PREDICTION AND CORRELATIONS OF SATURATED LIQUID MOLAR VOLUME AT ANY TEMPERATURE (INCLUDING NORMAL BOILING POINT) FOR PURE COMPONENTS AND MIXTURES

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by
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Abstract

There are many different correlations available in the literature applied to predict saturated liquid molar volumes for pure compounds. They are Rackett, Spencer and Danner, Yamada and Gunn, Yen Woods, Bradford and Thodos, Reidel, and Hankinson Thomson equations. The investigation of these empirical correlations shows that the best correlation was Hankinson and Thomson equation (HT) for nonpolar and Reidel for Polar components.

There are many methods are available in the literature to predict saturated molar volume of pure liquid compounds at normal boiling point. They are Tyn and Calus, Schroeder, and Le Bas methods. The results show that Tyn and Calus have the highest accuracy among the three correlations. Further more it is simple and easy to use.

The modification of HT equation has been started from the idea that the modification of constants may lead to more accurate results for calculating saturated liquid molar volume.

The value of constants in equation $V_r^{(0)}$ have been estimated using data of Ar for $(\omega = 0)$, the correlation coefficient of this equation is 0.99998. The second variable of HT equation is $V_r^{(\delta)}$ had constructed for compounds that have a maximum acentric factor like Methane, n-Pentane and Ethanol, and the correlation coefficient of this equation is 0.9896.

The new constants are

$a = -1.22916 \quad b = 0.087280 \quad c = 1.283902 \quad d = 0.902008$

$e = -0.707480 \quad f = 1.771180 \quad g = -1.70029 \quad h = 0.636584$

The experimental data of the molar volume of saturated liquids, obtained from the literature for the purpose of this investigation consists of 250 data points of six polar pure compounds, and 555 data points of twenty non polar pure compounds. The AAD%. of the twenty non polar compounds

for 555 data points is 1.1236%for Rackett, 4.1991% for Yen Wood, 0.9645% for Yamada and Gunn, 1.3593% for Spencer and Danner, 0.9449% for Reidel, 1.2860% for Bradford and Thodos, 0.9141% for Hankinson Thomson, and finally the AAD%. For the modified Hankinson Thomson equation is 0.7888%. The AAD%. of the six polar compounds for 250 data points is 2.4863% for Rackett, 4.7266% for Yen Wood, 2.5344% for Yamada and Gunn, 7.1465% for Spencer and Danner, 2.1153% for Reidel, 2.2019% for Bradford and Thodos, 2.2967% for Hankinson Thomson, and finally the AADW%. for the modified Hankinson Thomson equation is 1.7138%.

Another modified correlation was made for Tyn and Calus for changing the slop of data points to another constant, the deviation of data was decreased for nonpolar compounds. So effort was made to modify it to increase its accuracy and to reduce its deviation from experimental value as much as possible using statistical methods. The equation in modified form is:

$$V_b = 0.348 V_c^{1.016}$$

The AD% of nonpolar compounds is 3.7716% for Tyne and calus, 4.8210% for Schroeder, 9.5667% for Le Bas and finally the AD% for modified Tyne and calus is 1.1624%, but the results of polar compound were not satisfactory, The AD% of polar compounds is 1.164% for Tyne and calus, 6.2015% for Schroeder, 7.2987% for Le Bas and finally the AD% for modified Tyne and calus is 1.7436%.

On the other hand many other correlations were used to predict molar volumes for mixtures, Hankinson Thomson mixing rule was applied to Hankinson Thomson model and developed Hankinson Thomson. The experimental data of the molar volume of saturated liquids mixtures obtained from the literature for the purpose of this investigation consists of 792 data points of 26 mixtures. The results were obtained for modified HT equation equal to 2.8953 AAD%, while for HT equation is 5.2811 AAD%.

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Nomenclature

Symbol	Description	Units
AAD	Absolute Average Deviation	
EOS	Equation of state	
M.WT	Molecular weight	g/gmol
P	Pressure	Pa
PR	Peng Robinson	
R	Gas constant	J/mole.K
SRK	Sove Redlich Kowing	
T	Temperature	K
x	Mole fraction	
V	Volume	cm^3
V*	characteristic volume	
w	Acentric Factor	
Z	Compressibility factor	
Z_{RA}	unique constant for each compound	
ρ	Density	kg/m^3
α	adjustable parameters	
β	adjustable parameters	

Subscript

Symbol	Description
b	Boiling
c	Critical
cm	Critical for mixture
DB	Double bonds
i	Species
r	Reduced
rs	Reduced in saturation
s	Saturated
sat	Saturated
SC	Scaled
TB	Triple bonds

Superscript

Symbol	Description
(o)	At $\omega = 0$
(δ)	At any ω

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

Molar volume is one of the most important thermodynamic properties of a compound. In almost all design calculation, there is a need of the value of molar volume. For saturated liquid or vapor and for gas phase, volume V is important in high pressure processing and particularly in the design and operating high pressure pumps for all liquids in the chemical processing and factories. The volume handing and power characteristics of such pumps are strongly influenced by liquid's isothermal bulk compressibility [1].

Densities or molar volumes are needed in many engineering problems such as process calculations, simulations, equipment and pipe design, and liquid metering calculations. A good molar volume correlation should be accurate and reliable over the whole liquid region from the freezing point to the critical point. In most practical cases, the fluids of interest are mixtures [2].

So, there are many equations to calculate the molar volumes, the methods to be used in this work are based on the experimental data taken from literatures and fitting these data to the equations in terms of a suitable parameter.

Pure gases are classified as polar and non polar gases. Non polar gases are classified as [1, 2]:

1. Fluids with spherical molecules (simple fluids) as example Argon and Krypton, having a zero acentric factor (ω=0).
2. Quantum gases as example He, H, having negative acentric factor (ω<0).
3. Other nonpolar fluids as example Benzene, n-Butane, having positive acentric factor (ω>0).

Polar gases are classified as:

1. Non hydrogen bonding components such as Ketones, and aldehydes.
2. Hydrogen bonding compounds (a bond forms between the hydrogen atom attached to oxygen in one molecule with the oxygen atom of another molecule) such as alcohols, and water.

1.2 Aim of This Work

1- Calculate the molar volume of saturated liquid using many equations and to find the best one that gives the lowest deviation (and highest accuracy) and then efforts will be done to modify this equation to obtain if possible an expression that increases the accuracy as much as possible at moderate conditions and ranges of temperatures, this modification will be tried by using a statistical methods.

2- Calculate the molar volume at normal boiling point using three equations and find the best one, then to modify it using statistical method.

3- Applying a suitable mixing rule to the best equation and its modified.

CHAPTER TWO
THEORIES AND LITERATURES

2.1 Introduction.

Liquid densities are needed in many engineering problems such as process calculations, simulations, equipment and pipe design, high pressure vapor-liquid equilibrium studies and liquid metering calculations [3]. Corresponding states theory correlations play an important role in predicting these densities at various conditions [4]. Not infrequently densities and other properties are required at temperatures for which no experimental data exist [5]. A good liquid density correlation should be accurate and reliable over the whole liquid region from the freezing point to the critical point. In most practical cases, the fluids of interest are mixtures [6].

The merit of a complex equation of state lies in its versatility, i. e., the equation may be applicable to all phases, liquid, vapor, and dense phase. However, for the calculation of saturated liquid molar volume alone, simpler equations are often more accurate and easier to use. Numerous accurate corresponding states correlations for the liquid molar volume have been reported in the literature in the past decade [7]. A few of the most widely used correlations are discussed here.

2.2 Density and Molar Volume of Saturated Liquids.

Density shown by d or ρ is defined as mass per unit volume and it is reciprocal of specific volume. Density may also be presented in terms of number of moles per unit volume, which is called *molar density* and itis

reciprocal of molar volume. It can be obtained by dividing absolute density by molecular weight [8].

Density is perhaps one of the most important physical properties of a fluid, since in addition to its direct use in size calculations it is needed to predict other thermodynamic properties, methods to estimate transport properties of dense fluids also require reduced density. Therefore once an accurate value of density is used as an input parameter for a correlation to estimate a physical property, a more reliable value of that property can be calculated. Density may be expressed in the form of absolute density (ρ, g/cm^3), molar density (ρ m, mol/cm^3), specific volume (V, cm^3/g), molar volume (Vm, cm^3/mol), reduced density ($\rho r = \rho / \rho c = Vc/V$, dimensionless), or compressibility factor ($Z = PV/RT$ dimensionless) [9].

Density is a state function and for a pure compound depends on both temperature and pressure. Liquid densities decrease as temperature increases but the effect of pressure on liquid densities at moderate pressures is usually negligible. At low and moderate pressures (less than a few bars), saturated liquid density is nearly the same as actual density at the same temperature [10].

Equations of states or generalized correlations predict Vm or Z at a given T and P. Once Z is known, the absolute density can be calculated from:

$$\rho = \frac{MP}{ZRT} \tag{2-1}$$

where M is the molecular weight, R is the gas constant, and T is the absolute temperature. If M is in g/mol, P in bars, T in Kelvin, and R = 83.14 bar. cm^3/mol. K, then ρ is calculated in g/cm^3. Equation (2-1) is valid for gases once their Z values are calculated from an equation of state or a generalized correlation [8].

For high-pressure liquids, density may be estimated from cubic EOS such as PR or SRK equations. However, these equations break at carbon number of about C_{10} for liquid density calculations. They provide reasonable values of liquid density. The error of liquid density calculations from cubic equations of states increases at low and atmospheric pressures. For saturated liquids, special care should be taken to take the right Z value (the lowest root of a cubic equation). The Lee-Kesler correlation is particularly useful for rapid-hand calculations for a single data point. The most accurate method for prediction of saturated liquid densities is through Rackett equation. However, for high-pressure liquids the method of COSTALD correlation may be used combined with the Rackett equation to provide very accurate density values for both pure components and petroleum fractions. These methods are also applicable to nonhydrocarbons as well. At low pressures or when the pressure is near saturation pressure, no correction on the effect of pressure is required and saturated liquid density calculated from Rackett equation may be directly used as the density of compressed (subcooled) liquid at pressure of interest [10].

2.3 Critical Properties.

The critical point is a point on the pressure-volume temperature diagram where the saturated liquid and saturated vapor is identical and indistinguishable. The temperature, pressure, and volume of a pure substance at the critical point are called *critical temperature (Tc), critical pressure* (Pc), and *critical volume (Vc),* respectively. In other words, the critical temperature and pressure for a pure compound are the highest temperature and pressure at which the vapor and liquid phase can coexist at equilibrium. In fact, for a pure compound at temperatures above the critical temperature, it is impossible to liquefy a vapor no matter how high the pressure is. A fluid whose temperature

and pressure are above the critical point is called supercritical fluid [11]. For pure compounds, critical temperature and pressure are also called true critical temperature and true critical pressure. *Pseudocritical properties* are defined for mixtures and petroleum fractions, which are different from true critical properties. Pseudocritical properties are important in process calculations for the estimation of thermophysical properties of mixtures [12].

The critical compressibility factor, *Zc,* is defined from Tc, Pc, and Vc according to the general definition of compressibility factor [13].

$$Zc = \frac{PcVc}{RTc} \tag{2-2}$$

where R is the universal gas constant. According to Eq. (2.2), Zc is dimensionless and Vc must be in terms of molar volume (i.e., cm^3/mol) to be consistent with R values. Critical temperature, pressure, and volume *(Tc, Pc, Vc*) are called the *critical constants* or *critical properties.* Critical constants are important characteristics of pure compounds and mixtures and are used in corresponding states correlations and equations of state (EOS) to calculate *PVT* and many other thermodynamic, physical, and transport properties. The results of EOS calculations very much depend on the values of critical properties used. Critical volume may be expressed in terms of specific critical volume (i.e., m^3/kg), molar critical volume (i.e., m^3/kmol), or critical density dc (i.e., kg/m^3) or critical molar density (i.e., kmol/m^3) [14].

2.4 Reduced Properties.

The most generalized correlation is based on the observation that data for different fluids exhibit a remarkable uniformity when the thermodynamic coordinates are expressed in suitable dimensionless or reduced form. This fact is the experimental basis for the theorem of corresponding states. Thus the reduced conditions are [13, 15].

$$\left.\begin{aligned} Tr &= \frac{T}{Tc} \\ \Pr &= \frac{P}{Pc} \\ Vr &= \frac{V}{Vc} \end{aligned}\right\} \qquad (2\text{-}3)$$

2.5 Acentric Factor (*w*).

Acentric factor is a parameter that was originally defined by Pitzer to improve accuracy of corresponding state correlations for heavier and more complex compounds [15, 16]. Acentric factor is a defined parameter and not a measurable quantity. It is a dimensionless parameter represented by w and is defined as:

$$w = -1 - \log\left[\Pr_{sat}\right]_{Tr=0.7} \qquad (2\text{-}4)$$

The argument of the logarithm is the reduced vapor pressure (Psat/Pc) evaluated at reduced temperature of 0.7.

Acentric factor is defined in a way that for simple fluids such as argon and xenon it is zero and its value increases as the size and shape of molecule changes. For methane *w* =0.001 and for decane it is 0.489. Values reported for acentric factor of pure compounds are calculated based on Eq. (2.4), which depends on the values of vapor pressure. For this reason values reported for the acentric factor of a compound may slightly vary from one source to another depending on the relation used to estimate the vapor pressure. In addition, since calculation of the acentric factor requires values of critical temperature and pressure, reported values for w also depend on the values of Tc and Pc used [8]. Values of *w* for selected substance are given in ***Appendix A***.

2.6 Polar Compounds

Polar compounds are characterized by a non-zero dipole moment μ, which expresses the effect of electrostatic forces between molecules. Polar compounds are alcohol, phenol, water, ketones, aldehydes, ether, and alknitriles. The first three are hydrogen bonding compounds (a bond forms between the hydrogen atom attached to oxygen in one molecule), this makes their behavior in the vapor different and more complex than that of non–hydrogen bonding compounds (ketones, etc)[11, 17].

2.7 Boiling Point

The boiling point of a pure compound at a given pressure is the temperature at which vapor and liquid exist together at equilibrium. If the pressure is 1 atm, the boiling point is called the normal boiling point. However, usually the term *boiling point, Tb,* is used instead of normal boiling point and for other pressures the term *saturation temperature* is used. In some cases, especially for heavy hydrocarbons in which thermal cracking may occur at high temperatures, boiling points at pressures other than atmospheric are specified [8]. The boiling point, when available, is one of the most important characterization parameters for hydrocarbons and is frequently used in property estimation methods [18].

2.8 Equation of State.

An EOS is a mathematical equation that relates pressure, volume, and temperature. The simplest form of these equations is the ideal gas law that is only applicable to gases. In 1873, van der Waals proposed the first cubic EOS that was based on the theory of continuity of liquids and gases. Since then

many modifications of cubic equations have been developed and have found great industrial application especially in the petroleum industry because of their mathematical simplicity. More sophisticated equations are also proposed in recent decades that are useful for certain systems [8, 19].

Liquid densities can be calculated from equations of state (EOS). Normally, the accuracy of liquid density predictions with EOS is not sufficient, and therefore special correlations for liquid density are used. Many accurate correlations are available for saturated liquid densities of pure fluids. The accuracy of many models is not good enough for mixtures, mainly due to problems in formulating the mixing rules [6].

2.9 Alternative Analytical Methods.

2.9.1 Guggenheim Equation.

Guggenheim in (1945) suggested a simpler empirical formula for representing saturated liquid argon. The scaling volume was used in the calculation instead of the critical volume. It is of the following form:

$$\begin{aligned} &\rho_{rs} = 1 + \alpha(1 - T_r) + \beta(1 - T_r)^{1/3} \\ &where \quad \alpha = 3/4 \ \ and \quad \beta = 7/4 \\ &\rho_{rs} = 1/V_{SC} \\ &V_{SC} = \frac{V_{0.6}}{0.3862 - 0.0866\omega} \end{aligned} \tag{2-5}$$

In this investigation, Eq. 2-5 was used for representing saturated liquid densities for nonpolar and slightly polar compounds, but with the quantities α and β treated as two adjustable parameters. In addition, it was intended to correlate these two parameters in terms of the three parameter corresponding states formulation [21].

The Parameters α and β of the 23 compounds were determined by least squares method. Values of these parameters were also listed in [21] and were further correlated in the following forms linear in the acentric factor:

$$\alpha = 0.73098 + 0.28908\omega \quad (2\text{-}6)$$

$$\beta = 1.75238 + 0.74293\omega \quad (2\text{-}7)$$

The average deviation of the calculated densities and literature values for a total 595 data points tested was01 0.27%. The proposed correlation provide as accurate and simple means of predicting the temperature effect on saturated liquid densities.

2.9.2 Riedel.

Riedel in (1954) proposed an empirical equation for calculating saturated molar volume for liquids depending on two parameters corresponding states method (1-T_r) [22].

$$\rho_s / \rho_C = 1 + (1.69 + 0.984\omega)(1 - T_r)^{1/3} + 0.85(1 - T_r) \quad (2\text{-}8)$$

2.9.3 Alfred W. Francis.

Francis in (1958) presented simple equations which were published [23] for 44 hydrocarbons relating saturated liquid densities with temperature over wide ranges. Another equation showed a simple relation between liquid density and slopes of isochors, $(dP/dt)_V$, for compression of 27 hydrocarbons and hydrogen. The same forms of equations have now been found applicable to non-hydrocarbons over even wider ranges and with deviations hardly greater than uncertainties in observations, or an average of less than 0.0008.

$$\rho_s = A - BT - \frac{C}{E - T} \quad (2\text{-}9)$$

Eq. 2-9 has been derived for 81 non-hydrocarbons, including 27 inorganic liquids. The constants were presented for 130 pure substances [23, 24].

2.9.4 Yen and Woods.

Yen and Woods in (1966) proposed a generalized equation for the coefficient in terms of Z_C based on the three parameter corresponding states method [25]

$$
\begin{aligned}
&V_C / V_s = 1 + A(1-T_r)^{1/3} + B(1-T_r)^{2/3} + (0.93-B)(1-T_r)^{4/3} \\
&where \\
&V_s = Saturated\ liquid\ molar volume \\
&A = 17.4425 - 214.578Z_C + 989.625Z_C^2 - 1522.06Z_C^3 \\
&B = -3.28257 + 13.6377Z_C + 107.4844Z_C^2 - 384.211Z_C^3 \\
&B = 60.2091 - 402.063Z_C + 501Z_C^2 + 641Z_C^3
\end{aligned}
\qquad (2\text{-}10)
$$

This equation was widely used in hydrocarbon industry until the appearance of Rackett equation and its modifications.

2.9.5 Bradford and Thodos.

Bradford and Thodos in (1968) proposed a generalized equation for the coefficient in terms of Z_C based on the three parameter corresponding states method [26].

$$
\begin{aligned}
\rho_s / \rho_C = {} & 1 + (2.924 - 7.34Z_C)(1-T_r) - (1.139 - 3.796Z_C)(1-T_r)^2 + \\
& (2.785 - 3.544Z_C)(1-T_r)^{(0.16+0.586Z_C)}
\end{aligned}
\qquad (2\text{-}11)
$$

2.9.6 Rackett Equation.

Rackett proposed an unusually simple generalized equation for predicting liquid volumes. The accuracy of this equation is only moderate [27].

$$V_s = V_c Z_c^{(1-Tr)^{2/7}} \qquad (2\text{-}12)$$

This equation is in fact a generalized correlation for saturated liquids and it is in dimensionless form [8]. Rackett demonstrated the accuracy of equation 2-12 by comparing the actual Z_c with the best values of Z_c back calculated from the equation and experimental volumetric data for a number of substances [27].

2.9.7 Spencer and Danner.

Spencer and Danner in (1972) replaced Z_C in Eq 2-12 with adjustable parameter, Z_{RA} is

$$V_s = \frac{RT_C}{P_C} Z_{RA}^{(1-Tr)^{2/7}} \tag{2-13}$$

Z_{RA} is a unique constant for each compound, and are listed in the literature. If a value of Z_{RA} is not available, it may be estimated from this equation

$$Z_{RA} = 0.29056 - 0.08775w \tag{2-14}$$

Note that Eq. 2-13 does not predict the correct volume at the critical point unless $Z_{RA}=Z_C$ [28, 29]

2.9.8 Bhirud's Method.

Bhirud in [27] has presented the following corresponding states equation for the saturated liquid volume of normal (nonpolar) fluids

$$\ln \frac{P_C V_s}{RT} = \ln V^{(0)} + w \ln V^{(1)} \tag{2-15}$$

$$lnV^{(0)} = 1.39644 - 24.076T_r + 102.615T_r^2 - 255.719T_r^3 + 355.805T_r^4 - 256.671T_r^5 + 75.1088T_r^6 \tag{2-16}$$

$$\ln V^{(1)} = 13.4412 - 135.743T_r + 533.38T_r^2 - 1091.453T_r^3 + 1231.43T_r^4 - 728.227T_r^5 + 176.737T_r^6 \tag{2-17}$$

Above T_r=0.98, values of $lnV^{(0)}$ and $\ln V^{(1)}$ from tables in [28] should be used. Eq. 2-15 gave an average percent deviation of 0.76 percent for 752 data points for hydrocarbons for reduced temperatures between 0.3 and 1.0. Bhirud has extended his method to polar compounds, but the extension requires an experimental density [30].

2.9.9 Yamada and Gunn.

Yamada and Gunn in (1973) proposed that Zc in Equation 2-12 be correlated with the acentric factor.

$$V_s = V_c \left(0.29056 - 0.08775w\right)^{(1-Tr)^{2/7}} \tag{2-18}$$

If one experimental density, V_s^R is available at a reference temperature, T^R, Eqs 2-12 and 2-18 can be modified to give

$$V_s = V_s^R \left(0.29056 - 0.08775w\right)^{\phi} \tag{2-19a}$$

$$V_s = V_s^R Zc^{\phi} \tag{2-19b}$$

Where

$$\phi = (1 - T/T_c)^{2/7} - (1 - T^R/T_c)^{2/7} \tag{2-20}$$

An often used variation of Eq. 2-18 is

$$V_s = \frac{RT_C}{P_C}\left(0.29056 - 0.08775w\right)^{(1-Tr)^{2/7}} \tag{2-21}$$

However, this form dose not predict V_C correctly unless the actual $Z_C = 0.29056 - 0.08775w$, in which case it is identical to Eq 2-12 [28].

2.9.10 Hankinson Thomson Model (HT).

Upon careful examination of Yen-Woods equation, Rackett Equation, as modified by Spencer and Danner, and Gunn Yamada equation, Hankinson and Thomson [31] chose Gunn-Yamada equation to develop more accurate liquid molar volume correlation.

Gunn and Yamada presented a corresponding state correlation for the liquid molar volume in terms of T_r, and "scaled volume", V_{SC}

$$V_s = V_{SC} V_r^{(o)} \left(1 - w\,\delta\right) \tag{2-22}$$

Where $V_r^{(o)}$ and δ are function of T_r and V_{SC} is given by

$$V_{SC} = V_{0.6} / \left(0.3862 - 0.0866w\right) \tag{2-23}$$

Where $V_{0.6}$ is the liquid molar volume at T_r=0.6 [7].

Hankinson and Thomson modified the Gunn-Yamada equation as follows:

$$V_s = V^* V_r^{(o)} \left(1 - w_{SRK} V_r^{(\delta)}\right) \tag{2-24}$$

$$where\ V_r^{(o)} = 1 + a\left(1 - T_r\right)^{1/3} + b\left(1 - T_r\right)^{2/3} + c\left(1 - T_r\right) + d\left(1 - T_r\right)^{4/3} \tag{2-25}$$

$$when\ 0.25 \prec T_r \prec 0.95$$

$$V_r^{(\delta)} = \frac{e + fT_r + gT_r^2 + hT_r^3}{T_r - 1.00001}\ when\ 0.25 \prec T_r \prec 1.0 \tag{2-26}$$

$$T_r = \frac{T}{T_{C,HT}} \tag{2-27}$$

The pure-component specific parameters are the following: characteristic volume V*, slightly adjusted critical temperature $T_{C,HBT}$ and the SRK-acentric factor ω_{SRK}.

For Equation 2-25 and 2-26 the general parameters are the following:

$a = -1.52816$ $b = 1.43907$ $c = -0.81446$ $d = 0.190454$

$e = -0.296123$ $f = 0.386914$ $g = -0.0427258$ $h = -0.0480645$

w_{SRK} is the back calculated "acentric factor" that allows the soave R-K equation to best represent the vapor pressure.

V^* is an adjustable parameter called "characteristic volume." The values of this parameter were determined by regression analysis on the liquid molar volume data [31].

2.9.11 Other Equations.

There are many equations to estimate liquid molar volume as shown below [32, 33]:

2.9.11.1 Lyckman et al.

$$\rho_C / \rho_S = V_r = V_r^{(0)} + \omega V_r^{(1)} + \omega^2 V_r^{(2)} \tag{2-27}$$

$$where\ V_r^{(i)}\text{'s are generalized function of } T_r.$$

2.9.11.2 Halm and Stiel

$$1/\rho_S = V_s = V_r^{(0)} + \omega V^{(1)} + \chi V^{(2)} + +\omega^2 V^{(3)} + \chi V^{(4)} + \omega\chi V^{(5)} \quad (2\text{-}28)$$

where $V^{(i)}$*'s are generalized function of* T_r.

and $\chi = \log P_r (T_r \to 0.6) + 1.7\omega + 1.552$ (2-29)

2.9.11.3 Holmes

$$\rho_S/\rho_C = (1-\omega)\rho_r^{(0)} + \omega\rho_r^{(1)} \quad (2\text{-}30)$$

where $\rho_r^{(i)}$*'s are generalized function of* T_r *and* P_r.

2.9.11.4 Harmans

$$\rho_S/\rho_C = (0.43875 - 0.625 Z_C) f(T_r) \quad (2\text{-}31)$$

where $f(T_r)$ *are generalized function, density plot*.

2.9.11.5 Harlacher

$$\rho_S/\rho_C = 1 + K(1-T_r)^{1/3} + L(1-T_r)^{2/3} \quad (2\text{-}32)$$

where K and L are specified constants for each compounds (constants have generalized as function of the preacher and ω)

2.9.11.6 Ehrlich

$$\left[(\rho_s/\rho_C) - 1\right]^3 / \left[(\rho_s/\rho_C)(1-T_r)\right] = A + B(1-T_r) + C(1-T_r)^2 \quad (2\text{-}33)$$

Where A and B are specified constant for each compound.

2.9.11.7 Narsimham

$$\rho_S/\rho_C = 1 + \left[(0.422 \log P_C + 0.981)/(1 - T_b/T_C)^{0.40}\right](1-T_r)^{0.4} \quad (2\text{-}34)$$

The detailed information's of these equations are not found in the literatures because of absence of papers [33].

2.10 Methods for Calculating Saturated Liquid Molar Volume at Normal Boiling Points.

Two methods are presented here to estimate the liquid volume at the normal boiling point temperature. In addition, methods will be presented later that give the volume as a function of temperature which may also be used for obtaining V_b at T_b. Equations of state may also be used for estimating volumes.

2.10.1 Additive Methods.

Schroeder (1949) suggested a simple additive method for estimating molar volumes at the normal boiling point. His rule is to count the number of atoms of carbon, hydrogen, oxygen, and nitrogen, add one for each double bond, two for each triple bond and multiply the sum by seven [22]. Schroeder's original rule has been expanded to include halogens, sulfur, and triple bonds. This gives the volume in cubic centimeters per gram mole. This rule is surprisingly accurate, giving results within 3 to 4% error except for highly associated liquids. Table 2-1 gives the contributions to be used. The values in the table may be expressed in equation form as

$$\begin{aligned} V_b = 7\left(N_C + N_H + N_O + N_N + N_{DB} + 2N_{TB}\right) + 31.5N_{Br} + 24.5N_{Cl} \\ + 10.5N_F + 38.5N_I + 21N_S - 7^* \end{aligned} \tag{2-35}$$

where subscripts DB and TB stand for double and triple bonds and the last value* is counted once if the compound has one or more rings. V_b for benzene, for example, is $7(6+6+3)-7 = 98 cm^3 mole^{-1}$ compared to the experimental value of 95.8 or 2.3% error. The average error for the compounds tested is 3.9% with 5 strongly polar and associating substances having errors greater than 10% [22, 23].

The additive volume method of Le Bas (1915) is an alternative to Schroeder's rule. Volume increments from Le Bas are shown in table 2-1 and

calculated values of V_b are compared with experimental values. The average error for the compounds tested is 3.9% with 5 substances having errors greater than 10% [22, 23].

2.10.2 Tyn and Calus Method

In this method, V_b is related to the critical volume by

$$V_b = 0.285 V_c^{1.048} \tag{2-36}$$

where both V_b and V_c are expressed in cubic centimeters per gram mole. Comparisons with the substances show that this method is somewhat more accurate and has greater reliability since only 1 substance has an error of more than 10%. The table results are representative of the method where errors exceed 3% only for the low-boiling permanent gases (He, H2, Ne, Ar, Kr) and some polar nitrogen and phosphorus compounds (HCN, PH3, BF3).

Table 2-1: Group/Atom Contribution for Schroeder and Le Bas Methods

	Increment, cm^3/mol	
	Schroeder	**Le Bas**
Carbon	7.0	14.8
Hydrogen	7.0	3.7
Oxygen	7.0	7.4
In methyl esters and ethers		9.1
In ethyl esters and ethers		9.9
In higher esters and ethers		11.0
In acids		12.0
Joined to S,P and N		8.3
Nitrogen	7.0	
Doubly bonded		15.6
In primary amines		10.5
In secondary amines		12.0
Bromine	31.5	27.0
Chlorine	24.5	24.6
Flourine	10.5	8.7
Iodine	38.5	37.0
Sulfur	21.0	25.6
Ring,three-membered	-7.0	-6.0
Four-membered	-7.0	-8.5
Five-membered	-7.0	-11.5
Six-membered	-7.0	-15.0
Naphthalene	-7.0	-30.0
Anthracene	-7.0	-47.5
Double bond	7.0	
Triple bond	14.0	

2.11 Methods for Calculating Saturated Liquid Molar Volume for Mixtures.

The methods reviewed above are for pure components calculations. To extend the methods to mixtures, they must be modified to include the additional variable of composition. In essentially all cases, the inclusion is accomplished by averaging pure component constants to obtain constants which hopefully characterize the mixtures. Equations that do this are called mixing rules [16].

2.11.1 Extension of Rackett Equation to Mixture

Rackett in 1971 have reported an extensive evaluation of a form of the Rackett equation for predicting the saturated liquid density of pure compounds (21).

$$V_s = V_c Z_c^{(1-Tr)^{2/7}} \tag{2-12}$$

Spencer and Danner rearranged the Rackett equation by replacing V_C with $Z_C RT_C/P_C$ and then determined the best values of Z_C that would result in least errors for the prediction of saturated liquid molar volume for more than 100 pure fluids. They denoted the Z_C parameter "Z_{RA}" to distinguish it from the actual Z_C. Their modified equation was given in [34]. They recommended the following set of mixing rules for applying Eq. 2-13 to mixtures:

$$RT_C / P_C = R \sum_i^N x_i T_{Ci} / P_{Ci} \tag{2-37}$$

$$Z_{RA} = \sum_i^N x_i Z_{RAi} \tag{2-38}$$

$$T_C = \left(\sum_i^N x_i V_{Ci} T_{Ci} \right) \Big/ \left(\sum_i^N x_i V_{Ci} \right) \tag{2-39}$$

2.11.2 Extension of Yen-Woods Equation to Mixture

Eq (2-10) was extended to mixture as follows:

$$T_C = \sum_i^N x_i T_{Ci} \tag{2-40}$$

$$V_C = \sum_i^N x_i V_{Ci} \tag{2-41}$$

$$Z_C = \sum_i^N x_i Z_{Ci} \tag{2-42}$$

2.11.3 Extension of HT Equation to Mixture

The Hankinson-Thomson equation is slightly more accurate than the Spencer-Dannner's modified Rackett equation for pure fluids, but itis notably more accurate for mixtures. Hankinson and Thomson recommended the following set of mixing rules:

$$T_{cm} = \left(\sum_i^N x_i \left(V_{Ci} T_{Ci} \right)^{0.5} \right)^2 \Big/ V_{cm} \tag{2-43}$$

$$V_{cm} = \frac{1}{4}\left[\sum_i^N x_i V_i^{*} + 3\left(\sum_i^N x_i V_i^{*2/3} \right)\left(\sum_i^N x_i V_i^{*1/3} \right) \right] \tag{2-44}$$

$$\omega_{SRK} = \sum_i^N x_i \left(\omega_{SRK} \right)_i \tag{2-45}$$

Using T_{cm} from Eq. (2-43) to obtain Tr, V^* of Eq. (2-44) is a parameter fit to experimental data and is nearly identical to the pure component *Vc*, while ω_{SRK} is that value of ω that causes the Soave EOS to be most closely match experimental vapor pressure behavior and itis nearly equal to the true value of ω_i. However, results are only marginally affected if *V** and ω_{SRK} are replaced with the true values of *Vc* and ω.

CHAPTER THREE
INVESTIGATION AND DEVELOPMENT

3.1 Introduction.

Liquid molar volumes can be calculated from equations of state (EOS). Normally, the accuracy of liquid molar volumes prediction with EOS is not sufficient, and therefore special correlations for liquid molar volumes are used. Many accurate correlations are available for saturated liquid molar volumes of pure fluids. The accuracy of many models is not good enough for mixtures, mainly due to the problems in formulating the mixing rules.

In this chapter many different empirical equations were applied to calculate the molar volumes of saturated pure liquids such as Rackett, Spencer and Danner, Yamada and Gunn, Yen Woods, Bradford and Thodos,. Reidel, and Hankinson Thomson equations.

It is a well known fact that the evaluation of any correlations or prediction method is done by comparison of the results with the results of experimental dependable data. The deviation between the experimental results and the results of prediction or correlation method determine the accuracy of the method. The experimental data of the molar volume of saturated liquids, obtained from literature for the purpose of this investigation consists of 250 data points of six polar pure compounds as shown in table 3-1, and 555 data points of twenty non polar pure compounds as shown in table 3-2.

Table 3-1: Experimental Data for Polar Compounds

Compounds	Temp.range(K)	No.of points	Ref.
R-11	203.15-463.15	28	**35**
R-12	183.15-383.15	38	**35**
R-22	203.15-368.15	35	**35**
Water	273.15-638.15	74	**35**
Ammonia	223.15-403.15	37	**35**
Ethanol	275.95-508.65	38	**36**
Total		**250**	

Table 3-2: Experimental Data for Non-polar Compounds

Compounds	Temp.range(K)	No.of points	Ref.
Argon	83.80-150.00	16	**35**
1,3-butadiene	273.15-415.38	38	**36**
Benzene	280.00-555.00	43	**36**
Carbon Dioxide	216.55-303.00	43	**36**
Cyclopropane	291.66-397.22	20	**37**
R-245	233.15-377.59	27	**38**
R-123	223.15-453.15	38	**35**
R-134a	203.15-373.15	36	**35**
Isobutylene	255.37-417.87	31	**39**
Propane	85.50-360.00	16	**35**
Isobutane	261.32-407.50	30	**40**
n-Pentane	309.19-469.50	28	**41**
Isopentane	301.02-460.39	29	**41**
Neopentane	282.62-433.75	27	**41**
Oxygen	54.40-154.60	22	**35**
Nitrogen	63.10-126.20	16	**35**
Methane	90.70-180.00	20	**35**
Ethane	90.40-300.00	23	**35**
Ethylene	104.00-280.00	20	**35**
n-Butane	272.67-424.50	32	**40**
Total		**555**	

On the other hand many other correlations were used to predict molar volumes for mixtures, Hankinson Thomson mixing rule was applied to Hankinson Thomson model and developed Hankinson Thomson. The experimental data of the molar volume of saturated liquid mixtures obtained from literature for the purpose of this investigation consists of 792 data points of 26 mixtures as shown in table 3-3.

Table 3-3: Experimental Data for Mixtures

Mixtures	No.of points	Ref.
Butane-Octane	65	**42**
Aniline-Methanol	33	**43**
Benzene-Methanol	33	**43**
C_3H_7OH-CCl_4	30	**44**
$C_9H_{10}OH$-CCl_4	27	**44**
$C_5H_{12}OH$-CCl_4	30	**44**
$C_7H_{15}OH$-CCl_4	27	**44**
$C_8H_{17}OH$-CCl_4	30	**44**
CCl_4 -Benzene	8	**45**
CCl_4 -Hexane	8	**45**
Hexadecane-Benzene	9	**45**
Hexadecane-CCl_4	10	**45**
Hexadecan-Hexane	20	**45**
Iso C_3H_7OH-CCl_4	42	**44**
Iso $C_4H_{10}OH$-CCl_4	30	**44**
Iso $C_5H_{12}OH$ –CCl_4	27	**44**
Methane-nDecane	60	**46**
Methane-3methylpentane	28	**47**
Methanol-CCl_4	30	**44**
Phenol-Methanol	22	**43**
Toluene-Methanol	33	**43**
Tetradecane-nHexane	10	**45**
Tetra$C_5H_{12}OH$-CCl_4	27	**44**
Sec$C_4H_{10}OH$-CCl_4	27	**44**
R11-R12	48	**48**
Propane-nOctane	78	**42**
Total	**792**	

3.2 Selected Empirical Equations.

3.2.1 Rackett Equation.

Rackett equation (1970) [21] is the simplest in form among all equations considered and requires not arbitrary constants for its evaluation. One simply needs the critical constants Tc, Pc, and Zc. It is able to predict reasonable results from the triple points to the critical points for most substances. The results of pure non-polar compounds were very good excepted methane, and neopentane and this may be caused by some inaccurate experimental data as shown in table 3-4. Table 3-4 shows the maximum deviation from experimental data which is 3.8530% for neopentane and the minimum deviation is 0.3413% for Cyclopropane, but the results obtained when using this equation to calculate the molar volumes of saturated liquid of pure polar compound were not satisfactory as shown in table 3-5

Table 3-4: Results of Rackett Equation for non polar compounds

Compounds	No.of points	AAD%of Rackett
Argon	16	1.2159
1,3-butadiene	38	0.3881
Benzene	43	1.2541
CarbonDioxide	43	0.8098
Cyclopropane	20	0.3413
R-245	27	0.5815
R-123	38	0.8847
R-134a	36	1.1367
Isobutylene	31	1.4981
propane	16	0.5033
Isobutene	30	2.6388
n-pentane	28	0.3880
Isopentane	29	0.3416
Neopentane	27	3.8530
Oxygen	22	0.7665
Nitrogen	16	0.6281
Methane	20	3.4045
Ethane	23	1.0558
Ethylene	20	0.3515
n-Butane	32	0.4313
Total	**555**	**1.1236**

Table 3-5*:* Results of Rackett Equation for polar compounds

Compounds	No.of points	AAD%of Rackett
R-11	28	3.0047
R-12	38	2.0846
R-22	35	1.9436
water	74	3.8887
Ammonia	37	0.6045
Ethanol	38	3.3921
Total	**250**	**2.4863**

3.2.2 Yen-Woods Equation.

Another correlation is Yen-Woods (1966) [24], it was the worst one among all the correlations. Although it worked but it gave inaccurate results for polar and non polar compounds as shown in tables 3-6 and 3-7.

Table 3-6: Results of Yen-Woods Equation for non polar compounds

Compounds	No.of points	AAD%of Yen-Woods
Argon	16	10.2509
1,3-butadiene	38	1.2130
Benzene	43	2.5331
CarbonDioxide	43	3.1900
Cyclopropane	20	2.3417
R-245	27	1.5481
R-123	38	2.4261
R-134a	36	1.6740
Isobutylene	31	3.9476
propane	16	2.5684
Isobutene	30	6.4168
n-pentane	28	1.6426
Isopentane	29	2.2363
Neopentane	27	2.4586
Oxygen	22	8.4013
Nitrogen	16	9.7907
Methane	20	9.5177
Ethane	23	3.2869
Ethylene	20	5.7963
n-Butane	32	2.7421
Total	**555**	**4.1991**

Table 3-7*:* Results of Yen-Woods Equation for polar compounds

Compounds	No.of points	AAD%of Yen-Woods
R-11	28	9.5315
R-12	38	7.0427
R-22	35	4.6206
water	74	2.3345
Ammonia	37	1.0429
Ethanol	38	3.7874
Total	**250**	**4.7266**

3.2.3 Yamada and Gunn Equation.

Yamada and Gunn (1973) [22] is another form of Rackett equation but with some corrections in Zc. It worked very good with non polar compounds except methane, neopentane, and benzene as shown in table 3-8. Table 3-8 shows that the maximum deviation from experimental data is 3.1800% for neopentane and the minimum deviation is 0.1664% for R-123 and the results with polar compounds were not satisfactory except for some slightly polars like R-11, R-12, and R-22 as shown in table 3-9.

Table 3-8: Results of Yamada and Gunn Equation for non polar compounds

Compounds	No.of points	AAD%of Yamada and Gunn
Argon	16	1.3106
1,3-butadiene	38	0.3595
Benzene	43	2.1841
CarbonDioxide	43	0.4661
Cyclopropane	20	0.9185
R-245	27	0.2674
R-123	38	0.1664
R-134a	36	1.1265
Isobutylene	31	1.1540
propane	16	0.2609
Isobutene	30	2.0218
n-pentane	28	0.4364
Isopentane	29	0.2479
Neopentane	27	3.1800
Oxygen	22	0.4452

Nitrogen	16	0.3972
Methane	20	3.1389
Ethane	23	0.3791
Ethylene	20	0.5038
n-Butane	32	0.3276
Total	**555**	**0.9645**

Table 3-9: Results of Yamada and Gunn Equation for polar compounds

Compounds	No.of points	AAD%of Yamada and Gunn
R-11	28	0.6621
R-12	38	0.9435
R-22	35	1.3026
water	74	5.0097
Ammonia	37	3.6625
Ethanol	38	3.6262
Total	**250**	**2.5344**

3.2.4 Spencer and Danner Equation

Spencer and Danner equation (1972) [22, 23] is a modification of Rackett equation. It is structurally similar to the Rackett equation and requires only the critical constants and the acentric factor for application of pure fluids. It gave acceptable results with nonpolar compounds except methane, benzene, and cyclopropane which may be caused by inaccuracy in experimental data as shown in table 3-10. Table 3-10 shows that the maximum deviation from experimental data is 3.6946% for benzene and the minimum deviation is 0.3289% for n-butane, and it did not give good results with polar compounds as shown in table 3-11.

Table 3-10: Results of Spencer and Danner Equation for non polar compounds

Compounds	No.of points	AAD%of Spencer and Danner
Argon	16	1.5291
1,3-butadiene	38	1.5275
Benzene	43	3.6946
CarbonDioxide	43	1.1958
Cyclopropane	20	2.5920
R-245	27	1.2593
R-123	38	1.0697
R-134a	36	1.1317
Isobutylene	31	0.7932
propane	16	0.5149
Isobutene	30	0.7866
n-pentane	28	0.4528
Isopentane	29	0.7187
Neopentane	27	1.6287
Oxygen	22	1.6196
Nitrogen	16	1.5596
Methane	20	3.2777
Ethane	23	0.6351
Ethylene	20	0.8724
n-Butane	32	0.3289
Total	**555**	**1.3593**

Table 3-11: Results of Spencer and Danner Equation for polar compounds

Compounds	No.of points	AAD%of Spencer and Danner
R-11	28	2.8046
R-12	38	0.9698
R-22	35	1.8590
water	74	19.0296
Ammonia	37	13.8138
Ethanol	38	4.4025
Total	**250**	**7.1465**

3.2.5 Bradford and Thodos Equation

It is another equation to calculate the molar volume of saturated liquid of pure compounds [27], it gave an ordinary results as the equation mentioned before and the accuracy of the results for polar and non polar were close as shown in tables 3-12 and 3-13. Table 3-12 for non polar compounds shows that the maximum deviation from experimental point is 4.0155% for neopentane and the minimum deviation is 0.2678% for ethylene.

Table 3-12: Results of Bradford and Thodos Equation for non polar compounds

Compounds	No.of points	AAD%of Bradford and Thodos
Argon	16	1.6200
1,3-butadiene	38	0.3867
Benzene	43	1.4733
CarbonDioxide	43	0.8665
Cyclopropane	20	0.5269
R-245	27	0.9930
R-123	38	1.2697
R-134a	36	1.7788
Isobutylene	31	1.6029
propane	16	0.4647
Isobutene	30	2.4290
n-pentane	28	0.4925
Isopentane	29	0.5509
Neopentane	27	4.0155
Oxygen	22	1.3014
Nitrogen	16	0.2569
Methane	20	3.6158
Ethane	23	1.1813
Ethylene	20	0.2678
n-Butane	32	0.6281
Total	**555**	**1.2860**

Table 3-13: Results of Bradford and Thodos Equation for polar compounds

Compounds	No.of points	AAD%of Bradford and Thodos
R-11	28	2.7351
R-12	38	1.9797
R-22	35	2.0516
water	74	1.6564
Ammonia	37	1.7515
Ethanol	38	3.0371
Total	**250**	**2.2019**

3.2.6 Riedel Equation

Riedel equation (1954) [26] gave a very accurate result for non polar compounds when compared with all the equations mentioned before except for neopentane and methane as shown in table 3-14. Table 3-14 shows that the maximum deviation from experimental data is 3.5877% for methane and the minimum deviation is 0.1986% for n-butane. The results with polar compounds were not satisfactory except for some slightly polars like R-11, R-12, and R-22 as shown in table 3-15.

Table 3-14: Results of Reidel Equation for non polar compounds

Compounds	No.of points	AAD%of Reidel
Argon	16	0.5707
1,3-butadiene	38	0.2424
Benzene	43	1.8917
CarbonDioxide	43	0.4064
Cyclopropane	20	1.0929
R-245	27	0.7530
R-123	38	0.4834
R-134a	36	0.5388
Isobutylene	31	0.9352
propane	16	0.3994
Isobutene	30	2.0769
n-pentane	28	0.2609
Isopentane	29	0.2645
Neopentane	27	3.1909
Oxygen	22	0.6419

Nitrogen	16	0.4763
Methane	20	3.5877
Ethane	23	0.5778
Ethylene	20	0.3087
n-Butane	32	0.1986
Total	**555**	**0.9449**

Table 3-15: Results of Reidel Equation for polar compounds

Compounds	No.of points	AAD%of Reidel
R-11	28	0.3053
R-12	38	0.7232
R-22	35	0.9557
water	74	4.3409
Ammonia	37	3.1684
Ethanol	38	3.1984
Total	**250**	**2.1153**

3.2.7 Hankinson Thomson Equation (HT)

Hankinson Thomson Equation (1982) [25] is the best one among all the equations mentioned. It gave excellent results with nonpolar compounds except methane, neopentane, and benzene as shown in table 3-16. Table 3-16 shows that the maximum deviation from experimental data is 3.2673% for methane and the minimum deviation is 0.1374% for R-123, but the results of polar compounds were inaccurate except for some slightly polars like R-11, R-12, and R-22 as shown in table 3-17.

Table 3-16: Results of Hankinson Thomson Equation for non polar compounds

Compounds	No.of points	AAD%of Hankinson Thomson
Argon	16	1.2055
1,3-butadiene	38	0.2944
Benzene	43	2.1198
CarbonDioxide	43	0.4638

Cyclopropane	20	0.7948
R-245	27	0.2948
R-123	38	0.1374
R-134a	36	1.1277
Isobutylene	31	1.1234
propane	16	0.1536
Isobutene	30	2.0567
n-pentane	28	0.3463
Isopentane	29	0.3034
Neopentane	27	3.1464
Oxygen	22	0.1990
Nitrogen	16	0.2447
Methane	20	3.2673
Ethane	23	0.4084
Ethylene	20	0.3302
n-Butane	32	0.2651
Total	**555**	**0.9141**

Table 3-17: Results of Hankinson Thomson Equation for polar compounds

Compounds	No.of points	AAD%of Hankinson Thomson
R-11	28	0.6208
R-12	38	0.8867
R-22	35	1.2668
water	74	4.9832
Ammonia	37	3.5976
Ethanol	38	2.4252
Total	**250**	**2.2967**

3.3 Modification of Hankinson Thomson Equation.

The results indicate clearly that when using HT to predict the saturated liquid molar volume of the compounds, the deviations from experimental data are much less (more accurate results) than when using other equations.

In order to build a general idea about the results obtained from the HT equation, it was applied to polar and nonpolar compounds that listed in tables (3.1) and (3.2).

Appendix B, shows the comparison between the results obtained using the all methods mentioned that predict saturated liquid molar volume and

corresponding counterparts obtained from the HT equation. The comparison indicates that the HT equation is closer to the experimental data. The accuracy of using HT equation was shown when it is applied to all data range.

Therefore, the modification of HT equation has been started from the idea that the modification of constants may lead to more accurate results for calculating saturated liquid molar volume. At the beginning the data were classified and divided into polar and nonpolar components. Equation 2-15 represents the general form of HT equation.

$$V_s = V^* V_r^{(o)} \left(1 - w_{SRK} V_r^{(\delta)}\right) \tag{2-15}$$

$$where\ V_r^{(o)} = 1 + a\left(1 - T_r\right)^{1/3} + b\left(1 - T_r\right)^{2/3} + c\left(1 - T_r\right) + d\left(1 - T_r\right)^{4/3} \tag{2-16}$$

$$when\ 0.25 \prec T_r \prec 1.0$$

$$V_r^{(\delta)} = \frac{e + fT_r + gT_r^{\,2} + hT_r^{\,3}}{T_r - 1.00001}\ when\ 0.25 \prec T_r \prec 1.0 \tag{2-17}$$

$$T_r = \frac{T}{T_{C,HT}} \tag{2-18}$$

The constants in Eqs. 2-16 and 17 have been found using the idea of minimizing error of saturated liquid molar volume from experimental data (i. e. $Vs/V^* \cong 0$), this procedure was done best for $V_r^{(0)}$ when acentric factor goes to zero. The simple gases $(\omega = 0)$ like Ar, Kr have been used for calculating the constants of equation 2-16 using statistical methods as shown in equation 3-1

$$V_r^{(0)} = \frac{V_s}{V^*} \tag{3-1}$$

Experimental data for Argon was used for evaluating the constants; the number of points that used to fit this equation was 8 points. Numerical experimentation revealed that the most appropriate number of points to fit was 8 points. Fig. 3-1 represents the experimental data of Argon (Experimental V_r vs. T_r). This Figure was constructed by considering the equations above.

STATISTICA package was used for evaluation the constants using Quasi-Newton method, figure 3-1 showed the curve takes exactly the polynomial form like equation 2-16, and the correlation coefficient of this equation is 0.99998.

The coefficients of equation 2-16 had been found as follows:

Constant	*Value*
a	-1.22916
b	0.087280
c	1.283902
d	0.902008

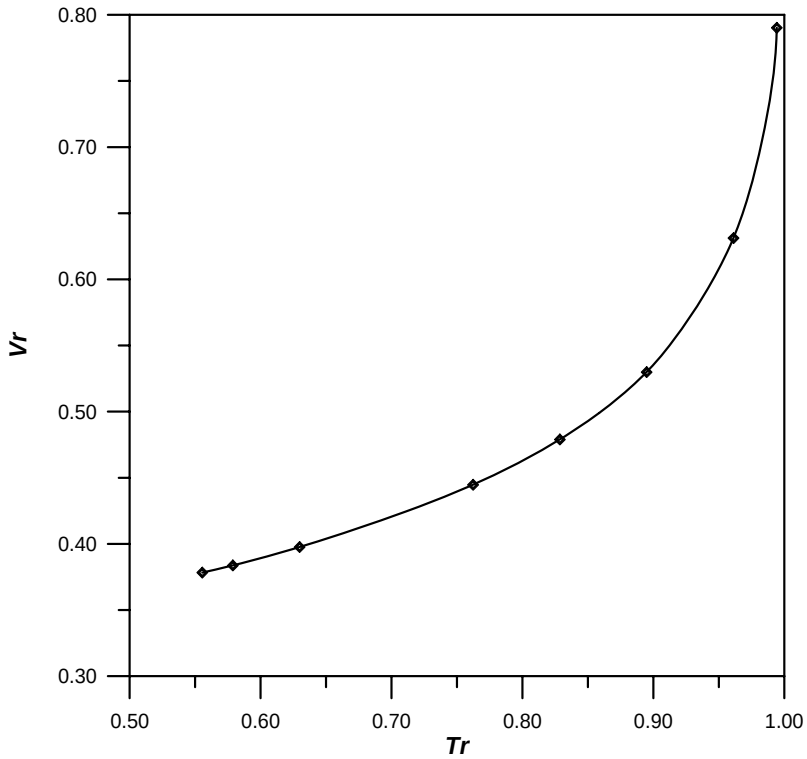

Figure 3-1*:* Experimental Data for Argon as function of reduced temperature

The second variable of HT equation is $V_r^{(\delta)}$ had constructed for compounds that have a maximum acentric factor in order to control all possible cases in the fit.

Figure 3-2, for Methane, n-Pentane and Ethanol illustrates that the curves of these three compounds are entirely different from those of Simple compounds. The two non-polar compounds above do have approximately maximum and minimum acentric factor. Therefore the end of Methane and Pentane curve is concave down, also for polar compounds the chosen of the best compounds depend on acentric factor as for Ethanol, the experimental data have low $V_r^{(\delta)}$ as shown in figure 3-2 for the points below the curve. This made it possible to construct a model that covers the case of compounds that will have $0.2 \leq \mathrm{Tr} \leq 1$.

The experimental data for the three compounds above have been calculated by arranging equation 2-15 in order to evaluate the experimental data for $V_r^{(\delta)}$ using equation 2-16 with new constants for Argon and to minimize the error of Vs from experimental data as shown in equation 3-2:

$$V_r^{(\delta)} = \frac{1}{\omega_{SRK}} \left(1 - \frac{V_s}{V^* V_r^{(0)}} \right) \tag{3-2}$$

The number of points that used was 5 points for Methane, 10 points for n-Pentane and 10 points for Ethanol, this equation has been applied to the rest of compounds in tables 3-1 and 3-2, including the polar compound in spite of the fact it has a high polarity as for water and Ammonia.

STATISTICA package was also used for evaluation of the constants using Quasi-Newton method, figure 3-2 showed the line takes exactly equation 2-17, and the correlation coefficient of this equation is 0.9896.

The coefficients of equation 2-17 had been found as follows:

Constant	*Value*
e	-0707480
f	1.771180
g	-1.70029
h	0.636584

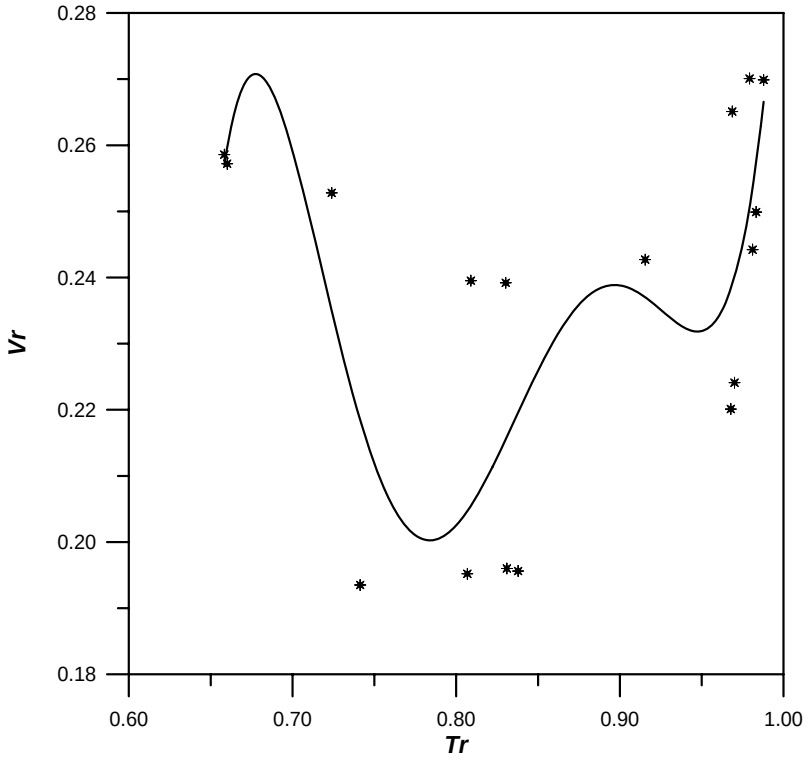

Figure 3-2*:* Experimental Data for Methane, Pentane and Ethanol as function of reduced temperature

The results of the modified equation are shown in Appendix B.

3.4 Application of the Developed Correlation.

In order to clarify the application of the developed correlation, the detailed calculations are given below for compounds, representative of the polar and nonpolar respectively.

Example 1: Calculation of saturated liquid molar volume for Argon using HT Equation and its Modified.

The properties of Argon are listed below

	M.WT	Tc K	Pc bar	W	Zc	Vc cm^3/mole
Argon	39.94	150.86	48.98	-0.00	0.291	74.57

Starting from HT equation (i.e. Eqs. 2-15, 16 and 17).

$$V_s = V^* V_r^{(o)} \left(1 - w_{SRK} V_r^{(\delta)}\right) \tag{2-15}$$

$$where\ V_r^{(o)} = 1 + a\left(1-T_r\right)^{1/3} + b\left(1-T_r\right)^{2/3} + c\left(1-T_r\right) + d\left(1-T_r\right)^{4/3} \tag{2-16}$$

$$when\ 0.25 \prec T_r \prec 1.0$$

$$V_r^{(\delta)} = \frac{e + fT_r + gT_r^{\,2} + hT_r^{\,3}}{T_r - 1.00001}\ when\ 0.25 \prec T_r \prec 1.0 \tag{2-17}$$

$$T_r = \frac{T}{T_{C,HT}} \tag{2-18}$$

Constants for HT Equation:

$a = -1.52816$ $b = 1.43907$ $c = -0.81446$ $d = 0.190454$

$e = -0.296123$ $f = 0.386914$ $g = -0.0427258$ $h = -0.0480645$

Constants for modified HT Equation:

$a = -1.22916$ $b = 0.087280$ $c = 1.283902$ $d = 0.902008$

$e = -0.707480$ $f = 1.771180$ $g = -1.70029$ $h = 0.636584$

Using HT Equation: T=150K, $V_s$exp=58.9233cm^3/mol

At Tr= 0.9943

$$V_r^{(o)} = 1 - 1.52816\left(1-0.9943\right)^{1/3} + 1.43907\left(1-0.9943\right)^{2/3} - 0.81446\left(1-0.9943\ \right) + 0.190454\left(1-0.9943\right)^{4/3}$$

$$V_r^{(o)} = 0.7685$$

$$V_s = 74.57 * 0.7685\left(1-0\right)$$

$$V_s = 57.3060\ \mathrm{Cm}^3 / mol$$

$$\%Dev. = \frac{Vs_{\exp.} - Vs_{cal.}}{Vs_{\exp.}} * 100$$

$$\%Dev. = \frac{58.9233 - 57.3060}{58.9233} * 100$$

$$\%Dev. = 2.7447\%$$

Using modified HT Equation:

At Tr=0.9943

$$V_r^{(o)} = 1 - 1.22916(1-0.9943)^{1/3} + 0.087280(1-0.9943)^{2/3} - 1.283902(1-0.9943) + 0.190454(1-0.9943)^{4/3}$$

$$V_r^{(o)} = 0.7896$$

$$V_s = 74.57 * 0.7896(1-0)$$

$$V_s = 58.8813 \text{ Cm}^3 / mol$$

$$\%Dev. = \frac{Vs_{\text{exp.}} - Vs_{cal.}}{Vs_{\text{exp.}}} * 100$$

$$\%Dev. = \frac{58.9233 - 58.8813}{58.9233} * 100$$

$$\%Dev. = 0.0713\%$$

The results show that HT equation was extended to work up to Tr=1.

Example 2: Calculation of saturated liquid molar volume for non-Polar compound (as for example 1,3-Butadiene) using HT Equation and its Modified.

The properties of 1,3-Butadiene are listed below

	M.WT	**Tc K**	**Pc bar**	**W**	**Zc**	**Vc cm^3/mole**
1,3-butadiene	54.092	425.00	43.20	0.195	0.270	221.00

By using the same equations and constants in example 1:

Using HT Equation: T=313.1500K, $V_s$exp=90.8637cm^3/mol

At Tr= 0.7368

$$V_r^{(o)} = 1 - 1.52816(1-0.7368)^{1/3} + 1.43907(1-0.7368)^{2/3} - 0.81446(1-0.7368) + 0.190454(1-0.7368)^{4/3}$$

$$V_r^{(o)} = 0.4295$$

$$V_r^{(\delta)} = \frac{-0.296123 + 0.386914 * 0.7368 - 0.0427258(0.7368)^2 - 0.0480645 * (0.7368)^3}{0.7368 - 1.00001}$$

$$V_r^{(\delta)} = 0.2031$$

$$V_s = 221.00*0.4295\left(1-0.195*0.2031\right)$$

$$V_s = 91.1512\ \mathrm{Cm}^3/mol$$

$$\%Dev. = \frac{Vs_{\exp.} - Vs_{cal.}}{Vs_{\exp.}} *100$$

$$\%Dev. = \frac{90.8637 - 91.1512}{90.8637} *100$$

$$\%Dev. = 0.3163\%$$

Using modified HT Equation:

At Tr=0.7368

$$V_r^{(o)} = 1 - 1.22916\left(1-0.7368\right)^{1/3} + 0.087280\left(1-0.7368\right)^{2/3} - 1.283902\left(1-0.7368\right) + 0.190454\left(1-0.7368\right)^{4/3}$$

$$V_r^{(o)} = 0.4339$$

$$V_r^{(\delta)} = \frac{-0.707480 + 1.771180*0.7368 - 1.70029\left(0.7368\right)^2 - 0.636584*\left(0.7368\right)^3}{0.7368 - 1.00001}$$

$$V_r^{(\delta)} = 0.2693$$

$$V_s = 221.00*0.4339\left(1-0.195*0.2693\right)$$

$$V_s = 90.8590\mathrm{Cm}^3/mol$$

$$\%Dev. = \frac{Vs_{\exp.} - Vs_{cal.}}{Vs_{\exp.}} *100$$

$$\%Dev. = \frac{90.8637 - 90.8590}{90.8637} *100$$

$$\%Dev. = 0.0052\%$$

Example 3: Calculation of saturated liquid molar volume for Polar compound (as for example Ammonia) using HT Equation and its Modified.

The properties of Ammonia are listed below

	M.WT	**Tc K**	**Pc bar**	**W**	**Zc**	**Vc cm^3/mole**
Ammonia	17.031	405.40	113.53	0.257	0.255	72.47

By using the same equations and constants in example 1:

Using HT Equation: T=403.1500K, $V_s$exp=53.1708cm^3/mol
At Tr= 0.9944

$$V_r^{(o)} = 1 - 1.52816(1-0.9944)^{1/3} + 1.43907(1-0.9944)^{2/3} - 0.81446(1-0.9943\ ) + 0.190454(1-0.9944)^{4/3}$$
$$V_r^{(o)} = 0.7702$$

$$V_r^{(\delta)} = \frac{-0.296123 + 0.386914*0.9944 - 0.0427258(0.9944)^2 - 0.0480645*(0.9944)^3}{0.9944 - 1.00001}$$

$$V_r^{(\delta)} = 0.1579$$

$$V_s = 72.47*0.7702(1 - 0.257*0.1579)$$
$$V_s = 53.5525\ \mathrm{Cm}^3/mol$$

$$\%Dev. = \frac{Vs_{\exp.} - Vs_{cal.}}{Vs_{\exp.}} *100$$
$$\%Dev. = \frac{53.1708 - 53.5525}{53.1708} *100$$
$$\%Dev. = 0.7178\%$$

Using modified HT Equation:

At Tr=0.9944

$$V_r^{(o)} = 1 - 1.22916(1-0.9944)^{1/3} + 0.087280(1-0.9944)^{2/3} - 1.283902(1-0.9944) + 0.190454(1-0.9944)^{4/3}$$
$$V_r^{(o)} = 0.7914$$

$$V_r^{(\delta)} = \frac{-0.707480 + 1.771180*0.9944 - 1.70029(0.9944)^2 - 0.636584*(0.9944)^3}{0.9944 - 1.00001}$$

$$V_r^{(\delta)} = 0.2798$$

$$V_s = 72.47*0.7914(1 - 0.257*0.2798)$$
$$V_s = 53.2255\mathrm{Cm}^3/mol$$

$$\%Dev. = \frac{Vs_{\exp.} - Vs_{cal.}}{Vs_{\exp.}} *100$$
$$\%Dev. = \frac{53.1708 - 53.2255}{53.1708} *100$$
$$\%Dev. = 0.1029\%$$

3.5 Estimation of Liquid Molar Volume at the Normal Boiling Point.

Three methods are available in literature to estimate saturated molar volumes at normal boiling points for polar and non polar compounds. The methods are Tyn and Calus, Schroeder, and Le Bas.

When using Tyn and Calus method, the results for nonpolar compounds were slightly high when it's compared with polar compounds, but this method can be considered the best one among the three methods as shown in tables 3-18 and 3-19.

The results of the two other methods Schroeder and Le Bas were inaccurate in comparison with Tyn and Calus method as shown in tables 3-18 and 3-19.

The development have been made by modifying Tyn and Calus using STATISTICA package for the experimental data in table 3-18, where 10 compounds were used for modifying the constants of Eq. 2-36 to new constants. The correlation coefficient was obtained as 0.998 as shown in modified Eq. 3-3.

$$V_b = 0.348 V_c^{1.016} \tag{3-3}$$

Table 3-18: Results for non polar compounds at Normal Boiling Point

Compounds	Tb(K)	V_{exp} (cm^3/mol)	%Dev. Tyn&Calus	%Dev. Schroeder	%Dev. Le Bas
1,3-butadiene	268.68	83.1643	1.8634	1.0049	2.1214
R-245	255.10	102.3376	2.1074	7.6586	3.2614
R-123	300.81	105.0635	1.1826	3.3918	4.9147
Isobutylene	266.24	89.6382	1.2513	1.5191	0.9351
propane	231.02	75.8349	3.0707	1.5363	2.4196
n-pentane	309.19	118.2	1.2265	0.6768	0.1692
Isopentane	300.99	117.793	1.7868	1.0246	0.5153
Neopentane	282.628	119.6	4.9469	0.5016	1.0033
Oxygen	90.2	28.0311	8.3215	25.0832	47.2015
Nitrogen	77.35	34.7374	8.2514	19.3951	39.5463

Methane	111.66	37.9737	7.7547	7.8311	22.0515
Ethane	184.6	55.2687	4.7102	1.3232	6.2759
Ethylene	169.42	49.4031	4.4263	0.8159	10.1271
n-Butane	272.67	96.66	1.9038	1.3863	0.4758
Total			**3.771679**	**4.8210**	**9.5667**

Table 3-19: Results for polar compounds at Normal Boiling Point

Compounds	Tb(K)	V_{exp} (cm^3/mol)	%Dev. Tyn&Calus	%Dev. Schroeder	%Dev. Le Bas
R-11	296.81	92.8398	0.8036	1.9817	4.8041
R-12	243.45	81.2535	1.4600	5.2348	0.1802
R-22	232.14	61.2193	1.2289	2.8084	1.1750
Total			**1.164**	**6.2015**	**7.2987**

3.6 Estimation of Liquid Molar Volume for Mixtures

Mixtures of two compounds have been used to calculate saturated liquid molar volume when using HT equation and its modified form. The modification of mixture was done only for using the same mixing rule of HT equation and applied to modify HT for pure compounds, because the results of pure compounds when using modified HT have been better than from using HT itself. The results of saturated liquid molar volume of mixtures for HT and its modified form with the same mixing rule are shown in appendix C.

Example 4: Calculation of saturated liquid molar volume for Mixtures (as for example 21.43%Propane and n-Octane) using HT Equation and its Modified.

The properties of Propane and n-Octane are listed below

	M.WT	Tc K	Pc bar	W	Zc	Vc cm^3/mole
propane	44.097	369.83	42.48	0.152	0.275	200.00
Octane	114.231	568.70	24.90	0.399	0.259	492.00

The experimental data for one point is

T=447.1500K and $V_s$exp=186.1187 cm^3/mole

The mixing rule of HT equation was taken from chapter two as follows

$$T_{cm} = \left(\sum_i^N x_i \left(V_{Ci} T_{Ci} \right)^{0.5} \right)^2 \Big/ V_{cm} \qquad (2\text{-}43)$$

$$V_{cm} = \frac{1}{4}\left[\sum_i^N x_i V_i^{*} + 3\left(\sum_i^N x_i V_i^{*2/3} \right)\left(\sum_i^N x_i V_i^{*1/3} \right) \right] \qquad (2\text{-}44)$$

$$\omega_{SRK} = \sum_i^N x_i \left(\omega_{SRK} \right)_i \qquad (2\text{-}45)$$

Substitute the properties in the above equations to find the properties for mixture.

$$\omega_{SRK} = (0.2143*0.152+0.7857*0.399)$$
$$= 0.3461$$

$$V_{cm} = \frac{1}{4}\begin{bmatrix} (0.2143*200+0.7857*492)+ \\ 3*\left(0.2143*200^{2/3}+0.7857*492^{2/3}\right) \\ *\left(0.2143*200^{1/3}+0.7857*492^{1/3}\right) \end{bmatrix}$$
$$= 422.1568 cm^3 / mol$$

$$T_{cm} = \left(0.2143*\left(200*369.83\right)^{0.5} + 0.7857*\left(492*568.70\right)^{0.5}\right)^2 \Big/ 422.1568$$
$$= 531.9576K$$

$$Tr = \frac{T}{T_{cm}} = \frac{447.1500}{531.9576}$$
$$= 0.84057$$

Using HT Equation:

At Tr= 0.8406

$$V_r^{(o)} = 1 - 1.52816(1-0.8406)^{1/3} + 1.43907(1-0.8406)^{2/3} - 0.81446(1-0.8406) + 0.190454(1-0.8406)^{4/3}$$

$$V_r^{(o)} = 0.4811$$

$$V_r^{(\delta)} = \frac{-0.296123 + 0.386914*0.8406 - 0.0427258(0.8406)^2 - 0.0480645*(0.8406)^3}{0.8406 - 1.00001}$$

$$V_r^{(\delta)} = 0.1858$$

$$V_s = 422.1568*0.4811(1 - 0.3461*0.1858)$$

$$V_s = 190.0422 \text{ cm}^3 / mol$$

$$\%Dev. = \frac{Vs_{\text{exp.}} - Vs_{cal.}}{Vs_{\text{exp.}}} * 100$$

$$\%Dev. = \frac{186.1187 - 190.0422}{186.1187} * 100$$

$$\%Dev. = 2.1081\%$$

Using modified HT Equation:

At Tr=0.8506

$$V_r^{(o)} = 1 - 1.22916(1-0.8506)^{1/3} + 0.087280(1-0.8506)^{2/3} - 1.283902(1-0.8506) + 0.190454(1-0.8506)^{4/3}$$

$$V_r^{(o)} = 0.4859$$

$$V_r^{(\delta)} = \frac{-0.707480 + 1.771180*0.8506 - 1.70029(0.8506)^2 - 0.636584*(0.8506)^3}{0.8506 - 1.00001}$$

$$V_r^{(\delta)} = 0.2632$$

$$V_s = 422.1568*0.4859(1 - 0.3461*0.2632)$$

$$V_s = 186.4383 \text{Cm}^3 / mol$$

$$\%Dev. = \frac{Vs_{\text{exp.}} - Vs_{cal.}}{Vs_{\text{exp.}}} * 100$$

$$\%Dev. = \frac{186.1187 - 186.4383}{186.1187} * 100$$

$$\%Dev. = 0.1717\%$$

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction.

Experimental data of the saturated liquid molar volume for pure polar and non polar compounds are listed in Appendix B.

On the other hand mixing rule was applied to Hankinson Thomson and it's development and the experimental data of mixtures and the results are shown in detailed in Appendix C.

4.2 The Development Correlations.

4.2.1 Pure Compounds.

Table 4-1 shows the results of investigation of the seven correlations available in the literature for pure twenty nonpolar compounds together with the modified method which will be discussed later. Table 4-2 on the other hand shows the results of investigation of seven methods for six polar pure compounds together with the modified method. All correlations worked with reduced temperature range from 0.23 to almost 1.00.

The results of Rackett equation of pure non-polar compounds were very good except for methane, and neopentane and that may be caused by some inaccurate experimental data**,** the AAD% of argon is 1.2159% and 0.3881% for1,3-butadiene and 3.4045% for methane and 3.8530%for neopentane, but the results obtained when using this equation to calculate the molar volumes of saturated liquid of pure polar compound were not

satisfactory, the AAD% of water is 3.8887% and 0.6045% for ammonia and 3.0047 % for R-11.

The results of Yen Woods equation of pure polar and non-polar compounds were inaccurate, the AAD% of argon is 10.2509% and 1.2130% for 1,3-butadiene and 9.5177% for methane and 2.4586% for neopentane and 2.3345% for water and 1.0429 % for ammonia and 9.5315% for R-11.

Yamada and Gunn worked very well with non polar compounds except for methane, neopentane, and benzene**,** the AAD% of argon is 1.3106% and 0.3595% for 1,3-butadiene and 3.1389% for methane and 3.1800% for neopentane, and the results with polar compounds were not satisfactory excepted some slightly polars like R-11, R-12, and R-22, the AAD% of water is 5.0097% and 3.6625% for ammonia and 0.6621 % for R-11.

Spencer and Danner equation gave acceptable results with nonpolar compounds except for methane, benzene, and cyclopropane, the AAD% of argon is 1.5291% and 1.5275% for 1,3-butadiene and 3.2777% for methane and 1.6287% for neopentane, and it did not give good results with polar compounds, the AAD% of water is 19.0296% and 13.8138% for ammonia and 2.8046 % for R-11.

Bradford and Thodos equation gave ordinary results as others and the results for polar and non polar were close and are considered to be good**,** the AAD% of argon is 1.6200% and 0.3867% for 1,3-butadiene and 3.6158% for methane and 4.0155%for neopentane and 1.6564% for water and 1.7515 % for ammonia and 2.7351% for R-11.

Riedel equation gave a very good result for non polar compounds when compared with all the equations mentioned before except for neopentane and methane, the AAD% of argon is 0.5707% and 0.2424% for 1,3-butadiene and 3.5877% for methane and 3.1909% for neopentane, the results with polar

compounds were not satisfactory except some slightly polars like R-11, R-12, and R-22, the AAD% of water is 4.3409% and 3.1684% for ammonia and 0.3053 % for R-11.

As shown in table 4-1 all the available correlations in the literature gave an acceptable accuracy except Yen Woods correlation. HT correlation had the highest accuracy for prediction of saturated molar volume of pure nonpolar compounds. On the other hand as shown in table 4-2 for prediction of saturated molar volume of pure polar compounds, Yen Woods and Spencer and Danner gave unacceptable results among the seven correlations. HT correlation had also the highest accuracy.

After concluded that the best equation that calculates the molar volume of liquid for saturation conditions (temperatures and pressures) was HT equation, efforts were made to modify this equation to decrease the percent deviation as much as possible, this may done by using a statistical program and statistical methods that give the best form of the correlation. Two modifications were developed in this thesis, the first modification was developed to correlate HT equation where the AAD% was 0.9141 for 20 pure non polar compounds (555 data points) and the AAD% was 2.2967 for 6 pure polar compounds (250 data points) which is relatively high deviation. Many attempts were done to modify this equation in order to reduce the percent deviation as much as possible, this modification was applied to 20 nonpolar compounds (555 data points) and applied to 6 polar compounds and it reduced the percent average absolute deviation from 0.9141% to 0.7888% for non polar compounds and from 2.2967 to 0.1.7138 for polar compounds. For example for argon the AAD% by using HT equation is 1.2055%, while the AAD% by using the developed HT equation is 0.1020% and for 1,3-butadiene the AAD% by using HT is 0.2944% where the AAD% by using the modified equation is 0.1448% and for methane the AAD% by using HT equation is

3.2673%, while the AAD% by using the developed HT equation is 3.2974% and for neopentane the AAD% by using HT equation is 3.1464%, while the AAD% by using the developed HT equation is 3.0844% and for water the AAD% by using HT equation is 4.9832%, while the AAD% by using the developed HT equation is 3.7971% and for ammonia the AAD% by using HT equation is 3.5976%, while the AAD% by using the developed HT equation is 2.6038% and for R-11 the AAD% by using HT equation is 0.6208%, while the AAD% by using the developed HT equation is 0.3677%. And the results are shown in tables 4-1 and 4-2.

Table 4-1: %Absolute Average deviation for non polar compounds

NO.	Component	NO. of points	Tr	AAD% (Racket)	AAD% (Yen Woods)	AAD% (Yamada Gunn)	AAD% (Spencer Denner)	AAD% (Reidel)	AAD% (Bradford&Thodos)	AAD% (HT)	AAD% Modified(HT)
1	Argon	16	0.55-0.99	1.2159	10.2509	1.3106	1.5291	0.5707	1.6200	1.2055	0.1020
2	1,3-butadiene	38	0.43-0.97	0.3881	1.2130	0.3595	1.5275	0.2424	0.3867	0.2944	0.1448
3	Benzene	43	0.49-0.98	1.2541	2.5331	2.1841	3.6946	1.8917	1.4733	2.1198	1.5124
4	CarbonDioxide	43	0.71-0.99	0.8098	3.1900	0.4661	1.1958	0.4064	0.8665	0.4638	0.2986
5	Cyclopropane	20	0.73-0.99	0.3413	2.3417	0.9185	2.5920	1.0929	0.5269	0.7948	0.9998
6	R-245	27	0.61-0.99	0.5815	1.5481	0.2674	1.2593	0.7530	0.9930	0.2948	0.3004
7	R-123	38	0.48-0.99	0.8847	2.4261	0.1664	1.0697	0.4834	1.2697	0.1374	0.1889
8	R-134a	36	0.54-0.99	1.1367	1.6740	1.1265	1.1317	0.5388	1.7788	1.1277	0.7062
9	Isobutylene	31	0.61-0.99	1.4981	3.9476	1.1540	0.7932	0.9352	1.6029	1.1234	0.9238
10	propane	16	0.23-0.97	0.5033	2.5684	0.2609	0.5149	0.3994	0.4647	0.1536	0.1625
11	Isobutene	30	0.64-1.00	2.6388	6.4168	2.0218	0.7866	2.0769	2.4290	2.0567	2.0065
12	n-pentane	28	0.65-0.99	0.3880	1.6426	0.4364	0.4528	0.2609	0.4925	0.3463	0.4463
13	Isopentane	29	0.65-1.00	0.3416	2.2363	0.2479	0.7187	0.2645	0.5509	0.3034	0.3579
14	Neopentane	27	0.65-1.00	3.8530	2.4586	3.1800	1.6287	3.1909	4.0155	3.1464	3.0844
15	Oxygen	22	0.35-0.97	0.7665	8.4013	0.4452	1.6196	0.6419	1.3014	0.1990	0.2053
16	Nitrogen	16	0.50-1.00	0.6281	9.7907	0.3972	1.5596	0.4763	0.2569	0.2447	0.2251
17	Methane	20	0.47-0.94	3.4045	9.5177	3.1389	3.2777	3.5877	3.6158	3.2673	3.2974
18	Ethane	23	0.29-0.98	1.0558	3.2869	0.3791	0.6351	0.5778	1.1813	0.4084	0.2849
19	Ethylene	20	0.36-0.99	0.3515	5.7963	0.5038	0.8724	0.3087	0.2678	0.3302	0.3158
20	n-Butane	32	0.64-0.99	0.4313	2.7421	0.3276	0.3289	0.1986	0.6281	0.2651	0.2130
Total		**555**		**1.1236**	**4.1991**	**0.9645**	**1.3593**	**0.9449**	**1.2860**	**0.9141**	**0.7888**

Table 4-2: % Absolute Average deviation for polar compounds

NO.	Component	NO. of points	Tr	AAD% (Racket)	AAD% (Yen Woods)	AAD% (Yamada Gunn)	AAD% (Spencer Denner)	AAD% (Reidel)	AAD% (Bradford&Thodos)	AAD% (HT)	AAD% Modified(HT)
1	**R-11**	28	0.43-0.98	3.0047	9.5315	0.6621	2.8046	0.3053	2.7351	0.6208	0.3677
2	**R-12**	38	0.47-0.99	2.0846	7.0427	0.9435	0.9698	0.7232	1.9797	0.8867	0.5802
3	**R-22**	35	0.55-0.99	1.9436	4.6206	1.3026	1.8590	0.9557	2.0516	1.2668	0.6359
4	**water**	74	0.42-0.98	3.8887	2.3345	5.0097	19.0296	4.3409	1.6564	4.9832	3.7971
5	**Ammonia**	37	0.55-0.99	0.6045	1.0429	3.6625	13.8138	3.1684	1.7515	3.5976	2.6038
6	**Ethanol**	38	0.53-0.98	3.3921	3.7874	3.6262	4.4025	3.1984	3.0371	2.4252	2.2982
Total		**250**		**2.4863**	**4.7266**	**2.5344**	**7.1465**	**2.1153**	**2.2019**	**2.2967**	**1.7138**

Further discussion has been shown from some of figures, to exhibit the developed equation. Figure 4-1 shows the saturated liquid molar volume for Argon as function of reduced temperature, the figure is not clearly explain the convergence from experimental data because all this work treated with small error between experimental and calculated data, the modified HT equation gave more accurate result from HT itself especially near Tr=1 in reason of HT equation was developed up to Tr=0.95 and the modified equation was extrapolate to Tr up to 1.0.

Figure 4-2 shows the experimental data of saturated liquid molar volume for 1,3-Butadien, in this figure also the HT equation is compatible with its modified at all ranges. Figure 4-2 is not like other figures to show the developed equation form for pure non-polar compounds as for example figure 4-3 for Methane, the experimental data exhibit error in continually of experimental reading not like other figures, this is shown at Tr>0.7, this is due to an error in references or the behavior of methane that would change at this ranges. Neopentane in figure 4-4 shows that the modified HT equation is better than HT equation especially at Tr=1, where at Tr=1 the calculated saturated liquid molar volume using HT is 267cm^3/mole while by using modified HT gave 307cm^3/mole for experimental point 311cm^3/mole. On the other hand Benzene in figure 4-5 shows also error in experimental data at the same range for Methane at Tr>0.7 but this error has acceptable deviation not as Methane.

Another figure shows pure polar and slightly polar compounds. Figure 4-6 for R11 exhibits convergence of HT equation with it is modified form, while figure 4-7 for Ammonias shows high deviation from experimental data at low reduced temperature and this deviation decreases slowly at Tr>0.9 for both HT and their modified form. The behavior for water was different, the

calculated data for both HT and it is modified form was far from experimental between 0.6<Tr>0.95 as shown in figure 4-8

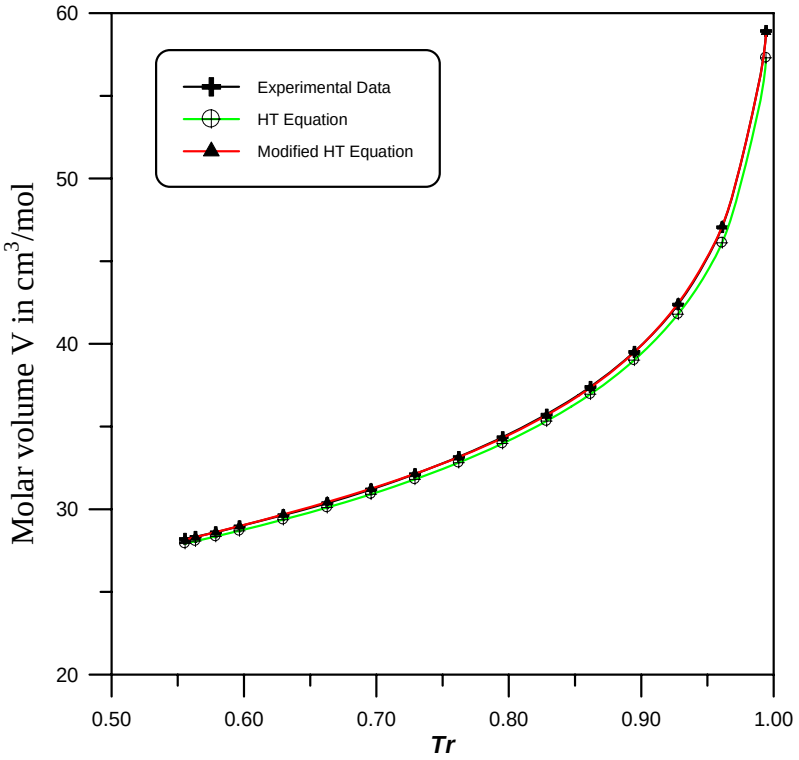

Figure 4-1: Experimental and calculated saturated liquid molar volume versus reduced temperature for Argon

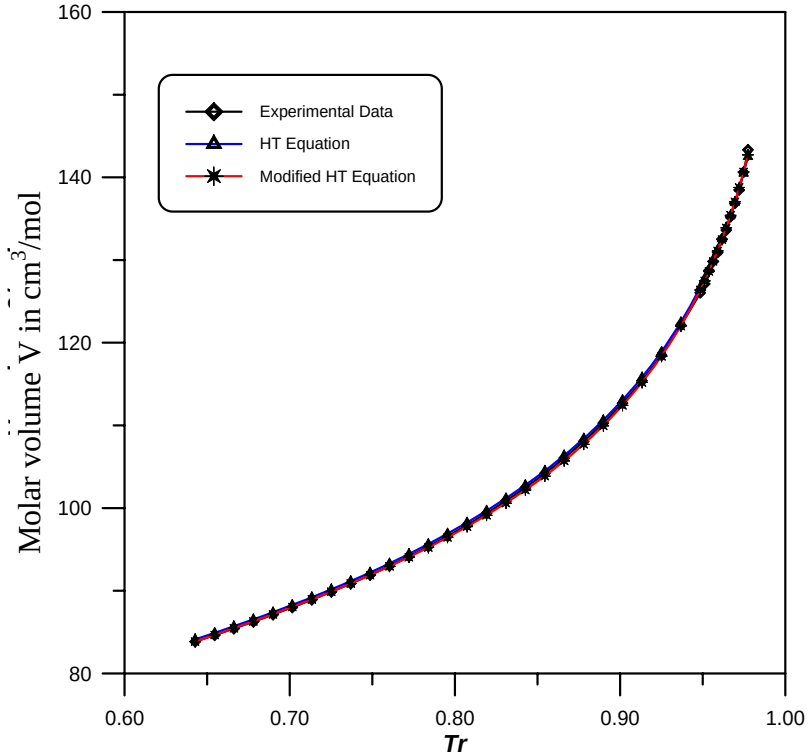

Figure 4-2: Experimental and calculated saturated liquid molar volume versus reduced temperature for 1,3-Butadien

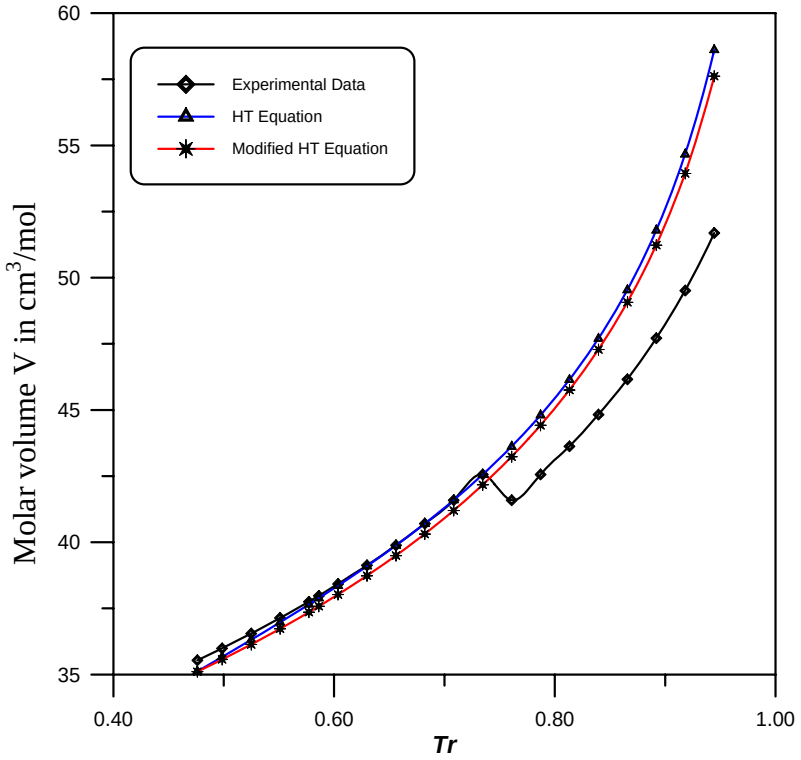

Figure 4-3: Experimental and calculated saturated liquid molar volume versus reduced temperature for Methane

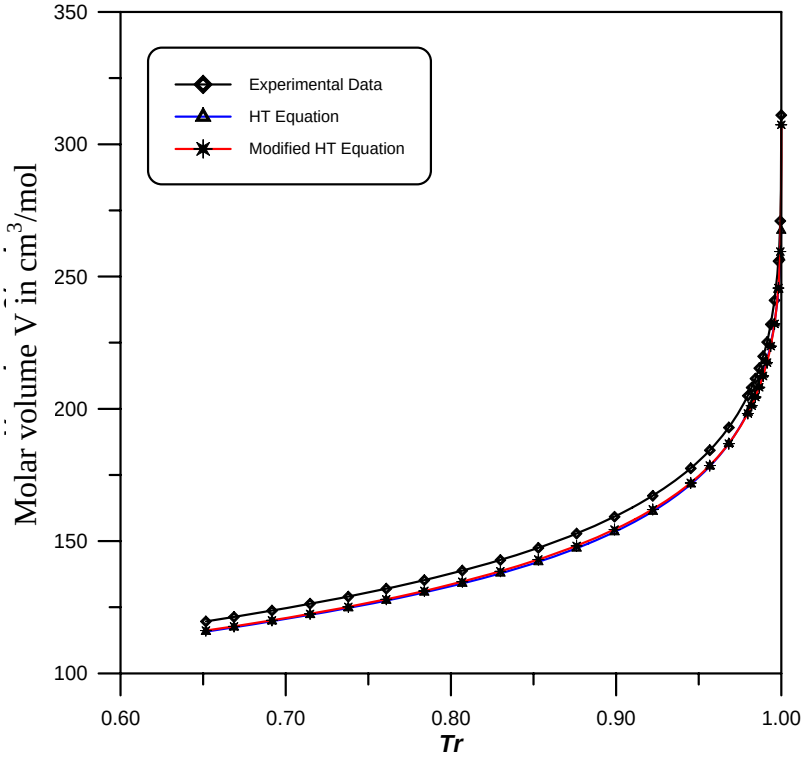

Figure 4-4: Experimental and calculated saturated liquid molar volume versus reduced temperature for Neopentane

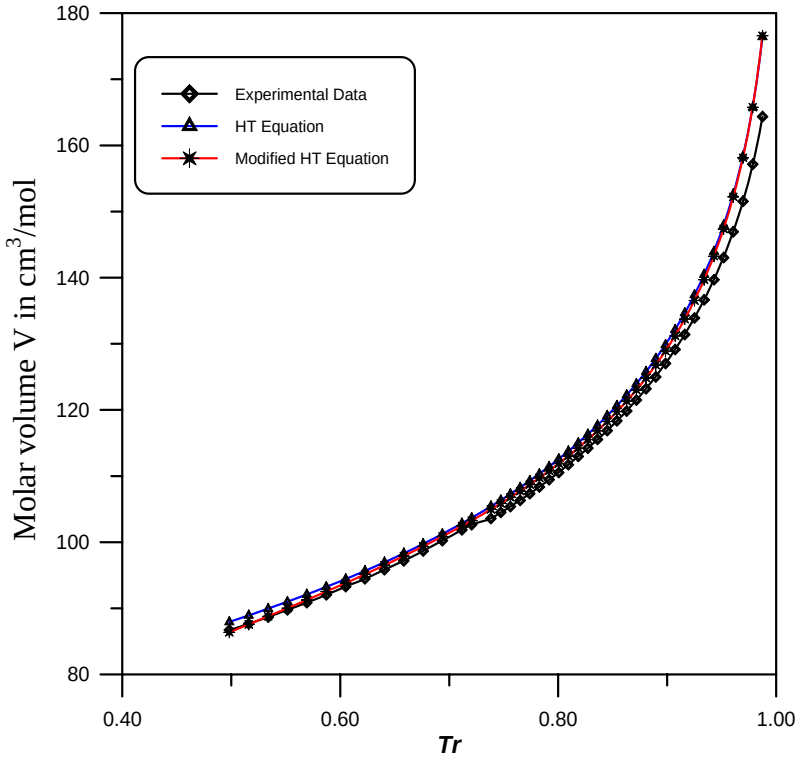

Figure 4-5: Experimental and calculated saturated liquid molar volume versus reduced temperature for Benzene

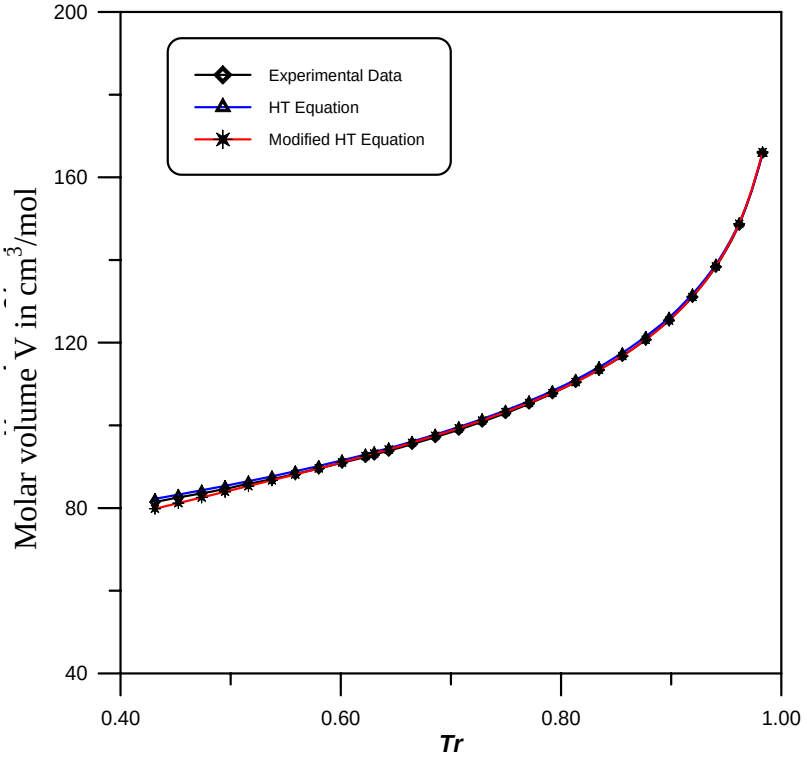

Figure 4-6: Experimental and calculated saturated liquid molar volume versus reduced temperature for R11

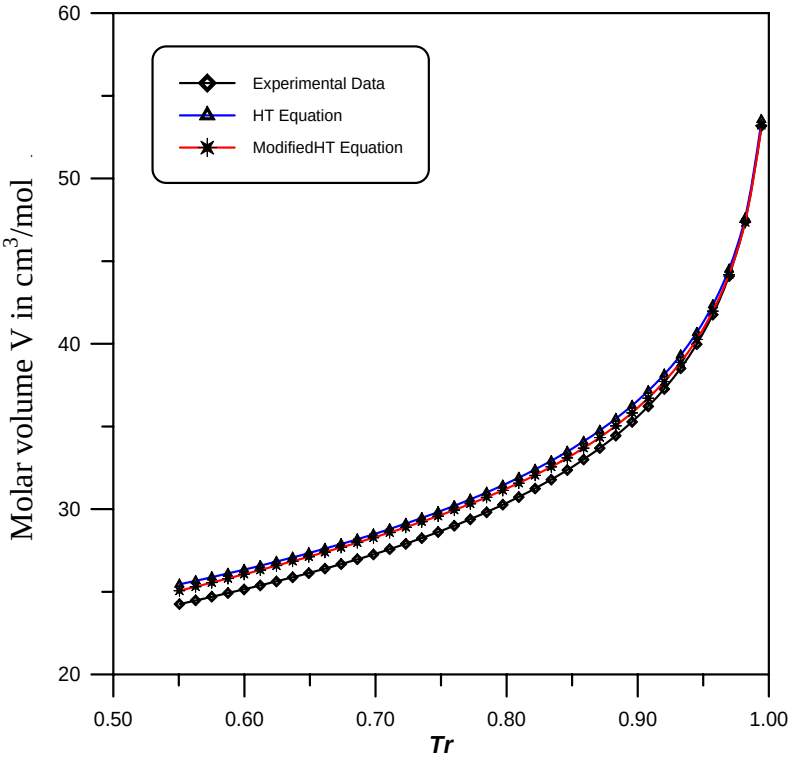

Figure 4-7: Experimental and calculated saturated liquid molar volume versus reduced temperature for Ammonia

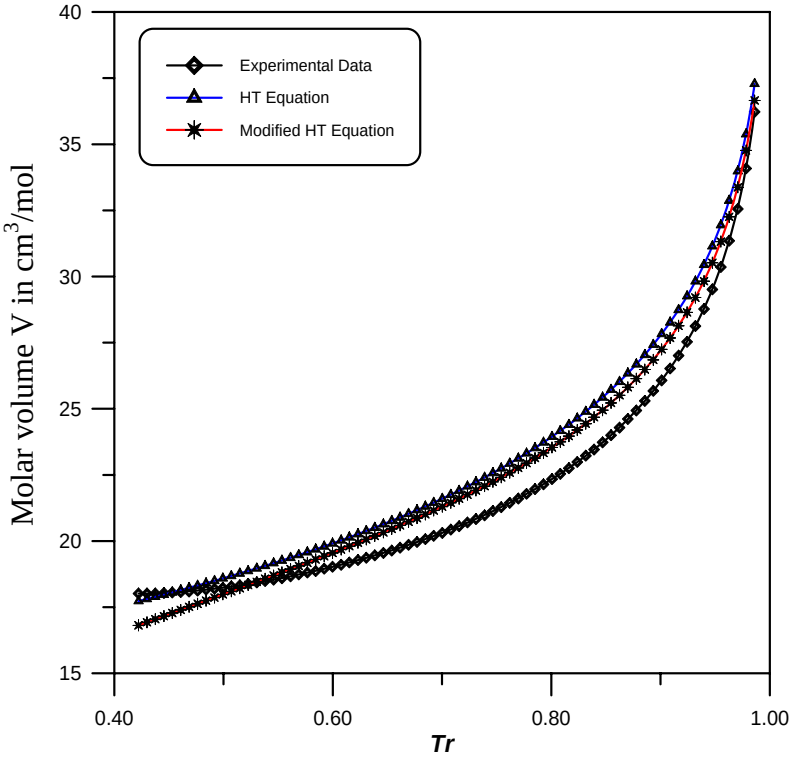

Figure 4-8: Experimental and calculated saturated liquid molar volume versus reduced temperature for Water

4.2.2 Saturated Molar Volume of Pure Liquid Compounds at Normal Boiling Point.

At least three methods are available in the literature to predict saturated molar volume of pure liquid compounds at normal boiling point. They are Tyn and Calus, Schroeder, and Le Bas methods. Table 4-3 shows the results of investigation for nonpolar compounds and table 4-4 for polar compounds. The two tables show that Tyn and Calus have the highest accuracy among the three correlations. Further more it is simple and easy to use. So effort was made to modify it to increase its accuracy and to reduce its deviation from experimental value as much as possible using statistical methods. The equation in modified form is:

$$V_b = 0.348 V_c^{1.016}$$

Table 4-3: Comparison of calculated saturated liquid molar volume at normal boiling point for three method and modified Tyn and Calus method for nonpolar compounds

Comp.	Tb(K)	V_{exp} (cm^3/mol)	%AD. Tyn&Calus	%AD. Schroeder	%AD. Le Bas	%AD. Modified TC
1,3-butadiene	268.68	83.1643	1.8634	1.0049	2.1214	0.8196
R-245	255.10	102.3376	2.1074	7.6586	3.2614	0.0586
R-123	300.81	105.0635	1.1826	3.3918	4.9147	0.7758
Isobutylene	266.24	89.6382	1.2513	1.5191	0.9351	1.1973
propane	231.02	75.8349	3.0707	1.5363	2.4196	0.1020
n-pentane	309.19	118.2	1.2265	0.6768	0.1692	0.3706
Isopentane	300.99	117.793	1.7868	1.0246	0.5153	0.1709
Neopentane	282.628	119.6	4.9469	0.5016	1.0033	3.3315
Oxygen	90.2	28.0311	8.3215	25.0832	47.2015	2.4323
Nitrogen	77.35	34.7374	8.2514	19.3951	39.5463	2.9976
Methane	111.66	37.9737	7.7547	7.8311	22.0515	2.7532
Ethane	184.6	55.2687	4.7102	1.3232	6.2759	0.7869
Ethylene	169.42	49.4031	4.4263	0.8159	10.1271	0.1588
n-Butane	272.67	96.66	1.9038	1.3863	0.4758	0.3176
Total			**3.7718**	**4.8210**	**9.5667**	**1.1624**

Table 4-4: Comparison of calculated saturated liquid molar volume at normal boiling point for three method and modified Tyn and Calus method for polar compounds

Compounds	Tb(K)	V_{exp} (cm^3/mol)	%AD. Tyn&Calus	%AD. Schroeder	%AD. Le Bas	%AD. Modified TC
R-11	296.81	92.8398	0.8036	1.9817	4.8041	1.5332
R-12	243.45	81.2535	1.4600	5.2348	0.1802	1.2932
R-22	232.14	61.2193	1.2289	2.8084	1.1750	2.4049
Total			**1.164**	**6.2015**	**7.2987**	**1.7436**

Figure 4-9 shows the experimental saturated liquid molar volume versus critical volume at normal boiling point for different compounds pure non-polar and polar compounds, the figure exhibits that saturated volume takes straight line and the equations of Tyn and Calus and it is modified have the same shape with slop of 0.285 and 0.348 for original Tyn and Calus and its modified form respectively.

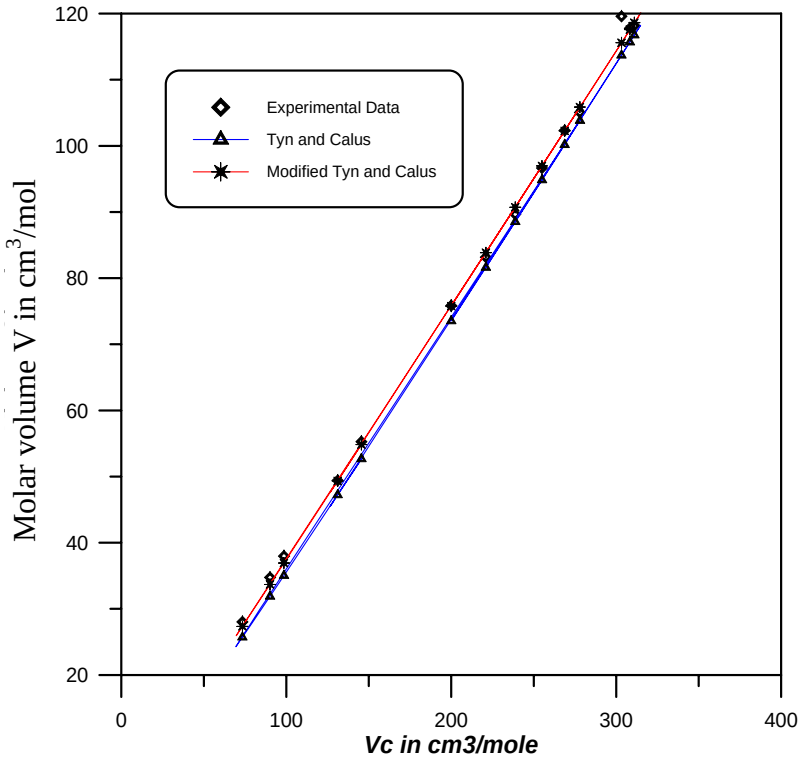

Figure 4-9: Experimental and calculated saturated liquid molar volume versus reduced volume at normal boiling point for different compounds

4.2.3 Extended to Mixture.

The experimental data of saturated liquid molar volume for binary mixture containing polar and non polar compounds and calculated molar volume using HT equation and modified HT equation using the same mixing rule of HT equation are listed in appendix C.

Applying HT mixing rule to HT equation gave good results except for phenol-methanol with 15.845AAD% and that may be caused by some incorrect experimental data. The results also showed a high AAD% in Butane-Octane with 11.8749 AAD%. and Propane-nOctane with 17.6698AAD% and that at reduced temperature range grater than 0.95, the AAD% is 0.8196% for CCl_4 –benzene and 1.5650% for CCl_4 –hexane, but when applying HT mixing rule to modified HT equation very good results were obtained for examples the AAD% for CCl_4 –Benzene is 0.3900% and the AAD% for CCl_4 –Hexane is 0.3132%.

The summary of all the above explanation is listed in table 4-5.

Table 4-5: % Absolute average deviation for binary mixtures

NO.	Component	NO. of points	AAD% (HT)	AAD% Modified(HT)
1	**Butane-Octane**	65	11.8749	8.3550
2	**Aniline-Methanol**	33	9.6239	5.2963
3	**Benzene-Methanol**	33	6.5555	3.7714
4	**C_3H_7OH-CCl_4**	30	4.2446	2.1279
5	**$C_9H_{10}OH$-CCl_4**	27	3.2842	1.2526
6	**$C_5H_{12}OH$-CCl_4**	30	3.3352	1.4694
7	**$C_7H_{15}OH$-CCl_4**	27	4.4231	1.9358
8	**$C_8H_{17}OH$-CCl_4**	30	4.3865	1.9846
9	**CCl_4 -Benzene**	8	0.8196	0.3900
10	**CCl_4 -Hexane**	8	1.5650	0.3132
11	**Hexadecane-Benzene**	9	5.2715	1.4254
12	**Hexadecane-CCl_4**	10	4.4146	0.8754
13	**Hexadecan-Hexane**	20	6.2232	0.5548
14	**Iso C_3H_7OH-CCl_4**	42	3.3892	1.6207
15	**Iso $C_4H_{10}OH$-CCl_4**	30	3.3141	1.4813
16	**Iso $C_5H_{12}OH$ –CCl_4**	27	3.8177	1.559
17	**Methane-nDecane**	60	2.651	0.7275

18	**Methane-3methylpentane**	28	1.6363	0.5648
19	**Methanol-CCl_4**	30	2.6853	1.3961
20	**Phenol-Methanol**	22	15.845	11.453
21	**Toluene-Methanol**	33	7.3423	4.2325
22	**Tetradecane-nHexane**	10	4.2314	0.2111
23	**TetraC_5H_{12}OH-CCl_4**	27	2.5777	1.7507
24	**SecC_4H_{10}OH-CCl_4**	27	3.621	1.6919
25	**R11-R12**	48	2.5077	2.0695
26	**Propane-nOctane**	78	17.6698	16.7696
	Total	**792**	**5.2811**	**2.8953**

Figures 4-10 and 4-11 show the experimental and calculated molar volume for binary mixture of Propane and Octane for two mole fractions of Propane, the figures show that the calculated data using HT and modified HT for the same mixing rule have acceptable results up to Tr=0.95. As shown in figure 4-11 the curves of experimental HT and modified HT are close together up to Tr=0.95. This is also true for Butane and Octane. (Figures 4-12, 4-13).

Figures 4-14 and 4-15 exhibit the data for molar volume for Benzene and Methanol at constant temperature but for different composition of Benzene, the results show good accuracy for both temperatures 20^{o}C and 40^{o}C. In figure 4-15, the modified HT equation has very close results with that of HT equation. Another polar mixture was plotted in figures 4-16 and 4-17 for Phenol and Methanol, they exhibit divergence in calculation at lower Tr the convergence of calculated data with the experimental points were shown from Tr=0.56 to Tr=0.62. These two figures indicate also that modified HT equation have better results than using HT equation.

Figure 4-18 show the effect of mole fraction of one compound in the mixture, for Aniline and Methanol in figure 4-18 have acceptable results in comparison with figure 4-19 where this figure has rather inaccurate results especially for HT equation. The experimental data in figure 4-19 probably were in error for $C_5H_{12}OH$ mole fraction between 0.0 and 0.1.

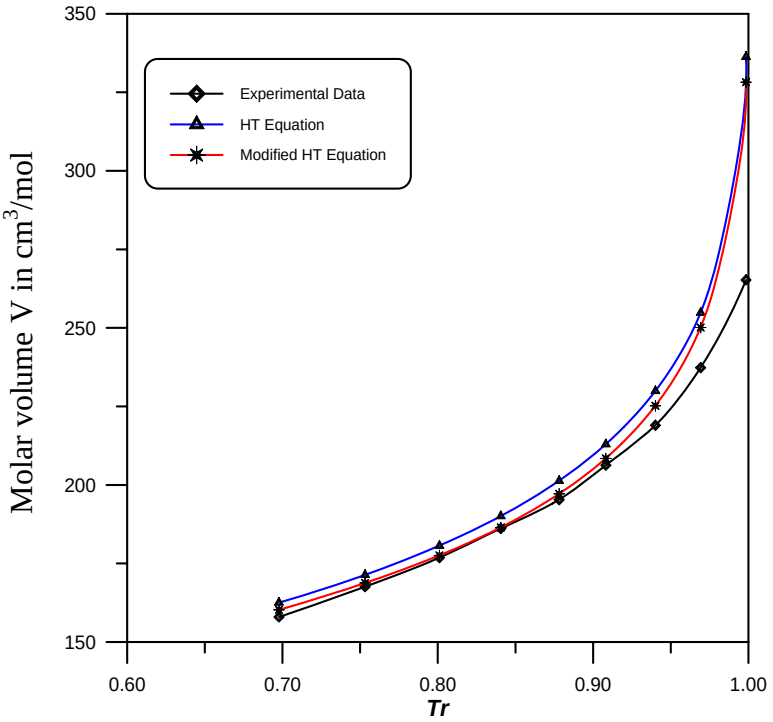

Figure 4-10: Experimental and calculated saturated liquid molar volume for mixture of 21.43%prpane and n-Octane

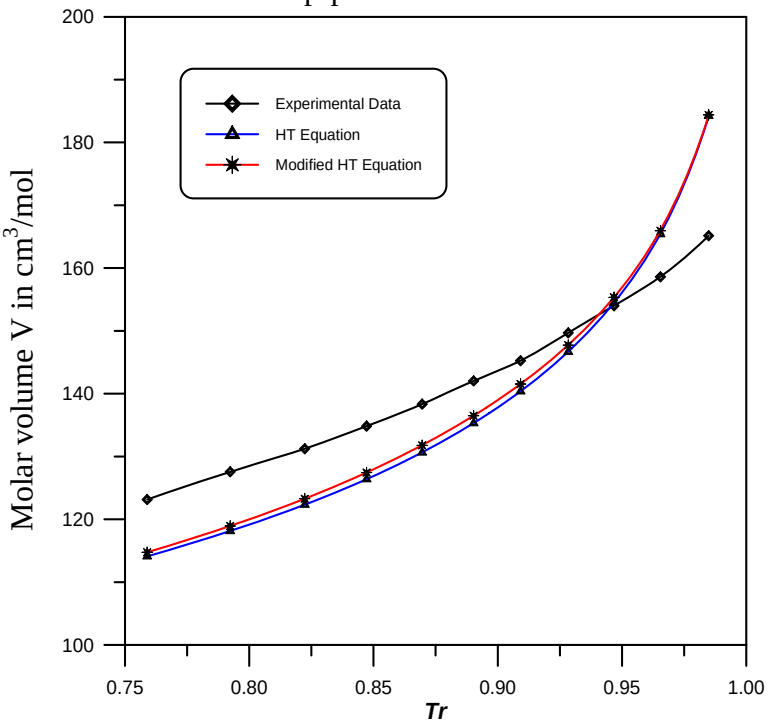

Figure 4-11: Experimental and calculated saturated liquid molar volume for mixture of 71.75%prpane and n-Octane

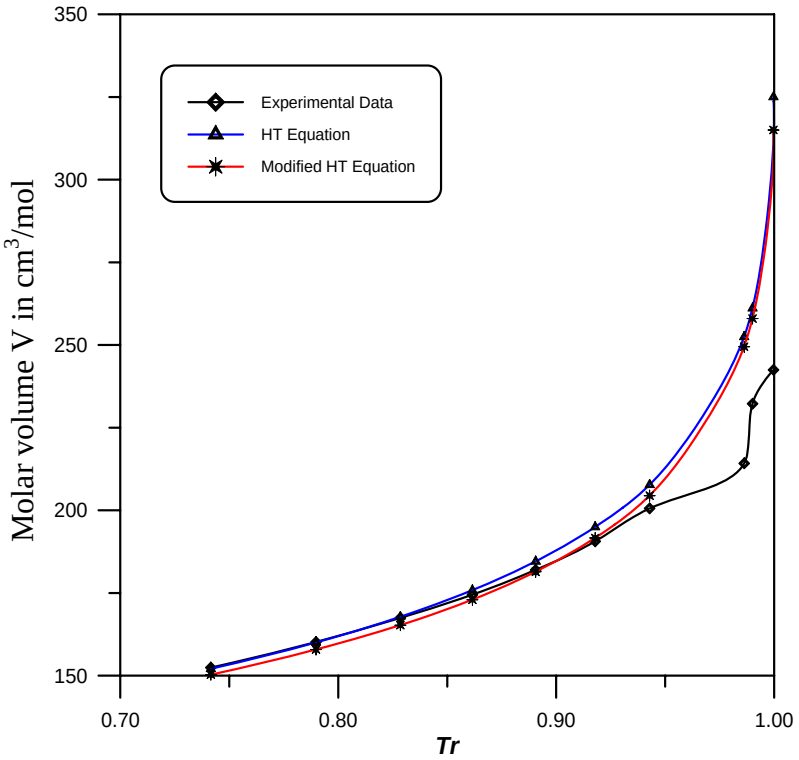

Figure 4-12: Experimental and calculated saturated liquid molar volume for mixture of 46.31%Butane and n-Octane

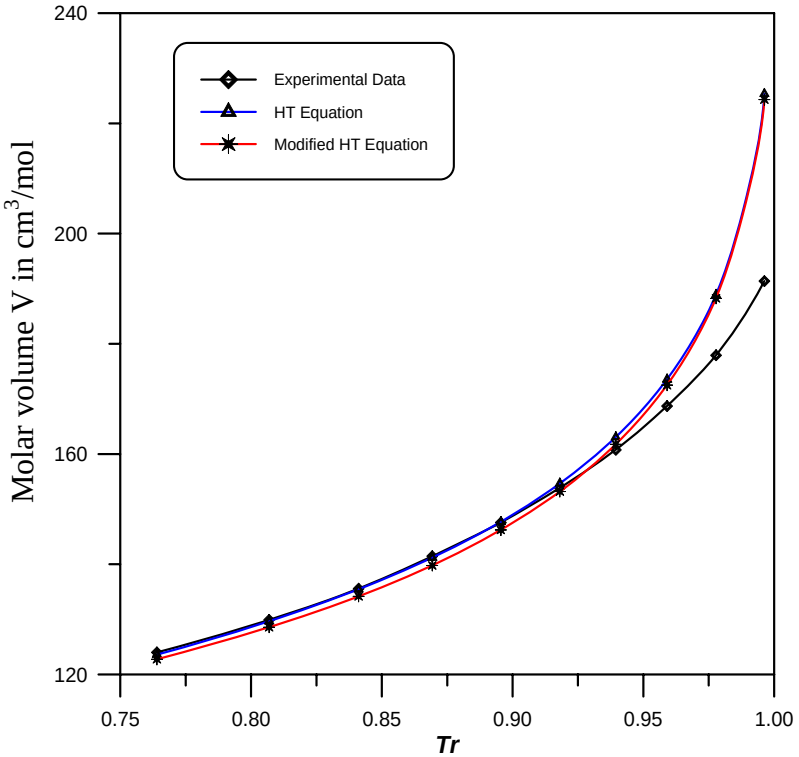

Figure 4-13: Experimental and calculated saturated liquid molar volume for mixture of 81.83%Butane and n-Octane

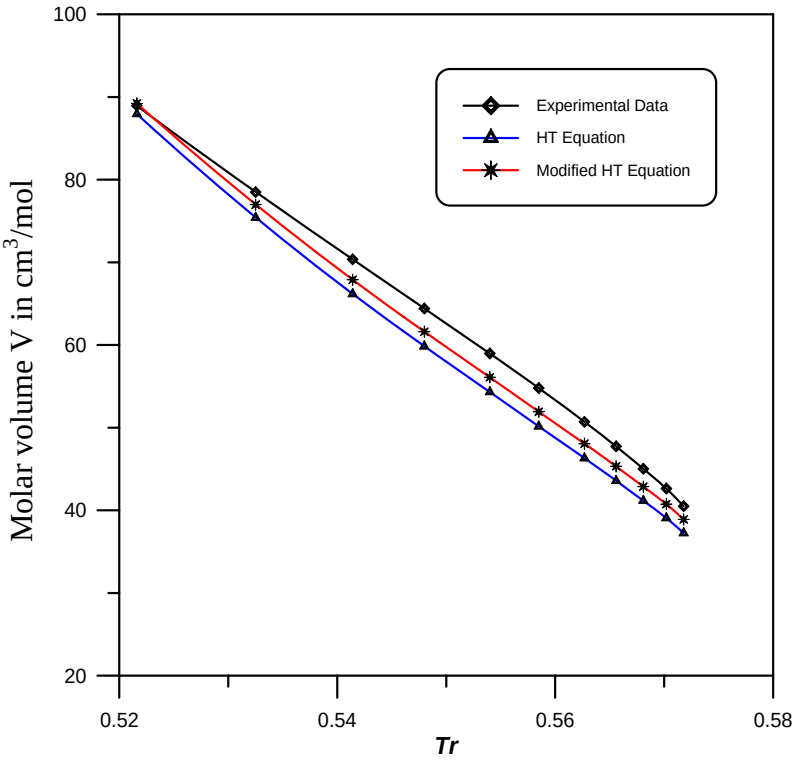

Figure 4-14: Experimental and calculated saturated liquid molar volume for mixture of Benzene and Methanol at 20°C

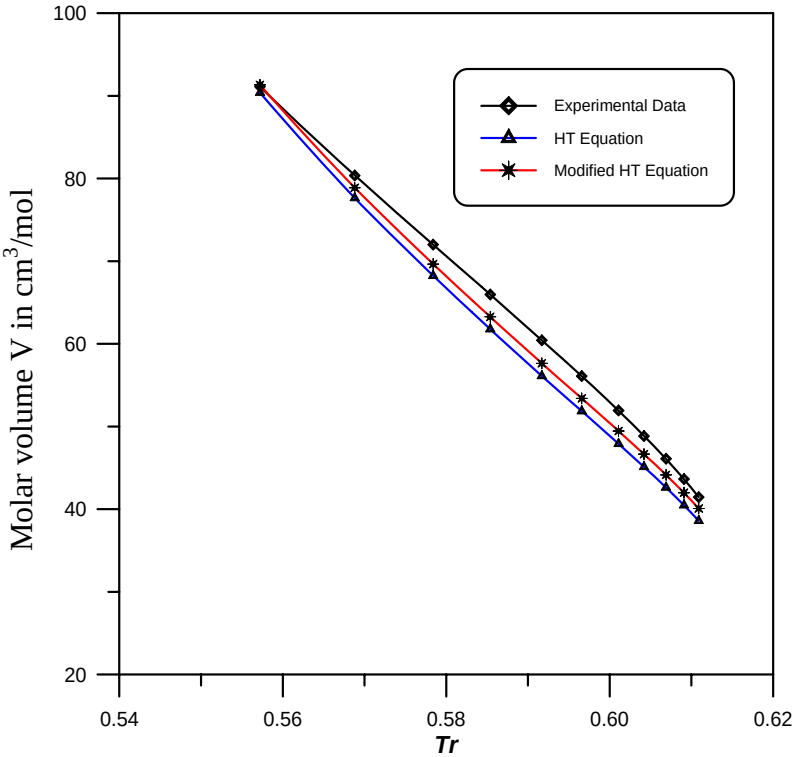

Figure 4-15: Experimental and calculated saturated liquid molar volume for mixture of Benzene and Methanol at 40°C

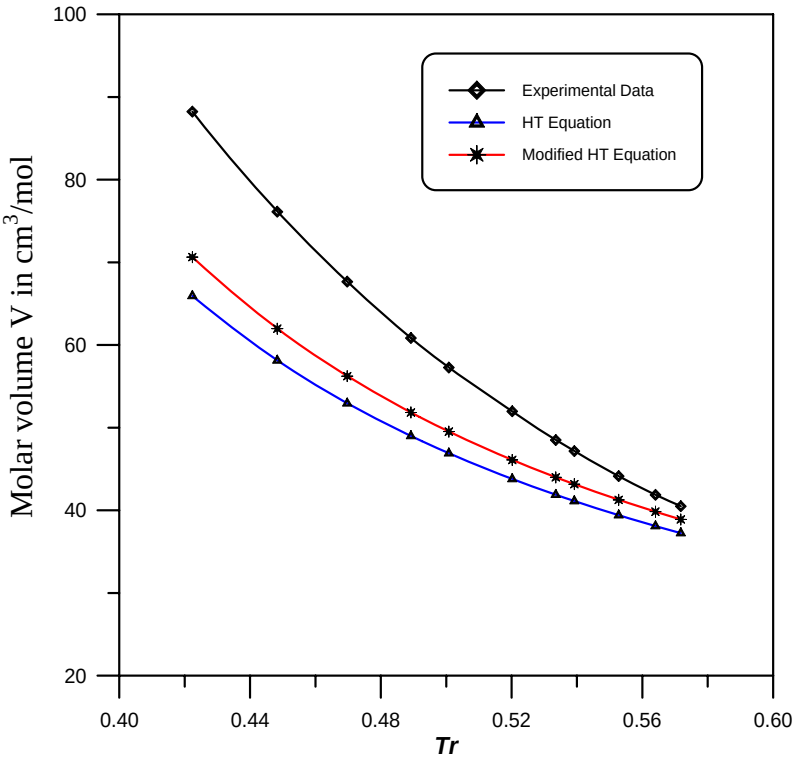

Figure 4-16: Experimental and calculated saturated liquid molar volume for mixture of Phenol and Methanol at 20°C

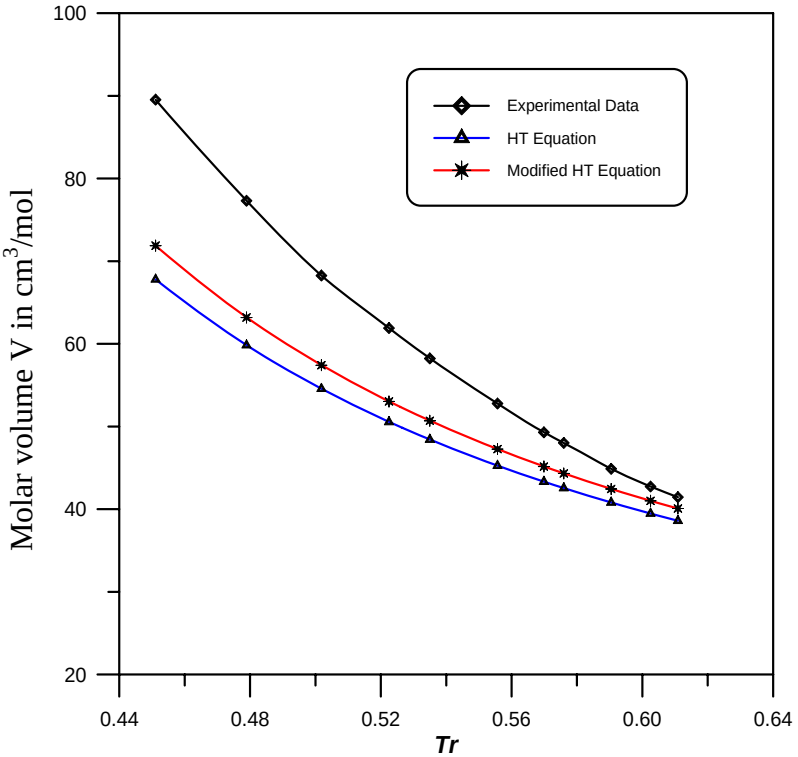

Figure 4-17: Experimental and calculated saturated liquid molar volume for mixture of Phenol and Methanol at 40°C

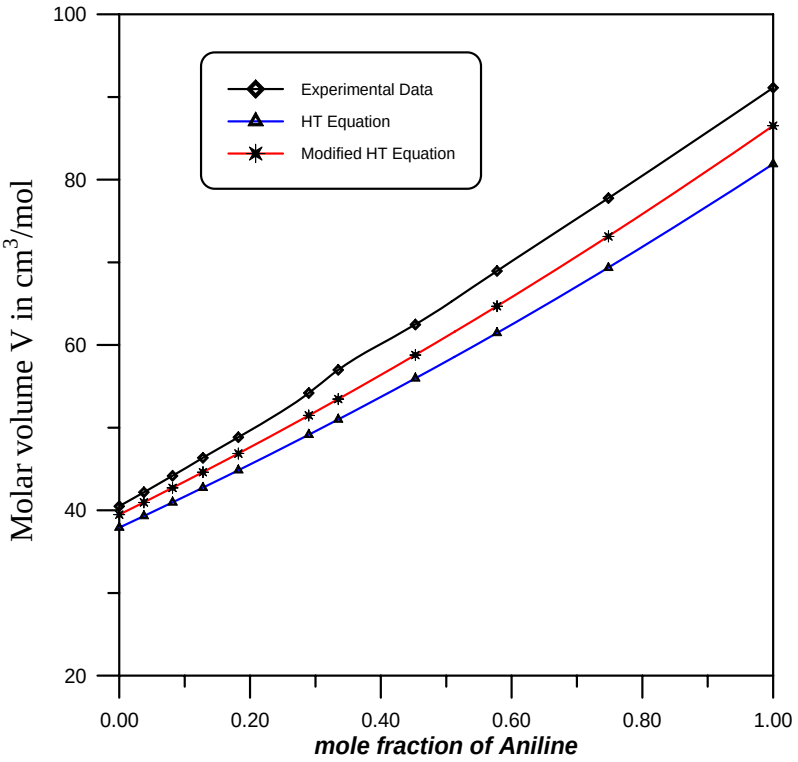

Figure 4-18: Experimental and calculated saturated liquid molar volume for mixture of Aniline and Methanol at 30°C as function of mole fraction of Aniline

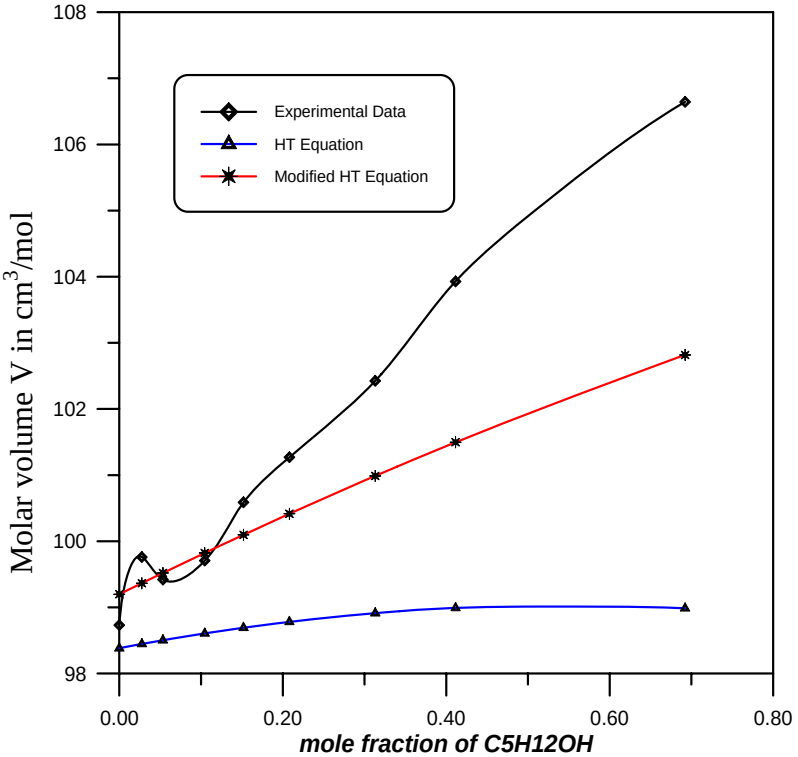

Figure 4-19: Experimental and calculated saturated liquid molar volume for mixture of $C_5H_{12}OH$ and CCl_4 at 40°C as function of mole fraction of $C_5H_{12}OH$

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

1. The accuracy of the modified HT has been increased rather than HT equation for both nonpolar and polar compounds; in addition the range of reduced temperature was extended from 0.25<Tr>0.95 for HT equation to 0.25<Tr>1.0 for modified HT equation according to pure components.
2. Another modified correlation was made for Tyn and Calus for changing the slop of data points to another constant, the deviation of data was decreased for nonpolar compounds and increased little for polar components.
3. The developes HT equation has been applied to mixture of polar and nonpolar compounds, more accurate results have been shown when using mixing rule of HT equation for modified HT equation in the range of reduced temperature 0.25<Tr>0.95

5.2 Recommendations

1- Modification of some of existing equation of state to predict saturated molar volume of pure compounds and mixture and compare it with the modified HT equation.

2- From the figures shown in chapter four the results have special shape with mathematical formulation, therefore new development may be derived.

3- Developing new mixing rule for calculation molar volume of mixture based on HT mixing rule and other mixing rule discussed in chapter two.

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Appendix A

Table A-1: Physical Properties of Components

Compounds	M.WT	Tc K	Pc bar	W	Zc	Vc cm^3/mole
Argon	39.94	150.86	48.98	-0.00	0.291	74.57
1,3-butadiene	54.092	425.00	43.20	0.195	0.270	221.00
Benzene	78.114	562.05	48.95	0.210	0.268	256.00
CarbonDioxide	44.010	304.12	73.74	0.225	0.274	94.07
Cyclopropane	42.081	398.25	55.75	0.130	0.274	162.80
R-245	134.050	380.40	31.48	0.297	0.267	268.74
R-123	152.931	456.90	36.74	0.282	0.269	278.05
R-134a	102.032	374.26	40.59	0.326	0.262	200.80
Isobutylene	56.108	417.90	40.00	0.199	0.275	238.80
propane	44.097	369.83	42.48	0.152	0.275	200.00
Isobutane	58.123	407.85	36.40	0.186	0.278	262.70
n-pentane	72.150	469.70	33.70	0.252	0.268	311.00
Isopentane	72.150	460.39	33.81	0.229	0.272	308.30
Neopentane	72.150	433.75	31.99	0.197	0.269	303.20
Oxygen	31.999	154.58	50.43	-0.016	0.288	73.37
Nitrogen	28.014	126.20	33.98	0.037	0.289	90.10
Methane	16.043	190.56	45.99	0.011	0.286	98.60
Ethane	30.070	305.32	48.72	0.099	0.279	145.50
Ethylene	28.054	282.34	50.41	0.087	0.282	131.10
n-Butane	58.123	425.12	37.96	0.200	0.274	255.00
R-11	137.368	471.10	44.72	0.195	0.283	248.00
R-12	120.913	385.10	41.30	0.179	0.280	217.00
R-22	86.468	369.28	49.86	0.221	0.274	166
water	18.015	647.15	220.64	0.344	0.229	55.95
Ammonia	17.031	405.40	113.53	0.257	0.255	72.47
Ethanol	46.069	513.92	61.48	0.649	0.240	167.00
Octane	114.231	568.70	24.90	0.399	0.259	492.00
Aniline	93.128	699.00	53.10	0.380	0.256	273.90
Phenol	94.113	694.25	61.30	0.442	0.243	229.00
2-butanol	74.123	536.05	41.79	0.574	0.252	269.00
1-Pentanol	88.150	588.15	39.09	0.579	0.262	326.00
2-methyl-1-butanol	88.150	575.40	39.40	0.605	0.260	329.00
2-methyl-2-butanol	88.150	545.00	37.90	0.478	0.270	323.00
1-heptanol	116.203	631.90	31.50	0.588	0.261	435.00
1-octanol	130.230	652.50	28.60	0.594	0.258	490.00
Carbone tetra-chloride	153.822	556	45.57	0.195	0.271	276
n-Hexadecane	226.446	723.00	14.00	0.718	0.241	1034.00

Component	M.WT	Tc K	Pc bar	W	Zc	Vc cm^3/mole
Tetra-decane	198.392	693	15.7	0.699	0.244	894.00
4-methyl cyclohexanone	112.215	587.70	35.70	0.254	0.271	410.00
Chloro triflouro methane	104.459	301.84	38.73	0.174	0.276	180.30
4-methyl cyclohexane	98.188	572.19	30.48	0.236	0.269	368
Acetonitrile	41.053	545.5	48.5	0.34	0.185	173
Methanol	32.042	512.64	80.97	0.565	0.224	118.00
1-Propanol	60.096	536.78	51.75	0.629	0.254	219.00
1,4-dioxane	88.106	587.00	51.70	0.618	0.255	238.00
1-butanol	74.123	563.05	44.23	0.590	0.260	275.00
Isobutanol	74.123	547.78	43.00	0.590	0.258	273.00
Tertbutanol	74.123	506.21	39.73	0.613	0.260	275.00
Cyclohexane	82.145	560.40	45.30	0.308	0.243	296.88
n-hexane	86.177	507.60	30.25	0.300	0.273	366.70
Toluene	92.141	591.75	41.08	0.264	0.264	316.00
2,4-dimethylpentane	100.204	519.70	27.40	0.304	0.265	417.50
Isooctane	114.231	543.90	25.70	0.304	0.266	469.70
n-decane	142.285	617.70	21.10	0.490	0.256	624.00
Deuterium oxide	20.028	643.89	216.71	-0.143	0.228	56.26
Hydrogene	2.016	32.98	12.93	-0.217	0.303	64.20
Trichloro triflouro ethane	187.375	487.4	33.78	0.249	0.274	325.00

A-2: Program for calculating saturated liquid molar volume for pure components (for example 1,3-Butadiene)

```
%   "simulation program for calculating molar volume for sat. liquid for
1,3-butadiene"
%   "Required constants,Tc=k,R=j/mol.k, w, Vc=cm3/mol, Pc=pa, Zc "
    clear
    clc

%   Critical Properties
    Tc=425;
    Pc=43.20;
    w=0.195;
    R=8.314;
    vc=221;
    zc=0.270;

%   "Input vapor liquid equilibrium"

T=[0,5,10,15,20,25,30,35,40,45,50,55,60,65,70,75,80,85,90,95,100,105,110,
115,120,125,130,131.12,132.23,133.34,134.45,135.57,136.68,137.79,138.90,1
40.01,141.12,142.23];

Vsexp1=[1.5499,1.5642,1.5790,1.5943,1.6102,1.6266,1.6436,1.6613,1.6798,1.
6990,1.7191,1.7403,1.7625,1.7858,1.8105,1.8366,1.8644,1.8941,1.9259,1.960
3,1.9976,2.0384,2.083,2.133,2.190,2.257,2.33,2.35,2.38,2.40,2.42,2.45,2.4
7,2.50,2.53,2.56,2.60,2.65];


%   "loop for calculating all needed variables"
for i=1:38
    Tk(i)=T(i)+273.15;
    Tr(i)=Tk(i)/Tc;
    Vsexp(i)=Vsexp1(i)*54.092;

    %   "Terms of Racket equation for required program to calculat sat.
molar vol."
Vscal1(i)=vc*(zc^((1-Tr(i))^(2/7)));
Error1(i)=abs(((Vsexp(i)-Vscal1(i))/Vsexp(i))*100);

%   "Terms of yen Woods equation for required program to calculat sat.
molar vol."
A(i)=17.4425-214.578*zc+989.625*zc^2-1522.06*zc^3;
B(i)=-3.28257+13.6377*zc+107.4844*zc^2-384.211*zc^3;
X(i)=1+A(i)*(1-Tr(i))^(1/3)+B(i)*(1-Tr(i))^(2/3)+(0.93-B(i))*(1-
Tr(i))^(4/3);
Vscal2(i)=vc/X(i);
Error2(i)=abs(((Vsexp(i)-Vscal2(i))/Vsexp(i))*100);


%   "Terms of Yamada Gunn equation for required program to calculat sat.
molar vol."
Vscal3(i)=vc*((0.29056-(0.08775*w))^((1-Tr(i))^(2/7)));
Error3(i)=abs(((Vsexp(i)-Vscal3(i))/Vsexp(i))*100);
```

```
%   "Terms of Spener Denner equation for required program to calculat
sat. molar vol."
Zra(i)=0.29056-(0.08775*w);
Vscal4(i)=((R*Tc/Pc)*(Zra(i)^(1+(1-Tr(i))^(2/7))))*10;
Error4(i)=abs(((Vsexp(i)-Vscal4(i))/Vsexp(i))*100);

%   "Terms of Reidel equation for required program to calculat sat. molar
vol."
Vscal5(i)=vc/(1+(1.69+0.984*w)*((1-Tr(i))^(1/3))+0.85*((1-Tr(i))));
Error5(i)=abs(((Vsexp(i)-Vscal5(i))/Vsexp(i))*100);

%   "Terms of Pradford and Thod. equation for required program to
calculat sat. molar vol."
Vscal6(i)=vc/(1+(2.924-7.34*zc)*(1-Tr(i))-(1.139-3.796*zc)*(1-
Tr(i))^2+(2.785-3.544*zc)*(1-Tr(i))^(0.160+0.586*zc));
Error6(i)=abs(((Vsexp(i)-Vscal6(i))/Vsexp(i))*100);

%   "Terms of HT equation for required program to calculat sat. molar
vol."
Vin(i)=1-(1.52816*(1-Tr(i))^(1/3))+(1.43907*(1-Tr(i))^(2/3))-(0.81446*(1-
Tr(i)))+(0.190454*(1-Tr(i))^(4/3));
Vfin(i)=(-0.296123+(0.386914*Tr(i))-(0.0427258*Tr(i)^2)-
(0.0480645*Tr(i)^3))/(Tr(i)-1.00001);
Vscal7(i)=vc*Vin(i)*(1-w*Vfin(i));
Error7(i)=abs(((Vsexp(i)-Vscal7(i))/Vsexp(i))*100);

%   "Terms of Modified HT equation for required program to calculat sat.
molar vol."
Vinm(i)=1-(1.22916*(1-Tr(i))^(1/3))+(0.087280*(1-
Tr(i))^(2/3))+(1.283902*(1-Tr(i)))-(0.902008*(1-Tr(i))^(4/3));
Vfinm(i)=(-0.707480+(1.771180*Tr(i))-
(1.70029*Tr(i)^2)+(0.636584*Tr(i)^3))/(Tr(i)-1.00001);
Vscal8(i)=vc*Vinm(i)*(1-w*Vfinm(i));
Vned(i)=Vsexp(i)/vc;
Error8(i)=abs(((Vsexp(i)-Vscal8(i))/Vsexp(i))*100);


end
E1=sum(Error1);
mean1=E1/i;
E2=sum(Error2);
mean2=E2/i;
E3=sum(Error3);
mean3=E3/i;
E4=sum(Error4);
mean4=E4/i;
E5=sum(Error5);
mean5=E5/i;
E6=sum(Error6);
mean6=E6/i;
E7=sum(Error7);
mean7=E7/i;
E8=sum(Error8);
mean8=E8/i;
```

```
%   "Printing all experimantal and calculated data"
disp('   ============================================      ')
disp('   Experimantal data for differernt temperature      ')
disp('   ============================================      ')
disp('      T         Tr      Vsexp   ')
disp('    ======    ======    ========  ')
disp([Tk',Tr',Vsexp'])
disp('   ============================================      ')
disp('   Calculated data using Racket Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error1'])
disp('=========')
disp('Mean Error=')
disp([mean1'])
disp('   ============================================      ')
disp('   Calculated data using yen Woods Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error2'])
disp('=========')
disp('Mean Error=')
disp([mean2'])
disp('   ============================================      ')
disp('   Calculated data using Yamada Gunn Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error3'])
disp('=========')
disp('Mean Error=')
disp([mean3'])
disp('   ============================================      ')
disp('   Calculated data using Spener Denner Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error4'])
disp('=========')
disp('Mean Error=')
disp([mean4'])
disp('   ============================================      ')
disp('   Calculated data using Reidel Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error5'])
disp('=========')
disp('Mean Error=')
disp([mean5'])
disp('   ============================================      ')
disp('   Calculated data using Pradford Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error6'])
disp('=========')
```

```
disp('Mean Error=')
disp([mean6'])
disp('   ==============================================      ')
disp('   Calculated data using HT Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error7'])
disp('=========')
disp('Mean Error=')
disp([mean7'])
disp('   ==============================================      ')
disp('   Calculated data using Modified HT Equation       ')
disp('   ============================================    ')
disp('    Error8         ')
disp('   ========  ')
disp([Error8'])
disp('=========')
disp('Mean Error=')
disp([mean8'])
```

A-3: Program for calculating saturated liquid molar volume for mixtures (for example 18.23% n-Butane and n-Octane)

```
%   "simulation program for calculating molar volume for sat. liquid for
18.23% n-Butane and n-Octane"
%   "Required constants,Tc=k,R=j/mol.k, w, Vc=cm3/mol, Pc=pa, Zc "
    clear
    clc
%   Critical Properties
    x1=0.4631;
    x2=1-x1;
    Tc1=425.12;
    Tc2=568.70;
    Pc1=37.96;
    Pc2=24.90;
    w1=0.200;
    w2=0.399;
    R=8.314;
    vc1=255;
    vc2=492;
    zc1=0.274;
    zc2=0.259;
    Mw1=58.123;
    Mw2=114.231;
    Mw=x1*Mw1+x2*Mw2;
%   "Input vapor liquid equilibrium"

Te=[102.7,127.2,146.8,163.6,178.3,192.1,204.8,226.8,228.7,233.6,238.8,241
.5,243.2,245.5];

Vsexp1=[0.579,0.551,0.527,0.506,0.485,0.463,0.44,0.412,0.38,0.364,0.345,0
.332,0.332,0.309];
%   "loop for calculating all needed variables"
for i=1:14
    T(i)=Te(i)+273.15;
    Vsexp(i)=(1/Vsexp1(i))*Mw;
    %   "Terms of Racket equation for required program to calculat sat.
molar vol."
TcR=x1*Tc1+x2*Tc2;
vcR=x1*vc1+x2*vc2;
zcR=x1*zc1+x2*zc2;
TrR(i)=T(i)/TcR;
Vscal1(i)=vcR*(zcR^((1-TrR(i))^(2/7)));
Error1(i)=abs(((Vsexp(i)-Vscal1(i))/Vsexp(i))*100);

%   "Terms of yen Woods equation for required program to calculat sat.
molar vol."
Tcy=x1*Tc1+x2*Tc2;
vcy=x1*vc1+x2*vc2;
zcy=x1*zc1+x2*zc2;
Try(i)=T(i)/Tcy;
A(i)=17.4425-214.578*zcy+989.625*zcy^2-1522.06*zcy^3;
B(i)=-3.28257+13.6377*zcy+107.4844*zcy^2-384.211*zcy^3;
X(i)=1+A(i)*(1-Try(i))^(1/3)+B(i)*(1-Try(i))^(2/3)+(0.93-B(i))*(1-
Try(i))^(4/3);
Vscal2(i)=vcy/X(i);
Error2(i)=abs(((Vsexp(i)-Vscal2(i))/Vsexp(i))*100);
```

```
%   "Terms of Yamada Gunn equation for required program to calculat sat.
molar vol."
wg=x1*w1+x2*w2;
Tcg=(x1*vc1*Tc1+x2*vc2*Tc2)/(x1*vc1+x2*vc2);
Trg(i)=T(i)/Tcg;
vcg=x1*vc1+x2*vc2;
Trg(i)=T(i)/Tcg;
Vscal3(i)=vcg*((0.29056-(0.08775*wg))^((1-Trg(i))^(2/7)));
Error3(i)=abs(((Vsexp(i)-Vscal3(i))/Vsexp(i))*100);

%   "Terms of Spener Denner equation for required program to calculat
sat. molar vol."
Zra1=0.29056-(0.08775*w1);
Zra2=0.29056-(0.08775*w2);
Zra=x1*Zra1+x2*Zra2;
Tcs=(x1*vc1*Tc1+x2*vc2*Tc2)/(x1*vc1+x2*vc2);
Trs(i)=T(i)/Tcs;
conss=R*((x1*Tc1/Pc1)+(x2*Tc2/Pc2));
Vscal4(i)=(conss*(Zra^(1+(1-Trs(i))^(2/7))))*10;
Error4(i)=abs(((Vsexp(i)-Vscal4(i))/Vsexp(i))*100);

%   "Terms of Reidel equation for required program to calculat sat. molar
vol."
TcR=x1*Tc1+x2*Tc2;
vcR=x1*vc1+x2*vc2;
wR=x1*w1+x2*w2;
TrR(i)=T(i)/TcR;
Vscal5(i)=vcR/(1+(1.69+0.984*wR)*((1-TrR(i))^(1/3))+0.85*((1-TrR(i))));
Error5(i)=abs(((Vsexp(i)-Vscal5(i))/Vsexp(i))*100);

%   "Terms of Pradford and Thod. equation for required program to
calculat sat. molar vol."
Vscal6(i)=vcR/(1+(2.924-7.34*zcR)*(1-TrR(i))-(1.139-3.796*zcR)*(1-
TrR(i))^2+(2.785-3.544*zcR)*(1-TrR(i))^(0.160+0.586*zcR));
Error6(i)=abs(((Vsexp(i)-Vscal6(i))/Vsexp(i))*100);

%   "Terms of HT equation for required program to calculat sat. molar
vol."
wsrk=x1*w1+x2*w2;
L=x1*vc1+x2*vc2;
M=x1*vc1^(2/3)+x2*vc2^(2/3);
N=x1*vc1^(1/3)+x2*vc2^(1/3);
v=(L+3*M*N)/4;
Tch=(x1*(vc1*Tc1)^0.5+x2*(vc2*Tc2)^0.5)^2/v;
Trh(i)=T(i)/Tch;

Vin(i)=1-(1.52816*(1-Trh(i))^(1/3))+(1.43907*(1-Trh(i))^(2/3))-
(0.81446*(1-Trh(i)))+(0.190454*(1-Trh(i))^(4/3));
Vfin(i)=(-0.296123+(0.386914*Trh(i))-(0.0427258*Trh(i)^2)-
(0.0480645*Trh(i)^3))/(Trh(i)-1.00001);
%Vin(i)=1-(1.22916*(1-Tr(i))^(1/3))+(0.087280*(1-
Tr(i))^(2/3))+(1.283902*(1-Tr(i)))-(0.902008*(1-Tr(i))^(4/3));
Vscal7(i)=v*Vin(i)*(1-wsrk*Vfin(i));
Error7(i)=abs(((Vsexp(i)-Vscal7(i))/Vsexp(i))*100);

%   "Terms of Modified HT equation for required program to calculat sat.
molar vol."
wsrk=x1*w1+x2*w2;
```

```
L=x1*vc1+x2*vc2;
M=x1*vc1^(2/3)+x2*vc2^(2/3);
N=x1*vc1^(1/3)+x2*vc2^(1/3);
v=(L+3*M*N)/4;
Tch=(x1*(vc1*Tc1)^0.5+x2*(vc2*Tc2)^0.5)^2/v;
Trh(i)=T(i)/Tch;
Vinm(i)=1-(1.22916*(1-Trs(i))^(1/3))+(0.087280*(1-
Trs(i))^(2/3))+(1.283902*(1-Trs(i)))-(0.902008*(1-Trs(i))^(4/3));
Vfinm(i)=(-0.707480+(1.771180*Trs(i))-
(1.70029*Trs(i)^2)+(0.636584*Trs(i)^3))/(Trs(i)-1.00001);
Vscal8(i)=v*Vinm(i)*(1-wsrk*Vfinm(i));
Error8(i)=abs(((Vsexp(i)-Vscal8(i))/Vsexp(i))*100);
end
E1=sum(Error1);
mean1=E1/i;
E2=sum(Error2);
mean2=E2/i;
E3=sum(Error3);
mean3=E3/i;
E4=sum(Error4);
mean4=E4/i;
E5=sum(Error5);
mean5=E5/i;
E6=sum(Error6);
mean6=E6/i;
E7=sum(Error7);
mean7=E7/i;
E8=sum(Error8);
mean8=E8/i;
%   "Printing all experimantal and calculated data"
disp('   ================================================      ')
disp('   Experimantal data for differernt temperature      ')
disp('   ================================================      ')
disp('      T      ')
disp('    ======  ')
disp([T'])
disp('     Vsexp   ')
disp('    ======    ')
disp([Vsexp'])
disp('      Trh    ')
disp('    ======    ')
disp([Trh'])
disp('   ================================================      ')
disp('   Calculated data using Racket Equation       ')
disp('   ================================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error1'])
disp('=========')
disp('Mean Error=')
disp([mean1'])
disp('   ================================================      ')
disp('   Calculated data using yen Woods Equation       ')
disp('   ================================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error2'])
disp('=========')
disp('Mean Error=')
```

```
disp([mean2'])
disp('   ============================================      ')
disp('   Calculated data using Yamada Gunn Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error3'])
disp('=========')
disp('Mean Error=')
disp([mean3'])
disp('   ============================================      ')
disp('   Calculated data using Spener Denner Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error4'])
disp('=========')
disp('Mean Error=')
disp([mean4'])
disp('   ============================================      ')
disp('   Calculated data using Reidel Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error5'])
disp('=========')
disp('Mean Error=')
disp([mean5'])
disp('   ============================================      ')
disp('   Calculated data using Pradford Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error6'])
disp('=========')
disp('Mean Error=')
disp([mean6'])
disp('   ============================================      ')
disp('   Calculated data using HT Equation       ')
disp('   ============================================    ')
disp('    Error1         ')
disp('   ========  ')
disp([Error7'])
disp('=========')
disp('Mean Error=')
disp([mean7'])
disp('   ============================================      ')
disp('   Calculated data using Modified HT Equation       ')
disp('   ============================================    ')
disp('    Error8         ')
disp('   ========  ')
disp([Error8'])
disp('=========')
disp('Mean Error=')
disp([mean8'])
```

Appendix B

Table B-1: Experimental and calculated saturated liquid molar volume of Argon

T K	Tr	Vexp. in cm^3/mol.	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
83.8000	0.5555	28.2033	0.6860	10.9840	0.8052	1.0249	0.8849	1.5249	0.9845	0.1958
85.0000	0.5634	28.3231	0.6067	11.1249	0.7253	0.9452	0.7648	1.4272	0.9004	0.0685
87.3000	0.5787	28.6028	0.6048	11.2235	0.7223	0.9421	0.6846	1.3889	0.8896	0.0132
90.0000	0.5966	28.9623	0.6650	11.2630	0.7809	1.0007	0.6530	1.4059	0.9403	0.0283
95.0000	0.6297	29.6414	0.6782	11.4257	0.7913	1.0110	0.4968	1.3401	0.9389	0.1085
100.0000	0.6629	30.3605	0.6186	11.6397	0.7288	0.9487	0.2691	1.2028	0.8674	0.2107
105.0000	0.6960	31.1994	0.7077	11.6503	0.8145	1.0342	0.1928	1.2147	0.9452	0.1244
110.0000	0.7292	32.1182	0.7596	11.6588	0.8629	1.0825	0.0827	1.1918	0.9847	0.0522
115.0000	0.7623	33.1568	0.8302	11.5925	0.9297	1.1492	0.0033	1.1909	1.0381	0.0432
120.0000	0.7954	34.3553	0.9412	11.4139	1.0364	1.2556	0.0417	1.2346	1.1220	0.1593
125.0000	0.8286	35.7135	0.9550	11.2588	1.0455	1.2647	0.1681	1.1872	1.0914	0.1255
130.0000	0.8617	37.3913	1.1037	10.8378	1.1887	1.4075	0.1441	1.2819	1.1651	0.1315
135.0000	0.8949	39.5086	1.3267	10.1723	1.4051	1.6235	0.0242	1.4600	1.2603	0.0520
140.0000	0.9280	42.3848	1.6968	9.0918	1.7669	1.9845	0.2755	1.7934	1.4056	0.1418
145.0000	0.9612	47.0587	2.7276	6.8082	2.7858	3.0011	1.2926	2.7797	2.0097	0.1063
150.0000	0.9943	58.9233	4.5467	1.8687	4.5797	4.7910	3.1529	4.2956	2.7447	0.0713
Error			1.2159	10.2509	1.3106	1.5291	0.5707	1.6200	1.2055	0.1020

Table B-2: Experimental and calculated saturated liquid molar volume of Ethylene

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
104.0000	0.3684	42.8385	0.8427	6.0923	1.1329	1.6315	0.0019	0.3416	0.8362	0.0258
110.0000	0.3896	43.3434	0.7502	6.0812	1.0374	1.5355	0.0121	0.2694	0.7738	0.1884
120.0000	0.4250	44.2131	0.6244	6.0866	0.9063	1.4037	0.0014	0.1786	0.6918	0.3395
130.0000	0.4604	45.1389	0.4968	6.0824	0.7733	1.2701	0.0072	0.0876	0.6005	0.4217
140.0000	0.4959	46.1208	0.3832	6.0842	0.6541	1.1503	0.0292	0.0119	0.5154	0.0133
150.0000	0.5313	47.1588	0.3012	6.1096	0.5663	1.0621	0.0818	0.0316	0.4542	0.3106
160.0000	0.5667	48.2809	0.2123	6.1165	0.4713	0.9666	0.1260	0.0816	0.3783	0.2195
169.4000	0.6000	49.4031	0.1657	6.1506	0.4187	0.9137	0.2029	0.0920	0.3373	0.263
170.0000	0.6021	49.4592	0.2005	6.1923	0.4531	0.9483	0.2454	0.0551	0.3722	0.3072
180.0000	0.6375	50.7777	0.1264	6.1877	0.3723	0.8670	0.3002	0.0915	0.2969	0.3448
190.0000	0.6729	52.2085	0.0900	6.2060	0.3286	0.8232	0.3892	0.0924	0.2531	0.2454
200.0000	0.7084	53.8076	0.0365	6.1865	0.2674	0.7616	0.4566	0.1136	0.1874	0.3695
210.0000	0.7438	55.5750	0.0376	6.2011	0.2601	0.7543	0.5728	0.0853	0.1735	0.3082
220.0000	0.7792	57.6229	0.0111	6.1342	0.2020	0.6959	0.6309	0.1139	0.1102	0.4807
230.0000	0.8146	60.0075	0.0598	6.0314	0.1427	0.6364	0.6783	0.1529	0.0525	0.3685
240.0000	0.8500	62.8690	0.1209	5.8697	0.0696	0.5629	0.6988	0.2186	0.0031	0.3021
250.0000	0.8855	66.4599	0.2214	5.6043	0.0451	0.4476	0.6600	0.3439	0.0679	0.3157
260.0000	0.9209	71.2852	0.3936	5.1714	0.2354	0.2564	0.5220	0.5682	0.1434	0.4718
270.0000	0.9563	78.6634	0.6760	4.4614	0.5428	0.0526	0.2400	0.9326	0.1936	0.4938
280.0000	0.9917	96.2533	1.2788	2.8762	1.1965	0.7095	0.3179	1.4946	0.1633	0.5272
Error			0.3515	5.7963	0.5038	0.8724	0.3087	0.2678	0.3302	0.3158

Table B-3: Experimental and calculated saturated liquid molar volume of Carbon Dioxide

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
216.5500	0.7121	37.3205	1.7535	4.6277	0.9236	0.3750	0.5451	1.9796	0.9549	0.4486
220.0000	0.7234	37.7166	1.7332	4.5968	0.9129	0.3856	0.5497	1.9524	0.9338	0.1133
225.0000	0.7398	38.3327	1.6681	4.5136	0.8625	0.4354	0.5202	1.8755	0.8665	0.3159
230.0000	0.7563	38.9489	1.7024	4.5307	0.9114	0.3871	0.5880	1.8961	0.8966	0.3056
235.0000	0.7727	39.6530	1.6180	4.4238	0.8432	0.4544	0.5373	1.7952	0.8079	0.1699
240.0000	0.7892	40.4012	1.5472	4.3286	0.7894	0.5076	0.4987	1.7049	0.7319	0.0422
245.0000	0.8056	41.1934	1.5076	4.2633	0.7673	0.5293	0.4896	1.6422	0.6864	0.0569
250.0000	0.8220	42.0736	1.4134	4.1398	0.6922	0.6035	0.4252	1.5207	0.5871	0.2077
255.0000	0.8385	43.0418	1.2962	3.9906	0.5955	0.6990	0.3365	1.3714	0.4658	0.3747
260.0000	0.8549	44.0980	1.1935	3.8539	0.5145	0.7789	0.2607	1.2306	0.3605	0.5158
265.0000	0.8714	45.2863	1.0523	3.6758	0.3971	0.8948	0.1456	1.0445	0.2200	0.6767
270.0000	0.8878	46.6066	0.9385	3.5240	0.3090	0.9817	0.0567	0.8776	0.1113	0.5853
273.1500	0.8982	47.4428	1.0529	3.6185	0.4398	0.8526	0.1851	0.9534	0.2308	0.6537
274.0000	0.9010	47.7068	1.0314	3.5903	0.4233	0.8689	0.1679	0.9209	0.2117	0.6668
275.0000	0.9042	48.0589	0.9372	3.4863	0.3355	0.9556	0.0794	0.8133	0.1211	0.7486
276.0000	0.9075	48.3670	0.9563	3.4986	0.3605	0.9309	0.1033	0.8185	0.1434	0.117
277.0000	0.9108	48.7191	0.9054	3.4390	0.3160	0.9748	0.0578	0.7532	0.0967	0.2524
278.0000	0.9141	49.0711	0.8780	3.4035	0.2950	0.9956	0.0357	0.7109	0.0737	0.3627
279.0000	0.9174	49.4232	0.8751	3.3932	0.2986	0.9920	0.0381	0.6926	0.0756	0.2466
280.0000	0.9207	49.8193	0.8090	3.3181	0.2395	1.0504	0.0220	0.6106	0.0153	0.2905
281.0000	0.9240	50.2154	0.7715	3.2723	0.2090	1.0804	0.0536	0.5566	0.0160	0.2038
282.0000	0.9273	50.6115	0.7641	3.2576	0.2087	1.0807	0.0551	0.5321	0.0167	0.185
283.0000	0.9306	51.0516	0.7018	3.1865	0.1540	1.1348	0.1108	0.4523	0.0713	0.2175
284.0000	0.9338	51.4917	0.6748	3.1519	0.1347	1.1538	0.1310	0.4071	0.0900	0.2125
285.0000	0.9371	51.9758	0.6002	3.0686	0.0683	1.2194	0.1981	0.3138	0.1551	0.2514
286.0000	0.9404	52.5039	0.4831	2.9419	0.0402	1.3264	0.3068	0.1776	0.2615	0.1292
287.0000	0.9437	52.9880	0.4958	2.9484	0.0191	1.3056	0.2861	0.1702	0.2381	0.2757
288.0000	0.9470	53.5602	0.3915	2.8354	0.1141	1.3994	0.3808	0.0455	0.3297	0.1342
289.0000	0.9503	54.0883	0.4246	2.8633	0.0720	1.3579	0.3382	0.0572	0.2837	0.3537
290.0000	0.9536	54.7044	0.3549	2.7864	0.1318	1.4169	0.3966	0.0342	0.3385	0.3709
291.0000	0.9569	55.3646	0.2736	2.6980	0.2027	1.4868	0.4651	0.1376	0.4034	0.2958
292.0000	0.9601	56.0247	0.2694	2.6892	0.1962	1.4804	0.4554	0.1646	0.3901	0.2407
293.0000	0.9634	56.7729	0.1956	2.6098	0.2584	1.5418	0.5127	0.2613	0.4442	0.3504
294.0000	0.9667	57.6091	0.0696	2.4776	0.3718	1.6538	0.6194	0.4101	0.5483	0.1081
295.0000	0.9700	58.4893	0.0126	2.3913	0.4407	1.7218	0.6793	0.5151	0.6067	0.1187
296.0000	0.9733	59.4135	0.0290	2.3735	0.4431	1.7242	0.6696	0.5542	0.5975	0.1611
297.0000	0.9766	60.4697	0.0966	2.3047	0.4952	1.7756	0.7052	0.6431	0.6366	0.2519
298.0000	0.9799	61.6580	0.1683	2.2333	0.5498	1.8295	0.7373	0.7340	0.6774	0.2462
299.0000	0.9832	63.0663	0.3186	2.0834	0.6807	1.9587	0.8370	0.8991	0.7938	0.5212
300.0000	0.9865	65.0908	1.0470	1.3437	1.3848	2.6537	1.4966	1.6319	1.4838	0.58
301.0000	0.9897	66.6751	0.5634	1.8476	0.8770	2.1524	0.9252	1.1469	0.9673	0.0554
302.0000	0.9930	69.2277	0.6627	1.7553	0.9433	2.2179	0.8904	1.2147	1.0376	0.1653
303.0000	0.9963	72.8806	0.5841	1.8351	0.8181	2.0943	0.5824	1.0367	0.9642	0.2636
Error			0.8098	3.1900	0.4661	1.1958	0.4064	0.8665	0.4638	0.2986

Table B-4: Experimental and calculated saturated liquid molar volume of Benzene

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
280.0000	0.4982	86.7065	0.1333	1.9130	1.3995	2.8984	0.6390	1.4102	1.4102	0.3947
290.0000	0.5160	87.6439	0.1676	1.9188	1.4212	2.9204	0.7005	1.4312	1.4460	0.0890
300.0000	0.5338	88.6594	0.1547	1.8758	1.3946	2.8934	0.7137	1.3562	1.4312	0.1351
310.0000	0.5516	89.7530	0.0992	1.7888	1.3247	2.8225	0.6831	1.2200	1.3705	0.2830
320.0000	0.5693	90.8466	0.0923	1.7504	1.3035	2.8010	0.7004	1.1448	1.3562	0.4467
330.0000	0.5871	92.0183	0.0510	1.6764	1.2472	2.7438	0.6819	1.0895	1.3042	0.5444
340.0000	0.6049	93.2681	0.0190	1.5724	1.1612	2.6566	0.6332	0.9542	1.2200	0.5827
350.0000	0.6227	94.4398	0.0534	1.6124	1.2190	2.7152	0.7266	1.7653	1.2771	0.7352
360.0000	0.6405	95.8459	0.0583	1.4646	1.0900	2.5843	0.6330	1.7955	1.1448	0.6748
370.0000	0.6583	97.1738	0.0189	1.4696	1.1131	2.6078	0.6899	1.8015	1.1623	0.7404
380.0000	0.6761	98.6580	0.0657	1.3865	1.0486	2.5423	0.6582	1.8042	1.0895	0.6950
390.0000	0.6939	100.2203	0.1089	1.3064	0.9870	2.4797	0.6280	1.8276	1.0171	0.6306
400.0000	0.7117	101.8607	0.1398	1.2384	0.9371	2.4291	0.6080	1.8306	0.9542	0.5585
405.0000	0.7206	102.6418	0.0810	1.2794	0.9868	2.4796	0.6719	1.9213	0.9966	0.5903
415.0000	0.7384	103.5792	0.7159	2.0495	1.7721	3.2765	1.4821	2.0107	1.7653	1.3249
420.0000	0.7473	104.5165	0.6978	2.0122	1.7433	3.2473	1.4664	2.1023	1.7275	1.2674
425.0000	0.7562	105.3758	0.7850	2.0817	1.8208	3.3259	1.5561	2.2291	1.7955	1.3128
430.0000	0.7651	106.3132	0.8291	2.1074	1.8543	3.3599	1.6014	2.4703	1.8190	1.3120
435.0000	0.7740	107.3286	0.8333	2.0927	1.8472	3.3527	1.6057	2.8091	1.8015	1.2687
440.0000	0.7828	108.3441	0.8739	2.1150	1.8767	3.3826	1.6459	3.4183	1.8202	1.2603
445.0000	0.7917	109.4377	0.8809	2.1033	1.8717	3.3776	1.6511	4.4961	1.8042	1.2167
450.0000	0.8006	110.5313	0.9295	2.1340	1.9085	3.4149	1.6973	7.3357	1.8296	1.2141
455.0000	0.8095	111.7030	0.9516	2.1379	1.9180	3.4245	1.7155	1.4102	1.8276	1.1846
460.0000	0.8184	112.9528	0.9518	2.1201	1.9050	3.4114	1.7106	1.4312	1.8029	1.1335
465.0000	0.8273	114.2027	1.0044	2.1557	1.9444	3.4514	1.7572	1.3562	1.8306	1.1360
470.0000	0.8362	115.5306	1.0444	2.1790	1.9707	3.4780	1.7899	1.2200	1.8453	1.1277
475.0000	0.8451	116.8585	1.1457	2.2649	2.0582	3.5668	1.8828	1.1448	1.9213	1.1832
480.0000	0.8540	118.3427	1.1792	2.2831	2.0766	3.5855	1.9060	1.0895	1.9286	1.1742
485.0000	0.8629	119.8269	1.2871	2.3772	2.1694	3.6796	2.0024	0.9542	2.0107	1.2439
490.0000	0.8718	121.4673	1.3452	2.4223	2.2112	3.7221	2.0471	1.7653	2.0427	1.2694
495.0000	0.8807	123.1858	1.4307	2.4965	2.2797	3.7916	2.1175	1.7955	2.1023	1.3287
500.0000	0.8896	124.9824	1.5554	2.6120	2.3867	3.9002	2.2254	1.8015	2.2016	1.4349
505.0000	0.8985	127.0134	1.6082	2.6572	2.4202	3.9342	2.2590	1.8042	2.2291	1.4786
510.0000	0.9074	129.1224	1.7351	2.7799	2.5270	4.0425	2.3651	1.8276	2.3318	1.6071
515.0000	0.9163	131.3877	1.8966	2.9410	2.6671	4.1847	2.5037	1.8306	2.4703	1.7828
520.0000	0.9252	133.8874	2.0630	3.1117	2.8103	4.3300	2.6452	1.9213	2.6153	1.9780
525.0000	0.9341	136.6214	2.2760	3.3352	2.9982	4.5207	2.8314	2.0107	2.8091	2.2365
530.0000	0.9430	139.6678	2.5333	3.6112	3.2278	4.7537	3.0604	2.1023	3.0498	2.5583
535.0000	0.9519	143.0267	2.9149	4.0233	3.5789	5.1100	3.4130	2.2291	3.4183	3.0256
540.0000	0.9608	146.9324	3.3737	4.5287	4.0027	5.5401	3.8437	2.4703	3.8683	3.5931
545.0000	0.9697	151.5412	4.0058	5.2318	4.5937	6.1398	4.4523	2.8091	4.4961	4.3556
550.0000	0.9786	157.1654	4.9830	6.3211	5.5202	7.0800	5.4197	3.4183	5.4725	5.4747
555.0000	0.9875	164.3519	6.8538	8.3854	7.3228	8.9092	7.3237	4.4961	7.3357	7.4477
Error			1.2541	2.5331	2.1841	3.6946	1.8917	1.4733	2.1198	1.5124

Table B-5: Experimental and calculated saturated liquid molar volume of R123

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
223.1500	0.4884	93.1350	0.9579	2.8963	0.0303	1.1865	0.7641	1.7059	0.0722	0.1812
233.1500	0.5103	94.3584	0.9992	2.9095	0.0228	1.1340	0.6851	1.7255	0.1444	0.214
243.1500	0.5322	95.7348	0.9402	2.8191	0.0230	1.1793	0.7054	1.6441	0.1136	0.2003
253.1500	0.5541	97.1112	0.9498	2.7974	0.0005	1.1571	0.6590	1.6319	0.1470	0.1748
263.1500	0.5759	98.6405	0.8748	2.6882	0.0613	1.2172	0.6966	1.5343	0.0928	0.385
273.1500	0.5978	100.1698	0.8805	2.6599	0.0416	1.1977	0.6559	1.5174	0.1147	0.1676
278.1500	0.6088	101.0874	0.7624	2.5221	0.1515	1.3063	0.7550	1.3870	0.0040	0.196
283.1500	0.6197	101.8520	0.8200	2.5629	0.0871	1.2426	0.6814	1.4331	0.0668	0.064
288.1500	0.6307	102.7696	0.7501	2.4736	0.1488	1.3037	0.7337	1.3507	0.0021	0.0687
293.1500	0.6416	103.5343	0.8549	2.5617	0.0373	1.1934	0.6141	1.4437	0.1097	0.9131
298.1500	0.6525	104.4519	0.8363	2.5239	0.0479	1.2039	0.6165	1.4122	0.0937	0.2896
300.9500	0.6587	105.0636	0.7440	2.4193	0.1350	1.2900	0.6988	1.3119	0.0030	0.1616
303.1500	0.6635	105.3695	0.8453	2.5139	0.0309	1.1871	0.5921	1.4079	0.1042	0.2495
308.1500	0.6744	106.2870	0.8829	2.5326	0.0145	1.1422	0.5398	1.4320	0.1420	0.1913
313.1500	0.6854	107.3576	0.8064	2.4351	0.0529	1.2088	0.6004	1.3407	0.0655	0.2549
318.1500	0.6963	108.4281	0.7635	2.3714	0.0868	1.2424	0.6283	1.2825	0.0214	0.2947
323.1500	0.7073	109.3457	0.8963	2.4860	0.0537	1.1035	0.4833	1.4002	0.1506	0.1703
328.1500	0.7182	110.5691	0.7835	2.3507	0.0491	1.2051	0.5811	1.2702	0.0350	0.2957
333.1500	0.7292	111.6396	0.8494	2.3969	0.0256	1.1313	0.5031	1.3189	0.0958	0.2528
338.1500	0.7401	112.8631	0.8183	2.3442	0.0044	1.1523	0.5212	1.2690	0.0593	0.1122
343.1500	0.7510	114.0865	0.8317	2.3365	0.0275	1.1294	0.4961	1.2626	0.0660	0.0342
348.1500	0.7620	115.3100	0.8917	2.3761	0.0973	1.0604	0.4253	1.3019	0.1181	0.0158
353.1500	0.7729	116.6864	0.8688	2.3314	0.0852	1.0724	0.4371	1.2563	0.0870	0.0037
358.1500	0.7839	118.0627	0.9011	2.3427	0.1282	1.0299	0.3949	1.2646	0.1098	0.0014
363.1500	0.7948	119.4391	0.9920	2.4133	0.2297	0.9296	0.2956	1.3297	0.1900	0.1647
368.1500	0.8058	120.9684	1.0175	2.4178	0.2668	0.8928	0.2613	1.3273	0.2046	0.0941
373.1500	0.8167	122.6507	0.9870	2.3658	0.2489	0.9106	0.2829	1.2664	0.1630	0.0793
378.1500	0.8276	124.3329	1.0351	2.3937	0.3094	0.8508	0.2277	1.2817	0.1988	0.0873
383.1500	0.8386	126.1681	1.0452	2.3837	0.3329	0.8276	0.2105	1.2562	0.1967	0.0308
388.1500	0.8495	128.1562	1.0301	2.3489	0.3320	0.8284	0.2188	1.2022	0.1693	0.0959
393.1500	0.8605	130.2972	1.0042	2.3042	0.3211	0.8392	0.2383	1.1338	0.1313	0.2667
398.1500	0.8714	132.4382	1.1008	2.3847	0.4327	0.7289	0.1372	1.1839	0.2148	0.2114
403.1500	0.8824	134.8851	1.1037	2.3723	0.4524	0.7094	0.1287	1.1358	0.2061	0.2387
413.1500	0.9042	140.5436	1.0630	2.3079	0.4490	0.7128	0.1572	0.9766	0.1459	0.1031
423.1500	0.9261	147.5784	0.9783	2.2161	0.4085	0.7528	0.2239	0.7467	0.0506	0.1428
433.1500	0.9480	156.7543	0.9035	2.1670	0.3884	0.7727	0.2623	0.4923	0.0192	0.2761
443.1500	0.9699	170.5181	0.6411	1.9996	0.2014	0.9575	0.4240	0.0123	0.2483	0.2719
453.1500	0.9918	199.7279	0.2072	1.4654	0.5082	1.6589	0.8336	0.9991	1.0636	0.2262
Error			0.8847	2.4261	0.1664	1.0697	0.4834	1.2697	0.1374	0.1889

Table B-6: Experimental and calculated saturated liquid molar volume of Butadiene

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
273.1500	0.6427	83.8372	0.6454	1.2244	0.2988	1.5067	0.1139	0.1353	0.3350	0.0095
278.1500	0.6545	84.6107	0.6349	1.2180	0.3004	1.5083	0.0874	0.1364	0.3333	0.0194
283.1500	0.6662	85.4113	0.6248	1.2108	0.3013	1.5092	0.0620	0.1383	0.3300	0.0376
288.1500	0.6780	86.2389	0.6131	1.2048	0.3037	1.5116	0.0357	0.1392	0.3271	0.0477
293.1500	0.6898	87.0989	0.6035	1.1961	0.3036	1.5115	0.0124	0.1429	0.3208	0.0464
298.1500	0.7015	87.9860	0.5875	1.1937	0.3097	1.5177	0.0165	0.1409	0.3197	0.0429
303.1500	0.7133	88.9056	0.5685	1.1939	0.3186	1.5268	0.0475	0.1367	0.3205	0.0346
308.1500	0.7251	89.8630	0.5493	1.1938	0.3273	1.5356	0.0776	0.1335	0.3202	0.0192
313.1500	0.7368	90.8637	0.5326	1.1908	0.3333	1.5416	0.1042	0.1337	0.3163	0.0052
318.1500	0.7486	91.9023	0.5085	1.1950	0.3463	1.5547	0.1370	0.1278	0.3187	0.0279
323.1500	0.7604	92.9896	0.4845	1.1988	0.3588	1.5674	0.1685	0.1235	0.3199	0.0555
328.1500	0.7721	94.1363	0.4672	1.1955	0.3642	1.5728	0.1918	0.1274	0.3134	0.0936
333.1500	0.7839	95.3371	0.4451	1.1968	0.3739	1.5827	0.2186	0.1282	0.3107	0.1297
338.1500	0.7956	96.5975	0.4176	1.2035	0.3886	1.5975	0.2492	0.1257	0.3126	0.1619
343.1500	0.8074	97.9336	0.3941	1.2061	0.3987	1.6078	0.2741	0.1294	0.3098	0.1986
348.1500	0.8192	99.3454	0.3658	1.2135	0.4130	1.6222	0.3018	0.1309	0.3110	0.2295
353.1500	0.8309	100.8491	0.3391	1.2195	0.4251	1.6345	0.3261	0.1368	0.3103	0.2592
358.1500	0.8427	102.4557	0.3124	1.2258	0.4363	1.6458	0.3480	0.1460	0.3091	0.2848
363.1500	0.8545	104.1758	0.2820	1.2365	0.4504	1.6601	0.3714	0.1551	0.3118	0.3003
368.1500	0.8662	106.0365	0.2560	1.2436	0.4591	1.6689	0.3877	0.1729	0.3103	0.3117
373.1500	0.8780	108.0542	0.2279	1.2541	0.4688	1.6787	0.4035	0.1932	0.3117	0.3100
378.1500	0.8898	110.2611	0.1999	1.2663	0.4769	1.6870	0.4160	0.2192	0.3140	0.2945
383.1500	0.9015	112.6736	0.1518	1.3015	0.5039	1.7142	0.4456	0.2311	0.3385	0.2417
388.1500	0.9133	115.3782	0.1134	1.3304	0.5190	1.7295	0.4621	0.2600	0.3557	0.1776
393.1500	0.9251	118.4615	0.0938	1.3454	0.5128	1.7233	0.4563	0.3158	0.3578	0.1067
398.1500	0.9368	122.0856	0.1333	1.3077	0.4442	1.6538	0.3879	0.4398	0.3058	0.0644
403.1500	0.9486	126.0344	0.0842	1.5418	0.6297	1.8415	0.5756	0.3183	0.5188	0.2711
404.2700	0.9512	127.1162	0.0662	1.5286	0.6035	1.8150	0.5505	0.3590	0.5007	0.2850
405.3800	0.9538	128.7390	0.3400	1.1224	0.1867	1.3933	0.1354	0.7865	0.0933	0.0886
406.4900	0.9564	129.8208	0.2797	1.1906	0.2387	1.4458	0.1892	0.7501	0.1549	0.0075
407.6000	0.9591	130.9026	0.1731	1.3068	0.3366	1.5450	0.2896	0.6682	0.2634	0.1520
408.7200	0.9617	132.5254	0.4151	1.0707	0.0838	1.2891	0.0401	0.9337	0.0226	0.0506
409.8300	0.9643	133.6072	0.1990	1.3009	0.2910	1.4988	0.2511	0.7438	0.2424	0.2080
410.9400	0.9669	135.2300	0.3208	1.1898	0.1580	1.3642	0.1232	0.8904	0.1234	0.1293
412.0500	0.9695	136.8528	0.3654	1.1590	0.1021	1.3076	0.0737	0.9603	0.0827	0.1298
413.1600	0.9721	138.4755	0.3236	1.2181	0.1322	1.3381	0.1118	0.9445	0.1293	0.2184
414.2700	0.9748	140.6392	0.5675	0.9897	0.1254	1.0774	0.1357	1.2123	0.1104	0.0205
415.3800	0.9774	143.3438	1.0624	0.5092	0.6360	0.5606	0.6335	1.7288	0.6019	0.4302
Error			0.3881	1.213020	0.3595	1.5275	0.2424	0.3867	0.2944	0.1448

Table B-7: Experimental and calculated saturated liquid molar volume of isoPentane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
301.0250	0.6538	117.8000	0.0567	2.3767	0.3605	1.0399	0.8303	0.4289	0.2879	0.157
310.0000	0.6733	119.7000	0.0360	2.3356	0.3743	1.0536	0.8144	0.3946	0.3113	0.1436
320.0000	0.6951	121.8000	0.1380	2.4159	0.2648	0.9448	0.6742	0.4800	0.2160	0.2366
330.0000	0.7168	124.1000	0.2046	2.4577	0.1900	0.8705	0.5709	0.5274	0.1593	0.1944
340.0000	0.7385	126.6000	0.2568	2.4825	0.1292	0.8101	0.4841	0.5570	0.1204	0.1921
350.0000	0.7602	129.3000	0.3185	2.5148	0.0582	0.7397	0.3901	0.5921	0.0749	0.2007
360.0000	0.7819	132.3000	0.3422	2.5061	0.0246	0.7063	0.3366	0.5840	0.0698	0.2615
370.0000	0.8037	135.5000	0.4412	2.5722	0.0849	0.5976	0.2112	0.6451	0.0085	0.2552
380.0000	0.8254	139.2000	0.4409	2.5352	0.0963	0.5861	0.1877	0.5990	0.0131	0.3461
390.0000	0.8471	143.2000	0.5535	2.6121	0.2213	0.4620	0.0556	0.6561	0.0780	0.3145
400.0000	0.8688	147.9000	0.5853	2.6061	0.2672	0.4164	0.0074	0.6202	0.0910	0.3389
410.0000	0.8905	153.4000	0.6074	2.5913	0.3053	0.3786	0.0278	0.5591	0.0996	0.3332
420.0000	0.9123	160.0000	0.6332	2.5842	0.3495	0.3347	0.0645	0.4820	0.1218	0.7635
430.0000	0.9340	168.4000	0.5869	2.5131	0.3254	0.3587	0.0318	0.3079	0.0895	0.6771
440.0000	0.9557	179.8000	0.4895	2.4124	0.2565	0.4271	0.0360	0.0530	0.0371	0.5188
445.0000	0.9666	187.5000	0.4228	2.3609	0.2078	0.4754	0.0695	0.1032	0.0111	0.4017
450.0000	0.9774	197.8000	0.3101	2.2856	0.1181	0.5645	0.1154	0.3056	0.0438	0.2987
451.0000	0.9796	200.4000	0.2601	2.2469	0.0737	0.6087	0.1442	0.3716	0.0800	0.3046
452.0000	0.9818	203.2000	0.2280	2.2285	0.0476	0.6346	0.1511	0.4184	0.0977	0.2941
453.0000	0.9839	206.3000	0.1904	2.2066	0.0164	0.6655	0.1584	0.4687	0.1208	0.2922
454.0000	0.9861	209.8000	0.1349	2.1694	0.0319	0.7135	0.1765	0.5334	0.1616	0.3136
455.0000	0.9883	213.8000	0.0667	2.1224	0.0921	0.7733	0.1979	0.6058	0.2160	0.3573
456.0000	0.9905	218.5000	0.0272	2.0530	0.1768	0.8574	0.2316	0.6958	0.2984	0.0432
457.0000	0.9926	224.1000	0.1046	2.0047	0.2435	0.9237	0.2289	0.7562	0.3703	0.0432
458.0000	0.9948	231.3000	0.2251	1.9166	0.3506	1.0301	0.2360	0.8347	0.4990	0.1464
459.0000	0.9970	241.5000	0.3853	1.7873	0.4926	1.1711	0.2179	0.8981	0.7063	0.1352
459.5000	0.9981	249.0000	0.4763	1.7015	0.5707	1.2487	0.1684	0.8916	0.8632	0.4858
460.0000	0.9992	261.1000	0.6340	1.5027	0.7084	1.3854	0.0993	0.8544	1.1852	1.2409
460.3900	1.0000	306.0000	0.7516	0.7516	0.7516	0.0647	0.7516	0.7516	2.3667	1.0916
Error			0.3416	2.2363	0.2479	0.7187	0.2645	0.5509	0.3034	0.3579

Table B-8: Experimental and calculated saturated liquid molar volume of Cyclopropane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
291.6667	0.7324	67.0482	0.1236	2.6793	1.1614	3.0203	1.2126	0.0856	1.1014	1.2550
297.2222	0.7463	67.9152	0.0601	2.7303	1.2060	3.0658	1.2961	0.1387	1.1395	1.2682
302.7778	0.7603	68.8085	0.0356	2.8129	1.2825	3.1437	1.4102	0.2224	1.2092	1.3092
308.3333	0.7742	69.7806	0.0947	2.8565	1.3211	3.1829	1.4852	0.2676	1.2409	1.3102
313.8889	0.7882	70.8315	0.1280	2.8719	1.3325	3.1945	1.5316	0.2847	1.2457	1.2838
319.4444	0.8021	71.9612	0.1473	2.8715	1.3287	3.1907	1.5612	0.2853	1.2359	1.2443
325.0000	0.8161	73.1698	0.1664	2.8691	1.3234	3.1853	1.5875	0.2827	1.2257	1.2077
330.5556	0.8300	74.5097	0.1300	2.8083	1.2607	3.1214	1.5544	0.2213	1.1599	1.1212
336.1111	0.8440	75.9284	0.1298	2.7830	1.2329	3.0932	1.5541	0.1922	1.1312	1.0802
341.6667	0.8579	77.5311	0.0515	2.6760	1.1245	2.9828	1.4705	0.0806	1.0250	0.9729
347.2222	0.8719	79.2651	0.0035	2.5916	1.0376	2.8942	1.4058	0.0127	0.9446	0.9058
352.7778	0.8858	81.2093	0.0948	2.4686	0.9115	2.7658	1.2990	0.1482	0.8308	0.8234
358.3333	0.8998	83.3636	0.1678	2.3634	0.8009	2.6532	1.2046	0.2722	0.7400	0.7866
363.8889	0.9137	85.8595	0.3050	2.1918	0.6216	2.4706	1.0380	0.4684	0.5910	0.7187
369.4444	0.9277	88.7495	0.4560	2.0064	0.4235	2.2689	0.8497	0.6873	0.4372	0.6788
375.0000	0.9416	92.1650	0.6016	1.8283	0.2243	2.0660	0.6578	0.9110	0.3019	0.6962
380.5556	0.9556	96.3949	0.7725	1.6285	0.0102	1.8272	0.4308	1.1706	0.1599	0.7510
386.1111	0.9695	101.9910	0.9852	1.3955	0.3025	1.5296	0.1531	1.4794	0.0034	0.8353
391.6667	0.9835	110.3195	1.1734	1.2085	0.6016	1.2250	0.0971	1.7500	0.0884	0.9954
397.2222	0.9974	130.1555	1.1989	1.1926	0.8630	0.9587	0.0591	1.5761	0.0852	0.7517
Error			0.3413	2.3417	0.9185	2.5920	1.0929	0.5269	0.7948	0.9998

Table B-9: Experimental and calculated saturated liquid molar volume of Propane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
85.5000	0.2312	60.1483	0.3949	3.2423	1.1472	1.4797	0.4072	0.6462	0.6379	0.0644
100.0000	0.2704	61.3830	0.1399	3.0369	0.8791	1.2107	0.5495	0.3732	0.4616	0.6201
120.0000	0.3245	63.1469	0.1256	2.8353	0.5955	0.9262	0.6611	0.0888	0.2906	0.4628
140.0000	0.3786	65.0431	0.3647	2.6522	0.3377	0.6675	0.7478	0.1630	0.1284	0.2345
160.0000	0.4326	67.0715	0.5414	2.5238	0.1417	0.4709	0.7744	0.3470	0.0102	0.2855
180.0000	0.4867	69.2323	0.6138	2.4917	0.0494	0.3783	0.6999	0.4227	0.0231	0.0557
200.0000	0.5408	71.6135	0.6546	2.4799	0.0125	0.3162	0.5977	0.4643	0.0453	0.0943
220.0000	0.5949	74.2593	0.6479	2.5029	0.0283	0.3003	0.4537	0.4582	0.0413	0.0259
231.1000	0.6249	75.8468	0.5943	2.5602	0.0121	0.3409	0.3272	0.4059	0.0019	0.0735
240.0000	0.6489	77.2579	0.6069	2.5448	0.0120	0.3167	0.2836	0.4209	0.0243	0.0296
260.0000	0.7030	80.7416	0.5498	2.5841	0.0176	0.3464	0.1090	0.3756	0.0118	0.0192
280.0000	0.7571	84.8867	0.4631	2.6312	0.0730	0.4020	0.0785	0.3159	0.0129	0.0398
300.0000	0.8112	90.0902	0.4301	2.5960	0.0688	0.3978	0.1875	0.3371	0.0265	0.0062
320.0000	0.8653	97.0134	0.4642	2.4604	0.0114	0.3173	0.1930	0.4718	0.1255	0.1643
340.0000	0.9193	107.2880	0.6015	2.1845	0.2111	0.1170	0.0411	0.7905	0.2753	0.1309
360.0000	0.9734	127.6167	0.8600	1.7686	0.5766	0.2498	0.2795	1.3539	0.3409	0.2947
Error			0.5033	2.5684	0.2609	0.5149	0.3994	0.4647	0.1536	0.1625

Table B-10: Experimental and calculated saturated liquid molar volume of Ethane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
90.4000	0.2961	46.1574	0.6564	3.2211	0.2684	1.1908	1.1318	0.8883	0.1438	0.2306
100.0000	0.3275	46.8791	0.7097	3.2576	0.2026	1.1244	1.0789	0.9308	0.1492	0.2656
110.0000	0.3603	47.6910	0.8115	3.2435	0.0868	1.0075	1.0701	1.0195	0.2078	0.4245
120.0000	0.3930	48.5630	0.9478	3.1891	0.0641	0.8552	1.0959	1.1407	0.3075	0.7363
130.0000	0.4258	49.4351	0.9868	3.2313	0.1173	0.8015	1.0251	1.1631	0.3161	0.068
140.0000	0.4585	50.3672	1.0415	3.2518	0.1871	0.7311	0.9707	1.1999	0.3475	0.526
150.0000	0.4913	51.3596	1.0989	3.2637	0.2602	0.6573	0.9199	1.2382	0.3887	0.0931
160.0000	0.5240	52.4120	1.1448	3.2813	0.3223	0.5947	0.8587	1.2641	0.4254	0.7498
170.0000	0.5568	53.5246	1.1631	3.3207	0.3573	0.5593	0.7715	1.2621	0.4415	0.4739
180.0000	0.5895	54.6973	1.1357	3.4000	0.3473	0.5694	0.6405	1.2146	0.4189	0.2403
184.6000	0.6046	55.2687	1.1230	3.4336	0.3429	0.5738	0.5810	1.1929	0.4107	0.1603
190.0000	0.6223	55.9903	1.1480	3.4289	0.3783	0.5382	0.5519	1.2074	0.4432	0.1272
200.0000	0.6551	57.4036	1.1678	3.4400	0.4180	0.4980	0.4744	1.2094	0.4818	0.093
210.0000	0.6878	58.9071	1.1073	3.5238	0.3782	0.5382	0.3202	1.1335	0.4455	0.0381
220.0000	0.7206	60.6211	1.1222	3.5157	0.4160	0.5001	0.2474	1.1368	0.4903	0.1069
230.0000	0.7533	62.5155	1.0965	3.5348	0.4150	0.5011	0.1407	1.1052	0.4978	0.1664
240.0000	0.7861	64.6505	1.0421	3.5662	0.3875	0.5288	0.0140	1.0526	0.4776	0.2085
250.0000	0.8188	67.1463	1.0205	3.5419	0.3961	0.5201	0.0681	1.0435	0.4875	0.2697
260.0000	0.8516	70.0932	0.9771	3.5139	0.3872	0.5292	0.1567	1.0277	0.4665	0.2607
270.0000	0.8843	73.7316	0.9493	3.4360	0.3999	0.5163	0.2091	1.0481	0.4410	0.1713
280.0000	0.9171	78.4827	0.9409	3.2922	0.4414	0.4744	0.2140	1.1161	0.3938	0.0662
290.0000	0.9498	85.4890	1.1089	2.8948	0.6771	0.2366	0.0034	1.3960	0.4371	0.4074
300.0000	0.9826	99.1709	1.7844	1.8158	1.4675	0.5612	0.7464	2.1788	0.7752	0.6696
Error			1.0558	3.2869	0.3791	0.6351	0.5778	1.1813	0.4084	0.2849

Table B-11: Experimental and calculated saturated liquid molar volume of Nitrogen

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
63.1000	0.5000	32.2161	21.0200	10.9348	0.5361	1.0083	0.0532	0.1598	0.3499	0.371
65.0000	0.5151	32.4962	1.0400	11.0546	0.5602	0.9845	0.1469	0.2117	0.3859	0.2567
70.0000	0.5547	33.3647	0.8292	11.0640	0.3619	1.1798	0.1324	0.0871	0.2136	0.1968
75.0000	0.5943	34.2611	0.7655	11.2084	0.3107	1.2302	0.2633	0.1085	0.1804	0.2694
77.3000	0.6125	34.7374	0.6356	11.1535	0.1873	1.3517	0.2231	0.0182	0.0630	0.2138
80.0000	0.6339	35.2696	0.6390	11.2516	0.1979	1.3413	0.3308	0.0669	0.0789	0.2802
85.0000	0.6735	36.3902	0.5098	11.2529	0.0834	1.4541	0.3933	0.0209	0.0296	0.2075
90.0000	0.7132	37.6228	0.4501	11.2836	0.0394	1.4974	0.5219	0.0412	0.0702	0.3467
95.0000	0.7528	39.0235	0.4070	11.2735	0.0136	1.5228	0.6623	0.0737	0.0914	0.2731
100.0000	0.7924	40.6763	0.3119	11.1293	0.0622	1.5973	0.7427	0.0476	0.1546	0.1552
105.0000	0.8320	42.6373	0.2540	10.9249	0.0979	1.6325	0.8496	0.0491	0.1590	0.1345
110.0000	0.8716	45.1025	0.1489	10.5250	0.1767	1.7101	0.8924	0.0099	0.1678	0.1016
115.0000	0.9113	48.4362	0.0712	9.7777	0.3636	1.8941	0.7951	0.2007	0.2062	0.2084
120.0000	0.9509	53.6468	0.6267	8.2557	0.8724	2.3951	0.3254	0.7387	0.3905	0.1496
125.0000	0.9905	65.9730	1.6440	4.8643	1.7962	3.3047	0.5911	1.5801	0.4165	0.2995
126.2000	1.0000	89.4767	0.6966	0.6966	0.6966	0.8503	0.6966	0.6966	0.9574	0.1389
Error			0.6281	9.7907	0.3972	1.5596	0.4763	0.2569	0.2447	0.2251

Table B-12: Experimental and calculated saturated liquid molar volume of iso-Butane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
261.3200	0.6407	97.8000	3.31	3.31	2.27	0.55	1.86	3.32	2.2932	2.0058
270.0000	0.6620	99.4400	3.3	3.3	2.27	0.54	1.92	3.32	2.2947	2.0579
280.0000	0.6865	101.4000	3.35	3.35	2.34	0.47	2.04	3.37	2.3538	2.1400
290.0000	0.7110	103.6000	3.32	3.32	2.33	0.48	2.09	3.34	2.3286	2.1056
300.0000	0.7356	105.9000	3.37	3.37	2.41	0.41	2.21	3.4	2.3861	2.1270
310.0000	0.7601	108.5000	3.34	3.34	2.41	0.41	2.26	3.37	2.3647	2.0501
320.0000	0.7846	111.3000	3.38	7.69	2.47	0.35	2.36	3.4	2.4042	2.0223
330.0000	0.8091	114.5000	3.34	7.69	2.47	0.35	2.39	3.35	2.3762	1.9251
340.0000	0.8336	118.1000	3.32	7.75	2.48	0.34	2.43	3.31	2.3612	1.8500
350.0000	0.8582	122.2000	3.32	7.72	2.52	0.3	2.5	3.28	2.3797	1.8314
360.0000	0.8827	127.1000	3.25	7.77	2.5	0.33	2.49	3.16	2.3423	1.7976
370.0000	0.9072	133.1000	3.13	7.73	2.43	0.39	2.43	2.98	2.2731	1.7943
380.0000	0.9317	140.8000	2.95	7.74	2.3	0.51	2.31	2.72	2.1783	1.8553
385.0000	0.9440	145.6000	2.87	7.67	2.25	0.56	2.26	2.58	2.1574	1.9559
390.0000	0.9562	151.6000	2.65	7.6	2.08	0.73	2.1	2.31	2.0299	1.9839
395.0000	0.9685	159.2000	2.45	7.55	1.93	0.88	1.96	2.05	1.9470	2.0897
396.0000	0.9709	161.1000	2.35	7.4	1.84	0.96	1.88	1.94	1.8786	2.0619
397.0000	0.9734	163.0000	2.33	7.18	1.84	0.96	1.89	1.91	1.8956	2.1202
398.0000	0.9758	165.2000	2.23	6.86	1.75	1.05	1.81	1.8	1.8242	2.0897
399.0000	0.9783	167.5000	2.18	6.7	1.71	1.09	1.78	1.74	1.8076	2.1134
400.0000	0.9808	170.1000	2.08	6.39	1.63	1.17	1.72	1.63	1.7475	2.0917
401.0000	0.9832	172.9000	2.02	6.07	1.59	1.2	1.7	1.58	1.7368	2.1161
402.0000	0.9857	176.1000	1.94	5.95	1.53	1.26	1.67	1.5	1.7023	2.1106
403.0000	0.9881	179.8000	1.85	5.91	1.46	1.33	1.63	1.41	1.6548	2.0818
404.0000	0.9906	184.2000	1.73	5.77	1.37	1.42	1.59	1.32	1.5895	2.0174
405.0000	0.9930	189.5000	1.68	5.69	1.34	1.45	1.63	1.3	1.5841	1.9804
406.0000	0.9955	196.5000	1.65	5.56	1.35	1.44	1.75	1.34	1.5994	1.8948
406.5000	0.9967	201.1000	1.7	5.47	1.42	1.37	1.9	1.45	1.6545	1.8435
407.0000	0.9979	207.0000	1.91	5.35	1.67	1.13	2.26	1.77	1.8517	1.8467
407.5000	0.9991	215.4000	2.87	5.21	2.68	0.15	3.47	2.93	2.7049	2.2365
Error			2.6388	6.4168	2.0218	0.7866	2.0769	2.4290	2.0567	2.0065

Table B-13: Experimental and calculated saturated liquid molar volume of Oxygen

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
54.4000	0.3519	24.5112	0.3318	7.7534	0.8791	2.3026	0.2141	1.3937	0.4620	0.2151
55.0000	0.3558	24.5432	0.2739	7.8444	0.9357	2.3599	0.1378	1.3294	0.5245	0.0712
60.0000	0.3881	24.9592	0.3503	7.9942	0.8405	2.2634	0.0625	1.3463	0.4783	0.0837
65.0000	0.4205	25.4072	0.4630	8.0963	0.7081	2.1291	0.0233	1.3978	0.3894	0.0329
70.0000	0.4528	25.8552	0.4773	8.2960	0.6745	2.0951	0.1148	1.3507	0.3936	0.4217
75.0000	0.4852	26.3672	0.6289	8.3355	0.5012	1.9193	0.1144	1.4389	0.2530	0.4475
80.0000	0.5175	26.8792	0.6603	8.4938	0.4485	1.8659	0.2344	1.4073	0.2276	0.7106
85.0000	0.5499	27.4231	0.6794	8.6519	0.4074	1.8241	0.3661	1.3629	0.2087	0.1085
90.0000	0.5822	28.0311	0.7824	8.7023	0.2802	1.6951	0.4114	1.4018	0.0996	0.1501
90.2000	0.5835	28.0311	0.6971	8.8019	0.3654	1.7816	0.5037	1.3145	0.1853	0.2416
95.0000	0.6146	28.6391	0.7207	8.9150	0.3182	1.7337	0.6215	1.2772	0.1517	0.2971
100.0000	0.6469	29.3431	0.8039	8.9476	0.2084	1.6224	0.6821	1.2973	0.0533	0.2428
105.0000	0.6793	30.0791	0.7779	9.0753	0.2071	1.6211	0.8497	1.2101	0.0618	0.1574
110.0000	0.7116	30.9110	0.8151	9.1040	0.1399	1.5529	0.9481	1.1879	0.0049	0.1776
115.0000	0.7440	31.8070	0.7569	9.2024	0.1666	1.5800	1.1369	1.0737	0.0448	0.0811
120.0000	0.7763	32.8630	0.8299	9.1132	0.0578	1.4697	1.1829	1.0944	0.0436	0.0561
125.0000	0.8086	34.0469	0.8278	9.0529	0.0211	1.4324	1.2933	1.0461	0.0471	0.038
130.0000	0.8410	35.4549	0.8803	8.8632	0.0758	1.3341	1.3309	1.0600	0.0886	0.0278
135.0000	0.8733	37.1508	0.9215	8.5929	0.1681	1.2405	1.3562	1.0728	0.0882	0.1391
140.0000	0.9057	39.3588	1.1196	8.0176	0.4287	0.9762	1.1856	1.2549	0.1916	0.2686
145.0000	0.9380	42.3667	1.3122	7.2346	0.7008	0.7003	0.9647	1.4438	0.1856	0.1937
150.0000	0.9704	47.3585	1.7530	5.7393	1.2603	0.1329	0.3879	1.8688	0.1958	0.3546
Error			0.7665	8.4013	0.4452	1.6196	0.6419	1.3014	0.1990	0.2053

Table B-14: Experimental and calculated saturated liquid molar volume of Methane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
90.7000	0.4760	35.5352	1.9984	5.5501	0.9754	0.1925	1.4896	2.6762	1.2044	1.1705
95.0000	0.4985	35.9844	1.9549	5.7111	0.9443	0.2240	1.3481	2.5964	1.1533	0.8915
100.0000	0.5248	36.5460	1.9376	5.8560	0.9423	0.2260	1.2173	2.5362	1.1312	0.6505
105.0000	0.5510	37.1395	1.9201	5.9932	0.9407	0.2276	1.0870	2.4755	1.1128	0.4596
110.0000	0.5772	37.7492	1.8511	6.1776	0.8877	0.2812	0.9055	2.3634	1.0462	0.2631
111.7000	0.5862	37.9738	1.8497	6.2142	0.8922	0.2767	0.8663	2.3473	1.0467	0.2287
115.0000	0.6035	38.4230	1.8448	6.2843	0.8990	0.2698	0.7885	2.3139	1.0466	0.1731
120.0000	0.6297	39.1289	1.8044	6.4169	0.8766	0.2924	0.6385	2.2308	1.0158	0.0864
125.0000	0.6560	39.8829	1.7556	6.5462	0.8467	0.3227	0.4819	2.1399	0.9795	0.0242
130.0000	0.6822	40.7011	1.7188	6.6484	0.8301	0.3395	0.3401	2.0621	0.9575	0.0012
135.0000	0.7084	41.5835	1.6704	6.7468	0.8029	0.3670	0.1895	1.9742	0.9254	0.0135
140.0000	0.7347	42.5621	1.6568	6.7887	0.8124	0.3575	0.0785	1.9231	0.9287	0.0192
145.0000	0.7609	41.5835	3.2178	12.0872	4.0779	5.3054	4.9710	2.9746	3.9651	4.8851
150.0000	0.7872	42.5621	3.6220	12.5041	4.4572	5.6892	5.4722	3.4106	4.3588	5.2541
155.0000	0.8134	43.6209	4.1525	13.0247	4.9610	6.1989	6.0939	3.9678	4.8861	5.7762
160.0000	0.8396	44.8241	4.7396	13.5652	5.5180	6.7625	6.7626	4.5754	5.4814	6.4006
165.0000	0.8659	46.1557	5.5442	14.2880	6.2894	7.5430	7.6387	5.3923	6.3143	7.3179
170.0000	0.8921	47.7119	6.5365	15.1419	7.2432	8.5080	8.6864	6.3866	7.3667	8.5355
175.0000	0.9183	49.5087	8.0100	16.4119	8.6715	9.9531	10.1967	7.8494	8.9560	10.4105
180.0000	0.9446	51.6905	10.3045	18.3975	10.9090	12.2171	12.5011	10.1206	11.4692	13.3867
Error			3.4045	9.5177	3.1389	3.2777	3.5877	3.6158	3.2673	3.2974

Table B-15: Experimental and calculated saturated liquid molar volume of isobutylene

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
255.3722	0.6111	87.9263	1.3536	4.5696	0.8179	0.1483	0.3253	1.5465	0.8627	0.3527
260.9278	0.6244	88.8021	1.3369	4.5527	0.8066	0.1371	0.3428	1.5290	0.8507	0.4058
266.4833	0.6377	89.6779	1.3554	4.5709	0.8304	0.1608	0.3948	1.5463	0.8725	0.4793
272.0389	0.6510	90.6237	1.3321	4.5449	0.8127	0.1432	0.4050	1.5214	0.8515	0.4975
277.5944	0.6643	91.5695	1.3485	4.5587	0.8348	0.1651	0.4540	1.5358	0.8688	0.5420
283.1500	0.6776	92.5504	1.3680	4.5744	0.8601	0.1903	0.5056	1.5527	0.8881	0.5772
288.7055	0.6908	93.6013	1.3559	4.5562	0.8541	0.1843	0.5253	1.5372	0.8748	0.5697
294.2611	0.7041	94.6522	1.3919	4.5863	0.8961	0.2261	0.5922	1.5691	0.9083	0.5993
299.8166	0.7174	95.8082	1.3672	4.5524	0.8781	0.2081	0.5982	1.5393	0.8804	0.5591
305.3722	0.7307	96.9642	1.3986	4.5749	0.9159	0.2457	0.6591	1.5646	0.9074	0.5660
310.9278	0.7440	98.1902	1.4168	4.5822	0.9410	0.2706	0.7062	1.5754	0.9204	0.5525
316.4833	0.7573	99.4864	1.4282	4.5811	0.9595	0.2890	0.7457	1.5780	0.9260	0.5264
322.0389	0.7706	100.8876	1.4047	4.5422	0.9436	0.2733	0.7496	1.5441	0.8962	0.4610
327.5944	0.7839	102.3238	1.4251	4.5469	0.9717	0.3011	0.7962	1.5521	0.9097	0.4360
333.1500	0.7972	103.8652	1.4282	4.5319	0.9829	0.3122	0.8245	1.5407	0.9058	0.3927
338.7055	0.8105	105.4766	1.4591	4.5437	1.0222	0.3513	0.8793	1.5548	0.9297	0.3776
344.2611	0.8238	107.2281	1.4630	4.5258	1.0350	0.3640	0.9061	1.5391	0.9271	0.3387
349.8166	0.8371	109.1898	1.3913	4.4281	0.9731	0.3025	0.8565	1.4446	0.8502	0.2304
355.3722	0.8504	111.3267	1.2990	4.3070	0.8912	0.2212	0.7850	1.3258	0.7541	0.1101
360.9278	0.8637	113.6737	1.1795	4.1559	0.7828	0.1135	0.6851	1.1757	0.6329	0.0256
366.4833	0.8770	116.2659	1.0336	3.9755	0.6489	0.0195	0.5576	0.9946	0.4883	0.1720
372.0389	0.8903	119.1034	0.9015	3.8073	0.5297	0.1380	0.4425	0.8219	0.3613	0.2850
377.5944	0.9036	122.1510	0.8617	3.7320	0.5034	0.1640	0.4185	0.7352	0.3314	0.2818
383.1500	0.9168	125.6541	0.7793	3.6109	0.4361	0.2309	0.3517	0.5987	0.2664	0.2895
388.7055	0.9301	129.6826	0.7029	3.4945	0.3766	0.2900	0.2918	0.4601	0.2175	0.2522
394.2611	0.9434	134.8671	0.3133	3.0554	0.0073	0.6569	0.0767	0.0003	0.1295	0.4777
399.8166	0.9567	141.5229	0.3169	2.3699	0.5986	1.2587	0.6762	0.7075	0.6964	0.8853
405.3722	0.9700	150.6308	1.3057	1.3192	1.5569	2.2107	1.6118	1.7766	1.5928	1.5870
410.9278	0.9833	163.5920	2.2368	0.3350	2.4473	3.0952	2.4281	2.7715	2.3913	2.1883
416.4833	0.9966	190.2151	2.6426	0.1396	2.7756	3.4213	2.3910	3.0220	2.6787	2.6596
417.8722	0.9999	238.5571	7.8432	6.1513	7.8841	8.4959	7.0090	7.5302	8.2552	10.9594
Error			1.4981	3.9476	1.1540	0.7932	0.9352	1.6029	1.1234	0.9238

Table B-16: Experimental and calculated saturated liquid molar volume of n-Butane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
272.6700	0.6414	96.6600	0.4262	3.3060	0.1554	0.1592	0.2719	0.6779	0.1976	0.1885
280.0000	0.6586	97.9600	0.4405	3.3131	0.1734	0.1412	0.2189	0.6870	0.2106	0.1317
290.0000	0.6822	99.8300	0.4727	3.3328	0.2109	0.1039	0.1354	0.7106	0.2375	0.0757
300.0000	0.7057	101.8000	0.5464	3.3918	0.2901	0.0249	0.0127	0.7734	0.3021	0.0134
310.0000	0.7292	104.0000	0.5552	3.3802	0.3049	0.0102	0.0431	0.7680	0.2985	0.0455
320.0000	0.7527	106.4000	0.5582	3.3587	0.3143	0.0008	0.0905	0.7528	0.2862	0.1069
330.0000	0.7763	109.0000	0.5895	3.3623	0.3524	0.0372	0.1629	0.7610	0.2997	0.1564
340.0000	0.7998	111.9000	0.6004	3.3404	0.3707	0.0554	0.2113	0.7423	0.2914	0.2340
350.0000	0.8233	115.1000	0.6493	3.3531	0.4275	0.1121	0.2935	0.7536	0.3208	0.2710
360.0000	0.8468	118.8000	0.6407	3.3022	0.4278	0.1124	0.3138	0.6970	0.2947	0.3492
370.0000	0.8703	123.0000	0.6901	3.3064	0.4870	0.1714	0.3868	0.6854	0.3310	0.3377
380.0000	0.8939	128.1000	0.6420	3.2067	0.4502	0.1347	0.3574	0.5594	0.2791	0.3695
390.0000	0.9174	134.3000	0.6273	3.1392	0.4488	0.1333	0.3575	0.4453	0.2773	0.2862
400.0000	0.9409	142.5000	0.4972	2.9553	0.3352	0.0201	0.2435	0.1887	0.1897	0.1965
405.0000	0.9527	147.7000	0.4581	2.8935	0.3061	0.0090	0.2178	0.0747	0.1898	0.0650
410.0000	0.9644	154.3000	0.3306	2.7470	0.1907	0.1240	0.1149	0.1340	0.1201	0.0276
411.0000	0.9668	155.8000	0.3294	2.7436	0.1922	0.1225	0.1210	0.1520	0.1331	0.0763
412.0000	0.9691	157.5000	0.2604	2.6713	0.1261	0.1884	0.0606	0.2374	0.0796	0.0594
413.0000	0.9715	159.2000	0.2601	2.6700	0.1289	0.1856	0.0704	0.2541	0.0959	0.1129
414.0000	0.9738	161.1000	0.2122	2.6205	0.0842	0.2301	0.0345	0.3179	0.0658	0.1203
415.0000	0.9762	163.2000	0.1313	2.5379	0.0068	0.3073	0.0322	0.4140	0.0040	0.0957
416.0000	0.9785	165.4000	0.0955	2.5024	0.0253	0.3393	0.0510	0.4641	0.0114	0.1168
417.0000	0.9809	167.9000	0.0051	2.4118	0.1117	0.4255	0.1206	0.5670	0.0800	0.0827
418.0000	0.9833	170.6000	0.0504	2.3582	0.1628	0.4763	0.1506	0.6327	0.1125	0.0817
419.0000	0.9856	173.7000	0.1479	2.2626	0.2554	0.5687	0.2162	0.7368	0.1860	0.0339
420.0000	0.9880	177.2000	0.2273	2.1869	0.3295	0.6425	0.2549	0.8173	0.2411	0.0044
421.0000	0.9903	181.3000	0.3097	2.1091	0.4056	0.7184	0.2837	0.8919	0.3000	0.0621
422.0000	0.9927	186.3000	0.4014	2.0220	0.4899	0.8025	0.3020	0.9605	0.3725	0.1610
423.0000	0.9950	192.9000	0.5588	1.8645	0.6379	0.9500	0.3517	1.0652	0.5236	0.3940
423.5000	0.9962	197.1000	0.6064	1.8130	0.6796	0.9916	0.3227	1.0654	0.5807	0.5333
424.0000	0.9974	202.6000	0.7193	1.6849	0.7851	1.0967	0.3321	1.1028	0.7235	0.8157
424.5000	0.9985	210.3000	0.7609	1.5997	0.8165	1.1280	0.2186	1.0102	0.8472	1.2113
Error			0.4313	2.7421	0.3276	0.3289	0.1986	0.6281	0.2651	0.2130

Table B-17: Experimental and calculated saturated liquid molar volume of n-Pentane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
309.1900	0.6583	118.2000	0.1476	1.3390	0.0251	0.0024	0.5381	0.0742	0.0742	0.0613
310.0000	0.6600	118.4000	0.1767	1.3061	0.0544	0.0317	0.5652	0.1245	0.0440	0.1872
320.0000	0.6813	120.4000	0.0808	1.3606	0.0393	0.0621	0.4480	0.2244	0.1245	0.5738
330.0000	0.7026	122.6000	0.0339	1.3646	0.0840	0.1068	0.3818	0.2677	0.1517	0.5427
340.0000	0.7239	124.9000	0.0627	1.4182	0.1783	0.2011	0.2685	0.3237	0.2244	0.4922
350.0000	0.7452	127.4000	0.1471	1.4589	0.2601	0.2830	0.1703	0.3856	0.2806	0.4797
360.0000	0.7664	130.2000	0.1666	1.4335	0.2768	0.2996	0.1400	0.4331	0.2677	0.5526
370.0000	0.7877	133.2000	0.2299	1.4528	0.3373	0.3601	0.0696	0.4644	0.2949	0.5972
380.0000	0.8090	136.5000	0.2984	1.4781	0.4026	0.4254	0.0020	0.4149	0.3237	0.6454
390.0000	0.8303	140.1000	0.4203	1.5592	0.5212	0.5440	0.1224	0.3433	0.4030	0.6414
400.0000	0.8516	144.3000	0.4477	1.5477	0.5448	0.5677	0.1436	0.2636	0.3856	0.7222
410.0000	0.8729	149.0000	0.5474	1.6145	0.6404	0.6633	0.2317	0.1719	0.4397	0.711
420.0000	0.8942	154.6000	0.5854	1.6274	0.6737	0.6966	0.2530	0.0326	0.4331	0.7255
430.0000	0.9155	161.3000	0.6524	1.6841	0.7353	0.7582	0.2991	0.7187	0.4595	0.6573
440.0000	0.9368	169.8000	0.6894	1.7360	0.7657	0.7887	0.3147	0.0742	0.4644	0.5411
450.0000	0.9581	181.4000	0.7030	1.8139	0.7708	0.7938	0.3196	0.1245	0.4614	0.3436
455.0000	0.9687	189.4000	0.6567	1.8352	0.7191	0.7420	0.2871	0.2244	0.4149	0.2545
460.0000	0.9793	200.2000	0.5916	1.8847	0.6470	0.6699	0.2709	0.2677	0.3529	0.172
461.0000	0.9815	202.9000	0.5821	1.9073	0.6358	0.6587	0.2795	0.3237	0.3433	0.1557
462.0000	0.9836	205.9000	0.5586	1.9199	0.6104	0.6333	0.2788	0.3856	0.3188	0.1572
463.0000	0.9857	209.3000	0.5058	1.9081	0.5555	0.5784	0.2551	0.4331	0.2636	0.1942
464.0000	0.9879	213.1000	0.4709	1.9208	0.5184	0.5413	0.2574	0.4644	0.2236	0.2239
465.0000	0.9900	217.5000	0.4290	1.9343	0.4739	0.4968	0.2642	0.4149	0.1719	0.2776
466.0000	0.9921	222.8000	0.3554	1.9261	0.3973	0.4202	0.2566	0.3433	0.0804	0.3921
467.0000	0.9943	229.4000	0.2766	1.9262	0.3149	0.3377	0.2711	0.2636	0.0326	0.5662
468.0000	0.9964	238.5000	0.1199	1.8654	0.1534	0.1762	0.2583	0.1719	0.2609	0.0362
469.0000	0.9985	253.7000	0.1415	1.7139	0.1156	0.0929	0.2640	0.0326	0.7187	0.0882
469.5000	0.9996	271.6000	0.7866	1.0570	0.7686	0.7460	0.0954	0.7187	1.6836	1.5061
Error			0.3880	1.6426	0.4364	0.4528	0.2609	0.4925	0.3463	0.4463

Table B-18: Experimental and calculated saturated liquid molar volume of R134a

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
203.1500	0.5428	68.8716	0.0960	1.1410	0.1102	0.1045	0.7522	1.2374	0.1004	2.2013
208.1500	0.5562	69.2797	0.2170	1.4123	0.2029	0.2086	0.4356	1.5250	0.4200	1.7036
213.1500	0.5695	69.7899	0.4072	1.5590	0.3932	0.3990	0.2415	1.6879	0.6148	1.3466
218.1500	0.5829	70.3000	0.6240	1.7322	0.6101	0.6159	0.0216	1.8774	0.8345	0.9839
223.1500	0.5962	70.9122	0.7235	1.7864	0.7097	0.7155	0.0811	1.9476	0.9348	0.7566
228.1500	0.6096	71.5244	0.8539	1.8716	0.8402	0.8460	0.2138	2.0486	1.0641	0.5187
233.1500	0.6230	72.2387	0.8739	1.8452	0.8604	0.8661	0.2361	2.0374	1.0810	0.4090
238.1500	0.6363	72.9529	0.9300	1.8550	0.9166	0.9224	0.2934	2.0620	1.1320	0.2827
243.1500	0.6497	73.6671	1.0237	1.9027	1.0104	1.0162	0.3873	2.1239	1.2187	0.1374
246.8500	0.6596	74.2793	1.0045	1.8485	0.9913	0.9971	0.3682	2.0796	1.1927	0.1290
248.1500	0.6630	74.4834	1.0183	1.8503	1.0052	1.0109	0.3818	2.0847	1.2039	0.1079
253.1500	0.6764	75.2996	1.0568	1.8422	1.0438	1.0496	0.4191	2.0889	1.2311	0.0519
258.1500	0.6898	76.1159	1.1414	1.8806	1.1286	1.1344	0.5011	2.1384	1.3023	0.0334
263.1500	0.7031	77.0342	1.1403	1.8329	1.1276	1.1334	0.4969	2.1000	1.2854	0.0186
268.1500	0.7165	77.9524	1.1932	1.8397	1.1807	1.1865	0.5452	2.1145	1.3204	0.0427
273.1500	0.7298	78.8707	1.3032	1.9042	1.2908	1.2966	0.6489	2.1848	1.4101	0.1096
278.1500	0.7432	79.8911	1.3440	1.8996	1.3319	1.3377	0.6828	2.1833	1.4284	0.0957
283.1500	0.7566	81.0134	1.3247	1.8351	1.3126	1.3184	0.6555	2.1187	1.3839	0.0109
288.1500	0.7699	82.1358	1.3805	1.8470	1.3687	1.3745	0.7014	2.1273	1.4124	0.0095
293.1500	0.7833	83.3601	1.3926	1.8159	1.3810	1.3868	0.7024	2.0888	1.3947	0.0818
298.1500	0.7966	84.5845	1.4948	1.8765	1.4834	1.4892	0.7912	2.1375	1.4645	0.0725
303.1500	0.8100	86.0130	1.4533	1.7944	1.4421	1.4479	0.7356	2.0377	1.3883	0.2101
308.1500	0.8234	87.4414	1.5253	1.8282	1.5144	1.5202	0.7910	2.0474	1.4230	0.2395
313.1500	0.8367	89.0739	1.4886	1.7554	1.4778	1.4836	0.7365	1.9426	1.3465	0.3772
318.1500	0.8501	90.8085	1.4827	1.7168	1.4723	1.4781	0.7109	1.8630	1.2986	0.4834
323.1500	0.8634	92.6451	1.5306	1.7359	1.5204	1.5262	0.7367	1.8303	1.3018	0.5333
328.1500	0.8768	94.6857	1.5503	1.7319	1.5404	1.5462	0.7328	1.7612	1.2744	0.6042
333.1500	0.8902	97.0324	1.4766	1.6409	1.4671	1.4729	0.6346	1.5891	1.1517	0.7562
338.1500	0.9035	99.5832	1.4738	1.6295	1.4645	1.4704	0.6057	1.4768	1.0973	0.8249
343.1500	0.9169	102.5422	1.4075	1.5664	1.3987	1.4045	0.5137	1.2880	0.9776	0.9370
348.1500	0.9302	105.9092	1.3896	1.5679	1.3812	1.3870	0.4713	1.1318	0.9037	0.9787
353.1500	0.9436	109.9905	1.2956	1.5166	1.2877	1.2935	0.3585	0.8807	0.7513	1.0668
358.1500	0.9570	115.0921	1.1378	1.4376	1.1305	1.1363	0.1952	0.5439	0.5312	1.1867
363.1500	0.9703	121.9282	0.8574	1.2968	0.8508	0.8566	0.0587	0.0608	0.1793	1.4036
368.1500	0.9837	132.3355	0.3638	1.0656	0.3583	0.3641	0.4344	0.6470	0.4188	1.8651
373.1500	0.9970	158.8638	1.9451	0.6018	1.9484	1.9428	2.1253	2.9414	3.1223	4.8519
Error			1.1367	1.6740	1.1265	1.1317	0.5388	1.7788	1.1277	0.7062

Table B-19: Experimental and calculated saturated liquid molar volume of R245

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
233.1500	0.6129	97.7865	0.4096	1.8491	0.3085	1.4256	0.9175	1.1814	0.7930	0.4276
238.7055	0.6275	98.8912	0.3864	1.7938	0.3237	1.4406	0.9236	1.1369	0.8951	0.3574
244.2611	0.6421	100.0294	0.3736	1.7486	0.3285	1.4453	0.9202	1.1023	0.9122	0.298
249.8166	0.6567	101.1928	0.3824	1.7250	0.3114	1.4284	0.8961	1.0887	1.0152	0.2372
255.3722	0.6713	102.3979	0.3995	1.7095	0.2859	1.4032	0.8645	1.0826	1.0538	0.1872
260.9278	0.6859	103.6533	0.4209	1.6979	0.2559	1.3735	0.8297	1.0796	1.0342	0.1511
266.4833	0.7005	104.9589	0.4509	1.6948	0.2169	1.3349	0.7870	1.0841	1.1961	0.1234
272.0389	0.7151	106.3148	0.4948	1.7055	0.1639	1.2826	0.7316	1.1009	1.0806	0.0978
277.5944	0.7297	107.7459	0.5345	1.7119	0.1147	1.2339	0.6813	1.1119	1.1489	0.0909
283.1500	0.7443	109.2440	0.5848	1.7289	0.0545	1.1743	0.6215	1.1314	1.1884	0.0865
288.7055	0.7590	110.8425	0.6229	1.7336	0.0060	1.1264	0.5750	1.1363	1.0999	0.1056
294.2611	0.7736	112.5331	0.6659	1.7435	0.0479	1.0731	0.5246	1.1435	1.2345	0.1297
299.8166	0.7882	114.3325	0.7098	1.7547	0.1031	1.0185	0.4747	1.1483	1.1115	0.1606
305.3722	0.8028	116.2742	0.7383	1.7510	0.1437	0.9784	0.4413	1.1340	1.1754	0.2124
310.9278	0.8174	118.3665	0.7604	1.7418	0.1786	0.9439	0.4155	1.1091	1.1377	0.2736
316.4833	0.8320	120.6346	0.7742	1.7256	0.2059	0.9169	0.3993	1.0710	1.1465	0.3433
322.0389	0.8466	123.1119	0.7759	1.6990	0.2221	0.9009	0.3964	1.0149	1.2044	0.4221
327.5944	0.8612	125.8403	0.7616	1.6591	0.2235	0.8995	0.4104	0.9363	1.1761	0.5101
333.1500	0.8758	128.8699	0.7305	1.6058	0.2094	0.9135	0.4419	0.8331	1.0699	0.6039
338.7055	0.8904	132.2679	0.6823	1.5402	0.1796	0.9429	0.4910	0.7035	1.1635	0.3989
344.2611	0.9050	136.1261	0.6174	1.4648	0.1351	0.9869	0.5562	0.5463	1.0582	0.7889
349.8166	0.9196	140.5953	0.5254	1.3720	0.0659	1.0553	0.6462	0.3491	1.0311	0.8774
355.3722	0.9342	145.8763	0.4148	1.2753	0.0187	1.1389	0.7497	0.1178	0.9595	0.3484
360.9278	0.9488	152.3457	0.2745	1.1715	0.1285	1.2475	0.8713	0.1614	0.9825	0.0045
366.4833	0.9634	160.7652	0.0639	1.0352	0.3015	1.4186	1.0368	0.5310	0.9840	0.0801
372.0389	0.9780	173.0178	0.3287	0.7896	0.6435	1.7568	1.3149	1.0963	0.8577	0.3012
377.5944	0.9926	197.8159	1.8165	0.3703	2.0436	3.1412	2.4124	2.6790	0.8690	0.4926
Error			0.5815	1.5481	0.2674	1.2593	0.7530	0.9930	0.2948	0.3003

Table B-20: Experimental and calculated saturated liquid molar volume of neoPentane

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
282.6280	0.6516	2119.6000	4.0430	2.4355	2.9175	1.3620	3.3038	3.4939	2.8825	2.2074
290.0000	0.6686	121.3000	4.0748	2.4962	2.9656	1.4109	3.3181	3.5456	2.9367	2.2308
300.0000	0.6916	123.7000	4.0809	2.5421	2.9946	1.4404	3.3030	3.5807	2.9771	3.2565
310.0000	0.7147	126.3000	4.1001	2.6024	3.0380	1.4844	3.3046	3.6318	3.0354	3.3272
320.0000	0.7378	129.0000	4.0354	2.5786	2.9980	1.4438	3.2258	3.6025	3.0137	3.3404
330.0000	0.7608	132.0000	4.0110	2.5965	3.0004	1.4462	3.1922	3.6185	3.0372	3.4155
340.0000	0.7839	135.2000	3.9196	2.5469	2.9371	1.3819	3.0966	3.5735	2.9974	3.4379
350.0000	0.8069	138.8000	3.8618	2.5312	2.9100	1.3544	3.0411	3.5699	2.9951	3.5006
360.0000	0.8300	142.8000	3.7779	2.4882	2.8595	1.3031	2.9669	3.5500	2.9698	3.5344
370.0000	0.8530	147.4000	3.7232	2.4722	2.8419	1.2852	2.9308	3.5718	2.9756	3.5826
380.0000	0.8761	152.8000	3.7095	2.4931	2.8701	1.3139	2.9464	3.6505	3.0227	3.6423
390.0000	0.8991	159.2000	3.6836	2.4931	2.8921	1.3362	2.9618	3.7375	3.0547	3.6412
400.0000	0.9222	167.1000	3.6556	2.4752	2.9207	1.3653	2.9890	3.8494	3.0774	3.5647
410.0000	0.9452	177.5000	3.6467	2.4460	2.9822	1.4278	3.0493	4.0155	3.1045	3.4018
415.0000	0.9568	184.3000	3.6660	2.4341	3.0451	1.4917	3.1068	4.1380	3.1327	3.2936
420.0000	0.9683	192.9000	3.6874	2.3984	3.1195	1.5673	3.1641	4.2728	3.1548	3.1517
425.0000	0.9798	204.9000	3.7849	2.3931	3.2865	1.7369	3.2828	4.4855	3.2461	3.0668
426.0000	0.9821	208.0000	3.8182	2.3967	3.3370	1.7882	3.3155	4.5396	3.2784	2.0674
427.0000	0.9844	211.4000	3.8299	2.3740	3.3674	1.8192	3.3236	4.5700	3.2899	2.0511
428.0000	0.9867	215.3000	3.8667	2.3710	3.4252	1.8778	3.3525	4.6219	3.3282	2.0683
429.0000	0.9890	219.8000	3.9055	2.3631	3.4876	1.9412	3.3771	4.6699	3.3719	2.1017
430.0000	0.9914	225.2000	3.9689	2.3713	3.5787	2.0338	3.4170	4.7327	3.4468	3.1851
431.0000	0.9937	231.9000	4.0325	2.3678	3.6756	2.1323	3.4412	4.7775	3.5351	3.3163
432.0000	0.9960	241.0000	4.1309	2.3842	3.8177	2.2766	3.4711	4.8187	3.6901	3.587
433.0000	0.9983	255.8000	4.2424	2.4015	3.9968	2.4586	3.4441	4.7624	3.9660	3.1984
433.5000	0.9994	271.0000	4.2660	2.4213	4.0868	2.5500	3.3222	4.5309	4.2682	4.0779
433.7500	1.0000	311.0000	2.5080	2.5080	2.5080	0.9460	2.5080	2.5080	1.1636	2.0316
Error			3.8530	2.4586	3.1800	1.6287	3.1909	4.0155	3.1464	3.0844

Table B-21: Experimental and calculated saturated liquid molar volume of Ammonia

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified (HT)
223.15	0.5504	24.2521	0.7261	2.1520	4.7942	15.0563	4.1005	2.7759	4.9089	3.3085
228.15	0.5628	24.4735	0.6779	2.0380	4.7112	14.9652	4.0366	2.6831	4.8308	3.3782
233.15	0.5751	24.6949	0.6555	1.9502	4.6545	14.9029	3.9983	2.6165	4.7776	3.4567
238.15	0.5874	24.9164	0.6598	1.8893	4.6248	14.8703	3.9865	2.5766	4.7501	3.5454
243.15	0.5998	25.1378	0.6915	1.8561	4.6228	14.8681	4.0018	2.5643	4.7490	3.6454
248.15	0.6121	25.3762	0.6840	1.7832	4.5793	14.8204	3.9753	2.5114	4.7049	3.6885
253.15	0.6244	25.6146	0.7070	1.7411	4.5668	14.8066	3.9789	2.4891	4.6903	3.7471
258.15	0.6368	25.8701	0.6954	1.6640	4.5173	14.7523	3.9454	2.4307	4.6373	3.7543
263.15	0.6491	26.1256	0.7178	1.6214	4.5024	14.7359	3.9455	2.4062	4.6174	3.7815
268.15	0.6614	26.3980	0.7106	1.5490	4.4557	14.6846	3.9134	2.3506	4.5643	3.7637
273.15	0.6738	26.6705	0.7415	1.5151	4.4475	14.6756	3.9189	2.3327	4.5482	3.7710
278.15	0.6861	26.9601	0.7484	1.4573	4.4134	14.6381	3.8978	2.2892	4.5046	3.7403
283.15	0.6984	27.2496	0.7981	1.4429	4.4224	14.6481	3.9189	2.2877	4.5028	3.7408
288.15	0.7108	27.5732	0.7681	1.3485	4.3476	14.5659	3.8557	2.2036	4.4155	3.6471
293.15	0.7231	27.8968	0.7878	1.3047	4.3229	14.5388	3.8415	2.1683	4.3770	3.5933
298.15	0.7354	28.2374	0.7989	1.2528	4.2879	14.5004	3.8161	2.1223	4.3268	3.5200
303.15	0.7478	28.6121	0.7465	1.1377	4.1856	14.3881	3.7226	2.0096	4.2078	3.3718
308.15	0.7601	28.9868	0.7567	1.0865	4.1465	14.3451	3.6909	1.9578	4.1505	3.2792
313.15	0.7724	29.3785	0.7748	1.0441	4.1136	14.3090	3.6643	1.9111	4.0982	3.1867
318.15	0.7848	29.8043	0.7497	0.9596	4.0341	14.2217	3.5901	1.8176	3.9980	3.0433
323.15	0.7971	30.2641	0.6913	0.8434	3.9180	14.0943	3.4781	1.6868	3.8601	2.8605
328.15	0.8094	30.7239	0.7221	0.8182	3.8916	14.0653	3.4540	1.6419	3.8106	2.7644
333.15	0.8218	31.2349	0.6839	0.7262	3.7913	13.9552	3.3549	1.5228	3.6864	2.5951
338.15	0.8341	31.7798	0.6471	0.6381	3.6894	13.8432	3.2525	1.3997	3.5598	2.4258
343.15	0.8464	32.3589	0.6269	0.5700	3.6012	13.7464	3.1623	1.2874	3.4463	2.2739
348.15	0.8588	32.9890	0.5892	0.4883	3.4911	13.6256	3.0487	1.1506	3.3106	2.1064
353.15	0.8711	33.6873	0.5074	0.3673	3.3311	13.4499	2.8837	0.9614	3.1250	1.8983
358.15	0.8834	34.4367	0.4630	0.2898	3.2045	13.3108	2.7502	0.8008	2.9730	1.7347
363.15	0.8958	35.2712	0.3938	0.1953	3.0461	13.1370	2.5838	0.6046	2.7903	1.5549
368.15	0.9081	36.2079	0.3039	0.0900	2.8590	12.9315	2.3876	0.3750	2.5804	1.3656
373.15	0.9204	37.2638	0.2164	0.0001	2.6650	12.7185	2.1840	0.1330	2.3660	1.1929
378.15	0.9328	38.5071	0.0498	0.1509	2.3781	12.4036	1.8889	0.2056	2.0625	0.9570
383.15	0.9451	39.9718	0.1278	0.2878	2.0642	12.0590	1.5701	0.5765	1.7369	0.7281
388.15	0.9574	41.7600	0.3216	0.4034	1.7112	11.6713	1.2210	0.9892	1.3787	0.4985
393.15	0.9698	44.0933	0.5914	0.5338	1.2452	11.1597	0.7802	1.5080	0.9153	0.1944
398.15	0.9821	47.3973	0.8179	0.5036	0.7575	10.6242	0.3748	2.0131	0.4330	0.1244
403.15	0.9944	53.1708	0.0165	0.8881	1.1178	11.0199	1.0571	1.4449	0.7178	0.1029
Error			0.6045	1.0429	3.6625	13.8138	3.1684	1.7515	3.5976	2.6038

Table B-22: Experimental and calculated saturated liquid molar volume of Ethanol

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
275.9500	0.5370	56.0199	5.1645	1.1656	7.1962	9.7779	6.6987	1.4222	6.3747	6.9633
290.1500	0.5646	56.8491	4.6640	0.8807	6.6712	9.2676	6.2984	1.0744	5.8312	6.851
302.0500	0.5877	57.5402	4.1525	0.5498	6.1395	8.7506	5.8764	0.6910	5.2922	4.9255
314.8500	0.6126	58.3234	3.5725	0.1670	5.5367	8.1646	5.3977	0.2525	4.6915	4.9955
323.0500	0.6286	58.8762	3.2278	0.0483	5.1757	7.8136	5.1199	0.0024	4.3383	4.4757
329.1500	0.6405	59.2908	2.9453	0.2345	4.8809	7.5271	4.8890	0.2089	4.0524	4.0896
333.1500	0.6483	59.6594	2.9021	0.2095	4.8267	7.4743	4.8774	0.1999	4.0068	3.9827
351.1500	0.6833	60.8571	1.7907	1.0379	3.6804	6.3600	3.9341	1.0952	2.9093	3.7454
361.1500	0.7027	61.6864	1.3071	1.3568	3.1723	5.8660	3.5461	1.4458	2.4431	2.2627
368.7500	0.7175	62.3774	0.9645	1.5721	2.8094	5.5131	3.2783	1.6817	2.1195	1.9559
375.5500	0.7308	63.0224	0.6419	1.7803	2.4679	5.1811	3.0249	1.9050	1.8188	1.6919
380.9500	0.7413	63.6213	0.4793	1.8493	2.2877	5.0060	2.9162	1.9835	1.6759	1.588
385.7500	0.7506	64.1280	0.2600	1.9869	2.0537	4.7784	2.7478	2.1274	1.4776	1.437
390.1500	0.7592	64.6348	0.0943	2.0766	1.8733	4.6031	2.6286	2.2210	1.3331	1.3419
394.1500	0.7669	65.0955	0.0831	2.1855	1.6825	4.4176	2.4948	2.3315	1.1772	2.2381
397.6500	0.7738	65.5101	0.2427	2.2851	1.5109	4.2508	2.3741	2.4309	1.0382	2.1493
404.0500	0.7862	66.3854	0.4137	2.3437	1.3150	4.0603	2.2723	2.4850	0.9075	1.1157
409.6500	0.7971	67.1686	0.6043	2.4370	1.1022	3.8534	2.1447	2.5693	0.7573	2.0619
414.6500	0.8068	67.9518	0.7072	2.4520	0.9774	3.7321	2.0972	2.5717	0.6935	0.0884
419.1500	0.8156	68.6428	0.8713	2.5387	0.7940	3.5538	1.9857	2.6429	0.5690	0.0532
423.3500	0.8238	69.2878	1.0709	2.6670	0.5764	3.3423	1.8373	2.7530	0.4101	0.9836
427.0500	0.8310	69.9327	1.1751	2.7075	0.4545	3.2238	1.7767	2.7739	0.3434	0.9951
430.5500	0.8378	70.5777	1.2612	2.7337	0.3509	3.1230	1.7318	2.7783	0.2948	0.0218
433.8500	0.8442	71.1766	1.3917	2.8088	0.2041	2.9803	1.6420	2.8296	0.2028	0.0045
436.9500	0.8502	71.7755	1.4965	2.8618	0.0832	2.8628	1.5752	2.8572	0.1360	0.008
439.9500	0.8561	72.4205	1.5396	2.8545	0.0231	2.8043	1.5672	2.8221	0.1307	0.0687
442.8500	0.8617	73.0194	1.6497	2.9173	0.1030	2.6818	1.4933	2.8550	0.0603	0.0658
493.6500	0.9606	90.8481	4.3070	5.0317	3.1954	0.3246	0.6601	3.4238	1.3094	1.6859
494.8500	0.9629	91.2627	4.8551	5.5887	3.7569	0.8705	1.1972	3.8879	1.7847	1.2489
496.1500	0.9654	92.2762	4.8631	5.6050	3.7866	0.8994	1.2173	3.8071	1.7271	1.3135
497.3500	0.9678	93.0133	5.1610	5.9155	4.1027	1.2067	1.5201	4.0174	1.9518	1.1113
498.5500	0.9701	93.7504	5.5270	6.2976	4.4874	1.5807	1.8930	4.2917	2.2378	3.8514
499.6500	0.9722	94.5797	5.7578	6.5458	4.7377	1.8240	2.1384	4.4368	2.3939	3.7129
500.8500	0.9746	95.5010	6.0765	6.8879	5.0786	2.1555	2.4768	4.6580	2.6232	3.5068
502.0500	0.9769	96.4224	6.4980	7.3384	5.5232	2.5876	2.9221	4.9769	2.9446	3.2152
503.1500	0.9790	97.2977	6.9557	7.8286	6.0035	3.0546	3.4078	5.3364	3.3004	2.8918
504.2500	0.9812	98.2191	7.4824	8.3942	6.5543	3.5901	3.9703	5.7603	3.7136	2.5168
505.3500	0.9833	99.2326	8.0523	9.0106	7.1508	4.1700	4.5876	6.2236	4.1572	2.117
506.4500	0.9855	100.2922	8.7496	9.7643	7.8771	4.8760	5.3450	6.8091	4.7089	6.9633
507.5500	0.9876	101.4439	9.5723	10.6559	8.7322	5.7074	6.2467	7.5155	5.3621	6.851
508.6500	0.9897	102.7339	10.5437	11.7123	9.7406	6.6878	7.3244	8.3670	6.1315	4.9255
Error			3.3921	3.7874	3.6262	4.4025	3.1984	3.0371	2.4252	2.2982

Table B-23: Experimental and calculated saturated liquid molar volume of R11

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
203.1500	0.4312	81.4592	3.9739	10.1125	0.9796	2.4832	0.0590	3.4322	0.8976	2.0096
213.1500	0.4525	82.5582	3.7881	10.0064	0.8310	2.6267	0.0347	3.2730	0.7755	1.6736
223.1500	0.4737	83.5197	3.8252	10.1333	0.8999	2.5602	0.0867	3.3361	0.8677	1.1768
233.1500	0.4949	84.6187	3.7438	10.1308	0.8544	2.6041	0.0942	3.2816	0.8424	0.8417
243.1500	0.5161	85.8550	3.5527	10.0079	0.7034	2.7500	0.0036	3.1183	0.7084	0.6597
253.1500	0.5374	86.9539	3.5886	10.1218	0.7740	2.6818	0.1179	3.1811	0.7927	0.3064
263.1500	0.5586	88.1903	3.5246	10.1251	0.7488	2.7061	0.1435	3.1446	0.7778	0.0933
273.1500	0.5798	89.5639	3.3711	10.0280	0.6377	2.8135	0.0827	3.0188	0.6735	0.0096
283.1500	0.6010	90.9376	3.2952	10.0081	0.6033	2.8466	0.0973	2.9702	0.6427	0.1084
293.1500	0.6223	92.3113	3.3008	10.0691	0.6500	2.8015	0.1913	3.0025	0.6895	0.2674
296.9500	0.6303	92.8608	3.2948	10.0820	0.6603	2.7916	0.2192	3.0066	0.6988	0.3105
303.1500	0.6435	93.8223	3.2417	10.0548	0.6353	2.8157	0.2229	2.9698	0.6714	0.3281
313.1500	0.6647	95.4708	3.1312	9.9785	0.5722	2.8766	0.2048	2.8849	0.6016	0.3061
323.1500	0.6859	97.1192	3.1294	10.0105	0.6174	2.8331	0.2929	2.9076	0.6368	0.3607
333.1500	0.7072	98.9050	3.1015	10.0058	0.6392	2.8120	0.3557	2.9027	0.6454	0.3642
343.1500	0.7284	100.8281	3.0650	9.9825	0.6553	2.7964	0.4107	2.8877	0.6455	0.3381
353.1500	0.7496	102.8886	3.0404	9.9610	0.6860	2.7668	0.4777	2.8823	0.6574	0.3072
363.1500	0.7709	105.2239	2.9166	9.8214	0.6232	2.8275	0.4485	2.7752	0.5736	0.1690
373.1500	0.7921	107.6965	2.8621	9.7419	0.6320	2.8190	0.4875	2.7339	0.5597	0.0944
383.1500	0.8133	110.4439	2.7827	9.6197	0.6211	2.8294	0.5032	2.6638	0.5254	0.0004
393.1500	0.8345	113.4660	2.7308	9.5081	0.6428	2.8085	0.5471	2.6162	0.5239	0.0548
403.1500	0.8558	116.7628	2.7720	9.4732	0.7627	2.6927	0.6844	2.6555	0.6225	0.0070
413.1500	0.8770	120.7465	2.6416	9.2281	0.7232	2.7308	0.6573	2.5160	0.5663	0.0574
423.1500	0.8982	125.4170	2.4972	8.9339	0.6816	2.7710	0.6226	2.3538	0.5162	0.0748
433.1500	0.9194	131.0491	2.3486	8.5899	0.6519	2.7997	0.5951	2.1772	0.4918	0.0091
443.1500	0.9407	138.3296	2.0792	8.0536	0.5275	2.9199	0.4716	1.8693	0.3966	0.0630
453.1500	0.9619	148.4948	1.6742	7.2700	0.3110	3.1289	0.2674	1.4208	0.2506	0.1802
463.1500	0.9831	165.9405	0.8588	5.8248	0.2142	3.6361	0.1691	0.6022	0.1323	0.1241
Error			3.0047	9.5315	0.6621	2.8046	0.3053	2.7351	0.6208	0.3677

Table B-24: Experimental and calculated saturated liquid molar volume of R12

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
183.1500	0.4756	73.5151	2.4116	7.2854	0.8435	0.9802	0.0391	2.1739	0.7930	1.0323
193.1500	0.5016	74.6033	2.4684	7.4123	0.9220	0.9032	0.1870	2.2507	0.8951	0.5168
203.1500	0.5275	75.8125	2.4428	7.4482	0.9200	0.9051	0.2544	2.2456	0.9122	0.1505
213.1500	0.5535	77.0216	2.5082	7.5746	1.0087	0.8180	0.4110	2.3317	1.0152	0.2380
223.1500	0.5795	78.3516	2.5123	7.6310	1.0380	0.7893	0.5074	2.3566	1.0538	0.5032
228.1500	0.5924	79.0771	2.4763	7.6171	1.0156	0.8113	0.5183	2.3309	1.0342	0.5758
233.1500	0.6054	79.6817	2.6254	7.7959	1.1759	0.6539	0.7106	2.4900	1.1961	0.8157
238.1500	0.6184	80.5281	2.4940	7.6785	1.0600	0.7677	0.6277	2.3688	1.0806	0.7663
243.1500	0.6314	81.2535	2.5499	7.7561	1.1292	0.6998	0.7285	2.4344	1.1489	0.8875
243.3500	0.6319	81.2535	2.5894	7.7983	1.1687	0.6609	0.7691	2.4743	1.1884	0.9288
248.1500	0.6444	82.0999	2.4877	7.7077	1.0822	0.7459	0.7132	2.3818	1.0999	0.8799
253.1500	0.6574	82.8254	2.6124	7.8538	1.2200	0.6106	0.8814	2.5157	1.2345	1.0442
258.1500	0.6703	83.7927	2.4769	7.7243	1.1014	0.7270	0.7935	2.3890	1.1115	0.9409
263.1500	0.6833	84.6391	2.5314	7.7924	1.1709	0.6588	0.8925	2.4518	1.1754	1.0144
268.1500	0.6963	85.6064	2.4836	7.7505	1.1398	0.6894	0.8905	2.4118	1.1377	0.9773
273.1500	0.7093	86.5737	2.4835	7.7564	1.1562	0.6732	0.9352	2.4188	1.1465	0.9785
278.1500	0.7223	87.5410	2.5336	7.8124	1.2228	0.6078	1.0290	2.4752	1.2044	1.0213
283.1500	0.7353	88.6292	2.4966	7.7741	1.2040	0.6263	1.0368	2.4438	1.1761	0.9717
288.1500	0.7482	89.8384	2.3810	7.6501	1.1081	0.7204	0.9667	2.3327	1.0699	0.8391
293.1500	0.7612	90.9266	2.4679	7.7357	1.2129	0.6176	1.0959	2.4228	1.1635	0.9017
298.1500	0.7742	92.2566	2.3529	7.6058	1.1190	0.7097	1.0255	2.3099	1.0582	0.7629
303.1500	0.7872	93.5867	2.3168	7.5550	1.1039	0.7245	1.0325	2.2744	1.0311	0.7005
308.1500	0.8002	95.0376	2.2348	7.4521	1.0444	0.7830	0.9938	2.1913	0.9595	0.5937
313.1500	0.8132	96.4886	2.2476	7.4444	1.0796	0.7485	1.0483	2.2011	0.9825	0.5827
318.1500	0.8261	98.0604	2.2369	7.4074	1.0927	0.7356	1.0791	2.1853	0.9840	0.5534
323.1500	0.8391	99.8741	2.0949	7.2271	0.9772	0.8490	0.9795	2.0356	0.8577	0.4022
328.1500	0.8521	101.6878	2.0893	7.1845	0.9981	0.8285	1.0146	2.0197	0.8690	0.3956
333.1500	0.8651	103.7434	1.9969	7.0443	0.9347	0.8907	0.9633	1.9137	0.7981	0.3170
338.1500	0.8781	106.0407	1.8507	6.8406	0.8201	1.0032	0.8587	1.7506	0.6787	0.2030
343.1500	0.8911	108.4590	1.8040	6.7332	0.8064	1.0167	0.8529	1.6829	0.6637	0.2090
348.1500	0.9041	111.2400	1.6761	6.5312	0.7151	1.1064	0.7674	1.5294	0.5764	0.1625
353.1500	0.9170	114.3837	1.5384	6.3079	0.6175	1.2022	0.6736	1.3612	0.4897	0.1404
358.1500	0.9300	118.0111	1.3808	6.0505	0.5048	1.3128	0.5635	1.1678	0.3973	0.1410
363.1500	0.9430	122.3640	1.1464	5.6961	0.3220	1.4923	0.3835	0.8925	0.2480	0.1177
368.1500	0.9560	127.6841	0.8855	5.2914	0.1215	1.6892	0.1893	0.5863	0.0993	0.1321
373.1500	0.9690	134.5762	0.5829	4.8099	0.1067	1.9132	0.0202	0.2394	0.0504	0.1821
378.1500	0.9820	144.7329	0.0759	4.0538	0.5120	2.3112	0.3668	0.2902	0.3388	0.1042
383.1500	0.9949	164.9253	0.6729	2.8309	1.0792	2.8681	0.6801	0.8978	0.7736	0.3622
Error			2.0846	7.0427	0.9435	0.9698	0.7232	1.9797	0.8867	0.5802

Table B-25: Experimental and calculated saturated liquid molar volume of R22

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
203.1500	0.5501	57.9336	2.2487	5.1950	1.4064	2.0019	0.7519	2.5239	1.4665	0.2585
208.1500	0.5637	58.4524	2.2530	5.2000	1.4180	2.0135	0.7905	2.5260	1.4836	0.4190
213.1500	0.5772	58.9712	2.2860	5.2336	1.4582	2.0539	0.8570	2.5566	1.5278	0.5893
218.1500	0.5907	59.5765	2.2000	5.1439	1.3805	1.9758	0.8060	2.4679	1.4527	0.6247
223.1500	0.6043	60.0953	2.2945	5.2389	1.4821	2.0779	0.9327	2.5599	1.5554	0.8204
228.1500	0.6178	60.7005	2.2752	5.2159	1.4709	2.0667	0.9468	2.5375	1.5437	0.8873
232.3500	0.6292	61.2193	2.2693	5.2064	1.4719	2.0677	0.9685	2.5289	1.5432	0.9412
233.1500	0.6314	61.3058	2.2917	5.2288	1.4955	2.0915	0.9959	2.5508	1.5664	0.9735
238.1500	0.6449	61.9976	2.2030	5.1323	1.4159	2.0114	0.9407	2.4581	1.4832	0.9403
243.1500	0.6584	62.6893	2.1563	5.0780	1.3782	1.9735	0.9265	2.4071	1.4404	0.9339
248.1500	0.6720	63.3810	2.1532	5.0675	1.3841	1.9794	0.9549	2.3992	1.4397	0.9566
253.1500	0.6855	64.0728	2.1958	5.1027	1.4355	2.0311	1.0279	2.4363	1.4831	1.0115
258.1500	0.6991	64.8510	2.1499	5.0459	1.3995	1.9949	1.0130	2.3840	1.4375	0.9669
263.1500	0.7126	65.6292	2.1576	5.0428	1.4168	2.0124	1.0504	2.3844	1.4439	0.9642
268.1500	0.7261	66.4074	2.2217	5.0964	1.4905	2.0865	1.1429	2.4401	1.5052	1.0071
273.1500	0.7397	67.2721	2.2139	5.0750	1.4933	2.0893	1.1637	2.4226	1.4942	0.9704
278.1500	0.7532	68.2233	2.1433	4.9874	1.4341	2.0297	1.1215	2.3406	1.4199	0.8641
283.1500	0.7668	69.1744	2.1470	4.9750	1.4491	2.0448	1.1521	2.3314	1.4187	0.8253
288.1500	0.7803	70.2120	2.1043	4.9134	1.4184	2.0140	1.1358	2.2737	1.3708	0.7363
293.1500	0.7938	71.2496	2.1505	4.9416	1.4766	2.0725	1.2066	2.3029	1.4107	0.7324
298.1500	0.8074	72.4602	2.0486	4.8162	1.3883	1.9836	1.1298	2.1811	1.3034	0.5819
303.1500	0.8209	73.6707	2.0585	4.8042	1.4117	2.0072	1.1628	2.1686	1.3073	0.5434
308.1500	0.8345	74.9678	2.0728	4.7951	1.4403	2.0359	1.1990	2.1569	1.3161	0.5133
313.1500	0.8480	76.4377	1.9947	4.6897	1.3778	1.9731	1.1425	2.0490	1.2341	0.3993
318.1500	0.8615	77.9941	1.9664	4.6339	1.3658	1.9611	1.1344	1.9865	1.2033	0.3449
323.1500	0.8751	79.7235	1.9043	4.5421	1.3215	1.9164	1.0919	1.8851	1.1413	0.2714
328.1500	0.8886	81.6258	1.8495	4.4566	1.2857	1.8804	1.0559	1.7851	1.0899	0.2239
333.1500	0.9022	83.7875	1.7479	4.3222	1.2050	1.7993	0.9733	1.6317	0.9969	0.1546
338.1500	0.9157	86.2086	1.6745	4.2163	1.1546	1.7485	0.9193	1.4986	0.9385	0.1435
343.1500	0.9292	89.0620	1.5319	4.0401	1.0381	1.6313	0.7988	1.2876	0.8208	0.1026
348.1500	0.9428	92.4343	1.3900	3.8662	0.9258	1.5184	0.6843	1.0672	0.7166	0.1095
353.1500	0.9563	96.6712	1.1497	3.5962	0.7209	1.3123	0.4839	0.7387	0.5331	0.0767
358.1500	0.9699	102.2916	0.8186	3.2426	0.4341	1.0239	0.2211	0.3130	0.2862	0.0186
363.1500	0.9834	110.8520	0.2371	2.6528	0.0854	0.5013	0.2133	0.3475	0.1719	0.2459
368.1500	0.9969	131.5178	1.4663	0.9261	1.6619	1.0845	1.3553	1.8783	1.7918	2.1037
Error			1.9436	4.6206	1.3026	1.8590	0.9557	2.0516	1.2668	0.6359

Table B-26: Experimental and calculated saturated liquid molar volume of Water

T K	Tr	Vexp. in cm^3/mol	%Dev. Racket	%Dev. Yen Woods	%Dev. Yamada Gunn	%Dev. Spencer Denner	%Dev. Reidel	%Dev. Bradford	%Dev. HT	%Dev. Modified HT
273.1510	0.4221	18.0150	11.9291	3.9215	1.7102	11.5399	2.3616	1.5980	1.5980	6.6947
278.1500	0.4298	18.0150	11.5021	3.5309	1.2753	12.0334	1.9260	0.6981	1.1511	6.0460
283.1500	0.4375	18.0150	11.0688	3.1344	0.8341	12.5341	1.4843	0.0258	0.6981	5.3973
288.1500	0.4453	18.0330	10.7183	2.8291	0.4861	12.9290	1.1352	0.7720	0.3389	4.8437
293.1500	0.4530	18.0510	10.3620	2.5183	0.1322	13.3305	0.7804	1.3403	0.0258	4.2910
298.1500	0.4607	18.0690	9.9996	2.2018	0.2276	13.7388	0.4198	1.9321	0.3960	3.7390
303.1500	0.4684	18.0871	9.6310	1.8795	0.5935	14.1541	0.0532	2.4480	0.7720	3.1877
308.1500	0.4762	18.1231	9.3461	1.6490	0.8655	14.4627	0.2198	2.8893	1.0533	2.7336
313.1500	0.4839	18.1591	9.0551	1.4126	1.1436	14.7783	0.4988	3.3585	1.3403	2.2806
318.1500	0.4916	18.1952	8.7577	1.1701	1.4280	15.1010	0.7839	3.7571	1.6332	1.8283
323.1500	0.4994	18.2312	8.4536	0.9213	1.7189	15.4312	1.0754	4.0876	1.9321	1.3767
328.1500	0.5071	18.2852	8.2334	0.7639	1.9160	15.6549	1.2735	4.4527	2.1365	1.0231
333.1500	0.5148	18.3213	7.9157	0.5020	2.2205	16.0004	1.5781	4.8543	2.4480	0.5724
338.1500	0.5225	18.3753	7.6815	0.3311	2.4315	16.2399	1.7897	5.0983	2.6653	0.2197
343.1500	0.5303	18.4293	7.4400	0.1530	2.6499	16.4877	2.0084	5.3859	2.8893	0.1331
348.1500	0.5380	18.4834	7.1910	0.0324	2.8757	16.7440	2.2343	5.7200	3.1204	0.4859
353.1500	0.5457	18.5374	6.9342	0.2253	3.1093	17.0090	2.4678	5.9115	3.3585	0.8393
358.1500	0.5534	18.5915	6.6694	0.4260	3.3509	17.2831	2.7089	6.1591	3.6041	1.1933
363.1500	0.5612	18.6635	6.4868	0.5376	3.5006	17.4531	2.8586	6.3725	3.7571	1.4504
368.1500	0.5689	18.7356	6.2954	0.6578	3.6591	17.6329	3.0168	6.5588	3.9182	1.7088
373.1500	0.5766	18.8077	6.0952	0.7868	3.8266	17.8230	3.1837	6.7263	4.0876	1.9688
378.1500	0.5843	18.8617	5.7959	1.0214	4.1026	18.1362	3.4582	6.7928	4.3653	2.3286
383.1500	0.5921	18.9518	5.6669	1.0725	4.1895	18.2348	3.5445	6.9520	4.4527	2.4954
388.1500	0.5998	19.0238	5.4382	1.2297	4.3855	18.4573	3.7391	7.0347	4.6488	2.7626
393.1500	0.6075	19.0959	5.1995	1.3969	4.5916	18.6912	3.9434	7.1454	4.8543	3.0329
398.1500	0.6152	19.1860	5.0395	1.4790	4.7098	18.8253	4.0600	7.2140	4.9710	3.2097
403.1500	0.6230	19.2761	4.8684	1.5723	4.8392	18.9722	4.1875	7.1790	5.0983	3.3909
408.1500	0.6307	19.3661	4.6858	1.6772	4.9803	19.1322	4.3263	7.2372	5.2364	3.5768
413.1500	0.6384	19.4562	4.4913	1.7940	5.1333	19.3059	4.4767	7.1736	5.3859	3.7680
418.1500	0.6462	19.5463	4.2846	1.9230	5.2987	19.4936	4.6391	7.0386	5.5469	3.9649
423.1500	0.6539	19.6364	4.0651	2.0647	5.4768	19.6957	4.8138	6.8943	5.7200	4.1680
428.1500	0.6616	19.7444	3.9202	2.1264	5.5718	19.8035	4.9054	6.7445	5.8090	4.2826
433.1500	0.6693	19.8525	3.7611	2.2023	5.6811	19.9275	5.0110	6.4151	5.9115	4.4053
438.1500	0.6771	19.9606	3.5873	2.2931	5.8052	20.0683	5.1310	6.0253	6.0280	4.5366
443.1500	0.6848	20.0687	3.3984	2.3991	5.9446	20.2266	5.2658	5.5342	6.1591	4.6772
448.1500	0.6925	20.1948	3.2801	2.4296	6.0052	20.2954	5.3219	4.8588	6.2104	4.7341
453.1500	0.7002	20.3029	3.0587	2.5683	6.1773	20.4906	5.4883	3.8077	6.3725	4.8955
458.1500	0.7080	20.4290	2.9060	2.6336	6.2726	20.5988	5.5780	1.5980	6.4568	4.9757
463.1500	0.7157	20.5551	2.7350	2.7174	6.3864	20.7279	5.6857	0.6981	6.5588	5.0690
468.1500	0.7234	20.6992	2.6297	2.7311	6.4268	20.7737	5.7200	0.0258	6.5864	5.0846
473.1500	0.7311	20.8253	2.4194	2.8548	6.5802	20.9479	5.8662	0.7720	6.7263	5.2071
478.1500	0.7389	20.9695	2.2723	2.9109	6.6627	21.0415	5.9414	1.3403	6.7943	5.2549
483.1500	0.7466	21.1316	2.1863	2.9020	6.6768	21.0575	5.9481	1.9321	6.7928	5.2307
488.1500	0.7543	21.2757	1.9931	3.0052	6.8060	21.2040	6.0686	2.4480	6.9056	5.3159
493.1500	0.7620	21.4379	1.8579	3.0464	6.8698	21.2764	6.1237	2.8893	6.9520	5.3327
498.1500	0.7698	21.6000	1.6962	3.1147	6.9603	21.3791	6.2047	3.3585	7.0242	5.3721
503.1500	0.7775	21.7801	1.5882	3.1258	6.9901	21.4129	6.2249	3.7571	7.0347	5.3484
508.1500	0.7852	21.9603	1.4501	3.1678	7.0503	21.4813	6.2747	4.0876	7.0747	5.3516
513.1500	0.7930	22.1404	1.2804	3.2420	7.1423	21.5857	6.3555	4.4527	7.1454	5.3833

518.1500	0.8007	22.3386	1.1572	3.2668	7.1812	21.6298	6.3829	4.8543	7.1620	5.3602
523.1500	0.8084	22.5368	0.9978	3.3286	7.2564	21.7152	6.4458	5.0983	7.2140	5.3709
528.1500	0.8161	22.7529	0.8787	3.3474	7.2849	21.7475	6.4616	5.3859	7.2182	5.3340
533.1500	0.8239	22.9871	0.7958	3.3279	7.2710	21.7318	6.4348	5.7200	7.1790	5.2543
538.1500	0.8316	23.2213	0.6676	3.3550	7.3029	21.7679	6.4526	5.9115	7.1846	5.2186
543.1500	0.8393	23.4555	0.4911	3.4314	7.3830	21.8588	6.5176	6.1591	7.2372	5.2299
548.1500	0.8470	23.7258	0.4147	3.4032	7.3511	21.8226	6.4708	6.3725	7.1770	5.1316
553.1500	0.8548	23.9960	0.2805	3.4344	7.3772	21.8522	6.4809	6.5588	7.1736	5.0907
558.1500	0.8625	24.2842	0.1585	3.4523	7.3853	21.8615	6.4725	6.7263	7.1512	5.0336
563.1500	0.8702	24.6085	0.1148	3.3887	7.3042	21.7694	6.3750	6.7928	7.0386	4.8910
568.1500	0.8779	24.9328	0.0058	3.4043	7.3000	21.7647	6.3532	6.9520	7.0019	4.8263
573.1500	0.8857	25.2931	0.0671	3.3583	7.2259	21.6806	6.2615	7.0347	6.8943	4.6966
578.1500	0.8934	25.6714	0.1526	3.3372	7.1709	21.6181	6.1883	7.1454	6.8046	4.5895
583.1500	0.9011	26.0677	0.2743	3.3535	7.1467	21.5907	6.1454	7.2140	6.7445	4.5173
588.1500	0.9088	26.5181	0.3101	3.2814	7.0218	21.4490	6.0026	7.1790	6.5829	4.3525
593.1500	0.9166	27.0045	0.3506	3.2148	6.8919	21.3015	5.8550	7.2372	6.4151	4.1894
598.1500	0.9243	27.5269	0.4199	3.1789	6.7809	21.1756	5.7269	7.1736	6.2650	4.0524
603.1500	0.9320	28.1214	0.4190	3.0724	6.5815	20.9493	5.5123	7.0386	6.0253	3.8374
608.1500	0.9398	28.7700	0.4561	3.0072	6.4059	20.7500	5.3235	6.8943	5.8077	3.6547
613.1500	0.9475	29.5086	0.4613	2.9127	6.1762	20.4893	5.0847	6.7445	5.5342	3.4289
618.1500	0.9552	30.3553	0.4552	2.8115	5.9091	20.1862	4.8147	6.4151	5.2207	3.1759
623.1500	0.9629	31.3461	0.4390	2.7072	5.5975	19.8327	4.5103	6.0253	4.8588	2.8873
628.1500	0.9707	32.5531	0.3747	2.5650	5.1891	19.3692	4.1264	5.5342	4.3936	2.5063
633.1500	0.9784	34.0844	0.2743	2.4038	4.6731	18.7836	3.6663	4.8588	3.8077	2.0077
638.1500	0.9861	36.2282	0.0244	2.1217	3.8815	17.8853	2.9968	3.8077	2.9159	1.1819
Error			3.8887	2.3345	5.0097	19.0296	4.3409	1.6564	4.9832	3.7971

Appendix C

Table C-1: Experimental and calculated saturated molar volume for mixture of 18.23vol.% n-Butane and n-Octane

Temp. K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Dev. Using modified HT Eq.
426.8500	0.7829	181.5053	2.3504	0.5594
455.8500	0.8360	194.0345	2.2482	0.1809
478.2500	0.8771	206.3542	2.3092	0.0446
496.4500	0.9105	218.9527	2.6613	0.3066
512.0500	0.9391	233.1895	3.2864	0.9559
526.6500	0.9659	252.4333	4.4787	2.2934
539.6500	0.9897	279.5766	9.1762	7.0445
544.9500	0.9995	298.8578	24.3937	20.2459
547.6500	1.0044	313.2606	28.8373	25.9721
550.8500	1.0103	338.7704	28.4073	26.6656
Total Error			10.8149	8.4269

Table C-2: Experimental and calculated saturated molar volume for mixture of 46.31vol.% n-Butane and n-Octane

Temp. K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Dev. Using modified HT Eq.
375.8500	0.7415	152.4134	0.2449	3.6530
400.3500	0.7898	160.1586	0.0930	4.1129
419.9500	0.8285	167.4523	0.1777	4.5404
436.7500	0.8616	174.4019	0.8143	4.7105
451.4500	0.8906	181.9534	1.4153	5.0338
465.2500	0.9179	190.5991	2.2606	5.3896
477.9500	0.9429	200.5622	3.5608	5.7762
499.9500	0.9863	214.1927	17.8534	1.2788
501.8500	0.9901	232.2300	12.4201	7.7637
506.7500	0.9997	242.4379	34.0539	8.2839
511.9500	1.0100	255.7895	34.5172	8.7218
514.6500	1.0153	265.8054	34.3321	9.3754
516.3500	1.0187	265.8054	35.6825	7.2820
518.6500	1.0232	285.5902	35.4527	10.4683
Total Error			15.2056	6.1707

Table C-3: Experimental and calculated saturated molar volume for mixture of 67.09vol.% n-Butane and n-Octane

Temp. K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Dev. Using modified HT Eq.
354.4500	0.7437	134.6013	0.5398	1.3906
376.3500	0.7896	140.5287	0.0158	1.0175
393.5500	0.8257	145.8822	0.6022	0.5420
408.1500	0.8563	151.3600	1.1590	0.0911
421.1500	0.8836	157.2652	1.7043	0.3982
432.8500	0.9081	164.0003	2.1370	0.8383
443.6500	0.9308	171.3381	2.9235	1.7001
453.7500	0.9520	179.7844	4.2308	3.1605
463.6500	0.9728	190.5178	6.8421	6.0072
473.3500	0.9931	220.7151	7.4124	6.6849
484.0500	1.0156	231.3841	34.7905	34.6899
487.0500	1.0219	240.0882	35.8575	36.1695
487.6500	1.0231	246.2641	35.7231	35.9469
Total Error			10.3029	9.8951

Table C-4: Experimental and calculated saturated molar volume for mixture of 81.83vol.% n-Butane and n-Octane

Temp. K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Dev. Using modified HT Eq.
346.9500	0.7640	123.9888	0.3102	0.9989
366.4500	0.8069	129.8818	0.1811	1.0111
381.9500	0.8411	135.5512	0.0825	1.0200
394.7500	0.8693	141.4448	0.1829	1.1761
406.6500	0.8955	147.5547	0.0839	0.9134
416.9500	0.9181	153.8690	0.5076	0.4323
426.6500	0.9395	160.7478	1.4372	0.6233
435.5500	0.9591	168.6860	2.8801	2.2637
444.0500	0.9778	177.9110	6.1677	5.8062
452.4500	0.9963	191.3665	17.7627	17.2276
461.6500	1.0166	218.2678	33.3987	33.2644
463.6500	1.0210	226.9695	34.4354	34.3833
466.1500	1.0265	242.2618	36.4425	36.3072
468.1500	1.0309	267.9130	39.5856	39.0550
Total Error			12.3899	12.4630

Table C-5: Experimental and calculated saturated molar volume for mixture of 94.61vol.% n-Butane and n-Octane

Temp. K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Dev. Using modified HT Eq.
339.4500	0.7824	116.0289	1.1044	2.1692
357.6500	0.8243	122.0503	1.2192	2.6340
371.8500	0.8571	127.6560	1.2207	2.9654
383.7500	0.8845	133.0734	0.9989	3.0725
394.2500	0.9087	138.9710	0.7877	3.2161
403.4500	0.9299	145.2428	0.4241	3.2710
411.9500	0.9495	152.1075	0.4282	3.0224
419.6500	0.9672	160.4914	1.5809	2.8702
426.8500	0.9838	171.7619	3.8996	2.8254
433.7500	0.9997	191.6841	21.9636	3.8040
436.5500	1.0062	206.5785	25.5379	4.5469
438.2500	1.0101	222.3535	27.1605	5.0473
439.4500	1.0129	240.7371	30.0697	7.0743
440.0000	1.0141	258.0052	32.8626	15.1029
Total Error			10.6613	4.8196

Table C-6: Experimental and calculated saturated molar volume for mixture of Aniline and Methanol at 20^oC

Mole fraction of Aniline	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Dev. Using modified HT Eq.
1.0000	0.4337	91.9783	10.9643	5.9296
0.7482	0.4612	78.4021	11.5675	6.7206
0.5778	0.4833	69.4058	11.4669	6.8051
0.4527	0.5018	62.9542	11.1292	6.6324
0.3347	0.5214	56.9183	10.4316	6.1011
0.2898	0.5294	54.5002	9.8314	5.5548
0.1821	0.5503	49.1606	8.7914	4.6742
0.1278	0.5617	46.6078	8.3189	4.2870
0.0814	0.5720	44.5721	8.1102	4.1591
0.0376	0.5822	42.5996	7.7350	3.8505
0	0.5914	40.9325	7.3988	3.5681
Total Error			9.6132	5.2984

Table C-7: Experimental and calculated saturated molar volume for mixture of Aniline and Methanol at 30°C

Mole fraction of Aniline	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.4194	91.1233	11.3058	5.8489
0.7482	0.4460	77.7513	12.0796	6.8208
0.5778	0.4674	68.9369	12.1792	7.1233
0.4527	0.4853	62.4537	11.7882	6.9037
0.3347	0.5042	56.9739	11.9395	7.2802
0.2898	0.5120	54.1797	10.7587	6.1282
0.1821	0.5321	48.8269	9.7009	5.2504
0.1278	0.5432	46.3368	9.3515	5.0069
0.0814	0.5531	44.1679	8.8737	4.6126
0.0376	0.5630	42.1809	8.4585	4.2784
0	0.5718	40.4877	8.0532	3.9393
Total Error			10.4081	5.7448

Table C-8: Experimental and calculated saturated molar volume for mixture of Aniline and Methanol at 40°C

Mole fraction of Aniline	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.4480	92.7108	10.5116	5.8655
0.7482	0.4764	78.9755	10.9764	6.5068
0.5778	0.4993	69.8450	10.7246	6.4231
0.4527	0.5184	63.2611	10.2039	6.0463
0.3347	0.5386	57.1849	9.4294	5.4177
0.2898	0.5469	54.9638	9.1466	5.1954
0.1821	0.5685	49.5443	7.9784	4.1554
0.1278	0.5802	46.9925	7.5117	3.7574
0.0814	0.5909	44.9074	7.2050	3.5102
0.0376	0.6014	42.9136	6.7833	3.1353
0	0.6109	41.4408	6.8830	3.2885
Total Error			8.8504	4.8456

Table C-9: Experimental and calculated saturated molar volume for mixture of Benzene and Methanol at 20°C

Mole fraction of Benzene	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.5216	88.9580	1.1368	0.3032
0.7857	0.5325	78.4851	3.9429	1.9347
0.6165	0.5414	70.3502	5.9428	3.5080
0.4936	0.5480	64.3969	7.0779	4.3363
0.3811	0.5540	58.9712	7.9166	4.8928
0.2932	0.5585	54.7740	8.4619	5.2147
0.2093	0.5627	50.7049	8.6974	5.2248
0.1481	0.5656	47.7298	8.7165	5.0710
0.0925	0.5681	45.0215	8.6052	4.7940
0.0435	0.5702	42.6188	8.3628	4.3956
0	0.5718	40.4877	8.0532	3.9393
Total Error			6.9922	3.9649

Table C-10: Experimental and calculated saturated molar volume for mixture of Benzene and Methanol at 30°C

Mole fraction of Benzene	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.5394	89.9931	0.9210	0.2925
0.7857	0.5507	79.4444	3.7041	1.9386
0.6165	0.5599	71.2038	5.6326	3.4502
0.4936	0.5667	65.2017	6.7553	4.2733
0.3811	0.5729	59.6664	7.4868	4.7261
0.2932	0.5776	55.3732	7.9222	4.9393
0.2093	0.5819	51.2473	8.1031	4.8983
0.1481	0.5849	48.2632	8.1417	4.7688
0.0925	0.5875	45.5354	8.0295	4.4952
0.0435	0.5896	43.1099	7.7763	4.0903
0	0.5914	40.9325	7.3988	3.5681
Total Error			6.5338	3.7673

Table C-11: Experimental and calculated saturated molar volume for mixture of Benzene and Methanol at 40°C

Mole fraction of Benzene	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.5572	91.1269	0.8008	0.2159
0.7857	0.5688	80.3612	3.4027	1.8446
0.6165	0.5784	71.9925	5.2271	3.2576
0.4936	0.5854	65.9553	6.3504	4.0860
0.3811	0.5917	60.4223	7.1425	4.6051
0.2932	0.5966	56.0892	7.5686	4.8120
0.2093	0.6011	51.9304	7.7539	4.7789
0.1481	0.6042	48.8393	7.6421	4.4967
0.0925	0.6069	46.0903	7.5308	4.2269
0.0435	0.6091	43.6291	7.2447	3.7909
0	0.6109	41.4408	6.8830	3.2885
Total Error			6.1406	3.5821

Table C-12: Experimental and calculated saturated molar volume for mixture of C_3H_7OH and CCl4 at 22°C

Mole fraction of C_3H_7OH	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5006	0.5460	0.6331
0.0350	0.5312	95.7644	1.0018	0.3136
0.0499	0.5315	95.6058	1.3552	0.0161
0.1087	0.5326	94.2480	1.9889	0.3875
0.1557	0.5335	93.3169	2.6501	0.8679
0.2026	0.5344	92.2251	3.1352	1.1696
0.4171	0.5385	87.3792	5.4363	2.6354
0.6178	0.5424	82.9741	7.6209	4.0413
0.8112	0.5462	78.8161	9.7235	5.3949
1.0000	0.5499	74.7463	11.6656	6.5999
Total Error			4.5123	2.2059

Table C-13: Experimental and calculated saturated molar volume for mixture of C_3H_7OH and CCl4 at 30°C

Mole fraction of C_3H_7OH	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.4791	0.4542	0.5563
0.0350	0.5456	96.7491	0.9139	0.2284
0.0499	0.5459	96.4716	1.1429	0.0550
0.1087	0.5471	95.1849	1.8459	0.4267
0.1557	0.5480	94.1372	2.3824	0.7864
0.2026	0.5489	93.1168	2.9388	1.1669
0.4171	0.5531	88.2530	5.2088	2.6295
0.6178	0.5571	83.7712	7.2985	3.9642
0.8112	0.5610	79.4601	9.2162	5.1502
1.0000	0.5648	75.4028	11.1598	6.3808
Total Error			4.2561	2.1345

Table C-14: Experimental and calculated saturated molar volume for mixture of C_3H_7OH and CCl4 at 40°C

Mole fraction of C_3H_7OH	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0350	0.5636	97.9451	0.7541	0.2002
0.0499	0.5639	97.6720	0.9860	0.0218
0.1087	0.5651	96.3340	1.6325	0.4114
0.1557	0.5660	95.3622	2.2437	0.8536
0.2026	0.5670	94.2889	2.7425	1.1826
0.4171	0.5714	89.3527	4.9251	2.5878
0.6178	0.5755	84.7333	6.8546	3.7865
0.8112	0.5795	80.3631	8.6952	4.9197
1.0000	0.5834	76.1673	10.4665	5.9956
Total Error			3.9654	2.0433

Table C-15: Experimental and calculated saturated molar volume for mixture of $C_4H_{10}OH$ and CCl4 at 22°C

Mole fraction of $C_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0397	0.5303	96.5137	1.1295	0.2009
0.0873	0.5300	96.2413	1.5349	0.0184
0.1463	0.5296	95.7965	1.9310	0.1801
0.2058	0.5292	95.6297	2.6220	0.6382
0.2884	0.5287	95.2233	3.4079	1.0948
0.4191	0.5279	94.4472	4.5308	1.6859
0.6182	0.5266	93.3501	6.3621	2.6913
1.0000	0.5242	91.5099	10.2541	4.9513
Total Error			3.5978	1.3368

Table C-16: Experimental and calculated saturated molar volume for mixture of $C_4H_{10}OH$ and CCl4 at 30°C

Mole fraction of $C_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0397	0.5447	97.4502	0.9862	0.1706
0.0873	0.5444	97.1325	1.3379	0.0014
0.1463	0.5440	96.7089	1.7466	0.1852
0.2058	0.5436	96.4350	2.3179	0.5303
0.2884	0.5430	95.9918	3.0525	0.9470
0.4191	0.5422	95.1938	4.1313	1.5133
0.6182	0.5409	94.1911	6.0220	2.6120
1.0000	0.5384	92.1928	9.6859	4.6977
Total Error			3.3108	1.2389

Table C-17: Experimental and calculated saturated molar volume for mixture of $C_4H_{10}OH$ and CCl4 at 40°C

Mole fraction of $C_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0397	0.5626	98.4049	0.5769	0.3931
0.0873	0.5623	98.1713	1.0049	0.1358
0.1463	0.5619	98.3820	2.0389	0.6921
0.2058	0.5615	97.4610	1.9497	0.3777
0.2884	0.5610	96.9162	2.5663	0.6886
0.4191	0.5601	95.8759	3.3765	1.0027
0.6182	0.5587	95.2205	5.5744	2.4528
1.0000	0.5562	93.1193	9.0543	4.4212
Total Error			2.9439	1.1820

Table C-18: Experimental and calculated saturated molar volume for mixture of $C_5H_{12}OH$ and CCl4 at 22°C

Mole fraction of $C_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0275	0.5297	97.0728	1.0791	0.2088
0.0533	0.5289	97.2956	1.2589	0.1358
0.1044	0.5273	97.6517	1.5355	0.0742
0.1520	0.5259	98.4530	2.2702	0.4657
0.2081	0.5242	99.1200	2.8625	0.8214
0.3132	0.5210	100.3415	3.9613	1.4690
0.4116	0.5181	101.9224	5.4175	2.5063
0.6924	0.5102	104.6867	8.0534	3.8487
1.0000	0.5018	108.2924	11.6518	5.9672
Total Error			3.8698	1.6067

Table C-19: Experimental and calculated saturated molar volume for mixture of $C_5H_{12}OH$ and CCl4 at 30°C

Mole fraction of $C_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0275	0.5441	97.7595	0.6816	0.4370
0.0533	0.5432	98.2495	1.1256	0.0922
0.1044	0.5416	98.5686	1.3529	0.0713
0.1520	0.5401	99.4056	2.1078	0.4971
0.2081	0.5384	100.0397	2.6523	0.8141
0.3132	0.5352	101.2565	3.7176	1.4463
0.4116	0.5322	102.8316	5.1389	2.4648
0.6924	0.5240	105.5021	7.6174	3.6984
1.0000	0.5154	109.0965	11.1257	5.7822
Total Error			3.6037	1.5796

Table C-20: Experimental and calculated saturated molar volume for mixture of $C_5H_{12}OH$ and CCl4 at 40°C

Mole fraction of $C_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0275	0.5620	97.7595	0.7007	1.6422
0.0533	0.5612	99.4191	0.9237	0.1012
0.1044	0.5595	99.7055	1.1048	0.1162
0.1520	0.5579	100.5873	1.8860	0.4880
0.2081	0.5561	101.2685	2.4578	0.8443
0.3132	0.5528	102.4239	3.4298	1.4039
0.4116	0.5497	103.9274	4.7501	2.3389
0.6924	0.5413	106.6444	7.1832	3.5898
Total Error			2.5322	1.2220

Table C-21: Experimental and calculated saturated molar volume for mixture of $C_7H_{15}OH$ and CCl4 at 22°C

Mole fraction of $C_7H_{15}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0391	0.5276	98.3545	1.1346	0.2278
0.1005	0.5230	101.1060	1.8922	0.2341
0.1514	0.5194	103.3681	2.5009	0.5918
0.2189	0.5146	106.5012	3.4294	1.1827
0.3014	0.5089	110.1962	4.4378	1.7642
0.3392	0.5063	111.8649	4.8799	2.0058
0.7562	0.4804	130.4626	10.0062	4.7447
1.0000	0.4671	141.5384	13.2402	6.4424
Total Error			4.6811	1.9737

Table C-22: Experimental and calculated saturated molar volume for mixture of $C_7H_{15}OH$ and CCl4 at 30°C

Mole fraction of $C_7H_{15}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0391	0.5419	99.3810	1.0689	0.1162
0.1005	0.5372	102.1384	1.7987	0.3313
0.1514	0.5334	104.3879	2.3687	0.6615
0.2189	0.5285	107.6033	3.3361	1.3073
0.3014	0.5227	111.2284	4.2410	1.8023
0.3392	0.5200	112.8493	4.6246	1.9927
0.7562	0.4935	131.4198	9.5566	4.6290
1.0000	0.4797	142.5804	12.7517	6.3450
Total Error			4.4737	1.9642

Table C-23: Experimental and calculated saturated molar volume for mixture of $C_7H_{15}OH$ and CCl4 at 40°C

Mole fraction of $C_7H_{15}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0391	0.5598	100.5618	0.8718	0.1208
0.1005	0.5549	103.3342	1.5800	0.3212
0.1514	0.5510	105.5784	2.1160	0.6305
0.2189	0.5459	108.7283	2.9860	1.1952
0.3014	0.5399	112.3688	3.8625	1.6838
0.3392	0.5372	113.8512	4.1109	1.7462
0.7562	0.5097	132.6714	9.0400	4.4981
1.0000	0.4956	143.8156	12.1112	6.1557
Total Error			4.1146	1.8695

Table C-24: Experimental and calculated saturated molar volume for mixture of $C_8H_{17}OH$ and CCl4 at 22°C

Mole fraction of $C_8H_{17}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0413	0.5266	99.1230	1.2304	0.1558
0.0473	0.5260	99.6126	1.4362	0.0212
0.1014	0.5209	102.8735	2.1384	0.4429
0.1515	0.5162	106.0323	2.9088	0.9497
0.1923	0.5125	108.5711	3.4953	1.3165
0.2976	0.5033	114.9577	4.8420	2.0741
0.4048	0.4944	121.4410	6.1836	2.7875
0.7095	0.4714	140.1672	10.1849	4.8615
1.0000	0.4523	157.6634	13.8339	6.4571
Total Error			4.6862	1.9636

Table C-25: Experimental and calculated saturated molar volume for mixture of $C_8H_{17}OH$ and CCl4 at 30°C

Mole fraction of $C_8H_{17}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0413	0.5408	98.6114	0.3835	1.6099
0.0473	0.5402	100.4645	1.1874	0.0499
0.1014	0.5350	103.7901	1.9223	0.4181
0.1515	0.5302	106.9379	2.6545	0.8981
0.1923	0.5264	109.5270	3.2638	1.2982
0.2976	0.5170	115.9566	4.5907	2.0620
0.4048	0.5078	122.5760	5.9822	2.8544
0.7095	0.4842	141.1776	9.7470	4.7607
1.0000	0.4646	158.8171	13.3565	6.3919
Total Error			4.3605	2.0836

Table C-25: Experimental and calculated saturated molar volume for mixture of $C_8H_{17}OH$ and CCl4 at 40°C

Mole fraction of $C_8H_{17}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7938	0.4174	0.4093
0.0413	0.5587	101.0229	0.6529	0.3634
0.0473	0.5581	101.7362	1.0681	0.0278
0.1014	0.5526	105.0866	1.7847	0.4935
0.1515	0.5477	108.2477	2.4907	0.9618
0.1923	0.5438	110.7457	2.9900	1.2621
0.2976	0.5340	117.2532	4.3135	2.0546
0.4048	0.5246	123.7324	5.5297	2.6998
0.7095	0.5002	142.3504	9.1497	4.5499
1.0000	0.4799	160.1845	12.7312	6.2449
Total Error			4.1128	1.9067

Table C-26: Experimental and calculated saturated molar volume for mixture of CCl4 and Benzene at 25°C

Mole fraction of CCl4	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.8887	0.5356	96.2873	0.8097	0.3205
0.7734	0.5350	95.4149	0.8598	0.2942
0.6941	0.5346	94.7492	0.8242	0.3473
0.5947	0.5340	94.0412	0.9098	0.2821
0.4430	0.5331	92.8705	0.9419	0.2827
0.3494	0.5326	92.1679	0.9802	0.2646
0.2576	0.5320	91.4628	0.9987	0.2663
0.1674	0.5315	90.0580	0.2324	1.0627
Total Error			0.8196	0.3900

Table C-27: Experimental and calculated saturated molar volume for mixture of CCl4 and Hexane at 25°C

Mole fraction of CCl4	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.8872	0.5428	101.0630	1.0868	0.0537
0.8349	0.5458	102.8788	1.2116	0.0544
0.7721	0.5493	105.0406	1.3296	0.1510
0.6091	0.5581	110.7119	1.6258	0.3874
0.5350	0.5619	113.2504	1.6971	0.4288
0.4421	0.5667	116.4438	1.7751	0.4676
0.2708	0.5750	122.3598	1.8870	0.5020
0.1447	0.5809	126.6868	1.9072	0.4606
Total Error			1.5650	0.3132

Table C-28: Experimental and calculated saturated molar volume for mixture of Hexadecane and Benzene at 25°C

Mole fraction of Hexadecane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.7656	0.4338	246.4570	9.7390	1.1501
0.5715	0.4548	207.1573	8.0040	1.6980
0.4563	0.4689	183.7843	7.0436	1.9631
0.3105	0.4884	154.0431	5.7637	2.0840
0.2727	0.4937	146.2473	5.3655	2.0190
0.1436	0.5120	119.5920	3.8274	1.5269
0.1091	0.5168	112.4297	3.3192	1.2725
0.0658	0.5226	103.3693	2.5505	0.8055
0.0317	0.5269	96.1927	1.8301	0.3095
Total Error			5.2715	1.4254

Table C-30: Experimental and calculated saturated molar volume for mixture of Hexadecane and CCl_4 at 25°C

Mole fraction of Hexadecane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.7183	0.4390	238.7490	8.8293	0.8695
0.5598	0.4570	207.7922	7.2231	1.1247
0.4256	0.4740	181.4822	5.9236	1.2557
0.3414	0.4856	164.9299	5.1074	1.2655
0.2601	0.4974	148.8764	4.2687	1.1692
0.2075	0.5053	138.4754	3.6979	1.0494
0.1563	0.5131	128.4205	3.1703	0.9396
0.1159	0.5193	120.3179	2.6011	0.6810
0.0710	0.5260	111.3512	1.9538	0.3630
0.0342	0.5314	103.9924	1.3707	0.0363
Total Error			4.4146	0.8754

Table C-31: Experimental and calculated saturated molar volume for mixture of Hexadecane and n-Hexane at 25°C

Mole fraction of Hexadecane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.7660	0.4389	255.4630	9.3147	0.5392
0.7504	0.4409	252.9697	9.1554	0.5665
0.7417	0.4420	251.5100	9.0421	0.5544
0.7121	0.4459	246.7248	8.7248	0.5844
0.6441	0.4552	235.5573	7.9439	0.5778
0.6314	0.4570	233.5323	7.8236	0.6012
0.6281	0.4575	232.9448	7.7682	0.5811
0.6224	0.4583	231.9908	7.6966	0.5722
0.5251	0.4731	216.1911	6.6835	0.6150
0.5244	0.4732	216.0495	6.6643	0.6024
0.5163	0.4745	214.7364	6.5822	0.6057
0.4201	0.4909	199.0753	5.5899	0.5937
0.4170	0.4914	198.6259	5.5844	0.6203
0.3998	0.4945	195.8054	5.3993	0.6032
0.3398	0.5059	186.1350	4.8389	0.6169
0.2640	0.5213	173.8213	4.0863	0.5496
0.2111	0.5330	165.2718	3.5843	0.5002
0.1564	0.5458	156.4685	3.0856	0.4453
0.1040	0.5588	148.1119	2.6552	0.4161
0.0553	0.5718	140.3234	2.2408	0.3506
Total Error			6.2232	0.5548

Table C-32: Experimental and calculated saturated molar volume for mixture of $isoC_3H_7OH$ and CCl_4 at 22°C

Mole fraction of $isoC_3H_7OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0452	0.5326	95.7041	1.2398	0.1141
0.0506	0.5328	95.6251	1.3389	0.0355
0.0972	0.5349	94.7687	2.0109	0.4579
0.0973	0.5349	94.7626	2.0079	0.4544
0.1368	0.5367	94.0629	2.5996	0.8966
0.1469	0.5371	93.8069	2.6702	0.9278
0.1866	0.5389	93.0599	3.2135	1.3215
0.1901	0.5391	93.0265	3.2949	1.3905
0.2745	0.5430	91.3002	4.2883	2.0670
0.3096	0.5447	90.6350	4.7497	2.3992
0.3605	0.5471	89.5106	5.2431	2.7023
0.3765	0.5479	89.1905	5.4313	2.8320
0.4469	0.5513	87.7240	6.1874	3.3301
Total Error			3.2060	1.3928

Table C-33: Experimental and calculated saturated molar volume for mixture of $isoC_3H_7OH$ and CCl_4 at 30°C

Mole fraction of $isoC_3H_7OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0452	0.5470	96.6940	1.1516	0.0286
0.0506	0.5472	96.6166	1.2513	0.0512
0.0972	0.5494	95.7089	1.8628	0.4885
0.0973	0.5494	95.7660	1.9247	0.5508
0.1368	0.5512	94.9497	2.3897	0.8687
0.1469	0.5517	94.7589	2.5263	0.9681
0.1866	0.5535	94.0226	3.0741	1.3707
0.1901	0.5537	93.9259	3.0894	1.3727
0.2745	0.5577	92.2205	4.0916	2.0672
0.3096	0.5594	91.5660	4.5586	2.4086
0.3605	0.5619	90.3869	4.9879	2.6514
0.3765	0.5627	90.1400	5.2508	2.8592
0.4469	0.5663	88.6972	6.0225	3.3804
Total Error			3.6000	1.7536

Table C-34: Experimental and calculated saturated molar volume for mixture of $isoC_3H_7OH$ and CCl_4 at 40°C

Mole fraction of $isoC_3H_7OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0452	0.5650	97.9604	1.0563	0.0650
0.0506	0.5653	97.8854	1.1570	0.1464
0.0972	0.5675	96.9269	1.7082	0.5285
0.0973	0.5675	96.9206	1.7051	0.5250
0.1368	0.5694	96.1803	2.2403	0.9187
0.1469	0.5699	95.9272	2.3115	0.9529
0.1866	0.5718	95.2044	2.8652	1.3659
0.1901	0.5720	95.1082	2.8806	1.3684
0.2745	0.5761	93.3631	3.8271	2.0154
0.3096	0.5779	92.7225	4.3016	2.3680
0.3605	0.5805	91.4892	4.6671	2.5511
0.3765	0.5813	91.3206	5.0080	2.8400
0.4469	0.5849	89.9083	5.8003	3.3890
Total Error			3.3616	1.7158

Table C-35: Experimental and calculated saturated molar volume for mixture of $isoC_4H_{10}OH$ and CCl_4 at 22°C

Mole fraction of $isoC_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0231	0.5307	96.5571	0.9267	0.3356
0.0509	0.5310	96.3741	1.1271	0.2387
0.1064	0.5314	96.2530	1.7785	0.2093
0.1540	0.5318	96.0301	2.2164	0.4706
0.2214	0.5324	95.8316	2.9570	0.9630
0.3198	0.5332	95.4158	3.9137	1.5539
0.4102	0.5339	95.0035	4.7659	2.0681
0.6162	0.5356	94.0804	6.7389	3.2662
1.0000	0.5388	92.4227	10.5310	5.5988
Total Error			3.5564	1.5274

Table C-36: Experimental and calculated saturated molar volume for mixture of $isoC_4H_{10}OH$ and CCl_4 at 30°C

Mole fraction of $isoC_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0231	0.5451	97.3613	0.6512	0.4419
0.0509	0.5454	97.4400	1.1128	0.0769
0.1064	0.5458	97.2187	1.6499	0.2627
0.1540	0.5462	96.9509	2.0327	0.4746
0.2214	0.5468	96.6477	2.6534	0.8537
0.3198	0.5476	96.2026	3.5608	1.4071
0.4102	0.5484	95.9062	4.5104	2.0332
0.6162	0.5501	94.9333	6.3915	3.1648
1.0000	0.5534	93.2365	10.0646	5.4267
Total Error			3.3145	1.4634

Table C-37: Experimental and calculated saturated molar volume for mixture of $isoC_4H_{10}OH$ and CCl_4 at 40°C

Mole fraction of $isoC_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0231	0.5631	98.4333	0.3637	0.5441
0.0509	0.5634	98.6596	0.9656	0.0338
0.1064	0.5638	98.4035	1.4541	0.2650
0.1540	0.5642	98.2293	1.9195	0.5679
0.2214	0.5648	97.9688	2.5661	0.9839
0.3198	0.5657	97.5184	3.4438	1.5226
0.4102	0.5665	97.0589	4.2086	1.9737
0.6162	0.5683	96.0656	6.0195	3.0650
1.0000	0.5717	94.1842	9.4195	5.1019
Total Error			3.0714	1.4532

Table C-38: Experimental and calculated saturated molar volume for mixture of $isoC_5H_{12}OH$ and CCl_4 at 22°C

Mole fraction of $isoC_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0372	0.5299	97.1624	1.1111	0.2207
0.1061	0.5286	97.9746	1.7422	0.1193
0.1603	0.5277	98.6879	2.3208	0.4676
0.2133	0.5267	99.4411	2.9465	0.8674
0.3070	0.5250	100.4968	3.7988	1.3092
0.4269	0.5229	102.0167	5.0816	2.0610
0.7656	0.5170	106.0897	8.6767	4.0890
1.0000	0.5129	108.9617	11.3619	5.6396
Total Error			4.1831	1.7049

Table C-39: Experimental and calculated saturated molar volume for mixture of $isoC_5H_{12}OH$ and CCl_4 at 30°C

Mole fraction of $isoC_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0372	0.5442	98.1069	0.9708	0.1871
0.1061	0.5430	98.8917	1.5525	0.1146
0.1603	0.5420	99.4412	1.9522	0.2903
0.2133	0.5410	100.0817	2.4528	0.5711
0.3070	0.5392	101.2581	3.3962	1.1219
0.4269	0.5371	102.7668	4.6344	1.8484
0.7656	0.5310	106.9664	8.2425	3.9525
1.0000	0.5269	109.9127	10.9154	5.5370
Total Error			3.8482	1.5684

Table C-40: Experimental and calculated saturated molar volume for mixture of $isoC_5H_{12}OH$ and CCl_4 at 40°C

Mole fraction of $isoC_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0372	0.5622	99.1999	0.6949	0.2744
0.1061	0.5609	100.0369	1.3035	0.0680
0.1603	0.5598	100.4872	1.5869	0.1366
0.2133	0.5588	100.8760	1.8243	0.1603
0.3070	0.5570	102.2653	2.9418	0.9065
0.4269	0.5548	103.6988	4.0686	1.5431
0.7656	0.5485	108.0830	7.7216	3.7662
1.0000	0.5442	111.0202	10.3001	5.3056
Total Error			3.4217	1.4038

Table C-41: Experimental and calculated saturated molar volume for mixture of Methane and n-Decan at 0°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.0560	0.4544	184.8700	6.9433	0.9972
0.1086	0.4670	176.3500	6.0516	0.8153
0.1553	0.4792	169.6600	5.7019	1.0989
0.1991	0.4916	163.3800	5.3649	1.3326
0.2388	0.5037	157.7000	5.0562	1.5206
0.2763	0.5161	152.3200	4.7414	1.6549
0.3120	0.5287	147.2100	4.4306	1.7524
0.3443	0.5410	142.5800	4.1241	1.7974
0.3741	0.5532	138.3100	3.8192	1.8007
0.4040	0.5662	134.0300	3.4881	1.7619
Total Error			4.9721	1.4532

Table C-42: Experimental and calculated saturated molar volume for mixture of Methane and n-Decan at 25°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.0486	0.4942	188.8100	4.7590	0.1728
0.0951	0.5061	182.0400	4.4272	0.0737
0.1379	0.5180	175.8100	4.1172	0.2733
0.1767	0.5295	170.1700	3.8316	0.4295
0.2120	0.5408	166.4800	4.3951	1.4030
0.2443	0.5517	160.3300	3.2898	0.6065
0.2748	0.5627	155.8900	3.0217	0.6397
0.3040	0.5739	151.6400	2.7463	0.6379
0.3330	0.5857	147.4200	2.4497	0.5978
0.3610	0.5979	143.3000	2.1045	0.4842
Total Error			3.5142	0.5318

Table C-43: Experimental and calculated saturated molar volume for mixture of Methane and n-Decan at 50°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.0450	0.5347	194.5600	3.7711	0.2600
0.0867	0.5462	188.1900	3.3989	0.1914
0.1259	0.5577	182.3900	3.1331	0.0595
0.1622	0.5691	176.9400	2.8311	0.0136
0.1968	0.5808	171.7300	2.5158	0.0156
0.2291	0.5923	166.8800	2.2070	0.0487
0.2569	0.6028	162.7000	1.9162	0.1162
0.2822	0.6129	158.9000	1.6326	0.2086
0.3082	0.6239	154.9900	1.3122	0.3451
0.3344	0.6355	151.0500	0.9573	0.5283
Total Error			2.3675	0.1787

Table C-44: Experimental and calculated saturated molar volume for mixture of Methane and n-Decan at 75°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.0412	0.5750	200.2800	2.7521	0.6114
0.0789	0.5860	194.6100	2.5174	0.5098
0.1155	0.5975	189.1000	2.2731	0.4466
0.0150	0.5677	183.9400	7.7968	0.8031
0.1829	0.6206	178.9600	1.7717	0.4348
0.2153	0.6327	174.0900	1.4960	0.4901
0.2430	0.6437	169.9200	1.2302	0.5822
0.2679	0.6541	166.1700	0.9645	0.7040
0.2920	0.6647	162.5400	0.6785	0.8619
0.3152	0.6754	159.0500	0.3743	1.0540
Total Error			2.1854	0.6447

Table C-45: Experimental and calculated saturated molar volume for mixture of Methane and n-Decan at 100°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.0372	0.6150	207.3000	2.2961	0.5978
0.0735	0.6264	201.9700	2.1845	0.4457
0.1080	0.6378	196.7900	2.0080	0.3912
0.1417	0.6496	191.7300	1.8139	0.3774
0.1730	0.6613	187.0300	1.6080	0.4068
0.2022	0.6728	182.6500	1.3900	0.4751
0.2298	0.6842	178.5000	1.1465	0.5910
0.2542	0.6949	174.8400	0.9040	0.7322
0.2766	0.7051	171.4800	0.6493	0.9038
0.2989	0.7158	168.1300	0.3558	1.1240
Total Error			1.4356	0.6045

Table C-46: Experimental and calculated saturated molar volume for mixture of Methane and n-Decan at 150°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.0324	0.6958	222.7900	0.6797	1.8296
0.0664	0.7077	217.4400	0.7837	1.5896
0.0990	0.7198	212.2000	0.9932	1.2666
0.1311	0.7324	207.0200	1.2784	0.8850
0.1631	0.7457	201.8700	1.6386	0.4436
0.1935	0.7590	196.9800	2.0720	0.0532
0.2214	0.7719	192.4800	2.5725	0.6005
Total Error			1.4312	0.9526

Table C-47: Experimental and calculated saturated molar volume for mixture of Methane and 3-Methylepentane at 25°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5911	130.6600	0.9509	0.3191
0.0234	0.5978	128.6900	1.0128	0.1508
0.0480	0.6051	126.6100	1.1040	0.0477
0.0726	0.6127	124.5100	1.2331	0.2789
0.0965	0.6203	122.4900	1.3649	0.5052
0.1202	0.6281	120.4600	1.5425	0.7714
0.1440	0.6363	118.4500	1.7240	1.0368
Total Error			1.2760	0.4443

Table C-48: Experimental and calculated saturated molar volume for mixture of Methane and 3-Methylepentane at 50°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.6407	135.4900	1.0248	0.0607
0.0191	0.6466	133.9000	1.0837	0.1811
0.0411	0.6536	132.0200	1.2062	0.3703
0.0630	0.6608	130.1700	1.3325	0.5590
0.0847	0.6682	128.3100	1.5011	0.7852
0.1061	0.6757	126.4600	1.7046	1.0412
0.1273	0.6834	124.6700	1.8979	1.2827
Total Error			1.3930	0.6115

Table C-49: Experimental and calculated saturated molar volume for mixture of Methane and 3-Methylepentane at 75°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.6902	140.9600	1.1334	0.2744
0.0149	0.6952	139.7000	1.2232	0.3941
0.0357	0.7023	137.9100	1.3903	0.5997
0.0559	0.7094	136.1800	1.5698	0.8133
0.0757	0.7165	134.4500	1.7962	1.0698
0.0949	0.7237	132.8000	2.0207	1.3206
0.1142	0.7311	131.1200	2.2909	1.6143
Total Error			1.6320	0.8695

Table C-50: Experimental and calculated saturated molar volume for mixture of Methane and 3-Methylepentane at 100°C

Mole fraction of Methane	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.7398	146.8000	1.6203	0.7032
0.0089	0.7429	146.0500	1.7019	0.5974
0.0297	0.7505	144.3600	1.8695	0.3098
0.0480	0.7573	142.6900	2.1738	0.1886
0.0669	0.7645	141.0500	2.4584	0.0098
0.0860	0.7721	139.4100	2.7677	0.1775
0.1049	0.7797	137.7800	3.1166	0.3513
Total Error			2.2440	0.3339

Table C-51: Experimental and calculated saturated molar volume for mixture of Methanol and CCl_4 at 22°C

Mole fraction of Methanol	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5308	96.6219	0.6490	0.5253
0.0104	0.5314	95.8865	0.6584	0.5474
0.0118	0.5314	95.8396	0.7134	0.4960
0.0215	0.5319	95.2765	0.8473	0.3900
0.0608	0.5338	93.2597	1.6576	0.3121
0.1030	0.5359	90.7961	2.1955	0.7309
0.1683	0.5392	87.1415	3.1536	1.5097
0.1982	0.5407	85.4879	3.5975	1.8728
0.3022	0.5459	79.6055	4.8992	2.8944
1.0000	0.5757	40.5595	7.8833	3.8286
Total Error			2.6255	1.3107

Table C-52: Experimental and calculated saturated molar volume for mixture of Methanol and CCl_4 at 30°C

Mole fraction of Methanol	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5452	97.5409	0.4949	0.5120
0.0104	0.5458	96.8606	0.5647	0.4722
0.0118	0.5458	96.7524	0.5568	0.4843
0.0215	0.5463	96.1856	0.6895	0.3788
0.0608	0.5483	94.1593	1.4985	0.3242
0.1030	0.5504	91.7394	2.0955	0.8058
0.1683	0.5538	88.0042	2.9865	1.5206
0.1982	0.5553	86.2842	3.3652	1.8192
0.3022	0.5607	80.4262	4.7301	2.9112
1.0000	0.5914	40.9221	7.3752	3.5435
Total Error			2.4357	1.2772

Table C-53: Experimental and calculated saturated molar volume for mixture of Methanol and CCl_4 at 40°C

Mole fraction of Methanol	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5632	98.7304	0.3302	0.4943
0.0608	0.5664	95.3241	1.3282	0.3402
0.1030	0.5686	92.8854	1.9212	0.8205
0.1683	0.5721	89.1219	2.8076	1.5348
0.1982	0.5737	87.3890	3.1849	1.8338
0.3022	0.5792	81.4336	4.4846	2.8653
1.0000	0.6109	41.4515	6.9071	3.3135
Total Error			2.9948	1.6004

Table C-54: Experimental and calculated saturated molar volume for mixture of Phenol and Methanol at 20°C

Mole fraction of Phenol	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.4223	88.2365	25.2767	19.9598
0.7539	0.4483	76.1153	23.6566	18.5896
0.5812	0.4697	67.6442	21.7548	16.8899
0.4437	0.4892	60.8271	19.4783	14.7772
0.3684	0.5008	57.2545	18.1183	13.5194
0.2541	0.5202	51.9691	15.7560	11.3203
0.1820	0.5335	48.4917	13.6460	9.2951
0.1529	0.5392	47.1505	12.8036	8.4907
0.0861	0.5528	44.1209	10.7075	6.4779
0.0344	0.5640	41.8574	9.0073	4.8421
0	0.5718	40.4877	8.0532	3.9393
Total Error			16.2053	11.6456

Table C-55: Experimental and calculated saturated molar volume for mixture of Phenol and Methanol at 30°C

Mole fraction of Phenol	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.4367	88.8697	24.7726	19.8347
0.7539	0.4636	76.6929	23.1123	18.4230
0.5812	0.4858	67.6643	20.5745	16.0477
0.4437	0.5059	61.3785	18.9310	14.5984
0.3684	0.5179	57.7239	17.4653	13.2233
0.2541	0.5379	52.2702	14.8376	10.7321
0.1820	0.5517	48.8910	12.8854	8.8617
0.1529	0.5576	47.6044	12.1437	8.1569
0.0861	0.5717	44.5626	10.0329	6.1133
0.0344	0.5833	42.2246	8.1788	4.3020
0	0.5914	40.9325	7.3988	3.5681
Total Error			15.4848	11.2601

Table C-56: Experimental and calculated saturated molar volume for mixture of Toluene and Methanol at 20°C

Mole fraction of Toluene	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.4954	106.3247	1.9103	0.5198
0.7564	0.5126	90.2663	5.4804	2.6418
0.5854	0.5257	78.9774	7.4432	4.3484
0.4472	0.5369	69.7699	8.4980	5.1990
0.3426	0.5455	62.9507	9.1725	5.7221
0.2687	0.5516	58.1137	9.4274	5.8627
0.1879	0.5582	52.8137	9.4380	5.7360
0.1289	0.5628	48.9166	9.1997	5.3837
0.0803	0.5664	45.7502	8.9374	5.0209
0.0364	0.5695	42.8381	8.4472	4.4247
0	0.5718	40.4877	8.0532	3.9393
Total Error			7.8188	4.4362

Table C-57: Experimental and calculated saturated molar volume for mixture of Toluene and Methanol at 30°C

Mole fraction of Toluene	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.5123	107.4656	1.6237	0.5171
0.7564	0.5301	91.2332	5.1062	2.5612
0.5854	0.5437	79.8308	7.0158	4.2142
0.4472	0.5552	70.6144	8.1359	5.1321
0.3426	0.5641	63.6742	8.7140	5.5539
0.2687	0.5704	58.7442	8.8811	5.6023
0.1879	0.5772	53.4060	8.8906	5.4735
0.1289	0.5820	49.4946	8.6806	5.1505
0.0803	0.5857	46.2438	8.3035	4.6686
0.0364	0.5889	43.3645	7.9287	4.1937
0	0.5914	40.9325	7.3988	3.5681
Total Error			7.3344	4.2396

Table C-58: Experimental and calculated saturated molar volume for mixture of Toluene and Methanol at 40°C

Mole fraction of Toluene	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
1.0000	0.5292	108.6568	1.3789	0.5034
0.7564	0.5476	92.2101	4.7392	2.4531
0.5854	0.5616	80.7029	6.6069	4.0615
0.4472	0.5735	71.3411	7.6170	4.8625
0.3426	0.5827	64.3830	8.2307	5.3172
0.2687	0.5892	59.4325	8.4204	5.3863
0.1879	0.5962	54.0185	8.3735	5.1959
0.1289	0.6012	50.0676	8.1474	4.8543
0.0803	0.6050	46.8193	7.8273	4.4304
0.0364	0.6083	43.8816	7.3850	3.8848
0	0.6109	41.4408	6.8830	3.2885
Total Error			6.8736	4.0216

Table C-58: Experimental and calculated saturated molar volume for mixture of Tetradecan and n-Hexane at 25°C

Mole fraction of Tetradecan	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.7946	0.4521	234.0072	7.5301	0.0575
0.6600	0.4685	216.4718	6.4083	0.0596
0.5391	0.4850	200.7612	5.4505	0.1511
0.4430	0.4995	188.3335	4.7358	0.2253
0.3631	0.5126	177.9941	4.1471	0.2580
0.2925	0.5251	168.8828	3.6436	0.2761
0.2192	0.5390	159.4360	3.1288	0.2736
0.1647	0.5500	152.4461	2.7659	0.2712
0.1084	0.5620	145.2494	2.4053	0.2634
0.0545	0.5743	138.4176	2.0990	0.2755
Total Error			4.2314	0.2111

Table C-59: Experimental and calculated saturated molar volume for mixture of terat-$C_5H_{12}OH$ and CCl_4 at 22°C

Mole fraction of terat-$C_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0457	0.5311	97.1158	0.8242	0.4722
0.1050	0.5319	97.8857	1.1582	0.2910
0.1624	0.5326	98.2545	1.1064	0.4972
0.2146	0.5332	99.3804	1.8527	0.1213
0.2906	0.5341	100.4756	2.3945	0.4680
0.4178	0.5356	101.9228	2.9370	0.6750
0.7677	0.5393	94.0906	7.4565	11.0585
1.0000	0.5416	109.2317	6.2585	2.4469
Total Error			2.7329	1.8444

Table C-60: Experimental and calculated saturated molar volume for mixture of terat-$C_5H_{12}OH$ and CCl_4 at 30°C

Mole fraction of terat-$C_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0457	0.5455	98.1267	0.7501	0.3734
0.1050	0.5463	98.9404	1.1082	0.1625
0.1624	0.5470	99.2766	1.0083	0.4114
0.2146	0.5477	100.3078	1.6406	0.0954
0.2906	0.5486	101.3828	2.1388	0.4044
0.4178	0.5501	102.9188	2.7284	0.6714
0.7677	0.5539	94.8675	7.9303	11.2703
1.0000	0.5562	109.7758	5.4893	1.9180
Total Error			2.5902	1.7555

Table C-61: Experimental and calculated saturated molar volume for mixture of terat-$C_5H_{12}OH$ and CCl_4 at 40°C

Mole fraction of terat-$C_5H_{12}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0457	0.5635	99.2895	0.5417	0.3950
0.1050	0.5643	100.3596	1.1299	0.0545
0.1624	0.5651	100.6729	0.9889	0.2292
0.2146	0.5658	101.5471	1.4425	0.1013
0.2906	0.5667	102.6182	1.9069	0.3835
0.4178	0.5683	104.2774	2.5648	0.7333
0.7677	0.5722	96.1019	8.2290	11.2743
1.0000	0.5746	110.4637	4.5340	1.2258
Total Error			2.4101	1.6523

Table C-62: Experimental and calculated saturated molar volume for mixture of sec-$C_4H_{10}OH$ and CCl_4 at 22°C

Mole fraction of sec-$C_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5306	96.5612	0.6084	0.5699
0.0395	0.5313	96.5240	1.1232	0.1871
0.0994	0.5325	96.2401	1.6700	0.1568
0.1588	0.5336	96.0965	2.3523	0.6407
0.2015	0.5345	95.8682	2.7150	0.8590
0.3090	0.5366	95.7000	4.0372	1.8272
0.4064	0.5385	94.9432	4.6259	2.0821
0.7069	0.5446	93.3743	7.2091	3.6556
1.0000	0.5506	91.9640	9.8423	5.3125
Total Error			3.7982	1.6990

Table C-63: Experimental and calculated saturated molar volume for mixture of sec-$C_4H_{10}OH$ and CCl_4 at 30°C

Mole fraction of sec-$C_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5449	97.5409	0.5173	0.4926
0.0395	0.5457	97.5867	1.1065	0.0303
0.0994	0.5469	97.2666	1.6036	0.2704
0.1588	0.5481	97.0212	2.1689	0.6423
0.2015	0.5490	96.8114	2.5414	0.8754
0.3090	0.5511	96.3423	3.5375	1.5223
0.4064	0.5531	95.9181	4.4396	2.1089
0.7069	0.5593	94.2773	6.8878	3.5773
1.0000	0.5655	92.7697	9.3630	5.1009
Total Error			3.5739	1.6245

Table C-64: Experimental and calculated saturated molar volume for mixture of sec-$C_4H_{10}OH$ and CCl_4 at 40°C

Mole fraction of sec-$C_4H_{10}OH$	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0	0.5629	98.7304	0.3534	0.4738
0.0395	0.5637	100.4493	2.5801	1.6464
0.0994	0.5650	98.5145	1.4706	0.3329
0.1588	0.5662	98.1681	1.9196	0.5943
0.2015	0.5671	98.0517	2.3743	0.9162
0.3090	0.5693	97.5793	3.3391	1.5447
0.4064	0.5714	97.0682	4.1299	2.0297
0.7069	0.5778	95.4777	6.5526	3.5087
1.0000	0.5842	93.7080	8.6987	4.7239
Total Error			3.4909	1.7523

Table C-65: Experimental and calculated saturated molar volume for mixture of R11 and R12 at 298K

Mole fraction of R11	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.1002	0.6335	117.4000	2.2211	1.4997
0.2116	0.6602	114.6000	3.0575	2.4913
0.2739	0.6765	113.1000	3.5160	3.0134
0.3680	0.7032	109.7000	3.0898	2.6441
0.3948	0.7113	108.6000	2.8047	2.3670
0.4994	0.7453	105.8000	2.7860	2.3520
0.5999	0.7821	103.8000	2.9074	2.4353
0.7549	0.8486	102.6000	3.0211	2.4809
0.7821	0.8618	102.8000	3.0130	2.4779
0.8715	0.9086	104.3000	1.9811	1.5840
0.9578	0.9600	113.0000	1.4607	1.6163
Total Error			2.7144	2.2693

Table C-66: Experimental and calculated saturated molar volume for mixture of R11 and R12 at 303K

Mole fraction of R11	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.1002	0.7928	134.6000	1.3407	0.5230
0.2116	0.8263	132.5000	1.3080	0.4489
0.2739	0.8467	132.0000	1.3948	0.5227
0.3680	0.8801	131.9000	1.1380	0.2898
0.4994	0.9328	131.9000	2.7430	3.3240
0.5999	0.9788	141.7000	7.7352	7.6147
Total Error			2.6100	2.1205

Table C-67: Experimental and calculated saturated molar volume for mixture of R11 and R12 at 323K

Mole fraction of R11	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.1002	0.6866	122.5000	2.0753	1.4717
0.2116	0.7156	119.6000	2.5953	2.0481
0.2739	0.7332	118.1000	2.8670	2.3300
0.3680	0.7622	115.5000	2.7630	2.2115
0.3948	0.7709	114.5000	2.4422	1.8797
0.4994	0.8078	112.3000	2.2110	1.5983
0.5999	0.8477	112.0000	2.5986	1.9543
0.7549	0.9198	112.8000	0.0818	0.5221
0.7821	0.9340	115.9000	0.7858	0.4779
0.8715	0.9848	127.4000	5.5009	5.0101
Total Error			2.3921	1.9504

Table C-68: Experimental and calculated saturated molar volume for mixture of R11 and R12 at 348K

Mole fraction of R11	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.1002	0.7397	128.2000	1.8651	1.2089
0.2116	0.7709	125.3000	1.9736	1.2999
0.2739	0.7900	124.0000	2.0726	1.3767
0.3948	0.8306	121.6000	1.6713	0.9229
0.4994	0.8703	120.2000	0.6068	0.1474
0.5996	0.9131	122.3000	0.1534	0.4493
0.5999	0.9132	122.2000	0.0596	0.5428
0.7132	0.9685	133.4000	1.3254	1.2658
0.7549	0.9909	138.8000	10.1810	9.7694
0.7821	0.7397	143.0000	1.8651	1.2089
Total Error			2.2121	1.8870

Table C-69: Experimental and calculated saturated molar volume for mixture of R11 and R12 at 373K

Mole fraction of R11	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
0.1002	0.7928	134.6000	1.3407	0.5230
0.2116	0.8263	132.5000	1.3080	0.4489
0.2739	0.8467	132.0000	1.3948	0.5227
0.3680	0.8801	131.9000	1.1380	0.2898
0.4994	0.9328	131.9000	2.7430	3.3240
0.5999	0.9788	141.7000	7.7352	7.6147
Total Error			2.6100	2.1205

Table C-70: Experimental and calculated saturated molar volume for mixture of 21.43%Propane and n-Octane

Temp. in K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
371.1500	0.6977	157.9638	2.8773	1.4324
400.6500	0.7532	167.5697	2.2477	0.7147
426.1500	0.8011	176.8294	2.1523	0.4153
447.1500	0.8406	186.1187	2.1081	0.1717
467.1500	0.8782	195.2781	3.0813	0.9639
483.1500	0.9082	206.2397	3.2351	1.0524
500.1500	0.9402	218.9874	4.9804	2.8210
515.6500	0.9693	237.3236	7.3517	5.3688
531.1500	0.9985	265.2441	26.7992	23.7525
535.1500	1.0060	277.8747	35.5472	33.2521
539.6500	1.0145	297.9018	33.7676	32.8096
547.1500	1.0286	367.4122	38.1202	37.8102
543.1500	1.0210	312.9378	34.9002	34.5661
Total Error			15.1668	13.4716

Table C-71: Experimental and calculated saturated molar volume for mixture of 33.06%Propane and n-Octane

Temp. in K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
365.6500	0.7162	149.0093	1.9989	0.8694
386.1500	0.7563	154.3131	2.4166	1.1946
405.6500	0.7945	160.8564	2.4204	1.0536
422.6500	0.8278	167.0545	2.7422	1.2254
439.1500	0.8601	172.1072	4.3727	2.7042
454.6500	0.8905	181.3639	4.1518	2.4192
469.1500	0.9189	189.6765	5.4421	3.7141
483.1500	0.9463	200.0982	7.3069	5.7153
497.1500	0.9737	213.2194	11.8210	10.5665
512.0500	1.0029	236.4797	44.5021	41.5687
515.8500	1.0104	246.0668	39.7452	38.9688
533.6500	1.0452	337.2026	43.4678	44.5710
520.1500	1.0188	256.4639	38.7388	39.1240
531.1500	1.0403	310.7328	41.0818	42.3829
526.1500	1.0305	277.5753	39.0396	40.2876
Total Error			19.2832	18.4244

Table C-72: Experimental and calculated saturated molar volume for mixture of 57.29%Propane and n-Octane

Temp. in K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
344.9500	0.7437	130.3719	2.0570	1.2716
360.1500	0.7764	134.6386	2.0034	1.1206
373.6500	0.8056	138.9329	1.9464	0.9585
385.1500	0.8303	142.9560	1.7885	0.7097
395.6500	0.8530	146.9270	1.4686	0.3166
407.1500	0.8778	151.4340	0.6827	0.5264
417.3500	0.8998	156.2262	0.1357	1.3552
427.4500	0.9215	160.9809	1.7858	2.9666
437.6500	0.9435	164.5583	5.5381	6.6158
447.6500	0.9651	174.2382	7.6099	8.4580
458.1500	0.9877	182.8425	17.1301	17.7419
469.6500	1.0125	196.9448	43.0938	42.6827
475.1500	1.0244	205.6979	43.6107	41.8984
478.1500	1.0308	211.5749	44.1911	42.0002
498.6500	1.0750	287.0203	53.8044	50.8740
481.6500	1.0384	219.7366	45.0639	42.4700
495.1500	1.0675	268.3016	51.3291	48.3144
488.4500	1.0530	238.1069	47.7331	44.6338
Total Error			20.6096	19.7175

Table C-73: Experimental and calculated saturated molar volume for mixture of 72.75%Propane and n-Octane

Temp. in K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
329.1500	0.7589	123.1404	7.3535	6.8235
343.6500	0.7923	127.5646	7.3948	6.7702
356.6500	0.8223	131.2317	6.7846	6.0664
367.4500	0.8472	134.8309	6.2644	5.4802
377.1500	0.8696	138.3330	5.5643	4.7413
386.1500	0.8903	142.0219	4.7407	3.9120
394.3500	0.9092	145.2497	3.3675	2.5675
402.6500	0.9284	149.6718	2.0128	1.2956
410.6500	0.9468	153.9997	0.2961	0.8726
418.7500	0.9655	158.5852	4.2839	4.6400
427.1500	0.9849	165.1417	11.5786	11.6556
435.3500	1.0038	172.2638	41.7666	42.5633
444.2500	1.0243	183.6490	42.6556	40.7791
449.1500	1.0356	192.4996	44.2951	41.7516
455.4500	1.0501	204.8393	47.2721	44.1011
458.6500	1.0575	218.1224	48.6045	45.5664
471.1500	1.0863	258.7444	56.7893	53.3405
466.3500	1.0752	238.4696	53.4622	49.9849
Total Error			21.91591	20.7173

Table C-74: Experimental and calculated saturated molar volume for mixture of 86.40%Propane and n-Octane

Temp. in K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
342.1500	0.8523	111.7401	0.8523	0.8466
351.6500	0.8759	114.6052	0.8759	0.2478
359.8500	0.8964	118.1393	0.8964	0.7789
367.5500	0.9155	122.1759	0.9155	1.2765
374.5500	0.9330	126.2005	0.9330	2.1554
381.7500	0.9509	130.4993	0.9509	3.9977
387.9500	0.9663	135.7854	0.9663	5.7788
394.6500	0.9830	142.2685	0.9830	10.3132
401.1500	0.9992	149.8191	0.9992	32.5349
408.0500	1.0164	160.1051	1.0164	37.8482
416.1500	1.0366	175.8532	1.0366	40.6226
420.8500	1.0483	191.5544	1.0483	43.4307
Total Error			15.3519	14.9860

Table C-75: Experimental and calculated saturated molar volume for mixture of 95.89%Propane and n-Octane

Temp. in K	Tr	Vexp. In cm^3/mol	%Dev. Using HT Eq.	%Devc. Using modified HT Eq.
334.7500	0.8819	103.4791	1.4432	0.9446
343.1500	0.9041	107.0148	2.1991	1.6287
350.2500	0.9228	111.0627	2.5902	1.9049
356.6500	0.9396	114.8643	3.6635	2.8124
362.9500	0.9562	119.8457	4.8169	3.7360
369.0500	0.9723	125.2787	7.3618	5.9768
374.9500	0.9878	133.0864	11.8072	10.1099
380.5500	1.0026	147.2712	32.1442	31.8081
387.1500	1.0200	213.5432	35.4278	37.6478
388.9500	1.0247	187.9180	35.4610	36.4437
Total Error			13.6915	13.3013

Bradford and Thodos ، 2.2967% ل Hankinson Thomson،واخيرا كان معدل الانحراف ل modified Hankinson Thomson هو 1.7138%.

تطوير اخر أجري لمعادلة Tyn and Calus بتغير الثوابت الى ثوابت اخرى، معدل الانحراف انخفظ للمركبات اللاقطبية. لذلك التأثير وجد لتطوير المعادلة لزيادة الدقة ولتقليل معدل الانحراف من النتائج العملية قدر الامكان بأستخدام الطرق الاحصائية. وكانت صيغة المعادلة الجديدة:

$$V_b = 0.348 V_c^{1.016}$$

حيث كان معدل الانحراف للمركبات الغير قطبية هو3.7716% لTyn and Calus، 4.8210%ل Schroeder ، 9.5667% ل Le Bas واخيرا كان معدل الانحراف modified Tyn and Calus هو 1.1624% لكن نتائج المركبات القطبية لم تكن مرضية، حيث كان معدل الانحراف هو 1.164%ال Tyne and calus ، 6.2015% لSchroeder، 7.2987% ل Le Bas، واخيرا معدل الانحراف لTyn and Calus المطورة هو 1.7436%.

ومن جهة اخرى هناك العديد من المعادلات استخدمت للتنبؤ بالحجم المولي للسوائل المشبعة للخلائط، Hankinson Thomson mixing rule طبقت ل Hankinson Thomson و Hankinson Thomson المطورة. حيث النتائج العملية للحجم المولي للسوائل المشبعة للخلائط تم الحصول عليها من المقالات لغرض التخمين والتي تتكون من (792نقطة)ل 26خليطا. وكانت معدل الانحراف الذي تم الحصول عليه منHankinson Thomson المطورة هو2.8953% بينما كان 5.2811 % ل Hankinson Thomson .

الخلاصة

هناك سبع علاقات رياضية مختلفة تطبق لحساب الحجم المولي للمركبات النقيـــة. هـــي Rackett، Spencer and Danner، Yamada and Gunn، Yen Woods، Bradford and Thodos، Reidel، وHankinson Thomson. التخمين لهذه العلاقات التجريبية أثبت أن افضل علاقة هـــي Hankinson Thomson.

توجد ثلاث طرق اخرى متوفرة في المصادر لحساب الحجم المولي للسوائل النقيـــة عنـــد درجة الغليان. هي Tyn and Calus، Schroeder، وطريقة Le Bas. النتائج اظهرت ان Tyn and Calus تملك اعلى دقة من الطرق الاخرى. أضافة الى سهولتها وبساطة استخدامها.

تطوير معادلة HT بدأ من فكرة ايجاد ثوابت ربما يقود الى نتائج اكثر دقـــة فـــي حـــساب الحجم المولي.

قيمة الثوابت في المعادلة $V^{(0)}$ تم حسابها بأستخدام النتائج العملية لمركب Ar $(\omega = 0)$، ان معامل التصحيح لهذه المعادلة ٠,٩٩٩٩٨. المتغير الثاني لمعادلة HT هو $V_r^{(\delta)}$ وجـــد للمركبـــات التي تملك اعلى معامل acentric مثل الميثان والبنتان والايثانول، كما ان معامل التـــصحيح لهـــذه المعادلة ٠,٩٨٩٦.

تم تلخيص الثوابت الجديدة كالاتي

a	-1.22916	b	0.087280	c	1.283902	d	0.902008
e	-0.707480	f	1.771180	g	-1.70029	h	0.636584

اما بالنسبة للنتائج العملية فقد تم الحصول عليها من المقالات لغرض تخمين البحث واجراء المقارنة بين النتائج العملية والنظرية وهي تتكون من ٢٥٠ نقطة لستة مركبات قطبية و٥٥٥ نقطة لعشرين مركب لاقطبي وكان معدل الانحراف للعشرين مركبا الغيـــر قطبيـــة (555 نقطـــة) هـــو 1.1236% لRackett، 4.1991% لYen Wood، 0.9645% لYamada and Gunn، 1.3593% لSpencer and Danner، 0.9449% لReidel، 1.2860% ل Bradford and Thodos، 0.9141% لHankinson Thomson واخيرا كان معـــدل الانحـــراف ل modified Hankinson Thomson هـــــو 0.7888%. وكـان معـدل الانحـراف للـست مركبـات القطبيـة (250نقطة) هو 2.4863% لRackett، 4.7266% ل Yen Wood، 2.5344% ل Yamada and Gunn، 7.1465% لSpencer and Danner، 2.1153% ل Reidel، 2.2019% ل

الشكر والتقدير

اتقدم بخالص الشكر والتقدير للاستاذ المشرف الدكتور محمود عمر عبد الله المحترم الذي ساعدني منذ البداية في نصائحه وارشاداته القيمة النابعة من خبرته الطويلة في هذا المجال.

ولا يسعني الا ان اقدم امتناني العميق وشكري الجزيل الى الاستاذ الدكتور قاسم جبار سليمان رئيس قسم الهندسة الكيمياوية في جامعة النهرين لمساعدته وارشاداته القيمة.

كما اود ان اشكر عميد كلية الهندسة لمساعدته على منحي الفترة اللازمة لاكمال متطلبات البحث.

كما واقدم شكري وعظيم امتناني لامي وابي وزوجي العزيزالدكتور أسامة الراوي على مساعدتهم لي وتشجيعهم الدائم على اتمام البحث.

واخيرا اود ان اشكر جميع اساتذتي وزملائي الذين اعانوني في انجاز هذا المشروع.

آلاء الربيعي

التنبؤ بأيجاد علاقات الحجم المولي للسائل المشبع في أي درجة حرارة (بظمنها درجة الغليان) للمركبات النقية والخلائط

رسالة

مقدمة الى كلية الهندسة في جامعة النهرين وهي جزء من متطلبات نيل درجة ماجستير علوم في الهندسة الكيمياوية

من قبل

آلاء حسين علي الربيعي

بكالوريوس علوم في الهندسة الكيمياوية ٢٠٠٦

جمادى الاخر ١٤٣٠

حزيران ٢٠٠٩