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Differential cross sections for elastic scattering of electrons from argon, neon, nitrogen and carbon monoxide†

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Abstract. Absolute differential elastic cross sections were measured for electrons scattered between 2° and 150° by static gas targets of argon, neon, nitrogen and carbon monoxide. The energy ranges were 20–800 eV for argon and nitrogen, 50–800 eV for neon and 200–800 eV for carbon monoxide. Within the combined uncertainties, the present data on argon and neon agree with the measurements of Jansen *et al*, Gupta and Rees, and Bromberg except for neon at 100 eV where our data is lower at small angles. Optical-model calculations by Byron and Joachain represent the small-angle scattering well at all energies but the large-angle scattering only at the higher energies. The present nitrogen cross sections agree with those of Bromberg and Jansen *et al* at the higher energies and with Srivastava *et al* at the lower energies. Within our relative uncertainty of 5% the isoelectronic nitrogen and carbon monoxide cross sections were equal at all angles for 500 and 800 eV. At 200 eV the nitrogen cross sections were generally 5–20% larger at angles up to 120°.

1. Introduction

In recent years there has been a renewed interest in the measurement of cross sections for elastic scattering of electrons from gases. This is due in part to the availability of new theoretical calculations of differential cross sections which allow a fairly detailed comparison of theory and experiment. While much of the theoretical work is for atomic hydrogen or helium, a few calculations are available for other monatomic gases. For argon and neon optical-model calculations have been made by Furness and McCarthy (1973), by Byron and Joachain (1975), and by Lewis *et al* (1974a, b) and relativistic calculations were reported by Fink and Yates (1970) and by Walker (1971). Unfortunately, no recent calculations are available for the diatomic gases measured in this paper.

The experimental work can be categorized into two groups. The first are absolute measurements in which the cross sections are calculated directly from measured quantities and thus are independent of the results of any other experiment or theoretical calculation. The second are relative cross sections which may be made absolute by comparison at one or more points with a previous measurement or calculation. Very

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few of the first type of measurement have been reported and these have been over a restricted angular or energy range. In fact, few relative measurements have been made at angles of less than 10°. Bromberg (1969, 1970, 1974) has made absolute measurements above 200 eV in several gases including the four which are the subject of this paper. His angular range was 3°–25° with some measurements to 110°. Kurepa *et al* (1971, 1973) have made measurements in argon and neon over a wide angular range (10°–150°) but only from 100 to 200 eV. Jansen *et al* (1976) have recently presented absolute cross sections for helium, neon, argon and nitrogen from 100 to 3000 eV over the angular range 5°–55°. In our earlier paper (DuBois and Rudd 1975a, to be referred to as I) we presented absolute values of argon cross sections from 12°–153° and from 20–800 eV. The large number of normalized or relative measurements have been reviewed by others (e.g. Jansen *et al* 1976, Williams and Crowe 1975) and will not be listed here.

In the present paper we have extended the angular range of our earlier paper down to 2° and have corrected an error in the absorption correction made on that data. In addition we present absolute cross sections for neon, nitrogen and carbon monoxide for the angular range of 2° or 3° to 150°. The energy range was 20–800 eV for argon and nitrogen, 50–800 eV for neon and 200–800 eV for carbon monoxide.

2. Experimental techniques and errors

The experimental apparatus is the same as that described earlier in I. An electron gun produces a beam with an angular divergence of 2° or less in a static target gas at a pressure of about 1 mTorr. A parallel-plate electrostatic analyser with an energy resolution of 0·35% selects electrons within an angular spread of ±0·24°. A channeltron detects individual electrons which are counted on a multiscaler. Magnetic shielding is used to reduce the field to below 5 mG.

Data acquisition for angles greater than 10° is as described in I; however for measurements at smaller angles it was not possible to collect the primary beam in a Faraday cup. The cup was swung out of the beam and elastic spectra were recorded by sweeping the analyser potential across the elastic peak at a constant time rate R. Measurement of the primary beam current I_{F1} in the cup before and after recording the spectra provided an indication that it stayed constant within 1% during the measurement. In calculating the cross sections, the integrated beam charge Q was replaced by I_{F1}/R. By this method measurements were taken up to 10° on either side of the beam direction with the angle reproducible to within ±0·05°. The zero angle was chosen to provide scattering symmetry but this agreed with the zero angle obtained by directing the primary beam into the analyser.

Since the primary beam was not collected during the small-angle measurements it struck the walls of the chamber. However, this was not believed to contribute significantly to the measured elastic spectrum. The closest surface struck by the beam was several centimetres from the entrance slit and in a completely different direction from that viewed by the analyser. Since the analyser acceptance angle is small (0·5° × 1·75°) and the gas pressure is low (typically 1 mTorr) the probability of multiple scattering is small. Another indication that scattering from solid surfaces was small was provided by the measured background which was less than 2% of the foreground even at the smallest angles measured.

Beam currents used in the small-angle measurements had to be reduced by several orders of magnitude from those used at larger angles to prevent the count rates from being too high. Because of this, it was decided to normalize the small-angle measurements to those taken at larger angles where the primary beam could be collected by the Faraday cup. Relative errors for several overlapping points for this normalization process were well within the relative uncertainty of 5%.

The analyser angular resolution was $\pm 0{\cdot}24°$ but a somewhat larger uncertainty in the scattering angle arose because of the angular spread of the beam. The beam

Table 1. Absolute differential cross sections for electrons elastically scattered from argon as a function of scattering angle and energy, in units of a_0^2 sr^{-1}. Numbers in parentheses are powers of ten that multiply the cross sections. Values at 5° and 15° obtained by interpolation. Errors in absolute cross sections are given for each energy.

θ (deg) \ E (eV)	20	50	100	200	500	800
2				6·50 (1)	5·98 (1)	4·77 (1)
3			6·01 (1)	5·72 (1)	5·01 (1)	4·00 (1)
4			5·32 (1)	5·01 (1)	4·14 (1)	3·42 (1)
5		4·53 (1)	4·71 (1)	4·40 (1)	3·55 (1)	2·90 (1)
6		4·16 (1)	4·40 (1)	3·84 (1)	3·10 (1)	2·51 (1)
8		3·53 (1)	3·59 (1)	2·86 (1)	2·28 (1)	1·76 (1)
10		3·01 (1)	2·78 (1)	2·09 (1)	1·64 (1)	1·29 (1)
12	3·85 (1)	2·55 (1)	2·14 (1)	1·56 (1)	1·11 (1)	7·55
14	3·72 (1)	2·24 (1)	1·69 (1)	1·15 (1)	7·63	5·25
15		2·04 (1)	1·50 (1)	1·01 (1)	6·50	4·39
20	3·32 (1)	1·43 (1)	8·73	4·94	2·83	1·82
25	2·83 (1)	9·84	4·89	2·58	1·45	9·06 (−1)
30	2·34 (1)	6·91	2·72	1·32	9·05 (−1)	5·77 (−1)
35	1·87 (1)	4·78	1·50	7·89 (−1)	6·42 (−1)	3·87 (−1)
40	1·43 (1)	3·05	8·57 (−1)	5·55 (−1)	4·40 (−1)	2·67 (−1)
45	1·02 (1)	1·87	4·90 (−1)	4·39 (−1)	3·21 (−1)	1·90 (−1)
50	6·62	1·04	2·98 (−1)	3·76 (−1)	2·44 (−1)	1·38 (−1)
55	4·18	4·84 (−1)	2·10 (−1)	3·36 (−1)	1·88 (−1)	1·06 (−1)
60	2·27	1·43 (−1)	1·91 (−1)	3·10 (−1)	1·44 (−1)	8·20 (−2)
65	1·06	3·21 (−2)	2·24 (−1)	2·84 (−1)	1·18 (−1)	6·66 (−2)
70	5·77 (−1)	9·49 (−2)	2·81 (−1)	2·64 (−1)	9·58 (−2)	5·69 (−2)
75	4·83 (−1)	2·68 (−1)	3·51 (−1)	2·39 (−1)	7·91 (−2)	4·94 (−2)
80	7·01 (−1)	5·25 (−1)	3·76 (−1)	2·02 (−1)	6·92 (−2)	4·45 (−2)
85	1·06	7·93 (−1)	4·62 (−1)	1·68 (−1)	6·19 (−2)	4·16 (−2)
90	1·53	1·03	4·81 (−1)	1·28 (−1)	5·67 (−2)	3·90 (−2)
95	1·82	1·17	4·49 (−1)	9·51 (−2)	5·32 (−2)	3·79 (−2)
100	2·04	1·25	3·98 (−1)	6·33 (−2)	5·22 (−2)	3·73 (−2)
105	2·05	1·22	3·13 (−1)	3·91 (−2)	5·52 (−2)	3·74 (−2)
110	1·88	1·08	2·12 (−1)	2·95 (−2)	5·94 (−2)	3·83 (−2)
115	1·61	8·66 (−1)	1·16 (−1)	3·71 (−2)	6·49 (−2)	3·91 (−2)
120	1·40	6·49 (−1)	4·63 (−2)	6·64 (−2)	7·39 (−2)	3·96 (−2)
125	1·22	4·21 (−1)	3·13 (−2)	1·19 (−1)	8·16 (−2)	4·10 (−2)
130	1·23	2·38 (−1)	8·26 (−2)	1·97 (−1)	9·33 (−2)	4·38 (−2)
135	1·46	1·29 (−1)	2·16 (−1)	2·86 (−1)	1·05 (−1)	4·51 (−2)
140	1·95	1·05 (−1)	4·37 (−1)	4·04 (−1)	1·17 (−1)	4·68 (−2)
145	2·62	1·88 (−1)	7·47 (−1)	5·42 (−1)	1·27 (−1)	4·95 (−2)
150	3·60	3·56 (−1)	1·08	6·49 (−1)	1·41 (−1)	5·16 (−2)
Absolute error (%)	(32)	(19)	(12)	(12)	(12)	(12)

profile was found to depend on beam energy. By direct measurement the FWHM had a value 0·7° at 800 eV, 0·8° at 400 eV, 2·3° at 100 eV and 1·5° at 50 eV. Using the relation derived by Silverstein (1959) it appears that the error made by using a simple $1/\sin\theta$ correction to the geometrical constant is less than 1% even in the worst case. Likewise the variation of the cross section with angle introduces an error calculated to be less than 1%.

For nitrogen and carbon monoxide the elastic peak presumably includes excitation to rotational and vibrational states since the energy resolution of the analyser is not great enough to resolve these.

3. Results

Absolute values of the elastic cross sections are tabulated in tables 1–4 for the four target gases used. The argon data extend and supersede those published previously in I and by DuBois and Rudd (1975b) in which an error was discovered in the

Table 2. Absolute differential cross sections for electrons elastically scattered from neon as a function of scattering angle and energy, in units of a_0^2 sr^{-1}. Numbers in parentheses are powers of ten that multiply the cross sections. Errors in absolute cross sections are given for each energy.

θ (deg) \ E (eV)	50	100	200	500	800
3			11·1	10·2	7·55
4			10·4	9·06	6·72
5		7·62	9·66	7·99	
6		7·16	9·02	7·08	5·34
8		6·34	7·84	5·54	4·24
10	4·33	5·52	6·30	4·24	3·40
12	3·89	5·04	5·46	3·50	2·65
15	3·38	4·32	4·40	2·58	
20	2·75	3·25	3·06	1·54	1·00
25	2·32	2·33	2·04	9·11 (−1)	5·47 (−1)
30	1·96	1·71	1·34	5·68 (−1)	3·32 (−1)
35			8·93 (−1)		2·17 (−1)
40	1·37	9·34 (−1)	6·19 (−1)	2·68 (−1)	1·53 (−1)
50	1·05	5·28 (−1)	3·01 (−1)	1·47 (−1)	8·47 (−2)
60	8·12 (−1)	3·18 (−1)	1·77 (−1)	9·67 (−2)	5·46 (−2)
70	6·04 (−1)	1·92 (−1)	1·14 (−1)	7·15 (−2)	3·75 (−2)
80	3·84 (−1)	1·04 (−1)	8·92 (−2)	5·56 (−2)	2·82 (−2)
90	2·11 (−1)	5·08 (−2)	8·20 (−2)	4·79 (−2)	2·26 (−2)
95	1·21 (−1)	4·32 (−2)			
100	4·04 (−2)	4·99 (−2)	8·75 (−2)	4·24 (−2)	1·89 (−2)
105	3·59 (−2)				
110	6·51 (−2)	1·14 (−1)	1·09 (−1)	3·96 (−2)	1·64 (−2)
120	2·60 (−1)	2·53 (−1)	1·39 (−1)	3·88 (−2)	1·46 (−2)
130	6·57 (−1)	4·73 (−1)	1·81 (−1)	3·76 (−2)	1·35 (−2)
140	1·17	7·33 (−1)	2·24 (−1)	3·76 (−2)	1·32 (−2)
150	1·74	1·03	2·62 (−1)	3·81 (−2)	1·29 (−2)
Absolute error (%)	(19)	(12)	(12)	(12)	(12)

Table 3. Absolute differential cross sections for electrons elastically scattered from nitrogen as a function of scattering angle and energy, in units of a_0^2 sr^{-1}. Numbers in parentheses are powers of ten that multiply the cross sections. Errors in absolute cross sections are given for each energy.

θ (deg) \ E (eV)	20	50	100	200	400	500	800
2					6·60 (01)	5·79 (01)	4·15 (01)
3				7·28 (01)	5·87 (01)	5·03 (01)	3·82 (01)
4			6·12 (01)	6·29 (01)	5·15 (01)	4·26 (01)	3·28 (01)
5		5·14 (01)	5·62 (01)	5·51 (01)	4·37 (01)	3·56 (01)	2·76 (01)
6		4·69 (01)	5·11 (01)	4·78 (01)	3·73 (01)	2·96 (01)	2·17 (01)
8		3·88 (01)	4·18 (01)	3·65 (01)	2·60 (01)	2·05 (01)	1·32 (01)
10		3·32 (01)	3·21 (01)	2·65 (01)	1·66 (01)	1·33 (01)	7·75
12	1·61 (01)	2·70 (01)	2·52 (01)	1·92 (01)	1·14 (01)	8·88	4·92
14	1·38 (01)	2·34 (01)	1·99 (01)	1·41 (01)	7·68	5·78	3·09
15		2·14 (01)	1·72 (01)	1·23 (01)	6·39	4·75	2·62
16	1·33 (01)	1·99 (01)	1·53 (01)	1·06 (01)	5·22	3·94	2·26
20	1·06 (01)	1·40 (01)	9·49	5·82	2·73	2·16	1·51
25	8·38	8·93	5·27	2·72	1·63	1·39	9·93 (−01)
30	6·91	5·68	2·80	1·52	1·13	9·93 (−01)	5·70 (−01)
40	4·35	2·47	1·09	7·74 (−01)	6·14 (−01)	4·59 (−01)	1·97 (−01)
50	2·78	1·14	5·97 (−01)	5·24 (−01)	2·91 (−01)	2·05 (−01)	1·19 (−01)
60	1·73	6·32 (−01)	3·90 (−01)	3·73 (−01)	1·80 (−01)	1·43 (−01)	6·35 (−02)
70	1·18	4·07 (−01)	2·86 (−01)	2·62 (−01)	1·41 (−01)	1·02 (−01)	4·23 (−02)
80	7·78 (−01)	2·89 (−01)	2·66 (−01)	1·92 (−01)	1·06 (−01)	6·74 (−02)	3·13 (−02)
85	6·93 (−01)	2·50 (−01)					
90	6·86 (−01)	2·36 (−01)	2·75 (−01)	1·71 (−01)	7·80 (−02)	5·26 (−02)	2·20 (−02)
95	7·90 (−01)	2·44 (−01)					
100	9·81 (−01)	2·84 (−01)	2·86 (−01)	1·98 (−01)	6·41 (−02)	4·62 (−02)	1·78 (−02)
110	1·42	4·63 (−01)	3·15 (−01)	1·85 (−01)	5·95 (−02)	4·12 (−02)	1·51 (−02)
120	1·86	7·48 (−01)	3·71 (−01)	1·90 (−01)	5·70 (−02)	3·36 (−02)	1·25 (−02)
130	2·24	1·12	4·69 (−01)	1·88 (−01)	5·27 (−02)	3·05 (−02)	1·10 (−02)
140	2·59	1·50	5·64 (−01)	1·87 (−01)	4·91 (−02)	2·90 (−02)	9·96 (−03)
150	2·81	1·90	6·84 (−01)	1·87 (−01)	4·71 (−02)	2·92 (−02)	9·65 (−03)
Absolute error (%)	(32)	(19)	(12)	(12)	(12)	(12)	(12)

calculation of the correction due to absorption effects. This error, which affected only the absolute values and not the angular distributions, ranged from 0% at 500 and 800 eV to 14% at 20 eV.

Figure 1 shows a graph of the differential cross section for nitrogen as a function of momentum transfer. These results are typical of those for all the gases measured. As previously discussed by Bromberg (1970) and by Jansen *et al* (1976) in the limit of zero momentum transfer the curves tend to merge. They relate the exponential dependence of the cross sections plotted against momentum transfer to the dipole polarizability of the gases. As can be seen for N_2, the 400 and 500 eV curves do tend to merge. However the 800 eV curve definitely deviates from an exponential dependence for angles between 2° and 5°. In addition, for energies smaller than 100 eV, the curves no longer extrapolate to a common point for zero momentum transfer.

Bromberg (1970) found that the isoelectronic molecules CO and N_2 have nearly the same elastic cross sections at 300–500 eV. Our present data confirm this result at 500 and 800 eV but at 200 eV some differences outside the 5% uncertainty in

Table 4. Absolute differential cross sections for electrons elastically scattered from carbon monoxide as a function of scattering angle and energy, in units of a_0^2 sr^{-1}. Numbers in parentheses are powers of ten that multiply the cross sections. Errors in absolute cross sections are given for each energy.

θ (deg) \ E (eV)	200	500	800
3	7·17 (1)	5·43 (1)	
4	5·72 (1)	4·57 (1)	3·40 (1)
5	5·05 (1)	3·68 (1)	2·61 (1)
6	4·35 (1)	3·05 (1)	2·13 (1)
8	3·24 (1)	2·02 (1)	1·33 (1)
10	2·38 (1)	1·36 (1)	7·41
12	1·75 (1)	8·91	4·53
15	1·09 (1)	4·78	2·52
20	4·87	2·18	1·49
25	2·34	1·39	9·44 (−1)
30	1·33	9·73 (−1)	5·30 (−1)
35	9·05 (−1)	6·58 (−1)	2·94 (−1)
40	7·18 (−1)	4·19 (−1)	1·96 (−1)
45	5·73 (−1)	2·75 (−1)	
50	4·76 (−1)	1·96 (−1)	1·19 (−1)
60	3·24 (−1)	1·39 (−1)	6·49 (−2)
70	2·22 (−1)	9·75 (−2)	4·48 (−2)
80	1·70 (−1)	6·77 (−2)	3·21 (−2)
90	1·61 (−1)	5·45 (−2)	2·27 (−2)
100	1·65 (−1)	4·68 (−2)	1·92 (−2)
110	1·75 (−1)	3·99 (−2)	1·59 (−2)
120	1·84 (−1)	3·44 (−2)	1·40 (−2)
130	1·86 (−1)	3·19 (−2)	1·23 (−2)
140	1·91 (−1)	3·00 (−2)	1·12 (−2)
150	2·01 (−1)	2·99 (−2)	1·09 (−2)
Absolute error (%)	(12)	(12)	(12)

the ratio of the two cross sections are noted. Up to 120° the N_2 cross sections are larger by 5–20% and a single preliminary run at 100 eV seems to indicate an even larger difference at lower energies. Differences in the dipole fields of the two molecules evidently have a greater effect on low energy electrons.

Tables 5–7 compare the present cross sections with previous experimental and theoretical values. For argon, such a comparison was previously made in I so only comparisons for small angles are shown. Within combined error bars, the present data agree with the experimental work of Bromberg and of Jansen *et al.* The theoretical calculations of Byron and Joachain and Joachain *et al* provide the best agreement with the present data both in magnitude and shape. This agreement is excellent at all angles for 500 and 800 eV in both argon and neon but at the lower energies their calculated values fall off more rapidly above 30°. The relativistic calculations by Fink and Yates increase much too slowly for small angles. Both calculations were discussed further in I.

For neon, agreement between the present and previous experiments is found for the higher energies but not for the lower energies. The present data increase more slowly for small angles at 100 eV than do the other experiments. In addition, there

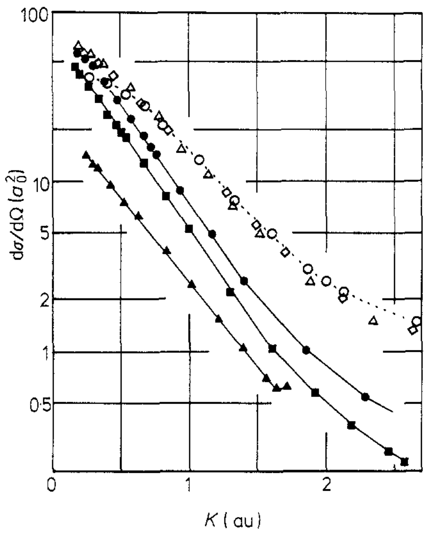

Figure 1. Differential elastic cross section plotted against momentum transfer for N_2. ▲ 20 eV, ■ 50 eV, ● 100 eV, △ 400 eV, ◇ 500 eV, ○ 800 eV. Relative errors for given energy are smaller than symbols used for plotting.

is general disagreement for the large-angle data. Also the data of Williams and Crowe (1975) indicate much lower minima at 50 and 100 eV than we measured. The discrepancy between the depth of these wide minima cannot be explained by differences in angular resolution in the two experiments since these were comparable.

Table 7 makes similar comparisons with previous absolute measurements for N_2. Agreement is found for all cases both in magnitude and shape. The relative measurements of Shyn *et al* (1972) are not included but tend to increase more rapidly for small angles than do the present measurements. This is also true for the relative data of Kambara and Kuchitsu (1972) though to a lesser extent. The relative data of Finn and Doering (1975) agree with the present data at 20 eV but increase more slowly for small angles at 50 and 100 eV.

Total elastic cross sections were obtained for Ar, Ne and N_2 by extrapolating $\sigma(\theta)$ to 180° and integrating $\sigma(\theta)\sin\theta$ against θ. The results are listed in table 8 with the estimated percentage of the total elastic cross section for angles greater than 150°. Also listed are other values for total elastic cross sections. In all cases, the present values agree within combined error bars with previous work.

4. Conclusions

The present elastic cross sections supplement previous experiments for Ar, Ne and N_2. Agreement with the small-angle measurements of Bromberg and of Jansen *et al* is excellent for Ar and N_2 and also for Ne at higher energies. For lower energies in Ne the present data is in disagreement with previously measured cross sections, increasing more slowly for small angles and falling between the measurements of Gupta and Rees (1975) and those of Williams and Crowe for large angles. In addition, the present data indicate considerably shallower minima in Ne than those measured by Williams and Crowe.

Table 5. Ratio of previous absolute measurements and theoretical calculations to the present data for argon. Experimental: DR, present data; J, Jansen *et al* (1976); B, Bromberg (1974); Theoretical: FY, Fink and Yates (1970); FM, Furness and McCarthy (1973); BJ, Byron and Joachain (1975). Combined absolute errors listed in parentheses where applicable.

	50 eV		100 eV				200 eV					500 eV				800 eV	
θ (deg)	FY/DR	FM/DR	J/DR	BJ/DR	FY/DR	FM/DR	J/DR	B/DR	BJ/DR	FY/DR	FM/DR	J/DR	B/DR	BJ/DR	FY/DR	BJ/DR	FY/DR
2										0·10					0·15		
3								0·94	1·06				0·91	0·97			
4					0·09					0·12					0·19		0·26
5		0·81	1·01	1·27		1·03	0·97	0·94	1·06		1·04	0·92	0·95	1·00			
6	0·14				0·11					0·15					0·23		0·28
8	0·17				0·13			0·94	1·07	0·18			0·93	0·97	0·25		0·30
10	0·19	0·99	1·03	1·25	0·15	1·22	1·01	0·99	1·10	0·22	1·27	0·93	0·93	0·96	0·27		0·32
12	0·21			1·27	0·18				1·09	0·25				0·99	0·30	1·11	0·35
14	0·23			1·25	0·21			1·02	1·09	0·29			0·99	0·99	0·32	1·04	0·34
15		1·10	1·08	1·24		1·35	1·06		1·06		1·26	1·01		0·96			
20	0·29	1·11	1·05	1·08	0·29	1·26	1·08	1·03	0·95	0·35	1·08	1·04	0·99	0·90	0·33	0·97	0·34
25		1·11	1·04	0·95		1·10	1·05		0·77		0·81	1·02	0·98	0·86			
30	0·36	1·04	1·06	0·82	0·38	0·93	1·11		0·70	0·39	0·73	0·97		0·84	0·31	0·96	0·34
Combined errors			(0·18)				(0·18)	(0·15)				(0·18)	(0·15)				

Table 6. Ratio of previous absolute measurements and theoretical calculations to the present data for neon. Experimental: DR, present data; J, Jansen *et al* (1976); B, Bromberg (1974); GR, Gupta and Rees (1975); WC, Williams and Crowe (1975). Theoretical: FY, Fink and Yates (1970); BJ, Byron and Joachain (1975). Combined absolute error listed in parentheses.

	50 eV	100 eV					200 eV						500 eV					800 eV
θ (deg)	WC/DR	WC/DR	GR/DR	J/DR	BJ/DR	FY/DR	WC/DR	GR/DR	J/DR	B/DR	BJ/DR	FY/DR	GR/DR	J/DR	B/DR	BJ/DR	FY/DR	FY/DR
3										1·03					0·97			
4												0·10					0·16	0·24
5				1·36	1·88				0·98	1·02	1·16		0·99	0·94	1·00	0·99		
6						0·12						0·11					0·19	0·27
8						0·13				0·97		0·12			1·04		0·22	0·29
10			1·48	1·40	1·83	0·14		1·00	0·98	1·02	1·12	0·15	1·10	1·09	1·11	1·10	0·22	0·31
12						0·15						0·16					0·26	0·32
15			1·41	1·32	1·57		0·98	0·94	0·94		0·99		1·04	1·05		1·04		
20		1·45	1·38	1·28	1·35	0·19	0·94	0·82	0·90	0·88	0·87	0·19	0·99	1·04	1·00	0·99	0·30	0·35
25	0·97	1·44	1·30	1·27	1·18		0·94	0·89	0·89	0·87	0·80	0·29	0·95	1·05	0·99	0·95		
30	1·09	1·46	1·27	1·23	1·00	0·26	0·94	0·89	0·90		0·74	0·24	0·90	1·03		0·90	0·31	0·36
40	1·25	1·29	1·31	1·18	0·67	0·31	0·94	0·85	0·86		0·62	0·26	0·82	0·92		0·82	0·29	0·34
50	1·28	1·27	1·29	1·20	0·45	0·34	0·99	0·95	0·91		0·59	0·28	0·85	0·95		0·85	0·30	0·34
60	1·31	1·28	1·22		0·39	0·33	1·00	0·92			0·59	0·22	0·87			0·87	0·30	0·34
70	1·29	1·23	1·16		0·48	0·28	1·03	0·94			0·66	0·27	0·88			0·88	0·31	0·35
80	1·09	1·14	1·17		0·69	0·18	1·09	0·87			0·69	0·27	0·89			0·89	0·33	0·35
90	0·74	0·95	1·14		0·92	0·08	1·24	1·01			0·69	0·28	0·87			0·87	0·33	0·34
100	0·72	0·76	1·30		0·50	0·18	1·29	1·05			0·68	0·32	0·88			0·88	0·34	0·34
110	0·33	0·90	0·85		0·20	0·30	1·27	0·98			0·66	0·34	0·89			0·89	0·33	0·33
120	0·88	1·10	0·67		0·23	0·31	1·26	0·93			0·67	0·35	0·88			0·88	0·32	0·33
130	0·97	0·96	0·61		0·28	0·29	1·30	0·84			0·67	0·39	0·90			0·90	0·32	0·32
140	1·01	0·99	0·63		0·33	0·27	1·23	0·82			0·69	0·35	0·92			0·92	0·31	0·30
150	1·08	0·96	0·67		0·36	0·25	1·21	0·85			0·71	0·35	0·91			0·91	0·31	0·29
Combined errors	(0·29)	(0·22)	(0·22)	(0·18)			(0·22)	(0·22)	(0·18)	(0·15)			(0·22)	(0·18)	(0·15)			

Table 7. Ratio of previous absolute measurements to the present data for N_2. DR, present data; J, Jansen *et al* (1976); B, Bromberg (1970); S, Srivastava *et al* (1975). Combined absolute errors listed in parentheses.

	20 eV	50 eV	100 eV	200 eV	400 eV		500 eV	
θ (deg)	S/DR	S/DR	J/DR	J/DR	J/DR	B/DR	J/DR	B/DR
2						1·15		1·20
3						1·05		1·15
4						1·00		1·15
5			1·09	0·99	0·98	1·00	1·11	1·15
6						0·98		1·16
8						1·00		1·14
10			1·11	1·02	1·09	1·07	1·17	1·17
12						1·07		1·14
14						1·06		1·13
15			1·18	1·03	1·06		1·14	
16						1·05		1·10
20	1·09	0·86	1·15	0·99	1·08	1·00	1·12	1·03
25			1·09	1·04	0·99	0·93		1·02
30	1·14	1·01	1·11	1·03	0·96	0·94	1·03	1·02
40	1·13	1·04	1·08	1·01	1·01	0·94	1·08	0·98
50	1·14	1·13	1·07	0·98	1·02	0·98	1·02	1·03
60	1·18	1·19				0·94		1·02
70	1·06	1·14				0·96		1·02
80	1·10	1·24				0·97		1·02
90	1·04	1·06				0·97		1·01
100	1·13	1·13				0·93		1·02
110						0·92		0·92
Combined errors	(0·47)	(0·34)	(0·18)	(0·18)	(0·18)	(0·15)	(0·18)	(0·15)

Table 8. Total elastic cross sections in units of a_0^2. Numbers in parentheses are estimated percentage of cross section occurring at angles larger than 150°. DR, present data with estimated error; J, Jansen *et al* (1976); B, Bromberg (1970); GR, Gupta and Rees (1975); S, Srivastava *et al* (1975); FD, Finn and Doering (1975).

	E(eV)	20	50	100	200	400	500	800
Argon	Area > 150° (%)	(5)	(1·4)	(1·9)	(0·7)	—	(0·13)	(0·06)
	DR	68·4	25·6	17·1	10·9	—	7·23	4·83
	J	—	—	13·6	10·8	—	7·12	—
Neon	Area > 150° (%)	—	(17)	(15)	(5)	—	(1·2)	(0·6)
	DR	—	11·0	7·90	5·40	—	2·82	1·74
	GR	—	—	8·55	4·92	—	2·55	—
	J	—	—	8·52	4·99	—	2·75	—
Nitrogen	Area > 150° (%)	(2·4)	(1·7)	(0·7)	(0·2)	0	0	0
	DR	32·6	25·8	17·7	12·6	7·54	5·88	3·8
	S	39·0	28·7	—	—	—	—	—
	J	—	—	18·5	13·2	8·37	7·15	—
	B	—	—	—	—	—	6·79	—
	FD	40·0	20·4	13·6	—	—	—	—
	DR error (%)	32	19	12	12	12	12	12

For all the gases studied, the differential cross sections plotted against momentum transfer tend to merge for small momentum transfers and higher energies. For 800 eV and angles less than 5° the cross sections depart from the exponential dependence demonstrated for other energies when plotted against momentum transfer.

A comparison of N_2 and CO cross sections indicates that there are only minor differences in the cross sections at higher energies but at 200 eV the N_2 cross sections tend to be 10–15% higher than those of CO.

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