soot or carbon monoxide was formed during these experiments with auxiliary oil. The fuse wire burned completely in one of the five experiments.

Results and Calculations

Table I gives the results of the five experiments to determine the energy equivalent of the standard calorimeter system. Table II gives the results of the five experiments on the combustion of $C_{10}H_8O$. The symbols used in these tables are the same as in earlier reports (*4*, *5*, *8*, *9*), and the manner of calculation and presentation of the data is explained in (*8*, *9*).

Applying the Washburn correction, 3.07 kJ mol^{-1}, to the value of ΔE_c (from Table II) to obtain ΔE_c° and using the recommended values for the standard enthalpies of formation of water and carbon dioxide (*1*), we obtain the following for $C_{10}H_8O(c)$ at 298.15 K:

$$\Delta E_c^\circ = -5136.78 \pm 2.30\ \text{kJ mol}^{-1}$$

$$\Delta H_c^\circ = -5140.5 \pm 5.7\ \text{kJ mol}^{-1} = -1228.61 \pm 1.36\ \text{kcal mol}^{-1}$$

$$\Delta H_f^\circ = 62.1 \pm 5.8\ \text{kJ mol}^{-1} = 14.84 \pm 1.39\ \text{kcal mol}^{-1}$$

The foregoing uncertainties are taken as twice the propagated standard deviation of the mean, including the following components, as appropriate: (a) for the certified value of the standard benzoic acid, ±0.004%; (b) for the determination of the energy equivalent of the standard calorimeter system (Table I); (c) for the combustion experiments on $C_{10}H_8O$ (Table II); (d) for the effect of unknown impurities, ±0.05%. One calorie is taken as exactly 4.184 J.

Using the previously selected value for the standard enthalpy of formation of naphthalene (*2*, *8*, *10*), $\Delta H_f^\circ = 18.66 \pm 0.23$ kcal mol^{-1} at 298.15 K, and the value for the dissociation of oxygen into its atoms recommended by Wagman et al. (*11*), $\Delta H^\circ = 119.10 \pm 0.01$ kcal mol^{-1} at 298.15 K, the standard enthalpy for the dissociation of $C_{10}H_8O(c)$ into naphthalene and molecular oxygen and into naphthalene and atomic oxygen was calculated as follows, at 298.15 K:

$$C_{10}H_8O(c) = C_{10}H_8(c) + {}^1/_2O_2(g);\quad \Delta H^\circ = 3.82 \pm 1.41\ \text{kcal mol}^{-1}$$

$$C_{10}H_8O(c) = C_{10}H_8(c) + O(g);\quad \Delta H^\circ = 63.4 \pm 1.4\ \text{kcal mol}^{-1}$$

Acknowledgment

Grateful acknowledgement is made to Professor John L. Margrave for permitting us to share the use of his combustion calorimetric equipment and to Professor Frederick D. Rossini for valuable advice during this investigation.

Literature Cited

(1) CODATA Key Values for Thermodynamics, *J. Chem. Thermodyn.*, **3**, 1 (1971); *CODATA Bull.*, **5**, 1 (1971).
(2) Coleman, D. J., Pilcher, G., *Trans. Faraday Soc.*, **62**, 821 (1966).
(3) Commission on Atomic Weights, International Union of Pure and Applied Chemistry, *Pure Appl. Chem.*, **4**, 37 (1974).
(4) Engel, P. S., Melaugh, R. A., Månsson, M., Timberlake, J. W., Garner, A. W., Rossini, F. D. *J. Chem. Thermodyn.*, **8**, 607 (1976).
(5) Engel, P. S., Montgomery, R. L., Månsson, M., Leckonby, R. A., Foyt, H. L., Rossini, F. D., *J. Chem. Thermodyn.*, in press.
(6) Fieser, L. F., Haddadin, M. J., *Can. J. Chem.*, **43**, 1599 (1965).
(7) Kybett, B. D., Johnson, G. K., Barker, C. K., Margrave, J. L., *J. Phys. Chem.*, **69**, 3603 (1965).
(8) Montgomery, R. L., Månsson, M., Rossini, F. D., *J. Chem. Eng. Data*, **23**, 0000 (1978).
(9) Montgomery, R. L., Månsson, M., Engel, P. S., Leckonby, R. A., Szilagyi, S., Timberlake, J. W., Rossini, F. D., *J. Chem. Eng. Data*, **23**, 0000 (1978).
(10) Speros, D. M., Rossini, F. D., *J. Phys. Chem.*, **64**, 1723 (1960).
(11) Wagman, D. D., Evans, W. H., Parker, V. B., Halow, L., Bailey, S. M., Schumm, R. H., *Natl. Bur. Stand. (U.S.), Tech. Note*, 270-3 (1968).
(12) Ziegler, G. R., *J. Am. Chem. Soc.*, **91**, 446 (1969).

Received for review December 19, 1977. Accepted January 30, 1978. Acknowledgment is made to the Robert A. Welch Foundation for support of this work.

Study of Vapor Pressure and Critical Properties of Perfluoro-*n*-hexane

A. H. N. Mousa[†]

Department of Chemical Engineering, The Ohio State University, Columbus, Ohio 43210

The vapor pressure of perfluoro-*n*-hexane was determined from 160 °C to the critical point and correlated by an equation. The critical properties were measured and compared with the most reliable values reported in literature.

Introduction

A lot of work has been done on binary systems containing perfluoro-*n*-hexane (*1*, *5*, *11*) but little work (*6*) has been done on the study of perfluoro-*n*-hexane of high purity. Burger and Cady (*2*) and Stiles and Cady (*10*) studied some physical properties of perfluoro-*n*-hexane but the purity of their sample was estimated by them to be 96.5 mol % pure. Crowder et al. (*4*) studied the vapor pressure from low pressure to the critical point, and they obtained two equations, one for pressures less than atmospheric pressure and the other for pressures to the critical value.

The objective of this work is to measure vapor pressure data and correlate them with an equation. Also to measure the critical properties and compare them with the most reliable values reported by Kudchodker, Alani, and Zwolinski (*8*).

Experimental Section

Perfluoro-*n*-hexane was supplied by Pierce Chemical Co. who stated that the purity is 98+%. The sample was further purified by placing it in contact with activated molecular sieves to absorb

---

[†] Address correspondence to this author at the Department of Chemical Engineering, Faculty of Engineering and Petroleum, University of Kuwait, Kuwait.

0021-9568/78/1723-0133$01.00/0 © 1978 American Chemical Society

Table I. Vapor Pressure Data of Perfluoro-*n*-hexane

T/K	P/kPa (measd)	P/kPa (calcd)	% dev
448.77	1868.13	1864.08	+0.22
447.46	1815.80	1815.85	−0.003
445.88	1759.05	1759.08	−0.002
444.01	1681.90	1693.70	−0.70
442.57	1644.66	1644.62	+0.002
441.27	1610.19	1601.26	+0.56
439.99	1559.65	1559.48	+0.01
438.50	1511.32	1511.91	−0.04
436.58	1452.09	1452.28	−0.01
435.54	1420.03	1420.76	−0.05
434.67	1394.86	1394.78	+0.006
433.42	1358.32	1358.16	+0.01

Table II. Critical Values of Perfluoro-*n*-hexane

Critical temp, K	Critical pressure, kPa	Critical density, g/cm^3	Ref
448.77	1868.13	0.5578	This work
447.65			6
449.55			3
451.65	1904.98		7

traces of moisture and was then degassed by subjecting the sample to a cycle of freezing, pumping, melting, and freezing. The degassed sample was kept in a flask attached to a high-vacuum train and surrounded by a mixture of dry ice and acetone.

Apparatus and Procedure

The apparatus and methods used for the measurements have been described in a previous publication (*9*).

The temperature was measured by a copper-to-constantan thermocouple, which was calibrated against a platinum resistance thermometer, and read to 0.01 K. The resistance thermometer was calibrated and certified by the National Bureau of Standards.

The pressure gauge had a dial 40 cm in diameter and could be read to 1.40 kPa. It was checked at intervals of 275 kPa up to 6000 kPa against a high-precision dead-weight guage with a pressure sensitivity of 0.10 kPa. The absolute accuracy of the temperature measurements is estimated to be ±0.2 K and that of the pressure measurements ±3.0 kPa.

Results

The vapor pressure data, shown in Table I have been best fitted, by the method of least squares, to the following equation with an average deviation of 0.13%

$$\log (P/\text{kPa}) = 7.153 - \frac{1742.42}{(T/\text{K})}$$

The critical values are shown in Table II together with the most reliable values recommended by Kudchodler et al. (*8*).

Discussion

As shown in Table II the critical properties are in good agreement with the most reliable values in literature. The vapor pressure equation has an average deviation of 0.13% between the calculated and measured pressure and has a coefficient of determination of 0.9993. When the vapor pressure equation obtained here was applied to the data reported by Crowder et al. (*4*) agreement within less than 6% was obtained.

Acknowledgment

The author is grateful to Professor W. B. Kay for his great help in making this study.

Literature Cited

(1) Bedford, R. G., Dunlap, R. D., *J. Am. Chem. Soc.*, **80**, 282 (1958).

(2) Burger, L. L., Cady, G. H., *J. Am. Chem. Soc.*, **73**, 4243 (1951).

(3) Cheng, C. H., McCoubrey, J. C., *J. Chem. Soc.*, 4993 (1963).

(4) Crowder, G. A., Talor, Z. L., Reed, III, T. M., Young, J. A., *J. Chem. Eng. Data*, **12**, 481 (1967).

(5) Dunlap, R. D., Scott, R. L., *J. Phys. Chem.*, **86**, 631 (1962).

(6) Dunlap, R. D., Murphy, C. J., Bedford, R. G., *J. Am. Chem. Soc.*, **80**, 83 (1958).

(7) Ermakov, G. V., Skripov, V. P., *Russ. J. Phys. Chem.*, **41**, 39 (1967).

(8) Kudchodler, A. P., Alani, G. M., Zwolinski, B. J., *Chem. Rev.*, **68**, 659 (1968).

(9) Mousa, A. H. N., Kay, W. B., Kreglewski, A., *J. Chem. Thermodyn.*, **4**, 301 (1972).

(10) Stiles, V. E., Cady, G. H., *J. Am. Chem. Soc.*, **74**, 3771 (1952).

(11) Williamson, A. G., Scott, R. L., *J. Phys. Chem.*, **65**, 275 (1961).

Received for review December 20, 1976. Accepted December 7, 1977.