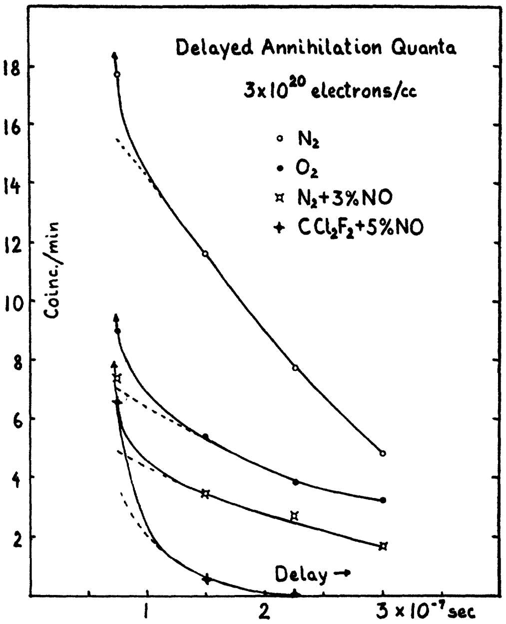

FIG. 1. Decay curves of positrons in several gases. The dotted lines are corrected for time resolution of the instrument.

three-quantum annihilation of triplet positronium in nitrogen. Figure 2 shows pulse height spectra obtained in a NaI scintillation spectrometer deliberately adjusted for low resolution to gain stability. It is seen that the photoelectron peak of the 510-kev radiation is markedly lower in pure N_2 while there is an increase of the number of lower energy electrons, compared with the spectrum from N_2+NO in which we expect almost pure two-quantum annihilation. The large number of small pulses present in both curves is due to scattered radiation from the walls of the gas vessel. The annihilation spectrum in pure O_2 resembles that in N_2+NO.

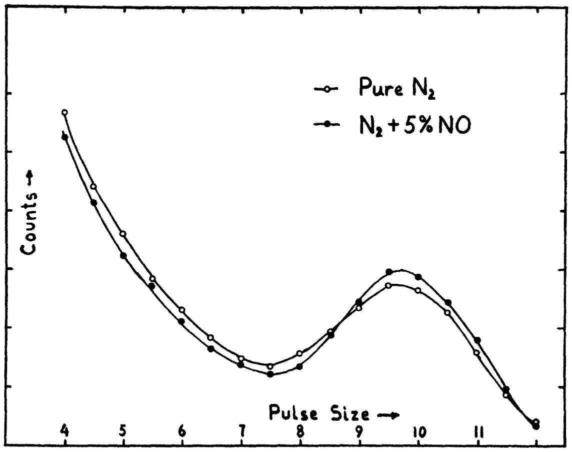

FIG. 2. Part of the scintillation spectrum of two-quantum (solid circles) and two-quantum plus three-quantum (open circles) annihilation. The uncertainty of individual points is indicated by the size of the circles.

The slight shift of the photoelectron peak to lower energies in N_2 is due to the large number of quanta just below 510 kev from the three-quantum process[3] falling within the experimental width of the two-quantum line. A similar phenomenon may explain the low value of the annihilation energy obtained by DuMond.[5]

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Infrared Absorption and Intrinsic Semiconductivity of Condensed Aromatic Systems

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IN order to explain the temperature dependence of the resistivity of polycrystalline graphite and carbons, it seems necessary to assume the existence of an energy gap between the filled and upper bands.[1] The familiar progressive change in color of condensed aromatic compounds with the size of the molecule is believed to be a manifestation of the change in this energy gap, which, as it decreases to zero, leads to the semimetallic properties of graphite.

The presence of aromatic rings in pyrolyzed cellulose products is known.[2] The writer has studied the infrared absorption of Cellophane char films ($\sim20\mu$ thick). The transmission curves for several films are presented in Fig. 1, and their charring temperatures are given in Table I.

The curves reveal two main features. One is a band of complete absorption extending through the visible region and terminating in the infrared. The limit of this band is seen to move progressively toward longer wavelengths as the treatment temperature increases. The other feature is the presence of characteristic bands corresponding to different types of bonds present in the char. As will be shown, the shifting band is of an electronic origin and corresponds, probably, to motion of electrons in the aromatic lattice. Midpoints of the transparency expressed in electron volts

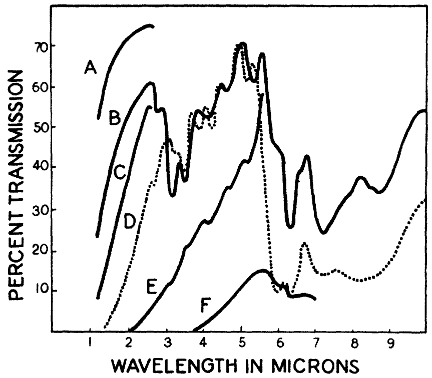

FIG. 1. Infrared transmission curves for Cellophane char films.

TABLE I. Transparency and resistance data.

Sample	Treatment temp. °C	Midpoint of transparency in ev	ΔE in ev from R *vs* T
A	300	1.2	...
B	350	0.87	...
C	425	0.71	0.8
D	500	0.50	0.62
E	540	$\gtrsim$0.33	0.41
F	630	$\lesssim$0.28	0.22
G	700	$\sim$0.2	0.09
H	800	...	0.03

are given in Table I. For the 540° and 630°C films, the uncertainty is caused by the strong bond absorptions. The films treated to 700°C and higher are almost completely opaque. However, the band edges are detectable at large slit widths, and the approximate position for the film charred at 700°C is given in Table I.

The resistances of several films were measured over the range 20° to 120°C and were found to be very strongly temperature dependent. This dependence was approximated by the relationship for intrinsic semiconductors, $R \sim \exp\Delta E/2kT$; and values of ΔE thus obtained are presented in Table I.

The rough agreement evident between the energy values given in columns 3 and 4 of Table I up to 630°C shows that the advancing absorption band corresponds to an electronic excitation. Furthermore, it demonstrates that the size of the energy gap decreases as the condensing process progresses. At higher charring temperatures, the agreement is gradually destroyed by the presence of an increasing number of excess electrons in the upper band (peripheral valence electrons becoming mobile after removal of the attached hydrogen atoms[1]). The slopes of the resistance *versus* temperature curves are decreased by the presence of such electrons; hence, the ΔE's evaluated from the formula become smaller than the real values in column 3. In samples treated to higher temperatures i.e., $\gtrsim 630$°C, these excess electrons probably cause the large over-all absorption in the infrared. The general trend of the variation of size of the gap seems consistent with the value 0.1 ev predicted for calcined cokes.[1]

The variable cut-off feature of these films suggests their use as infrared filters. Further studies of their properties are in progress.

The author is indebted to Professor S. Mrozowski for suggesting this problem and for continued advice and encouragement, and to Mr. G. W. LeSuer and other members of the laboratory for their valuable assistance.

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Beta-Spectrum of Cl^{36}

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In 1949 we reported[1] our work on the beta-ray spectrum of Cl^{36} and showed the pronounced curvature of its Kurie plot toward the energy axis down to the very low energy region. This was the first shape of this kind ever observed among the forbidden spectra.

Because of the unfavorable source thickness used (0.3 mg/cm² to 1 mg/cm²), the energy region of the spectrum below 180 kev was not extensively investigated, as its true shape is probably somewhat distorted. Nevertheless, we found a good fit from 200 kev to the upper energy limit 713 kev between the observed spectrum and the so-called D_2 correction factor (using Marshak's notation),[2] which is the unique forbidden correction factor for a transition where the spin change is ±3. Meanwhile, Townes[3] determined the spin of Cl^{36} to be 2. Since argon 36 contains an even number of both neutrons and protons, its spin is probably zero. With a spin change of 2, and parity change either yes or no, a beta-transition can be any one of the many transitions allowed by the selection rules. Although the fitting of this spectrum with the theoretical factors C_{2S}, C_{2A}, C_{2P}, or C_{3V} is out of the question (see Fig. 1), the factors C_{2V} and C_{2T} (for $I=2\rightarrow I=0$) contain several nuclear matrix elements which, at present, one is free to adjust to obtain the best fit. In other words, the fitting of C_{2V} and C_{2T} to the observed results involves considerable arbitrariness; thereby, it offers the greatest latitude in matching.

The previously reported unsatisfactory matching of C_{2V} or C_{2T} with the measurements in the case of Cl^{36} required the introduction of a linear combination to account for the spectrum shape.[4] The possibility of fitting the C_{2T} correction factor with the Cl^{36} spectrum has been recently brought to our attention by Fulbright and Milton.[5] Since the spectrum shape which they observed is essentially the same as the one which we reported in 1949, it is obvious that the unsatisfactory fitting of either C_{2V} or C_{2T} to the observed spectrum must be owing to the unfavorable ratios of the matrix elements used.

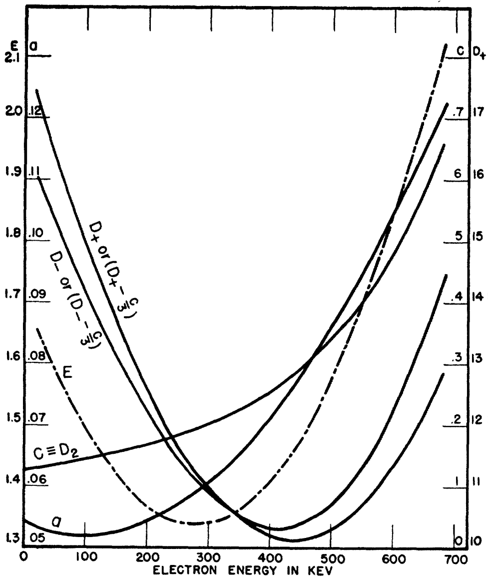

FIG. 1. The correction factors for each distinct matrix element in the second forbidden transitions of Cl^{36} ($\Delta I = 2\rightarrow 0$). The notation is that of E. J. Konopinski, Revs. Modern Phys. **15**, 209 (1943):

$$C_{2S}=\Sigma_{ij}\,|R_{ij}|^2[D_-]\,;\quad C_{2A}=\Sigma_{ij}\,|T_{ij}|^2(\tfrac{1}{4})\,[D_- - \tfrac{1}{3}c],$$
$$C_{2V}=\Sigma_{ij}\,|R_{ij}|^2[D_+]+\Sigma_{ij}\,|A_{ij}|^2[3a]-i\,\Sigma_{ij}\,(R_{ij}A_{ij}^+ + \text{c.c.})\,[E],$$
$$C_{2T}=\Sigma_{ij}\,|T_{ij}|^2(\tfrac{1}{4})\,[D_+ - \tfrac{1}{3}c]+\Sigma_{ij}\,|A_{ij}|^2[3a]-\Sigma_{ij}\,(T_{ij}A_{ij}^+ + \text{c.c.})\,[E/2].$$

With the following ratio of matrix elements,

$$|T_{ij}|^2 : |A_{ij}|^2 : |A_{ij}^+T_{ij} + \text{c. c.}| = 1:18:2(18)^{\frac{1}{2}},$$

we obtain a good fit for C_{2T} to the experimental spectrum from about 200 kev to the upper limit of 716 kev, in contradiction to the previously reported unsuccessful attempt.[4] Figure 2 shows the Kurie plot of the Cl^{36} spectrum corrected by C_{2T}, yielding indistinguishable results from that obtained with the D_2 correction

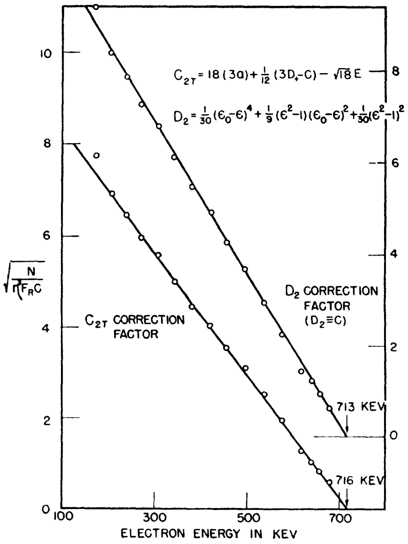

FIG. 2. Corrected Kurie plots of Cl^{36} spectrum