12.2110 | 8.3641 | 3.0323 |
| 20 | 8.1393 | 10.0440 | 9.2324 | 9.0980 | 7.5670 | 4.4855 | 1.6570 |
| 30 | 4.9203 | 5.0470 | 4.5488 | 4.6290 | 2.8768 | 1.3501 | 0.6164 |
| 40 | 2.9339 | 2.8850 | 2.3204 | 2.0610 | 1.3866 | 0.6615 | 0.4509 |
| 50 | 1.9643 | 1.9130 | 1.4704 | 1.2640 | 0.6873 | 0.4951 | 0.3159 |
| 60 | 1.3768 | 1.2522 | 0.9873 | 1.0000 | 0.6541 | 0.2972 | 0.1993 |
| 70 | 0.7684 | 0.7654 | 0.6998 | 0.8349 | 0.6490 | 0.2028 | 0.1134 |
| 80 | 0.6600 | 0.7691 | 0.7558 | 0.7447 | 0.4273 | 0.1476 | 0.0678 |
| 90 | 0.7528 | 0.7563 | 0.7162 | 0.6768 | 0.2597 | 0.1084 | 0.0596 |
| 100 | 0.8472 | 0.8092 | 0.8178 | 0.5402 | 0.1939 | 0.1058 | 0.0841 |
| 110 | 1.0161 | 1.0320 | 0.7121 | 0.5804 | 0.2545 | 0.1141 | 0.0946 |
| 120 | 1.0991 | 1.1034 | 0.8297 | 0.6617 | 0.3280 | 0.2147 | 0.1267 |
| 130 | 1.2089 | 1.0930 | 0.8445 | 0.7382 | 0.5917 | 0.3238 | 0.1866 |

## $CHF_3$

Absolute cross sections for elastic scattering of electrons from $CHF_3$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°.

All these data are recommended in Table 19.

**Reference:**


Márcio T., N. Varella, C. Winstead, V. Mckoy, M. Kitajima and H. Tanaka, *Phys. Rev. A* **65** 022702 (2002).


Table 19. Differential cross sections ($10^{-16}$ $cm^2/sr$) for elastic scattering from $CHF_3$. Their absolute uncertainties are 15%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.5 | 7.0 | 8.0 |
| 15 | - | - | - | - | - | - | - | - |
| 20 | 9.6869 | 7.5023 | 5.4249 | 6.7053 | 6.7146 | 6.4416 | 6.4840 | 6.5110 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 25 | 6.9478 | 5.7449 | - | - | - | - | - | - |
| 30 | 6.0904 | 4.8100 | 3.8389 | 4.1436 | 4.0816 | 4.6603 | 4.4950 | 4.1289 |
| 35 | 4.4904 | 3.8554 | - | - | - | - | - | - |
| 40 | 4.0253 | 3.2733 | 3.1524 | 3.1566 | 3.1587 | 3.3108 | 3.1550 | 3.1992 |
| 45 | 3.3327 | 2.7083 | - | - | - | - | - | - |
| 50 | 3.2382 | 2.4114 | 2.2942 | 2.4882 | 2.5785 | 2.4440 | 2.1730 | 2.7750 |
| 55 | 2.7542 | - | - | - | - | - | - | - |
| 60 | 2.4263 | 2.1154 | 2.0532 | 2.0347 | 2.0618 | 1.7840 | 1.5492 | 1.3405 |
| 65 | 2.1290 | - | - | - | - | - | - | - |
| 70 | 1.9364 | 1.8134 | 1.5601 | 1.6556 | 1.4514 | 1.2392 | 1.0041 | 0.9010 |
| 80 | 1.6762 | 1.5821 | 1.3502 | 1.3835 | 1.1383 | 0.8841 | 0.6806 | 0.6028 |
| 90 | 1.6596 | 1.4240 | 1.1844 | 1.0640 | 0.8284 | 0.5768 | 0.5668 | 0.5356 |
| 100 | 1.2772 | 1.2108 | 1.0814 | 0.8631 | 0.6731 | 0.4882 | 0.4707 | 0.5301 |
| 110 | 1.1922 | 1.0968 | 0.9240 | 0.7209 | 0.5561 | 0.5272 | 0.5313 | 0.5243 |
| 120 | 1.0928 | 1.0080 | 0.8603 | 0.6441 | 0.5409 | 0.5442 | 0.6051 | 0.6241 |
| 130 | 1.0524 | 0.9638 | 0.7440 | 0.6087 | 0.6297 | 0.7722 | 0.7365 | 0.7556 |

(continued)

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 9.0 | 10 | 15 | 20 | 30 | 60 | 100 |
| 15 | - | - | 8.4548 | 9.5002 | 12.1410 | 11.9050 | 6.6705 |
| 20 | 6.5873 | 7.3083 | 6.2872 | 7.2141 | 8.6783 | 6.8642 | 3.7217 |
| 25 | - | - | - | - | - | - | - |
| 30 | 4.7737 | 4.7163 | 4.2750 | 3.8040 | 3.4654 | 1.5453 | 0.9134 |
| 35 | - | - | - | - | - | - | - |
| 40 | 3.2033 | 3.2311 | 2.6826 | 2.0897 | 1.1538 | 0.7087 | 0.6237 |
| 45 | - | - | - | - | - | - | - |
| 50 | 2.2542 | 2.1301 | 1.6188 | 1.1224 | 0.7951 | 0.7031 | 0.3117 |
| 55 | - | - | - | - | - | - | - |
| 60 | 1.4336 | 1.3653 | 1.0298 | 0.7820 | 0.7492 | 0.4744 | 0.1915 |
| 65 | - | - | - | - | - | - | - |
| 70 | 0.8992 | 0.8555 | 0.7528 | 0.8545 | 0.7682 | 0.2643 | 0.1724 |
| 80 | 0.6296 | 0.6595 | 0.8004 | 0.8357 | 0.5775 | 0.1533 | 0.1286 |
| 90 | 0.6331 | 0.6376 | 0.7544 | 0.7317 | 0.3213 | 0.1304 | 0.0864 |
| 100 | 0.5809 | 0.6808 | 0.7628 | 0.5666 | 0.2219 | 0.1255 | 0.0849 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 | 0.6149 | 0.7013 | 0.7915 | 0.5301 | 0.2873 | 0.1596 | 0.1053 |
| 120 | 0.6619 | 0.7507 | 0.7513 | 0.5853 | 0.4531 | 0.2845 | 0.1615 |
| 130 | 0.8209 | 0.8503 | 0.8633 | 0.7619 | 0.6315 | 0.3845 | 0.2268 |

## $NF_3$

Absolute cross sections for elastic scattering of electrons from $NF_3$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°. The DCS were analyzed using a phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 20.

**Reference:**

L. Boesten, Y. Tachibana, Y. Nakano, T. Shinohara, H. Tanaka and M. A. Dillon, *J. Phys. B: At. Mol. Opt. Phys.* **29** 5475 (1996).

Table 20. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $NF_3$. The estimated uncertainty in the DCS data is 15%, whilst the uncertainty on the integral and momentum transfer cross sections is 20%–25%.

| angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 7.0 | 7.5 | 8 |
| 15 | — | — | — | — | — | — | — | — |
| 20 | 0.933 | 1.430 | 2.199 | 2.960 | 2.729 | 2.671 | 2.896 | 2.908 |
| 30 | 0.667 | 1.216 | 2.436 | 2.949 | 2.807 | 2.932 | 3.036 | 3.132 |
| 40 | 0.656 | 1.078 | 2.331 | 2.822 | 2.577 | 2.868 | 2.731 | 2.699 |
| 50 | 0.729 | 1.197 | 2.052 | 2.511 | 2.119 | 2.123 | 2.224 | 2.115 |
| 60 | 0.787 | 1.152 | 1.768 | 1.818 | 1.552 | 1.655 | 1.517 | 1.460 |
| 70 | 0.962 | 1.074 | 1.329 | 1.297 | 1.261 | 1.137 | 1.108 | 1.209 |
| 80 | 0.981 | 1.100 | 1.114 | 1.099 | 0.947 | 0.808 | 0.851 | 0.868 |
| 90 | 1.097 | 1.011 | 0.920 | 0.794 | 0.714 | 0.727 | 0.719 | 0.766 |
| 100 | 1.053 | 0.884 | 0.685 | 0.640 | 0.641 | 0.663 | 0.704 | 0.702 |
| 110 | 0.998 | 0.843 | 0.598 | 0.542 | 0.622 | 0.666 | 0.704 | 0.707 |
| 120 | 0.992 | 0.778 | 0.584 | 0.539 | 0.637 | 0.652 | 0.661 | 0.639 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 130 | 0.920 | 0.723 | 0.576 | 0.604 | 0.765 | 0.655 | 0.645 | 0.623 |
| ICS | 11.90 | 12.98 | 17.24 | 18.41 | 18.11 | 17.35 | 17.47 | 17.89 |
| MTCS | 12.46 | 12.39 | 14.24 | 14.92 | 14.92 | 14.24 | 14.17 | 12.82 |

(Continued)

| angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 10 | 15 | 20 | 25 | 30 | 50 | 60 | 100 |
| 15 | 3.323 | 4.641 | 6.890 | 9.051 | 10.710 | 12.330 | 11.200 | 9.000 |
| 20 | 3.168 | 3.946 | 5.006 | 6.490 | 6.946 | 6.715 | 5.955 | 3.201 |
| 30 | 3.037 | 3.077 | 2.777 | 2.863 | 2.657 | 1.838 | 1.243 | 0.851 |
| 40 | 2.680 | 2.107 | 1.680 | 1.358 | 1.004 | 0.666 | 0.671 | 0.623 |
| 50 | 1.934 | 1.271 | 0.934 | 0.742 | 0.616 | 0.621 | 0.537 | 0.340 |
| 60 | 1.390 | 0.826 | 0.750 | 0.688 | 0.639 | 0.601 | 0.328 | 0.195 |
| 70 | 0.954 | 0.715 | 0.799 | 0.747 | 0.671 | 0.340 | 0.232 | 0.156 |
| 80 | 0.737 | 0.725 | 0.798 | 0.665 | 0.509 | 0.196 | 0.155 | 0.116 |
| 90 | 0.702 | 0.786 | 0.715 | 0.510 | 0.320 | 0.116 | 0.109 | 0.067 |
| 100 | 0.694 | 0.738 | 0.569 | 0.322 | 0.191 | 0.093 | 0.093 | 0.073 |
| 110 | 0.673 | 0.610 | 0.462 | 0.295 | 0.200 | 0.146 | 0.152 | 0.108 |
| 120 | 0.626 | 0.555 | 0.561 | 0.440 | 0.376 | 0.314 | 0.265 | 0.169 |
| 130 | 0.605 | 0.598 | 0.746 | 0.725 | 0.623 | 0.483 | 0.378 | 0.273 |
| ICS | 16.91 | 14.60 | 14.48 | 14.05 | 13.33 | 12.32 | 11.03 | 9.72 |
| MTCS | 13.53 | 10.41 | 9.87 | 8.54 | 7.63 | 6.62 | 5.81 | 5.42 |

## $SF_6$

The interaction of low-energy electrons with $SF_6$ has been the subject of numerous experimental and theoretical studies, due to its involvement in plasma discharge processes and as the most commonly used insulating gas in the electrical industry. $SF_6$ is a non-polar molecule and has a high polarizability of 44 au. Absolute elastic differential cross sections have been measured at 11 different energies ranging from 2.7 eV to 75 eV including at several resonant energies. The magnetic angle-changing device was employed in conjunction with a spectrometer to measure the cross sections to backward angles at low impact energies. At higher impact energies, there is a heating problem caused by the high electric current flowing through the coils, required to deflect the high-energy electron beam. All these data are recommended in Table 21.

**Reference:**

H. Cho, R. J. Gulley, K. W. Trantham, L. J. Uhlmann, C. J. Dedman and S. J. Buckman, *J. Phys. B: At. Mol. Opt. Phys.* **33** 3531 (2000).

Table 21. Differential cross sections (in units of $10^{-16}$ $cm^2$ $sr^{-1}$) for elastic electron scattering from $SF_6$. The experimental uncertainties on each measured point are indicated in the table as a percentage.

| Angle | Energy (eV) | | | | |
|---|---|---|---|---|---|
| (deg) | 2.7 | 5.0 | 7.0 | 8.5 | 10 |
| 15 | - | - | 5.896(8) | 8.500(11) | 11.168(7) |
| 20 | 1.949(13) | 3.939(11) | 7.899(7) | 8.823(9) | 8.892(7) |
| 25 | 1.990(8) | 4.225(7) | 6.843(7) | 7.720(7) | 7.558(8) |
| 30 | 2.336(7) | 4.001(8) | 5.899(7) | 6.404(7) | 6.236(7) |
| 35 | 2.467(7) | 3.827(8) | 4.893(7) | 5.201(8) | 4.811(7) |
| 40 | 2.516(8) | 3.597(7) | 3.988(7) | 3.893(7) | 3.507(7) |
| 45 | 2.506(8) | 3.143(8) | 2.995(7) | 2.811(7) | 2.517(7) |
| 50 | 2.401(8) | 2.819(9) | 2.201(7) | 2.066(7) | 1.708(8) |
| 55 | 2.184(8) | 2.329(7) | 1.550(7) | 1.442(7) | 1.189(7) |
| 60 | 2.049(7) | 1.894(7) | 1.107(7) | 1.089(7) | 1.028(7) |
| 65 | 1.787(7) | 1.422(8) | 0.873(7) | 0.953(7) | 0.982(7) |
| 70 | 1.539(7) | 1.150(7) | 0.802(7) | 0.941(7) | 1.091(8) |
| 75 | 1.405(7) | 0.907(9) | 0.842(7) | 1.073(7) | 1.263(7) |
| 80 | 1.199(7) | 0.825(8) | 1.002(7) | 1.263(7) | 1.456(9) |
| 85 | 1.077(8) | 0.795(7) | 1.153(7) | 1.317(8) | 1.531(8) |
| 90 | 0.969(8) | 0.884(8) | 1.288(7) | 1.391(8) | 1.516(9) |
| 95 | 0.906(8) | 0.960(9) | 1.388(7) | 1.385(7) | 1.413(12) |
| 100 | 0.935(8) | 1.124(8) | 1.420(7) | 1.345(7) | 1.244(8) |
| 105 | 0.981(8) | 1.229(7) | 1.397(7) | 1.217(7) | 1.067(8) |
| 110 | 1.037(7) | 1.268(9) | 1.296(7) | 1.069(8) | 0.952(7) |
| 115 | 1.057(7) | 1.254(8) | 1.165(8) | 0.945(7) | 0.831(7) |
| 120 | 1.099(8) | 1.231(9) | 1.048(7) | 0.816(7) | 0.771(8) |
| 125 | 1.236(7) | 1.150(11) | 0.909(7) | 0.745(7) | 0.779(7) |
| 130 | 1.311(7) | 1.016(9) | 0.810(7) | 0.830(12) | 0.846(8) |
| 135 | 1.351(7) | 0.956(8) | 0.977(7) | 0.956(7) | 0.916(7) |
| 140 | 1.372(7) | 0.908(8) | 0.999(7) | 0.995(7) | 0.999(8) |

| | | | | | |
|---|---|---|---|---|---|
| 145 | 1.402(8) | 0.792(8) | 1.006(7) | 1.072(8) | 1.113(7) |
| 150 | 1.415(7) | 0.744(9) | 1.110(7) | 1.233(7) | 1.173(7) |
| 155 | 1.390(7) | 0.703(8) | 1.235(7) | 1.305(8) | 1.247(7) |
| 160 | 1.485(7) | 0.641(7) | 1.288(7) | 1.467(8) | 1.306(7) |
| 165 | 1.486(7) | 0.606(7) | 1.395(8) | 1.571(9) | 1.357(7) |
| 170 | 1.485(7) | 0.576(8) | 1.467(7) | 1.618(8) | 1.369(7) |
| 175 | 1.499(7) | 0.572(7) | 1.512(7) | 1.706(7) | 1.440(7) |
| 180 | 1.500(7) | 0.535(9) | 1.542(7) | 1.775(7) | 1.473(8) |

(Continued)

| Angle | Energy (eV) | | | | | |
|---|---|---|---|---|---|---|
| (deg) | 12 | 15 | 20 | 30 | 50 | 75 |
| 10 | 13.788(17) | - | 23.711(8) | 55.574(8) | 49.457(7) | 45.477(8) |
| 15 | 15.218(8) | 12.994(7) | 15.656(7) | 23.329(7) | 24.678(7) | 15.422(8) |
| 20 | 12.415(7) | 11.128(7) | 10.983(9) | 13.255(7) | 9.672(8) | 4.414(9) |
| 25 | 9.312(7) | 8.699(7) | 7.988(7) | 6.916(7) | 3.510(8) | 1.369(13) |
| 30 | 6.651(7) | 6.652(7) | 5.246(8) | 3.307(7) | 1.606(8) | 1.230(8) |
| 35 | 4.511(7) | 4.649(7) | 3.228(10) | 1.573(7) | 1.295(8) | 1.379(10) |
| 40 | 2.911(8) | 3.046(7) | 1.867(7) | 0.988(7) | 1.376(8) | 1.326(10) |
| 45 | 1.724(7) | 1.837(7) | 1.002(9) | 0.993(7) | 1.378(7) | 0.965(8) |
| 50 | 1.104(7) | 1.126(7) | 0.703(9) | 1.266(7) | 1.159(10) | 0.670(8) |
| 55 | 0.748(7) | 0.839(7) | 0.740(9) | 1.369(7) | 1.038(8) | 0.478(8) |
| 60 | 0.677(8) | 0.869(7) | 0.984(9) | 1.430(7) | 0.758(10) | 0.340(8) |
| 65 | 0.737(8) | 1.053(7) | 1.331(11) | - | 0.533(11) | 0.298(8) |
| 70 | 0.858(8) | 1.246(7) | 1.433(10) | 1.052(8) | 0.342(9) | 0.274(10) |
| 75 | 0.994(8) | 1.393(7) | 1.500(8) | - | 0.236(9) | 0.262(10) |
| 80 | 1.088(8) | 1.403(7) | 1.343(7) | 0.655(8) | 0.180(12) | 0.248(12) |
| 85 | 1.103(8) | 1.308(7) | 1.128(8) | - | 0.199(9) | 0.231(9) |
| 90 | 1.168(7) | 1.218(7) | 1.011(8) | 0.402(7) | 0.234(9) | 0.214(11) |
| 95 | 1.193(8) | 1.069(7) | 0.823(9) | - | 0.283(8) | 0.218(14) |
| 100 | 1.132(8) | 0.974(8) | 0.690(7) | 0.473(7) | 0.316(9) | 0.194(8) |
| 105 | 1.095(7) | 0.864(7) | 0.596(8) | - | 0.320(10) | 0.182(9) |
| 110 | 1.117(7) | 0.791(7) | 0.611(8) | 0.643(8) | 0.348(10) | 0.210(10) |
| 115 | 1.210(8) | 0.778(7) | 0.602(8) | - | 0.389(11) | 0.262(13) |
| 120 | 1.376(8) | 0.765(7) | 0.669(8) | 0.873(7) | 0.420(10) | 0.356(10) |
| 125 | 1.450(7) | 0.811(7) | 0.811(9) | - | 0.469(11) | 0.472(11) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 130 | 1.544(7) | 0.867(7) | 0.933(7) | 1.098(7) | 0.583(12) | 0.632(13) |
| 135 | 1.566(7) | 0.971(7) | - | - | - | - |
| 140 | 1.616(7) | 1.118(7) | - | - | - | - |
| 145 | 1.651(7) | 1.257(7) | - | - | - | - |
| 150 | 1.686(7) | 1.353(7) | - | - | - | - |
| 155 | 1.711(7) | 1.495(8) | - | - | - | - |
| 160 | 1.758(7) | 1.652(7) | - | - | - | - |
| 165 | 1.752(8) | 1.774(7) | - | - | - | - |
| 170 | 1.829(8) | 1.915(7) | - | - | - | - |
| 175 | 1.862(7) | 1.940(7) | - | - | - | - |
| 180 | 1.843(7) | 1.973(7) | - | - | - | - |

## $SiH_4$

Absolute cross sections for elastic scattering of electrons from $SiH_4$ have been determined in the energy range of 1.8–100 eV and over the scattering angles of 10–130°. The DCS were then analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 22.

**Reference:**

H. Tanaka, L. Boesten, H. Sato, M. Kimura, M. A. Dillon and D. Spence, *J. Phys. B: At. Mol. Opt. Phys.* **23** 577 (1990).

Table 22. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $SiH_4$. The absolute uncertainties on the DCS are 15%, while the uncertainties on the ICS and MTCS are in the range of 20 to 30%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.8 | 2.15 | 2.65 | 3.0 | 4.0 | 5.0 | 7.5 | 10 |
| 10 | - | - | - | - | - | - | - | - |
| 15 | - | - | - | - | - | - | - | - |
| 20 | 3.352 | 4.243 | 5.166 | 7.407 | 11.221 | 13.490 | 18.709 | 19.985 |
| 30 | 2.861 | 4.233 | 5.858 | 6.459 | 11.032 | 12.450 | 17.061 | 15.271 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 40 | 1.870 | 3.058 | 4.818 | 5.587 | 7.980 | 9.524 | 10.870 | 7.998 |
| 50 | 1.073 | 2.056 | 3.365 | 3.702 | 5.580 | 6.696 | 6.403 | 4.227 |
| 60 | 1.080 | 1.575 | 2.477 | 2.723 | 3.423 | 3.994 | 3.467 | 2.091 |
| 70 | 1.340 | 1.853 | 2.331 | 2.309 | 2.144 | 2.283 | 1.855 | 0.990 |
| 80 | 2.017 | 2.370 | 2.466 | 2.360 | 1.828 | 1.655 | 1.344 | 0.936 |
| 90 | 3.064 | 3.058 | 2.686 | 2.670 | 1.525 | 1.524 | 1.490 | 1.334 |
| 100 | 3.019 | 2.990 | 2.844 | 2.605 | 1.563 | 1.578 | 1.801 | 1.400 |
| 110 | 2.359 | 2.581 | 2.458 | 2.325 | 1.517 | 1.432 | 1.966 | 1.370 |
| 120 | 1.771 | 2.163 | 2.036 | 1.831 | 1.333 | 1.432 | 1.709 | 1.150 |
| 130 | 1.458 | 1.806 | 1.861 | 1.729 | 1.475 | 1.552 | 1.521 | 0.892 |
| ICS | 27.5 | 31.6 | 34.8 | 36.5 | 40.1 | 44.4 | 49.9 | 39.4 |
| MTCS | 29.0 | 30.1 | 29.1 | 28.1 | 24.5 | 25.6 | 24.4 | 15.8 |

(continued)

| Angle | Energy (eV) | | | |
|---|---|---|---|---|
| (deg) | 15 | 20 | 40 | 100 |
| 10 | 23.473 | 23.48 | 35.644 | 10.11 |
| 15 | 21.948 | 19.857 | 17.68 | 4.165 |
| 20 | 18.028 | 15.426 | 9.891 | 1.684 |
| 30 | 10.248 | 7.035 | 2.447 | 0.509 |
| 40 | 4.657 | 2.708 | 0.734 | 0.277 |
| 50 | 1.917 | 0.891 | 0.364 | 0.127 |
| 60 | 0.699 | 0.423 | 0.255 | 0.0915 |
| 70 | 0.478 | 0.426 | 0.227 | 0.101 |
| 80 | 0.612 | 0.540 | 0.229 | 0.0923 |
| 90 | 0.750 | 0.519 | 0.276 | 0.0599 |
| 100 | 0.768 | 0.415 | 0.241 | 0.0268 |
| 110 | 0.612 | 0.326 | 0.196 | 0.00941 |
| 120 | 0.400 | 0.209 | 0.131 | 0.0192 |
| 130 | 0.244 | 0.147 | 0.0943 | 0.0461 |
| ICS | 28.7 | 20.7 | 14.0 | 4.3 |
| MTCS | 11.2 | 8.7 | 2.9 | 1.2 |

## $Si_2H_6$

Absolute cross sections for elastic scattering of electrons from $Si_2H_6$ have been determined in the energy range of 2–100 eV and over the scattering angles of 10–130°. These DCS were analyzed using a molecular phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 23.

**Reference:**

M. A. Dillon, L. Boesten, H. Tanaka, M. Kimura and H.Sato, *J. Phys. B: At. Mol. Opt. Phys.* **27** 1209 (1994).

Table 23. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $Si_2H_6$. The estimated uncertainty in the DCS data is 15%–20%, whilst the uncertainty on the integral and momentum transfer cross sections is 30%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 2.0 | 3.0 | 4.0 | 5.0 | 7.5 | 10 | 15 | 20 |
| 10 | - | - | - | - | - | 40.54 | 68.49 | 80.82 |
| 20 | 18.165 | 15.02 | 18.05 | 21.42 | 29.46 | 32.41 | 36.03 | 32.96 |
| 30 | 7.681 | 12.31 | 15.83 | 17.52 | 16.23 | 15.29 | 13.66 | 9.716 |
| 40 | 5.845 | 9.025 | 10.70 | 10.16 | 7.56 | 6.445 | 4.257 | 3.477 |
| 50 | 3.482 | 5.444 | 5.181 | 4.705 | 3.404 | 2.774 | 2.409 | 2.138 |
| 60 | 2.913 | 3.213 | 3.337 | 2.885 | 2.389 | 2.065 | 1.758 | 1.215 |
| 70 | 2.911 | 3.271 | 3.016 | 2.689 | 2.528 | 2.025 | 1.224 | 0.741 |
| 80 | 2.639 | 3.131 | 3.107 | 3.115 | 3.174 | 1.859 | 0.982 | 0.701 |
| 90 | 2.685 | 3.331 | 2.775 | 2.890 | 2.715 | 1.713 | 1.035 | 0.751 |
| 100 | 2.489 | 3.498 | 2.802 | 2.638 | 2.373 | 1.518 | 1.102 | 0.661 |
| 110 | 2.462 | 3.486 | 3.142 | 2.762 | 2.175 | 1.339 | 0.958 | 0.410 |
| 115 | - | - | - | - | - | - | - | - |
| 120 | 2.399 | 4.344 | 3.311 | 2.543 | 1.860 | 1.333 | 0.656 | 0.277 |
| 125 | - | - | - | - | - | - | - | - |
| 130 | 2.378 | 4.459 | 3.459 | 2.536 | 1.609 | 1.418 | 0.410 | 0.238 |
| ICS | 49.3 | 82.8 | 83.2 | 83.1 | 68.8 | 61.4 | 54.6 | 50.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MTCS | 38.0 | 62.6 | 53.1 | 44.4 | 35.4 | 30.3 | 16.5 | 10.7 |

(continued)

| Angle | Energy (eV) | |
|---|---|---|
| (deg) | 40 | 100 |
| 10 | 63.36 | 26.00 |
| 20 | 10.33 | 2.218 |
| 30 | 1.955 | 0.8952 |
| 40 | 0.9451 | 0.4386 |
| 50 | 0.380 | 0.1936 |
| 60 | 0.313 | 0.1420 |
| 70 | 0.267 | 0.1626 |
| 80 | 0.245 | 0.1583 |
| 90 | 0.245 | 0.08568 |
| 100 | 0.247 | 0.03399 |
| 110 | 0.218 | 0.01414 |
| 115 | - | 0.0135 |
| 120 | 0.141 | 0.01846 |
| 125 | - | 0.04159 |
| 130 | 0.141 | 0.068 |
| ICS | 23.7 | 9.6 |
| MTCS | 4.7 | 1.7 |

## $GeH_4$

Absolute cross sections for elastic scattering of electrons from $GeH_4$ have been determined in the energy range of 1–100 eV and over the scattering angles of 10–130°. The DCS were analyzed using a phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 24.

**Reference:**

M. A. Dillon, L. Boesten, H. Tanaka, M. Kimura and H.Sato, *J. Phys. B: At. Mol. Opt. Phys.* **26** 3147 (1993).

Table24. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $GeH_4$. The absolute uncertainties on the DCS are 15%–20%, while the uncertainties on the ICS and MTCS are in the range of 20 to 30%

.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.0 | 2.0 | 2.5 | 3.0 | 5.0 | 7.5 | 10 | 15 |
| 10 | - | - | - | - | - | - | 28.21 | 32.22 |
| 20 | 1.835 | 3.655 | 4.47 | 6.991 | 15.81 | 17.49 | 19.24 | 20.11 |
| 30 | 0.9723 | 2.470 | 2.732 | 5.271 | 11.660 | 12.560 | 12.830 | 10.230 |
| 40 | 0.4523 | 1.629 | 2.088 | 4.056 | 8.195 | 8.734 | 7.117 | 4.206 |
| 45 | - | - | - | - | - | - | - | - |
| 50 | 0.2067 | 1.249 | 1.650 | 2.664 | 4.624 | 4.644 | 3.856 | 1.639 |
| 55 | - | - | - | - | - | - | - | - |
| 60 | 0.3381 | 1.419 | 1.735 | 2.180 | 2.801 | 2.619 | 1.804 | 0.815 |
| 65 | - | - | - | - | - | - | - | - |
| 70 | 0.6484 | 1.863 | 2.052 | 2.175 | 2.110 | 1.705 | 1.050 | 0.724 |
| 75 | - | - | - | - | - | - | - | - |
| 80 | 0.9420 | 2.475 | 2.636 | 2.369 | 1.989 | 1.379 | 1.077 | 0.630 |
| 85 | - | - | - | - | - | - | - | - |
| 90 | 0.9632 | 2.612 | 2.573 | 2.820 | 1.773 | 1.439 | 1.129 | 0.597 |
| 95 | - | - | - | - | - | - | - | - |
| 100 | 0.9854 | 2.507 | 2.338 | 2.314 | 1.894 | 1.547 | 1.079 | 0.491 |
| 105 | - | - | - | - | - | - | - | - |
| 110 | 0.6952 | 1.835 | 1.859 | 1.835 | 1.716 | 1.519 | 1.019 | 0.376 |
| 115 | - | - | - | - | - | - | - | - |
| 120 | 0.4742 | 1.359 | 1.487 | 1.442 | 1.341 | 1.369 | 0.848 | 0.311 |
| 125 | - | - | - | - | - | - | - | - |
| 130 | 0.3256 | 1.222 | 1.422 | 1.431 | 1.387 | 1.176 | 0.679 | 0.244 |
| ICS | 8.40 | 26.45 | 28.76 | 34.07 | 45.48 | 43.40 | 39.42 | 30.14 |
| MTCS | 7.11 | 26.03 | 27.31 | 27.67 | 26.87 | 21.72 | 18.54 | 11.48 |

(continued)

| Angle | Energy (eV) | | |
|---|---|---|---|
| (deg) | 20 | 60 | 100 |
| 10 | 20.04 | 16.95 | — |
| 20 | 19.20 | 3.536 | 2.063 |
| 30 | 7.094 | 0.416 | 0.376 |
| 40 | 2.227 | 0.253 | 0.281 |
| 45 | — | 0.239 | 0.230 |
| 50 | 0.680 | 0.263 | 0.192 |
| 55 | 0.235 | 0.235 | 0.191 |
| 60 | 0.463 | 0.205 | 0.168 |
| 65 | — | 0.183 | 0.163 |
| 70 | 0.461 | 0.142 | 0.121 |
| 75 | — | 0.113 | 0.0736 |
| 80 | 0.416 | 0.0871 | 0.0449 |
| 85 | — | 0.0603 | 0.0234 |
| 90 | 0.293 | 0.0505 | 0.0216 |
| 95 | — | 0.0354 | 0.0297 |
| 100 | 0.19 | 0.0267 | 0.0625 |
| 105 | — | 0.0325 | 0.0956 |
| 110 | 0.139 | 0.0368 | 0.113 |
| 115 | — | 0.0479 | 0.144 |
| 120 | 0.125 | 0.0528 | 0.116 |
| 125 | — | 0.0509 | 0.106 |
| 130 | 0.14 | 0.0438 | 0.0965 |
| ICS | 23.63 | 7.47 | 6.36 |
| MTCS | 6.52 | 1.44 | 1.60 |

C. Enviromental Issues-Related Gases

## $CF_3Cl$, $CF_3Br$, and $CF_3I$

Absolute differential cross sections for elastic scattering of electrons from $CF_3Cl$, $CF_3Br$, and $CF_3I$ have been determined in the energy range of 0.7–100 eV and over the scattering angular range of 15–130. $CF_3X$ (X = Cl, Br, I) are fluoromethane molecules in which one fluorine atom is replaced with a halogen atom. This series of molecules has both fundamental importance and applications ranging from the depletion of the ozone layer to plasmas. $CF_3Cl$ is more heavily studied than any other halofluorocarbon. In a molecule with a permanent dipole moment, the long-range electron-dipole interaction dominates the scattering at low energies and small scattering angles. The permanent dipole moments of $CF_3Cl$, $CF_3Br$, and $CF_3I$ which we will now discuss below, are 0.5 D, 0.65 D, and 1.05 D, respectively, i.e. about the same magnitude with each other, and small compared with other polar molecules in the series. Therefore, we can expect that they might share similar qualitatively behavior in their cross sections.

The data for $CF_3Cl$ is presented in Table 25, while those for $CF_3Br$ and $CF_3I$ are given as follows in Tables 26 and 27, respectively.

**References:**


K. Sunohara, M. Kitajima, H. Tanaka, M. Kimura and H. Cho, *J. Phys. B: At. Mol. Opt. Phys.* **36** 1843 (2003).

M. Kitajima, M. Okamoto, K. Sunohara, H. Tanaka, H. Cho, S. Samukawa, S. Eden and N. J. Mason, *J. Phys. B: At. Mol. Opt. Phys.* **35** 3257 (2002).


Table 25. Differential cross sections (in units of $10^{-16}$ $cm^2$ $sr^{-1}$) for elastic electron scattering from $CF_3Cl$. Experimental errors are estimated to be in the range 15–20%.

| Angle | Energy (eV) | | | | |
|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 5.0 | 8.0 |
| 15 | 2.77 | 3.27 | 2.18 | 6.38 | 10.85 |
| 20 | 2.09 | 3.00 | 2.15 | 5.77 | 9.92 |
| 30 | 1.77 | 2.73 | 2.45 | 4.94 | 8.98 |
| 40 | 1.60 | 2.58 | 2.72 | 4.30 | 6.82 |

| | | | | | |
|---|---|---|---|---|---|
| 50 | 1.71 | 2.66 | 2.54 | 3.68 | 3.65 |
| 60 | 1.80 | 2.57 | 2.37 | 2.82 | 2.14 |
| 70 | 1.88 | 2.36 | 2.06 | 2.00 | 1.51 |
| 80 | 1.82 | 2.11 | 1.52 | 1.48 | 1.31 |
| 90 | 1.63 | 1.88 | 1.16 | 1.21 | 1.46 |
| 100 | 1.41 | 1.50 | 0.92 | 1.03 | 1.35 |
| 110 | 1.15 | 1.33 | 0.78 | 0.93 | 1.10 |
| 120 | 0.92 | 1.23 | 0.75 | 0.88 | 0.82 |
| 130 | 0.71 | 1.30 | 0.77 | 0.89 | 0.87 |

(continued)

| Angle | Energy (eV) | | | | |
|---|---|---|---|---|---|
| (deg) | 10 | 20 | 30 | 60 | 100 |
| 15 | 19.86 | 15.48 | 19.46 | 17.68 | 8.88 |
| 20 | 16.17 | 11.42 | 11.16 | 6.62 | 2.83 |
| 30 | 8.11 | 5.03 | 3.20 | 1.53 | 1.56 |
| 40 | 4.34 | 1.95 | 1.42 | 1.38 | 0.87 |
| 50 | 2.10 | 1.27 | 1.37 | 0.75 | 0.37 |
| 60 | 1.17 | 1.22 | 1.13 | 0.36 | 0.26 |
| 70 | 1.08 | 1.09 | 0.69 | 0.26 | 0.25 |
| 80 | 1.44 | 0.83 | 0.53 | 0.24 | 0.20 |
| 90 | 1.36 | 0.75 | 0.61 | 0.28 | 0.19 |
| 100 | 1.21 | 0.91 | 0.61 | 0.29 | 0.17 |
| 110 | 0.87 | 0.92 | 0.64 | 0.28 | 0.14 |

| | | | | | |
|---|---|---|---|---|---|
| 120 | 0.78 | 0.84 | 0.63 | 0.34 | 0.15 |
| 130 | 1.10 | 0.80 | 0.65 | 0.38 | 0.23 |

## $CF_3Br$

Table 26. Differential cross sections (in units of $10^{-16}$ $cm^2$ $sr^{-1}$) for elastic electron scattering from $CF_3Br$. Experimental errors are estimated to be in the range 15–20%.

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 0.7 | 1.1 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 |
| 15 | 7.00 | 3.72 | 2.88 | 2.16 | 2.93 | 6.29 | 10.83 |
| 20 | 6.78 | 3.36 | 2.31 | 2.00 | 2.47 | 4.96 | 9.25 |
| 30 | 4.71 | 2.50 | 2.11 | 1.96 | 2.78 | 4.27 | 7.51 |
| 40 | 3.37 | 2.18 | 2.29 | 2.32 | 3.17 | 4.00 | 5.52 |
| 50 | 2.70 | 2.15 | 2.21 | 2.59 | 3.39 | 4.16 | 4.36 |
| 60 | 2.50 | 2.21 | 2.35 | 2.78 | 3.20 | 3.67 | 3.18 |
| 70 | 2.39 | 2.14 | 2.20 | 2.30 | 2.58 | 2.82 | 2.22 |
| 80 | 2.38 | 2.10 | 1.85 | 1.83 | 1.95 | 2.08 | 1.86 |
| 90 | 2.34 | 2.02 | 1.62 | 1.41 | 1.31 | 1.49 | 1.65 |
| 100 | 2.17 | 1.87 | 1.53 | 1.13 | 0.98 | 1.08 | 1.35 |
| 110 | 2.04 | 1.82 | 1.32 | 0.95 | 0.73 | 0.98 | 1.20 |
| 120 | 2.11 | 1.71 | 1.19 | 0.85 | 0.59 | 0.82 | 0.99 |
| 130 | 2.07 | 1.77 | 1.27 | 0.87 | 0.67 | 0.77 | 0.98 |

(continued)

| Angle | Energy (eV) | | | | | | |
|---|---|---|---|---|---|---|---|
| (deg) | 6.0 | 8.0 | 10 | 20 | 30 | 60 | 100 |
| 15 | 13.43 | 17.24 | 18.81 | 26.60 | 23.50 | 20.56 | 3.33 |
| 20 | 11.05 | 14.42 | 15.81 | 18.34 | 13.75 | 7.87 | 2.86 |
| 30 | 8.87 | 9.31 | 11.12 | 6.89 | 3.43 | 1.77 | 1.38 |
| 40 | 6.40 | 5.80 | 5.53 | 2.47 | 1.42 | 1.03 | 0.56 |
| 50 | 4.42 | 3.06 | 2.40 | 1.43 | 1.14 | 0.65 | 0.37 |
| 60 | 2.85 | 1.75 | 1.36 | 1.28 | 0.88 | 0.44 | 0.31 |
| 70 | 2.00 | 1.47 | 1.43 | 1.09 | 0.65 | 0.34 | 0.27 |
| 80 | 1.64 | 1.47 | 1.70 | 0.80 | 0.50 | 0.27 | 0.19 |
| 90 | 1.56 | 1.56 | 1.57 | 0.69 | 0.38 | 0.16 | 0.11 |
| 100 | 1.42 | 1.30 | 1.23 | 0.78 | 0.35 | 0.15 | 0.09 |
| 110 | 1.18 | 0.99 | 0.90 | 0.77 | 0.37 | 0.18 | 0.17 |
| 120 | 0.97 | 0.84 | 0.89 | 0.79 | 0.47 | 0.26 | 0.22 |
| 130 | 0.91 | 0.99 | 1.16 | 0.85 | 0.60 | 0.37 | 0.28 |

## $CF_3I$

Table 27. Differential cross sections (in units of $10^{-16}$ $cm^2$ $sr^{-1}$) for elastic electron scattering from $CF_3Br$. Experimental errors are estimated to be in the range 10–15%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 3.0 | 4.0 | 6.0 | 8.0 | 10 | 20 | 60 |
| 20 | 2.22 | 3.35 | 6.79 | 15.73 | 19.25 | 23.04 | 20.77 | 4.06 |
| 30 | 1.21 | 2.27 | 6.16 | 11.24 | 12.03 | 12.44 | 6.62 | 1.10 |
| 40 | 0.82 | 3.16 | 4.96 | 7.01 | 6.40 | 5.62 | 1.98 | 0.66 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 50 | 1.00 | 3.49 | 3.88 | 4.33 | 3.03 | 2.39 | 1.16 | 0.51 |
| 60 | 1.02 | 3.52 | 3.18 | 2.65 | 1.67 | 1.36 | 1.15 | 0.31 |
| 70 | 1.09 | 3.20 | 3.10 | 1.92 | 1.36 | 1.50 | 1.08 | 0.18 |
| 80 | 0.97 | 2.61 | 2.28 | 1.70 | 1.39 | 1.30 | 0.89 | 0.14 |
| 90 | 0.82 | 1.91 | 1.94 | 1.70 | 1.46 | 1.24 | 0.68 | 0.12 |
| 100 | 0.70 | 1.41 | 1.63 | 1.52 | 1.23 | 1.00 | 0.53 | 0.16 |
| 110 | 0.55 | 0.90 | 1.14 | 1.21 | 0.94 | 0.82 | 0.54 | 0.27 |
| 120 | 0.46 | 0.68 | 0.89 | 0.92 | 0.85 | 0.90 | 0.65 | 0.43 |
| 130 | 0.40 | 0.84 | 1.03 | 1.16 | 1.15 | 1.29 | 0.72 | 0.51 |

## $CO_2$

Absolute cross sections for elastic scattering of electrons from $CO_2$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°. The DCS were analyzed using a phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 28.

**Reference:**

H. Tanaka, T. Ishikawa, T. Masai, T. Sagara, L. Boesten, M. Takekawa, Y. Itikawa and M. Kimura, *Phys. Rev. A* **57** 1798 (1998).

Table 28. Differential cross sections for elastic electron scattering (in units of $10^{-16}$ $cm^2/sr$) and integral elastic (ICS) and elastic momentum transfer cross sections (MTCS), respectively (in units of $10^{-16}$ $cm^2$), from $CO_2$. The absolute uncertainties on the DCS are 10–15%, while the uncertainties on the ICS and MTCS are in the range of 20 to 30%

| Angle | Energy (eV) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 | 2.0 | 3.0 | 3.8 | 4.0 | 5.0 | 6.0 | 6.5 | 7.0 |
| 15 | — | — | — | — | — | — | — | — | — |
| 20 | 0.958 | 0.7505 | 0.716 | 1.3536 | 1.3537 | 0.5824 | 0.6823 | 0.8599 | 0.8828 |
| 30 | 0.762 | 0.5472 | 0.4868 | 0.8831 | 1.0269 | 0.7486 | 0.773 | 0.8236 | 0.8313 |
| 40 | 0.541 | 0.3896 | 0.3069 | 0.6294 | 0.777 | 0.8076 | 0.8244 | 0.9132 | 0.9039 |
| 50 | 0.405 | 0.2455 | 0.3118 | 0.5897 | 0.6857 | 0.8994 | 0.8383 | 0.9286 | 0.9391 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 60 | 0.3289 | 0.2368 | 0.3386 | 0.5715 | 0.6472 | 0.8079 | 0.8373 | 0.895 | 0.8025 |
| 70 | 0.2957 | 0.2489 | 0.3779 | 0.5367 | 0.5834 | 0.7272 | 0.7644 | 0.6978 | 0.7558 |
| 80 | 0.27 | 0.2765 | 0.3876 | 0.5539 | 0.5595 | 0.6026 | 0.6422 | 0.6616 | 0.6258 |
| 90 | 0.2405 | 0.2845 | 0.3937 | 0.5739 | 0.5037 | 0.4794 | 0.5258 | 0.53 | 0.5273 |
| 100 | 0.308 | 0.3021 | 0.395 | 0.5096 | 0.4431 | 0.391 | 0.4518 | 0.4252 | 0.4333 |
| 110 | 0.304 | 0.3276 | 0.438 | 0.5187 | 0.4217 | 0.2647 | 0.3476 | 0.339 | 0.3766 |
| 120 | 0.3567 | 0.3776 | 0.483 | 0.528 | 0.4258 | 0.2523 | 0.3136 | 0.3201 | 0.3798 |
| 130 | 0.365 | 0.3992 | 0.5173 | 0.5475 | 0.4803 | 0.2853 | 0.3798 | 0.352 | 0.3724 |
| ICS | 5.04 | 4.62 | 5.77 | 8.25 | 8.16 | 6.85 | 7.59 | 7.8 | 7.87 |
| MTCS | 4.48 | 4.53 | 5.96 | 7.69 | 7.22 | 5.66 | 6.69 | 6.56 | 6.56 |

(Continued)

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 8.0 | 9.0 | 10 | 15 | 20 | 30 | 60 | 100 |
| 15 | 5.089 | 7.183 | 11.52 | 10.843 | 7.7149 | — | — | — |
| 20 | 1.1594 | 1.4958 | 2.2977 | 3.843 | 5.6871 | 8.731 | 5.671 | 3.7543 |
| 30 | 1.002 | 1.1588 | 1.5342 | 2.718 | 3.2623 | 3.154 | 1.786 | 0.995 |
| 40 | 0.964 | 1.087 | 1.2136 | 1.7789 | 1.8542 | 1.4363 | 0.6597 | 0.3969 |
| 50 | 0.8542 | 0.9487 | 0.9926 | 1.1756 | 1.2248 | 0.743 | 0.3412 | 0.2026 |
| 60 | 0.7214 | 0.8375 | 0.743 | 0.7997 | 0.7475 | 0.4678 | 0.1683 | 0.1502 |
| 70 | 0.6755 | 0.6622 | 0.626 | 0.5777 | 0.4324 | 0.306 | 0.1109 | 0.1124 |
| 80 | 0.6761 | 0.5799 | 0.5468 | 0.4471 | 0.3516 | 0.1896 | 0.0936 | 0.084 |
| 90 | 0.5343 | 0.5394 | 0.4856 | 0.3596 | 0.3041 | 0.1882 | 0.0911 | 0.0697 |
| 100 | 0.4596 | 0.4811 | 0.4478 | 0.3673 | 0.3071 | 0.2391 | 0.0812 | 0.0754 |
| 110 | 0.4263 | 0.4381 | 0.4319 | 0.4046 | 0.3887 | 0.2536 | 0.1175 | 0.088 |
| 120 | 0.4058 | 0.4816 | 0.5304 | 0.5445 | 0.5493 | 0.3195 | 0.1805 | 0.1076 |
| 130 | 0.5183 | 0.6006 | 0.7077 | 0.7832 | 0.6738 | 0.4441 | 0.2748 | 0.1373 |
| ICS | 8.99 | 10.06 | 11.4 | 13.79 | 14.59 | 15.01 | 11.04 | 8.1 |
| MTCS | 8.07 | 9.24 | 9.94 | 11.19 | 10.17 | 7.51 | 4.15 | 2.65 |

## $N_2O$

Absolute cross sections for elastic scattering of electrons from $N_2O$ have been determined in the energy range of 1.5–100 eV and over the scattering angles of 15–130°. The DCS were analyzed using a phase-shift approach in order to extrapolate them to lower and higher angles, to facilitate derivation of the integral cross sections.

All these data are recommended in Table 29.

**Reference:**

M. Kitajima, Y. Sakamoto, R. J. Gulley, M. Hoshino, J. C. Gibson, H. Tanaka and S. J. Buckman, *J. Phys. B: At. Mol. Opt. Phys.* **33** 1687 (2000).

Table 29. Differential cross sections in units of $10^{-16}$ $cm^2/sr$, for elastic electron scattering from $N_2O$. The ANU results are designated (A) and the Sophia results (S). For the ANU results the figures in parentheses represent the absolute error, expressed as a percentage, while for the Sophia data the estimated uncertainty is 15%. The figures at the base of each column are the ICS, for which the estimated uncertainty is 25%.

| Angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 1.5 (S) | 2.0 (S) | 2.0 (A) | 2.2 (S) | 2.3 (A) | 2.4 (S) | 2.5 (S) | 3.0 (S) |
| 15 | — | — | — | — | — | — | — | — |
| 20 | 1.35 | 2.35 | — | 2.38 | — | 2.58 | 2.42 | 1.63 |
| 25 | — | — | — | — | 1.911(14) | — | — | — |
| 30 | 0.96 | 1.82 | 1.620(9) | 2.02 | 1.753(10) | 2.47 | 2.09 | 1.78 |
| 35 | — | — | — | — | 1.678(10) | — | — | — |
| 40 | 0.67 | 1.35 | 1.149(10) | 1.49 | 1.562(10) | 1.97 | 1.87 | 1.68 |
| 45 | — | — | — | — | 1.475(10) | — | — | — |
| 50 | 0.46 | 0.96 | 0.702(9) | 1.18 | 1.385(9) | 1.54 | 1.51 | 1.68 |
| 55 | — | — | — | — | 1.224(7) | — | — | — |
| 60 | 0.32 | 0.71 | 0.624(9) | 0.88 | 1.099(7) | 1.19 | 1.19 | 1.48 |
| 65 | — | — | — | — | 0.922(7) | — | — | — |
| 70 | 0.30 | 0.52 | 0.479(9) | 0.66 | 0.783(7) | 0.93 | 0.86 | 1.10 |
| 75 | — | — | — | — | 0.678(7) | — | — | — |
| 80 | 0.30 | 0.45 | 0.399(8) | 0.52 | 0.580(7) | 0.67 | 0.64 | 0.82 |
| 85 | — | — | — | — | 0.531(7) | — | — | — |
| 90 | 0.35 | 0.45 | 0.406(9) | 0.47 | 0.503(8) | 0.51 | 0.50 | 0.62 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 95 | — | — | — | — | 0.491(7) | — | — | — |
| 100 | 0.46 | 0.52 | 0.478(8) | 0.49 | 0.496(7) | 0.47 | 0.45 | 0.41 |
| 105 | — | — | — | — | 0.514(7) | — | — | — |
| 110 | 0.56 | 0.59 | 0.602(9) | 0.59 | 0.542(7) | 0.50 | 0.50 | 0.33 |
| 115 | — | — | — | — | 0.601(7) | — | — | — |
| 120 | 0.66 | 0.78 | 0.692(10) | 0.75 | 0.699(8) | 0.60 | 0.57 | 0.28 |
| 125 | — | — | — | — | 0.826(7) | — | — | — |
| 130 | 0.76 | 1.02 | 0.825(8) | 0.96 | 0.980(7) | 0.77 | 0.79 | 0.30 |
| ICS | — | 12.57 | 10.14 | 12.21 | 12.84 | 12.90 | — | 9.98 |

(Continued)

| angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 3.0 (A) | 3.5 (S) | 4.0 (S) | 4.0 (A) | 5.0 (S) | 5.0 (A) | 6.0 (S) | 6.0 (A) |
| 15 | — | — | — | — | — | 0.722(16) | — | 0.877(21) |
| 20 | — | 0.98 | 0.68 | 0.640(10) | 0.57 | 0.640(8) | 0.60 | 0.610(8) |
| 25 | — | — | — | 0.783(11) | — | 0.652(8) | — | 0.661(9) |
| 30 | — | 1.10 | 0.84 | 0.826(8) | 0.62 | 0.763(7) | 0.68 | 0.769(8) |
| 35 | 1.747(7) | — | — | 0.895(9) | — | 0.853(7) | — | 0.859(8) |
| 40 | 1.761(7) | 1.22 | 1.01 | 0.990(11) | 0.80 | 0.941(9) | 0.86 | 0.935(8) |
| 45 | 1.711(7) | — | — | 1.027(10) | — | 1.011(8) | — | 1.000(8) |
| 50 | 1.663(7) | 1.37 | 1.15 | 1.038(11) | 0.95 | 1.015(7) | 1.02 | 0.997(7) |
| 55 | 1.542(7) | — | — | 1.065(10) | — | 1.029(8) | — | 0.995(8) |
| 60 | 1.454(7) | 1.22 | 1.10 | 0.958(8) | 1.04 | 1.041(7) | 1.08 | 0.962(7) |
| 65 | 1.315(7) | — | — | 0.925(10) | — | 1.003(7) | — | 0.950(7) |
| 70 | 1.177(7) | 1.08 | 1.06 | 0.838(11) | 0.94 | 0.939(8) | 0.94 | 0.869(7) |
| 75 | 1.041(7) | — | — | 0.776(10) | — | 0.894(8) | — | 0.840(8) |
| 80 | 0.906(7) | 0.89 | 0.83 | 0.714(10) | 0.83 | 0.810(7) | 0.77 | 0.781(7) |
| 85 | 0.786(7) | — | — | 0.662(8) | — | 0.754(8) | — | 0.710(7) |
| 90 | 0.676(7) | 0.71 | 0.70 | 0.561(11) | 0.68 | 0.666(7) | 0.69 | 0.624(7) |
| 95 | 0.587(7) | — | — | 0.501(9) | — | 0.601(7) | — | 0.553(7) |
| 100 | 0.486(7) | 0.50 | 0.58 | 0.447(10) | 0.52 | 0.502(8) | 0.55 | 0.485(7) |
| 105 | 0.410(7) | — | — | 0.373(7) | — | 0.446(7) | — | 0.419(8) |
| 110 | 0.349(7) | 0.39 | 0.40 | 0.314(14) | 0.40 | 0.370(8) | 0.40 | 0.368(11) |
| 115 | 0.307(7) | — | — | 0.266(8) | — | 0.324(8) | — | 0.317(10) |
| 120 | 0.280(7) | 0.28 | 0.30 | 0.245(8) | 0.31 | 0.284(8) | 0.30 | 0.295(10) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 125 | 0.276(7) | — | — | 0.243(8) | — | 0.260(8) | — | 0.279(11) |
| 130 | 0.311(8) | 0.23 | 0.25 | 0.215(9) | 0.27 | 0.249(7) | 0.30 | 0.263(9) |
| ICS | 11.47 | — | 8.34 | 7.39 | 7.60 | 7.96 | 7.73 | 8.10 |

(Continued)

| angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 7.0 (S) | 7.0 (A) | 7.5 (A) | 8.0 (S) | 8.0 (A) | 9.0 (S) | 9.0 (A) | 10 (S) |
| 15 | — | 0.995(16) | 2.224(8) | — | 1.912(15) | — | 3.053(12) | — |
| 20 | 0.94 | 0.912(7) | 1.270(7) | 1.62 | 1.570(7) | 2.34 | 2.382(7) | 2.69 |
| 25 | 0.85 | 0.881(7) | 1.063(7) | 1.26 | 1.336(7) | — | 1.860(7) | 2.21 |
| 30 | 0.80 | 0.875(7) | 0.977(7) | 1.12 | 1.153(7) | 1.53 | 1.544(7) | 1.84 |
| 35 | 0.79 | 0.916(7) | 0.922(7) | 0.99 | 1.067(7) | — | 1.341(7) | 1.57 |
| 40 | 0.86 | 0.945(7) | 0.908(7) | 0.99 | 1.043(7) | 1.17 | 1.206(7) | 1.34 |
| 45 | 0.93 | 0.976(7) | 0.912(7) | 0.99 | 1.020(7) | — | 1.119(8) | 1.19 |
| 50 | 0.99 | 0.984(7) | 0.920(7) | 0.95 | 0.990(7) | 1.04 | 1.028(7) | 1.09 |
| 55 | 0.95 | 0.988(7) | 0.908(7) | 0.87 | 0.962(7) | — | 0.956(7) | 1.01 |
| 60 | 0.90 | 0.930(7) | 0.861(7) | 0.89 | 0.919(7) | 0.86 | 0.893(7) | 0.94 |
| 65 | 0.90 | 0.887(7) | 0.786(8) | 0.83 | 0.864(7) | — | 0.811(9) | 0.86 |
| 70 | 0.85 | 0.849(8) | 0.738(7) | 0.80 | 0.806(7) | 0.77 | 0.754(7) | 0.78 |
| 75 | 0.83 | 0.777(7) | 0.681(7) | 0.74 | 0.748(7) | — | 0.680(7) | 0.74 |
| 80 | 0.74 | 0.719(7) | 0.626(7) | 0.70 | 0.665(7) | 0.64 | 0.610(7) | 0.64 |
| 85 | 0.70 | 0.659(7) | 0.568(7) | 0.59 | 0.605(7) | — | 0.550(7) | 0.58 |
| 90 | 0.61 | 0.591(7) | 0.508(7) | 0.53 | 0.541(7) | 0.51 | 0.490(7) | 0.51 |
| 95 | 0.56 | 0.518(7) | 0.453(7) | 0.46 | 0.482(7) | — | 0.432(7) | 0.44 |
| 100 | 0.48 | 0.454(7) | 0.405(7) | 0.45 | 0.424(7) | 0.41 | 0.384(7) | 0.40 |
| 105 | 0.39 | 0.396(7) | 0.350(8) | 0.39 | 0.374(7) | — | 0.358(7) | 0.36 |
| 110 | 0.36 | 0.346(7) | 0.329(7) | 0.36 | 0.355(7) | 0.34 | 0.356(7) | 0.35 |
| 115 | 0.33 | 0.313(7) | 0.305(8) | 0.35 | 0.352(7) | — | 0.377(7) | 0.40 |
| 120 | 0.31 | 0.302(7) | 0.322(7) | 0.37 | 0.386(7) | 0.43 | 0.446(7) | 0.44 |
| 125 | 0.35 | 0.324(7) | 0.357(8) | 0.40 | 0.462(7) | — | 0.552(7) | 0.56 |
| 130 | 0.35 | 0.369(8) | 0.419(7) | 0.48 | 0.653(7) | 0.61 | 0.693(7) | 0.69 |
| ICS | — | 8.34 | 8.82 | 9.25 | 10.35 | — | 11.11 | 10.39 |

(Continued)

| angle | Energy (eV) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (deg) | 10 (A) | 15 (S) | 15 (A) | 20 (S) | 20 (A) | 30 (S) | 60 (S) | 100 (S) |
| 15 | 4.133(8) | — | 6.454(10) | — | 8.201(8) | — | — | — |
| 20 | 3.107(8) | 4.38 | 4.850(7) | 6.67 | 5.661(8) | 5.98 | 4.31 | 3.23 |
| 25 | 2.566(8) | — | — | — | — | — | — | — |
| 30 | 2.142(8) | 2.72 | 2.869(10) | 3.48 | 2.821(8) | 2.60 | 1.38 | 0.94 |
| 35 | 1.717(8) | — | — | — | — | — | — | — |
| 40 | 1.517(9) | 1.79 | 1.814(7) | 1.88 | 1.649(8) | 1.27 | 0.63 | 0.35 |
| 45 | 1.312(8) | — | — | — | — | — | — | — |
| 50 | 1.235(11) | 1.29 | 1.299(8) | 1.24 | 1.099(8) | 0.75 | 0.32 | 0.19 |
| 55 | 1.122(8) | — | — | — | — | — | — | — |
| 60 | 1.042(11) | 0.97 | 0.987(8) | 0.84 | 0.747(8) | 0.45 | 0.18 | 0.12 |
| 65 | 0.955(12) | — | — | — | — | — | — | — |
| 70 | 0.878(16) | 0.78 | 0.772(8) | 0.61 | 0.528(8) | 0.30 | 0.11 | 0.10 |
| 75 | 0.797(12) | — | — | — | — | — | — | — |
| 80 | 0.699(11) | 0.59 | 0.595(8) | 0.40 | 0.345(8) | 0.15 | 0.10 | 0.09 |
| 85 | 0.626(8) | — | — | — | — | — | — | — |
| 90 | 0.523(11) | 0.40 | 0.396(10) | 0.27 | 0.236(8) | 0.16 | 0.09 | 0.08 |
| 95 | 0.494(10) | — | 0.336(8) | — | — | — | — | — |
| 100 | 0.457(12) | 0.30 | 0.293(9) | 0.26 | 0.246(8) | 0.23 | 0.08 | 0.09 |
| 105 | 0.415(10) | — | 0.278(13) | — | — | — | — | — |
| 110 | 0.442(13) | 0.35 | 0.339(15) | 0.35 | 0.340(8) | 0.27 | 0.12 | 0.11 |
| 115 | 0.463(13) | — | — | — | — | — | — | — |
| 120 | 0.525(10) | 0.48 | 0.467(18) | 0.52 | 0.498(9) | 0.33 | 0.19 | 0.12 |
| 125 | 0.689(15) | — | — | — | — | — | — | — |
| 130 | 0.830(14) | 0.72 | 0.671(9) | 0.7 | 0.696(9) | 0.43 | 0.28 | 0.14 |
| ICS | 14.36 | — | 14.30 | — | 13.77 | — | 4.27 | 2.95 |

## $H_2O$

Water vapour has attracted significant research interest in recent years as a target for low energy electron collision studies. This results from the broad application of collision cross section data in fields as diverse as planetary science, the interstellar medium and radiation chemistry and biology. Indeed, cross sections for water are amongst some of the essential parameters in modeling the effects of ionizing radiation on humans and other species. The magnetic angle-changing device is again employed in conjunction with the spectrometer to measure the cross sections to the backward angles. The absolute differential cross sections (DCS) for elastic scattering from $H_2O$ at nine incident energies between 4 and 50 eV, and at scattering angles between 10 and 180° are presented in Table 30.

**Reference:**

H. Cho, Y. S. Park, H. Tanaka and S. J. Buckman, *J. Phys. B: At. Mol. Opt. Phys.* **37** 625 (2004).

Table 30. Differential cross sections (in units of $10^{-16}$ cm$^2$ sr$^{-1}$) for elastic electron scattering from $H_2O$. The experimental uncertainties on each measured point are indicated in the table in brackets as an absolute value.

| Angle | Energy (eV) | | | | |
|---|---|---|---|---|---|
| (deg) | 4 | 6 | 8 | 10 | 15 |
| 10 | - | - | - | 10.01 (1.011) | 10.99 (1.429) |
| 20 | 5.223 (0.501) | 4.209 (0.463) | 5.012 (0.534) | 4.555 (0.451) | 5.120 (0.563) |
| 30 | 2.973 (0.377) | 2.241 (0.217) | 2.472 (0.225) | 2.511 (0.226) | 3.038 (0.283) |
| 40 | 1.735 (0.154) | 1.513 (0.133) | 1.455 (0.147) | 1.726 (0.147) | 1.803 (0.153) |
| 50 | 1.107 (0.149) | 1.146 (0.124) | 1.207 (0.155) | 1.327 (0.104) | 1.198 (0.115) |
| 60 | 0.981 (0.088) | 0.897 (0.097) | 0.954 (0.124) | 1.033 (0.099) | 0.783 (0.091) |
| 70 | 0.680 (0.061) | 0.887 (0.087) | 0.883 (0.106) | 0.769 (0.081) | 0.591 (0.055) |
| 80 | 0.520 (0.067) | 0.704 (0.063) | 0.779 (0.092) | 0.652 (0.061) | 0.450 (0.038) |
| 90 | 0.451 (0.044) | 0.562 (0.072) | 0.570 (0.063) | 0.515 (0.062) | 0.333 (0.030) |
| 100 | 0.367 (0.035) | 0.423 (0.046) | 0.424 (0.044) | 0.398 (0.052) | 0.343 (0.045) |
| 110 | 0.255 (0.028) | 0.344 (0.067) | 0.397 (0.043) | 0.340 (0.036) | 0.338 (0.047) |
| 120 | 0.211 (0.026) | 0.310 (0.033) | 0.408 (0.036) | 0.369 (0.054) | 0.385 (0.045) |
| 130 | 0.272 (0.026) | 0.374 (0.037) | 0.461 (0.043) | 0.474 (0.056) | 0.526 (0.052) |
| 140 | 0.283 (0.041) | 0.418 (0.035) | 0.630 (0.093) | 0.601 (0.056) | 0.779 (0.067) |
| 150 | 0.339 (0.043) | 0.440 (0.041) | 0.945 (0.113) | 0.924 (0.085) | 0.902 (0.097) |

| | | | | | |
|---|---|---|---|---|---|
| 160 | 0.384 (0.032) | 0.601 (0.064) | 0.992 (0.107) | 1.104 (0.097) | 1.312 (0.144) |
| 170 | 0.502 (0.066) | 0.751 (0.076) | 1.050 (0.102) | 1.382 (0.096) | 1.465 (0.180) |
| 180 | 0.577 (0.057) | 0.835 (0.084) | 1.314 (0.146) | 1.576 (0.197) | 1.737 (0.191) |

(Continued)

| Angle | Energy (eV) | | | |
|---|---|---|---|---|
| (deg) | 20 | 30 | 40 | 50 |
| 10 | 9.913 (1.169) | 11.04 (1.170) | 11.05 (0.961) | 11.03 (1.211) |
| 20 | 4.500 (0.414) | 4.978 (0.641) | 5.911 (0.579) | 4.538 (0.404) |
| 30 | 2.794 (0.299) | 2.533 (0.279) | 2.030 (0.219) | 1.991 (0.169) |
| 40 | 1.546 (0.136) | 1.220 (0.115) | 0.832 (0.099) | 0.854 (0.097) |
| 50 | 1.117 (0.110) | 0.891 (0.064) | 0.371 (0.034) | 0.352 (0.037) |
| 60 | 0.628 (0.069) | 0.512 (0.051) | 0.227 (0.018) | 0.189 (0.016) |
| 70 | 0.388 (0.042) | 0.281 (0.032) | 0.162 (0.015) | 0.107 (0.013) |
| 80 | 0.315 (0.033) | 0.194 (0.026) | 0.101 (0.010) | 0.070 (0.008) |
| 90 | 0.291 (0.043) | 0.178 (0.016) | 0.084 (0.011) | 0.057 (0.007) |
| 100 | 0.253 (0.028) | 0.156 (0.014) | 0.076 (0.010) | 0.061 (0.006) |
| 110 | 0.273 (0.032) | 0.157 (0.015) | 0.083 (0.011) | 0.058 (0.007) |
| 120 | 0.349 (0.033) | 0.180 (0.019) | 0.129 (0.014) | 0.085 (0.011) |
| 130 | 0.425 (0.046) | 0.269 (0.038) | 0.195 (0.023) | 0.132 (0.014) |
| 140 | 0.552 (0.061) | 0.344 (0.046) | 0.288 (0.032) | 0.166 (0.024) |
| 150 | 0.736 (0.068) | 0.431 (0.052) | 0.379 (0.041) | 0.204 (0.021) |
| 160 | 0.889 (0.094) | 0.492 (0.059) | 0.442 (0.053) | 0.264 (0.025) |
| 170 | 1.020 (0.090) | 0.547 (0.059) | 0.504 (0.072) | 0.303 (0.030) |
| 180 | 1.093 (0.124) | 0.620 (0.056) | 0.585 (0.077) | 0.345 (0.031) |

## 5 Concluding Remarks

In this report elastic differential cross sections for electron collisions with polyatomic molecules have been reviewed with particular emphasis on the methodology for the precise measurement of absolute values. A selection of the latest results, from a range extending over the past three decades, have been presented and briefly discussed. In particular, we have chosen data for specific interest in the fields of fusion plasmas, processing plasmas and environmental modeling.


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