PENNING IONIZATION ELECTRON SPECTROSCOPY. III.* IONIZATION OF CADMIUM

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In two previous papers the Penning ionization of mercury by helium and neon atoms in metastable states was reported and specific phenomena of this reaction were described[1,2]. The method used consisted of the measurement of the energy distribution of the electrons released[3,4].

It seemed worthwhile to extend the investigation to cadmium as to the member of the Cd–Zn–Hg group. Moreover, the paper of Silfast[5] on the laser action in the He*–Cd system as well as that of Schearer and Padovani[6] on the deexcitation of helium metastables by Cd atom made desirable the measurement of the population of the ground state and the excited Cd^+ states in ionizing collisions with metastables by a direct method.

The technique of Penning ionization electron spectroscopy[3,4] as applied to the ionization of Cd by long-lived excited atoms X*:

$$X^* + Cd \rightarrow Cd^+ - X + e$$

is based on the energy balance

$$E_e = E(X^*) - I(Cd) - E_k(Cd^+ + X)\,,$$

where E_e is the energy of the released electron, $E(X^*)$ the energy of metastable atoms, I are the first or higher ionization potentials and E_k the total kinetic energy of the products. The value of $E(X^*)$ being accurately known for noble gas metastables, the ionization potential can easily be determined, when $E_k = 0$ which is mostly the case[4]. If $E_k \neq 0$ (as it is in the ionization of Hg by metastable helium atom in the 2^1S state (see[1,2]), the weak interaction of reactants or products can be studied[1,2].

EXPERIMENTAL

The apparatus used was described in previous papers[3,4]. Cadmium was evaporated from a small oven, attached to the collision region. Inner wals of the collision chamber and of the channels therein were covered by benzene sut. This reduced substantially the current of scattered electrons. Collector electron current of the order of 10^{-12} A was easily obtained.

RESULTS

The differentiated electron energy distribution curves in ionization by means of neon metastables (energy 16·61 and 16·71 eV) and by helium metastables (energy 19·81 and 20·61 eV) are shown in Figs 1 and 2. Ionization into the Cd^+ $^2S_{1/2}$ ground state and the excited $^2P_{1/2}$ and

* Part II: Chem. Phys. Letters *2*, 359 (1968).

$^2P_{3/2}$ states by Ne* atoms, and into the $^2D_{5/2}$, $^2D_{3/2}$ and still higher $^2D_{3/2}$ states by He* atoms is clearly demonstrated.

The electron energy resolution was not high enough to resolve the broad bands into individual peaks for states with close lying energies. But even so, when comparing the areas under the bands for the ionization into the $^2D_{5/2,3/2}$ and $^2P_{3/2,1/2}$ states with both 2^1S and 2^3S He atoms (see Table I), the cross sections for the ionization into the $^2D_{5/2,3/2}$ states seem to be higher than those

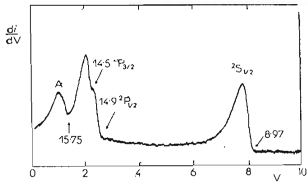

FIG. 1

Electron Energy Distribution Curves for Ionization of Cd Atoms by Neon Metastables

Calibration gas: argon.

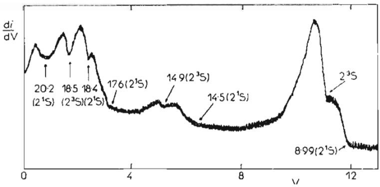

FIG. 2

Electron Energy Distribution Curves for Ionization of Cd Atoms by Helium Atoms in the Metastable 2^1S and 2^3S states

Ionization potential into the $^2S_{1/2}$ ground state is taken as standard.

TABLE I

Ionization Potentials and Ionization Cross Sections of Cd Determined by Penning Ionization Electron Spectroscopy

Ionization by	$^2S_{1/2}$	$^2P_{1/2}$	$^2P_{3/2}$	$^2D_{5/2}$	$^2D_{3/2}$	$^2S_{1/2}$	$^2D_{3/2}$
				Ionisation potential, eV			
$h\nu$	8·99	14·46	14·76	17·58	18·28	19·29	20·19
Ne*	8·97	14·5	14·8	—	—	—	—
He*	8·99	14·5	14·9	17·6	18·4	—	20·2
				Relative abundance			
	1	0·2		0·5		—	0·02
				Cross section σ, 10^{-15} cm^2			
	2·6	0·5		1·3		—	0·05

into the $^2P_{3/2,1/2}$ states or the higher $^2D_{3/2}$ state. Thus one of the conditions for the laser oscillation at 4416 Å ($^2D_{5/2} \rightarrow {}^2P_{3/2}$) is really fulfilled.

As in the case of mercury ionization, the cross section for the ionization of cadmium into the $^2S_{1/2}$ ground state is much higher than that into the excited states. This again is in sharp contrast to photoionization[7].

Taking the total deexcitation cross section by the He metastables ($2^1S + 2^3S$) into the energetically accessible Cd^+ states as $4{\cdot}5 \cdot 10^{-15}$ cm^2 (see[6]) the values of the individual cross sections into corresponding excited states are approximately as given in Table I.

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ANALYTISCHE METHODEN ZUR BESTIMMUNG VON AEROSOLEN UNTER VERWENDUNG VON MEMBRANULTRAFILTERN XVI.*

ZUR UNTERSUCHUNG DER STRUKTUR UND DER EIGENSCHAFTEN VON ANALYTISCHEN PORENFILTERN MIT HILFE DER RASTERELEKTRONENMIKROSKOPIE

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Die Filtrationstheorie bei den analytischen Porenfiltern soll die hydrodynamischen Eigenschaften und die Abscheidungseigenschaften des Filters beschreiben. Die Gleichungen für den Druckabfall und Wirkungsgrad ermöglichen dann diese beiden Größen für die realen Filter und die bekannten Filtrationsbedingungen zu errechnen[1-3]. Zur Überprüfung dieser Theorie und zur Verfolgung

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