MEASUREMENT OF THE FORMATION PROBABILITIES OF μ^- ATOMS IN THE COMPOUNDS LiCl, CsCl, ZnO, AND CuAl

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(Presented by A. SAMOILOV)

The relative probabilities of μ-mesic-atom formation in the compounds LiCl, CsCl, ZnO, and CuAl were measured. The interest in this kind of measurements is due to the fact that, according to the data of previous authors [1 – – 7], the "Z-law" [8] insufficiently reflects the experiment. The measurements were made on the JINR synchrocyclotron. The measurement technique consisted of analyzing the time intervals between the stopping of a muon and the escape of the decay electron. From the obtained experimental curves, to which a least-squares fit was applied [9], the relative formation probabilities of μ-mesic atoms of different kinds were determined

$$p\left(\frac{Z_1}{Z_2}\right)=\frac{W(Z_1)}{W(Z_2)}, \qquad (1)$$

where $W(Z_1)$ and $W(Z_2)$ are the formation probabilities of mesic atoms Z_1 and Z_2, respectively. Our data along with that available from other sources are listed in the table. From our results it follows that

1) $\frac{W(Z_1)}{W(Z_2)} \neq \frac{k_1 Z_1}{k_2 Z_2}$,

where K_1 and K_2 are the respective atomic concentrations of the elements Z_1 and Z_2:

2) $\frac{W(Z_1)}{W(Z_2)} \neq \frac{K_1}{K_2}$;

3) $\frac{W(Z_1)}{W(Z_2)} \neq \frac{K_1}{K_2}\left(\frac{Z_1}{Z_2}\right)^n$,

where n is some fixed number.

Gershtein showed qualitatively that in molecules with an ionic bond (typical metal – typical metalloid) [10] the formation of μ-mesic atoms of the metalloid, i.e., of the element possessing a higher electron affinity than the metal, should somewhat prevail in comparison to the "Z-law." As can be seen from the table, our data confirm this tendency. Molecules with other types of bonds (covalent, metallic) are also made up of atoms with differing electron affinity. Using this, all the experimental data can be systematized in such a way as to check the above-mentioned tendency also in compounds of another type. Let us apply to the experiment the "Z-law"

$$\varphi=\frac{W(Z_1)}{W(Z_2)}\cdot\frac{K_2 Z_2}{K_1 Z_1}, \qquad (2)$$

where K_1 and Z_2 refer to the element with the higher electron affinity. Then, if there is indeed a tendency toward predominant formation of the mesic atom of the element with the higher electron affinity in comparison to the "Z-law", then $\phi > 1$; if the "Z-law" is satisfied, $\phi = 1$ and, if this tendency does not exist, $\phi < 1$. As can be seen from the second last column, of the 24 inorganic compounds (insulators and alloys) only in one – Sb_2O_3 – is this tendency disrupted. In the remaining cases $\phi \geqslant 1$. Only in four cases an equality is observed within the error limits. As regards the compound Sb_2O_3, there are no reliable data on the electron affinity of antimony. Departure

Table 1

Material	Compound	Ratio	Experiment	Z_1K_1/Z_2K_2	K_1/K_2	n	φ	Author
Insulators	Al_2O_3	O/Al	1.5±0.2	0.923	1.50	0±0.27	0.63±0.22	Stearns
	CaS	S/Ca	0.8±0.2	0.800	1.00	1.00±1.13	1.00±0.25	
	P_2O_5	O/P	2.7±0.3	1.333	2.50	−0.12±0.18	2.03±0.22	Sens
	Al_2O_3	O/Al	2.3±0.2	0.923	1.50	−0.88±0.18	1.53±0.14	
	SiO_2	O/Si	2.59±0.17	1.143	2.00	−0.46±0.12	2.26±0.15	
	KOH	O/K	2.2±0.4	0.421	1.00	−0.91±0.21	5.23±0.96	
	KHF_2	F/K	1.70±0.24	0.948	2.00	0.19±0.27	1.79±0.25	
	LiI	I/Li	15.8±2.0	17.67	1.00	0.96±0.04	0.89±0.11	Lathrop
	PbF_2	F/Pb	0.208±0.014	0.219	2.00	1.02±0.07	0.95±0.14	Astbury
	BiF_3	F/Bi	0.633±0.060	0.325	3.00	0.70±0.04	1.95±0.19	Eckhause
	UF_4	F/U	0.658±0.065	0.392	4.00	0.78±0.04	1.68±0.17	
	CuS	Cu/S	1.89±0.18	1.810	1.00	1.07±0.16	1.04±0.10	Baijal
	Sb_2S_3	S/Sb	0.61±0.04	0.470	1.50	0.78±0.05	1.30±0.08	
	PbS	S/Pb	0.35±0.004	0.195	1.00	0.65±0.08	1.79±0.22	
	CuO	Cu/O	6.14±0.85	3.620	1.00	1.41±0.11	1.70±0.14	
	Sb_2O_3	Sb/O	1.86±0.10	4.250	0.67	0.55±0.03	0.44±0.02	
	PbO	O/Pb	0.219±0.025	0.098	1.00	0.65±0.05	2.24±0.25	
	LiCl	Cl/Li	7.20±1.10	5.120	1.00	1.21±0.09	1.41±0.22	Present authors
	CsCl	Cs/Li	0.566±0.031	0.336	1.00	0.52±0.06	1.68±0.09	
	ZnO	O/Zn	0.405±0.013	0.268	1.00	0.69±0.02	1.51±0.05	
Alloys	AgZn	Ag/Zn	2.2±0.7	1.570	1.00	1.75±0.71	1.40±0.44	Lathrop
	$CuAl_1$	Cu/Al	1.75±0.18	1.111	0.50	1.56±0.13	1.58±0.16	Eckhause
	$CuAl_2$	Cu/Al	2.08±0.25	1.111	0.50	1.77±0.18	1.89±0.23	
	CuAu	Cu/Au	2.94±0.28	2.020	5.50	0.62±0.09	1.45±0.14	Baijal
	AgLi	Ag/Li	11.7±3.4	9.100	0.58	1.08±0.11	1.29±0.36	
	CuAl	Cu/Al	0.91±0.04	0.200	0.09	3.08±0.00	4.55±0.20	Present authors
Organic materials	$C_4O_2H_8$	O/C	0.33±0.04	0.670	0.50	−1.43±0.42	0.49±0.06	Fafarman
	$C_6H_4Cl_2$	Cl/C	0.44±0.04	0.940	0.33	0.27±0.08	0.47±0.04	Sens
	$C_6H_4Cl_2$	Cl/C	0.48±0.05	0.940	0.33	0.35±0.09	0.57±0.05	
	CCl_4	Cl/C	4.1±0.8	11.32	4.00	0.024±0.19	0.36±0.07	

from the tendency for $\phi > 1$ is observed in carbon compounds (3 cases), which apparently may be due to the more complicated spatial structure of the molecules. Thus, on the basis of the experimental data there is some tendency toward predominant formation of the mesic atom of the element with the higher electron affinity. The existence of such a tendency suggests that the structure of the external electron shells of the atoms bound in the molecule plays a very important role in the formation mechanism of the μ-mesic atom.

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