EXPERIMENTAL INVESTIGATION OF THE THERMAL CONDUCTIVITIES OF C_6D_6, C_6H_6 AND C_6D_{12}, C_6H_{12} IN THE GASEOUS PHASE

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Results of the measurement of the thermal conductivities of C_6D_6, C_6H_6 and C_6D_{12}, C_6H_{12} in the temperature interval 300-600°K are presented.

The transfer coefficients of deuterium- and hydrogen-containing isotopic compounds have been studied very little. While some experimental data on viscosity for the liquid and gas phases [1, 2] have been available, for a long time only data for D_2O and H_2O [3] were known on the thermal conductivities of isotopic compounds. Subsequently, experimental data have been obtained for two systems in the liquid phase: C_6H_6, C_6D_6 and C_6H_{12}, C_6D_{12} [4]. The results of these experiments showed that the thermal conductivity of a deuterium-containing compound is less than for a hydrogen-containing compound. In this paper, the results of the experiments on thermal conductivity and also on viscosity have been compared with Valleau's theory [5]. In this case, no satisfactory agreement was obtained between the experimental results and theoretical calculations for the transfer coefficients in the liquid phase. This, obviously, is a consequence of the assumptions on the constancy of the specific heat and the exchange conditions of the rotational energy, which were assumed for the derivation of the working equations.

It was interesting to investigate the thermal conductivities of these same systems in the gas phase, which is important both from the practical aspect as well as from the point of view of explaining the exchange of the various forms of energy during change both of the mass and of the moments of inertia in polyatomic molecules.

Earlier, in our papers [6, 7], the results of investigations on D_2O, H_2O, CD_4, CH_4, and C_2D_4, C_2H_4 conducted by the hot-wire method were given. The investigations of C_6D_6, C_6H_6 and C_6D_{12}, C_6H_{12} were carried out on the same experimental facility [6].

In determining the coefficients of thermal conductivity, the following corrections were taken into consideration: for the radiation from the measurement wire, for the heat removal from the ends, and for the fall of temperature in the wall of the measurement tube.

In order to elucidate the question of the magnitude of the correction for the temperature drop, preliminary experiments were conducted with C_6H_6 and C_6H_{12} at several temperatures

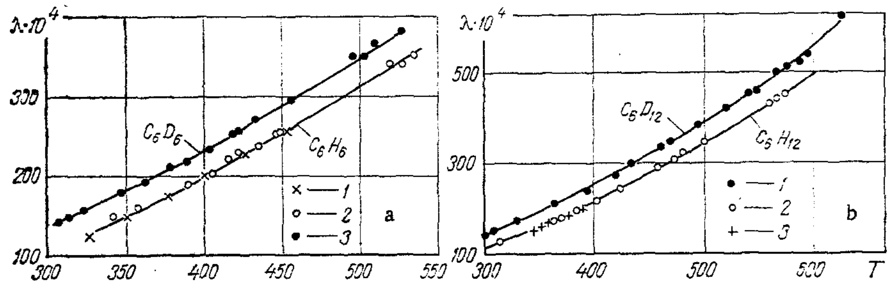

Fig. 1. Experimental data: a) for C_6H_6 [1) recommended in [3]; 2) authors' data] and C_6D_6 [3) authors' data]; b) for C_6H_{12} [1) authors' experiments] and C_6H_{12} [2) authors' experiments; 3) Vines' experiments [8]]. λ, W/(m•°K); T, °K.

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TABLE 1. Experimental Data on $\lambda_{C_6D_6}$

P, mm Hg	Q, W	$T_f - T_w$, °K	δT_q, °K	ΔT_g, °K	λ', W/(m·°K)	λ_{rad}, W/(m·°K)	$\delta\lambda_e$, W/(m·°K)	λ, W/(m·°K)	T_{av}, °K
88	0,1083	24,59	0,03	24,56	0,0143	0,0000	0,0002	0,0141	307,1
88	0,1473	32,26	0,04	32,22	0,0148	0,0000	0,0002	0,0145	312,8
88	0,2298	46,70	0,07	46,63	0,0159	0,0000	0,0002	0,0157	324,3
88	0,1158	20,78	0,03	20,75	0,0181	0,0000	0,0003	0,0178	348,4
88	0,2392	39,01	0,07	38,94	0,0198	0,0001	0,0003	0,0194	362,1
88	0,1203	18,03	0,03	18,00	0,0216	0,0001	0,0003	0,0212	377,9
173	0,2425	34,85	0,07	34,78	0,0226	0,0002	0,0003	0,0220	389,7
173	0,3869	52,26	0,11	52,15	0,0241	0,0003	0,0003	0,0234	402,0
250	0,1288	16,15	0,03	16,12	0,0259	0,0002	0,0003	0,0254	418,7
231	0,2555	31,40	0,07	31,33	0,0264	0,0003	0,0003	0,0257	421,6
218	0,4024	47,39	0,11	47,28	0,0276	0,0005	0,0003	0,0267	432,5
182	0,7391	79,03	0,20	78,83	0,0304	0,0007	0,0003	0,0293	454,8
176	0,1419	12,92	0,04	12,88	0,0357	0,0007	0,0005	0,0345	495,0
224	0,2705	24,39	0,07	24,32	0,0361	0,0008	0,0005	0,0348	501,8
180	0,4128	35,97	0,11	35,86	0,0373	0,0008	0,0005	0,0361	508,8
441	0,7247	60,43	0,19	60,24	0,0390	0,0010	0,0005	0,0374	524,9
					$\lambda_{C_6H_6}$				
80	0,1147	24,87	0,03	24,84	0,0149	0,0001	0,0002	0,0146	340,2
80	0,2385	47,14	0,07	47,07	0,0164	0,0001	0,0003	0,0160	356,5
142	0,1247	20,71	0,03	20,68	0,0195	0,0001	0,0003	0,0191	390,4
234	0,2509	39,12	0,07	39,05	0,0208	0,0002	0,0003	0,0203	402,6
234	0,3988	56,29	0,11	56,18	0,0230	0,0003	0,0003	0,0224	415,3
234	0,1213	16,77	0,03	16,74	0,0235	0,0003	0,0003	0,0229	419,4
230	0,2558	34,16	0,07	34,09	0,0243	0,0003	0,0003	0,0237	432,6
230	0,2360	29,19	0,06	29,13	0,0262	0,0005	0,0003	0,0254	446,9
230	0,0810	9,86	0,02	9,84	0,0267	0,0005	0,0004	0,0258	448,3
186	0,1466	13,57	0,04	13,53	0,0351	0,0008	0,0005	0,0338	448,3
186	0,2775	25,39	0,07	25,32	0,0355	0,0009	0,0005	0,0341	525,0
412	0,4212	37,58	0,11	37,47	0,0364	0,0010	0,0005	0,0349	532,5
					$\lambda_{C_6D_{12}}$				
92	0,0604	12,81	0,02	12,79	0,0153	—	0,0002	0,0151	299,6
92	0,1045	21,60	0,03	21,57	0,0157	—	0,0002	0,0155	306,3
92	0,2255	42,92	0,07	42,85	0,0171	—	0,0002	0,0169	322,6
85	0,2328	35,86	0,07	35,79	0,0211	0,0001	0,0003	0,0207	357,2
85	0,2464	30,65	0,07	30,58	0,0261	0,0002	0,0003	0,0256	393,9
236	0,0772	8,62	0,02	8,60	0,0291	0,0002	0,0003	0,0286	417,4
236	0,2496	26,26	0,07	26,19	0,0309	0,0003	0,0003	0,0303	429,1
250	0,7124	65,77	0,18	65,59	0,0352	0,0006	0,0005	0,0341	457,8
220	0,2471	21,68	0,06	21,62	0,0370	0,0006	0,0005	0,0359	469,5
303	0,6624	53,31	0,17	53,14	0,0404	0,0008	0,0005	0,0391	491,3
322	0,2748	20,10	0,07	20,03	0,0444	0,0008	0,0005	0,0431	518,5
326	0,1446	9,90	0,04	9,86	0,0475	0,0009	0,0006	0,0460	537,5
309	0,2708	18,37	0,07	18,30	0,0479	0,0009	0,0006	0,0464	542,8
282	0,7004	44,39	0,18	44,21	0,0513	0,0009	0,0006	0,0498	559,9
271	0,2750	16,87	0,07	16,80	0,0530	0,0010	0,0006	0,0514	568,2
486	0,6983	41,14	0,17	40,97	0,0552	0,0015	0,0006	0,0531	583,8
472	0,2841	16,52	0,07	16,45	0,0560	0,0014	0,0006	0,0540	592,6
560	0,7164	35,79	0,17	35,62	0,0652	0,0023	0,0007	0,0622	634,1
					$\lambda_{C_6H_{12}}$				
83	0,0492	13,08	0,01	13,07	0,0122	—	0,0002	0,0120	298,6
83	0,1484	34,70	0,04	34,66	0,0138	—	0,0002	0,0136	315,3
77	0,0712	12,70	0,02	12,68	0,0182	—	0,0002	0,0180	359,9
77	0,1194	20,61	0,03	20,58	0,0188	0,0001	0,0003	0,0184	365,4
77	0,2439	39,32	0,07	39,25	0,0201	0,0001	0,0003	0,0197	378,3
200	0,0749	10,41	0,02	10,39	0,0234	0,0002	0,0003	0,0229	403,0
150	0,2400	30,64	0,06	30,58	0,0254	0,0003	0,0003	0,0248	421,3
137	0,6746	73,51	0,18	73,33	0,0298	0,0006	0,0003	0,0289	452,1
265	0,1322	13,32	0,03	13,29	0,0322	0,0006	0,0005	0,0311	468,9
234	0,2519	24,37	0,07	24,30	0,0336	0,0006	0,0005	0,0325	476,1
224	0,6734	59,68	0,18	59,50	0,0367	0,0008	0,0005	0,0354	499,9
250	0,1883	13,76	0,05	13,71	0,0445	0,0012	0,0005	0,0428	556,5
475	0,3959	28,23	0,10	28,13	0,0456	0,0013	0,0005	0,0438	565,3
265	0,6566	44,53	0,16	44,37	0,0479	0,0014	0,0006	0,0459	572,4

and various pressures. The results of these experiments showed that at pressures of 100-500 mm Hg the correction for the temperature drop is negligibly small (tenths of 1%). Therefore, the main experiments were conducted at one pressure.

Table 1 and Fig. 1a show the experimental data on λ for deuterated C_6D_6 vapor (content of primary substance 99.4%) and normal C_6H_6 benzene in the temperature range 300-530°K. The

deviation from the recommended data on $\lambda_{C_6H_6}$ [3] does not exceed the experimental errors, which amount to 1.5%.

The results of the investigation of λ for deuterated C_6D_{12} (content of primary substance 99.7%) and for normal C_6H_{12} cyclohexane are shown in Table 1. Our data on the thermal conductivity of C_6H_{12} coincide within the limits of 2% with Vines' data [8].

It can be seen from the results of the experiments shown in Fig. 1a for C_6D_6 and C_6H_6 and in Fig. 1b for C_6D_{12} and C_6D_{12} that over the entire temperature range investigated the thermal conductivities of deuterium-containing compounds are greater than the thermal conductivities of hydrogen-containing compounds.

A future investigation of other thermophysical properties of these compounds, in particular, viscosity and specific heat, should be interesting since it may allow the effect of the replacement of hydrogen by deuterium on the transfer coefficients to be explained.

NOTATION

P, experiment pressure; Q, flow of heat from the hot platinum wire; T_W, temperature of wire; T_w, wall temperature; δT_q, fall of temperature in the wall of the quartz tube; ΔT_g, temperature difference in gas layer; λ', coefficient of thermal conductivity, without taking account of heat removal from the ends and loss by radiation; λ_{rad}, correction for radiation; $\delta\lambda_e$, correction for heat removal from the ends of the measurement tube; λ, coefficient of thermal conductivity; T_{av}, reference temperature.

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