of enthalpies and entropies in the initial and activated state; R_g, universal gas constant; k and h, Boltzmann and Planck constants; E_{0t}, maximum energy density on the axis of the beam for threshold interaction; and Z, normalized intensity of the radiation.

LITERATURE CITED

1. S. I. Anisimov, Heat and Mass Exchange VI. Specimen Proc. of the Sixth All-Union Conf. on Heat and Mass Exchange [in Russian], Minsk (1981), Part 1, pp. 3-20.
2. S. I. Anisimov, V. A. Gal'burt, and M. I. Tribel'skii, Kvantovaya Elektron., 8, 1671 (1981).
3. V. K. Pustovalov and I. A. Khorunzhii, Kvantovaya Elektron., 13, 1461 (1986).
4. G. V. Sazonova, Heat and Mass Exchange in Polymer Systems and Suspensions, Proc. of the Int. School-Seminar [in Russian], Part 2, Minsk (1984), pp. 67-73.
5. V. K. Pustovalov and G. S. Romanov, Dokl. Akad. Nauk BSSR, 29, 50 (1985).
6. V. K. Pustovalov and D. S. Bobuchenko, Dokl. Akad. Nauk BSSR, 30, 513 (1986).
7. F. S. Barns, Tr. Inst. Inzh. Elektrotekh. Radioelektron., 63, 6 (1975).
8. A. A. Samarskii, Theory of Difference Schemes [in Russian], Moscow (1983).
9. R. Birngruber, F. Hillenkamp, and V.-P. Gabel, Health Phys., 48, 781 (1985).
10. T. J. White, M. A. Mainster, et al., Bull. Math. Biophys., 32, 315 (1970).
11. A. J. Welch and G. D. Polhamus, IEEE Trans. Biomed. End., BME-31, 633 (1984).
12. J. R. Hayes and M. L. Wolbarsht, Aerospace Medicine, 39, 474 (1968).
13. J. D. Lund and E. S. Beatrice, Health Phys., 36, 7 (1979).
14. W. S. Weinberg, R. Birngruber, and B. Lorenz, IEEE J. Quantum Electron., QE-20, 1481 (1984).

THE DENSITIES OF MONOHYDRIC SATURATED ALCOHOLS

T. S. Khasanshin and T. B. Zykova

UDC 536.7:547.26

Analytic relationships have been derived of the density to the number of carbon atoms for a series of liquid n-alcohols from propan-1-ol to octadecan-1-ol at 263-513°K and atmospheric pressure.

Particular interest attaches to regularity in the properties in homologous series of organic compounds because these can be used to survey and predict properties for largely unexamined members.

The behavior of the density has been examined [1] for n-alcohols containing 1-12 carbon atoms; beginning with propan-1-ol, there is a smooth variation in density at constant temperature and atmospheric pressure within the accuracy of the measurements.

Here we extend the bounds in temperature (263-513°K) and in number of alcohols (C_3–C_{18}). We consider virtually all known alcohols, amongst which the light n-alcohols have been most fully examined and the heavy ones less so.

First, graphs were plotted with ρ and N as coordinates to give isotherms over the range 263-513°K with a step of 10°K for the density as a function of the number of carbon atoms on the basis of [2-8] for the C_3-C_6, C_8, C_{10}, C_{12} alcohols, as well as the accurate measurements of [9] for C_{16} and the densities recommended in [10] for C_{14}, C_{16}, and C_{18}. Then the densities of C_7, C_9, C_{11}, C_{13}, C_{15} and C_{17} alcohols were read from the curves to increase the data volume.

The final processing incorporated all these results and the densities found graphically.

Mogilev Technological Institute. Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 53, No. 2, pp. 272-274, August, 1987. Original article submitted June 9, 1986.

TABLE 1. Coefficients in (1)

Temp., deg K	a_0	$a_1 \cdot 10^2$	$a_2 \cdot 10^3$	$a_3 \cdot 10^4$	$a_4 \cdot 10^6$	N range	Homolog number	Max. deviation, %
263,15	0,808964481	0,688163042	—0,288428592	—	—	3—8	7	0,03
273,15	0,800005594	0,737743441	—0,316743481	—	—	3—9	9	0,03
283,15	0,787838010	0,982328007	—0,714675967	0,219527655	—	3—10	7	0,01
293,15	0,778962730	1,019576650	—0,718075904	0,206328124	—	3—10	9	0,01
298,15	0,774922212	1,014422810	—0,680426447	0,179594794	—	3—12	11	0,01
303,15	0,769858648	1,062803240	—0,728948058	0,196274773	—	3—12	9	0,015
313,15	0,758626100	1,234638410	—1,024723800	0,440757639	—0,763519704	3—14	9	0,02
323,15	0,748132969	1,332743130	—1,128892580	0,490161604	—0,843438350	3—17	15	0,06
333,15	0,736452981	1,480249410	—1,317987770	0,603842151	—1,102189220	3—18	14	0,08
343,15	0,724454032	1,625911690	—1,498906990	0,710878672	—1,340150740	3—18	14	0,12
353,15	0,712028532	1,770451580	—1,661252900	0,797087232	—1,513806320	3—18	14	0,14
363,15	0,700234436	1,854655920	—1,701726010	0,792884494	—1,467971590	3—18	14	0,14
373,15	0,687548699	1,977576290	—1,826097090	0,858415157	—1,606328670	4—18	14	0,16
383,15	0,674838364	2,052098620	—1,817388290	0,808038494	—1,427695320	4—18	14	0,13
393,15	0,676811881	1,491851080	—0,875809742	0,185755517	—	5—18	16	0,16
403,15	0,661713333	1,639015510	—0,974240860	0,208497891	—	5—18	16	0,18
413,15	0,652725745	1,612860480	—0,925360606	0,192334841	—	6—18	16	0,16
423,15	0,639184854	1,697860370	—0,966634884	0,199776941	—	6—18	16	0,17
433,15	0,614032823	2,073890450	—1,244823500	0,269244711	—	7—18	16	0,22
443,15	0,597278146	2,223916190	—1,333777210	0,288507182	—	7—18	16	0,24
453,15	0,574919482	2,504319100	—1,523842120	0,333383431	—	8—18	16	0,27
463,15	0,556459630	2,675067400	—1,620900670	0,353664993	—	8—18	16	0,28
473,15	0,619032291	0,917291772	—0,226405719	—	—	9—18	16	0,12
483,15	0,605380232	0,971705444	—0,237381473	—	—	9—18	16	0,13
493,15	0,604307085	0,837432450	—0,181162626	—	—	10—18	16	0,18
503,15	0,586977962	0,941270169	—0,208844731	—	—	10—18	16	0,20
513,15	0,554254513	1,257701550	—0,308322189	—	—	11—18	11	0,20

TABLE 2. Densities (g/cm³) at Atmospheric Pressure for Liquid Tridecan-1-ol (C_{13}), Pentadecan-1-ol (C_{15}), and Heptadecan-1-ol (C_{17})

T, K	C_{13}	C_{15}	C_{17}	T, K	C_{13}	C_{15}	C_{17}
313,15	0,8210	—	—	433,15	0,7324	0,7359	0,7391
323,15	0,8142	0,8168	—	443,15	0,7244	0,7281	0,7316
333,15	0,8073	0,8099	0,8118	453,15	0,7162	0,7202	0,7241
343,15	0,8004	0,8032	0,8050	463,15	0,7080	0,7124	0,7165
353,15	0,7933	0,7962	0,7981	473,15	0,7000	0,7057	0,7095
363,15	0,7860	0,7888	0,7907	483,15	0,6916	0,6977	0,7020
373,15	0,7787	0,7817	0,7836	493,15	0,6826	0,6892	0,6943
383,15	0,7712	0,7742	0,7762	503,15	0,6740	0,6812	0,6866
393,15	0,7636	0,7662	0,7686	513,15	0,6656	0,6735	0,6790
403,15	0,7559	0,7587	0,7612	523,15	0,6568*	0,6657*	0,6713*
413,15	0,7483	0,7514	0,7540	533,15	0,6483*	0,6577*	0,6635*
423,15	0,7404	0,7438	0,7466				

*Extrapolation.

We described $\rho = f(N)$ via

$$\rho = \sum_{i=0}^{n} a_i N^i, \tag{1}$$

where ρ is in g/cm³ and N is the number of carbon atoms in the n-alcohol molecule.

Computer least-squares fitting was used to estimate the a_i in (1); Table 1 gives the values, the ranges in the number of carbon atoms, and the deviations in the densities calculated via (1) from the measured values for the members in the series for which they are maximal.

Equations (1) describe the most reliable densities [2-9] within the errors in the calculations and experiments (0.02-0.10%). The results of [10] for C_{14}, C_{16}, and C_{18} are evidently described (Table 1) with an error of not more than 0.3%. We compared the calculations for C_7, C_9, and C_{11} with the reliable measurements of [11] for 293-333 K; the discrepancies did not exceed 0.1%. Equations (1) enable one to predict the densities (Table 2) in set ranges for the C_{13}, C_{15}, and C_{17} alcohols, for which there are only restricted measurements [12]. In that study, the measurements were made at three points in the range 323-373 K, and they agree with the calculations within 0.1%. The possible errors in the recommended densities in Table 2 are estimated as 0.1-0.3%.

LITERATURE CITED

1. T. S. Khasanshin, Inzh.-Fiz. Zh., 52, No. 1, 101-106 (1987).
2. T. S. Khasanshin, Inzh.-Fiz. Zh., 45, No. 3, 461-467 (1983).
3. T. S. Khasanshin and T. B. Zykova, Inzh.-Fiz. Zh., 46, No. 4, 558-565 (1984).
4. T. S. Khasanshin and T. B. Zykova, Inzh.-Fiz. Zh., 48, No. 2, 256-263 (1985).
5. T. S. Khasanshin, The Thermodynamic Parameters of Hexan-1-ol at Atmospheric Pressure [in Russian], Dep. VINITI 20 August 1984, No. 5925-84, Minsk (1984).
6. T. S. Khasanshin, The Thermodynamic Parameters of Octan-1-ol at Atmospheric Pressure [in Russian], Dep. VINITI 2 April 1985, No. 2233-85, Minsk (1985).
7. T. S. Khasanshin, The Thermodynamic Parameters of Decan-1-ol at Atmospheric Pressure [in Russian], Dep. VINITI 20 February 1986, No. 1178-V86, Minsk (1986).
8. T. S. Khasanshin, Zh. Prikl. Khim., 60, No. 3, 652-653 (1987).
9. G. H. Findenegg, Monatshefte für Chemie, 104, No. 4, 998-1007 (1973).
10. R. C. Wilhoit and B. J. Zwolinski, J. Phys. Chem. Ref. Data, 2, Supplement, No. 1, 346-374 (1973).
11. M. D. Pena and G. Tardajos, J. Chem. Thermodynamics, 11, 441-445 (1979).
12. H. Stage, Fette Seifen, No. 11, 667-682 (1951).