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DOUBLE DIFFERENTIAL CROSS SECTIONS FOR ELECTRONS EJECTED FROM H_2 , O_2 , N_2 , CO_2 , CH_4 , H_2O AND Ar BY 50 keV PROTONS

by

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ABSTRACT

Tabulated values of double differential cross section measurements are presented for electrons ejected from H_2 , O_2 , N_2 , CO_2 , CH_4 , H_2O and Ar by 50 keV protons. The angular range extends from 0 to 100° and the electron energy from 5 to 150 eV.

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ANGULAR DISTRIBUTION; ARGON; CARBON DIOXIDE; DIFFERENTIAL CROSS SECTIONS; ELECTRON EMISSION; ELECTRONS; HYDROGEN; KEV RANGE 10-100; METHANE; NITROGEN; OXYGEN; PROTONS; WATER

EDITORIAL NOTE

From 27 April 1987, the Australian Atomic Energy Commission (AAEC) is replaced by Australian Nuclear Science and Technology Organisation (ANSTO). Serial numbers for reports with an issue date after April 1987 have the prefix ANSTO with no change of the symbol (E, M, S or C) or numbering sequence.

CONTENTS

1. INTRODUCTION

The double differential cross sections (DDCS) for the ejection of electrons from target atoms and molecules by heavy charged particles are important in the study of radiation dosimetry [*e.g.* McGowan, 1975]. The purpose of this report is to present tabulated values of measured double differential cross sections for electron ejection from molecules made of elements that are the main constituents of living matter. The rare gas argon has also been included for comparison with other measurements. A proton energy of 50 keV was used, in the middle of the range of energies of interest in many radiation dosimetry calculations. As our apparatus could measure electrons ejected at zero degrees, the peak that arises from the process of charge capture into the continuum is covered.

2. APPARATUS AND RESULTS

The apparatus used for these measurements has been described in earlier publications [Gibson and Petersen 1978, Gibson and Reid 1984] and the techniques used to calibrate the various gases against the standard helium are described in Gibson and Reid [1987]. The absolute values in **tables 1-7** ultimately rest upon the normalisation of the helium measurements against published total ionisation cross sections. Details of this procedure were given by Gibson and Reid [1986] who also compared their results with other published work. As in the case of helium the present data agree with published cross sections in energy dependence, but decrease to a much greater with increasing angle.

3. ACKNOWLEDGEMENTS

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TABLE 1. DDCS for 50 keV H^+ on Hydrogen ($m^2\ eV^{-1}\ sr^{-1}$)

Energy (eV)	Angle (degrees) 0	1	2	3	4	5	7	10	20
5	1.15-21	9.84-22	9.01-22	8.45-22	7.97-22	7.60-22	7.05-22	6.23-22	3.27-22
10	3.81-21	1.73-21	1.53-21	1.42-21	1.33-21	1.27-21	1.20-21	1.11-21	6.23-22
15	4.30-21	2.73-21	2.37-21	2.09-21	1.89-21	1.72-21	1.49-21	1.18-21	4.98-22
20	4.76-21	3.33-21	2.77-21	2.38-21	2.08-21	1.83-21	1.49-21	1.08-21	4.04-22
22	5.65-21	4.14-21	3.29-21	2.68-21	2.25-21	1.90-21	1.45-21	1.02-21	3.69-22
24	6.88-21	4.74-21	3.54-21	2.75-21	2.19-21	1.82-21	1.30-21	8.85-22	3.29-22
25	7.94-21	5.24-21	3.74-21	2.79-21	2.15-21	1.73-21	1.21-21	8.03-22	3.04-22
26	9.60-21	5.76-21	3.92-21	2.81-21	2.09-21	1.65-21	1.11-21	7.33-22	2.90-22
27	1.29-20	6.59-21	4.24-21	2.89-21	2.09-21	1.59-21	1.03-21	6.62-22	2.70-22
28	1.52-20	4.86-21	3.25-21	2.30-21	1.72-21	1.34-21	9.10-22	6.11-22	2.57-22
30	6.76-21	2.31-21	1.76-21	1.40-21	1.14-21	9.59-22	7.30-22	5.38-22	2.36-22
35	8.67-22	7.66-22	6.62-22	5.86-22	5.30-22	4.88-22	4.26-22	3.55-22	1.78-22
40	4.30-22	3.99-22	3.63-22	3.35-22	3.15-22	3.00-22	2.79-22	2.51-22	1.37-22
50	1.97-22	1.90-22	1.78-22	1.69-22	1.62-22	1.59-22	1.53-22	1.44-22	8.66-23
60	1.47-22	1.53-22	1.42-22	1.33-22	1.27-22	1.22-22	1.15-22	1.03-22	5.63-23
80	6.60-23	6.87-23	6.37-23	6.00-23	5.71-23	5.50-23	5.15-23	4.57-23	2.44-23
100	2.97-23	3.07-23	2.83-23	2.64-23	2.50-23	2.40-23	2.20-23	1.89-23	9.16-24
150	3.20-24	3.20-24	2.86-24	2.59-24	2.34-24	2.13-24	1.75-24	1.23-24	5.59-25

Energy (eV)	Angle (degrees) 30	40	50	60	70	80	90	100
5	1.63-22	8.81-23	6.19-23	4.00-23	2.97-23	2.37-23	1.85-23	1.90-23
10	2.84-22	1.38-22	7.86-23	4.03-23	1.97-23	1.13-23	7.24-24	7.16-24
15	2.18-22	1.07-22	5.89-23	2.81-23	1.23-23	6.28-24	3.47-24	3.12-24
20	1.74-22	8.53-23	4.49-23	1.98-23	7.84-24	3.61-24	1.77-24	1.50-24
22	1.59-22	7.75-23	3.96-23	1.69-23	6.67-24	2.93-24	1.44-24	1.24-24
24	1.47-22	7.16-23	3.62-23	1.49-23	5.75-24	2.49-24	1.20-24	1.01-24
25	1.37-22	6.69-23	3.33-23	1.37-23	5.13-24	2.24-24	1.21-24	9.84-25
26	1.31-22	6.41-23	3.20-23	1.30-23	4.85-24	2.10-24	1.03-24	7.71-25
27	1.22-22	5.91-23	2.88-23	1.16-23	4.29-24	1.89-24	9.94-25	8.05-25
28	1.19-22	5.85-23	2.89-23	1.14-23	4.18-24	1.80-24	8.49-25	7.43-25
30	1.09-22	5.26-23	2.49-23	9.62-24	3.47-24	1.52-24	7.77-25	6.28-25
35	8.68-23	4.17-23	1.91-23	6.86-24	2.31-24	9.93-25	5.28-25	4.31-25
40	6.89-23	3.23-23	1.41-23	4.81-24	1.63-24	7.09-25	3.72-25	3.42-25
50	4.35-23	1.93-23	7.58-24	2.35-24	8.14-25	3.73-25	2.04-25	1.74-25
60	2.80-23	1.19-23	4.25-24	1.34-24	4.73-25	2.15-25	1.26-25	7.91-26
80	1.14-23	4.07-24	1.18-24	3.79-25	1.48-25	6.45-26	4.46-26	3.82-26
100	3.90-24	1.26-24	3.57-25	1.25-25	5.17-26	2.72-26	2.36-26	2.34-26
150	3.47-25	8.90-26	2.33-26	2.41-26	1.60-26	4.63-27	7.62-27	1.09-26

TABLE 2. DDCS for 50 keV H^+ on Oxygen ($m^2\ eV^{-1}\ sr^{-1}$)

Energy (eV)	Angle (degrees) 0	1	2	3	4	5	7	10	20
5	1.49-21	7.22-22	6.89-22	6.68-22	6.57-22	6.55-22	6.57-22	6.55-22	4.93-22
10	3.94-21	2.47-21	2.17-21	1.92-21	1.74-21	1.60-21	1.39-21	1.18-21	7.59-22
15	4.32-21	2.52-21	2.31-21	2.14-21	2.03-21	1.90-21	1.77-21	1.55-21	8.11-22
20	5.89-21	4.00-21	3.45-21	3.01-21	2.70-21	2.47-21	2.06-21	1.62-21	7.01-22
22	7.26-21	5.01-21	4.21-21	3.60-21	3.12-21	2.78-21	2.24-21	1.68-21	6.87-22
24	9.59-21	6.42-21	5.11-21	4.17-21	3.46-21	2.97-21	2.23-21	1.55-21	6.17-22
26	1.44-20	8.57-21	6.43-21	4.98-21	3.93-21	3.23-21	2.24-21	1.43-21	5.63-22
27	1.98-20	9.55-21	6.96-21	5.22-21	4.02-21	3.19-21	2.14-21	1.31-21	5.25-22
28	3.38-20	1.52-20	1.02-20	7.10-21	5.11-21	3.83-21	2.30-21	1.24-21	4.72-22
29	4.78-20	9.48-21	6.77-21	5.03-21	3.81-21	3.00-21	1.97-21	1.19-21	4.88-22
30	2.23-20	9.08-21	6.48-21	4.75-21	3.61-21	2.85-21	1.85-21	1.10-21	4.53-22
35	1.75-21	1.41-21	1.25-21	1.13-21	1.04-21	9.66-22	8.56-22	7.17-22	3.58-22
40	9.68-22	8.43-22	7.74-22	7.24-22	6.85-22	6.55-22	6.12-22	5.48-22	2.97-22
50	4.43-22	4.17-22	3.89-22	3.67-22	3.51-22	3.41-22	3.27-22	3.02-22	1.84-22
60	3.01-22	3.15-22	2.94-22	2.76-22	2.63-22	2.56-22	2.41-22	2.18-22	1.27-22
80	1.43-22	1.49-22	1.39-22	1.31-22	1.25-22	1.21-22	1.14-22	1.03-22	6.22-23
100	7.61-23	7.88-23	7.28-23	6.83-23	6.45-23	6.18-23	5.73-23	5.01-23	3.09-23
150	1.79-23	1.81-23	1.65-23	1.51-23	1.39-23	1.30-23	1.13-23	8.97-24	5.04-24

Energy (eV)	Angle (degrees) 30	40	50	60	70	80	90	100
5	3.42-22	2.51-22	1.90-22	1.25-22	8.47-23	6.73-23	5.14-23	4.64-23
10	4.19-22	2.43-22	1.55-22	8.51-23	5.37-23	3.90-23	2.82-23	2.48-23
15	4.02-22	2.11-22	1.21-22	6.06-23	3.68-23	2.57-23	1.79-23	1.50-23
20	3.25-22	1.69-22	9.61-23	4.77-23	2.77-23	1.80-23	1.22-23	1.05-23
22	3.10-22	1.56-22	8.47-23	4.17-23	2.44-23	1.61-23	1.07-23	9.03-24
24	2.81-22	1.43-22	7.90-23	3.82-23	2.19-23	1.42-23	9.54-24	7.85-24
26	2.55-22	1.28-22	6.98-23	3.37-23	1.93-23	1.26-23	8.37-24	6.84-24
27	2.39-22	1.22-22	6.74-23	3.27-23	1.89-23	1.22-23	8.17-24	6.77-24
28	2.12-22	1.07-22	5.82-23	2.78-23	1.60-23	1.02-23	6.81-24	5.69-24
29	2.21-22	1.10-22	5.90-23	2.83-23	1.64-23	1.06-23	7.25-24	6.01-24
30	2.06-22	1.02-22	5.38-23	2.53-23	1.45-23	9.43-24	6.38-24	5.32-24
35	1.75-22	9.01-23	4.93-23	2.34-23	1.30-23	8.05-24	5.49-24	4.74-24
40	1.46-22	7.38-23	3.92-23	1.83-23	9.91-24	6.22-24	4.15-24	3.62-24
50	9.55-23	5.01-23	2.77-23	1.28-23	6.61-24	3.97-24	2.76-24	2.46-24
60	6.87-23	3.51-23	1.71-23	7.76-24	3.90-24	2.53-24	1.78-24	1.47-24
80	3.52-23	1.76-23	7.35-24	3.30-24	1.71-24	1.18-24	8.74-25	7.68-25
100	1.81-23	8.83-24	3.23-24	1.53-24	8.04-25	5.75-25	4.36-25	3.98-25
150	3.10-24	1.37-24	5.36-25	3.02-25	1.50-25	1.02-25	8.19-26	7.77-26

TABLE 3. DDCS for 50 keV H^+ on Nitrogen ($m^2\ eV^{-1}\ sr^{-1}$)

Energy (eV)	Angle (degrees) 0	1	2	3	4	5	7	10	20
5	7.97-21	6.87-21	5.36-21	4.30-21	3.53-21	2.97-21	2.21-21	1.55-21	7.81-22
7	1.20-20	7.69-21	5.91-21	4.70-21	3.82-21	3.20-21	2.31-21	1.56-21	6.72-22
10	6.40-21	3.19-21	2.71-21	2.36-21	2.10-21	1.90-21	1.60-21	1.27-21	6.25-22
15	3.50-21	2.05-21	1.87-21	1.71-21	1.59-21	1.51-21	1.37-21	1.18-21	5.85-22
20	5.30-21	4.11-21	3.32-21	2.76-21	2.35-21	2.06-21	1.66-21	1.26-21	5.40-22
22	6.40-21	4.68-21	3.65-21	2.95-21	2.44-21	2.10-21	1.62-21	1.20-21	4.98-22
24	8.68-21	6.43-21	4.65-21	3.50-21	2.75-21	2.23-21	1.62-21	1.13-21	4.71-22
25	1.13-20	7.93-21	5.45-21	3.94-21	3.00-21	2.37-21	1.63-21	1.11-21	4.63-22
26	1.44-20	9.46-21	6.11-21	4.19-21	3.04-21	2.33-21	1.53-21	1.01-21	4.31-22
27	2.00-20	1.14-20	7.01-21	4.61-21	3.23-21	2.41-21	1.52-21	9.81-22	4.23-22
28	2.72-20	1.04-20	6.30-21	4.11-21	2.84-21	2.12-21	1.35-21	8.88-22	4.00-22
30	9.63-21	3.99-21	2.92-21	2.23-21	1.78-21	1.47-21	1.09-21	7.96-22	3.70-22
35	1.49-21	1.28-21	1.08-21	9.35-22	8.29-22	7.55-22	6.50-22	5.41-22	2.79-22
40	7.74-22	6.35-22	5.76-22	5.35-22	5.02-22	4.79-22	4.45-22	3.99-22	2.23-22
50	3.66-22	3.48-22	3.19-22	2.99-22	2.84-22	2.76-22	2.62-22	2.45-22	1.51-22
60	2.47-22	2.58-22	2.38-22	2.27-22	2.14-22	2.08-22	1.96-22	1.76-22	1.06-22
80	1.13-22	1.17-22	1.09-22	1.04-22	9.87-23	9.53-23	8.99-23	8.13-23	5.22-23
100	5.85-23	6.04-23	5.57-23	5.22-23	4.95-23	4.72-23	4.34-23	3.80-23	2.41-23
150	1.08-23	1.10-23	9.95-24	9.12-24	8.42-24	7.84-24	6.82-24	5.39-24	3.07-24

Energy (eV)	Angle (degrees) 30	40	50	60	70	80	90	100
5	4.58-22	2.78-22	1.91-22	1.28-22	9.44-23	7.56-23	5.62-23	5.28-23
7	3.68-22	2.20-22	1.46-22	9.59-23	6.99-23	5.33-23	3.91-23	3.58-23
10	3.31-22	1.90-22	1.21-22	7.40-23	4.97-23	3.54-23	2.46-23	2.27-23
15	2.94-22	1.60-22	9.56-23	5.42-23	3.34-23	2.23-23	1.51-23	1.39-23
20	2.57-22	1.34-22	7.75-23	4.19-23	2.44-23	1.56-23	1.04-23	9.24-24
22	2.36-22	1.25-22	7.18-23	3.85-23	2.21-23	1.38-23	8.90-24	8.10-24
24	2.23-22	1.17-22	6.64-23	3.50-23	1.98-23	1.25-23	8.34-24	7.50-24
25	2.21-22	1.16-22	6.54-23	3.40-23	1.88-23	1.15-23	7.56-24	6.83-24
26	2.09-22	1.11-22	6.28-23	3.29-23	1.83-23	1.14-23	7.17-24	6.69-24
27	2.03-22	1.07-22	6.04-23	3.16-23	1.75-23	1.08-23	6.92-24	6.28-24
28	1.94-22	1.03-22	5.81-23	3.03-23	1.65-23	1.01-23	6.65-24	6.07-24
30	1.82-22	9.53-23	5.34-23	2.76-23	1.51-23	9.40-24	6.07-24	5.46-24
35	1.44-22	7.77-23	4.38-23	2.25-23	1.20-23	7.29-24	4.86-24	4.47-24
40	1.19-22	6.42-23	3.62-23	1.83-23	9.62-24	5.88-24	3.77-24	3.49-24
50	8.19-23	4.39-23	2.43-23	1.21-23	6.10-24	3.76-24	2.54-24	2.42-24
60	6.11-23	3.20-23	1.52-23	7.40-24	3.92-24	2.47-24	1.71-24	1.40-24
80	3.11-23	1.60-23	6.31-24	3.03-24	1.65-24	1.12-24	8.02-25	6.87-25
100	1.48-23	7.48-24	2.74-24	1.36-24	7.56-25	5.23-25	3.79-25	3.33-25
150	2.04-24	9.83-25	4.38-25	2.31-25	1.24-25	8.05-26	6.39-26	5.94-26

TABLE 4. DDCS for 50 keV H^+ on Carbon Dioxide ($m^2\ eV^{-1}\ sr^{-1}$)

Energy (eV)	Angle (degrees) 0	1	2	3	4	5	7	10	20
5	2.79-21	2.43-21	2.27-21	2.13-21	2.06-21	1.98-21	1.92-21	1.77-21	1.10-21
7	3.09-21	1.67-21	1.58-21	1.51-21	1.46-21	1.44-21	1.41-21	1.36-21	9.20-22
10	5.41-21	3.13-21	2.68-21	2.32-21	2.09-21	1.91-21	1.69-21	1.45-21	8.22-22
15	5.19-21	2.93-21	2.59-21	2.32-21	2.10-21	1.97-21	1.74-21	1.46-21	7.10-22
20	5.92-21	3.87-21	3.27-21	2.81-21	2.47-21	2.22-21	1.82-21	1.38-21	5.88-22
22	7.38-21	5.01-21	4.00-21	3.31-21	2.80-21	2.45-21	1.93-21	1.46-21	6.22-22
24	8.84-21	5.82-21	4.40-21	3.46-21	2.80-21	2.35-21	1.75-21	1.25-21	5.11-22
25	1.13-20	6.88-21	5.07-21	3.88-21	3.07-21	2.52-21	1.83-21	1.26-21	5.32-22
26	1.31-20	6.88-21	4.92-21	3.67-21	2.85-21	2.29-21	1.63-21	1.11-21	4.70-22
27	1.66-20	7.78-21	5.30-21	3.80-21	2.85-21	2.25-21	1.54-21	1.03-21	4.45-22
28	2.16-20	7.03-21	4.75-21	3.40-21	2.56-21	2.02-21	1.39-21	9.49-22	4.25-22
30	1.07-20	4.41-21	3.20-21	2.43-21	1.92-21	1.58-21	1.16-21	8.23-22	3.73-22
35	1.57-21	1.29-21	1.13-21	1.00-21	9.08-22	8.32-22	7.29-22	6.02-22	3.01-22
40	9.30-22	8.31-22	7.63-22	7.09-22	6.65-22	6.32-22	5.75-22	4.92-22	2.65-22
50	3.80-22	3.52-22	3.36-22	3.23-22	3.13-22	3.08-22	2.96-22	2.74-22	1.65-22
60	2.76-22	2.87-22	2.66-22	2.51-22	2.38-22	2.29-22	2.12-22	1.89-22	1.14-22
80	1.29-22	1.34-22	1.24-22	1.16-22	1.10-22	1.06-22	9.93-23	8.86-23	5.83-23
100	6.81-23	7.03-23	6.48-23	6.05-23	5.72-23	5.46-23	5.02-23	4.37-23	2.84-23
150	1.50-23	1.53-23	1.38-23	1.26-23	1.16-23	1.07-23	9.26-24	7.21-24	4.19-24

Energy (eV)	Angle (degrees) 30	40	50	60	70	80	90	100
5	6.57-22	4.20-22	2.81-22	1.69-22	1.28-22	1.04-22	8.79-23	8.53-23
7	5.30-22	3.23-22	2.14-22	1.26-22	9.41-23	7.37-23	5.54-23	5.17-23
10	4.39-22	2.65-22	1.74-22	1.02-22	7.22-23	5.38-23	3.86-23	3.43-23
15	3.52-22	2.03-22	1.32-22	7.56-23	5.03-23	3.48-23	2.40-23	2.11-23
20	2.84-22	1.71-22	1.12-22	6.41-23	4.01-23	2.67-23	1.79-23	1.56-23
22	2.96-22	1.65-22	1.02-22	5.58-23	3.44-23	2.24-23	1.49-23	1.33-23
24	2.42-22	1.41-22	9.30-23	5.13-23	3.26-23	2.15-23	1.46-23	1.26-23
25	2.58-22	1.46-22	8.91-23	4.84-23	3.04-23	1.96-23	1.30-23	1.14-23
26	2.24-22	1.31-22	8.74-23	4.79-23	2.94-23	1.90-23	1.28-23	1.11-23
27	2.20-22	1.26-22	8.35-23	4.49-23	2.76-23	1.79-23	1.26-23	1.07-23
28	2.06-22	1.22-22	8.18-23	4.47-23	2.70-23	1.72-23	1.16-23	9.91-24
30	1.86-22	1.07-22	7.43-23	4.05-23	2.44-23	1.54-23	1.04-23	9.05-24
35	1.53-22	8.97-23	6.19-23	3.30-23	1.93-23	1.19-23	7.92-24	7.01-24
40	1.38-22	8.03-23	5.27-23	2.75-23	1.50-23	9.11-24	6.11-24	5.46-24
50	9.17-23	5.51-23	3.59-23	1.83-23	9.77-24	5.91-24	4.01-24	3.64-24
60	6.80-23	4.00-23	2.29-23	1.14-23	5.92-24	3.79-24	2.66-24	2.18-24
80	3.69-23	2.13-23	1.03-23	4.69-24	2.56-24	1.75-24	1.29-24	1.10-24
100	1.94-23	1.05-23	4.71-24	2.15-24	1.18-24	8.54-25	6.34-25	5.51-25
150	3.24-24	1.55-24	7.66-25	4.02-25	2.07-25	1.42-25	1.10-25	9.91-26

TABLE 5. DDCS for 50 keV H^+ on Methane ($m^2\ eV^{-1}\ sr^{-1}$)

Energy (eV)	Angle (degrees) 0	1	2	3	4	5	7	10	20
5	2.80-20	2.38-20	1.92-20	1.60-20	1.36-20	1.17-20	8.91-21	6.12-21	1.88-21
7	3.46-20	1.74-20	1.43-20	1.21-20	1.04-20	9.06-21	7.05-21	5.01-21	1.62-21
10	1.30-20	6.70-21	5.74-21	5.03-21	4.49-21	4.03-21	3.41-21	2.70-21	1.28-21
15	8.76-21	5.10-21	4.48-21	4.01-21	3.66-21	3.39-21	2.93-21	2.38-21	1.08-21
20	9.26-21	5.41-21	4.68-21	4.11-21	3.66-21	3.32-21	2.79-21	2.16-21	8.78-22
22	1.18-20	7.65-21	6.24-21	5.23-21	4.45-21	3.86-21	3.01-21	2.15-21	8.34-22
24	1.57-20	1.02-20	7.83-21	6.15-21	4.95-21	4.09-21	2.93-21	1.91-21	7.28-22
26	2.45-20	1.31-20	9.46-21	7.07-21	5.44-21	4.29-21	2.88-21	1.73-21	6.87-22
27	3.11-20	1.25-20	8.99-21	6.65-21	5.08-21	3.99-21	2.61-21	1.56-21	6.29-22
28	5.18-20	1.86-20	1.25-20	8.69-21	6.27-21	4.66-21	2.81-21	1.53-21	6.22-22
30	2.35-20	1.03-20	7.47-21	5.53-21	4.26-21	3.39-21	2.22-21	1.35-21	5.78-22
35	2.72-21	2.02-21	1.78-21	1.60-21	1.45-21	1.34-21	1.17-21	9.68-22	4.72-22
40	1.35-21	1.12-21	1.03-21	9.61-22	9.07-22	8.69-22	8.07-22	7.16-22	3.79-22
50	6.80-22	6.36-22	5.97-22	5.66-22	5.41-22	5.23-22	5.02-22	4.60-22	2.68-22
60	4.77-22	4.93-22	4.55-22	4.24-22	4.03-22	3.86-22	3.58-22	3.10-22	1.85-22
80	2.07-22	2.15-22	1.99-22	1.87-22	1.78-22	1.70-22	1.59-22	1.41-22	8.99-23
100	9.91-23	1.03-22	9.49-23	8.88-23	8.38-23	8.02-23	7.40-23	6.45-23	4.10-23
150	1.55-23	1.57-23	1.42-23	1.30-23	1.19-23	1.11-23	9.51-24	7.34-24	3.86-24

Energy (eV)	Angle (degrees) 30	40	50	60	70	80	90	100
5	9.66-22	5.94-22	3.81-22	2.20-22	1.54-22	1.12-22	7.58-23	6.88-23
7	8.05-22	4.72-22	2.94-22	1.67-22	1.10-22	7.60-23	5.16-23	4.46-23
10	6.74-22	3.79-22	2.29-22	1.25-22	7.88-23	5.12-23	3.23-23	2.66-23
15	5.37-22	2.89-22	1.70-22	8.97-23	5.24-23	3.18-23	1.81-23	1.48-23
20	4.32-22	2.37-22	1.35-22	6.93-23	3.76-23	2.12-23	1.23-23	9.67-24
22	4.03-22	2.16-22	1.22-22	6.19-23	3.34-23	1.87-23	1.04-23	8.37-24
24	3.62-22	1.97-22	1.10-22	5.69-23	3.03-23	1.66-23	9.15-24	7.45-24
26	3.41-22	1.83-22	1.02-22	5.02-23	2.63-23	1.44-23	8.38-24	6.48-24
27	3.15-22	1.72-22	9.54-23	4.85-23	2.53-23	1.39-23	7.91-24	6.38-24
28	3.15-22	1.71-22	9.42-23	4.68-23	2.36-23	1.27-23	7.17-24	5.77-24
30	2.95-22	1.60-22	8.81-23	4.28-23	2.11-23	1.11-23	6.32-24	5.15-24
35	2.44-22	1.30-22	7.09-23	3.30-23	1.57-23	8.07-24	4.63-24	3.79-24
40	2.04-22	1.08-22	5.68-23	2.60-23	1.19-23	6.09-24	3.47-24	2.80-24
50	1.46-22	7.54-23	3.79-23	1.58-23	6.85-24	3.54-24	2.19-24	1.85-24
60	1.07-22	5.27-23	2.31-23	9.79-24	4.07-24	2.17-24	1.38-24	9.71-25
80	5.51-23	2.44-23	7.50-24	3.25-24	1.52-24	8.45-25	5.66-25	4.42-25
100	2.61-23	1.02-23	2.84-24	1.21-24	5.93-25	3.59-25	2.50-25	2.08-25
150	2.42-24	7.00-25	2.45-25	1.51-25	8.32-26	3.52-26	3.06-26	3.47-26

TABLE 6. DDCS for 50 keV H^+ on Water Vapour ($m^2\ eV^{-1}\ sr^{-1}$)

Energy (eV)	Angle (degrees) 0	1	2	3	4	5	7	10	20
5	4.35-21	2.94-21	2.70-21	2.52-21	2.38-21	2.29-21	2.13-21	1.92-21	1.08-21
10	5.34-21	2.61-21	2.37-21	2.20-21	2.06-21	1.95-21	1.81-21	1.62-21	9.76-22
15	5.21-21	3.25-21	2.89-21	2.62-21	2.42-21	2.26-21	2.00-21	1.68-21	8.12-22
20	6.43-21	5.07-21	4.22-21	3.60-21	3.10-21	2.74-21	2.20-21	1.63-21	6.66-22
22	7.43-21	5.83-21	4.70-21	3.89-21	3.28-21	2.82-21	2.17-21	1.53-21	5.96-22
24	9.63-21	7.09-21	5.46-21	4.32-21	3.50-21	2.91-21	2.10-21	1.39-21	5.36-22
26	1.41-20	6.44-21	4.97-21	3.95-21	3.20-21	2.66-21	1.93-21	1.28-21	5.01-22
27	2.31-20	9.62-21	6.99-21	5.23-21	4.03-21	3.19-21	2.12-21	1.28-21	4.78-22
28	2.76-20	7.79-21	5.71-21	4.32-21	3.36-21	2.69-21	1.82-21	1.13-21	4.44-22
29	2.58-20	8.18-21	5.90-21	4.38-21	3.36-21	2.66-21	1.76-21	1.06-21	4.29-22
30	8.58-21	3.62-21	2.89-21	2.39-21	2.00-21	1.72-21	1.33-21	9.43-22	4.13-22
35	1.42-21	1.31-21	1.15-21	1.03-21	9.42-22	8.80-22	7.70-22	6.37-22	3.17-22
40	7.26-22	7.20-22	6.59-22	6.10-22	5.75-22	5.49-22	5.08-22	4.52-22	2.48-22
50	3.56-22	3.65-22	3.43-22	3.27-22	3.15-22	3.07-22	2.97-22	2.77-22	1.69-22
60	2.35-22	2.46-22	2.30-22	2.19-22	2.10-22	2.04-22	1.94-22	1.79-22	1.19-22
80	1.07-22	1.12-22	1.05-22	1.00-22	9.59-23	9.32-23	9.00-23	8.41-23	5.76-23
100	5.63-23	5.87-23	5.47-23	5.18-23	4.96-23	4.81-23	4.56-23	4.19-23	2.83-23
150	1.18-23	1.22-23	1.11-23	1.03-23	9.68-24	9.14-24	8.26-24	6.96-24	4.21-24

Energy (eV)	Angle (degrees) 30	40	50	60	70	80	90	100
5	6.23-22	3.97-22	2.80-22	1.52-22	8.96-23	6.87-23	5.56-23	5.34-23
10	5.52-22	3.24-22	2.01-22	1.03-22	5.78-23	3.76-23	2.35-23	2.11-23
15	4.24-22	2.39-22	1.42-22	7.09-23	3.94-23	2.37-23	1.35-23	1.17-23
20	3.32-22	1.84-22	1.06-22	5.29-23	2.84-23	1.62-23	8.83-24	7.54-24
22	2.95-22	1.64-22	9.39-23	4.66-23	2.49-23	1.41-23	7.98-24	6.71-24
24	2.65-22	1.47-22	8.51-23	4.31-23	2.25-23	1.24-23	6.73-24	5.55-24
26	2.52-22	1.39-22	7.94-23	3.83-23	1.96-23	1.06-23	5.92-24	5.03-24
27	2.42-22	1.33-22	7.44-23	3.60-23	1.83-23	1.01-23	5.74-24	4.59-24
28	2.25-22	1.24-22	6.99-23	3.45-23	1.75-23	9.62-24	5.52-24	4.69-24
29	2.18-22	1.21-22	6.81-23	3.28-23	1.65-23	8.93-24	5.07-24	4.30-24
30	2.14-22	1.19-22	6.62-23	3.10-23	1.55-23	8.30-24	4.71-24	3.86-24
35	1.70-22	9.32-23	5.12-23	2.39-23	1.17-23	6.19-24	3.54-24	3.09-24
40	1.36-22	7.51-23	4.13-23	1.90-23	8.96-24	4.69-24	2.71-24	2.35-24
50	9.70-23	5.26-23	2.79-23	1.18-23	5.18-24	2.81-24	1.74-24	1.57-24
60	7.20-23	3.85-23	1.71-23	7.41-24	3.28-24	1.78-24	1.15-24	8.12-25
80	3.81-23	1.80-23	6.81-24	2.86-24	1.35-24	7.76-25	5.34-25	4.16-25
100	1.95-23	8.24-24	2.87-24	1.26-24	6.08-25	3.81-25	2.74-25	2.27-25
150	2.78-24	1.03-24	4.03-25	2.13-25	1.10-25	6.38-26	5.11-26	5.14-26

TABLE 7. DDCS for 50 keV H^+ on Argon ($m^2\ eV^{-1}\ sr^{-1}$)

Energy (eV)	Angle (degrees) 0	1	2	3	4	5	7	10	20
5	5.27-21	2.96-21	2.45-21	2.11-21	1.86-21	1.69-21	1.48-21	1.30-21	9.32-22
7	5.18-21	2.76-21	2.38-21	2.09-21	1.89-21	1.75-21	1.57-21	1.39-21	8.62-22
10	4.02-21	1.82-21	1.73-21	1.66-21	1.61-21	1.57-21	1.50-21	1.36-21	7.46-22
15	3.23-21	2.08-21	1.89-21	1.73-21	1.62-21	1.55-21	1.43-21	1.27-21	6.44-22
20	4.14-21	3.18-21	2.74-21	2.41-21	2.16-21	1.96-21	1.65-21	1.31-21	5.45-22
22	4.77-21	3.77-21	3.10-21	2.65-21	2.27-21	2.03-21	1.64-21	1.25-21	4.91-22
24	6.60-21	5.23-21	3.97-21	3.15-21	2.56-21	2.15-21	1.63-21	1.16-21	4.53-22
25	8.45-21	6.41-21	4.64-21	3.51-21	2.75-21	2.27-21	1.64-21	1.14-21	4.48-22
26	1.08-20	7.10-21	4.93-21	3.63-21	2.75-21	2.19-21	1.54-21	1.05-21	4.21-22
27	1.52-20	8.87-21	5.70-21	3.89-21	2.82-21	2.15-21	1.43-21	9.68-22	3.96-22
28	2.15-20	7.76-21	4.98-21	3.41-21	2.46-21	1.91-21	1.27-21	8.68-22	3.69-22
30	8.32-21	3.40-21	2.53-21	1.95-21	1.58-21	1.33-21	1.01-21	7.58-22	3.35-22
35	1.16-21	1.06-21	9.21-22	8.21-22	7.42-22	6.86-22	6.03-22	5.11-22	2.63-22
40	6.06-22	5.79-22	5.27-22	4.87-22	4.57-22	4.38-22	4.10-22	3.68-22	2.07-22
50	2.80-22	2.81-22	2.62-22	2.50-22	2.39-22	2.35-22	2.29-22	2.17-22	1.36-22
60	1.94-22	2.04-22	1.90-22	1.80-22	1.72-22	1.66-22	1.57-22	1.43-22	9.14-23
80	9.04-23	9.41-23	8.78-23	8.33-23	7.97-23	7.68-23	7.28-23	6.64-23	4.41-23
100	4.84-23	5.03-23	4.64-23	4.37-23	4.14-23	3.99-23	3.69-23	3.28-23	2.11-23
150	1.07-23	1.09-23	9.91-24	9.09-24	8.37-24	7.81-24	6.77-24	5.32-24	2.95-24

Energy (eV)	Angle (degrees) 30	40	50	60	70	80	90	100
5	6.16-22	4.02-22	2.73-22	1.66-22	1.08-22	8.05-23	5.96-23	5.60-23
7	5.12-22	3.18-22	2.09-22	1.27-22	8.02-23	5.72-23	4.11-23	3.69-23
10	4.25-22	2.56-22	1.66-22	9.85-23	6.06-23	4.13-23	2.78-23	2.41-23
15	3.30-22	1.85-22	1.15-22	6.80-23	4.21-23	2.80-23	1.92-23	1.62-23
20	2.62-22	1.43-22	8.53-23	4.78-23	2.79-23	1.80-23	1.20-23	1.03-23
22	2.35-22	1.30-22	7.92-23	4.48-23	2.57-23	1.63-23	1.07-23	9.14-24
24	2.16-22	1.21-22	7.16-23	4.03-23	2.29-23	1.44-23	9.42-24	8.13-24
25	2.11-22	1.17-22	6.91-23	3.81-23	2.13-23	1.34-23	8.95-24	7.52-24
26	2.04-22	1.12-22	6.56-23	3.58-23	1.99-23	1.26-23	8.50-24	7.11-24
27	1.92-22	1.07-22	6.39-23	3.52-23	1.95-23	1.18-23	7.90-24	6.63-24
28	1.84-22	1.02-22	6.02-23	3.24-23	1.79-23	1.10-23	7.61-24	6.44-24
30	1.67-22	9.40-23	5.60-23	3.03-23	1.63-23	1.01-23	6.76-24	5.84-24
35	1.39-22	7.88-23	4.61-23	2.39-23	1.26-23	7.59-24	5.16-24	4.46-24
40	1.13-22	6.40-23	3.70-23	1.89-23	9.83-24	5.89-24	4.14-24	3.67-24
50	7.78-23	4.40-23	2.48-23	1.19-23	5.95-24	3.62-24	2.55-24	2.36-24
60	5.50-23	3.03-23	1.51-23	7.06-24	3.56-24	2.33-24	1.65-24	1.35-24
80	2.71-23	1.45-23	5.70-24	2.60-24	1.43-24	9.76-25	7.04-25	6.01-25
100	1.30-23	6.40-24	2.27-24	1.08-24	6.01-25	4.00-25	3.03-25	2.75-25
150	1.79-24	7.56-25	2.97-25	1.93-25	1.14-25	6.40-26	5.93-26	6.39-26