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EXCESS VOLUMES OF MIXING:
THE BENZENE +
TRICHLOROETHYLENE SYSTEM

—
DAVID STEVEN PICKERELL



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EXCESS VOLUMES OF MIXING:
The Benzene + Trichloroethylene System

by

Captain David Steven Pickerell
B.S., United States Military Academy, 1978

A Thesis
Submitted to the Faculty of the
Graduate School of the University of Louisville
in Partial Fulfillment of the Requirements
for the Degree of

Master of Science

Department of Chemical Engineering
University of Louisville
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checked for consistency, by the data point, by the data set, and by the system at a given temperature, with favorable results. The relationship between temperatures and excess volumes was noted to invert near both ends of the excess volume curve.

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The Benzene - Trichloroethylene System

By

Captain David Steven Pickerell
B.S., United States Military Academy, 1978

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ABSTRACT

The excess volume function for the benzene + trichloroethylene (TCE) system was studied at temperatures of 10, 25, 30, and 40 °C in this investigation. Prior to describing this system, benzene + cyclohexane at 25 °C, the test system, was analyzed to determine the ability of the investigator to obtain accurate results with the apparatus and procedures described in this work. The results of the test system were in excellent agreement with those of other experimenters and with the parameters described by Handa and Benson in their summary of this system.

The excess volume function of each system studied was described by a smoothing equation that was derived from an average of 72 data points per system. All of these systems were found to have excess volume curves that were uniformly positive in shape. The benzene + TCE system at all temperatures had maximum values at about 58 percent benzene. This maximum value for the excess volume was related to temperature by the equation $V_{eT} = -.00140 * T + .653697$, where T is in K and V_{eT} is in cc/mol. The data were also checked for consistency, by the data point, by the data set, and by the system at a given temperature, with favorable results. The relationship between temperatures and excess volumes was noted to invert near both ends of the excess volume curve.

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CHAPTER I

INTRODUCTION

When mixing two miscible liquids of known volume, the volume of the resultant mixture frequently differs from the sum of the two known component volumes. This difference is known as the excess volume of mixing.

This volume change on mixing can be caused by a variety of geometric, energetic, and chemical means. Because of the complex nature of the factors giving rise to excess volumes of mixing, accurate excess volume data can be used to test theories of liquid mixtures. Excess volume data can also be used to convert other excess functions evaluated at constant pressure to their equivalent expressions in terms of mixing at constant volume; most notably, the excess Gibbs free energy can be related to the excess volume of mixing through the equation: (Prausnitz, p. 196)

$$V^E = G^E / P_{T,x} \quad (1)$$

Where: V^E is the excess volume

G^E is the excess Gibbs free energy

P is pressure

Note: The right hand quantity is measured at constant temperature (T) and composition (x).

Additionally, excess volume data can be used industrially to accurately determine the quantities of liquids necessary to be mixed in order to yield a mixture of precise

composition and volume. It can also be used to determine composition from the density measurements of a mixture.

(Handa, p. 186)

CHAPTER II

BACKGROUND

For the purposes of this discussion, a binary mixture will be defined as a physical, non-reactive combination of two components in a single fluid phase. There exist thermodynamic properties of each particular mixture that distinguish it from any other mixture of the same two components. These properties can be divided into two broad categories: intensive and extensive. An extensive property is one that depends on the amount of material present. These properties include total mass (M), total volume (V), enthalpy (H), entropy (S), and Gibbs free energy (G). An intensive property, on the other hand, is independent of the amount of mixture present. Temperature (T), total pressure (P), specific volume (v), and density (ρ) are examples of intensive properties. Due to their intensive nature and ease of measurement, most of the other properties are described as functions of temperature and pressure.

Additionally, although much information is generally known about single component system properties, relatively little is available on the properties of mixtures. Therefore, it is helpful to discuss the properties of mixtures in terms of the pure component properties. One way of doing this is to define a reference, or standard, state as the pure component at the temperature and pressure of the

system. This standard state is referred to as "Raoult's Law" standard state (Prausnitz, pp. 21-22) and will be used throughout this work.

For an ideal solution to exist, the total volume of the solution must be equal to the sum of the total component volumes. In terms of molar volumes:

$$v^{ID} = \sum x_1 v_1^0 \quad (2)$$

where: v^{ID} is the total molar volume of an ideal solution

v_1^0 is the molar volume of component 1 in solution

x_1 is the mole fraction of component 1 in solution

Ideal behavior is seldom observed in real solutions. Therefore, a correction factor needs to be included. (Smith, p. 245)

$$v = \sum x_1 v_1^0 + \Delta v \quad (3)$$

where: v is the total molar volume of a real solution

Δv is the molar volume change on mixing

A measure of the deviation of a solution from ideal behavior is the excess volume, which is defined as: (Smith, p. 266)

$$v^E = v - v^{ID} \quad (4)$$

where: v^E is the total molar excess volume of a solution

It is convenient at this time to introduce the concept of partial molar volumes. (Prausnitz, p. 196)

$$\bar{v}_1 = \left(\partial n v / \partial n_1 \right)_{T, P, n_j} \quad (5)$$

where: $\bar{v}_1$ is the partial molar volume of component 1

Note: This volume is calculated at conditions of constant temperature, pressure, and total moles of all components except that of component 1.

This concept is particularly useful in that for all solutions at constant temperature and pressure:

$$V = \sum x_1 \bar{V}_1 \quad (6)$$

Now, referring to equations 3 and 4,

$$V^E = (\sum x_1 V_1^0 + \Delta V) - \sum x_1 V_1^0 \quad (7)$$

Further simplification yields

$$V^E = \Delta V \quad (8)$$

Equation 8 results since, by definition, $\Delta V^{ID} = 0$, (Prausnitz, p. 195) and thus, the excess volume is not a "new" property. Other excess properties, for example, the excess Gibbs free energy, are different from the change in the property on mixing.

By definition of Raoult's standard state,

$$\bar{V}_1^{ID} = V_1^0 \quad (9)$$

Since equation 6 applies to all mixtures and with equations 2 and 9,

$$V^{ID} = \sum x_1 \bar{V}_1 = \sum x_1 V_1^0 \quad (10)$$

is another way of defining an ideal solution.

Since $V^E = \Delta V$, if the molar volume change on mixing can be determined experimentally, so can the excess molar volume of mixing. Thus, a measure of the deviation of a solution from ideal behavior can be determined.

Experimental data for molar excess volumes of binary

solutions are usually fit to a smoothing function of form:

(Handa, p. 200)

$$v^E = x_1 (1 - x_1) \sum_{j=0}^{n-1} a_j (1 - 2x_1)^j \quad (11)$$

where: a_j are the fitting constants determined by a least-squares analysis

n is the number of coefficients

The units of v^E are generally cc/mol.

The number of coefficients to be used in smoothing the data is determined by carrying out the least-squares analysis for increasingly larger values of n . Usually, n varies from 2 to 5. For each fit, a standard deviation is calculated.

$$\sigma = \left[\sum_{i=1}^m (v_i^E \text{ observed} - v_i^E \text{ smoothed})^2 / (m - n) \right]^{1/2} \quad (12)$$

where: m is the number of experimental data points

The minimum number of coefficients is selected for the smoothing equation that will yield the lowest population standard deviation.

This curve fitting technique is extremely flexible and capable of describing most of the possible excess molar volume curve types. As noted in Figures 1, 2, and 3, excess volume data can be uniformly positive, uniformly negative, or can have both a minimum and a maximum while changing sign somewhere in the middle of the mole fraction range.

Although quite a large number of binary systems have been studied, relatively few of them have been investigated over a wide range of temperatures. The bulk of the excess volume research has been conducted near 25 or 30 °C. For

FIGURE 1
BENZENE + CYCLOHEXANE 25 C

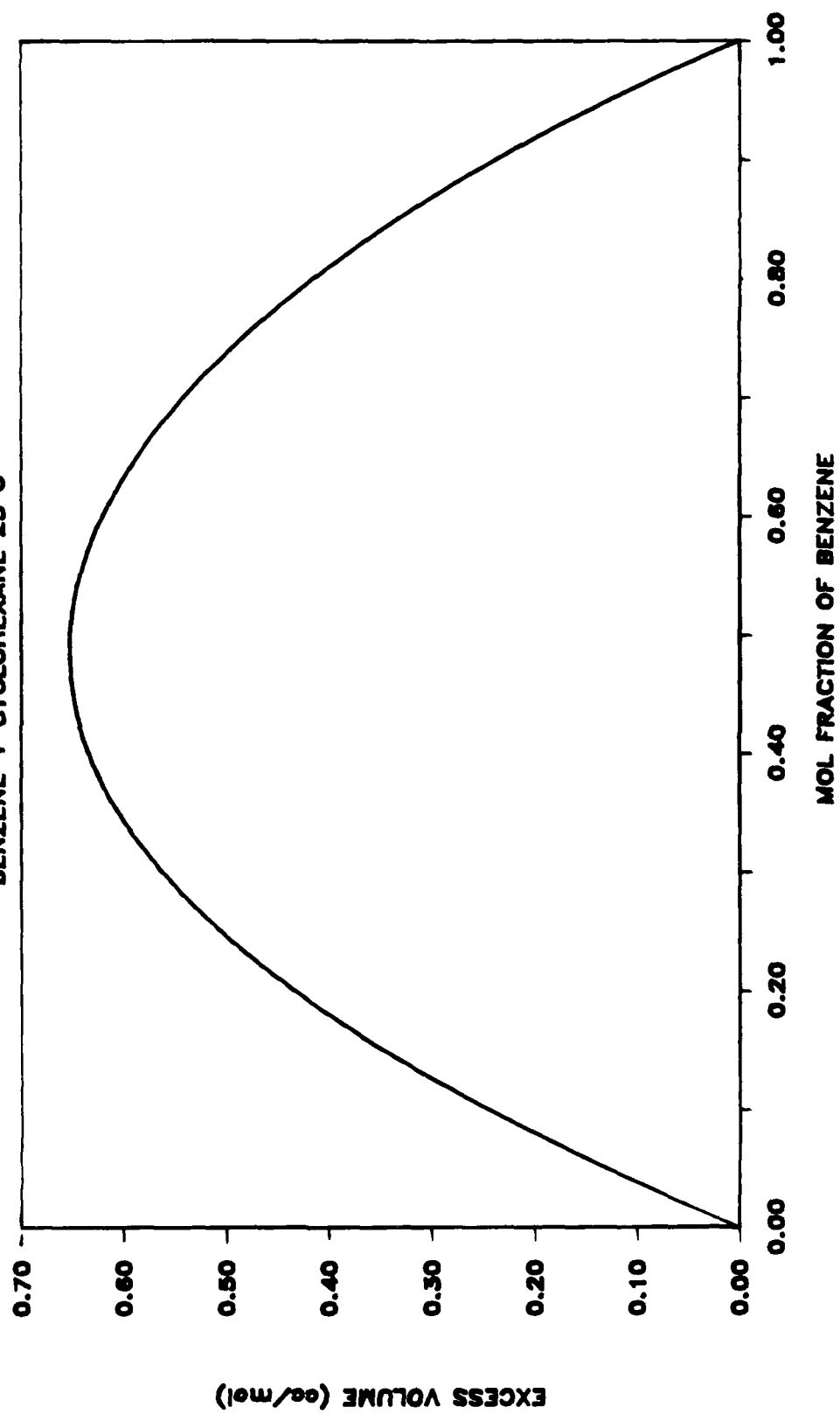


FIGURE 2
BENZENE + PROPYLENE CARBONATE 30 C

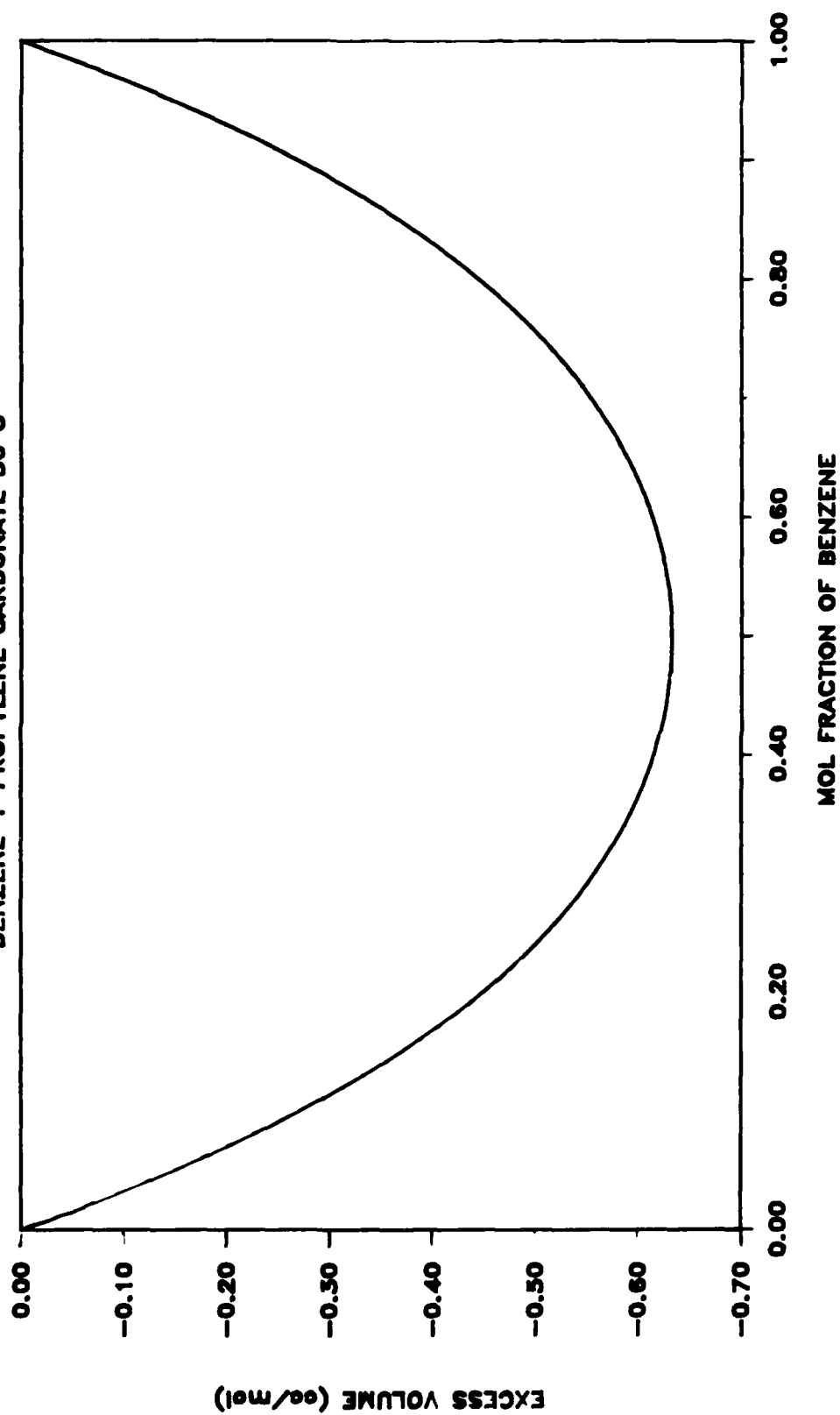
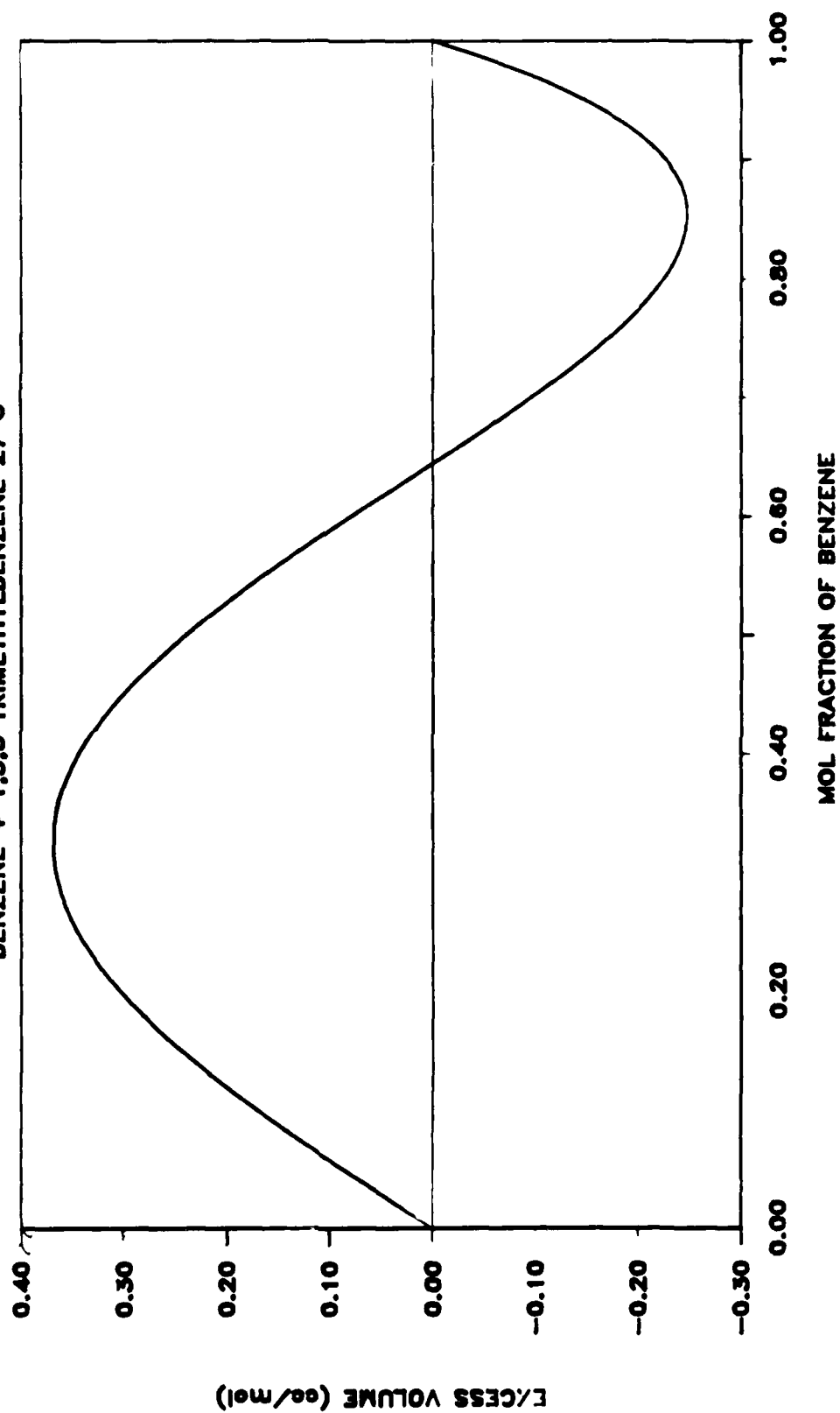


FIGURE 3
BENZENE + 1,3,5 TRIMETHYLBENZENE 27 C



those systems that were studied at several temperatures, there appears to be no discernable trend of the data with increasing temperature.

The purpose of this thesis was twofold. First, to investigate the benzene + cyclohexane system at 25 °C for the purpose of establishing a comparable level of accuracy for the procedures and equipment used in this investigation. And second, to investigate the benzene + trichloroethylene system at a variety of temperatures to determine the significance of temperature change on this previously unstudied system.

As an aside, this investigation also focused on improving the apparatus and procedures previously set out in an effort to improve the accuracy of the experimental data. Where appropriate, the significant improvements and lessons learned will be noted.

CHAPTER III

INSTRUMENTATION AND EQUIPMENT

The dilatometer used in this investigation, shown in Figure 4, was essentially that designed by Kumaran and McGlashan (Kumaran, pp. 260-262), with a few modifications. The capillary tubes, noted as C, C1, and C2, were precision bore capillaries with a .05 millimeter inside diameter. Capillary C had a reference mark CR near the bottom. The buret, labeled B, was one centimeter precision bore tubing. The bulb at the bottom of the buret, BB, was a blown glass bulb with a volume of about 10 cc below the reference mark BR. Mixing bulb A and tubes S1 and S2 were not calibrated. The taps, T1 and T2, were Teflon and had Buna-N O-rings midway up the shaft. Tap T2 also had a level bubble attached to its screw cap. The small addition on top of capillary C was half of a ground glass joint that was attached to capillary C by a small piece of Tygon tubing. The back-pressure device discussed later was attached to the dilatometer at this joint. The dilatometer was assembled by Custom Glassblowing of Louisville.

A plexiglass frame shown in figure 5 was built to support the dilatometer. Two of the three support blocks on the frame were adjustable from the top so the dilatometer could be leveled while it hung in the temperature bath. A thermometer was also affixed to the stand for monitoring the

FIGURE 4

DILATOMETER USED IN THIS WORK

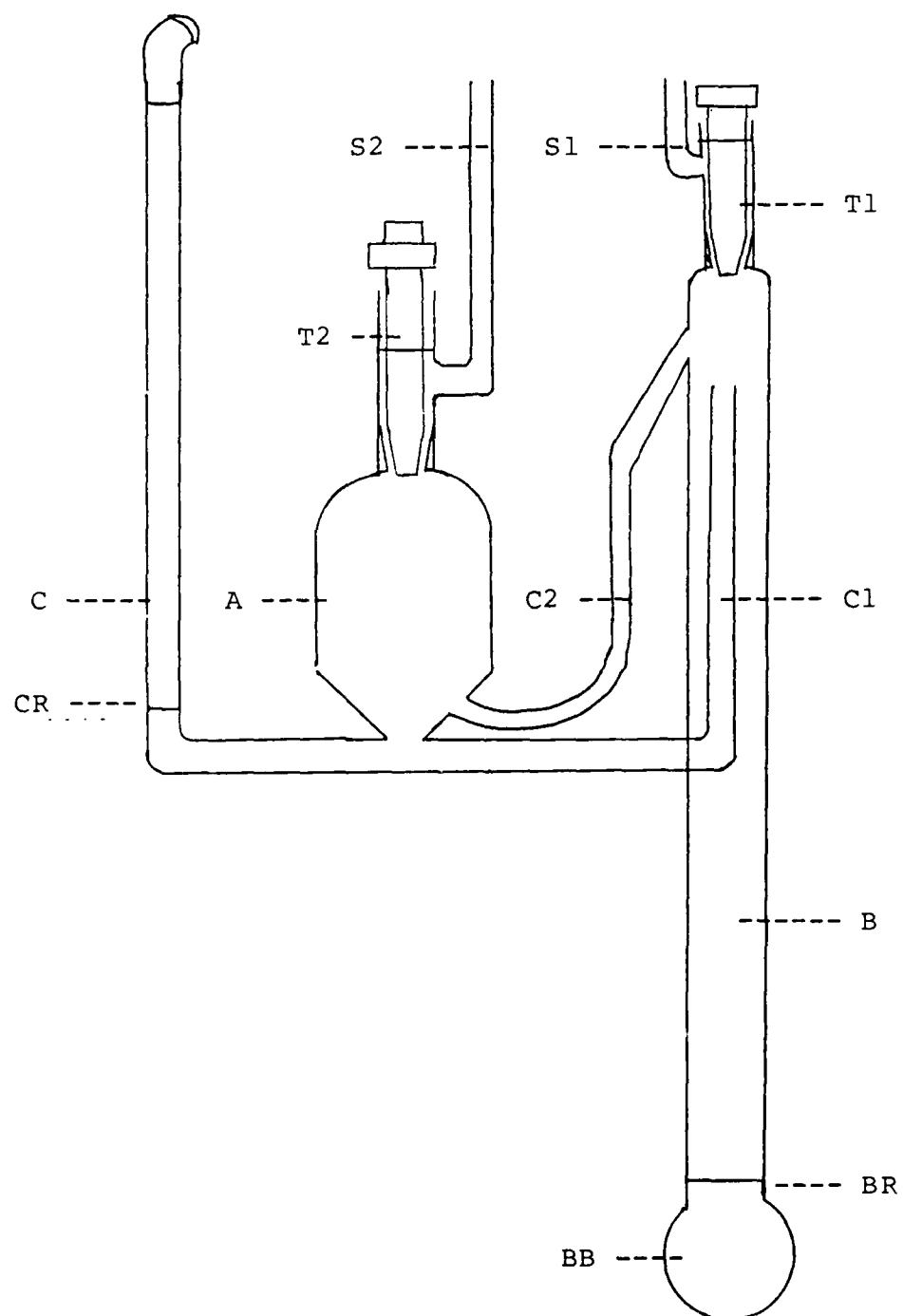
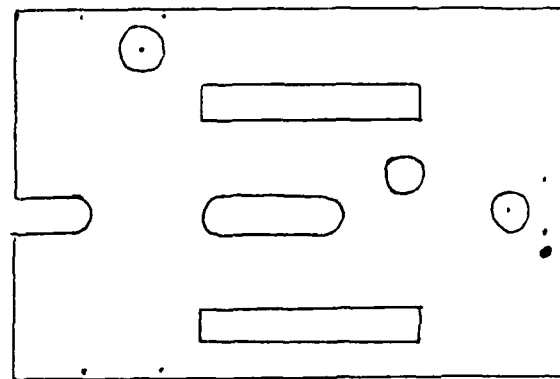


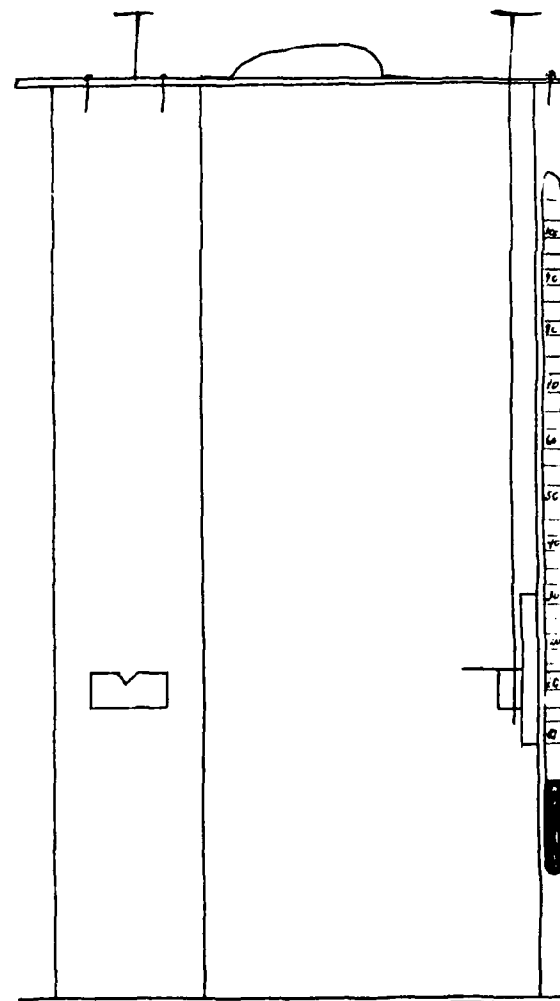
FIGURE 5
DILATOMETER SUPPORT STAND



TOP VIEW



LEFT SIDE VIEW



FRONT VIEW

temperature of the water in the bath. The dilatometer was mounted to a rectangular piece of plexiglass with copper wire so that the dilatometer could be easily separated from the plexiglass for cleaning and glassblowing, as necessary. The rectangular plate had a small cross member attached to the bottom so the dilatometer would fit neatly into the support stand.

The back-pressure device shown in Figure 6 was constructed to apply a measurable pressure on the column of mercury in capillary C in order to calculate pressure corrected excess volume data. This device consisted of a U shaped tube that was partially filled with mercury. One end of the tube was vented to the room, while the other was connected to a "T" joint. Also attached to this joint were a three lead stopcock and a piece of Tygon tubing with half of a ground glass joint on the end. The second lead of the stopcock was vented to the air, while the remaining lead was attached to an aspirator bulb. The ground glass joint on the Tygon tubing was used to connect the back-pressure device to capillary C on the dilatometer.

The temperature bath used in this investigation was a Tamson model TCV-70 temperature bath with glass panes on two sides and is shown in Figure 7. Distilled water was used as the heat transfer medium in the bath. There were two heating units inside the bath. The main heating unit was a quartz heater with adjustable heating capacity. The secondary heating element was a more standard metal

FIGURE 6

BACK-PRESSURE DEVICE

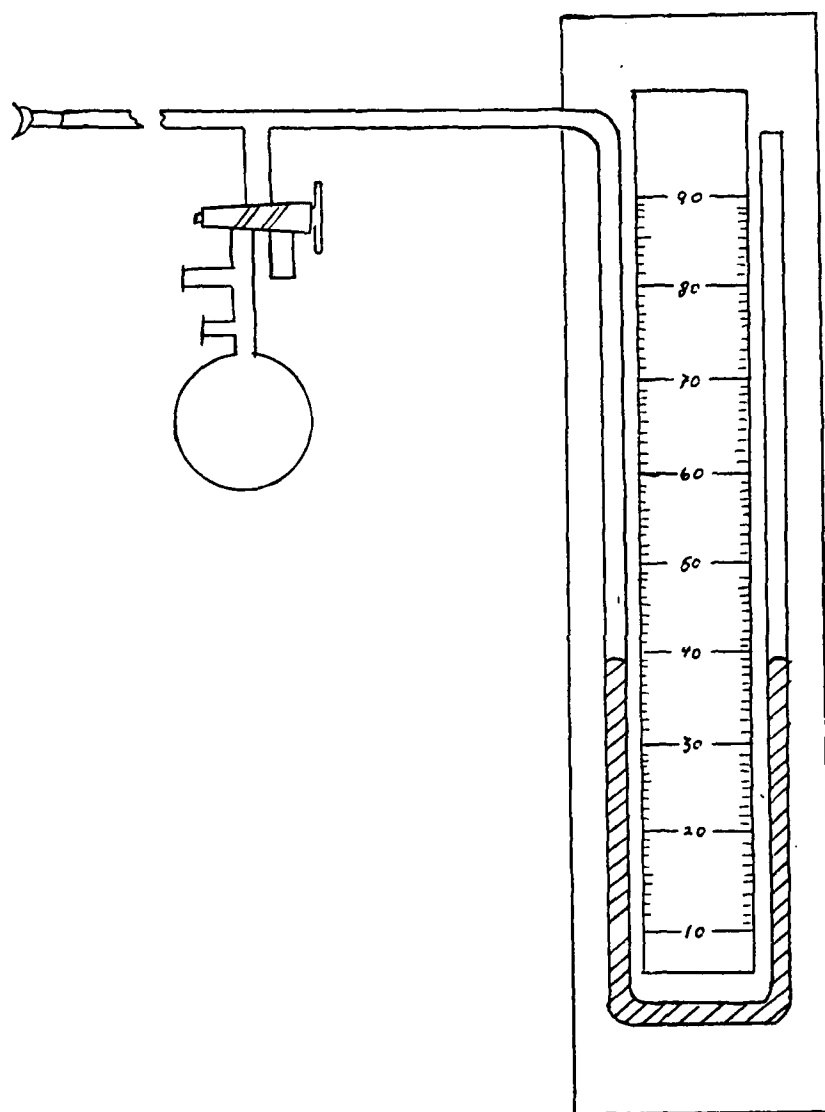
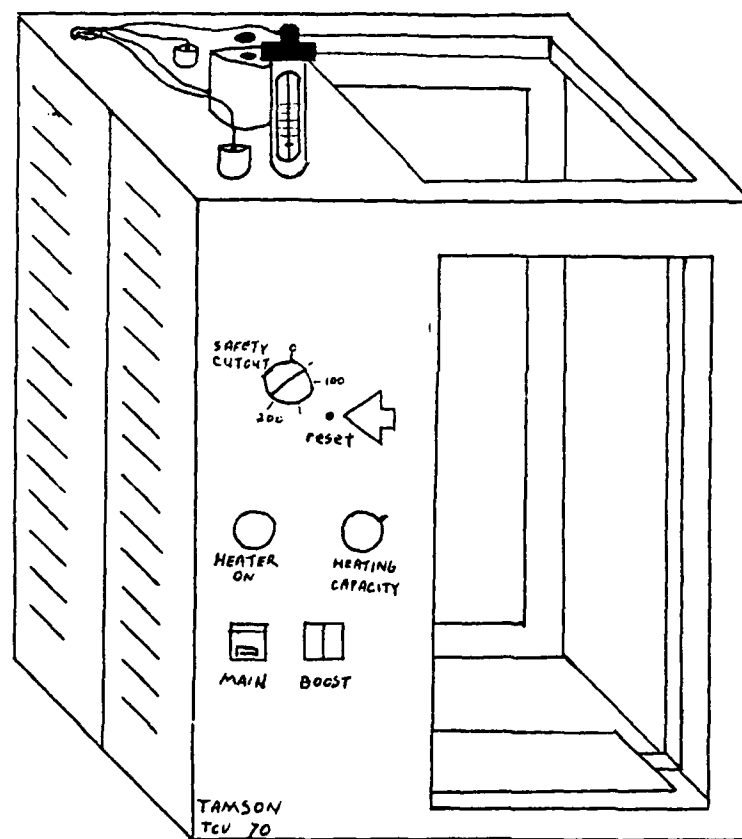


FIGURE 7
TAMSON TCV-70 TEMPERATURE BATH



resistance-type element that was used only as a boost heater to help bring the bath initially to a temperature near the set point. There was also a propeller and baffle assembly to circulate the water and keep the temperature uniform throughout the bath. The temperature was controlled by means of a thermoregulator which protruded through the top of the bath. By carefully setting the controls on the bath, one could control the temperature to $\pm .001^{\circ}\text{C}$ of the set point value.

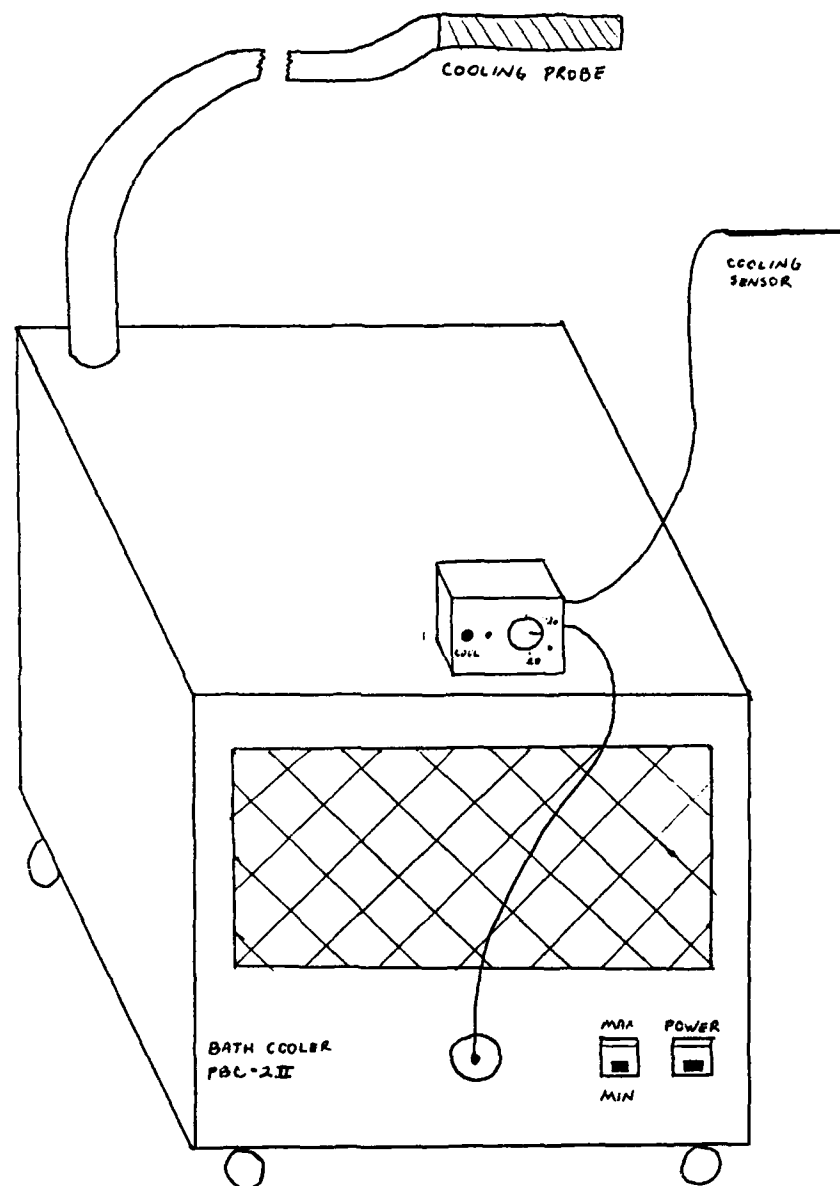
When cooling was required, the Neslab PBC-2 II portable bath cooler in Figure 8 was used in conjunction with a Cryotrol temperature controller. The cooling probe was inserted through an opening in the top of the temperature bath and the temperature sensor was inserted through a small hole in the top of the dilatometer support stand.

All weights were measured with an Ainsworth model Delta N-V (Type 24N) scale. This scale had a digital readout to $\pm .00001$ grams, with the last two digits being read on a vernier scale.

Height measurements were made with the use of cathetometers. A Gaertner Scientific Corporation precision cathetometer was used to measure all heights except those on the buret. This cathetometer could be read to $\pm .0001$ cm, with the last digit being read on a vernier scale. The height measurements on the buret were made with an Eberbach cathetometer that could only be read to $\pm .01$ cm, with the last digit being read on a vernier scale.

FIGURE 8

NESLAB PBC 2-II BATH COOLER WITH CRYOTROL CONTROLLER



CHAPTER IV

PROCEDURES

A detailed, step by step, account of the procedures followed during this thesis work is located in Appendix A. The buret was recalibrated before the excess volume experimentation began, although this is unnecessary unless a previous calibration is suspect or the volume of the bulb has changed due to glassblowing.

First, the system to be studied was specified. This included selection of the operating temperature as well as the two components of the binary system.

Next, one of the components was designated (arbitrarily) as the solvent and the other as the solute. Upon completion of a run, these roles were reversed, and the next run begun.

The condition of constant operating temperature was then achieved in the temperature bath. This was accomplished by adjusting the screw cap on the thermoregulator and the heating capacity control on the temperature bath. If cooling was necessary, the bath cooler controls were also adjusted.

The dilatometer was next cleaned and loaded. All initial readings were recorded at this time. Care was taken to ensure that thermal equilibrium was reached before any readings were made. Generally, about 20 minutes were

required to reach thermal equilibrium.

Next, with the buret on the right, the dilatometer was tilted clockwise such that a small amount of mercury spilled into the buret. The dilatometer was then placed back in the temperature bath and thermal equilibrium was again reached. All mercury levels were then recorded with respect to the appropriate reference mark.

A pressure correction was then conducted by placing a known back-pressure on the system and measuring its effect. This correction is an essential factor in the excess volume data for two reasons. First, there may be some small amount of gas bubbles entrained in the system which, if not corrected for, could expand and influence the data. Also, with taps T1 and T2 sealed, pressure differentials can be set up within the dilatometer by virtue of the differing mercury column heights.

The tilting of the dilatometer and measurement of the mercury levels was repeated successively until the capacity of the dilatometer was reached. Then the roles of the solvent and the solute were reversed, and the experiment was repeated.

Finally, the data were evaluated for internal consistency as well as consistency between data sets. If these evaluations proved unsatisfactory, additional data were taken as required to achieve the desired level of agreement.

The benzene used in this investigation was a glass-distilled, 99.9 + % pure Aldrich product. The densities

used for the benzene were: .8895 cc/mol at 10 °C, .8790 cc/mol at 25 °C, .8684 cc/mol at 30 °C, and .8577 cc/mol at 40 °C. (API 44 Tables).

The trichloroethylene used here was a 99 + %, ACS reagent grade product of Aldrich. The densities used here were: 1.4825 cc/mol at 10 °C, 1.4554 cc/mol at 25 °C, 1.4475 cc/mol at 30 °C, and 1.4300 cc/mol at 40 °C. (Gallant, p. 42).

The cyclohexane used in this work was a 99.9 + % pure product of Burdick and Jackson. At 25 °C, the density of cyclohexane is .7739 cc/mol.

CHAPTER V

RESULTS

A. Data Analysis.

A total of 19 runs were made for this thesis, three for the test system, benzene + cyclohexane, and 16 for the benzene + trichloroethylene system. The experimental data for each run were initially written in a data log. The purpose of run one was primarily to get familiar with the operating requirements of the system. The data for this run were discarded for numerous procedural errors that obviously effected the results. The data for runs number 9, 10, and 13 were also discarded because various parts of the dilatometer broke during each run. In run 9, tap T1 was broken into two parts under the O-ring. In run 10, the magnetic stirrer initially located inside the mixing bowl developed a crack and had to be removed. In run 13, capillary C broke where it joined the horizontal tube. Additionally, runs 9 and 12 were discarded because of degassing problems which left large gas bubbles inside the buret after the run had started. No further data analysis was performed on these five runs.

The data for the remaining 14 runs were transcribed to a computer spread sheet for further analysis. These data are located in Appendix B. With the aid of the spread sheet, the mole fraction and excess volume data could be

calculated immediately after each data point was recorded, as shown in Appendix C-1. These data are reported here without regard for significant figures, which will be addressed separately. Generally, two sets of data were required to sufficiently specify the excess volume curve for a given temperature and set of components. However, late in runs 15 and 18, a small amount of solute escaped from the mixing bowl during a tilt. This caused a separation in the mercury column in capillary C and would also have resulted in a miscalculation of the amount of solute added to the mixing bowl if the runs were continued beyond that point. This error apparently resulted from rotating the dilatometer too far during the tilt. Because of this problem, three sets of data were required to specify the curves of the benzene + trichloroethylene system at 10 and 40 °C. Run 7 was also terminated prematurely due to degassing problems, but there were several good data points available, so runs 7 and 8 were combined for further analysis.

The remaining data sets were grouped by temperature and component systems. Set one was benzene + cyclohexane at 25 °C, runs 2 and 3. Set two was benzene + trichloroethylene at 25 °C, initially runs 4 and 5, although set two was eventually comprised of runs 5 and 6. Set three was benzene + trichloroethylene at 30 °C, runs 7, 8, and 11. Set four was benzene + trichloroethylene at 40 °C, runs 14, 15, and 16. Finally, set five was benzene + trichloroethylene at 10 °C, runs 17, 18, and 19. The mole fraction and excess volume

data from these sets were converted into data files using the program "Makefile". These files were then accessed by the program "Curvfit" which yielded the curve fitting constants as described in the Background section of this work. A listing of these programs is found in Appendix D. The program "Curvfit" was run for curve fitting constants ranging from 2 to 5. The set of constants yielding the lowest population standard deviation was then used to describe the smoothing function. These data are presented in Appendix C-2.

Additionally, several data consistency checks were made. First, an internal consistency check was made using the population standard deviation. A population standard deviation above that reported by other investigators measuring excess volume data, greater than .01, would warrant a set of runs being discarded. Next, consistency between data runs in a set was investigated. If the data points in the overlap region between the two runs were offset, the more suspect run would be done over, and a new pairing made. Finally, consistency between successive data points was checked. This was accomplished by eliminating the data point that differed the most from the smoothing function and re-running the "Curvfit" program. Then, the next worse data point would be removed, and so on until ten percent of the data points had been removed, one at a time. If a clustering of bad data points was observed, the run in which this clustering occurred would be thrown out. This was the

case with run 4, where the entire set of eliminated data points fell in succession. Run 4 was discarded, and run 6 was conducted to take its place.

Finally, as the data points were eliminated during the consistency checks, any change in the population standard deviation was noted. If the elimination of one or more data points caused a reduction in the standard deviation of .002 cc/mole or more, the points were permanently removed from the data set as erroneous data. This was only done in the benzene + cyclohexane system at 25 °C where 106 data points were initially taken, but 10 were thrown out due to error. Regardless of analytical technique, if a data point was obviously in error, it was eliminated as long as ten percent or less of the data in a complete set was discarded.

In fitting the data to a smoothing equation, it was noted that the coefficient matrix had a propensity toward being ill conditioned. With this in mind, the data were actually fit as $V_e/(x_1x_2)$ as opposed to V_e in an effort to eliminate some of the ill conditioning. The L_1 condition number (a measure of the tendency to lose significant figures in certain matrix operations) was also estimated and reported. It should be noted that if the condition number is written as $C * (10)^n$ it should be expected that the last n significant digits of the final answer may be in error (Maron, pp. 159-160). Where possible, 6 digits were carried forward in an effort to preserve the accuracy of the final data presented by the output from the "curvfit" program.

The worst condition number reported in this work was 593 for the benzene + trichloroethylene system at 40 °C. This would indicate that 2 significant digits might be eliminated. However, it should be recalled here that the cathetometer used to read the height measurements on the buret was only accurate to within .01 cm. For the data reported here, this level of accuracy translates to only three significant digits for mole fractions of benzene less than .20 or greater than .80, and four significant digits for the rest of the data range. This indicates that the ill conditioning of the coefficient matrix did not affect the results of this investigation, but might well affect the results of further investigations if the accuracy of this cathetometer is improved.

It should be noted here that when all five systems studied in this work are compared, the population standard deviation generally decreases when the number of data points taken increases. Also, for the same number of curve fitting constants, the L_1 condition number is smaller for a larger number of data points.

Minor temperature fluctuations appeared to have little effect on the results. Although the thermometers used to monitor each system varied from a National Bureau of Standards calibrated thermometer graduated in .05 °C increments for the 25 °C runs, to an uncalibrated thermometer graduated in .1 °C increments for the 10 and 40 °C runs, the standard deviations show no trend with degree of accuracy of

the thermometer. This is attributed to the fact that the bath was able to control the temperature consistently better than any of the thermometers could measure it. The actual temperature at which the run was conducted may be questionable, but the consistency of the data due to temperature fluctuation was excellent. Runs 1 through 6 were conducted at better than $25^{\circ}\text{C} \pm .01^{\circ}\text{C}$, (thickness of the marks on the thermometer was the determining factor here). Runs 7 through 11 were conducted at $30^{\circ}\text{C} \pm .05^{\circ}\text{C}$, due to lack of thermometer calibration. Runs 12 through 16 were conducted at $40^{\circ}\text{C} \pm .1^{\circ}\text{C}$ and runs 17 through 19 were conducted at $10^{\circ}\text{C} \pm .1^{\circ}\text{C}$, again due in part to the lack of NBS calibration and also to the level of graduation being $.1^{\circ}\text{C}$.

B. The benzene + cyclohexane system.

The benzene + cyclohexane system at 25°C has been proposed as the test system for excess volume data. Such a great volume of data has been reported on this system that it is possible to measure the accuracy of the equipment and experimental technique used in an investigation. Once an accuracy level has been established for this system, an investigator may ascribe the same level of accuracy to all new data he generates with the same apparatus and technique.

Handa and Benson went to great lengths to document the test system parameters in their work. (Handa, pp. 200-205) Table 1 contains a comparison between the data generated in this investigation, the summary of Handa and Benson, and a summary of 14 other works. There were 106 data points taken

in this work in an effort to accurately describe this system. The average number of data points used in the 14 other works was about 34. Handa and Benson used a composite of three works judged by them to be the best and most representative data available. There were 164 data points total among these three data sets. Comparison 1 in Table 1 was based on a least-squares curve fit with all 164 data points weighted equally. Comparison 2 in Table 1 was based on a least-squares curve fit with each of the 164 data points being assigned a weight equal to the inverse of the squared standard deviation of that point from the smoothed curve in the work from which it was taken.

TABLE 1
DATA COMPARISON FOR THE BENZENE + CYCLOHEXANE SYSTEM

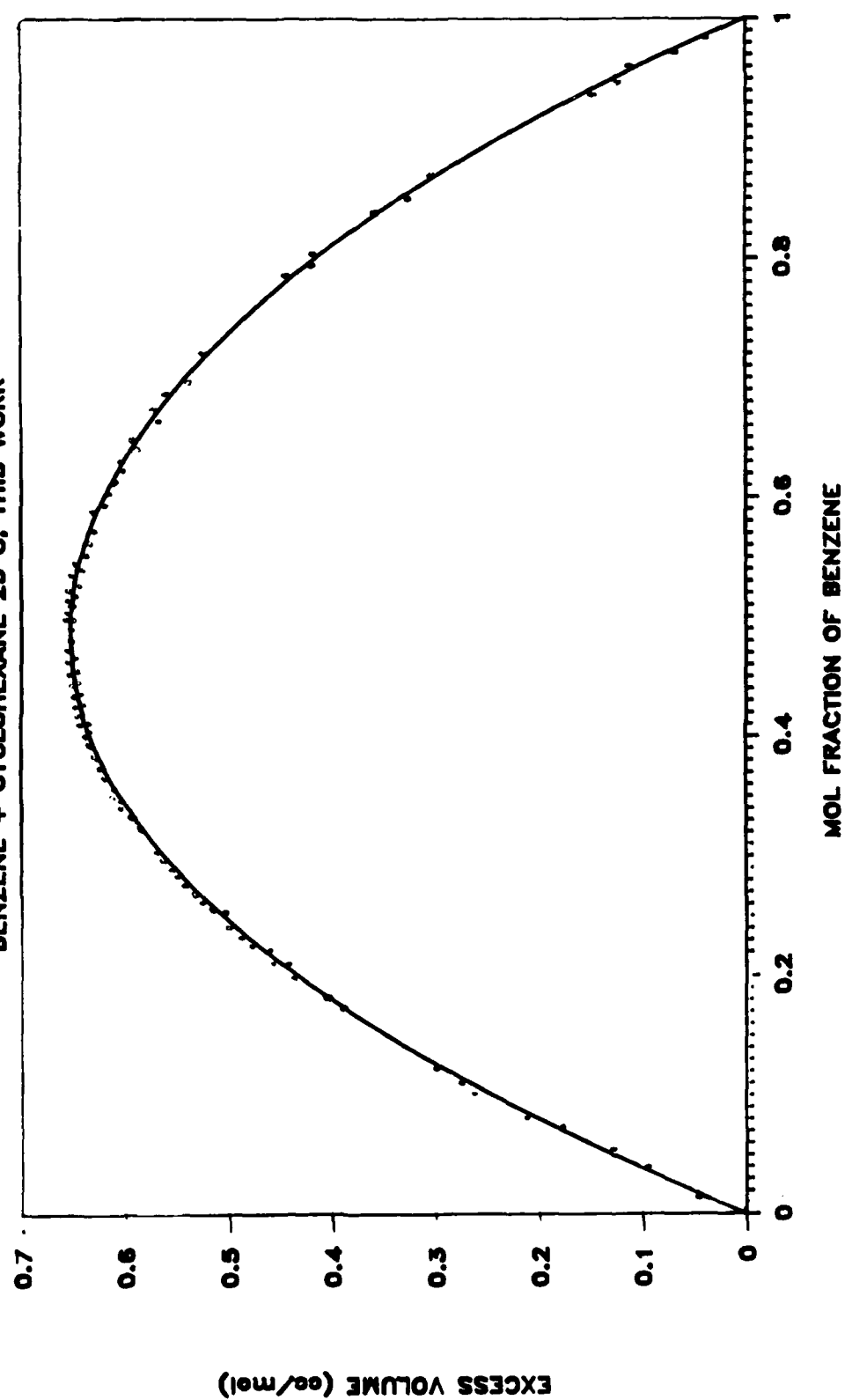
	Std dev. (cc/mol)	Location of max.	v^E at max. (cc/mol)	v^E at .5 (cc/mol)
This work	.00275	.485	.6529	.6523
Handa & Benson Comparison 1	.00157	.491	.6511	.6509
Handa & Benson Comparison 2	.00161	.491	.6520	.6518
Range of Other Works	.00003 - .0050	.485 - .494	.6315 - .6555	.6312 - .6552

Figure 9 shows the smoothed excess volume curve calculated in this work. The equation for this curve is:

$$v^E = x_1 (1 - x_1) [2.6092 + .15423(1 - 2x_1) + .12096(1 - 2x_1)^2 - .14836(1 - 2x_1)^3]$$

The experimental data upon which this curve was based are

FIGURE 9
BENZENE + CYCLOHEXANE 25 C. THIS WORK



superimposed on the figure in an effort to show how well the smoothed curve actually describes the data. There is no point in presenting a figure comparing this work to the data presented by Handa and Benson because the curves are indistinguishable on any reasonable scale.

C. The benzene + trichloroethylene system.

It should be noted first, that although the accuracy of these data cannot be shown directly by comparison with known values, it can be inferred from the accuracy of the benzene + cyclohexane system discussed above.

Figures 10 through 13 are the smoothed curves describing the benzene + trichloroethylene system at 10, 25, 30, and 40 °C, respectively, as calculated in this work from the equation:

$$V^E = x_1 (1 - x_1) [a_0 + a_1 (1 - 2x_1) + a_2 (1 - 2x_1)^2 + a_3 (1 - 2x_1)^3 + a_4 (1 - 2x_1)^4]$$

Table 2 contains the curve fitting constants used to calculate these curves, and the standard deviation from the fit for each temperature.

All four of these curves are overlaid in Figure 14 for comparison. There was little utility in describing the curves at both 25 and 30 °C, as there was very little change between the two sets of data. In fact, throughout much of the range of these two curves, they are sufficiently close that the standard deviations of each data set could cause these sets to become intertwined.

FIGURE 10
BENZENE + TRICHLOROETHYLENE 10 C

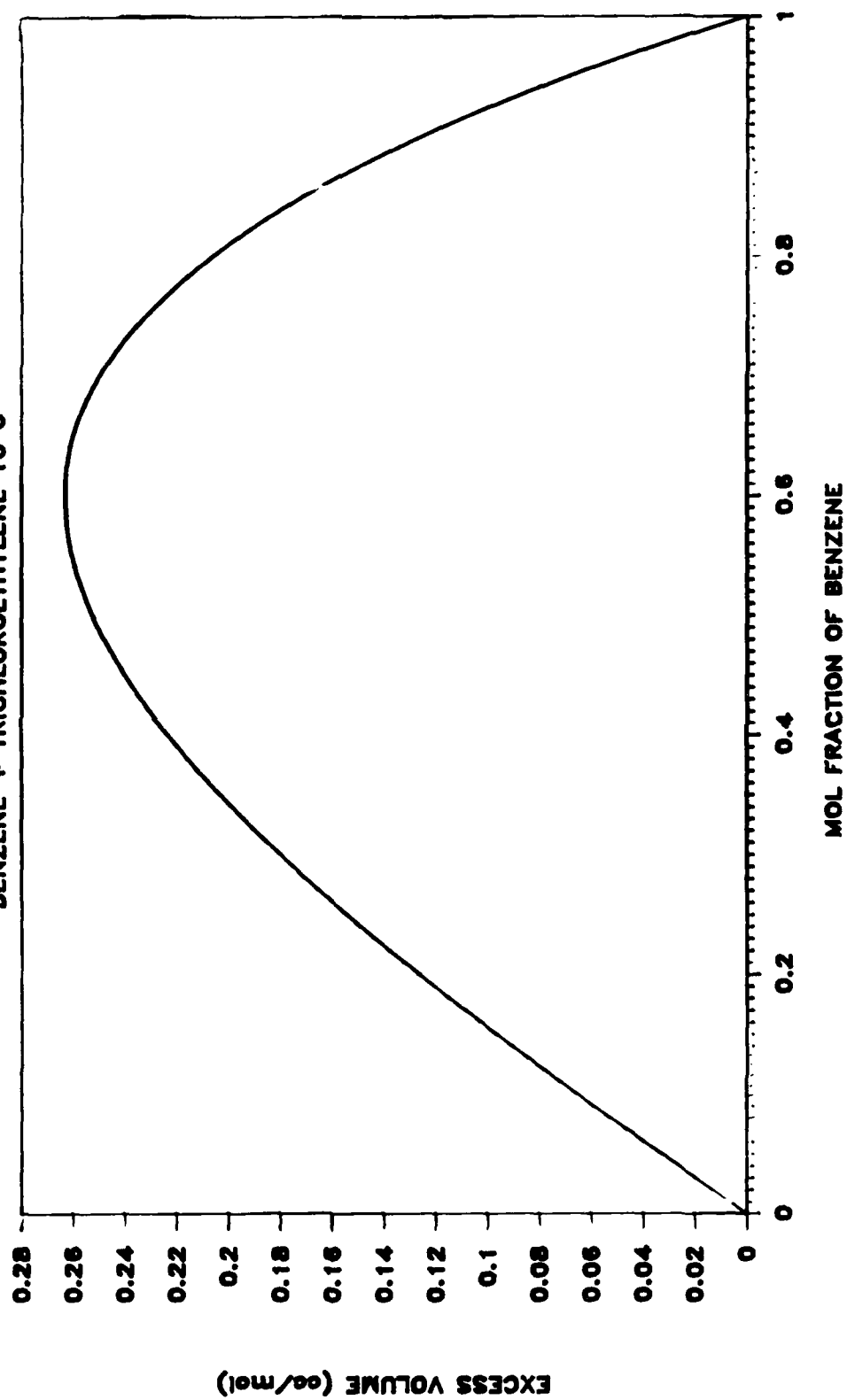


FIGURE 11
BENZENE + TRICHLOROETHYLENE 25 C

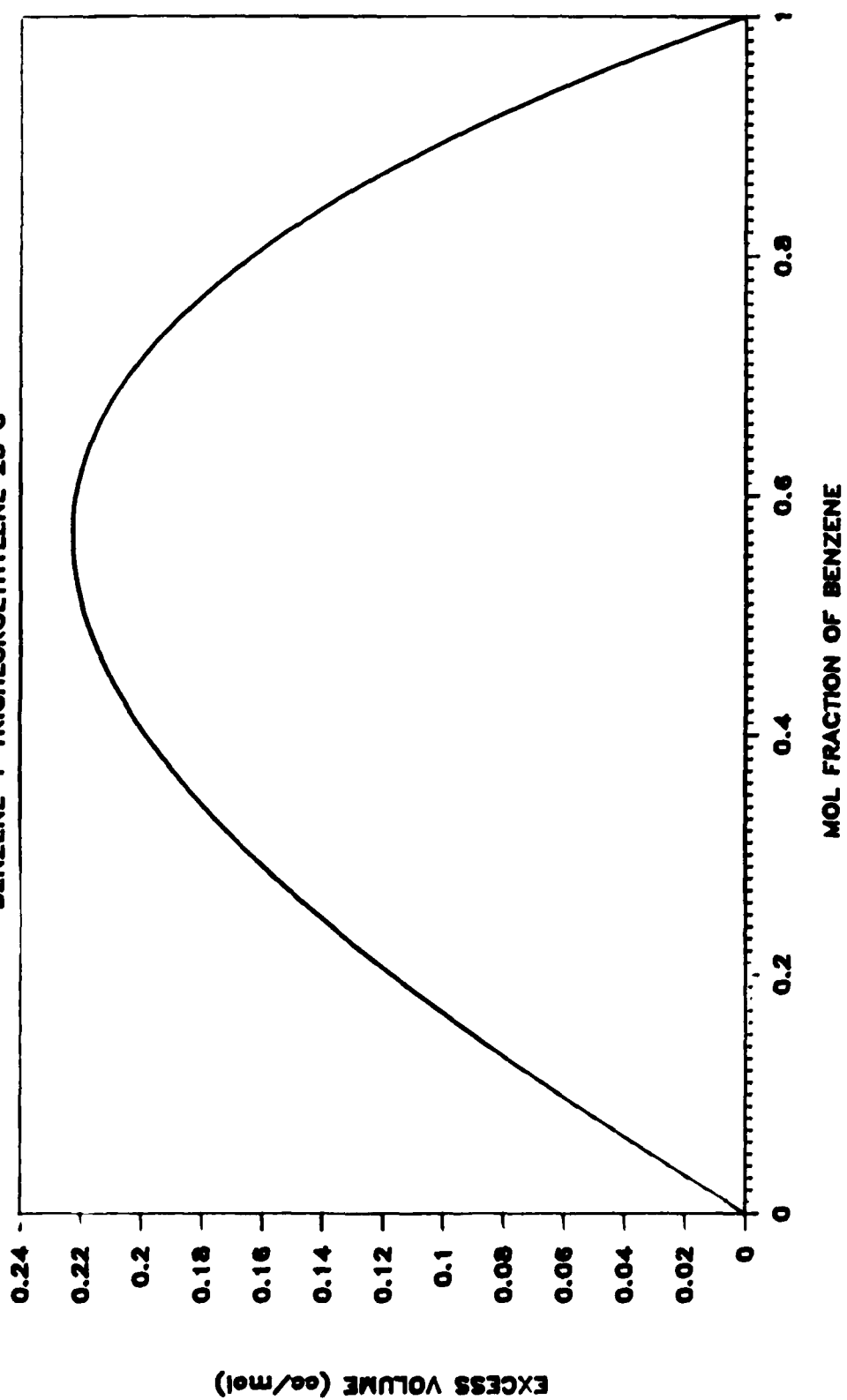


FIGURE 12
BENZENE + TRICHLOROETHYLENE 30 C

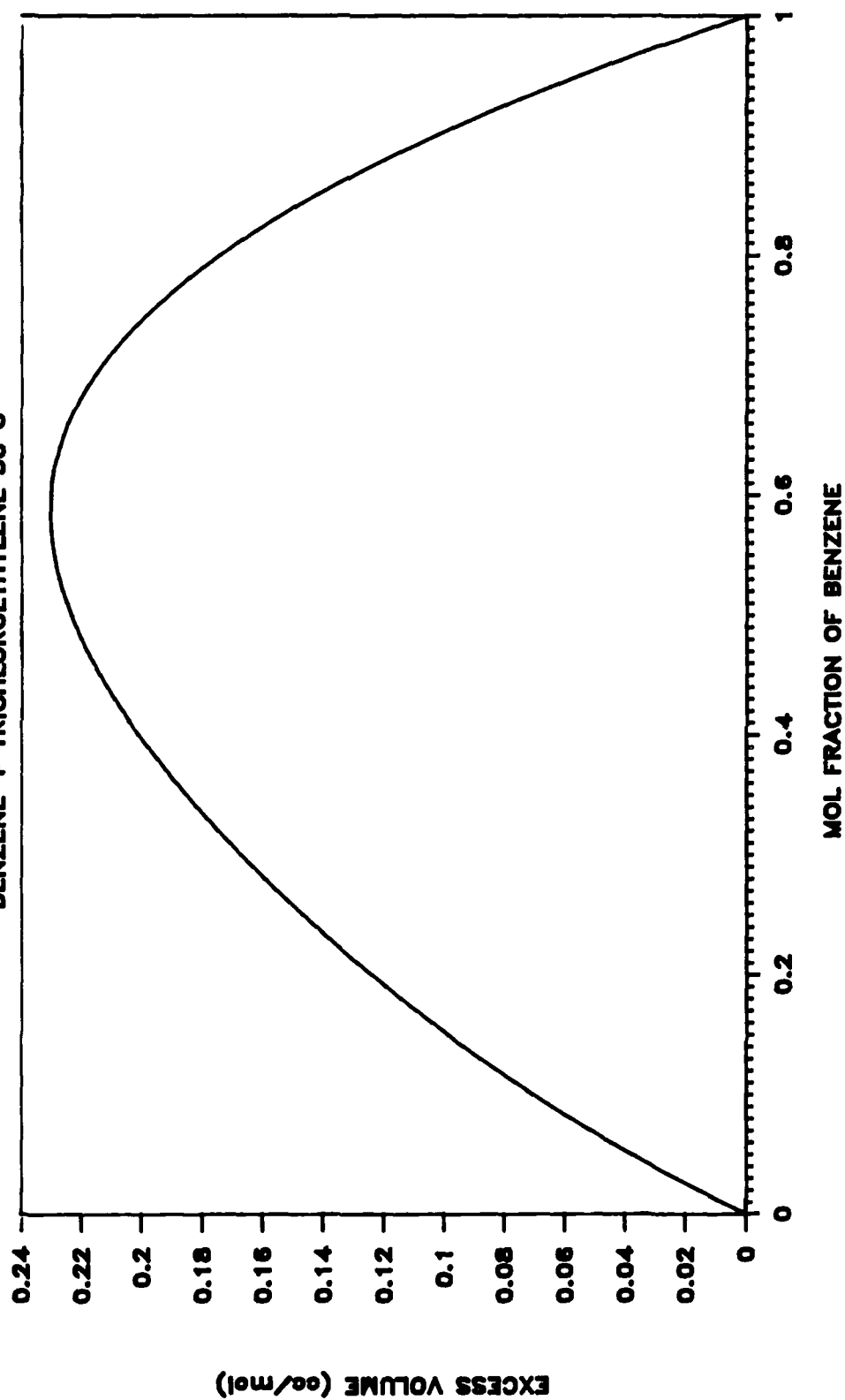


FIGURE 13
BENZENE + TRICHLOROETHYLENE 40 C

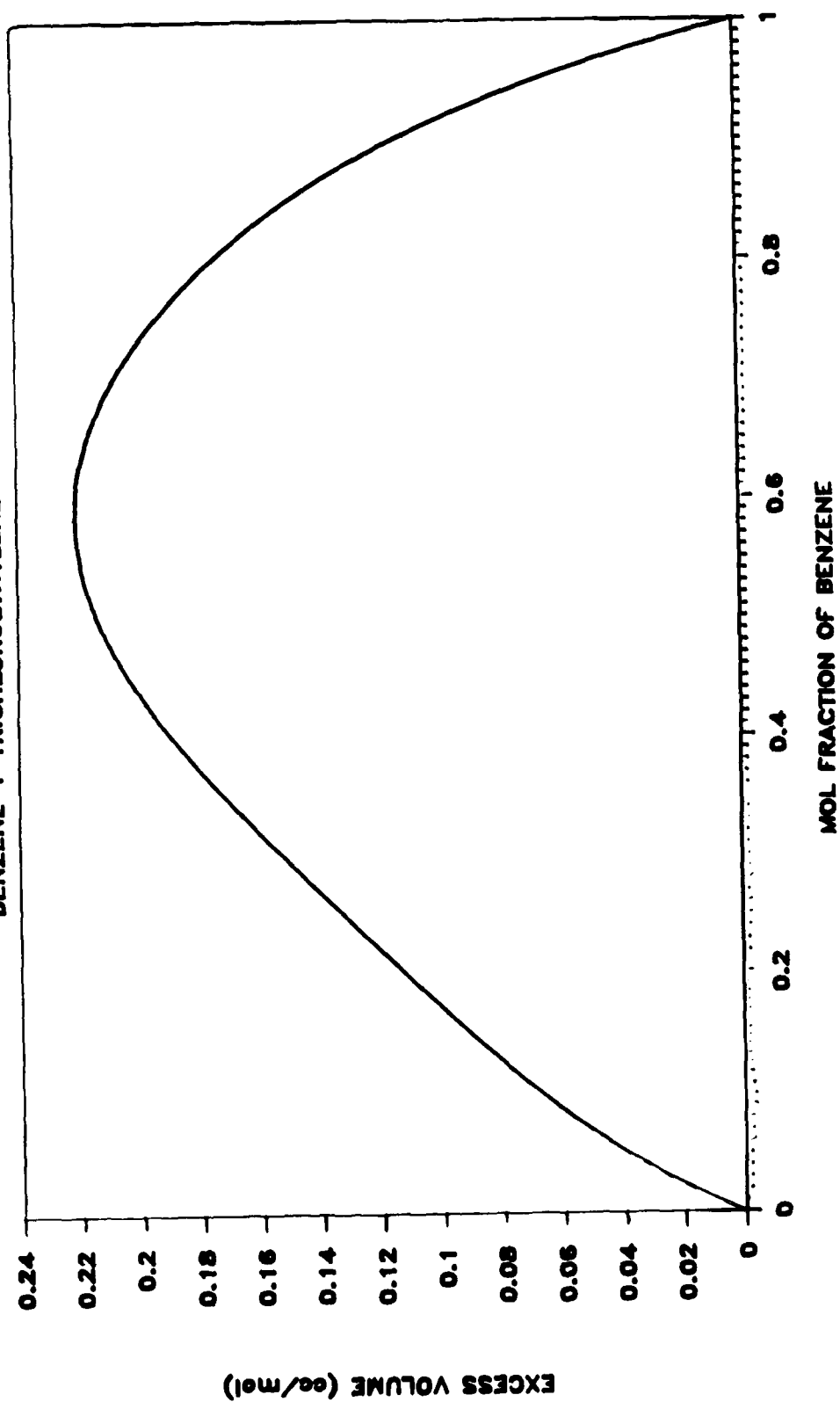


FIGURE 14
BENZENE + TRICHLOROETHYLENE SYSTEM

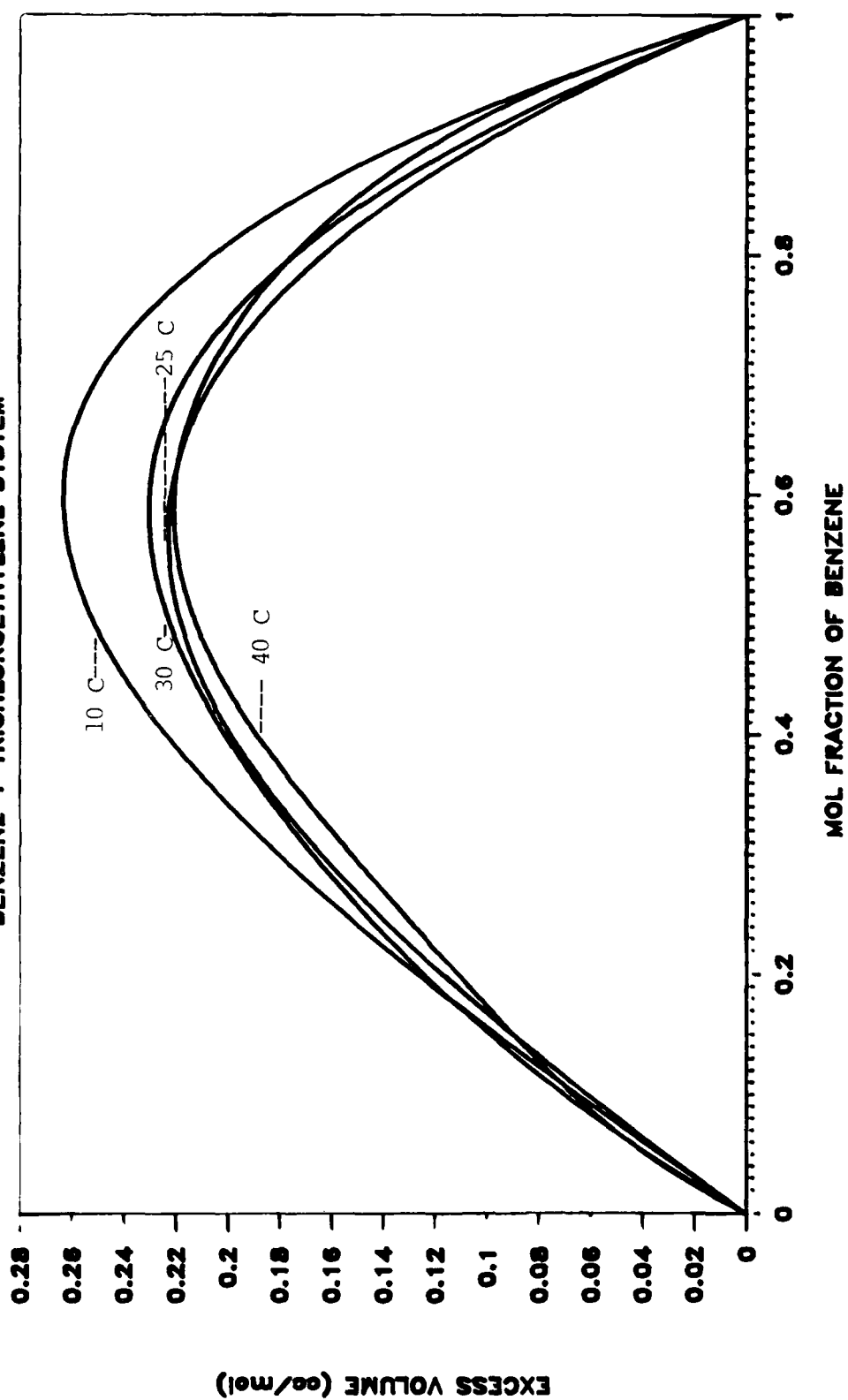


TABLE 2
CURVE FITTING DATA FOR THE
BENZENE + TRICHLOROETHYLENE SYSTEM

Temp (°C)	a ₀	a ₁	a ₂	a ₃	a ₄	std. dev (cc/mol)
10	1.01164	-.41103	.07189	0	0	.00801
25	.87624	-.23889	0	0	0	.00825
30	.89426	-.30734	.10541	.13159	0	.00324
40	.85454	-.33061	-.05882	.00471	.46645	.00409

The maximum point, which occurs between .565 and .597 on all four of these curves is in sufficient agreement to say that there is no tendency for the data to skew one way or the other with increasing temperature. It should also be noted that over the majority of the mole fraction range, the molar excess volume of the system decreases with increasing temperature. Although all four of the curves are relatively uniform in curvature, increasingly more curve fitting constants were generally required to accurately describe the system as the temperature increased.

Below .20, and again above .60 mole fraction of benzene, an inversion in the relationship of mole fraction to excess volume was observed to occur. Figures 15 and 16 are expanded views of Figure 14 below .20 and above .60 mole fraction of benzene, respectively. The explanation of this phenomenon is beyond the scope of this investigation, but highlights the complex nature of the forces involved in this system.

FIGURE 15
EXPANDED VIEW OF FIG 14 (.00 TO .20)

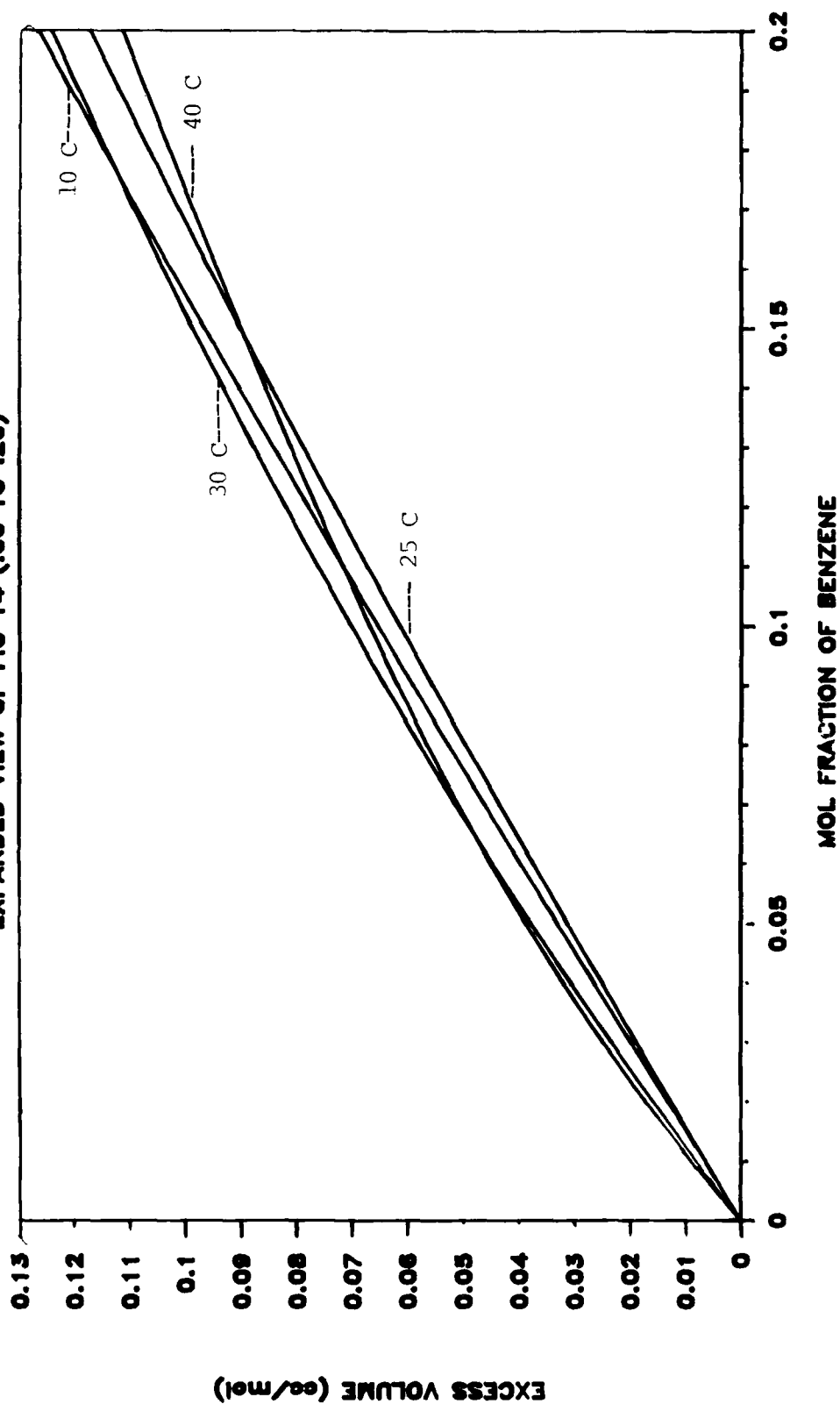
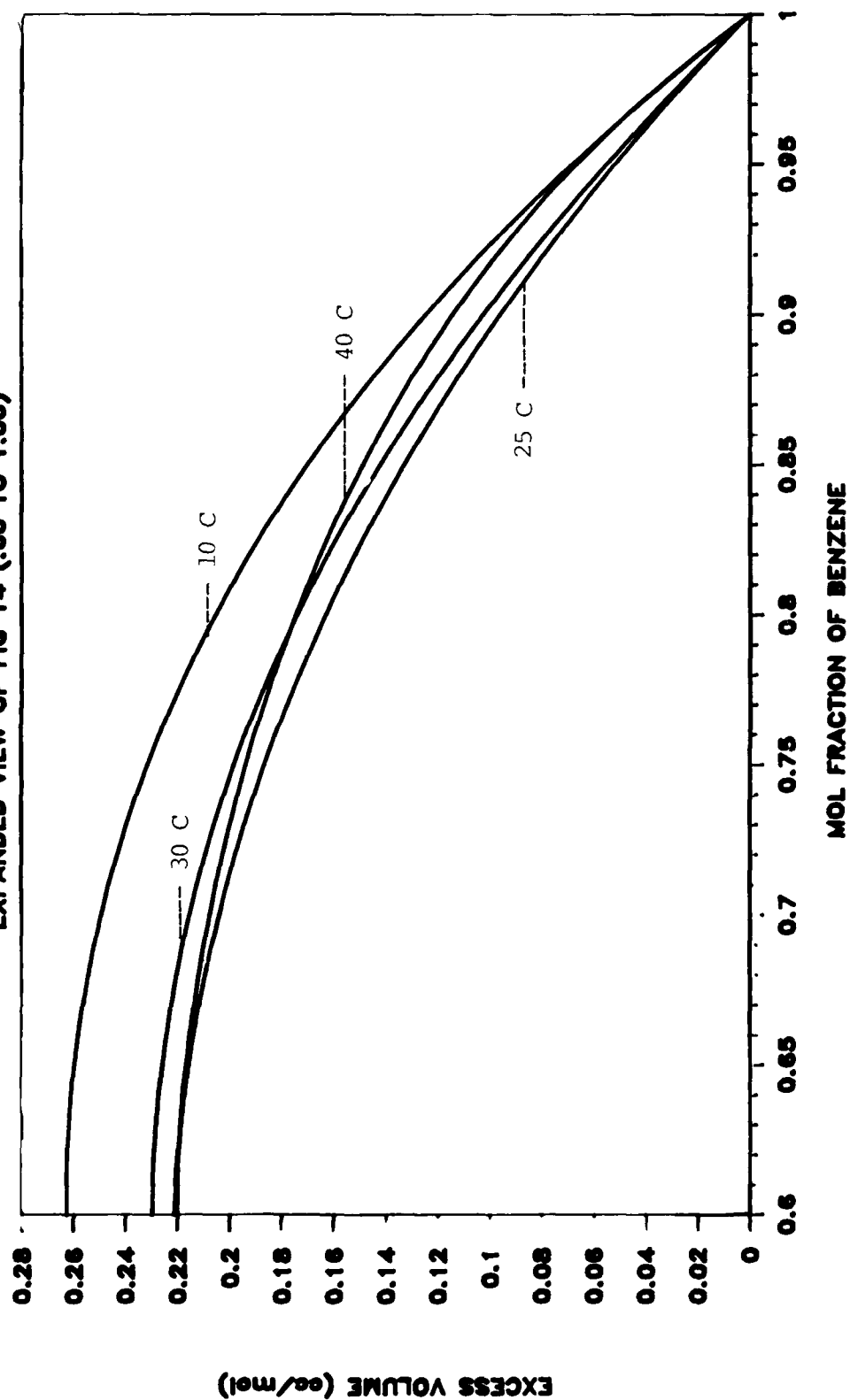


FIGURE 16
EXPANDED VIEW OF FIG 14 (.60 TO 1.00)



All four of these data sets have reasonable standard deviations, but the 10 and 25 °C sets had notably higher standard deviations than those for the 30 and 40 °C sets. See Appendix C-2 for specific information about standard deviations, data point error, and condition numbers for each temperature in this system. Finally, the data appear to be sufficiently good for information at other temperatures between 10 and 40 °C to be interpolated with reasonable accuracy. An empirical equation relating the height of the excess volume peak to the temperature of the system is:

$$V_{eT} = -.00140 * T + .653697$$

Where the units of V_{eT} are cc/mol and T is in K. This equation was derived from a linear regression of the peak values for the four temperatures.

CHAPTER VI

CONCLUSIONS

1. The data for the benzene + cyclohexane system compare well with other experimenters in terms of standard deviation, maximum value, and general shape of the curve, but is slightly low in the location of the maximum point on the x axis, although it is within the range of acceptability.
2. The data presented for the benzene + trichloroethylene system are as good as the data for the benzene + cyclohexane system, have standard deviations that are within acceptable limits, have peak values near 58 percent benzene, and can be used to interpolate data at other temperatures.
3. For the benzene + trichloroethylene system, as the temperature increases, the number of fitting constants required to describe the curve generally increases.
4. For the majority of the benzene + trichloroethylene system, the excess volume of mixing decreases with increasing temperature, although an inversion of this relationship takes place near both ends of the excess volume versus mole fraction curve.
5. As more data points are taken to describe a given system, the standard deviation and the L_1 condition decrease.

6. The inaccuracy of reading the temperature from an uncalibrated thermometer had no effect on the internal consistency of the data. This implies that the temperature bath was controlled to a degree of precision better than any of the thermometers were capable of reading.
7. With an increase in the precision of the cathetometer that measures the buret data, an increase of precision in the excess volume data and the standard deviations would follow. The excess volume precision would likely increase decimal point for decimal point with the precision increase of the cathetometer, with modifications made for ill conditioning if too few data points are collected.
8. The curve fitting constants and standard deviations for each of the benzene + trichloroethylene systems are as noted in Table 2.

CHAPTER VII

RECOMMENDATIONS

1. Obtain a second high precision cathetometer to measure the height data on the buret.
2. Obtain NBS calibrated thermometers to cover a wide range of temperatures, perhaps at ten degree increments from 0 to 100 °C, to accurately set the temperature bath at the desired set point.
3. Take as many data points as possible in further investigations to lower the population standard deviation and to keep the ill conditioning of the coefficient matrix from negating the positive effects gained from the use of higher precision equipment.
4. Continue the study of the benzene + trichloroethylene system at extreme temperatures, such as -10, 0 and 60 °C, to see if the observed trends continue to manifest themselves.
5. Obtain and calibrate a spare set of capillaries and burets for use in case of accidental breakage.

APPENDIX A
DETAILED PROCEDURES

APPENDIX A-1
BURET CALIBRATION

Buret Calibration

1. Clean the dilatometer.
2. Fill a syringe to a reasonable level with clean mercury, less than half full is acceptable. The rationale for this amount is that if the weighing will be done in an enclosed scale, the entire syringe (needle, body, and plunger) must fit within the confines of the scale when the scale doors are shut. Never attempt to over fill the syringe and attempt to get an accurate weight with the scale doors open because the room air currents are sufficient to cause errors in the weight.
3. Weigh the syringe and record this weight.
4. Tilt the dilatometer such that the buret is inclined slightly above horizontal. Slowly inject the mercury into the buret while keeping the opening of the needle flat against the side of the buret. The mercury drops should slowly run down the wall of the buret and pool up at the bottom.
5. When all mercury possible has been injected into the buret, withdraw the syringe and reweigh it. Care must be taken to ensure that no mercury remaining in the syringe is allowed to escape. Record this weight.
6. Repeat steps 2 - 5 as many times as needed to ensure the mercury level in the buret is above the reference mark at the lower end of the buret. Better results can be

achieved if the level is as close to the reference line as possible, as long as it is above it.

7. Visually inspect the mercury in the buret to ensure that no air bubbles are visible. If a bubble is detected, tilt the dilatometer in a manner such that the trapped air bubble(s) may rejoin the air above the mercury.
8. Replace the tap on the buret and tighten it. For calibration of the buret only, the tap with the level bubble should be used on the buret and the plain tap on the mixing bowl.
9. Place the dilatometer in the stand and place the stand in the temperature bath. Insert the cooling unit temperature sensor into the bath through a hole in the top of the stand.
10. Level the dilatometer by using the level bubble and making appropriate corrections with the height adjustment rods.
11. Allow the system to reach thermal equilibrium at the desired operating temperature, which should be held constant throughout the calibration.
12. Read the height to the reference line and the height to the meniscus using a cathetometer. Record these readings.
13. Fill a syringe with a small aliquot of mercury. The smaller the amount, the better the calibration will be. One-half cc works well.
14. Remove the temperature sensor from the bath and

- withdraw the stand. Take the dilatometer out of the stand and open the tap on the buret, being careful to exclude the entrance of any water into the buret.
15. Weigh the mercury addition and add it to the buret as in steps 3 - 5.
 16. Reassemble the apparatus and allow it to reach thermal equilibrium as in steps 7 - 11.
 17. Measure the height to the reference line and to the meniscus as in step 12. Note: Whenever the dilatometer is moved, the reference line must be remeasured.
 18. Repeat steps 13 - 17 until the range of the cathetometer is exceeded or the desired height of the buret has been calibrated.
 19. When a calibration run has been completed, calculate the cross-sectional area for each addition.
 20. Mathematically analyze the data for the mean cross-sectional area, the population standard deviation, and the sample standard deviation. For a calibration run to be successful, the standard deviation values must be regarded as "good" by some standard. For two or more runs to be consistent, the standard deviations and the means should all be in "reasonable" agreement.

APPENDIX A-2

DILATOMETER CLEANING PROCEDURES

Dilatometer Cleaning Procedures

1. The dilatometer should be cleaned prior to each loading.
2. Pour nitric acid into the buret in sufficient quantities to fill the buret and the mixing bowl. A funnel with a short stem should be used.
3. Tilt the dilatometer back and forth in such a manner that the nitric acid comes in contact with all of the inner surface of the dilatometer, to include the capillaries.
4. Pour out the nitric acid and fill as much of the dilatometer as possible with distilled water.
5. Rinse the dilatometer as in step 3, then pour out water.
6. Add ethyl alcohol to the dilatometer as in step 2, then rinse as in step 3 and pour out the alcohol.
7. Execute step 6 again with acetone instead of alcohol.
8. When the acetone has been poured out, connect a vacuum pump to capillary C. Allow the vacuum to operate until tubes S1 and S2 as well as taps T1 and T2 are dry.
9. Turn off the vacuum and insert both taps tightly. Then turn the vacuum back on and let it operate until the dilatometer is completely dry on the inside.

Note: It is helpful to conduct the vacuum operation with the dilatometer in an inverted position. This prevents acetone from collecting in the bulb at the bottom of the buret and speeds the drying process considerably.

APPENDIX A-3

DILATOMETER LOADING PROCEDURES

Dilatometer Loading Procedures

Refer to Figure 4 for the nomenclature used in this section.

1. First, clean the dilatometer.
2. Inject mercury into the mixing bowl through tap T2 with a long needle and a small tube attached to a syringe. Care should be taken to keep the tube opening just above the level of the mercury to ensure that no air bubbles become entrapped in the mercury pool.
3. As the horizontal tube fills with mercury, inspect periodically for the formation of air bubbles. If any bubbles form, tilt the dilatometer appropriately to allow the air bubble(s) to escape.
4. Continue to fill the mixing bowl with mercury until about two thirds of the upper hemispherical portion of the bowl are full.
5. Put both taps in place, but do not fully seat them. Allow T2 to be open enough so that mercury can be injected through S2 into the mixing bowl.
6. Place the dilatometer in its stand and lower it into the temperature bath which is set at the run operating temperature.
7. When thermal equilibrium has been reached, remove the dilatometer from the temperature bath and inject just enough mercury into the mixing bowl through S2 so that, when tap T2 is closed, no air will be trapped inside,

but not enough so that there is an overflow of mercury into S2 or a pressurizing effect when T2 is closed.

8. Close T2 and place the dilatometer back in the temperature bath.
9. Again, allow for thermal equilibrium to be reached, then measure the heights of the mercury columns in C, C1, and C2 with respect to CR.
10. When it is desired to operate the dilatometer near or above the ambient temperature, both the solvent and the solute should be degassed prior to loading them into the dilatometer. This can be most conveniently accomplished by bringing each component to boiling just prior to injecting it into the dilatometer.
11. Remove the dilatometer from the bath and open both taps, being careful not to allow any water to enter the dilatometer. Inject the solute component into the buret. This is accomplished with the help of a long needle and a syringe. Fill the buret with this component by placing the opening of the needle against the side of the buret and slowly injecting the solute in such a manner that it flows down the walls of the buret in a film.
12. Continue to fill the buret until the level of the solute is above the upper openings of both C1 and C2.
13. Momentarily, tilt the dilatometer toward the buret such that mercury drops flow from both C1 and C2. When the air trapped inside C2 has escaped into the buret, tilt

the buret upright again.

14. Tilt the dilatometer in such a manner that mercury flows into the buret only from C1. Allow mercury to flow from C1 into the buret until the bulb at the bottom is full of mercury and the meniscus of the mercury is slightly above reference line BR.
15. As mercury falls into the buret, the solute level will rise. The excess solute should be removed with a syringe through tap T1 from time to time.
16. Once this portion of the procedure is complete, ensure the solute level is even with the lower opening of S1.
17. Replace tap T1, but leave it slightly vented to S1.
18. Fill the vacant space in the mixing bowl with the solvent as in step 2. Bring the level of the solvent even with the lower opening of S2.
19. Replace tap T2, but leave it slightly vented to S2.
20. Place the dilatometer back into its stand and lower it into the temperature bath.
21. When thermal equilibrium has been reached, seal both taps and measure the heights of mercury in columns C, C1, C2, and the mixing bowl with respect to CR and the height of mercury in the buret with respect to BR.
22. If any of the capillary readings cannot be made conveniently, their levels may be adjusted in the following manner. Remove the dilatometer from the temperature bath. Open tap T1 partially, and either allow more solute into the buret or remove a few drops, as

required, by tilting the dilatometer appropriately. Place the dilatometer back in the temperature bath and execute step 21 again. By iterating through steps 21 and 22, acceptable mercury levels can be obtained in all three capillareis.

APPENDIX A-4

TEMPERATURE CONTROL

Temperature Control

These procedures were designed for use with the TCV-70 Tamson thermostatic bath and the PBC-2 II Neslab portable bath cooler with a Cryotrol temperature controller.

1. The bath should be filled with a suitable heat transfer medium before beginning a run, as prescribed in the operating manual. For most applications, distilled water is sufficient.
2. Cooling is usually required only when the desired run temperature is less than 8 degrees above the ambient temperature.
3. If cooling is required, the cooler should be set for minimum cooling duty and the Cryotrol temperature controller should be set at a temperature close to, but below the desired operating temperature. This permits the more accurate temperature controller on the thermostatic bath to control the bath temperature.
4. The heating capacity on the temperature bath should be set to the lowest possible value. This setting is experimentally determined in the following manner:
 - a. Turn the bath and the cooler (if appropriate) on and ensure the temperature of the water in the bath is below the desired operating temperature.
 - b. Set the temperature control on the bath to the desired temperature.

- c. Set the heating capacity knob to its lowest value.
 - d. Allow the bath to operate and observe the temperature.
 - e. Adjust the heating capacity upwards until the temperature in the bath begins to climb.
 - f. Verify that the bath can reach the desired operating temperature by adjusting the set point upwards so that the bath temperature climbs above the desired operating temperature. If the temperature quite climbing before the operating temperature is exceeded, continue adjusting the heating capacity upwards until this goal is achieved.
- 5. Set the temperature controller on the bath lower than the desired operating temperature and allow the bath to stabilize there.
 - 6. Adjust the temperature controller very slightly upwards and again allow the bath to stabilize in temperature.
 - 7. Repeat the procedure in step 6 until the operating temperature is reached.
 - 8. The temperature controls are now set for a run and should not need adjusting unless ambient conditions change significantly.
 - 9. At the end of each day of operation, refill the temperature bath with distilled water.
 - 10. Let the bath run continuously during a run to prevent instability and to facilitate the next day's operation.

APPENDIX A-5
OPERATING PROCEDURES

Operating Procedures

Before beginning, choose an operating temperature and set-up the temperature bath appropriately. Also, choose the two component system to be investigated.

1. Designate one component as the solute and the other as the solvent.
2. Clean and load the dilatometer, recording the appropriate data as described in the loading procedures.
3. Remove the dilatometer from the bath.
4. With the buret on the right, tilt the dilatometer in a clockwise direction, allowing a few drops of mercury to spill into the buret from capillary C1. Right the dilatometer and place it back in the temperature bath.

Note: After the tilt, inspect capillary C2 to ensure that there is no separation in the mercury column. If this should occur, immediately retilt the dilatometer. An abrupt tilt reduces the risk of mercury separation.

5. Allow the system to reach thermal equilibrium. This takes about 30 minutes, and can be visually determined by observing the mercury in capillary C. When this mercury level reaches a stationary location, thermal equilibrium has been reached.
6. Connect capillary C to the back pressure device and turn the stopcock to the vent position.
7. Read and record the levels of mercury in capillaries C,

- C1, and C2; the mixing bowl; and the buret. Also, record the level of reference marks CR and BR.
8. Turn the stopcock to the closed position and put a back pressure of about 24 cm on the system as determined by observing the change in height of the mercury in the U tube.
 9. Record the net change of height of mercury in the U tube, ensuring that any initial differential in mercury column heights is accounted for.
 10. Record the change in height of mercury in capillary C.
 11. For the first few tilts, only a few drops of mercury should be allowed to spill into the buret. This facilitates a more accurate determination of infinite dilution values.
 12. After the first few tilts, gradually increasing amounts of mercury may be spilled into the buret until, eventually, the change in mercury height in the buret is about 1 cm per tilt. Once this value is reached, the run should be finished out at about 1 cm of mercury change in the buret per tilt.
 13. This procedure should continue until the mercury in the buret reaches the point where the buret cross-sectional area begins to vary as it merges with the horizontal tube.
 14. Repeat steps 1 - 13 with the solute and solvent roles reversed. This procedure should yield two curves that merge at the center with a significant overlap.

APPENDIX B
EXPERIMENTAL DATA

NOMENCLATURE FOR APPENDIX B

A	Mixing bowl on the dilatometer
B	Buret on the dilatometer
BR	Reference mark on the buret
C, C1, C2	Capillary tubes on the dilatometer
CR	Reference mark on capillary C
ΔC_{pi}	Pressure corrected change in height of mercury in C
ΔU	Back-pressure applied to C

TABLE 3

EXPERIMENTAL DATA FOR DILUTION RUN #2

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LOAD	0.0847	3.9908		4.1064	4.0714					
INITIAL	0.0853	2.1622	1.6787	-0.6320	-0.5710	5.65	6.02			
1	0.0929	2.4424	1.6417	1.5323	2.0239	5.62	6.16	-0.1150		24.60
2	0.0849	2.5811	1.6069	1.9475	2.2647	5.63	6.30	-0.1351		24.10
3	0.0574	2.6611	1.6451	2.3716	2.4124	5.64	6.40	-0.1475		28.10
4	0.0868	2.8200	1.6086	3.1676	3.2854	5.60	6.48	-0.1405		24.25
5	0.0539	2.9256	1.5905	4.0520	4.0189	5.60	6.54	-0.1330		24.45
6	0.0964	3.0678	1.5874	4.6886	4.7367	5.60	6.66	-0.1149		24.55
7	0.0956	3.4289	1.5746	2.5891	3.2255	6.03	7.57	-0.0919		25.10
8	0.0583	3.9319	1.5233	1.8327	1.8949	6.03	8.23	-0.1106		24.05
9	0.0292	4.3234	1.4749	1.4297	1.6792	6.04	8.77	-0.1192		24.35
10	0.0858	4.4922	1.4869	1.4039	1.7722	6.03	8.92	-0.1113		24.20
11	0.0642	4.6917	1.4527	2.2232	2.3119	6.25	9.37	-0.1155		24.00
12	0.0937	5.1164	1.4405	1.5456	1.9350	6.23	9.91	-0.1044		24.00
13	0.0978	5.1758	1.4339	1.6766	1.7905	6.23	10.04	-0.1239		24.60
14	0.1018	5.4009	1.4196	2.6918	2.7344	6.25	10.30	-0.1387		24.70
15	0.1011	5.7066	1.4017	1.5738	1.7004	6.25	10.94	-0.1257		24.50
16	0.0999	5.8441	1.3991	1.6303	1.7311	6.27	11.13	-0.1287		24.20
17	0.0825	6.3108	1.3522	1.5864	1.6953	6.27	11.82	-0.1189		24.40
18	0.1049	6.4954	1.3395	1.5934	1.6759	6.25	12.12	-0.1067		24.60
19	0.0908	6.7022	1.3114	1.6900	1.7680	6.23	12.47	-0.1110		23.90
20	0.1087	6.8938	1.3002	1.7585	1.8479	6.26	12.79	-0.1131		24.40
21	0.0690	6.9527	1.2864	1.6345	1.6911	6.27	12.99	-0.1074		24.30
22	0.0978	7.2244	1.2647	1.4782	1.5129	6.25	13.46	-0.1472		23.70
23	0.0807	7.3924	1.2202	1.5363	1.5914	6.24	13.84	-0.1041		24.00
24	0.0890	7.4739	1.1958	1.6157	1.6548	6.24	14.08	-0.0897		24.10
25	0.0986	7.8097	1.1577	1.6737	1.6542	6.24	14.78	-0.1039		24.20
26	0.1241	7.9567	1.1905	1.6544	1.7310	6.23	15.00	-0.1342		24.55
27	0.0955	7.9793	1.1630	1.7841	1.8399	6.25	15.14	-0.1262		24.00
28	0.0916	8.0678	1.1384	1.6776	1.7510	6.28	15.36	-0.1049		24.00
29	0.0873	8.1169	1.1037	1.7201	1.7903	6.25	15.45	-0.1299		24.45
30	0.1018	8.3249	1.0884	1.6237	1.6440	6.24	15.92	-0.1157		24.35
31	0.0767	8.4124	1.0749	1.6817	1.6799	6.28	16.19	-0.1013		24.00
32	0.1110	8.5429	1.0719	1.7884	1.7992	6.28	16.50	-0.1035		24.60
33	0.1208	8.6564	1.0822	1.5804	1.5775	6.29	16.78	-0.1187		25.05
34	0.1287	8.8043	1.0690	1.7869	1.7947	6.29	17.07			

TABLE 3

EXPERIMENTAL DATA FOR DILUTION RUN #2 (CONTINUED)

TILT #	CR	C	R	C2	C1	$\frac{1}{R}$	B	del C	pi	del U
35	0.0111	8.8017	0.9291	1.5781	1.6350	6.27	17.38	-0.1260		24.15
36	-0.0041	8.8816	0.9069	1.5220	1.5519	6.27	17.64	-0.1234		24.25
37	-0.0210	8.9679	0.8801	1.6929	1.7061	6.25	17.87	-0.0998		23.90
38	0.0445	9.1724	0.8814	1.5060	1.6354	6.24	18.30	-0.1185		24.25
39	-0.0128	9.2281	0.8562	1.6507	1.6653	6.28	18.62	-0.1167		24.05
40	0.0028	9.3814	0.8345	1.6385	1.3649	6.27	19.02	-0.1234		23.70
41	-0.0377	9.4355	0.7782	1.6406	1.6457	6.24	19.26	-0.1074		23.85
42	-0.0052	9.5919	0.7593	1.6554	1.6781	6.26	19.66	-0.0841		24.40
43	-0.0100	9.7086	0.7240	1.5895	1.5976	6.28	20.00	-0.1257		24.20
44	-0.0010	9.9765	0.7117	1.4239	1.4403	6.27	20.89	-0.1140		24.25
45	0.0208	10.1045	0.6756	1.6149	1.6071	6.31	21.31	-0.1009		24.40
46	0.0071	10.2573	0.6707	1.4632	1.4734	6.31	21.91	-0.1117		24.50
47	-0.0036	10.3924	0.6224	1.6235	1.6108	6.29	22.45	-0.0853		24.15
48	-0.2967	10.2055	0.3230	1.1757	1.1673	6.27	22.85	-0.1064		24.15
49	-0.2723	10.3894	0.3089	1.4249	1.4293	6.27	23.31	-0.0769		23.65
50	-0.4540	10.3476	0.1500	1.2287	1.2148	6.31	23.81	-0.0921		24.15

TABLE 4

EXPERIMENTAL DATA FOR DILUTION RUN #3

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LOAD	0.0465	5.7926		5.6246	5.6825					
INITIAL	0.1012	1.0252	1.7170	-0.3385	-0.3298	6.34	6.6			
1	0.0613	1.2406	1.6858	1.4343	1.4417	6.33	6.69	-0.1086		24.10
2	0.1011	1.4965	1.6849	1.6402	1.6539	6.35	6.91	-0.0609		24.40
3	0.0815	1.6857	1.6655	1.6391	1.6538	6.37	7.08	-0.1017		23.80
4	0.0802	2.0073	1.6470	1.6107	1.6386	6.32	7.33	-0.0795		23.65
5	0.0732	2.2234	1.6256	1.5959	1.6082	6.32	7.49	-0.1051		23.80
6	0.1342	2.5413	1.6668	1.5935	1.6019	6.02	7.41	-0.1130		24.60
7	0.0983	2.6969	1.6288	1.6712	1.6305	6.01	7.60	-0.0905		24.20
8	0.1084	2.8577	1.6144	1.5918	1.6077	6.00	7.73	-0.0884		24.25
9	0.1161	2.9949	1.6735	1.6914	1.7023	6.00	7.88	-0.0901		23.95
10	0.0993	3.2550	1.5946	1.6898	1.6955	6.00	8.14	-0.0898		24.00
11	0.0969	3.4921	1.5671	1.7357	1.7484	6.01	8.31	-0.1115		23.95
12	0.1239	3.5570	1.5973	1.7976	1.8004	6.01	8.45	-0.0940		24.50
13	0.1035	3.6941	1.5822	1.6754	1.6754	6.01	8.63	-0.0829		23.90
14	0.1319	3.9884	1.5917	1.4504	1.4622	6.02	8.99	-0.0911		24.00
15	0.1410	4.1807	1.5706	1.5960	1.7095	6.02	9.20	-0.0932		23.90
16	0.1518	4.2925	1.5757	1.5984	1.6280	6.05	9.34	-0.1144		23.90
17	0.0863	4.3600	1.5140	1.6362	1.6578	6.00	9.49	-0.0939		24.35
18	0.0883	4.4849	1.5035	1.6330	1.6427	6.00	9.65	-0.1046		24.30
19	0.0966	4.6226	1.4999	1.5642	1.5900	6.02	9.85	-0.0982		24.20
20	0.1268	4.6196	1.5034	1.7475	1.7562	6.02	10.07	-0.0979		24.25
21	0.1296	4.8885	1.4964	1.7897	1.7942	6.02	10.23	-0.1007		24.60
22	0.1091	5.0118	1.4807	1.6418	1.6734	6.01	10.41	-0.1059		23.85
23	0.1302	5.1423	1.4835	1.7019	1.7047	6.02	10.62	-0.1009		24.00
24	0.1355	5.2534	1.4595	1.6142	1.6446	6.03	10.83	-0.0849		24.10
25	0.1250	5.3653	1.4533	1.6891	1.6963	6.02	11.00	-0.0933		24.00
26	0.1305	5.4841	1.4387	1.6375	1.6450	6.03	11.20	-0.0913		24.30
27	0.1109	5.5502	1.4199	1.6008	1.5936	6.02	11.33	-0.0985		24.60
28	0.1180	5.6495	1.4061	1.6308	1.6320	6.01	11.52	-0.0837		24.30
29	0.1135	5.7404	1.4004	1.5616	1.5628	6.01	11.64	-0.1070		23.60
30	0.1128	5.8221	1.3868	1.5113	1.5184	6.03	11.87	-0.0907		24.15
31	0.2075	5.9734	1.4673	1.7336	1.7418	6.07	12.11	-0.1083		24.00
32	0.1419	6.1176	1.3940	1.5375	1.5829	6.05	12.50	-0.0978		23.90
33	0.1337	6.2221	1.3679	1.5749	1.5988	6.06	12.69	-0.1106		24.25
34	0.1202	6.2855	1.3452	1.6269	1.6490	6.03	12.81	-0.1103		24.20

TABLE 4

EXPERIMENTAL DATA FOR DILUTION RUN #3 (CONTINUED)

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
35	0.1152	6.4446	1.3280	1.7243	1.7319	6.02	13.02	-0.1285		24.45
36	0.1036	6.5240	1.3106	1.5866	1.6170	6.01	13.24	-0.0989		24.05
37	0.1477	6.6514	1.3225	1.6861	1.7287	6.03	13.49	-0.1009		24.25
38	0.1386	6.7113	1.3091	1.7172	1.7428	6.02	13.67	-0.0999		24.10
39	0.1434	6.8242	1.2949	1.5788	1.6004	6.03	13.92	-0.1005		24.40
40	0.1483	6.9203	1.2783	1.6130	1.6169	6.03	14.14	-0.1003		23.95
41	0.1300	6.9929	1.2613	1.6941	1.6972	6.02	14.34	-0.1135		24.15
42	0.1454	7.1073	1.2418	1.7550	1.7574	6.02	14.66	-0.0939		24.30
43	0.1289	7.1624	1.2349	1.7346	1.7287	6.02	14.82	-0.1046		24.15
44	0.1345	7.2512	1.2194	1.7534	1.7560	6.00	15.05	-0.1099		24.10
45	0.1038	7.3105	1.1786	1.7142	1.7657	6.01	15.26	-0.1009		24.30
46	0.1421	7.4199	1.2037	1.7275	1.7360	6.01	15.51	-0.1069		23.75
47	0.1207	7.4468	1.1744	1.5982	1.6067	6.00	15.67	-0.0925		23.95
48	0.2080	7.6339	1.2379	1.7465	1.7493	6.09	15.97	-0.1094		23.75
49	0.1365	7.6432	1.1628	1.6229	1.6328	6.03	16.20	-0.1184		24.30
50	0.0991	7.6843	1.1081	1.6410	1.6527	6.00	16.38	-0.1224		24.10
51	0.1444	7.8101	1.1308	1.6632	1.6713	6.02	16.79	-0.0816		24.20
52	0.1949	7.9521	1.1597	1.7723	1.7883	6.08	17.07	-0.1193		23.80
53	0.1014	7.9397	1.0749	1.6586	1.6676	6.01	17.27	-0.1123		24.05
54	0.1480	8.0525	1.0771	1.6803	1.6787	6.00	17.52	-0.1125		23.80
55	0.2980	8.2846	1.2165	1.8564	1.8590	6.19	18.03	-0.0996		23.75
56	0.1279	8.1918	1.0487	1.6590	1.6668	6.02	18.12	-0.1048		24.30

TABLE 5
EXPERIMENTAL DATA FOR DILUTION RUN #4

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LOAD	0.0029	6.1049		5.8614	5.9315					
INITIAL	0.7611	7.0111	2.7203	-0.5069	-0.4603	5.11	5.33			
1	-0.0240	6.4267	1.9264	1.7892	1.7628	5.13	5.37	-0.0010		23.80
2	-0.0179	6.6011	1.9297	2.1351	2.1477	5.14	5.47	-0.0990		23.80
3	-0.0331	6.6422	1.8988	2.0996	2.1012	5.15	5.62	-0.1040		23.60
4	-0.0127	6.7676	1.8585	1.4230	1.4316	5.16	5.87	-0.0806		24.45
5	-0.0350	7.0215	1.8184	0.7775	1.1505	4.97	6.19	-0.1055		23.70
6	-0.0383	7.1151	1.7988	1.5576	1.8522	4.94	6.44	-0.0904		23.90
7	-0.0018	7.2504	1.8600	1.3643	1.5675	4.98	6.67	-0.1238		24.25
8	-0.0682	7.2570	1.7962	2.1513	2.1778	4.94	6.73	-0.1147		24.95
9	-0.0904	7.3055	1.7519	1.6567	1.6673	4.95	6.94	-0.1026		23.65
10	-0.0171	7.4624	1.7652	1.4818	1.9650	4.97	7.19	-0.0803		23.80
11	-0.0557	7.4743	1.7369	2.1383	2.1328	4.93	7.28	-0.1311		24.70
12	-0.0114	7.7047	1.7246	1.0917	1.5597	4.95	7.83	-0.0948		24.35
13	-0.0293	7.7827	1.7526	1.6417	1.9064	4.98	8.00	-0.1262		24.30
14	-0.0349	7.8216	1.7120	1.6155	1.7924	4.97	8.22	-0.0928		24.90
15	-0.0270	7.9233	1.6937	1.4902	1.7550	4.96	8.49	-0.1153		24.00
16	-0.0607	7.9903	1.6404	1.1939	1.5720	4.92	8.88	-0.2322		24.10
17	-0.0306	8.0931	1.6723	1.4775	1.7420	4.98	9.02	-0.1341		23.75
18	-0.0112	8.0840	1.6853	1.6546	1.8968	4.97	9.16	-0.0851		23.45
19	-0.0195	8.1107	1.6528	1.3730	1.8300	4.98	9.47	-0.0878		23.65
20	-0.0491	8.1525	1.6105	1.6382	1.6300	4.98	9.82	-0.1562		23.80
21	-0.0616	8.1517	1.5950	1.4880	1.5748	4.95	10.16	-0.1022		23.60
22	-0.0335	8.3427	1.5693	1.0732	1.4212	4.95	10.80	-0.1022		23.80
23	-0.0222	8.4264	1.5410	1.4334	1.6117	4.97	11.23	-0.0999		23.85
24	-0.0207	8.5203	1.5295	1.5575	1.8857	4.98	11.55	-0.1082		23.50
25	-0.0368	8.5533	1.5076	1.6271	1.8069	4.97	11.93	-0.1029		23.90
26	-0.0264	8.6312	1.4937	1.6016	1.7364	4.98	12.31	-0.0825		23.80
27	-0.0533	8.6489	1.4390	1.7250	1.8630	4.93	12.76	-0.0755		24.10
28	-0.0505	8.7362	1.4291	1.7189	1.8297	4.96	13.08	-0.0932		23.95
29	-0.1251	8.6474	1.3314	1.5658	1.6234	4.99	13.41	-0.1251		24.05
30	-0.1277	8.6611	1.2868	1.5622	1.7852	4.97	13.73	-0.1194		24.00
31	-0.1167	8.6905	1.2694	1.8009	1.8357	4.95	14.18	-0.1243		24.05
32	-0.0867	8.7703	1.2632	1.6107	1.6129	4.96	14.54	-0.0858		23.90
33	-0.4090	8.5024	1.0395	1.6567	1.6424	4.87	15.00	-0.0835		23.75
34	-0.3562	8.6065	1.0214	1.5077	1.6944	4.86	15.47	-0.0727		24.10

TABLE 5

EXPERIMENTAL DATA FOR DILUTION RUN #4 (CONTINUED)

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
35	-0.3576	8.6974	1.0293	1.5829	1.7733	4.87	15.91	-0.1337		23.65
36	-0.4001	8.6782	0.9775	1.5601	1.6554	4.88	16.48	-0.1140		24.15
37	-0.4008	8.7376	0.9071	1.3420	1.5768	4.88	17.40	-0.1035		23.65
38	-0.4159	8.7779	0.8776	1.5555	1.8098	4.87	17.92	-0.1147		24.15
39	-0.4712	8.7381	0.7825	1.6857	1.8314	4.90	18.61	-0.0953		23.85
40	-0.4577	8.7917	0.7514	1.7367	1.7303	4.91	19.16	-0.0983		23.60
41	-0.5780	8.6815	0.6002	1.6020	1.6816	4.92	19.88	-0.0731		24.20
42	-0.5746	8.7113	0.5937	1.4483	1.6461	4.95	20.70	-0.0390		23.75
43	-0.5804	8.8193	0.5588	1.6833	1.8232	4.92	21.57	-0.1272		23.85

TABLE 6

EXPERIMENTAL DATA FOR DILUTION RUN #5

TILT #	CR	C	A	C2	C1	BE	B	del C	pi	del U
LOFO	-0.0946	5.0459		4.7473	4.7321					
INITIAL	-0.1582	-0.2274	1.8029	-0.1739	-0.0900	5.07	5.26			
1	-0.2363	-0.2910	1.7667	1.8576	1.9383	5.03	5.29	-0.0742		23.95
2	-0.1903	-0.1751	1.7612	1.7948	1.8380	5.05	5.64	-0.0905		23.95
3	-0.1763	0.0040	1.7748	1.8959	1.9294	5.05	5.88	-0.0955		23.75
4	-0.1696	0.0741	1.7767	1.8963	1.9270	5.03	6.19	-0.0863		24.10
5	-0.1571	0.1507	1.7463	1.8177	1.8598	5.05	6.53	-0.1196		24.25
6	-0.1975	0.2021	1.6956	1.8587	1.9153	5.04	6.82	-0.0897		24.35
7	-0.2254	0.3636	1.6648	1.7056	1.7451	5.05	7.32	-0.0939		24.10
8	-0.1901	0.5522	1.6207	1.8035	1.8422	5.07	7.88	-0.1163		24.00
9	-0.1941	0.6186	1.6161	1.8555	1.8880	5.07	8.17	-0.1045		23.75
10	-0.1890	0.7524	1.5825	1.7234	1.7679	5.06	8.72	-0.0685		24.25
11	-0.1639	0.8385	1.6120	2.2604	2.1013	5.08	9.11	-0.1077		24.35
12	-0.1530	1.0567	1.5855	1.6297	1.6664	5.08	9.57	-0.1006		24.15
13	-0.1589	1.1168	1.5523	1.8583	1.9001	5.07	10.09	-0.0974		24.10
14	-0.1688	1.3325	1.4889	1.6665	1.7212	5.08	11.06	-0.0012		24.35
15	-0.1630	1.3934	1.4673	1.7680	1.8490	5.07	11.39	-0.1087		24.05
16	-0.2015	1.4664	1.3890	1.6983	1.7576	5.07	12.03	-0.1050		24.35
17	-0.2158	1.5683	1.3500	1.4639	1.5258	5.04	12.37	-0.1122		24.30
18	-0.2294	1.6727	1.3159	1.6464	1.6867	5.05	12.92	-0.1205		24.20
19	-0.2325	1.7857	1.2569	1.4722	1.5157	5.06	13.39	-0.1154		24.25
20	-0.2276	1.8807	1.2278	1.7156	1.7949	5.05	13.89	-0.0363		24.25
21	-0.1847	1.9635	1.2417	1.6643	1.6983	5.04	14.41	-0.1156		24.35
22	-0.2086	2.0393	1.2178	1.6376	1.8774	5.04	14.78	-0.1253		24.45
23	-0.1625	2.2146	1.2105	1.5174	1.5782	5.03	15.22	-0.0370		24.40
24	-0.1551	2.2693	1.2058	1.7256	1.7707	5.03	15.69	-0.0424		23.95
25	-0.1690	2.3890	1.1469	1.7369	1.7932	5.02	16.31	-0.0983		24.35
26	-0.1648	2.4539	1.1215	1.9081	1.9536	5.04	17.10	-0.0994		24.05
27	-0.1563	2.5679	1.0805	1.8608	1.9109	5.03	17.57	-0.0890		24.10
28	-0.1467	2.6418	1.0583	1.6731	1.7100	5.03	18.32	-0.0982		23.75

TABLE 7
EXPERIMENTAL DATA FOR DILUTION RUN #6

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LOFO	-0.1561	5.6042		3.3246	3.2371					
INITIAL	-0.0813	1.1699	1.8107	0.1036	0.0782	4.9	5.12			
1	-0.0720	1.1541	1.8041	1.5487	1.5445	4.89	5.14	-0.1372		24.35
2	-0.0702	1.3087	1.7871	1.7289	1.7702	4.90	5.36	-0.1539		24.20
3	-0.0638	1.4719	1.7824	1.7642	1.7517	4.89	5.61	-0.1513		23.75
4	-0.0658	1.6534	1.7851	1.6711	1.7714	4.90	5.95	-0.1404		23.50
5	-0.0779	1.7671	1.7414	1.7456	1.7911	4.91	6.23	-0.1387		23.75
6	-0.0849	1.9117	1.7307	1.8440	1.8540	4.90	6.56	-0.1350		24.05
7	-0.0960	2.1630	1.6881	1.6991	1.8301	4.89	7.01	-0.1317		23.60
8	-0.0758	2.2093	1.6831	1.8201	1.8141	4.89	7.41	-0.1565		24.05
9	-0.0878	2.4859	1.6596	1.7428	1.7363	4.90	7.98	-0.1427		23.85
10	-0.0878	2.5781	1.6178	1.7399	1.7929	4.90	8.51	-0.1546		23.70
11	-0.0876	2.7144	1.5761	1.5866	1.6904	4.89	8.86	-0.1544		23.95
12	-0.0798	2.7946	1.5663	1.7326	1.7409	4.90	9.19	-0.1503		24.15
13	-0.0660	2.9051	1.5432	1.6441	1.7111	4.89	9.52	-0.1451		23.95
14	-0.0773	2.9192	1.5287	1.7517	1.8067	4.88	9.85	-0.1411		24.05
15	-0.0764	3.0672	1.4789	1.6449	1.6354	4.87	10.44	-0.1417		24.00
16	-0.0840	3.1590	1.4541	1.5864	1.5789	4.88	10.87	-0.1504		23.60
17	-0.0635	3.2219	1.4346	1.5586	1.5485	4.88	11.21	-0.1446		24.00
18	-0.0676	3.2961	1.4131	1.6883	1.7835	4.90	11.82	-0.1507		23.65
19	-0.0742	3.3500	1.3740	1.5939	1.5937	4.88	12.28	-0.1571		24.05
20	-0.0808	3.3749	1.3550	1.5542	1.7065	4.89	12.85	-0.1383		24.00
21	-0.0812	3.5157	1.3011	1.5117	1.6136	4.88	13.58	-0.1416		24.00
22	-0.0762	3.5740	1.2777	1.6399	1.7632	4.89	14.07	-0.1584		24.05
23	-0.1074	3.5761	1.2162	1.6731	1.6353	4.88	14.58	-0.1260		24.10
24	-0.1104	3.5966	1.1878	1.8697	1.7272	4.89	14.95	-0.1411		24.05
25	-0.1121	3.7051	1.1427	1.6395	1.4434	4.90	15.76	-0.1292		24.25
26	-0.1249	3.7857	1.1028	1.5585	1.6032	4.89	16.18	-0.1429		23.95
27	-0.1372	3.7883	1.0787	1.5991	1.6025	4.89	16.61	-0.1390		24.00
28	-0.1181	3.8149	1.0712	1.7100	1.6759	4.88	17.14	-0.1569		24.05
29	-0.1430	3.7924	1.0173	1.5544	1.5435	4.88	17.67	-0.1480		23.85
30	-0.1418	3.9245	0.9871	1.5578	1.6399	4.88	17.99	-0.1242		23.95
31	-0.1264	3.9228	0.9673	1.5500	1.5831	4.86	18.31	-0.1412		24.00
32	-0.1348	4.0052	0.9314	1.3804	1.3770	4.87	18.99	-0.1261		23.70
33	-0.0970	4.0378	0.9132	1.6417	1.6810	4.87	19.65	-0.1357		24.05
34	-0.0921	4.0395	0.8985	1.1184	1.7415	4.87	20.13	-0.1317		23.95

TABLE 7

EXPERIMENTAL DATA FOR DILUTION RUN #6 (CONTINUED)

TILT #	CR	C	A	C2	C1	BR	Ei	del C	pi	del U
35	-0.0840	4.0827	0.8763	1.5729	1.6089	4.86	20.61	-0.1397		24.25
36	-0.0737	4.1043	0.8389	1.6722	1.7685	4.86	21.24	-0.1374		24.05

TABLE 8
EXPERIMENTAL DATA FOR DILUTION RUN #7

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LOAD	-0.1543	7.4287		4.7222	4.7354					
INITIAL	0.0096	0.9025	1.9201	5.1825	5.1614	4.95	5.14			
1	-0.0161	0.9361	1.8822	1.3273	1.3465	4.93	5.43	-0.1131		24.00
2	-0.0341	1.0715	1.8209	1.8111	1.6711	4.94	5.65	-0.1094		24.05
3	-0.0518	1.2736	1.7769	1.1742	1.3041	4.93	6.11	-0.1281		23.75
4	-0.0573	1.4357	1.7467	1.5537	1.5510	4.95	6.38	-0.1188		23.90
5	-0.0792	1.5346	1.7272	1.4657	1.6412	4.91	6.69	-0.1323		24.15
6	-0.0889	1.6679	1.6817	1.4923	1.6579	4.91	7.06	-0.0993		24.05
7	-0.0972	1.7919	1.6646	1.3692	1.6592	4.91	7.36	-0.0884		23.95

TABLE 9
EXPERIMENTAL DATA FOR DILUTION RUN #8

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LOAD	-0.6498	10.3102		2.5715	2.5663					
INITIAL	-0.1526	2.1718	1.8742	-0.2147	-0.2390	4.93	5.12			
1	-0.1489	2.2089	1.7973	0.4483	0.3564	4.94	5.33	-0.1393		24.10
2	-0.2073	2.3449	1.7757	1.2332	1.2317	4.97	5.53	-0.1265		23.70
3	-0.1534	2.5279	1.7509	1.3383	1.3211	4.95	5.91	-0.0641		24.05
4	-0.1359	3.0511	1.7704	1.2997	1.2717	4.95	6.87	-0.1207		23.85
5	-0.1556	3.1803	1.6914	-0.5464	-0.2060	4.96	7.50	-0.1323		23.75
6	-0.1709	3.3120	1.6589	0.9898	0.9677	4.97	7.84	-0.1323		23.85
7	-0.1868	3.4426	1.6161	0.9522	0.9481	4.97	8.26	-0.1397		24.00
8	-0.1900	3.5469	1.5838	1.2591	1.2622	4.96	8.58	-0.1432		24.05
9	-0.1805	3.6675	1.5408	0.5154	0.8279	4.95	9.17	-0.1126		24.05
10	-0.1236	3.9466	1.5238	0.7732	1.0871	4.98	10.33	-0.0425		23.90
11	-0.1555	4.0496	1.5155	1.4131	1.3891	4.98	10.55	-0.1400		24.00
12	-0.2121	4.1310	1.4419	1.4254	1.4549	4.96	11.10	-0.1748		24.10
13	-0.2080	4.1503	1.4144	1.3617	1.5771	4.94	11.46	-0.1126		24.05
14	-0.1945	4.2800	1.3560	1.4043	1.5414	4.93	12.20	-0.1143		23.90
15	-0.1208	4.3896	1.3709	0.9434	1.3350	4.96	12.79	-0.1220		24.00
16	-0.1921	4.4542	1.3072	1.4318	1.6005	4.97	13.29	-0.1374		24.00
17	-0.2059	4.4706	1.2583	1.5708	1.6372	4.97	13.85	-0.1429		23.80
18	-0.1994	4.5251	1.2237	1.3912	1.4304	4.96	14.40	-0.1044		23.90
19	-0.1730	4.6121	1.1964	1.0790	1.4477	4.96	15.09	-0.1175		23.75
20	-0.1429	4.7297	1.1960	0.1961	0.8190	4.97	15.82	-0.1234		24.15
21	-0.1177	4.7782	1.2302	1.4067	1.4631	4.97	16.20	-0.1224		24.10
22	-0.1193	4.8274	1.1697	1.6320	1.6211	4.98	16.81	-0.1160		24.00
23	-0.1233	4.8851	1.1576	1.3352	1.4171	4.99	17.30	-0.1305		24.10
24	-0.1485	4.9028	1.1041	1.2785	1.3973	4.97	18.02	-0.1227		23.70
25	-0.1851	4.9400	1.0123	1.6069	1.5762	4.99	18.45	-0.1613		24.10
26	-0.2089	4.9017	0.9623	1.6050	1.6067	4.99	19.00	-0.1244		24.05
27	-0.2101	4.9567	0.9190	1.4987	1.5715	4.97	19.56	-0.1478		24.10
28	-0.1713	5.0106	0.8822	1.0103	1.3320	4.97	20.14	-0.0938		23.90
29	-0.1973	5.0306	0.8237	1.4384	1.5887	4.96	20.91	-0.1064		23.95
30	-0.1663	5.0730	0.8087	0.9900	1.4865	4.98	21.65	-0.1238		24.15

TABLE 10
EXPERIMENTAL DATA FOR DILUTION RUN #11

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LORD	0.0429	2.5542		4.6967	4.814					
INITIAL	0.0004	2.4506	2.0513	0.9030	0.9118	4.92	5.46			
1	0.0048	2.5352	2.0450	1.5634	1.5577	5.07	5.82	-0.1282		24.00
2	0.0148	2.6499	2.0437	1.9345	1.9430	5.02	6.05	-0.1227		24.15
3	0.0212	2.8365	2.0138	1.6096	1.6195	5.03	6.57	-0.1516		24.05
4	0.0035	2.9657	1.9637	1.7789	1.8131	5.02	7.18	-0.1290		23.95
5	-0.0101	3.2320	1.8983	1.5907	1.6337	5.02	8.07	-0.1414		24.00
6	-0.0214	3.3291	1.8517	1.5696	1.6423	5.03	8.62	-0.1470		23.95
7	-0.0434	3.4388	1.8228	1.7322	1.8130	5.02	9.06	-0.1533		23.85
8	-0.0289	3.5569	1.7793	1.8949	1.9479	5.03	9.61	-0.0906		23.95
9	-0.0239	3.6980	1.7506	1.9572	1.9845	5.03	10.08	-0.1139		23.90
10	-0.0190	3.8365	1.7172	1.9599	1.9606	5.04	10.65	-0.1510		24.00
11	-0.0495	3.9312	1.6674	1.9273	1.9331	5.01	11.31	-0.0901		23.90
12	-0.0743	4.0312	1.6114	2.0617	2.0720	5.03	11.76	-0.1366		24.15
13	-0.0452	4.1562	1.5844	2.0140	1.9549	5.04	12.43	-0.1005		24.20
14	-0.0265	4.3012	1.5562	2.0610	2.0856	5.01	12.98	-0.1317		23.95
15	-0.0397	4.4449	1.5252	1.4421	1.6234	5.02	13.71	-0.0736		24.05
16	0.0031	4.5204	1.5130	2.0317	2.0824	5.02	14.07	-0.0795		23.90
17	-0.0014	4.6724	1.5119	2.0316	1.9660	5.01	14.62	-0.1486		23.65
18	-0.0203	4.7109	1.4677	2.1334	2.1756	5.01	15.05	-0.1235		24.00
19	-0.0048	4.7941	1.4345	2.1421	2.1020	5.02	15.61	-0.1162		24.00
20	-0.0009	4.9302	1.4146	2.0589	2.0350	5.01	16.14	-0.1259		24.00
21	0.0005	5.0739	1.3614	1.6724	1.7910	5.01	17.07	-0.1252		24.05
22	0.0213	5.1631	1.3507	2.1175	2.1510	5.01	17.53	-0.1235		23.90
23	0.0222	5.2425	1.3124	1.6586	1.8183	5.03	18.19	-0.1116		23.95
24	0.0196	5.3903	1.2607	1.2670	1.5629	5.03	19.23	-0.1284		24.05
25	0.0099	5.5196	1.1933	1.5356	1.7223	5.03	20.07	-0.1221		23.95
26	0.0246	5.6103	1.1614	1.9094	2.0113	5.02	20.76	-0.1209		23.95
27	0.0291	5.7073	1.1384	1.6388	1.7750	5.03	21.43	-0.1103		23.90

TABLE 11
EXPERIMENTAL DATA FOR DILUTION RUN #14

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LORD	0.1383	4.7762		4.5506	4.6143					
INITIAL	1.212	3.0331	2.9005	5.0702	5.0538	7.25	7.46			
1	1.1828	3.2669	2.8552	1.6854	2.0098	7.24	8.00	-0.1659		23.90
2	1.1821	3.3933	2.8196	2.3756	2.4948	7.23	8.22	-0.1478		23.95
3	1.2058	3.6527	2.7970	2.3258	2.6391	7.24	8.72	-0.1476		23.95
4	1.2048	3.8556	2.7865	2.4097	2.7025	7.24	9.16	-0.1861		24.00
5.1	1.2053	3.9713	2.7603	2.3982	2.7183	7.24	9.52	-0.1628		23.95
5.2	1.4950	4.9784	3.0421	6.4103	6.4604	7.37	9.68			
6	1.5081	5.1232	3.0059	2.6753	2.9110	7.38	10.33	-0.1414		24.05
7	1.5187	5.2809	2.9891	2.5616	2.9549	7.39	10.69	-0.1476		24.10
8	1.5057	5.4537	2.9488	2.5994	2.9334	7.38	11.30	-0.1727		24.15
9	1.5051	5.5848	2.9157	2.6438	3.0197	7.39	11.89	-0.1727		24.00
10	1.4990	5.6705	2.8770	2.6003	2.9584	7.38	12.49	-0.1534		23.85
11	1.5005	5.8123	2.8165	2.4775	2.9991	7.39	13.26	-0.1491		24.20
12	1.4994	5.9376	2.7701	2.6837	3.0193	7.39	14.04	-0.1471		24.20
13	1.5001	6.0399	2.7014	2.7272	3.0537	7.40	14.73	-0.1252		24.05
14	1.4926	6.1177	2.6845	2.5630	2.9988	7.38	15.41	-0.1094		24.10
15	1.4849	6.2169	2.6384	2.6699	3.0370	7.38	16.09	-0.1505		24.10
16	1.4953	6.3252	2.5851	2.5487	2.9721	7.38	17.02	-0.1385		24.15
17	1.5043	6.4019	2.5291	2.6494	3.0885	7.38	18.12	-0.1395		24.15
18	1.4951	6.5074	2.4604	2.7569	3.0939	7.38	19.44	-0.1212		24.10
19	1.4811	6.5507	2.4001	2.6770	3.0816	7.39	20.26	-0.1371		23.95
20	1.4821	6.5929	2.2968	2.7160	3.0464	7.38	21.20	-0.1205		24.10
21	1.4733	6.6349	2.2392	2.7013	2.9505	7.39	22.02	-0.1257		23.95
22	1.4781	6.6773	2.1555	2.4756	2.7629	7.39	23.13	-0.1268		24.00
23	1.4512	6.7098	2.1294	2.4542	2.8202	7.38	24.28	-0.1302		23.90

TABLE 12

EXPERIMENTAL DATA FOR DILUTION RUN #15

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LOAD	1.4258	5.1184		4.3619	4.3765					
INITIAL	1.4053	3.6757	3.0925	2.0034	2.0236	7.37	7.56			
1	1.3977	3.8650	3.0458	1.4946	1.5224	7.39	8.13	-0.1556		24.00
2	1.3923	3.9367	3.0265	2.1541	2.1870	7.38	8.66	-0.1219		24.00
3	1.4001	4.1658	2.9705	2.2957	2.3369	7.38	9.32	-0.1492		23.85
4	1.4114	4.2907	2.9412	2.3032	2.3453	7.39	9.05	-0.1393		24.20
5	1.4163	4.4334	2.9075	2.5755	2.3787	7.38	10.36	-0.1139		23.95
6	1.4231	4.6186	2.8856	2.3473	2.4042	7.38	11.11	-0.1030		23.95
7	1.4147	4.8227	2.8391	2.2610	2.3183	7.37	12.12	-0.0950		24.00
8	1.4200	5.1144	2.7424	1.4669	1.5705	7.38	13.55	-0.1072		24.00
9	1.4251	5.2610	2.7108	2.5313	2.5797	7.38	14.05	-0.1412		24.15
10	1.4319	5.4019	2.6736	2.4993	2.5383	7.39	14.87	-0.1134		24.05
11	1.4403	5.5543	2.5941	2.5587	2.6074	7.39	15.70	-0.1101		23.95
12	1.4500	5.7077	2.5742	2.5376	2.5783	7.39	16.54	-0.1423		23.90

TABLE 13
EXPERIMENTAL DATA FOR DILUTION RUN #16

TILT #	CR	C	A	C2	C1	BR	B	d _{el} C	p _i	d _{el} U
LOAD										
INITIAL	1.4502	4.2467		4.3080	4.3587					
	1.4563	3.9456	3.1057	1.4967	1.5001	7.38	7.7			
1	1.4643	5.5315	2.7282	1.0153	1.0708	7.38	14.30	-0.1309		23.95
2	1.4662	5.6650	2.6700	2.7150	2.7469	7.39	15.01	-0.1124		23.90
3	1.4533	5.8372	2.6146	2.7419	2.7732	7.38	15.93	-0.1246		23.90
4	1.4546	5.9970	2.5591	2.7732	2.8232	7.39	16.89	-0.1169		24.05
5	1.4473	6.1656	2.4913	2.8688	2.5796	7.38	17.98	-0.1253		24.00
6	1.4554	6.2837	2.4503	2.7778	2.8305	7.38	18.91	-0.0905		23.90
7	1.4505	6.4654	2.3553	2.7821	2.8296	7.40	20.16	-0.0961		24.05
8	1.4572	6.6271	2.3051	2.9022	2.9534	7.39	21.18	-0.1170		23.95
9	1.4519	6.7853	2.2343	2.7568	2.9824	7.38	22.37	-0.1187		24.05

TABLE 14

EXPERIMENTAL DATA FOR DILUTION RUN #17

TILT #	CR	C	A	C2	C1	BR	B	del C	pi	del U
LOAD	1.6693	4.8263		4.7747	4.8066					
INITIAL	1.4803	3.6977	3.1551	0.5530	0.6344	7.41	7.53			
1	1.4998	3.9899	3.1422	3.6494	3.6711	7.42	7.81	-0.0970		23.95
2	1.4938	4.2256	3.1104	3.6239	3.6384	7.42	8.16	-0.0999		23.90
3	1.4958	4.5621	3.0732	3.4939	3.5097	7.41	8.87	-0.0919		24.00
4	1.4973	4.9340	3.0210	3.6207	3.6539	7.41	9.79	-0.0893		24.00
5	1.5001	5.2574	2.9668	3.6376	3.6570	7.42	10.90	-0.1067		23.90
6	1.6885	5.7181	3.0525	3.6955	3.7186	7.43	11.65	-0.1004		23.85
7	1.4972	5.8613	2.8503	3.4873	3.5042	7.41	12.73	-0.0955		24.00
8	1.5002	6.0487	2.7830	3.5488	3.5758	7.40	13.71	-0.0915		23.95
9	1.5309	6.2841	2.7352	3.5981	3.6202	7.43	14.60	-0.1062		23.80
10	1.4966	6.6116	2.6504	3.5594	3.5835	7.41	15.65	-0.1057		23.85
11	1.4912	6.6322	2.5494	3.7559	3.7918	7.42	16.48	-0.1067		24.05
12	1.4924	6.7105	2.5061	3.6312	3.6522	7.40	17.47	-0.0916		24.00
13	1.4995	6.7949	2.4534	3.5287	3.5502	7.42	18.57	-0.1028		24.00
14	1.4991	6.8284	2.3932	3.6175	3.6390	7.41	19.40	-0.1109		23.90
15	1.4864	6.8888	2.3011	3.5683	3.5959	7.40	20.81	-0.0942		23.75
16	1.4971	6.9591	2.2562	3.6075	3.6398	7.40	21.98	-0.0939		24.00
17	1.4780	7.0082	2.1492	3.6066	3.6387	7.40	23.28	-0.1004		23.95
18	1.4728	7.0710	2.0440	3.5775	3.6031	7.40	24.59	-0.1064		24.00

TABLE 15
EXPERIMENTAL DATA FOR DILUTION RUN #18

TILT #	CR	C	A	C2	C1	BR	B	del C pi	del U
LOAD	1.4733	4.4019		4.4671	4.5049				
INITIAL	1.4761	3.165	3.1183	1.9499	1.9903	7.41	7.53		
1	1.4586	3.2160	3.1107	3.4934	3.5430	7.40	7.70	-0.1475	24.05
2	1.4653	3.3559	3.0587	3.6070	3.6483	7.39	8.23	-0.1453	23.80
3	1.4487	3.5698	3.0041	3.5052	3.5616	7.40	8.71	-0.1470	24.00
4	1.4704	3.7520	2.9751	3.4841	3.7107	7.39	9.19	-0.1370	24.00
5	1.4464	3.9385	2.9523	3.4342	3.5579	7.39	9.85	-0.1698	24.00
6	1.4577	4.1639	2.9334	3.4355	3.5582	7.40	10.61	-0.1409	23.90
7	1.4753	4.3852	2.8953	3.5083	3.5157	7.39	11.33	-0.1292	24.00
8	1.4634	4.5803	2.8629	3.5451	3.5131	7.39	12.00	-0.1465	24.05
9	1.4760	4.7725	2.8170	3.5446	3.6673	7.39	12.86	-0.1482	24.05
10	1.4691	5.0036	2.7539	3.3911	3.4403	7.39	13.80	-0.1295	24.00
11	1.4767	5.2522	2.6840	3.4965	3.5224	7.37	14.92	-0.1353	23.95

TABLE 16

EXPERIMENTAL DATA FOR DILUTION RUN #19

TILT #	CR	C	A	C2	C1	BR	E	del C	pi	del U
LOAD	1.4677	4.4802		4.5317	4.5457					
INITIAL	1.4656	2.7230	3.1433	2.4702	2.4996	7.39	7.53			
1	1.4867	4.7768	2.8637	5.5585	5.6044	7.37	12.01	-0.1244		23.95
2	1.4750	5.0968	2.7595	3.9863	4.0257	7.38	13.80	-0.1373		23.95
3	1.4825	5.0501	2.7177	3.8437	3.8914	7.39	14.55	-0.1423		24.00
4	1.4857	5.0127	2.6963	4.0530	4.1912	7.38	15.06	-0.2313		24.05
5	1.4673	5.0745	2.6071	5.3330	5.3741	7.38	16.19	-0.1438		24.00
6	1.4781	5.3506	2.5121	3.6876	3.7224	7.39	17.90	-0.0954		23.95
7	1.4813	5.4986	2.4756	3.5270	3.5583	7.38	18.69	-0.1088		24.10
8	1.4793	5.7094	2.3951	3.5507	3.5914	7.39	19.99	-0.0886		24.00
9	1.5002	5.9557	2.3265	3.5816	3.6145	7.38	21.40	-0.0854		23.90

APPENDIX C
CALCULATED DATA

NOMENCLATURE FOR APPENDIX C

CTOT	Cumulative change in height of mercury in C
del A	Change in height of mercury in mixing bowl
del B	Change in height of mercury in buret
del C, C1, C2	Change in height of mercury in a capillary
del n_c	Number of moles of solute added to solvent
del V_c	Volume of solute added to the solvent
del V_{em}	Excess molar volume of mixing
n_{cTOT}	Total number of moles of solute in mixing bowl
x (Benz)	Mole fraction of benzene in mixing bowl

APPENDIX C-1

SPREADSHEET GENERATED DATA

TABLE 17

CALCULATED DATA FOR DILUTION RUN #2

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL V ₀	DEL n ₀	n ₀ TOT	x (BENZ)	C TOT	DEL V ₀	DEL V ₀ (P CORR)
1	0.17	2.5873	2.1567	0.2726	-0.0446	0.21754	0.00200	0.00200	0.98259	0.2726	0.00563	0.048985
2	0.13	0.2488	0.4232	0.1467	-0.0268	0.11391	0.00104	0.00304	0.97372	0.4193	0.00792	0.068332
3	0.09	0.1752	0.4516	0.1075	0.0657	0.08173	0.00075	0.00379	0.96745	0.5268	0.00819	0.070150
4	0.12	0.8436	0.7666	0.1295	-0.0659	0.12271	0.00112	0.00492	0.95819	0.6563	0.01283	0.108880
5	0.06	0.7664	0.9173	0.1385	0.0148	0.07695	0.00070	0.00563	0.95247	0.7948	0.01385	0.116851
6	0.12	0.6753	0.5941	0.0997	-0.0456	0.11666	0.00107	0.00670	0.94394	0.8945	0.01668	0.139468
7	0.48	-1.5104	-2.0987	0.3619	-0.0120	0.31251	0.00287	0.00958	0.92180	1.2564	0.02249	0.183574
8	0.66	-1.2933	-0.7191	0.5403	-0.0140	0.48208	0.00443	0.01401	0.88961	1.7967	0.03214	0.253147
9	0.53	-0.1866	-0.3739	0.4206	-0.0193	0.40584	0.00373	0.01774	0.86421	2.2173	0.03971	0.303852
10	0.16	0.0364	-0.0824	0.1122	-0.0426	0.12470	0.00114	0.01889	0.85670	2.3295	0.04210	0.319363
11	0.23	0.5613	0.8409	0.2211	-0.0146	0.20532	0.00188	0.02078	0.84460	2.5506	0.04554	0.340557
12	0.56	-0.4124	-0.7131	0.3892	-0.0047	0.41935	0.00385	0.02463	0.82093	2.9398	0.05301	0.385329
13	0.13	-0.1426	0.1329	0.0613	-0.0047	0.10181	0.00093	0.02557	0.81538	3.0011	0.05337	0.385332
14	0.24	0.9999	1.0112	0.2211	-0.0183	0.22290	0.00204	0.02762	0.80349	3.2222	0.05758	0.409599
15	0.64	-1.0333	-1.1173	0.3064	-0.0172	0.46392	0.00426	0.03188	0.77983	3.5286	0.06286	0.433999
16	0.17	0.0319	0.0577	0.1387	-0.0014	0.13495	0.00124	0.03313	0.77320	3.6673	0.06515	0.446027
17	0.69	-0.0184	-0.0265	0.4841	-0.0295	0.54052	0.00497	0.03810	0.74776	4.1514	0.07426	0.491665
18	0.32	-0.0418	-0.0154	0.1622	-0.0351	0.25003	0.00229	0.04040	0.73655	4.3136	0.07721	0.503508
19	0.37	0.1062	0.1107	0.2209	-0.0140	0.29412	0.00270	0.04310	0.72379	4.5345	0.08072	0.517239
20	0.29	0.0620	0.0506	0.1737	-0.0291	0.22950	0.00211	0.04521	0.71413	4.7082	0.08409	0.531683
21	0.19	-0.1171	-0.0843	0.0986	0.0259	0.14548	0.00133	0.04655	0.70814	4.8068	0.08487	0.532071
22	0.49	-0.2070	-0.1851	0.2429	-0.0505	0.37745	0.00347	0.05002	0.69306	5.0497	0.09051	0.555400
23	0.39	0.0956	0.0752	0.1851	-0.0274	0.30899	0.00284	0.05286	0.68118	5.2348	0.09356	0.564226
24	0.24	0.0551	0.0711	0.0732	-0.0327	0.19052	0.00175	0.05461	0.67406	5.3080	0.09477	0.565601
25	0.70	-0.0102	0.0484	0.3262	-0.0477	0.54984	0.00505	0.05967	0.65432	5.6342	0.10077	0.583754
26	0.23	0.0513	-0.0448	0.1215	0.0073	0.18055	0.00166	0.06133	0.64809	5.7557	0.10201	0.585293
27	0.12	0.1375	0.1583	0.0512	0.0011	0.09939	0.00091	0.06224	0.64471	5.8069	0.10314	0.588741
28	0.19	-0.0850	-0.1026	0.0924	-0.0207	0.14572	0.00134	0.06358	0.63981	5.8993	0.10515	0.595641
29	0.12	0.0436	0.0468	0.0534	-0.0304	0.09574	0.00088	0.06446	0.63664	5.9527	0.10618	0.598474
30	0.48	-0.1608	-0.1109	0.1935	-0.0296	0.37174	0.00341	0.06788	0.62460	6.1462	0.10970	0.606660
31	0.23	0.0610	0.0831	0.1126	0.0116	0.18299	0.00168	0.06956	0.61884	6.2588	0.11071	0.607657
32	0.31	0.0850	0.0724	0.0962	-0.0373	0.24599	0.00226	0.07183	0.61127	6.3550	0.11342	0.613835
33	0.27	-0.2315	-0.2178	0.1037	0.0005	0.20384	0.00187	0.07370	0.60513	6.4587	0.11459	0.613927
34	0.29	0.2093	0.1986	0.1400	-0.0211	0.23474	0.00215	0.07586	0.59821	6.5987	0.11752	0.622424

TABLE 17

CALCULATED DATA FOR DILUTION RUN #2 (CONTINUED)

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL V ₀	DEL M ₀	M ₀ TOT	x (BENZ)	C TOT	DEL V ₀	DEL V ₀ (P CORR)
35	0.33	-0.0421	-0.0912	0.1150	-0.0223	0.25652	0.00235	0.07822	0.59083	6.7137	0.11964	0.625833
36	0.26	-0.0679	-0.0409	0.0951	-0.0070	0.20204	0.00185	0.08008	0.58514	6.8088	0.12104	0.627072
37	0.25	0.1711	0.1878	0.1032	-0.0099	0.20249	0.00186	0.08194	0.57955	6.9120	0.12282	0.630177
38	0.44	-0.1362	-0.2524	0.1390	-0.0642	0.33829	0.00311	0.08505	0.57045	7.0510	0.12633	0.638050
39	0.28	0.0872	0.2020	0.1130	0.0321	0.22479	0.00206	0.08712	0.56456	7.1640	0.12663	0.632918
40	0.41	-0.3160	-0.0278	0.1377	-0.0373	0.31555	0.00290	0.09002	0.55648	7.3017	0.13035	0.642213
41	0.27	0.3213	0.0426	0.0946	-0.0158	0.21827	0.00200	0.09203	0.55104	7.3963	0.13156	0.641809
42	0.38	-0.0001	-0.0177	0.1239	-0.0514	0.29780	0.00273	0.09476	0.54377	7.5202	0.13425	0.646297
43	0.32	-0.0757	-0.0611	0.1215	-0.0305	0.24861	0.00228	0.09705	0.53785	7.6417	0.13627	0.648383
44	0.90	-0.1663	-0.1746	0.2589	-0.0213	0.70001	0.00643	0.10349	0.52186	7.9006	0.14063	0.649757
45	0.38	0.1450	0.1692	0.1062	-0.0579	0.30369	0.00279	0.10628	0.51521	8.0068	0.14309	0.652676
46	0.60	-0.1200	-0.1380	0.1665	0.0098	0.46613	0.00428	0.11057	0.50533	8.1733	0.14492	0.648356
47	0.56	0.1481	0.1710	0.1458	-0.0376	0.44499	0.00409	0.11466	0.49624	8.3191	0.14818	0.651022
48	0.42	-0.1504	-0.1547	0.1062	-0.0063	0.32408	0.00298	0.11764	0.48983	8.4253	0.14964	0.648933
49	0.46	0.2376	0.2248	0.1595	-0.0385	0.36908	0.00339	0.12103	0.48273	8.5848	0.15286	0.653309
50	0.46	-0.0328	-0.0145	0.1399	0.0228	0.36004	0.00331	0.12434	0.47599	8.7247	0.15434	0.650431

VOLUME OF BENZENE CHARGED RUN #2= 10.0983
 MOLES OF BENZENE CHARGED RUN #2= 0.11295

TABLE 18

CALCULATED DATA FOR DILUTION RUN #3

TILT	DEL A	DEL C1	DEL C2	DEL C	DEL A	DEL Vb	DEL mb	mb TOT	x (BENZ)	C TOT	DEL Vø	DEL Vm (P CORR)
1	0.10	1.8114	1.8127	0.2553	0.0037	0.14276	0.00159	0.00159	0.01419	0.2553	0.00437	0.038921
2	0.20	0.1724	0.1661	0.2161	-0.0407	0.16291	0.00182	0.00341	0.02991	0.2161	0.00454	0.039805
3	0.15	0.0195	0.0185	0.2088	0.0002	0.11835	0.00132	0.00474	0.04102	0.2088	0.00370	0.032020
4	0.30	-0.0189	-0.0271	0.3229	-0.0172	0.23453	0.00262	0.00736	0.06230	0.3229	0.00602	0.051000
5	0.16	-0.0184	-0.0078	0.2231	-0.0144	0.12505	0.00139	0.00876	0.07327	0.2231	0.00421	0.035235
6	0.22	-0.0679	-0.0634	0.2569	-0.0198	0.17027	0.00190	0.01066	0.08779	0.2569	0.00491	0.040415
7	0.20	0.1145	0.1136	0.1935	-0.0021	0.16095	0.00180	0.01247	0.10111	0.1935	0.00346	0.028128
8	0.14	-0.0829	-0.0895	0.1487	-0.0245	0.10677	0.00119	0.01366	0.10973	0.1487	0.00307	0.024666
9	0.15	0.0869	0.0919	0.1295	0.0514	0.12085	0.00135	0.01501	0.11929	0.1295	0.00138	0.011004
10	0.26	0.0100	0.0152	0.2769	-0.0621	0.20442	0.00228	0.01730	0.13500	0.2769	0.00601	0.046912
11	0.17	0.0553	0.0483	0.1795	-0.0251	0.13520	0.00151	0.01881	0.14509	0.1795	0.00363	0.028008
12	0.13	0.0250	0.0349	0.0979	0.0032	0.10305	0.00115	0.01996	0.15262	0.0979	0.00167	0.012839
13	0.18	-0.1046	-0.1018	0.1575	0.0053	0.13755	0.00153	0.02150	0.16247	0.1575	0.00269	0.020387
14	0.35	-0.2416	-0.2534	0.2659	-0.0189	0.26579	0.00297	0.02447	0.18087	0.2659	0.00505	0.037324
15	0.21	0.2382	0.2365	0.1832	-0.0302	0.17317	0.00193	0.02641	0.19243	0.1832	0.00378	0.027575
16	0.11	-0.0923	-0.1084	0.1010	-0.0057	0.08273	0.00092	0.02734	0.19783	0.1010	0.00189	0.013707
17	0.20	0.0953	0.1033	0.1330	0.0038	0.16042	0.00179	0.02913	0.20811	0.1330	0.00229	0.016369
18	0.16	-0.0171	-0.0052	0.1229	-0.0125	0.12512	0.00139	0.03053	0.21595	0.1229	0.00240	0.016953
19	0.18	-0.0610	-0.0771	0.1294	-0.0119	0.13876	0.00155	0.03208	0.22447	0.1294	0.00250	0.017536
20	0.22	0.1360	0.1531	0.1668	-0.0267	0.17772	0.00198	0.03407	0.23510	0.1668	0.00343	0.023685
21	0.16	0.0352	0.0394	0.0661	-0.0098	0.12684	0.00141	0.03549	0.24252	0.0661	0.00134	0.009201
22	0.19	-0.1003	-0.1274	0.1438	0.0048	0.14501	0.00162	0.03711	0.25082	0.1438	0.00246	0.016671
23	0.20	0.0102	0.0390	0.1094	-0.0183	0.15777	0.00176	0.03888	0.25965	0.1094	0.00226	0.015132
24	0.20	-0.0654	-0.0930	0.1058	-0.0293	0.15409	0.00172	0.04060	0.26808	0.1058	0.00239	0.015816
25	0.18	0.0622	0.0854	0.1224	0.0043	0.14383	0.00160	0.04221	0.27577	0.1224	0.00209	0.013685
26	0.19	-0.0568	-0.0571	0.1133	-0.0201	0.14703	0.00164	0.04385	0.28347	0.1133	0.00236	0.015292
27	0.14	-0.0318	-0.0171	0.0857	0.0008	0.10896	0.00121	0.04507	0.28907	0.0857	0.00150	0.009658
28	0.20	0.0313	0.0229	0.0922	-0.0209	0.15786	0.00176	0.04684	0.29703	0.0922	0.00200	0.012715
29	0.12	-0.0647	-0.0647	0.0954	-0.0012	0.09184	0.00102	0.04787	0.30158	0.0954	0.00171	0.010302
30	0.21	-0.0437	-0.0496	0.0824	-0.0129	0.16309	0.00182	0.04969	0.30951	0.0824	0.00169	0.010527
31	0.20	0.1287	0.1276	0.0566	-0.0142	0.16145	0.00180	0.05150	0.31719	0.0566	0.00125	0.007739
32	0.41	-0.0933	-0.1305	0.2098	-0.0077	0.31768	0.00355	0.05505	0.33182	0.2098	0.00385	0.023258
33	0.18	0.0241	0.0456	0.1127	-0.0179	0.14245	0.00159	0.05664	0.33817	0.1127	0.00231	0.013839
34	0.15	0.0637	0.0655	0.0769	-0.0092	0.11997	0.00134	0.05798	0.34343	0.0769	0.00152	0.009051

TABLE 18

CALCULATED DATA FOR DILUTION RUN #3 (CONTINUED)

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vb	DEL nb	nb TOT	x (BENZ)	C TOT	DEL V ₀	DEL V _{0m} (P CORR)
35	0.22	0.0879	0.1024	0.1641	-0.0122	0.17597	0.00196	0.05995	0.35100	0.1641	0.00313	0.018332
36	0.23	-0.1033	-0.1261	0.0910	-0.0058	0.17636	0.00197	0.06193	0.35841	0.0910	0.00171	0.009939
37	0.23	0.0676	0.0554	0.0833	-0.0322	0.18262	0.00204	0.06397	0.36590	0.0833	0.00204	0.011721
38	0.19	0.0232	0.0402	0.0690	-0.0043	0.15018	0.00167	0.06555	0.37194	0.0690	0.00130	0.007368
39	0.24	-0.1472	-0.1432	0.1081	-0.0190	0.18313	0.00204	0.06770	0.37914	0.1081	0.00225	0.012629
40	0.22	0.0116	0.0293	0.0912	-0.0215	0.17332	0.00193	0.06964	0.38591	0.0912	0.00199	0.011078
41	0.21	0.0986	0.0994	0.0909	0.0013	0.16826	0.00188	0.07152	0.39215	0.0909	0.00159	0.008721
42	0.32	0.0448	0.0455	0.0990	-0.0349	0.25264	0.00282	0.07434	0.40142	0.0990	0.00237	0.012824
43	0.16	-0.0122	-0.0039	0.0716	0.0096	0.12523	0.00140	0.07574	0.40592	0.0716	0.00110	0.005896
44	0.25	0.0217	0.0132	0.0832	-0.0211	0.19674	0.00220	0.07795	0.41284	0.0832	0.00185	0.009805
45	0.20	0.0404	-0.0085	0.0900	-0.0101	0.15746	0.00176	0.07971	0.41827	0.0900	0.00177	0.009319
46	0.25	-0.0680	-0.0250	0.0711	-0.0132	0.19448	0.00217	0.08188	0.42483	0.0711	0.00149	0.007762
47	0.17	-0.1079	-0.1079	0.0483	-0.0079	0.12953	0.00144	0.08333	0.42912	0.0483	0.00099	0.005133
48	0.21	0.0553	0.0610	0.0998	-0.0238	0.16681	0.00186	0.08520	0.43456	0.0998	0.00219	0.011190
49	0.29	-0.0450	-0.0521	0.0808	-0.0036	0.22578	0.00252	0.08772	0.44175	0.0808	0.00149	0.007546
50	0.21	0.0573	0.0555	0.0785	-0.0173	0.16675	0.00186	0.08959	0.44694	0.0785	0.00170	0.008487
51	0.38	-0.0267	-0.0231	0.0805	-0.0226	0.29723	0.00332	0.09291	0.45597	0.0805	0.00182	0.008970
52	0.23	0.0665	0.0586	0.0915	-0.0216	0.18265	0.00204	0.09496	0.46137	0.0915	0.00200	0.009758
53	0.27	-0.0272	-0.0202	0.0811	0.0097	0.21097	0.00235	0.09732	0.46747	0.0811	0.00128	0.006173
54	0.26	-0.0355	-0.0249	0.0662	-0.0444	0.20290	0.00226	0.09959	0.47321	0.0662	0.00196	0.009330
55	0.32	0.0303	0.0261	0.0821	-0.0106	0.25204	0.00281	0.10240	0.48018	0.0821	0.00164	0.007712
56	0.26	-0.0221	-0.0273	0.0773	0.0023	0.20309	0.00227	0.10468	0.48566	0.0773	0.00133	0.006174

VOLUME OF T-C-E CHARGED RUN #3=

9.91122

MOLES OF T-C-E CHARGED RUN #3=

0.11086

TABLE 19

CALCULATED DATA FOR DILUTION RUN #4

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vc	DEL nc	nc TOT	x (BENZ)	C TOT	DEL Vc	DEL Vem (P CORR)
1	0.02	3.0082	3.0812	0.2007	-0.0098	0.12374	0.00137	0.00137	0.98775	0.2007	0.00370	0.032925
2	0.09	0.3788	0.3398	0.1693	-0.0028	0.08335	0.00092	0.00230	0.97967	0.3690	0.00659	0.058193
3	0.14	-0.0313	-0.0203	0.0563	-0.0157	0.10891	0.00121	0.00351	0.96930	0.4253	0.00782	0.068311
4	0.24	-0.6900	-0.6970	0.1050	-0.0607	0.16367	0.00182	0.00533	0.95414	0.5303	0.01047	0.090015
5	0.51	-0.2598	-0.6232	0.2762	-0.0178	0.38444	0.00427	0.00961	0.92031	0.8065	0.01463	0.121237
6	0.28	0.7050	0.7834	0.0969	-0.0163	0.24607	0.00273	0.01235	0.89989	0.9034	0.01631	0.132179
7	0.19	-0.3212	-0.2298	0.0988	0.0247	0.13928	0.00154	0.01390	0.88873	1.0022	0.01736	0.138927
8	0.10	0.6767	0.8534	0.0730	0.0026	0.10560	0.00117	0.01507	0.88045	1.0752	0.01903	0.150946
9	0.20	-0.4883	-0.4724	0.0707	-0.0221	0.13985	0.00155	0.01663	0.86972	1.1459	0.02072	0.162327
10	0.23	0.2244	-0.2482	0.0856	-0.0600	0.18001	0.00200	0.01863	0.85629	1.2295	0.02286	0.176276
11	0.13	0.2064	0.6951	0.0505	-0.0103	0.11799	0.00131	0.01995	0.84771	1.2800	0.02255	0.172161
12	0.53	-0.6174	-1.0909	0.1861	-0.0566	0.38547	0.00428	0.02423	0.82084	1.4661	0.02701	0.199639
13	0.14	0.3646	0.5679	0.0959	-0.0459	0.12638	0.00140	0.02564	0.81239	1.5620	0.02692	0.196983
14	0.23	-0.1084	-0.0206	0.0445	-0.0350	0.17815	0.00198	0.02762	0.80078	1.6065	0.02911	0.209921
15	0.28	-0.0453	-0.1332	0.0938	-0.0262	0.21649	0.00240	0.03003	0.78711	1.7003	0.03247	0.224358
16	0.43	-0.1493	-0.2626	0.1007	-0.0196	0.33003	0.00367	0.03370	0.76714	1.8737	0.03326	0.228543
17	0.08	0.1399	0.2535	0.0727	0.0018	0.06974	0.00077	0.03448	0.76305	1.8802	0.03377	0.225977
18	0.15	0.1354	0.1577	-0.0285	-0.0064	0.12287	0.00136	0.03585	0.75595	1.8452	0.03283	0.223511
19	0.30	-0.0585	-0.2733	0.0350	-0.0242	0.22946	0.00255	0.03840	0.74303	1.9516	0.03493	0.229027
20	0.35	-0.1704	0.2948	0.0714	-0.0127	0.27679	0.00307	0.04148	0.72803	1.9633	0.03505	0.225309
21	0.35	-0.0427	-0.1377	0.0117	-0.0130	0.27137	0.00301	0.04450	0.71390	2.1262	0.03850	0.238882
22	0.66	-0.1817	-0.4429	0.1629	-0.0438	0.50669	0.00563	0.05014	0.68893	2.1986	0.03971	0.240861
23	0.41	0.1792	0.3489	0.0724	-0.0396	0.33102	0.00368	0.05382	0.67354	2.2910	0.04089	0.243926
24	0.31	0.2725	0.1226	0.0924	-0.0130	0.25021	0.00278	0.05661	0.66236	2.3401	0.04163	0.243340
25	0.39	-0.0627	0.0857	0.0491	-0.0058	0.30637	0.00340	0.06002	0.64916	2.4076	0.04312	0.247412
26	0.37	-0.0809	-0.0359	0.0675	-0.0243	0.28820	0.00320	0.06322	0.63721	2.4522	0.04395	0.245977
27	0.50	0.1535	0.1503	0.0446	-0.0278	0.39765	0.00442	0.06765	0.62144	2.5367	0.04522	0.249529
28	0.29	-0.0361	-0.0089	0.0845	-0.0127	0.22671	0.00252	0.07017	0.61279	2.5225	0.04521	0.245385
29	0.30	-0.1317	-0.0785	-0.0142	-0.0231	0.23162	0.00257	0.07275	0.60419	2.5388	0.04582	0.245325
30	0.34	0.1644	0.0010	0.0163	-0.0420	0.26943	0.00300	0.07575	0.59449	2.5572	0.04592	0.240479
31	0.47	0.0395	0.2277	0.0184	-0.0284	0.37346	0.00415	0.07990	0.58155	2.6070	0.04687	0.241702
32	0.35	-0.2528	-0.2202	0.0498	-0.0362	0.26618	0.00296	0.08287	0.57267	2.6614	0.04544	0.228508
33	0.55	0.3518	0.3683	0.0544	0.0936	0.44426	0.00494	0.08781	0.55844	2.7127	0.04933	0.243000
34	0.48	-0.0008	-0.2018	0.0513	-0.0709	0.37297	0.00415	0.09196	0.54702			

TABLE 19

CALCULATED DATA FOR DILUTION RUN #4 (CONTINUED)

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vc	DEL nc	nc TOT	x (BENZ)	C TOT	DEL Vc	DEL Vcm (P CORR)
35	0.43	0.0803	0.0766	0.0923	0.0093	0.34012	0.00378	0.09574	0.53701	2.8050	0.04967	0.240220
36	0.56	-0.0754	0.0197	0.0233	-0.0093	0.43834	0.00487	0.10062	0.52464	2.8283	0.05037	0.237981
37	0.92	-0.0779	-0.2174	0.0601	-0.0697	0.71651	0.00797	0.10859	0.50559	2.8884	0.05249	0.239001
38	0.53	0.2481	0.2286	0.0554	-0.0144	0.42425	0.00472	0.11331	0.49496	2.9438	0.05251	0.234067
39	0.66	0.0769	0.1855	0.0155	-0.0398	0.52244	0.00581	0.11913	0.48246	2.9593	0.05320	0.231137
40	0.54	-0.1146	0.0375	0.0401	-0.0446	0.42227	0.00469	0.12383	0.47281	2.9994	0.05401	0.229943
41	0.71	0.0716	-0.0144	0.0101	-0.0309	0.55802	0.00620	0.13004	0.46063	3.0095	0.05388	0.223501
42	0.79	-0.0389	-0.1571	0.0264	-0.0099	0.61629	0.00685	0.13689	0.44789	3.0359	0.05390	0.217407
43	0.90	0.1829	0.2408	0.1138	-0.0291	0.71358	0.00794	0.14483	0.43399	3.1497	0.05646	0.220670

VOLUME OF BENZENE CHARGED RUN #4= 9.92877
 MOLES OF BENZENE CHARGED RUN #4= 0.11105

TABLE 20

CALCULATED DATA FOR DILUTION RUN #5

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL VB	DEL NB	NB TOT	X (BENZ)	C TOT	DEL V _e	DEL V _{em} (P CORR)
1	0.07	2.1064	2.1096	0.0145	0.0419	0.12972	0.00145	0.00145	0.01301	0.0145	-0.0004	-0.00435
2	0.33	-0.1463	-0.1188	0.0699	-0.0515	0.25418	0.00284	0.00429	0.03754	0.0844	0.00241	0.021074
3	0.24	0.0774	0.0871	0.1651	-0.0004	0.19120	0.00213	0.00643	0.05521	0.2495	0.00443	0.038050
4	0.33	-0.0091	0.0037	0.0634	-0.0048	0.25879	0.00289	0.00932	0.07811	0.3129	0.00563	0.047180
5	0.32	-0.0797	-0.0911	0.0641	-0.0429	0.24801	0.00277	0.01210	0.09904	0.3770	0.00745	0.061023
6	0.30	0.0959	0.0814	0.0918	-0.0103	0.23850	0.00266	0.01476	0.11829	0.4688	0.00849	0.068054
7	0.49	-0.1423	-0.1252	0.1894	-0.0029	0.37966	0.00424	0.01901	0.14729	0.6582	0.01172	0.090837
8	0.54	0.0618	0.0626	0.1593	-0.0794	0.42584	0.00476	0.02377	0.17764	0.8115	0.01581	0.118168
9	0.29	0.0498	0.0560	0.0704	-0.0006	0.22938	0.00256	0.02634	0.19310	0.8819	0.01566	0.114801
10	0.56	-0.1252	-0.1372	0.1287	-0.0387	0.43467	0.00486	0.03120	0.22087	1.0106	0.01859	0.131596
11	0.37	0.3083	0.5119	0.0610	0.0044	0.30482	0.00340	0.03461	0.23923	1.0716	0.01894	0.130895
12	0.46	-0.4458	-0.6416	0.2073	-0.0374	0.34158	0.00382	0.03843	0.25880	1.2789	0.02335	0.157255
13	0.53	0.2396	0.2345	0.0660	-0.0273	0.42420	0.00474	0.04318	0.28175	1.3449	0.02434	0.158838
14	0.96	-0.1690	-0.1819	0.2256	-0.0535	0.74691	0.00835	0.05153	0.31887	1.5705	0.02869	0.177559
15	0.34	0.1220	0.0957	0.0551	-0.0274	0.27059	0.00302	0.05456	0.33139	1.6256	0.02934	0.178200
16	0.64	-0.0529	-0.0312	0.1115	-0.0398	0.50060	0.00559	0.06016	0.35339	1.7371	0.03153	0.185219
17	0.37	-0.2175	-0.2201	0.1162	-0.0247	0.28250	0.00315	0.06332	0.36517	1.8533	0.03333	0.192248
18	0.54	0.1745	0.1961	0.1180	-0.0205	0.43021	0.00481	0.06813	0.38231	1.9713	0.03537	0.198464
19	0.46	-0.1679	-0.1711	0.1161	-0.0559	0.35486	0.00396	0.07210	0.39577	2.0874	0.03805	0.208861
20	0.51	0.2743	0.2385	0.0901	-0.0340	0.40920	0.00457	0.07668	0.41057	2.1775	0.03913	0.209543
21	0.53	-0.1395	-0.0942	0.0399	-0.0290	0.41164	0.00460	0.08128	0.42476	2.2174	0.03988	0.208402
22	0.37	0.2030	-0.0028	0.0997	.0000	0.29382	0.00328	0.08457	0.43447	2.3171	0.04115	0.211411
23	0.45	-0.3453	-0.1663	0.1292	-0.0534	0.34395	0.00384	0.08842	0.44543	2.4463	0.04423	0.222848
24	0.47	0.1851	0.2008	0.0473	-0.0121	0.37557	0.00420	0.09262	0.45692	2.4936	0.04435	0.218809
25	0.63	0.0364	0.0252	0.1396	-0.0450	0.49534	0.00554	0.09816	0.47137	2.6272	0.04740	0.227654
26	0.77	0.1562	0.1670	0.0607	-0.0296	0.60981	0.00682	0.10498	0.48814	2.6879	0.04821	0.224192
27	0.48	-0.0512	-0.0558	0.1055	-0.0495	0.37467	0.00419	0.10317	0.49792	2.7934	0.05041	0.229954
28	0.75	-0.2105	-0.1973	0.0643	-0.0918	0.58115	0.00650	0.11567	0.51238	2.8577	0.05126	0.227093

VOLUME OF T-C-E CHARGED RUN #5= 9.893264
 MOLES OF T-C-E CHARGED RUN #5= 0.110064

TABLE 21

CALCULATED DATA FOR DILUTION RUN #6

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vc	DEL nc	nc TOT	x (BENZ)	C TOT	DEL Vc	DEL Vem (P CORR)
1	0.03	1.4570	1.4358	-0.0251	-0.0159	0.07486	0.00083	0.00083	0.99255	-0.0251	-0.0001	-0.00146
2	0.21	0.2239	0.1784	0.1528	-0.0188	0.17188	0.00191	0.00274	0.97587	0.1277	0.00260	0.022891
3	0.26	-0.0249	0.0289	0.1568	-0.0111	0.20404	0.00227	0.00501	0.95678	0.2845	0.00525	0.045285
4	0.33	0.0217	-0.0911	0.1835	-0.0047	0.25765	0.00286	0.00788	0.93372	0.4680	0.00823	0.069239
5	0.27	0.0318	0.0866	0.1258	-0.0316	0.21392	0.00238	0.01026	0.91540	0.5938	0.01111	0.091618
6	0.34	0.0699	0.1054	0.1516	-0.0037	0.26984	0.00300	0.01326	0.89329	0.7454	0.01331	0.107065
7	0.46	-0.0128	-0.1338	0.2624	-0.0315	0.35827	0.00398	0.01725	0.86553	1.0078	0.01846	0.143922
8	0.40	-0.0362	0.1008	0.0261	-0.0252	0.31495	0.00350	0.02075	0.84252	1.0339	0.01883	0.142897
9	0.56	0.0658	-0.0653	0.2886	-0.0115	0.43700	0.00486	0.02561	0.81255	1.3225	0.02371	0.173493
10	0.53	0.0566	-0.0029	0.0922	-0.0418	0.41674	0.00463	0.03025	0.78588	1.4147	0.02590	0.183307
11	0.36	-0.1027	0.1582	0.0724	-0.0419	0.27788	0.00309	0.03334	0.76906	1.5508	0.02832	0.196142
12	0.32	0.0427	0.1582	0.0724	-0.0176	0.25461	0.00283	0.03618	0.75426	1.6232	0.02917	0.198133
13	0.34	-0.0436	-0.1223	0.0967	-0.0369	0.26379	0.00293	0.03911	0.73952	1.7199	0.03123	0.207960
14	0.34	0.1069	0.1189	0.0254	-0.0032	0.27074	0.00301	0.04213	0.72497	1.7453	0.03107	0.202869
15	0.60	-0.1722	-0.1077	0.1471	-0.0507	0.46574	0.00518	0.04731	0.70125	1.8924	0.03453	0.218078
16	0.42	-0.0490	-0.0509	0.0994	-0.0172	0.32772	0.00364	0.05095	0.68547	1.9918	0.03572	0.220502
17	0.34	-0.0508	-0.0483	0.0424	-0.0400	0.26497	0.00294	0.05390	0.67321	2.0342	0.03687	0.223512
18	0.59	0.2391	0.1338	0.0783	-0.0174	0.46948	0.00522	0.05913	0.65255	2.1125	0.03787	0.222546
19	0.48	-0.1832	-0.0878	0.0605	-0.0325	0.37176	0.00413	0.06326	0.63706	2.1730	0.03922	0.225012
20	0.56	0.1194	-0.0331	0.0315	-0.0124	0.44086	0.00490	0.06817	0.61963	2.2045	0.03939	0.219817
21	0.74	-0.0925	-0.0421	0.1412	-0.0535	0.57815	0.00643	0.07460	0.59816	2.3457	0.04264	0.229681
22	0.48	0.1446	0.1232	0.0533	-0.0284	0.38132	0.00424	0.07885	0.58479	2.3990	0.04317	0.227344
23	0.52	-0.0967	0.0644	0.0333	-0.0303	0.40737	0.00453	0.08338	0.57116	2.4323	0.04374	0.224960
24	0.36	0.0949	0.1996	0.0235	-0.0254	0.28765	0.00320	0.08658	0.56191	2.4558	0.04410	0.223130
25	0.80	-0.2821	-0.2285	0.1112	-0.0434	0.61855	0.00688	0.09346	0.54300	2.5670	0.04637	0.226727
26	0.43	0.1726	-0.0682	0.0924	-0.0271	0.33919	0.00377	0.09724	0.53316	2.6594	0.04775	0.229254
27	0.43	0.0116	0.0529	0.0149	-0.0118	0.33848	0.00376	0.10100	0.52369	2.6743	0.04773	0.225110
28	0.54	0.0543	0.0918	0.0075	-0.0266	0.42623	0.00474	0.10575	0.51224	2.6818	0.04816	0.222175
29	0.53	-0.1075	-0.1307	0.0024	-0.0290	0.41156	0.00457	0.11032	0.50164	2.6842	0.04823	0.217896
30	0.32	0.0892	0.0022	0.1309	-0.0314	0.25266	0.00281	0.11314	0.49535	2.8151	0.05055	0.225506
31	0.34	-0.0662	-0.0232	-0.0171	-0.0352	0.26515	0.00295	0.11609	0.48892	2.7980	0.05035	0.221691
32	0.67	-0.1977	-0.1612	0.0908	-0.0275	0.51926	0.00577	0.12186	0.47679	2.8888	0.05180	0.222408
33	0.66	0.2662	0.2235	-0.0052	-0.0560	0.52647	0.00585	0.12772	0.46509	2.8836	0.05223	0.218755
34	0.48	0.0556	-0.2282	-0.0032	-0.0196	0.37350	0.00415	0.13188	0.45713	2.8804	0.05152	0.212086

TABLE 21

CALCULATED DATA FOR DILUTION RUN #6 (CONTINUED)

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vc	DEL nc	nc TOT	x (BENZ)	C TOT	DEL Va	DEL V _{corr} (P CORR)
35	0.49	-0.1407	0.1464	0.0351	-0.0303	0.38452	0.00427	0.13616	0.44922	2.9155	0.05235	0.211762
36	0.63	0.1493	0.0890	0.0113	-0.0477	0.49647	0.00554	0.14170	0.43936	2.9263	0.05285	0.209123
VOLUME OF BENZENE CHARGED RUN #4=						9.92877						
MOLES OF BENZENE CHARGED RUN #4=						0.11105						

TABLE 22

CALCULATED DATA FOR RUN #7

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vg	DEL nc	nc TOT	x (BENZ)	C TOT	DEL Vg	DEL Vm (P CORR)
1	0.31	-3.7892	-3.8295	0.0593	-0.0122	0.10800	0.00118	0.00118	0.98946	0.0593	0.00126	0.011243
2	0.21	0.3426	0.5018	0.1534	-0.0433	0.17973	0.00198	0.00317	0.97240	0.2127	0.00454	0.039556
3	0.47	-0.3493	-0.6192	0.2198	-0.0263	0.35153	0.00387	0.00704	0.94069	0.4325	0.00815	0.068638
4	0.25	0.2524	0.3850	0.1676	-0.0247	0.20744	0.00228	0.00932	0.92292	0.6001	0.01109	0.091668
5	0.35	0.1121	-0.0661	0.1208	0.0024	0.27539	0.00303	0.01236	0.90036	0.7209	0.01276	0.102890
6	0.37	0.0264	0.0363	0.1430	-0.0358	0.29138	0.00321	0.01557	0.87765	0.8639	0.01596	0.125420
7	0.30	0.0036	-0.1148	0.1323	-0.0088	0.23338	0.00257	0.01814	0.86027	0.9962	0.01782	0.137265

VOL. BENZENE CHARGED RUN #7= 10.04766

MOL BENZENE CHARGED RUN #7= 0.11171

TABLE 23

CALCULATED DATA FOR RUN #8

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vc	DEL nc	nc TOT	x (BENZ)	C TOT	DEL Vc	DEL Vem (P CORR)
1	0.20	0.5917	0.6593	0.0334	-0.0806	0.17910	0.00197	0.00197	0.98236	0.0334	0.00202	0.018107
2	0.17	0.9337	0.8433	0.1944	0.0368	0.16489	0.00181	0.00378	0.96666	0.2278	0.00339	0.029840
3	0.40	0.0355	0.0512	0.1291	-0.0787	0.31534	0.00347	0.00726	0.93800	0.3569	0.00771	0.065861
4	0.96	-0.0669	-0.0561	0.5057	0.0020	0.75095	0.00827	0.01553	0.87615	0.8626	0.01528	0.121829
5	0.62	-1.4580	-1.8264	0.1489	-0.0593	0.42811	0.00471	0.02025	0.84440	1.0115	0.01902	0.146167
6	0.33	1.1890	1.5515	0.1470	-0.0172	0.30752	0.00338	0.02364	0.82298	1.1585	0.02088	0.156412
7	0.42	-0.0037	-0.0217	0.1465	-0.0269	0.32904	0.00362	0.02726	0.80129	1.3050	0.02367	0.172557
8	0.33	0.3173	0.3101	0.1075	-0.0291	0.27002	0.00297	0.03024	0.78423	1.4125	0.02562	0.182830
9	0.60	-0.4438	-0.7532	0.1111	-0.0525	0.44946	0.00495	0.03519	0.75746	1.5236	0.02798	0.192822
10	1.13	0.2023	0.2009	0.2222	-0.0739	0.89366	0.00984	0.04503	0.70934	1.7458	0.03221	0.207877
11	0.22	0.3339	0.6718	0.1349	0.0236	0.19044	0.00209	0.04713	0.69986	1.8807	0.03300	0.210163
12	0.57	0.1224	0.0689	0.1380	-0.0170	0.45057	0.00496	0.05210	0.67842	2.0187	0.03623	0.223631
13	0.75	0.1181	-0.0678	0.1152	-0.0316	0.29900	0.00329	0.05539	0.66490	2.0939	0.03666	0.221816
14	0.38	-0.0492	0.0291	0.1162	-0.0719	0.58803	0.00647	0.06187	0.63982	2.1501	0.03945	0.229647
15	0.56	-0.2801	-0.5346	0.0359	-0.0588	0.42487	0.00468	0.06655	0.62285	2.1860	0.03986	0.225917
16	0.49	0.3368	0.5597	0.1359	0.0076	0.40032	0.00441	0.07096	0.60767	2.3219	0.04112	0.227378
17	0.56	0.0505	0.1528	0.0302	-0.0351	0.44294	0.00487	0.07584	0.59170	2.3521	0.04243	0.228442
18	0.56	-0.2133	-0.1861	0.0480	-0.0411	0.43224	0.00476	0.08060	0.57691	2.4001	0.04332	0.227400
19	0.69	-0.0391	-0.3386	0.0606	-0.1537	0.53514	0.00589	0.08650	0.55960	2.4607	0.04464	0.227320
20	0.72	-0.6588	-0.9130	0.0875	-0.0305	0.53695	0.00591	0.09241	0.54324	2.5482	0.04579	0.226353
21	0.38	0.6189	1.1854	0.0239	0.0090	0.33014	0.00363	0.09605	0.53364	2.5715	0.04550	0.220952
22	0.60	0.1596	0.2269	0.0508	-0.0589	0.47757	0.00526	0.10131	0.52035	2.6223	0.04760	0.225374
23	0.48	-0.2000	-0.2928	0.0617	-0.0079	0.36782	0.00405	0.10536	0.51056	2.6840	0.04782	0.222143
24	0.74	0.0054	-0.0315	0.0429	-0.0285	0.58008	0.00639	0.11175	0.49584	2.7269	0.04893	0.220775
25	0.41	0.2155	0.3650	0.0738	-0.0552	0.39195	0.00365	0.11541	0.48779	2.8007	0.05080	0.225453
26	0.55	0.0543	0.0219	-0.0145	-0.0262	0.43283	0.00476	0.12018	0.47768	2.7862	0.04995	0.217090
27	0.58	-0.0340	-0.1051	0.0562	-0.0421	0.45255	0.00498	0.12516	0.46755	2.8424	0.05128	0.218141
28	0.58	-0.2783	-0.5272	0.0151	-0.0756	0.44072	0.00485	0.13002	0.45809	2.8575	0.05203	0.216851
29	0.78	0.2827	0.4541	0.0460	-0.0325	0.62500	0.00688	0.13691	0.44531	2.9035	0.05210	0.211119
30	0.72	-0.1332	-0.4794	0.0114	-0.0460	0.55397	0.00610	0.14301	0.43456	2.9149	0.05258	0.207914

VOL. BENZENE CHARGED RUN #8= 9.88650
 MOL BENZENE CHARGED RUN #8= 0.10991

TABLE 24

CALCULATED DATA FOR RUN #11

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL VB	DEL RB	RB TOT	X (BENZ)	C TOT	DEL VA	DEL Vm (P CORR)
1	0.21	0.6415	0.6560	0.0802	-0.0107	0.18777	0.00208	0.00208	0.01822	0.0802	0.00161	0.014099
2	0.28	0.3753	0.3611	0.1047	-0.0113	0.23273	0.00258	0.00467	0.03991	0.1849	0.00348	0.029752
3	0.51	-0.3299	-0.3313	0.1802	-0.0263	0.38837	0.00431	0.00899	0.07405	0.3651	0.00713	0.058777
4	0.62	0.2113	0.1870	0.1469	-0.0324	0.49346	0.00548	0.01447	0.11408	0.5120	0.00967	0.076202
5	0.89	-0.1658	-0.1746	0.2799	-0.0518	0.69218	0.00769	0.02217	0.16472	0.7919	0.01499	0.111401
6	0.54	0.0199	-0.0098	0.1084	-0.0353	0.42381	0.00471	0.02688	0.19297	0.9003	0.01663	0.119386
7	0.45	0.1927	0.1846	0.1317	-0.0069	0.35972	0.00399	0.03088	0.21549	1.0320	0.01847	0.128906
8	0.54	0.1204	0.1482	0.1036	-0.0580	0.42840	0.00476	0.03564	0.24072	1.1356	0.02117	0.142961
9	0.47	0.0316	0.0573	0.1361	-0.0337	0.37030	0.00411	0.03976	0.26126	1.2717	0.02317	0.152271
10	0.56	-0.0286	-0.0022	0.1336	-0.0383	0.43878	0.00487	0.04464	0.28420	1.4053	0.02566	0.163410
11	0.69	0.0030	-0.0021	0.1252	-0.0193	0.54133	0.00601	0.05066	0.31061	1.5305	0.02748	0.168535
12	0.43	0.1637	0.1592	0.1248	-0.0312	0.34307	0.00381	0.05447	0.32637	1.6553	0.02996	0.179547
13	0.66	-0.1462	-0.0768	0.0959	-0.0561	0.51382	0.00571	0.06018	0.34868	1.7512	0.03206	0.185762
14	0.58	0.1120	0.0283	0.1263	-0.0469	0.45750	0.00508	0.06527	0.36730	1.8775	0.03419	0.192394
15	0.72	-0.4490	-0.6057	0.1569	-0.0178	0.54613	0.00607	0.07134	0.38820	2.0344	0.03637	0.197912
16	0.36	0.4162	0.5468	0.0327	-0.0550	0.29951	0.00332	0.07467	0.39909	2.0671	0.03762	0.201064
17	0.56	-0.1119	0.0044	0.1565	-0.0034	0.43742	0.00486	0.07954	0.41431	2.2236	0.03947	0.205634
18	0.43	0.2285	0.1207	0.0574	-0.0253	0.34353	0.00381	0.08335	0.42574	2.2810	0.04096	0.209205
19	0.55	-0.0891	-0.0068	0.0677	-0.0487	0.42978	0.00477	0.08813	0.43942	2.3487	0.04256	0.212224
20	0.54	-0.0709	-0.0871	0.1322	-0.0238	0.42083	0.00467	0.09281	0.45220	2.4809	0.04449	0.216756
21	0.93	-0.2454	-0.3879	0.1423	-0.0546	0.71836	0.00798	0.10080	0.47271	2.6232	0.04756	0.223048
22	0.46	0.3392	0.4243	0.0684	-0.0315	0.37442	0.00416	0.10496	0.48281	2.6916	0.04836	0.222469
23	0.64	-0.3336	-0.4598	0.0785	-0.0392	0.48801	0.00542	0.11039	0.49540	2.7701	0.04987	0.223810
24	1.04	-0.2528	-0.3890	0.1504	-0.0491	0.80451	0.00894	0.11933	0.51487	2.9205	0.05275	0.227605
25	0.84	0.1691	0.2783	0.1390	-0.0577	0.66693	0.00741	0.12675	0.52991	3.0595	0.05536	0.231456
26	0.70	0.2743	0.3591	0.0760	-0.0466	0.56040	0.00623	0.13298	0.54185	3.1355	0.05651	0.230265
27	0.66	-0.2408	-0.2251	0.0925	-0.0275	0.50951	0.00566	0.13864	0.55218	3.2280	0.05779	0.230163

VOL. T-C-E CHARGED RUN #11=

10.20606

MOL T-C-E CHARGED RUN #11=

0.11244

TABLE 25

CALCULATED DATA FOR DILUTION RUN #14

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vc	DEL nc	nc TOT	x (BENZ)	C TOT	DEL Vc	DEL Vem (P CORR)
1	0.55	-3.0148	-3.3556	0.2630	-0.0161	0.31843	0.00346	0.00346	0.96969	0.2630	0.00496	0.043416
2	0.23	0.4857	0.6909	0.1271	-0.0349	0.20132	0.00213	0.00565	0.95147	0.3901	0.00755	0.064820
3	0.49	0.1206	-0.0735	0.2357	-0.0463	0.38524	0.00419	0.00984	0.91843	0.6258	0.01194	0.098947
4	0.44	0.0644	0.0849	0.2039	-0.0095	0.34783	0.00378	0.01363	0.89052	0.8297	0.01494	0.119982
5.1	0.36	0.0153	-0.0120	0.1152	-0.0267	0.28248	0.00307	0.01670	0.86906	0.9449	0.01728	0.135436
5.2												
6	0.64	-3.5625	-3.7481	0.1317	-0.0493	0.37236	0.00405	0.02076	0.84232	1.0766	0.02001	0.151976
7	0.35	0.0333	-0.1243	0.1471	-0.0274	0.27296	0.00297	0.02373	0.82373	1.2237	0.02224	0.165190
8	0.62	-0.0085	0.0508	0.1858	-0.0273	0.48715	0.00530	0.02903	0.79252	1.4095	0.02556	0.182708
9	0.58	0.0869	0.0450	0.1317	-0.0325	0.45736	0.00497	0.03401	0.76530	1.5412	0.02800	0.193252
10	0.61	-0.0552	-0.0374	0.0918	-0.0326	0.47691	0.00519	0.03920	0.73884	1.6330	0.02962	0.197315
11	0.76	0.0392	-0.1243	0.1403	-0.0620	0.59472	0.00647	0.04567	0.70830	1.7733	0.03262	0.208375
12	0.78	0.0213	0.2073	0.1264	-0.0453	0.61598	0.00670	0.05238	0.67922	1.8997	0.03457	0.211747
13	0.68	0.0337	0.0428	0.1016	-0.0694	0.53483	0.00582	0.05820	0.65584	2.0013	0.03677	0.217483
14	0.70	-0.0474	-0.1567	0.0853	-0.0094	0.54554	0.00593	0.06413	0.63360	2.0866	0.03720	0.212533
15	0.68	0.0459	0.1146	0.1069	-0.0384	0.53632	0.00583	0.06997	0.61315	2.1935	0.03968	0.219382
16	0.93	-0.0753	-0.1316	0.0979	-0.0637	0.72593	0.00790	0.07787	0.58749	2.2914	0.04185	0.221651
17	1.10	0.1074	0.0917	0.0677	-0.0650	0.86650	0.00943	0.08730	0.55954	2.3591	0.04308	0.217339
18	1.32	0.0146	0.1167	0.1147	-0.0595	1.03789	0.01129	0.09860	0.52937	2.4738	0.04498	0.214724
19	0.81	0.0017	-0.0659	0.0573	-0.0463	0.63432	0.00690	0.10550	0.51248	2.5311	0.04580	0.211640
20	0.95	-0.0362	0.0380	0.0412	-0.1043	0.74532	0.00811	0.11361	0.49397	2.5723	0.04753	0.211692
21	0.81	-0.0871	-0.0059	0.0508	-0.0488	0.63381	0.00689	0.12051	0.47925	2.6231	0.04746	0.205073
22	1.11	-0.1924	-0.2305	0.0376	-0.0885	0.86331	0.00939	0.12991	0.46055	2.6607	0.04883	0.202780
23	1.16	0.0842	0.0055	0.0594	0.0008	0.91163	0.00992	0.13983	0.44232	2.7201	0.04831	0.192670

VOL. BENZENE CHARGED RUN #14= 10.10079
 MOL BENZENE CHARGED RUN #14= 0.11091

TABLE 26

CALCULATED DATA FOR RUN #15

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vb	DEL nb	nb TOT	x (BENZ)	C TOT	DEL V _e	DEL V _{em} (P CORR)
1	0.55	-0.4936	-0.5012	0.1969	-0.0391	0.41383	0.00454	0.00454	0.03989	0.1969	0.00419	0.0368
2	0.54	0.6700	0.6649	0.0771	-0.0139	0.44732	0.00491	0.00945	0.07958	0.2740	0.00511	0.0430
3	0.66	0.1421	0.1338	0.2213	-0.0638	0.52267	0.00573	0.01519	0.12199	0.4953	0.00994	0.0798
4	0.52	-0.0024	-0.0038	0.1136	-0.0406	0.40784	0.00447	0.01967	0.15247	0.6089	0.01154	0.0895
5	0.52	0.0280	0.2674	0.1378	-0.0386	0.41319	0.00453	0.02421	0.18126	0.7467	0.01394	0.1044
6	0.75	0.0187	-0.2350	0.1784	-0.0287	0.58454	0.00641	0.03062	0.21880	0.9251	0.01692	0.1209
7	1.02	-0.0770	-0.0779	0.2125	-0.0381	0.79746	0.00875	0.03938	0.26479	1.1376	0.02085	0.1402
8	1.42	-0.7536	-0.7994	0.2864	-0.1020	1.08645	0.01193	0.05131	0.31938	1.4240	0.02708	0.1686
9	0.50	1.0041	1.0593	0.1415	-0.0367	0.42887	0.00470	0.05602	0.33876	1.5655	0.02847	0.1722
10	0.81	-0.0477	-0.0388	0.1341	-0.0440	0.63392	0.00696	0.06298	0.36546	1.6996	0.03095	0.1796
11	0.83	0.0602	0.0510	0.1440	-0.0879	0.65312	0.00717	0.07015	0.39081	1.8436	0.03428	0.1910
12	0.84	-0.0388	-0.0308	0.1437	-0.0296	0.65776	0.00722	0.07738	0.41438	1.9873	0.03585	0.1920

VOL. T-C-E CHARGED RUN #15=

10.04795

MDL T-C-E CHARGED RUN #15=

0.10936

TABLE 27

CALCULATED DATA FOR RUN #16

TILT	DEL 8	DEL C1	DEL C2	DEL C	DEL A	DEL Vc	DEL nc	nc TOT	x (BENZ)	C TOT	DEL Vc	DEL Vem (P CORR)
1	6.60	-0.4373	-0.4794	1.5779	-0.3855	5.16156	0.05667	0.05667	0.33905	1.5779	0.03488	0.2087
2	0.70	1.6742	1.6978	0.1316	-0.0601	0.60900	0.00668	0.06336	0.36447	1.7095	0.03141	0.1807
3	0.93	0.0392	0.0398	0.1851	-0.0425	0.73100	0.00802	0.07139	0.39252	1.8946	0.03440	0.1892
4	0.95	0.0487	0.0300	0.1585	-0.0568	0.74669	0.00819	0.07959	0.41873	2.0531	0.03746	0.1971
5	1.10	-0.2363	0.1029	0.1759	-0.0605	0.86060	0.00345	0.08904	0.44626	2.2290	0.04066	0.2038
6	0.93	0.2428	-0.0991	0.1100	-0.0491	0.73214	0.00803	0.09708	0.46770	2.3390	0.04235	0.2041
7	1.23	0.0040	0.0092	0.1866	-0.0901	0.96519	0.01059	0.10767	0.49356	2.5256	0.04640	0.2127
8	1.03	0.1171	0.1134	0.1550	-0.0569	0.81214	0.00891	0.11659	0.51345	2.6806	0.04860	0.2141
9	1.20	0.0343	-0.1401	0.1635	-0.0655	0.93954	0.01031	0.12691	0.53460	2.8441	0.05166	0.2176

VOL. BENZENE CHARGED RUN #16= 10.15151
 MOL BENZENE CHARGED RUN #16= 0.11049

TABLE 28

CALCULATED DATA FOR DILUTION RUN #17

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vc	DEL mc	mc TOT	x (BENZ)	C TOT	DEL Vc	DEL Vem (P CORR)
1	0.27	3.0172	3.0769	0.2727	-0.0324	0.31996	0.00361	0.00361	0.96909	0.2727	0.00541	0.046331
2	0.35	-0.0267	-0.0195	0.2417	-0.0258	0.27376	0.00308	0.00659	0.94413	0.5144	0.00958	0.079928
3	0.72	-0.1307	-0.1320	0.3345	-0.0392	0.56019	0.00632	0.01301	0.89686	0.8489	0.01575	0.124785
4	0.92	0.1427	0.1253	0.3704	-0.0537	0.72651	0.00819	0.02121	0.84217	1.2193	0.02257	0.167942
5	1.10	0.0003	0.0141	0.3206	-0.0570	0.86322	0.00973	0.03095	0.78528	1.5399	0.02834	0.196586
6	0.74	-0.1268	-0.1305	0.2723	-0.1027	0.57597	0.00649	0.03745	0.75141	1.8122	0.03397	0.225508
7	1.10	-0.0231	-0.0169	0.3345	-0.0109	0.86226	0.00972	0.04718	0.70583	2.1467	0.03827	0.238624
8	0.99	0.0686	0.0585	0.1844	-0.0703	0.77893	0.00878	0.05597	0.66917	2.3311	0.04259	0.251752
9	0.86	0.0137	0.0186	0.2047	-0.0785	0.67526	0.00761	0.06359	0.64033	2.5358	0.04640	0.262429
10	1.07	-0.0024	-0.0044	0.3618	-0.0505	0.83931	0.00947	0.07306	0.60778	2.8976	0.05232	0.280883
11	0.82	0.2137	0.2019	0.0260	-0.0956	0.65068	0.00734	0.08040	0.58473	2.9236	0.05358	0.276751
12	1.01	-0.1408	-0.1259	0.0771	-0.0445	0.78763	0.00888	0.08929	0.55907	3.0007	0.05401	0.266720
13	1.08	-0.1091	-0.1096	0.0773	-0.0598	0.84340	0.00951	0.09880	0.53398	3.0780	0.05568	0.262618
14	0.84	0.0892	0.0892	0.0339	-0.0598	0.66216	0.00747	0.10627	0.51580	3.1119	0.05630	0.256511
15	1.42	-0.0304	-0.0365	0.0731	-0.0794	1.11283	0.01255	0.11883	0.48789	3.1850	0.05791	0.249555
16	1.17	0.0332	0.0285	0.0596	-0.0556	0.91898	0.01036	0.12920	0.46703	3.2446	0.05854	0.241488
17	1.30	0.0180	0.0182	0.0682	-0.0879	1.02051	0.01151	0.14071	0.44585	3.3128	0.06034	0.237624
18	1.31	-0.0304	-0.0239	0.0680	-0.1000	1.02675	0.01158	0.15230	0.42639	3.3808	0.06177	0.232665

VOL. BENZENE CHARGED RUN #17= 9.94220

MOL BENZENE CHARGED RUN #17= 0.11322

TABLE 29

CALCULATED DATA FOR DILUTION RUN #18

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL VB	DEL MB	MB TOT	X (BENZ)	C TOT	DEL V _o	DEL V _{em} (P CORR)
1	0.18	1.5702	1.5610	0.0685	0.0099	0.19677	0.00224	0.00224	0.01949	0.0685	0.00104	0.009062
2	0.54	0.0986	0.1069	0.1332	-0.0587	0.42728	0.00486	0.00710	0.05931	0.2017	0.00462	0.038634
3	0.47	-0.0701	-0.0852	0.2305	-0.0380	0.36596	0.00416	0.01127	0.09092	0.4322	0.00835	0.067418
4	0.49	0.1274	-0.0428	0.1605	-0.0507	0.38591	0.00439	0.01566	0.12204	0.5927	0.01143	0.089058
5	0.66	-0.1288	-0.0259	0.2105	0.0012	0.51503	0.00586	0.02153	0.16040	0.8032	0.01427	0.106305
6	0.75	-0.0110	-0.0100	0.2141	-0.0302	0.58801	0.00669	0.02823	0.20029	1.0173	0.01861	0.132055
7	0.73	-0.0601	0.0552	0.2037	-0.0557	0.57261	0.00652	0.03475	0.23565	1.2210	0.02268	0.153801
8	0.67	0.0093	0.0487	0.2070	-0.0205	0.52665	0.00599	0.04074	0.26552	1.4280	0.02575	0.167796
9	0.86	0.1416	-0.0131	0.1796	-0.0585	0.67696	0.00770	0.04845	0.30065	1.6076	0.02962	0.183785
10	0.94	-0.2201	-0.1466	0.2380	-0.0562	0.73094	0.00832	0.05678	0.33499	1.8456	0.03378	0.199330
11	1.14	0.0745	0.0978	0.2410	-0.0775	0.89741	0.01021	0.06700	0.37281	2.0866	0.03845	0.213978

VOL. T-C-E CHARGED RUN #18=

9.98975

MOL T-C-E CHARGED RUN #18=

0.11272

TABLE 30

CALCULATED DATA FOR DILUTION RUN #19

TILT	DEL B	DEL C1	DEL C2	DEL C	DEL A	DEL Vb	DEL nb	nb TOT	x (BENZ)	C TOT	DEL V _e	DEL V _{em} (P CORR)
1	4.50	3.0837	3.0672	2.0327	-0.3007	3.63948	0.04144	0.04144	0.26884	2.0327	0.04144	0.268842
2	1.78	-1.5670	-1.5605	0.3317	-0.0925	1.34094	0.01527	0.05671	0.33474	2.3644	0.04366	0.257697
3	0.74	-0.1418	-0.1501	-0.0542	-0.0493	0.57536	0.00655	0.06326	0.35951	2.3102	0.04193	0.238313
4	0.52	0.2966	0.2061	-0.0406	-0.0246	0.41686	0.00474	0.06801	0.37633	2.2696	0.04092	0.226459
5	1.13	1.2013	1.2984	0.0802	-0.0708	0.93086	0.01060	0.07861	0.41088	2.3498	0.04302	0.224887
6	1.70	-1.6625	-1.6562	0.2653	-0.1058	1.27479	0.01451	0.09313	0.45243	2.6151	0.04826	0.234490
7	0.80	-0.1673	-0.1638	0.1448	-0.0397	0.62174	0.00708	0.10021	0.47064	2.7599	0.04969	0.233374
8	1.29	0.0351	0.0257	0.2128	-0.0785	1.01310	0.01153	0.11175	0.49784	2.9727	0.05411	0.241076
9	1.42	0.0022	0.0100	0.2074	-0.0895	1.11423	0.01268	0.12443	0.52471	3.1801	0.05802	0.244675

VOL. T-C-E CHARGED RUN #19= 10.01291
 MOL. T-C-E CHARGED RUN #19= 0.11298

APPENDIX C-2

MAIN FRAME COMPUTER GENERATED DATA

How many curve fitting constants do you want?
(must be between 2 and 5)

4

What is the name of the data file to be used?
bzcyclo

(Data must be stored in x,y pairs with format f7.6,1x,f7.6.
The first line of the file must contain the number
of data points in the file, with format I3)

gamma 1 = 2.60920
gamma 2 = 0.15423
gamma 3 = 0.12096
gamma 4 = -0.14836

x benzene	molar Ve	Ve fit	Error
0.982598D+00	0.485850D-01	0.462777D-01	0.270732D-02
0.973725D+00	0.683320D-01	0.690231D-01	-.691116D-03
0.958196D+00	0.108880D+00	0.107496D+00	0.138387D-02
0.952479D+00	0.116851D+00	0.121243D+00	-.439170D-02
0.943940D+00	0.139468D+00	0.141367D+00	-.189859D-02
0.864218D+00	0.303852D+00	0.307255D+00	-.340286D-02
0.856702D+00	0.319363D+00	0.320978D+00	-.161528D-02
0.844607D+00	0.340557D+00	0.342412D+00	-.185517D-02
0.820936D+00	0.385329D+00	0.382094D+00	0.323525D-02
0.815388D+00	0.385332D+00	0.390970D+00	-.563751D-02
0.803499D+00	0.409599D+00	0.409457D+00	0.142003D-03
0.747767D+00	0.491665D+00	0.486718D+00	0.494717D-02
0.736557D+00	0.503508D+00	0.500435D+00	0.307281D-02
0.723792D+00	0.517239D+00	0.515328D+00	0.191133D-02
0.714135D+00	0.531683D+00	0.526083D+00	0.560028D-02
0.708145D+00	0.532071D+00	0.532534D+00	-.462511D-03
0.681188D+00	0.564226D+00	0.559488D+00	0.473795D-02
0.674067D+00	0.565601D+00	0.566043D+00	-.442270D-03
0.654324D+00	0.583754D+00	0.582986D+00	0.767930D-03
0.648091D+00	0.585293D+00	0.587959D+00	-.266625D-02
0.644710D+00	0.588741D+00	0.590581D+00	-.184042D-02
0.639817D+00	0.595641D+00	0.594282D+00	0.135879D-02
0.636642D+00	0.598474D+00	0.596624D+00	0.184991D-02
0.624607D+00	0.606660D+00	0.605075D+00	0.158466D-02
0.618849D+00	0.607657D+00	0.608880D+00	-.122312D-02
0.611273D+00	0.613835D+00	0.613650D+00	0.184562D-03
0.605135D+00	0.613927D+00	0.617318D+00	-.339148D-02
0.598217D+00	0.622424D+00	0.621241D+00	0.118302D-02
0.590836D+00	0.625833D+00	0.625178D+00	0.654957D-03
0.585149D+00	0.627072D+00	0.628036D+00	-.964451D-03
0.579559D+00	0.630177D+00	0.630697D+00	-.520206D-03
0.570454D+00	0.638050D+00	0.634714D+00	0.333599D-02
0.564560D+00	0.632918D+00	0.637104D+00	-.418604D-02
0.556489D+00	0.642213D+00	0.640108D+00	0.210523D-02
0.551040D+00	0.641809D+00	0.641959D+00	-.150180D-03
0.543776D+00	0.646297D+00	0.644205D+00	0.209188D-02

x benzene	molar Ve	Ve fit	Error
0.537856D+00	0.648883D+00	0.645847D+00	0.303595D-02
0.521861D+00	0.649757D+00	0.649432D+00	0.325362D-03
0.515214D+00	0.652676D+00	0.650553D+00	0.212270D-02
0.505334D+00	0.648356D+00	0.651818D+00	- .346232D-02
0.496249D+00	0.651022D+00	0.652555D+00	- .153255D-02
0.489836D+00	0.648933D+00	0.652826D+00	- .389343D-02
0.482731D+00	0.653309D+00	0.652887D+00	0.422191D-03
0.475997D+00	0.650431D+00	0.652709D+00	- .227818D-02
0.172190D-01	0.471990D-01	0.463225D-01	0.876486D-03
0.361580D-01	0.959350D-01	0.954183D-01	0.516677D-03
0.494660D-01	0.125853D+00	0.128731D+00	- .287770D-02
0.747810D-01	0.183639D+00	0.189341D+00	- .570240D-02
0.877360D-01	0.220394D+00	0.218940D+00	0.145427D-02
0.104803D+00	0.262044D+00	0.256447D+00	0.559743D-02
0.120358D+00	0.287366D+00	0.289146D+00	- .178020D-02
0.130382D+00	0.313017D+00	0.309464D+00	0.355329D-02
0.179718D+00	0.400060D+00	0.400779D+00	- .718890D-03
0.190922D+00	0.418912D+00	0.419498D+00	- .586347D-03
0.211727D+00	0.452778D+00	0.452278D+00	0.500304D-03
0.224716D+00	0.474713D+00	0.471439D+00	0.327392D-02
0.230720D+00	0.482885D+00	0.480031D+00	0.285373D-02
0.242240D+00	0.493453D+00	0.495720D+00	- .226725D-02
0.250965D+00	0.508297D+00	0.507116D+00	0.118064D-02
0.260400D+00	0.520316D+00	0.518950D+00	0.136638D-02
0.272142D+00	0.537775D+00	0.532949D+00	0.482619D-02
0.280297D+00	0.538673D+00	0.542199D+00	- .352568D-02
0.289399D+00	0.549923D+00	0.552067D+00	- .214405D-02
0.299045D+00	0.560414D+00	0.562003D+00	- .158892D-02
0.308215D+00	0.568427D+00	0.570953D+00	- .252556D-02
0.316561D+00	0.573586D+00	0.578680D+00	- .509393D-02
0.324888D+00	0.584616D+00	0.585995D+00	- .137862D-02
0.330929D+00	0.587967D+00	0.591055D+00	- .308834D-02
0.339491D+00	0.594755D+00	0.597875D+00	- .312049D-02
0.344372D+00	0.600667D+00	0.601579D+00	- .912272D-03
0.352865D+00	0.604277D+00	0.607707D+00	- .342954D-02
0.383310D+00	0.622445D+00	0.626392D+00	- .394675D-02
0.388859D+00	0.624959D+00	0.629251D+00	- .429166D-02
0.396821D+00	0.636891D+00	0.633061D+00	0.382952D-02
0.404594D+00	0.637774D+00	0.636452D+00	0.132161D-02
0.412435D+00	0.641954D+00	0.639545D+00	0.240885D-02
0.418731D+00	0.639717D+00	0.641792D+00	- .207453D-02
0.426227D+00	0.645108D+00	0.644192D+00	0.975675D-03
0.433145D+00	0.647773D+00	0.646145D+00	0.162761D-02
0.439704D+00	0.648037D+00	0.647766D+00	0.271440D-03
0.449272D+00	0.650932D+00	0.649727D+00	0.120475D-02
0.453895D+00	0.648650D+00	0.650505D+00	- .185520D-02
0.461003D+00	0.652311D+00	0.651487D+00	0.824420D-03
0.466560D+00	0.653528D+00	0.652073D+00	0.145462D-02
0.473266D+00	0.653148D+00	0.652572D+00	0.576277D-03
0.477641D+00	0.651683D+00	0.652774D+00	- .109070D-02
0.483168D+00	0.656913D+00	0.652890D+00	0.402257D-02
0.490465D+00	0.653824D+00	0.652809D+00	0.101514D-02

x benzene	molar V_e	V_e fit	Error
0.495724D+00	0.656270D+00	0.652585D+00	0.368547D-02
0.504833D+00	0.651586D+00	0.651870D+00	- .283602D-03
0.510269D+00	0.654122D+00	0.651247D+00	0.287527D-02
0.516402D+00	0.650495D+00	0.650369D+00	0.126235D-03
0.522156D+00	0.653896D+00	0.649377D+00	0.451917D-02
0.529117D+00	0.648458D+00	0.647960D+00	0.497927D-03
0.534580D+00	0.646847D+00	0.646683D+00	0.164340D-03

The standard deviation for this set of fitting constants is: 0.275033D-02

The condition number for the A matrix is: 85.648

How many curve fitting constants do you want?
(must be between 2 and 5)

3

What is the name of the data file to be used?

(Data must be stored in x,y pairs with format f7.6,1x,f7.6.
The first line of the file must contain the number
of data points in the file, with format I3)

bztcel0

gamma 1 = 1.01164
gamma 2 = -0.41103
gamma 3 = 0.07189

x benzene	molar Ve	Ve fit	Error
0.969098D+00	0.463310D-01	0.437391D-01	0.259194D-02
0.944136D+00	0.799280D-01	0.756058D-01	0.432216D-02
0.896863D+00	0.124785D+00	0.127944D+00	- .315855D-02
0.842176D+00	0.167942D+00	0.176326D+00	- .838376D-02
0.785282D+00	0.196586D+00	0.214067D+00	- .174805D-01
0.751412D+00	0.225508D+00	0.230967D+00	- .545917D-02
0.705836D+00	0.238624D+00	0.247712D+00	- .908774D-02
0.669171D+00	0.251752D+00	0.256568D+00	- .481563D-02
0.640336D+00	0.262429D+00	0.260861D+00	0.156848D-02
0.607783D+00	0.280883D+00	0.263076D+00	0.178068D-01
0.584737D+00	0.276751D+00	0.263063D+00	0.136885D-01
0.559076D+00	0.266720D+00	0.261599D+00	0.512113D-02
0.533984D+00	0.262618D+00	0.258777D+00	0.384121D-02
0.524715D+00	0.244675D+00	0.257403D+00	- .127283D-01
0.515808D+00	0.256511D+00	0.255921D+00	0.589782D-03
0.497848D+00	0.241076D+00	0.252464D+00	- .113879D-01
0.487898D+00	0.249555D+00	0.250287D+00	- .732191D-03
0.470640D+00	0.233374D+00	0.246087D+00	- .127131D-01
0.467030D+00	0.241488D+00	0.245142D+00	- .365426D-02
0.452433D+00	0.234490D+00	0.241095D+00	- .660545D-02
0.445852D+00	0.237624D+00	0.239155D+00	- .153093D-02
0.426399D+00	0.232665D+00	0.233013D+00	- .347925D-03
0.410887D+00	0.224887D+00	0.227697D+00	- .281029D-02
0.376333D+00	0.226459D+00	0.214610D+00	0.118487D-01
0.372813D+00	0.213978D+00	0.213186D+00	0.792293D-03
0.334998D+00	0.199330D+00	0.196894D+00	0.243565D-02
0.300654D+00	0.183785D+00	0.180655D+00	0.312989D-02
0.265523D+00	0.167796D+00	0.162783D+00	0.501307D-02
0.235653D+00	0.153801D+00	0.146695D+00	0.710610D-02
0.200290D+00	0.132095D+00	0.126712D+00	0.538291D-02

x benzene	molar V_e	V_e fit	Error
0.160402D+00	0.106305D+00	0.103110D+00	0.319477D-02
0.122046D+00	0.890580D-01	0.795076D-01	0.955043D-02
0.909280D-01	0.674180D-01	0.598027D-01	0.761532D-02
0.593100D-01	0.386340D-01	0.393453D-01	-.711347D-03
0.194920D-01	0.906200D-02	0.130540D-01	-.399202D-02

The standard deviation for this set of fitting constants is: 0.801066D-02

The condition number for the A matrix is: 13.978

How many curve fitting constants do you want?
(must be between 2 and 5)

2

What is the name of the data file to be used?
bztce25

(Data must be stored in x,y pairs with format f7.6,1x,f7.6.
The first line of the file must contain the number
of data points in the file, with format I3)

gamma 1 = 0.87624
gamma 2 = -0.23889

x benzene	molar Ve	Ve fit	Error
0.1301000-01	0.0000000+00	0.8263840-02	- .8263840-02
0.3754400-01	0.2107400-01	0.2367840-01	- .2604400-02
0.5521000-01	0.3803400-01	0.3462120-01	0.3412790-02
0.7811400-01	0.4718000-01	0.4858450-01	- .1404450-02
0.9904500-01	0.6102300-01	0.6109660-01	- .7360560-04
0.1182960+00	0.6805400-01	0.7237190-01	- .4317860-02
0.1472990+00	0.9083700-01	0.8889170-01	0.1945300-02
0.1776410+00	0.1181680+00	0.1055060+00	0.1266240-01
0.1931070+00	0.1148010+00	0.1136860+00	0.1115360-02
0.2208740+00	0.1315960+00	0.1278410+00	0.3755090-02
0.2392330+00	0.1308950+00	0.1368010+00	- .5905680-02
0.2588030+00	0.1572550+00	0.1459780+00	0.1127690-01
0.2817500+00	0.1588380+00	0.1562200+00	0.2618080-02
0.3168780+00	0.1775590+00	0.1715190+00	0.6039640-02
0.3313990+00	0.1782000+00	0.1763030+00	0.1897100-02
0.3533900+00	0.1852190+00	0.1842190+00	0.9996710-03
0.3651730+00	0.1922480+00	0.1881980+00	0.4050110-02
0.3823140+00	0.1976480+00	0.1936460+00	0.4002280-02
0.3957710+00	0.2088610+00	0.1976320+00	0.1122890-01
0.4105790+00	0.2095430+00	0.2017140+00	0.7828880-02
0.4247610+00	0.2084020+00	0.2053160+00	0.3085820-02
0.4344730+00	0.2114110+00	0.2076050+00	0.3805910-02
0.4393690+00	0.2091230+00	0.2087030+00	0.4198120-03
0.4454340+00	0.2228480+00	0.2100110+00	0.1283700-01
0.4492270+00	0.2117620+00	0.2107990+00	0.9629660-03
0.4569270+00	0.2188090+00	0.2123280+00	0.6481400-02
0.4571390+00	0.2120860+00	0.2123680+00	- .2823210-03
0.4650950+00	0.2187550+00	0.2138430+00	0.4911530-02
0.4713760+00	0.2276510+00	0.2149340+00	0.1271680-01
0.4767920+00	0.2224080+00	0.2158220+00	0.6586100-02
0.4881420+00	0.2241920+00	0.2175210+00	0.6670820-02
0.4889200+00	0.2216910+00	0.2176300+00	0.4061400-02
0.4953540+00	0.2255060+00	0.2184860+00	0.7019830-02
0.4979260+00	0.2299540+00	0.2188080+00	0.1114550-01
0.5016450+00	0.2178960+00	0.2192540+00	- .1358100-02
0.5122410+00	0.2221750+00	0.2203900+00	0.1785050-02
0.5123820+00	0.2270930+00	0.2204040+00	0.6689290-02
0.5236970+00	0.2251100+00	0.2213920+00	0.3717920-02
0.5331660+00	0.2292540+00	0.2220400+00	0.7213760-02

x benzene	molar Ve	Ve fit	Error
0.5430050+00	0.2267270+00	0.2225380+00	0.4188790-02
0.5619150+00	0.2231300+00	0.2229830+00	0.1469630-03
0.5711650+00	0.2249600+00	0.2229500+00	0.2009530-02
0.5847980+00	0.2273440+00	0.2225970+00	0.4747360-02
0.5981630+00	0.2296810+00	0.2218900+00	0.7791210-02
0.6196330+00	0.2198170+00	0.2199910+00	- .1738020-03
0.6370690+00	0.2250170+00	0.2177390+00	0.7272810-02
0.6525540+00	0.2225460+00	0.2151930+00	0.7352850-02
0.6732190+00	0.2235120+00	0.2109760+00	0.1253640-01
0.6854700+00	0.2205020+00	0.2080230+00	0.1247850-01
0.7012540+00	0.2180780+00	0.2037140+00	0.1436420-01
0.7249780+00	0.2028690+00	0.1961410+00	0.6727950-02
0.7395210+00	0.2079600+00	0.1908340+00	0.1712580-01
0.7542630+00	0.1981330+00	0.1849280+00	0.1320480-01
0.7690610+00	0.1961420+00	0.1784570+00	0.1768460-01
0.7858890+00	0.1833070+00	0.1704270+00	0.1288010-01
0.8125520+00	0.1734930+00	0.1562060+00	0.1728680-01
0.8425270+00	0.1428970+00	0.1379680+00	0.4928840-02
0.8655390+00	0.1439220+00	0.1223040+00	0.2161830-01
0.8932940+00	0.1070650+00	0.1014350+00	0.5630460-02
0.9154020+00	0.9161800-01	0.8322700-01	0.8391020-02
0.9337220+00	0.6923900-01	0.6705050-01	0.2188510-02
0.9567850+00	0.4528500-01	0.4525420-01	0.3084940-04
0.9758730+00	0.2289100-01	0.2598420-01	- .3093240-02
0.9925540+00	0.0000000+00	0.8215150-02	- .8215150-02

The standard deviation for this set of fitting constants is: 0.8254980-02

The condition number for the A matrix is: 3.536

How many curve fitting constants do you want?
(must be between 2 and 5)

4

What is the name of the data file to be used?

(Data must be stored in x,y pairs with format f7.6,1x,f7.6.
The first line of the file must contain the number
of data points in the file, with format I3)

bztce30

gamma 1 = 0.89426
gamma 2 = -0.30734
gamma 3 = 0.10541
gamma 4 = 0.13159

x benzene	molar Ve	Ve fit	Error
0.989460D+00	0.112430D-01	0.122299D-01	-.986934D-03
0.982364D+00	0.181070D-01	0.202826D-01	-.217564D-02
0.972405D+00	0.395560D-01	0.313350D-01	0.822104D-02
0.966669D+00	0.298400D-01	0.375670D-01	-.772700D-02
0.940691D+00	0.686380D-01	0.645471D-01	0.409092D-02
0.938009D+00	0.658610D-01	0.672150D-01	-.135402D-02
0.922929D+00	0.916680D-01	0.818014D-01	0.986656D-02
0.900360D+00	0.102890D+00	0.102306D+00	0.584055D-03
0.877652D+00	0.125420D+00	0.121320D+00	0.409986D-02
0.876150D+00	0.121829D+00	0.122520D+00	-.691479D-03
0.860273D+00	0.137265D+00	0.134774D+00	0.249123D-02
0.844404D+00	0.146167D+00	0.146228D+00	-.612595D-04
0.822984D+00	0.156412D+00	0.160440D+00	-.402815D-02
0.801236D+00	0.172557D+00	0.173416D+00	-.859403D-03
0.784230D+00	0.182830D+00	0.182558D+00	0.272153D-03
0.757469D+00	0.192822D+00	0.195193D+00	-.237056D-02
0.709341D+00	0.207877D+00	0.212724D+00	-.484723D-02
0.699865D+00	0.210163D+00	0.215421D+00	-.525827D-02
0.678422D+00	0.223631D+00	0.220648D+00	0.298347D-02
0.664903D+00	0.221816D+00	0.223335D+00	-.151867D-02
0.639829D+00	0.229647D+00	0.227124D+00	0.252302D-02
0.622858D+00	0.225917D+00	0.228843D+00	-.292620D-02
0.607671D+00	0.227378D+00	0.229829D+00	-.245051D-02
0.591708D+00	0.228442D+00	0.230323D+00	-.188125D-02
0.576918D+00	0.227400D+00	0.230307D+00	-.290651D-02
0.559602D+00	0.227320D+00	0.229731D+00	-.241139D-02
0.552187D+00	0.230163D+00	0.229309D+00	0.854281D-03
0.543240D+00	0.226353D+00	0.228663D+00	-.230954D-02
0.541851D+00	0.230265D+00	0.228549D+00	0.171589D-02
0.533647D+00	0.220952D+00	0.227809D+00	-.685657D-02
0.529917D+00	0.231456D+00	0.227433D+00	0.402348D-02
0.520355D+00	0.225374D+00	0.226359D+00	-.984671D-03
0.514879D+00	0.227605D+00	0.225674D+00	0.193107D-02
0.510561D+00	0.222143D+00	0.225099D+00	-.295591D-02
0.495842D+00	0.220775D+00	0.222912D+00	-.213748D-02

x benzene	molar V_e	V_e fit	Error
0.495406D+00	0.223810D+00	0.222842D+00	0.967507D-03
0.487794D+00	0.225453D+00	0.221573D+00	0.387963D-02
0.482813D+00	0.222469D+00	0.220695D+00	0.177372D-02
0.477685D+00	0.217090D+00	0.219753D+00	-.266269D-02
0.472717D+00	0.223048D+00	0.218803D+00	0.424519D-02
0.467554D+00	0.218141D+00	0.217778D+00	0.362953D-03
0.458093D+00	0.216851D+00	0.215803D+00	0.104806D-02
0.452200D+00	0.216756D+00	0.214511D+00	0.224542D-02
0.445314D+00	0.211119D+00	0.212942D+00	-.182257D-02
0.439422D+00	0.212224D+00	0.211550D+00	0.674260D-03
0.434569D+00	0.207914D+00	0.210370D+00	-.245588D-02
0.425742D+00	0.209205D+00	0.208148D+00	0.105690D-02
0.414317D+00	0.205634D+00	0.205131D+00	0.502708D-03
0.399096D+00	0.201064D+00	0.200874D+00	0.189559D-03
0.388208D+00	0.197912D+00	0.197670D+00	0.242495D-03
0.367306D+00	0.192394D+00	0.191161D+00	0.123294D-02
0.348663D+00	0.185762D+00	0.184980D+00	0.781984D-03
0.326372D+00	0.179547D+00	0.177148D+00	0.239902D-02
0.310619D+00	0.168535D+00	0.171334D+00	-.279929D-02
0.284206D+00	0.163410D+00	0.161084D+00	0.232599D-02
0.261264D+00	0.152271D+00	0.151677D+00	0.594324D-03
0.240727D+00	0.142961D+00	0.142855D+00	0.105565D-03
0.215495D+00	0.128906D+00	0.131484D+00	-.257825D-02
0.192976D+00	0.119386D+00	0.120812D+00	-.142642D-02
0.164728D+00	0.111401D+00	0.106668D+00	0.473318D-02
0.114082D+00	0.762020D-01	0.788673D-01	-.266533D-02
0.740570D-01	0.587770D-01	0.541921D-01	0.458487D-02
0.399180D-01	0.297520D-01	0.307834D-01	-.103136D-02
0.182280D-01	0.140990D-01	0.145618D-01	-.462826D-03

The standard deviation for this set of fitting constants is: 0.324163D-02

The condition number for the A matrix is: 102.370

How many curve fitting constants do you want?
(must be between 2 and 5)
5

What is the name of the data file to be used?

(Data must be stored in x,y pairs with format f7.6,1x,f7.6.
The first line of the file must contain the number
of data points in the file, with format I3)

bztce40

gamma 1 = 0.85454
gamma 2 = -0.33061
gamma 3 = -0.05882
gamma 4 = 0.00471
gamma 5 = 0.46645

x benzene	molar Ve	Ve fit	Error
0.969899D+00	0.434160D-01	0.432678D-01	0.148242D-03
0.951472D+00	0.648200D-01	0.651825D-01	-.362475D-03
0.918437D+00	0.989470D-01	0.985864D-01	0.360564D-03
0.890820D+00	0.119982D+00	0.121693D+00	-.171133D-02
0.869868D+00	0.135436D+00	0.136899D+00	-.146329D-02
0.842820D+00	0.151976D+00	0.153309D+00	-.133307D-02
0.823735D+00	0.165190D+00	0.163292D+00	0.189772D-02
0.792527D+00	0.182708D+00	0.177835D+00	0.487340D-02
0.765307D+00	0.193252D+00	0.188534D+00	0.471764D-02
0.738845D+00	0.197315D+00	0.197356D+00	-.408940D-04
0.708804D+00	0.208375D+00	0.205736D+00	0.263893D-02
0.679124D+00	0.211747D+00	0.211989D+00	-.242169D-03
0.655846D+00	0.217483D+00	0.215810D+00	0.167298D-02
0.633601D+00	0.212533D+00	0.218445D+00	-.591246D-02
0.613155D+00	0.219382D+00	0.220002D+00	-.620193D-03
0.587495D+00	0.221691D+00	0.220776D+00	0.915049D-03
0.559544D+00	0.217339D+00	0.220123D+00	-.278402D-02
0.534600D+00	0.217635D+00	0.218235D+00	-.600181D-03
0.529376D+00	0.214724D+00	0.217686D+00	-.296222D-02
0.513456D+00	0.214054D+00	0.215691D+00	-.163723D-02
0.512489D+00	0.211640D+00	0.215555D+00	-.391460D-02
0.493974D+00	0.211692D+00	0.212605D+00	-.912664D-03
0.493567D+00	0.212702D+00	0.212533D+00	0.169214D-03
0.479250D+00	0.205073D+00	0.209817D+00	-.474385D-02
0.467709D+00	0.204068D+00	0.207368D+00	-.330042D-02
0.460552D+00	0.202780D+00	0.205738D+00	-.295775D-02
0.446261D+00	0.203816D+00	0.202234D+00	0.158180D-02
0.442328D+00	0.192670D+00	0.201214D+00	-.854402D-02
0.418731D+00	0.197095D+00	0.194617D+00	0.247846D-02
0.414360D+00	0.191983D+00	0.193315D+00	-.133248D-02
0.392527D+00	0.189177D+00	0.186419D+00	0.275795D-02
0.390818D+00	0.190993D+00	0.185856D+00	0.513721D-02
0.365469D+00	0.179608D+00	0.177140D+00	0.246812D-02
0.364479D+00	0.180706D+00	0.176787D+00	0.391921D-02

x benzene	molar Ve	Ve fit	Error
0.338761D+00	0.172183D+00	0.167331D+00	0.485217D-02
0.319381D+00	0.168569D+00	0.159901D+00	0.866764D-02
0.264791D+00	0.140219D+00	0.138090D+00	0.212928D-02
0.218802D+00	0.120911D+00	0.119222D+00	0.168927D-02
0.181261D+00	0.104382D+00	0.103606D+00	0.775806D-03
0.152472D+00	0.894560D-01	0.913321D-01	-.187611D-02
0.121998D+00	0.798130D-01	0.776992D-01	0.211379D-02
0.795871D-01	0.430330D-01	0.564715D-01	-.134385D-01
0.398951D-01	0.368480D-01	0.321225D-01	0.472549D-02

The standard deviation for this set of fitting constants is: 0.409454D-02

The condition number for the A matrix is: 593.794

APPENDIX D
PROGRAM DOCUMENTATION

```
* This program is designed to fit the data found in a user specified
* data file to a smoothing equation which is standard for excess
* volume data. The data file must be set up in a specific format,
* which may be accomplished by using the supplementary program
* titled "makefile" to construct the data set. Actually, the
* program fits the data for  $V_e/(x_1x_2)$  and then compensates after
* fitting to arrive at the final  $V_e$ -fit data and the correct
* standard deviation. This method was chosen to lessen the severity
* of the ill-conditioning of the matrix while performing the least-
* squares analysis on the data. The program utilizes IMSL subroutines
* to calculate the condition number of the "A" matrix and to solve the
* linear system of equations. The user must specify how many fitting
* constants are desired in the analysis. (May be between 2 and 5).
```

```
* Variable dictionary:
*   a: coefficient matrix from  $|A|x=b$ 
*   b: solution vector from  $|A|x=b$ 
*   cond: the L1 type condition number of matrix A
*   error: difference between the actual and smoothed excess volume
*   fac: matrix of the Lu factorization of the A matrix. Not used.
*   gamma: vector of least-squares fitting constants.
* infofile: user specified data file containing experimental data
*   ipvt: vector containing pivoting information. Not used here.
*   k: user specified number of fitting constants
*   n: number of data points in the data file
*   rcond: inverse of the L1 condition number
*   sse: sum of the square error for all data points
*   v: experimental excess volume data
*   vefit: excess volume from the smoothing equation
* wkarea: the work area required by IMSL version 9 routine LEQT2F
*   x: mole fraction of more volatile component
```

```
* Dimension variables and declare double precision
```

```
real*8 a(5,5),fac(5,5),x(200),v(200),b(5),gamma(5),vefit(200)
real*8 error(200),wkarea(100),sse,rcond,cond
integer*4 ipvt(5),k,n
character*14 infofile
```

```
* Fill data vectors and arrays with zeros
```

```
data a/25*0.0d0/
data x/200*0.0d0/
data v/200*0.0d0/
data b/5*0.0d0/
data gamma/5*0.0d0/
data vefit/200*0.0d0/
data error/200*0.0d0/
```

```
* Interact with user for number of fitting constants and
* name of data file
```

```
print *, 'How many curve fitting constants do you want?'
print *, '(must be between 2 and 5)'
print *
```

```

      read *, k

      print *, 'What is the name of the data file to be used?'
      print *
      print *, '(Data must be stored in x,y pairs with format f7.6,1x,f7.6.)'
      print *, 'The first line of the file must contain the number'
      print *, 'of data points in the file, with format I3)'
      print *
      read '(A)', infofile
      print *
      print *

* Fill x and V files with experimental data

      open(unit= 1, file= infofile, status= 'old')
      read (1,10),n
      format(1x,i3)
10      read (1,20), (x(i),v(i),i=1,n)
20      format(1x,f7.6,1x,f7.6)
      close(unit= 1)

* Convert Ve data to form Ve/(x1x2)

      do 50 i=1,n
          v(i)=v(i)/(x(i)-x(i)**2)
50      continue

* Calculate coefficient matrix

      do 51 j=1,k
          do 52 l=1,k
              do 53 i=1,n
                  a(j,l)=a(j,l)+(1-2*x(i))**(j+l-2)
53                  continue
52              continue
51          continue

* Calculate solution vector

      do 54 l=1,k
          do 55 i=1,n
              b(l)=b(l)+v(i)*(1-2*x(i))**(l-1)
              gamma(l)=b(l)
55          continue
54      continue

* Call IMSL subroutines...For convenience, both version 9
* and version 10 function calls are included

      call DLFCRG (k,A,5,FAC,5,IPVT,RCOND)
      call DLSARG (k,a,5,b,1,gamma)
      COND=1.0D0/RCOND
*      (IMSL version 10)

```

```

*      call LEQT2F(a,1,k,5,gamma,4,wkarea,ier)
*      (IMSL version 9)

*      Print least-squares fitting constants

      print 104, (i,gamma(i),i=1,k)
104      format(1x,'gamma ',11,' = ',f9.5)
      print *
      print *

*      Calculate Ve fit for each data point and correct to the form
*      Ve from the form  $Ve/(x1x2)$ . Also calculate error for each
*      data point and accumulate square error.

      do 204 i=1,n
        do 205 j=1,k
          vefit(i)=vefit(i)+gamma(j)*(1-2*x(i))**(j-1)
205          continue
          vefit(i)=vefit(i)*(x(i)-x(i)**2)
          v(i)=v(i)*(x(i)-x(i)**2)
          error(i)=v(i)-vefit(i)
          sse=sse+error(i)**2
204          continue

*      Calculate standard deviation for the data set

      sigma=(sse/(n-k))**.5

*      Print data summary point by point

      print *, ' x benzene      molar Ve      Ve fit
cError'
      print *, ' _____ '
      print *
      print 106, (x(i),v(i),vefit(i),error(i),i=1,n)
106      format(1x,4(d12.6,4x))
      print *
      print *
      print *

*      Print standard deviation information

      print 108, sigma
108      format(1x,'The standard deviation for this set of fitting constant
cs is: ',d12.6)
      print *
      print *

*      Print the condition number of the A matrix

      PRINT 109, COND
109      FORMAT(1X,'The condition number for the A matrix is: ',f8.3)

      end

```

```

* This program is designed to supplement the program named curvfit.
* Its purpose is to create a data file of experimental data points
* that is in a proper format to be accessed by the curvfit program.
* This program interacts with the user to determine the name of the
* data file, and then prompts the user to enter the data in the
* proper format. The data are arranged here as a text file, but are
* read by the program curvfit as numeric.

* Variable dictionary:
*   infile : the user specified name of the data file being made
*   k : the number of data points to be included in the file
*   line : the information from a single data point.

* Declare variables and dimension them
      character *20 line(200), infile

* Ask the user for the name of the data file to be created
      print *, 'What is the name of the file you want to create?'
      read '(A)', infile

* Read in the data elements to the file, number of data points first.
      open (unit = 1, file = infile, status = 'new')

      print *, 'How many data points will be in this file?'
      read *, k
      write (1,10), k
10      format(1x,i3)

* Prompt the user to enter the data points in the correct format.
      print *, 'Enter the data points as x,y pairs, where x is'
      print *, 'the mole fraction of the more volatile component'
      print *, 'and y is the experimental molar excess volume.'
      print *
      print *, '(There should be a space before the x points and'
      print *, ' a space between the x and y points, and their formats'
      print *, ' should be f7.6.)'
      print *
      print *, '      x      Ve'
      print *

* Read in the data points.
      do 100 i=1,k
        read 20, line(i)
        write (1,20) line(i)
20        format(1x,a20)
100      continue

      close (unit = 1)

      end

```

APPENDIX E
BURET CALIBRATION DATA

APPENDIX E-1
EXPERIMENTAL DATA

TABLE 31

EXPERIMENTAL DATA FOR BURET CALIBRATION

RUN 1

POINT NUMBER	WT OF HG ADDED (G)	HT OF HG IN BURET (CM)	REF LINE HEIGHT (CM)
INITIAL	136.92488	0.2723	0.1575
1	25.31131	2.0117	-0.5710
2	20.76882	3.9717	-0.5063
3	17.22815	5.5975	-0.5184
4	22.66185	7.7166	-0.5101
5	15.37205	9.1562	-0.5276

RUN 2

POINT NUMBER	WT OF HG ADDED (G)	HT OF HG IN BURET (CM)	REF LINE HEIGHT (CM)
INITIAL	147.70806	0.6726	-0.4971
1	14.28067	1.9920	-0.5126
2	14.22029	3.3230	-0.5250
3	12.84957	4.5506	-0.5036
4	13.54833	5.7898	-0.5378
5	13.78516	7.1099	-0.5104
6	13.56552	8.3903	-0.5119
7	17.10570	10.0010	-0.5194

RUN 3

POINT NUMBER	WT OF HG ADDED (G)	HT OF HG IN BURET (CM)	REF LINE HEIGHT (CM)
INITIAL	162.67139	2.0926	-0.4613
1	12.03903	3.1739	-0.5217
2	13.28431	4.4089	-0.5414
3	12.06771	5.5758	-0.5109
4	14.32788	6.8920	-0.5266
5	15.23696	8.3225	-0.5400
6	15.02251	9.7895	-0.4939

APPENDIX E-2
CALCULATED DATA

TABLE 312

CALCULATED DATA FOR BURET CALIBRATION

RUN 1				RUN 2				RUN 3			
POINT NUMBER	CHANGE IN HEIGHT (CM)	CROSS SEC. AREA (CM ²)		POINT NUMBER	CHANGE IN HEIGHT (CM)	CROSS SEC. AREA (CM ²)		POINT NUMBER	CHANGE IN HEIGHT (CM)	CROSS SEC. AREA (CM ²)	
1	2.4679	0.757827		1	1.3349	0.790466		1	1.1417	0.779153	
2	1.8953	0.809687		2	1.3434	0.782143		2	1.2547	0.782316	
3	1.6379	0.777203		3	1.2062	0.787141		3	1.1364	0.784652	
4	2.1108	0.793289		4	1.2734	0.786148		4	1.3319	0.794865	
5	1.4571	0.779517		5	1.2927	0.787947		5	1.4439	0.779730	
				6	1.2819	0.781926		6	1.4209	0.781200	
				7	1.6182	0.781073					
AVERAGE AREA (CM ²) = .783505				AVERAGE AREA (CM ²) = .785263				AVERAGE AREA (CM ²) = .783653			
n DEVIATION (CM ²) = .017298				n DEVIATION (CM ²) = .003316				n DEVIATION (CM ²) = .005325			
n-1 DEVIATION (CM ²) = .019340				n-1 DEVIATION (CM ²) = .003582				n-1 DEVIATION (CM ²) = .005833			
				VOLUME OF BB (CM ³) = 9.9955				VOLUME OF BB (CM ³) = 10.0182			

APPENDIX F
SAMPLE CALCULATIONS

Sample Calculations

A. Excess volume data.

This set of calculations is taken from dilution run #17, benzene + trichloroethylene 10 °C, data point 2.

Benzene is the solvent.

1. Volume of solvent charged in the mixing bowl:

The following measurements are provided:

Load (Data taken when mixing bowl is full of mercury)

CR 1.6693 cm
C 4.8263 cm
C2 4.7747 cm
C1 4.8066 cm

Initial (Data taken after solvent and solute have been charged)

CR 1.4803 cm
C 3.6977 cm
A 3.1551 cm
C2 0.5530 cm
C1 0.6344 cm
BR 7.41 cm
B 7.53 cm

Cross sectional areas:

C .01767 cm²
C1 .01773 cm²
C2 .01776 cm²
B .78452 cm²

Note: The capillary cross sectional areas were determined in a prior thesis, before the dilatometer was assembled. The buret cross sectional area and the bulb volume were determined in this work. (See buret calibration in the sample calculations).

$$\begin{aligned}
 V_{sc} = & V_{BB} + B_{ca} (B_i - BR_i) \\
 & + C1_{ca} [(C1_i - CR_i) - (C1_l - CR_l)] \\
 & + C2_{ca} [(C2_i - CR_i) - (C2_l - CR_l)] \\
 & + C_{ca} [(C_i - CR_i) - (C_l - CR_l)]
 \end{aligned}$$

Where: V represents a volume
 B refers to buret measurements
 BR refers to buret reference line measurements
 C1 refers to measurements on capillary C1
 C2 refers to measurements on capillary C2
 C refers to measurements on capillary C
 CR refers to capillary reference line measurements

subscript i indicates an initial measurement
 subscript l indicates a load measurement
 subscript ca indicates cross sectional area
 subscript BB indicates buret bulb
 subscript sc indicates solvent charged

For run #17:

$$\begin{aligned}
 V_{sc} = & 10.0069 + .78452 (7.53 - 7.41) \\
 & + .01773 [(6.344 - 1.4803) - (4.8066 - 1.6693)] \\
 & + .01776 [(5.530 - 1.4803) - (4.7747 - 1.6693)] \\
 & + .01767 [(3.6977 - 1.4803) - (4.8263 - 1.6693)] \\
 = & 9.9422 \text{ cc}
 \end{aligned}$$

2. Moles of solvent charged in the mixing bowl:

$$n_{sc} = V_{sc} / v_{\text{solvent}}$$

where: n_{sc} is the number of moles of solvent charged
 v_{solvent} is the specific volume of the solvent

$$n_{sc} = 9.9422 / 87.8134 = .1132 \text{ gmole}$$

The rest of the data will be illustrated by Figures 17, 18, and 19.

3. Change in height of mercury in buret, B:

$$\text{del } B = (B_2 - BR_2) - (B_1 - BR_1)$$

$$\text{del } B = (8.16 - 7.42) - (7.81 - 7.42) = .35 \text{ cm}$$

4. Change in height of mercury in capillary C1:

$$\text{del } C1 = (C1_2 - CR_2) - (C1_1 - CR_1)$$

$$\text{del } C1 = (3.6384 - 1.4938) - (3.6711 - 1.4998) = -.0267 \text{ cm}$$

FIGURE 17

RUN #17, DATA POINT #1

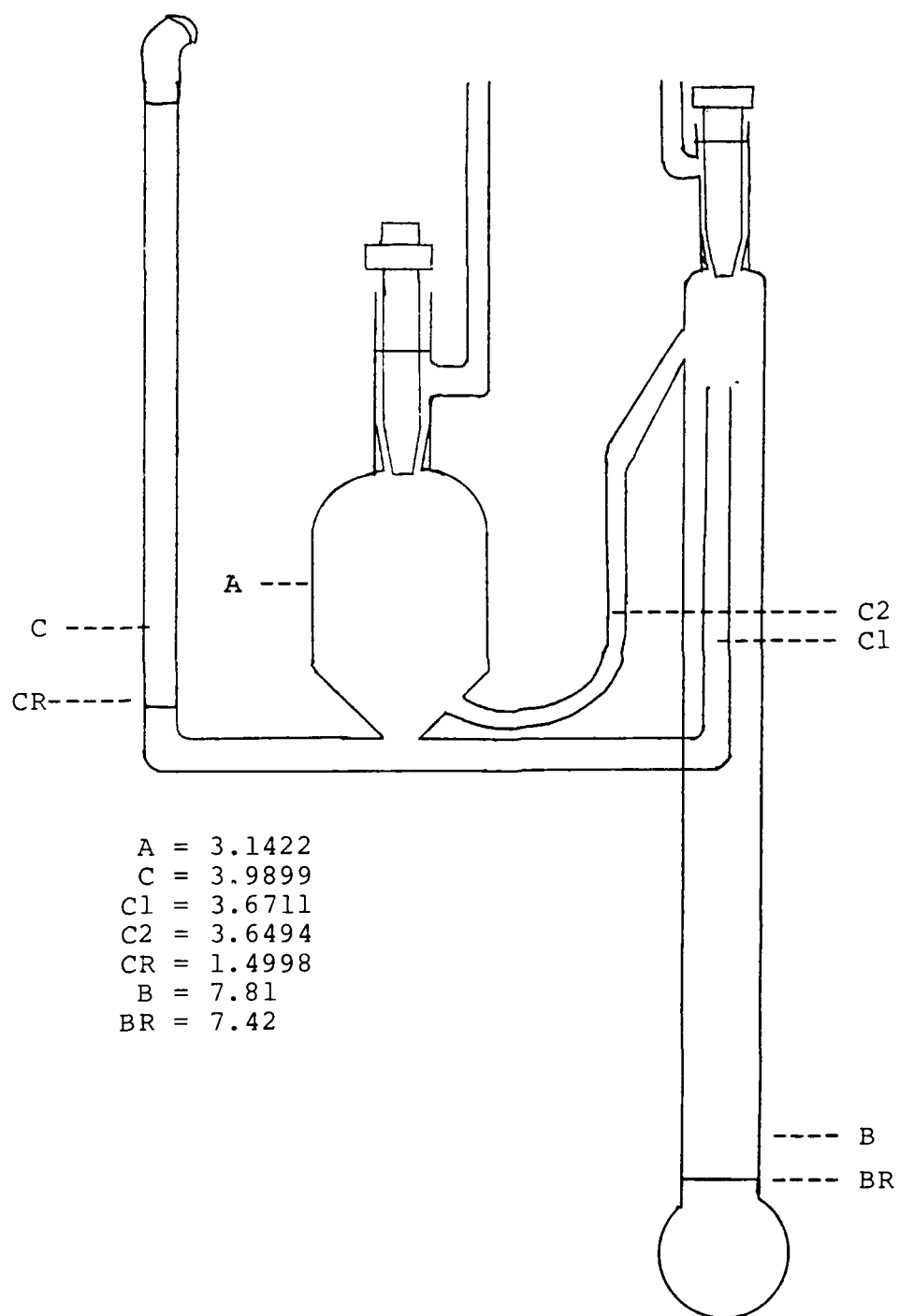


FIGURE 18

RUN #17, DATA POINT #2 BEFORE PRESSURE CORRECTION

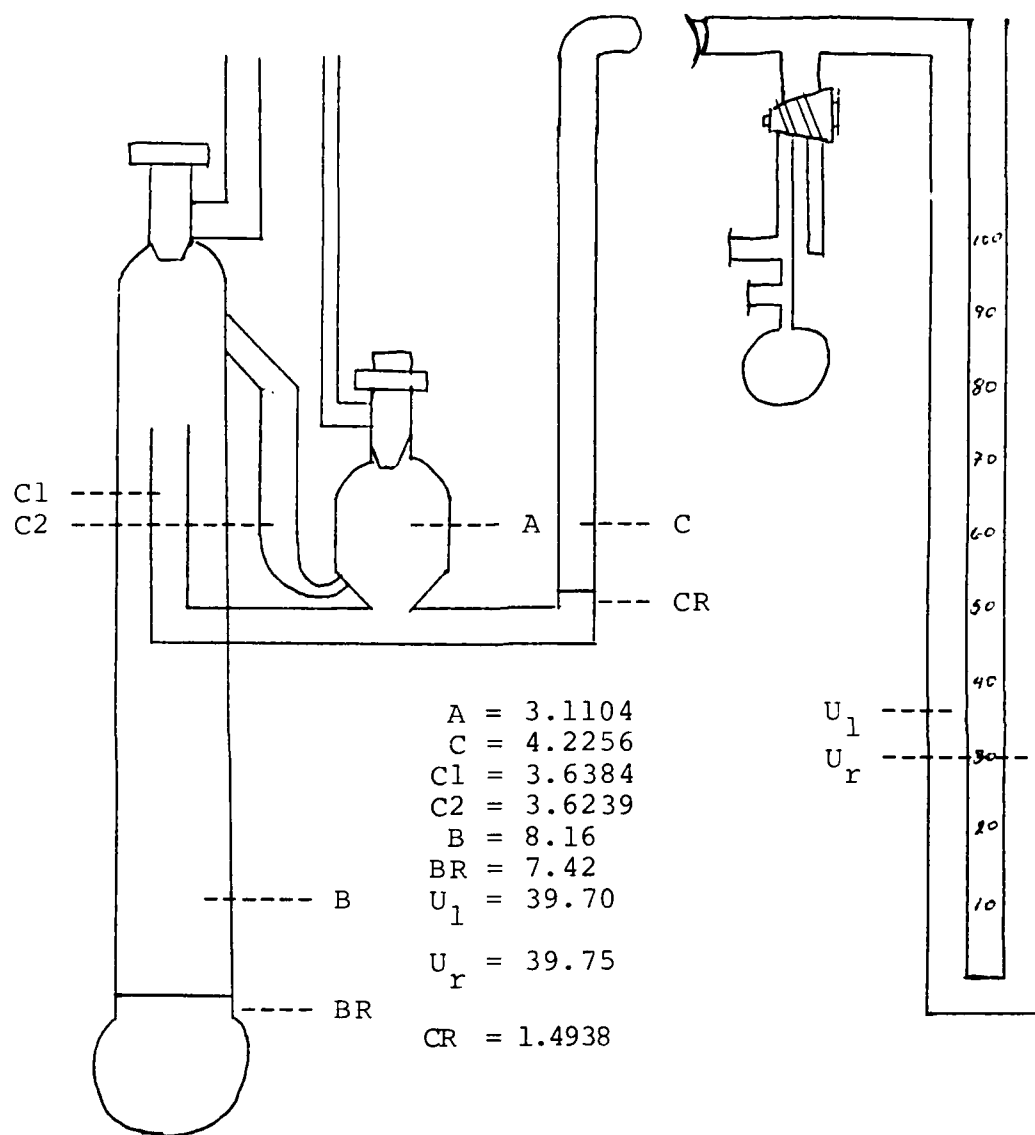
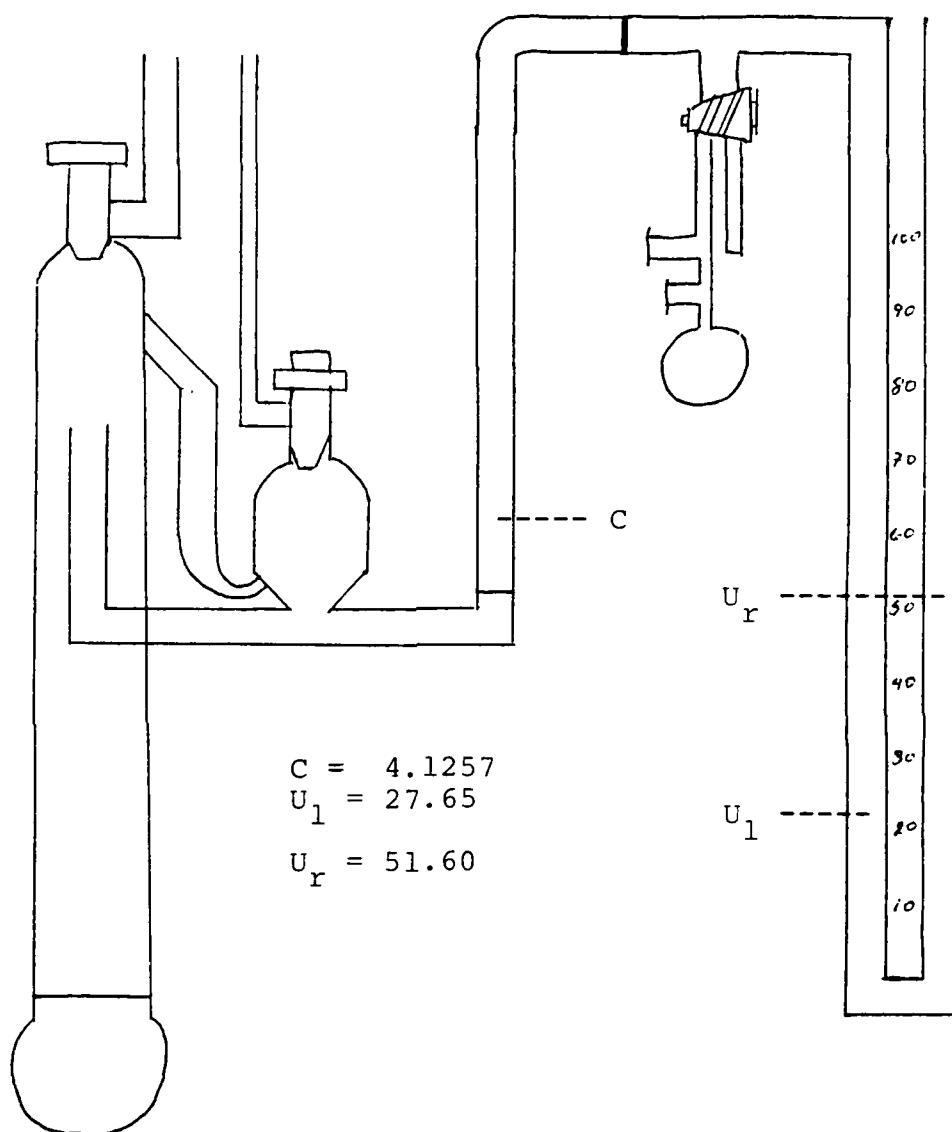


FIGURE 19

RUN #17, DATA POINT #2 AFTER PRESSURE CORRECTION



5. Change in height of mercury in capillary C2:

$$\text{del } C2 = (C2_2 - CR_2) - (C2_1 - CR_1)$$

$$\text{del } C2 = (3.6239 - 1.4938) - (3.6494 - 1.4998)$$

$$= -.0195 \text{ cm}$$

6. Change in height of mercury in capillary C:

$$\text{del } C = (C_{B2} - CR_2) - (C_{B1} - CR_1)$$

$$\text{del } C = (4.2256 - 1.4938) - (3.9899 - 1.4998)$$

$$= .2417 \text{ cm}$$

7. Change of height of mercury in mixing bowl:

$$\text{del } A = (A_2 - CR_2) - (A_1 - CR_1)$$

$$\text{del } A = (3.1104 - 1.4938) - (3.1422 - 1.4998)$$

$$= -.0258 \text{ cm}$$

8. Volume of solute added to solvent:

$$\text{del } V_c = (\text{del } B) * B_{ca} + (\text{del } C1) * C1_{ca} + (\text{del } C2) * C2_{ca}$$

$$\text{del } V_c = (.35) * .78452 + (-.0267) * .01773$$

$$+ (-.0195) * .01776 = .27376 \text{ cc}$$

9. Number of moles of solute added to the solvent:

$$\text{del } n_c = \text{del } V_c / v_{\text{solute}}$$

$$\text{del } n_c = .27376 / 88.627319 = .003089 \text{ gmole}$$

10. Total number of moles of solute in the mixing bowl:

$$n_{cTOT2} = n_{cTOT1} + \text{del } n_c$$

$$n_{cTOT2} = .003610 + .003089 = .006699 \text{ gmole}$$

11. Mole fraction of benzene in mixing bowl:

$$x(\text{Benz}) = n_{sc} / (n_{sc} + n_{cTOT})$$

$$x(\text{Benz}) = .1132 / (.1132 + .006699) = .9441$$

12. Cumulative height change of mercury in capillary C:

$$CTOT_2 = CTOT_1 + \text{del } C$$

$$CTOT_2 = .27268 + .2417 = .5144 \text{ cm}$$

13. Pressure corrected change in height of mercury in capillary C:

$$\Delta C_{pi} = C_{A2} - C_{B2}$$

$$\Delta C_{pi} = 4.1257 - 4.2256 = -.0999 \text{ cm}$$

14. Back-pressure applied:

$$\Delta U = (U_{lb} - U_{rb}) + (U_{ra} - U_{la})$$

$$\Delta U = (39.70 - 39.75) + (51.60 - 27.65) = 23.90 \text{ cm}$$

15. Excess volume (pressure corrected): (Kumaran, p. 265)

$$V^E = CTOT \cdot C_{ca} \cdot [1 - (\Delta C_{pi} / \Delta U)] \\ \cdot [1 - (\Delta A / CTOT)]$$

$$V^E = .5144 \cdot .01767 \cdot [1 - (-.0999/23.90)] \\ \cdot [1 - (-.0258/.5144)]$$

$$V^E = .009585 \text{ cc}$$

16. Molar excess volume (pressure corrected):

$$V_{em} = V^E / (n_{sc} + n_{cTOT})$$

$$V_{em} = .009585 / (.1132 + .006699) = .0799 \text{ cc/gmole}$$

B. Buret Calibration Data

Calibration was conducted at 24.947 °C. The mercury density at this temperature is 13.5337 g/cc. This value was obtained from Figure 20.

1. Cross sectional area (using run #2 point 1):

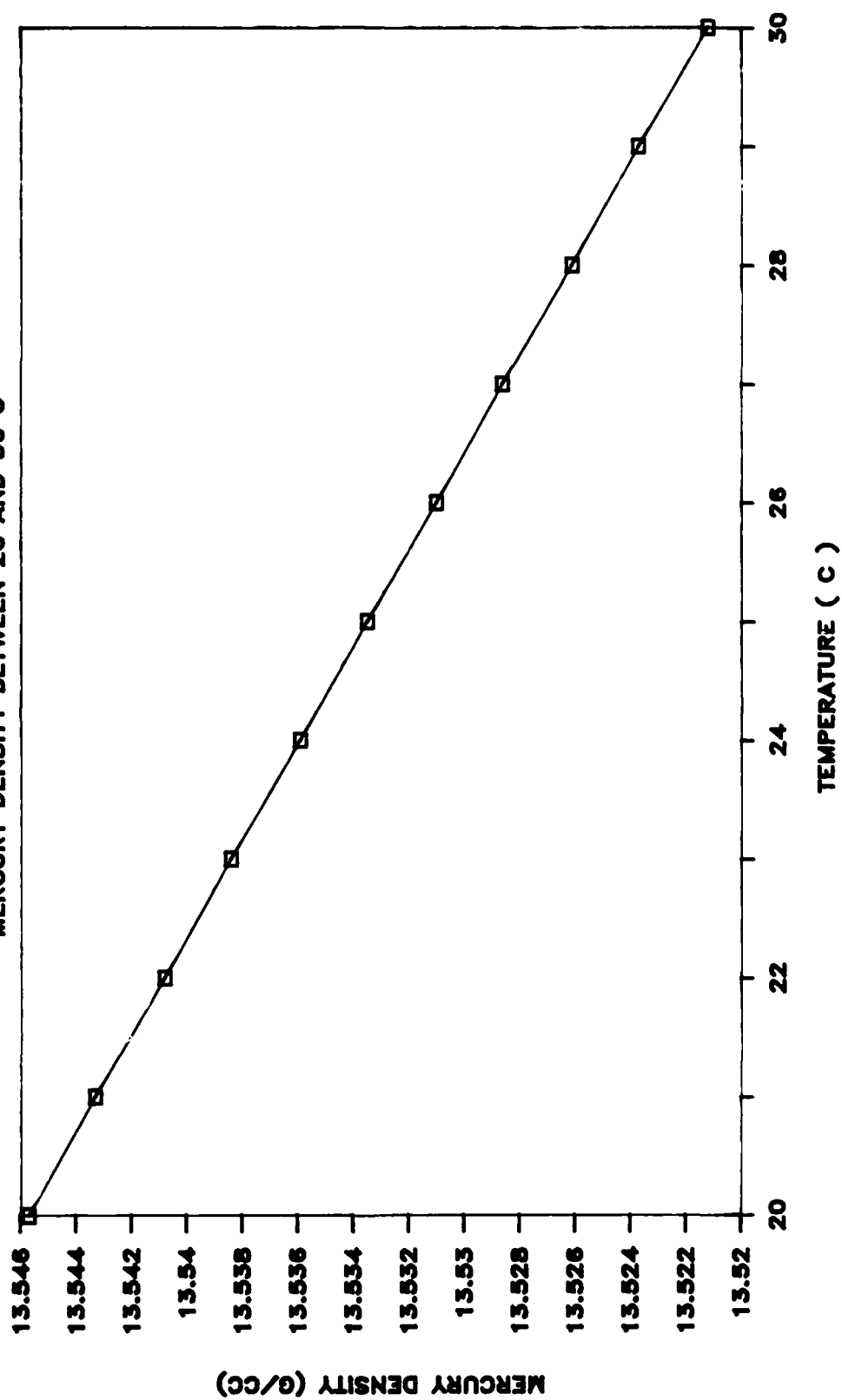
$$A = w / (\rho \cdot \Delta h)$$

where: A is the cross sectional area
 w is the weight of mercury added
 ρ is the density of mercury
 Δh is the change in height of mercury

$$\Delta h = (2.5046 - 1.1697) = 1.3349 \text{ cm}$$

$$A = 14.28067 / (13.5337 \cdot 1.3349) = .7904662 \text{ cm}^2$$

FIGURE 20
MERCURY DENSITY BETWEEN 20 AND 30 C



2. Average cross sectional area and standard deviations
(using run #2):

$$\bar{A} = \sum A_i / n$$

where: $\bar{A}$ is the average cross sectional area
 A_i is the cross sectional area of data point i
 n is the number of data points in the run

Using the statistical functions on a Texas Instruments
 TI-55 III calculator,

$$\bar{A} = 5.4968473 / 7 = .7852639 \text{ cm}^2$$

$$\sigma_n = .0033168$$

$$\sigma_{n-1} = .0035825$$

Note: The final A value used was that calculated from the
 13 data points in runs 2 and 3 combined. Run 1 was
 discarded due to poor agreement with the other runs.

3. Volume of the bulb BB (from run #2):

V_{BB} = Volume of mercury initially charged - volume of
 mercury above BR

Weight of mercury charged = 147.70806 g

Height of mercury charged = 1.1697 cm above BR

$$A = .7853 \text{ cm}^2$$

Weight of mercury above BR: $w = A * \rho * \Delta h$

$$w = .7853 * 13.5337 * 1.1697 = 12.431589 \text{ g}$$

Weight of mercury below BR = weight of mercury charged
 - weight of mercury above BR

$$\text{Weight of mercury below BR} = 147.70806 - 12.431589$$

$$= 135.27647 \text{ g}$$

V_{BB} = weight of mercury below BR / density of mercury

$$V_{BB} = 135.27647 / 13.5337 = 9.9955 \text{ cc}$$

Note: The volume used for the bulb was the average for runs
 2 and 3.

APPENDIX G
NOMENCLATURE

NOMENCLATURE

A	Mixing bowl on the dilatometer
$\bar{A}$	Average cross sectional area
A_1	Cross sectional area of data point 1
a_j	Least-squares fitting constants
B	Buret on the dilatometer
BB	Bulb at the bottom of buret
B_{ca}	Buret cross sectional area
BR	Reference mark on the buret
C	Condition number
C, C1, C2	Capillary tubes on the dilatometer
C, C1, C2 _{ca}	Capillary cross sectional area
CR	Reference mark on capillary C
CTOT	Cumulative change in height of mercury in C
del A	Change in height of mercury in mixing bowl
del B	Change in height of mercury in buret
del C, C1, C2	Change in height of mercury in a capillary
del C pi	Pressure corrected change in height of mercury in C
del n _c	Number of moles of solute added to solvent
del V _c	Volume of solute added to the solvent
del U	Back-pressure applied to C
G ^E	Excess Gibbs free energy of mixing
m	Number of data points used to fit a curve
n	Number of coefficients in least-squares fit

n	Number of data points in buret calibration run
n_{cTOT}	Total number of moles of solute in mixing bowl
n_{sc}	Number of moles of solvent charged
P	Total pressure
$S1, S2$	Vent tubes on the dilatometer
T	Temperature
$T1, T2$	Taps on the dilatometer
U_1	Back-pressure reading 1 on U tube
V_{BB}	Volume of bulb BB
v^E	Excess molar volume of mixing
v_{eT}	Maximum excess volume at temperature T
$\bar{V}_1$	Partial molar volume of component 1
v_1^o	Molar volume of component 1 in solution
v^{ID}	Molar volume of an ideal solution
v_i^E	Excess volume of mixing for data point 1
v_{sc}	Volume of solvent charged
v_{solute}	Specific volume of the solute
$v_{solvent}$	Specific volume of the solvent
w	weight of mercury added
$x \text{ (Benz)}$	Mole fraction of benzene in mixing bowl
x_1	Mole fraction of component 1 in solution
Δh	Change in height of mercury in calibration run
Δv	Molar volume change on mixing
σ_n	Population standard deviation
σ_{n-1}	Standard deviation of a point
f	Density

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VITA

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[REDACTED]

His elementary education was obtained in the public schools of Fairborn, Ohio, and secondary education at Park Hills High School, Fairborn, Ohio, where he graduated in 1974, ranking seventh in his class.

In July, 1974, he entered the United States Military Academy at West Point, New York. In 1978, he graduated with a Bachelor of Science degree, concentrating in chemistry. Upon graduation, he was commissioned as a second lieutenant in the United States Army.

He has served as an Armored Cavalry Platoon Leader, Logistics Officer for an Armored Cavalry Squadron, and Commander of a Cavalry Troop. In December of 1983, he was married to Jeannette Rae Harvie. He currently has two children, Anna Christine, and Rebekah Kay, and is expecting a third in December. His hobbies include gardening, skiing, and other forms of athletic endeavor.