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SOLUBILITY OF THE HIGHLY SOLUBLE GASES, 1,3-BUTADIENE AND TRANS-2-BUTENE IN CARBON DISULFIDE AND SEVERAL POLAR SOLVENTS

by

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Thesis submitted to the School of Graduate Studies of the University of Ottawa in partial fulfillment of the requirements for the degree of

MASTER OF APPLIED SCIENCE

in the

Department of Chemical Engineering
University of Ottawa

1982

ABSTRACT

The solubilities of highly soluble gases, of 1,3-butadiene and trans-2-butene were measured in the solvents, acetone, acetic acid, carbon disulfide, dimethyl formamide, N,N-dimethyl acetamide and ethyl acetate at atmospheric pressure and temperatures ranging from 278.15°K to 323.15°K. It was found that the solubilities of 1,3 butadiene in the solvents, carbon disulfide, dimethyl formamide and N,N-dimethyl acetamide were especially higher than those of trans-2-butene in the same solvents at the same temperature. When possible, the experimental results were compared with those predicted by theoretical correlations such as the ideal gas solubility and the regular solution theory. Consequently, it became clear that neither correlation could be used for predicting solubilities of highly soluble gases.

ACKNOWLEDGMENT

The author wishes to express his appreciation and gratitude to Dr. W. Hayduk for his kind assistance and guidance throughout this work.

Many thanks are also extended to Mr. G. Gasperetti and his staff for their technical assistance in constructing and maintaining the apparatus.

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a	Calculation parameter [cm^3 solute atm^2/cm^3 solvent]
A	Margules constant [-]
b	Calculation parameter [cm^3 solute atm^2/cm^3 solvent]
c	Calculation parameter [cm^3 solute atm/cm^3 solvent]
f	Fugacity [atm]
F	Liquid flow rate [cm^3/min]
G	Gibbs free energy [J]
H	Enthalpy [J]
L	Ostwald coefficient [cm^3 solute/cm^3 solvent]
n	The number of moles [moles]
P	Pressure [atm]
R	Gas constant [J/mole ^oK]
S	Entropy [J]
T	Temperature [^oK]
U	Internal energy [J]
V	Volume [cm^3/mole]
x	Liquid phase mole fraction [-]
y	Gas phase mole fraction [-]
Y	Slope [cm^3 gas/min]
α	Hydrogen-bonding factor [-]
γ	Activity coefficient [-]
δ	Solubility parameter $[J/cm^3]^{1/2}$
ϕ	Fugacity coefficient [-]

Superscript

G	Gas phase
i	Ideal
L	Liquid phase
S	Saturation
V	Vaporization
-	Partial molal quantity
~	Mixture

Subscript

i	i-th component
P_2	Partial pressure, P_2
r	Room temperature
t	Total
1	Solvent
2	Solute

INTRODUCTION

A knowledge of equilibrium gas solubility is indispensable for the design of absorption equipment for many chemical processes. Corresponding to the practical needs of the chemical industry, many studies concerning gas solubilities in liquids have been reported. Several reviews related to this subject are available including those of Markham and Kobe (1941)[1], Croxton (1949)[2], Rowlinson and Richardson (1959)[3], and Clever and Battino (1966)[4]. From those reviews it is found that no general or widely applicable theory has yet appeared except perhaps for several original studies, which include the concept of ideal gas solubility, the regular solution theory proposed by Hildebrand[5], the cavity model theory proposed by Uhlig[6], and the thermodynamic considerations for a gas solubility by Reiss[7], Sherwood[8] and Pierotti[9]. For a thorough understanding of solubility phenomena, further experimental research as well as theoretical studies are needed.

Among various kinds of gas solubility research, the study of the solubility of highly soluble gases is in a unique position as very few experimental results have been reported. In 1973, Hayduk et al[10] reported their experimental results, in which the solubilities of n-butane as a solute gas at 298.2°K and atmospheric pressure in hexane, heptane, octane and dodecane were all approximately 80 mol %.

Such high values of solubility significantly change the usual concept of gas solubility in which the gas solubility in liquids is normally considered to be at most 5 mol %.

In the separation and purification process of 1,3-butadiene[11] the first step usually involves a conventional fractional distillation. This process separates the hydrocarbon mixture into a series of fractions having about the same boiling point. One of these fractions involves the C_4 hydrocarbons: isobutane, trans-2-butene, cis-2-butene, 1-butene, 1,3-butadiene, isobutylene and n-butane. The boiling points of these hydrocarbons are so similar that the second step usually depends upon liquid extraction or extractive distillation in order to separate 1,3-butadiene from the C_4 stream[12], [13], [14], [15]. In the purification of 1,3-butadiene, the separation between 1,3-butadiene and trans-2-butene is considered the most difficult. At this stage, the problem involves determining which solvent is the most effective extractive medium. Although a number of solvents have been suggested, a systematic research study has not yet been made comparing the solubilities of various C_4 components in many solvents.

In this work, the solubilities of 1,3-butadiene and trans-2-butene were measured in six solvents, some of which have been used as the extractive medium on a commercial basis. As expected, the results obtained showed that 1,3-butadiene was highly soluble in some of the solvents.

The results from this work are intended to give some indication of the solubility of 1,3-butadiene compared with that of trans-2-butene, which is the most difficult of the C_4 components to separate from 1,3-butadiene. The experimental results may also aid in elucidating the phenomenon of high gas solubility.

IDEAL GAS SOLUBILITY

A mathematical description of the gas-liquid equilibrium for the solute gas component in the binary system is expressed as follows:

$$\bar{G}_2^{\,G} = \bar{G}_2^{\,L} \quad [T,P] \tag{1}$$

In this equation, $\bar{G}_2^{\,G}$ and $\bar{G}_2^{\,L}$ are the partial molal Gibbs-Helmholtz free energy. The denotation, [T,P], means that the temperature and pressure are constant. For a binary gas-liquid system, the number of intensive properties is two according to the Gibbs phase rule. That is, the state of the system can be completely described by fixing two independent intensive properties. Thus the temperature and pressure are usually kept constant in solubility experiments.

The fugacities at constant temperature of the solute gas component in the gas and liquid phases, $\hat{f}_2^{\,G}$ and $\hat{f}_2^{\,L}$, are defined as follows:

$$d\bar{G}_2^{\,G} = RT\, d\ell n\, \hat{f}_2^{\,G} \tag{2}$$

$$d\bar{G}_2^{\,L} = RT\, d\ell n\, \hat{f}_2^{\,L} \tag{3}$$

where

$$\lim_{P_t \to 0} \frac{\hat{f}_2^{\,G}}{P_t y_2} = 1 \tag{4}$$

$$\lim_{P_t \to 0} \frac{\hat{f}_2^{\,L}}{P_t x_2} = 1 \tag{5}$$

In the above equations P_t is the total pressure, y_2 is the solute gas composition in the gas phase and x_2 is the composition in the liquid phase.

The change in Gibbs-Helmholtz free energy of the solute gas component during the solution process can be obtained from Equations (2) and (3) as follows:

$$\overline{G}_2^{L} - \overline{G}_2^{G} = RT \ln \frac{\hat{f}_2^{L}}{f_2^{G}} \qquad (6)$$

The combination of Equation (1) and Equation (6) results in the following:

$$\hat{f}_2^{G} = \hat{f}_2^{L} \qquad (7)$$

Equation (7) plays a very important role in the determination of the phase equilibria, whether the system is at a high or low temperature, or at a high or low pressure. This equation, however, is of little use for practical phase equilibrium determinations since the dependence of the fugacities of both phases on temperature, pressure and composition of the system is not known. Equation (7) then can be rewritten in terms of the fugacity coefficient and the activity coefficient.

$$\hat{\phi}_2 P_t y_2 = \gamma_2 P_2^{s} x_2 \qquad (8)$$

In Equation (8) $\hat{\phi}_2$ is the fugacity coefficient defined as:

$$\ln \hat{\phi}_2 = \ln \left(\frac{\hat{f}_2^G}{P_t y_2}\right) = \frac{1}{RT} \int_0^{P_t} \left[\left(\frac{\partial (nV)}{\partial n_2}\right)_{T,P,n_I} - \frac{RT}{P}\right] dP \quad (9)$$

When the pressure is low, it is known that $\hat{\phi}_2$ is nearly equal to unity. The γ_2 in Equation (8) is the activity coefficient which also has a value of unity when the non-ideality of the liquid is neglected. The P_2^s is the vapor pressure of the solute component as a liquid.

For the case when the pressure is low and the liquid phase is assumed to be ideal, Equation (8) then can be reduced to the following form:

$$P_2 = P_2^s x_2 \quad (10)$$

In Equation (10), P_2 is the partial pressure of the solute gas component. The ideal gas solubility is defined in Equation (10) for a gas partial pressure of one atmosphere;

$$x_2^i = \frac{1}{P_2^s} \quad (11)$$

When the solution temperature is above the critical temperature of the solute gas, a hypothetical saturation pressure may be obtained by extrapolating the saturation curve of the pure liquid beyond its critical temperature to the solution temperature. Thus a hypothetical ideal gas solubility is available for systems in which the solute gas is at a supercritical temperature.

Another useful characteristic of the ideal gas

solubility relationship is that the ideal gas solubility becomes unity when the system temperature is reduced to the normal boiling point of the solute gas. It may be observed from Equation (11), that the gas vapor pressure diminishes as the system temperature is reduced to the normal boiling point of the solute gas. This result can also be experimentally justified. That is, a very small amount of solvent and a large amount of solute gas at its boiling point would tend to form a liquid phase with the solute component mole fraction in the liquid phase almost equal to unity, provided that both components were miscible and liquid did not freeze as the temperature was reduced to the gas normal boiling point.

The ideal gas solubility relationships, however, erroneously suggests that the gas solubility is dependent only on the nature of the solute and not on the solvent, and that for a constant partial pressure the solubility of a gas always decreases with increasing temperature. Actually, solubilities of a single gas often vary greatly from solvent to solvent and in many instances a gas solubility increases with increasing temperature.

Gas Solubility Based on the Regular Solution Theory

The regular solution theory was proposed by Hildebrand[5] for the first time in 1929. In this theory although other specific molecular interactions were neglected, the heat of mixing was taken into account. According to this theory internal energy change of component i, associated with the solution of a gas in a solvent was described in terms of solubility parameter:

$$\delta_i = \left(\frac{\Delta U_i^V}{V_i}\right)^{1/2} \tag{12}$$

From thermodynamic relationship, ΔU_i^V can be expressed as follows:

$$\Delta U_i^V = \Delta H_i^V - RT \tag{13}$$

Inserting Equation (13) into Equation (12), the solubility parameter can be rewritten as:

$$\delta_i = \left(\frac{\Delta H_i^V - RT}{V_i}\right)^{1/2} \tag{14}$$

In Equation (14) ΔH_i^V is the enthalpy of evaporation, and V_i is the liquid molar volume.

Using solubility parameter expressed by Equation (14), Hildebrand proposed an equation which can predict a gas solubility in a liquid:

$$\ell n x_2 = \ell n x_2^{\,i} - \frac{V_2}{RT}(\delta_1 - \delta_2)^2 \tag{15}$$

This Equation (15) is referred to as the equation of the regular solution theory[16], [17], [18]. It is well known that the prediction of gas solubility by this equation is at least partially successful for solutions where both solute and solvent are non-polar or slightly polar substances. For application of the regular solution theory, recommended values of solubility parameters and hypothetical liquid molar volumes of various solutes are available in the literature [17], [18]

The Effect of Temperature on Gas Solubility

A systematic study concerning the effect of temperature on gas solubility was made by Hildebrand et al.[18] They considered the simple case where the solvent was essentially non-volatile and the solubility was sufficiently low to make the activity coefficient of the solute independent of the mole fraction solubility.

From Equations (2) and (3), the change in Gibbs-Helmholtz free energy of solute component in the dissolution process can be given as follows:

$$\bar{G}_2^{L} - G_2^{G} = RT\ln\frac{\hat{f}_2^{L}}{f_2^{G}} \qquad (16)$$

The entropy change for the same process can be obtained by differentiating Equation (16) with respect to T.

$$\bar{S}_2^{\,L} - S_2^{\,G} = \frac{-\partial}{\partial T}\left(\bar{G}_2^{\,L} - G_2^{\,G}\right)_{P,n_1,n_2}$$

$$= \left[\frac{\partial\left(\bar{G}_2^{\,L} - G_2^{\,G}\right)}{\partial\ \ell n x_2}\right]_{P,T}\left[\frac{\partial\ \ell n x_2}{\partial T}\right]_{\bar{G}_2^{\,L} - G_2^{\,G},P}$$

$$= RT\left[\frac{\partial\ \ell n\ \hat{f}_2^{\,L}}{\partial\ \ell n x_2}\right]_{P,T}\left[\frac{\partial\ \ell n x_2}{\partial T}\right]_{\bar{G}_2^{\,L} - G_2^{\,G},P} \qquad (17)$$

When the solvent is non-volatile Equation (17) can be rewritten as:

$$\bar{S}_2^{\,L} - S_2^{\,G} = \left[\frac{\partial\ \ell n\ \hat{f}_2^{\,L}}{\partial\ \ell n x_2}\right]_{P,T}\left[\frac{\partial\ \ell n x_2}{\partial T}\right]_{\bar{G}_2^{\,L} = G_2^{\,G},P} \qquad (18)$$

The general expression for $\hat{f}_2^{\,L}$ can be given by

$$\hat{f}_2^{\,L} = f_2^{\,L} \cdot \gamma_2 \cdot x_2 \qquad (19)$$

When the activity coefficient of the solute is regarded as being independent of x_2, Equation (19) becomes:

$$\hat{f}_2^{\,L} = (\text{constant}) \cdot x_2 \qquad (20)$$

The substitution of Equation (20) into Equation (18) results in:

$$\Delta\bar{S}_2 = R\left[\frac{\partial\ \ell n x_2}{\partial\ \ell n T}\right]_{\text{sat.},P} \qquad (21)$$

where the $\Delta\bar{S}_2 = \bar{S}_2^{\,L} - S_2^{\,G}$, sat. denotes saturation at equilibrium.

The corresponding change of the enthalpy can be obtained as follows immediately from Equation (21)

$$\Delta\bar{H}_2 = T\Delta\bar{S}_2$$

$$= -R\left[\frac{\partial \ln x_2}{\partial (1/T)}\right]_{sat.,P} \qquad (22)$$

The Equations (21) and (22) are physically meaningful equations in that they can explain qualitatively the experimentally determined fact that plots of log x_2 against log T, and plots of log x_2 against 1/T are essentially linear. Such plots have been found linear, especially for a short range of temperature, even for volatile solvents and gases of high solubility.

The Effect of Molecular Interaction on Gas Solubility

In the dissolution process of a gas in a liquid, the solubility depends upon the molecular interaction between solvent molecules, and solute and solvent molecules. Systematic studies of these effects on gas solubility, however, are rare. The discussions are usually qualitative rather than quantitative.

The solubility of the gas is sometimes enhanced as a result of a specific affinity between solute and solvent molecules. But, the strength of this affinity does not always determine the solubility, since the solvent molecules may attract each other much more strongly than the solute molecules. Highly self-associated solvent molecules will not tend to separate with ease. It becomes clear, therefore, that

solubility phenomenon is difficult to understand from a single view point. Several different types of affinities will be considered.

The first involves a reversible chemical reaction between the gas and liquid, which occurs, for example, in the sulfurous acid-water and ammonium-water systems. In this case, the gas solubility is highly enhanced and usually greatly exceeds the ideal gas solubility. The second type of affinity involves hydrogen-bonding[19], [20]. Hydrogen atoms linked to an electronegative atom behave as electron-acceptors. Thus the hydrogen atoms tend to be attracted to other electronegative atoms. When such an attraction takes place not only between solvent molecules but also between solute and solvent molecules, the solubility is expected to increase. As an example in this case, the acetylene-acetone system belongs to this category. Usually solubilities for systems exhibiting hydrogen-bonding, do not surpass the ideal gas solubility as they may in the cases in which reversible chemical reactions occur. The third type of molecular interaction can be considered a weak physical attraction between solute and solvent molecules. The resulting solubilities are what would be considered normal or very approximately the ideal gas solubility.

Solvents are usually classified into two categories. One is the protic solvent that has hydrogen attached to an electronegative atom, and the other is an aprotic solvent that has no hydrogen atom attached to the electronegative

atom. Both of these two types of solvents, however, can promote the dissolution of a solute gas by forming a hydrogen bond between solute and solvent molecules, provided that the solute gas also possesses hydrogen atoms which have a positive nature.

In these experiments the following solvents were used: carbon disulfide, acetone, acetic acid, dimethyl formamide, N,N-dimethyl acetamide and ethyl acetate. Of all these solvents, only acetic acid is a protic solvent because in this molecule there is a hydrogen atom attached to an oxygen atom. Furthermore, this substance has another oxygen of the carbonyl group, which is negatively charged. Thus in the liquid state, acetic acid exists as a dimer, forming two hydrogen bonds. It is, therefore, expected that the attractive forces between a solute gas and the acetic acid molecules will be much smaller by comparison, so that a solute gas might be expected to dissolve sparingly. All the remaining aprotic solvents except for carbon disulfide possess carbonyl group in which the oxygen is an electron-rich site. This oxygen is then expected to work as a nucleophilic atom for solute gases which have electrophilic atoms. In these cases solubility will be expected to be enhanced. Carbon disulfide itself is a non-polar substance, but the two sulfur atoms symmetrically attached to the carbon produce electronegative sites, which may also enhance the solubility of solute gases which have electrophilic atoms.

The gases used in this work are 1,3-butadiene and trans-2-butene. It is known that hydrogen attached to the carbons which are linked to another carbon by double or triple bonds are electrophilic. Therefore, it is expected that those solute gases may form hydrogen bonds with solvents which have nucleophilic atoms in their molecules.

Hayduk et al.[21] proposed a hydrogen-bonding factor defined as the ratio of the actual solubility to the ideal gas solubility for the purpose of analyzing solubility phenomena mainly for polar or hydrogen-bonding systems. They postulated that, for systems which involve a hydrogen-bonding solvent, a strong interaction between solvent molecules results in a reduced solubility. Then they tried to correlate hydrogen-bonding factors in different solvents for which gas solubility data were available such as acetone and acetic acid. Consequently they were able to obtain a fairly consistent relationship. The detailed discussion concerning this correlation is made later.

Miyano et al.[22] proposed a simple correlating equation of gas solubility using hydrogen-bonding factors. The original simplified Margules equation is written as:

$$\ln \gamma_2 = \frac{A}{RT} x_1^2 \qquad (23)$$

In the above equation, A is an empirical constant which depends upon temperature.

By defining $A_{12} = A/RT$, and assuming that the activity coefficient can be given as

$$\gamma_2 = \frac{x_2^i}{x_2} = 1/\alpha \qquad (24)$$

Equation (23) can be changed into a correlating equation:

$$\ln \alpha = -A_{12} x_1^2 \qquad (25)$$

APPARATUS AND PROCEDURE

For the measurement solubility of highly soluble gas, a spiral tube-type solubility apparatus, first proposed by Morrisson and Billet[23], and then modified by Hayduk and Cheng[24], was remodified. The schematic diagram of the apparatus is shown in Figure 1 and Figure 2.

The apparatus in Figure 1 is for degassing the solvent. It was constructed of glass to avoid contamination of the solvent during degassing. The procedure for degassing involved first putting a suitable amount of solvent (about 40 cm^3) into the flask which was equipped with a tape heater, and then applying a vacuum. When the boiling point of the solvent was high, a heater was used to raise the solvent temperature to facilitate boiling. After a sufficient boiling time had elapsed to degass the solvent (usually 20 to 30 minutes) the liquid was allowed to flow into a column packed with glass beads where further degassing was performed for more than 10 minutes. Then the vacuum was released and the degassed solvent, stored in the void space of the beads, was withdrawn by means of syringe through the septum rubber

stopper installed at the lower end of the packed column. By using a syringe, driven by a syringe-pump device, the degassed solvent was injected into the spiral tube of the solubility apparatus.

A gas-tight syringe with a capacity of 5 cm^3 was used for all the experiments. This syringe was combined with one of three interchangeable constant speed motors, attached to a syringe infusion pump to give the necessary solvent flows. Thus three motor speeds, 1/5 rpm, 1/20 rpm and 1/60 rpm were used to give the three different liquid rates, 0.01751 cm^3/min, 0.00615 cm^3/min and 0.00147 cm^3/ min. These liquid flow rates were measured by calibration using distilled water at room temperature. The average calibration temperature for each flow rate was 22.0°C., 22.6°C and 23.5°C. For calibration of the syringe pump, the quantity of water infused into a plastic vial during a 2 to 8 hour period was accurately weighed.

In Figure 2 is shown a schematic diagram of the solubility apparatus. The apparatus consists of a gas burette, a spiral tube, a miniature capillary U-tube manometer and a solution collecting burette enclosed inside a cylindrical glass jacket through which water at constant temperature is circulated. The top part of the spiral tube containing the tip of a long needle of the syringe, is connected to the upper end of the gas burette which serves as a storage chamber for the solute gas. The lower end of the spiral tube is attached to a capillary U-tube where the saturated solvent, flowing

down the spiral tube, is utilized as the manometer liquid to balance the internal pressure of the confined space (from the free mercury surface to the saturated liquid column observed in the U-tube) with atmospheric pressure. The saturated liquid held momentarily in the U-tube, overflows into the solution collecting burette.

For high solubility measurements involved in this work, several modifications were made to both the gas burette and the spiral tube. Three different solubility devices were constructed using burette sizes of 50 cm^3, 100 cm^3 and 250 cm^3 depending on the extent of solubility to be measured. The burettes utilized in the experiments are much bigger than those suitable for low solubility systems, the sizes of which are usually from 5 cm^3 to 20 cm^3. Several different aspects were considered in the modified design of the spiral tube including the total length of the tube; the angle of descent of the spiral tube, the radius of the spiral coil and the radius of the spiral tube itself. For high solubility systems, the liquid flow rates had to be much smaller than those for the more common low solubility systems to avoid the need for extremely large sized gas burettes.

The residence time for the solvent liquid to pass through the entire spiral tube, was usually 15 to 30 minutes for the low solubility systems. This residence time was determined by measuring the duration of time from the initial starting time of the syringe pump to the time when the liquid

was first observed in the U-tube manometer for the first time. When the apparatus using the larger and longer spiral tube was used for the high solubility systems, the residence time was found to be three to five times greater than when low solubilities were measured, because of the very low liquid flow rates. Thus modifications of the spiral tube were made for high solubility systems. Fortunately, the solvent was more easily saturated if the flow was low as confirmed experimentally by changing the solvent flow rate. The same solubility values were obtained for two different flow rates and with resulting differences in residence times. Thus a new spiral tube which allowed the liquid solvent to flow through the tube in a relatively short time was used in these experiments. In making the residence time shorter, the number of the coils in the spiral tubes, the radius of the spiral coil and the radius of the spiral tube itself were all reduced in size from that used in the measurement of low gas solubilities. In addition, the angle of descent of the spiral tube was increased to make the residence time shorter. This also helped to promote the measurement of solubility in solvents of high viscosity.

For solubility measurements at temperatures higher than the ambient, the solvent was preheated to the experimental temperature. A heat exchanger was attached to the long syringe needle to adjust the temperature of the solvent infused, to the system temperature. A heat exchanger

formerly used was attached to the syringe itself, but in that method sometimes bubbles were formed in the syringe especially during measurements at 50°C. It was considered that the formation of such bubbles inside the syringe seriously affected the liquid flow rates and that this effect could not be tolerated. Therefore a new heat exchange method was introduced, involving a tube containing a tight fitting stainless steel sheath for the needle.

The vertical length of the heat exchanger was made 5 cm in length. The inner diameter of the long needle used was 0.9 mm. When the maximum liquid rate of 0.01751 cm^3/min was used, the liquid velocity through the needle was only 2.8 cm/min; that is, the residence time was approximately 1.8 minutes in the needle. This residence time was considered long enough for the solvent liquid to be heated to the temperature of the experiment.

Briefly, the experimental procedure was as follows: while the solvent was being degassed, the solubility apparatus was purged with solute gas. Then the syringe was filled with about 4 cm^3 of degassed solvent and attached to the infusion pump. The long needle of the syringe was inserted into the spiral tube after being equipped with the heat exchanger. It was confirmed at the beginning of each run that the tip of the needle touched the wall of the spiral tube in order to ensure a continuous supply of solvent (otherwise, a dropwise supply of the solvent caused an intolerable fluctuation in pressure). Next the solvent stopcock was closed and the

infusion pump was switched on. The solubility apparatus was left with the solute gas flowing through the apparatus until a steady-state was achieved. Then the flow of solute gas was shut off and the mercury level was raised by operating the mercury lift. The mercury level, which was adjusted according to the amount of solute gas dissolved in the solvent in the spiral tube, balancing the internal pressure with atmospheric pressure with the help of U-tube manometer, was recorded every 5 minutes. The solubility was determined from a knowledge of the gas volume reduction rate and solvent flow rate used in the experiment.

PROPERTIES OF TEST FLUIDS

Acetylene, 1,3-butadiene and trans-2-butene were purchased from the Matheson Company of Canada. These gases had specified minimum purities of 99.6, 99.0 and 99.0% respectively. The molar volumes of these gases were calculated by three parameter correlations using Lee and Kestler[26], [27] table. These results are shown in Table I.

The cyclohexane, benzene, acetone, acetic acid, carbon disulfide, dimethyl formamide, N,N-dimethyl acetamide, and ethyl acetate, were supplied by J.T. Baker and were specified to have minimum purities of 99.9, 99.9, 99.6, 99.9, 99.9, 99.0, 99.5 and 99.6 respectively. Densities of all these solvents except for the density of carbon disulfide at 278.15°K were measured in this laboratory using a digital precision density meter purchased from

Anton Paar. The density of carbon disulfide at 278.15°K was taken from the literature[28]. Vapor pressures of solvents were calculated by Antoine's equation[26]. Both densities and vapor pressures of the solvents are also given in Table I.

TREATMENT OF DATA

As mentioned in the Apparatus and Procedure section the three liquid flow rates were measured at room temperature, corresponding to the three different motors of the infusion pump. When a degassed solvent enters the solubility apparatus, it can be assumed that there is a slight volume expansion of the solvent because of the difference in temperature between the syringe and the solubility apparatus. Thus the liquid flow rate, F_r, was corrected so that the actual flow rate inside the solubility apparatus, F, could be obtained. The true flow rate, F, is given by the following expression:

$$F = F_r \cdot \frac{\rho_r}{\rho_s} \qquad (26)$$

In the above expression ρ_r is the density of the solvent at the temperature and ρ_s is the density of the solvent at the experimental temperature.

The residual solute gas volume decreased linearly with time corresponding to the constant liquid flow rate. Thus the best slope of the solute gas volume-time relationship was calculated by means of the least squares method. Then the mole fraction solubility, x_2, and the Ostwald

coefficient, L, were calculated from the result. The latter is defined as the ratio of the volume of the solute gas absorbed, to the volume of the solvent, at a solute gas partial pressure equal to the total pressure.

According to the Henry's law the mole fraction solubility of dissolved gas exerting a solute gas partial pressure, P_2, can be expressed as follows:

$$x_{2,P_2} = \frac{P_2}{1} x_2 \qquad (27)$$

In the above expression x_2 is the mole fraction solubility at a solute gas partial pressure of one atmosphere.

The Ostwald coefficient can be written in terms of the calculated slope, and the true liquid flow rate, expressed by Y, and F, respectively:

$$L = \frac{Y}{F} \cdot \frac{P_t}{P_t - P_1^s(1 - x_{2,P_2})} \qquad (28)$$

In Equation (28), the term $P_t/(P_t - P_1^s(1 - x_{2,P_2}))$ is the correction term to obtain the Ostwald coefficient at a solute gas partial pressure of P_t.

By inserting Equations (26) and (27) into Equation (28)

$$L = \frac{Y}{F_r \cdot \frac{\rho_r}{\rho_s}} \cdot \frac{P_t}{P_t - P_1^s \cdot (1 - P_2 x_2)} \qquad (29)$$

In Equation (29), in order to obtain the Ostwald coefficient, however, x_2 needs to be known beforehand. To obtain the x_2

value, the following procedure was taken. Initially an estimated Ostwald coefficient L', was calculated based on a gas partial pressure equal to one atmosphere, as follows:

$$L' = \frac{Y}{F_r \cdot \frac{\rho_r}{\rho_s}} \cdot \frac{1}{P_t - P_1^s (1 - P_2 \cdot x_2)} \qquad (30)$$

The L' is the estimated Ostwald coefficient which is different from the true Ostwald coefficient in that this quantity is for a solute gas partial pressure of one atmosphere. This redefined value L' was then related to x_2 which was also defined for a gas partial pressure of one atmosphere, as follows:

$$x_2 = \frac{\frac{L'}{V_2^G}}{\frac{L'}{V_2^G} + \frac{1}{V_1}} \qquad (31)$$

In the above expression, V_1 and V_2^G, are molar volumes of solvent, and solute gas, respectively.

By eliminating L' from Equations (30) and (31), x_2 can be given by:

$$x_2 = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \qquad (32)$$

where

$$a = Y \cdot P_t \cdot P_1^s \qquad (33)$$

$$b = -\left[Y \cdot P_t \cdot (P_1^s + 1) + \frac{V_2^G}{V_1} P_t \cdot F_r \frac{\rho_r}{\rho_s} (P_t - P_1^s) \right] \qquad (34)$$

$$c = Y \cdot P_t \qquad (35)$$

The actual Ostwald coefficient, L, then was obtained by inserting Equation (32) into Equation (29).

In Appendix, the FORTRAN computer program and the printouts of the detailed calculation results for each system are shown together with experimental raw data.

RESULTS AND DISCUSSIONS

For the purpose of confirming the accuracy of the experimental results, solubilities of acetylene were measured in cyclohexane and benzene at 323.15°K. These systems were chosen because a former worker in our laboratory, Miyano[22] had worked on the same systems, so that the results would be comparable.

The average solubility obtained for acetylene in cyclohexane at 323.15°K was 0.00754 expressed as a mole fraction solubility, while the result by Miyano was 0.00756[22]. Thus the deviation between the results was found to be 0.3%. It was thus considered that the result obtained agreed well with Miyano's.

For the solubility of acetylene in benzene at 323.15°K, Miyano had indicated that Horiuti's value (29) which was 0.116, was considerably lower than his result, 0.0132. Thus also for the purpose of checking Miyano's result, the experiment of this system was repeated. The

result obtained in this work was 0.0131, essentially confirming Miyano's result. The deviation of the value obtained in this work from Miyano's was found to be 0.8%. Again good agreement between Miyano's and this work was obtained. It became clear that Horiuti's solubilities in benzene were consistently lower than ours. It was considered unusual that Horiuti's data, usually considered of good accuracy, should be in error. The many experiments performed, however, confirmed this fact. Thus the experimental technique and procedure were considered satisfactory. The results of the preliminary experiments are shown in Table II.

The solubilities of 1,3-butadiene and trans-2-butene were measured in the six solvents, carbon disulfide, acetone, acetic acid, dimethyl formamide, N,N-dimethyl acetamide and ethyl acetate at two different temperatures. All solubilities except for the systems involving carbon disulfide were measured at 298.15°K and 323.15°K. The solubilities in carbon disulfide were measured at 278.15°K and 298.15°K, because of low boiling point of this chemical. The results of the experiments are given in Table III and Table IV where the solubilities are expressed in the form of mole fraction, and in Table V and Table VI in the form of the Ostwald coefficient. Also, in these Tables the average or recommended values and the maximum deviations are given for each system.

As can be seen, in each gas-solvent system, the absolute deviation of the solubility has a general tendency to decrease with increasing temperature. In other words, since solubilities always increased with decreasing

temperature, it could be said that the larger absolute deviation tended to occur at higher solubilities. It was, however, considered that despite such a tendency, experimental errors were sufficiently small to make the results useful. The overall maximum deviation from the average was found 1.3% for the systems involving 1,3-butadiene and 2.0% for the systems involving trans-2-butene.

Experimental solubility data for the same systems as in these experiments were sought by means of a computer search procedure which is available in the University. As a result of this search, it became evident that no other experimental data were available for these systems.

By comparing the solubilities of 1,3-butadiene with those of trans-2-butene, it was found that except for solubilities in carbon disulfide, solubilities of 1,3-butadiene in each solvent were all higher than those of trans-2-butene in the same solvent at the same temperature. This cause for this tendency was considered to be different chemical nature of the two gases. The 1,3-butadiene is a diene, while the trans-2-butene has only one double bond. Therefore, 1,3-butadiene has more electron-acceptor hydrogen atoms in its molecule than trans-2-butene. Thus 1,3-butadiene probably was more attracted to the electron-donor solvents in the liquids than trans-2-butene and hence was more soluble.

The maximum difference in solubility between the two gases in the same solvent was observed for carbon disulfide at a temperature of 278.15°K. For all the other

systems the solubilities were measured at two different temperatures, 298.15°K and 323.15°K. Thus a comparison was made for those systems (excluding carbon disulfide) using the relative solubility, which was defined as the ratio of the mole fraction solubilities of the two gases. The results of this comparison are shown in Table VII. It was found that there was a very large ratio of solubility of 1,3-butadiene to that of trans-2-butene in the two solvents dimethyl formamide and N,N-dimethyl acetamide. Thus it may be concluded that dimethyl formamide and N,N-dimethyl acetamide as well as carbon disulfide could possibly function as an effective solvent for the separation of 1,3-butadiene from trans-2-butene in the vapor phase. It should be noted, however, that the selection of solvent as an absorption medium cannot be made from a single viewpoint such as solubility.

The logarithm of the solubilities were plotted against logarithms of absolute temperature. These solubilities along with the normal boiling points of the solute gases were joined by a smooth curve. These plots are shown in Figure 3 and Figure 4, together with the ideal gas solubilities. In these figures it can be observed that the solubilities, except for those in carbon disulfide, have a general tendency to change with temperature in a way similar to those for the ideal gas solubilities. Such an observation has been reported by many investigators[16].

Although there were differences in solubilities between the two gases in the same solvent at the same

temperature, except for carbon disulfide, the order of increasing solubility was the same for both gases. This tendency is probably the result of the fact that 1,3-butadiene and trans-2-butene are similar substances in that both possess almost the same molecular weight, even though there is a difference in the number of double-bonded carbons.

The solubilities of both gases were lowest in acetic acid. This seems to result from the high association tendency of this chemical. The three solvents, dimethyl formamide, N,N-dimethyl acetamide and acetone, all had larger solubilities than those in acetic acid. These substances are very polar like acetic acid, but are at the same time, aprotic solvents which do not have electrophilic hydrogen atoms in their molecules. The solvent ethyl acetate is also very polar, but less polar than the foregoing three substances. It may be concluded that these qualitative considerations do not provide a suitable basis for explaining the observed solubility behavior.

In the case of carbon disulfide, the solubilities of both 1,3-butadiene and trans-2-butene were measured at a temperature near the normal boiling points of these gases (268.7°K and 274.0°K, respectively). It would appear from Figure 3 and Figure 4, that the solubilities of these gases approach a mole fraction of unity as the solution temperature is reduced toward the normal boiling points. This phenomenon has been observed for other highly soluble gases.

In Table VIII are listed the gas and solvent properties necessary to predict gas solubilities according to the regular solution theory. In the application of this theory, it is generally recognized that the predicted values by this theory agree with experimental data only when the system substances are both non-polar or only slightly polar. In this experiment, however, in spite of the deviation from this condition, the regular solution theory was applied to predict gas solubilities for the three least polar solvents, carbon disulfide, acetic acid and ethyl acetate. One reason for this was to see the limitation in applying the regular solution theory to high solubility systems. In Table IX and Table X are shown solubilities predicted by this theory along with the experimental and ideal gas solubilities. These results are plotted against the logarithm of absolute temperature in Figures 5 to 10.

One of the observations that can be made from these plots is that all solubilities except for that of trans-2-butene in acetic acid, are less than the ideal gas solubilities, but greater than those predicted by the regular solution theory. In the case of acetic acid, which had the lowest solubilities of all the solvents, the solubilities predicted by the regular solution theory were the closest to the experimental ones for the three solvents. In Figure 8 it can be seen that the solubility of the trans-2-butene in acetic acid approximately agrees with the predicted solubility

despite its polarity and self-association. For both solubilities in carbon disulfide and ethyl acetate, the actual solubilities are always higher than those by the regular solution theory. Especially for carbon disulfide, the difference is large, being more than 0.2 in mole fraction. From these various results it may be concluded that the regular solution theory may not be useful for high solubility systems. Its partial success with acetic acid is probably fortuitous.

Hayduk et al.[21] presented a consistent correlation diagram of hydrogen-bonding factors in acetone and acetic acid for several gases. The new data obtained in this work were transformed into the hydrogen-bonding factors and added to this diagram. The results are shown in Figure 11. As can be seen in this figure, the new data for 1,3-butadiene and trans-2-butene, also follow a consistent trend. It is seen that the hydrogen-bonding factors in acetone for all the solute gases are higher than those factors in acetic acid, which indicates that these gases are more soluble in acetone than in acetic acid. In the case of solubilities of carbon dioxide and acetylene, the hydrogen-bonding factors in acetone exceed unity. This means that these gases have solubilities in acetone greater than the ideal gas solubilities. It appears likely than acetylene reacts to some extent with acetone, but not with acetic acid. The observed correlation indicates that there is a possibility that a solubility in either solvent can be predicted at least approximately if

the solubility in the other solvent is known. At present, however, such diagrams are not available because of the lack of experimental data. It is hoped that more solubility data will help to produce more accurate solubility correlations.

In Table XI and Table XII are given hydrogen-bonding factors and Margules constants which were calculated from Equations (24) and (25), along with experimental solubilities and the ideal gas solubilities. The Margules constants were then plotted against the inverse of the absolute temperature as shown in Figure 12 and Figure 13, and linearly interpolated corresponding to the solubility changes with temperature. Such a graph is expected to be useful for converting hydrogen-bonding factors to solubilities or vice versa.

CONCLUSION

In this work it was found that the solubilities of 1,3-butadiene were always higher than those of trans-2-butene in the same solvent at the same temperature. For this reason it was considered that the affinities between 1,3-butadiene and the solvents used in the experiments were stronger than those between trans-2-butene and the same solvents because of the difference in the strength of hydrogen bonds.

It was also found that the maximum difference in solubility for the two gases in the same solvent occurred with carbon disulfide at a temperature of 278.15°K. Large

differences in solubility were also observed in dimethyl formamide and N,N-dimethyl acetamide at 298.15°K. From these results it would be expected that these solvents could possibly be used as good absorbents for the isolation of 1,3-butadiene from trans-2-butene.

The regular solution theory was found unsuitable for highly soluble gases. Its application appears to be limited to system where the polarity and solubility are low. It was, however, found that the regular solution theory predicted solubilities relatively well for the very polar solvent, acetic acid. This was considered fortuitous.

The plots of hydrogen-bonding factors in one solvent against those in the other solvent for several gases were found useful for the purpose of a semi-empirical correlation of gas solubility. In order to produce such correlations much more new experimental data are required.

Table I

Properties of Test Fluids

Gas Molar Volumes, m^3/kmol

Temp. °K	1,3-Butadiene	Trans-2-butene	Acetylene
278.15	22.01	21.94	
298.15	23.77	23.70	
323.15	25.93	25.77	26.36

Properties of Solvents

Solvent	Temp. °K	Density kg/ m^3	Vapor Pressure atm
Cyclohexane	323.15	745.97	0.3578
Benzene	323.15	848.01	0.3549
Acetone	298.15	785.38	0.3005
	323.15	858.07	0.8025
Acetic acid	298.15	1040.0	0.0199
	323.15	1015.8	0.0745
Carbon disulfide	278.15	1285.0(28)	0.2080
	298.15	1255.4	0.4721
Dimethyl formamide	298.15	943.94	0.0 (a)
	323.15	920.08	0.0204(28)
N,N-dimethyl	298.15	938.07	0.0 (a)
Acetamide	323.15	917.01	0.0109(28)
Ethyl acetate	298.15	894.11	0.1264
	323.15	863.17	0.3759

(a) These values were experimentally confirmed.

Table II

Acetylene Solubility, Mole Fraction, x_2, at 323.15°K

Solvent	No	Solubility	Avg.	Miyano	Horiuti
Cyclohexane	1	0.00753	0.00754	0.0756	-
	2	0.00755			
Benzene	1	0.0130	0.0131	0.0132	0.0116
	2	0.0135			
	3	0.0131			
	4	0.0131			
	5	0.0130			

Table III

1,3-Butadiene Solubility, Mole Fraction, x_2

Solvent	Temp. °K	1	2	3	Avg.	Δx_2
Acetone	298.15	0.2426 (-0.5%)	0.2441 (0.2%)	0.2445 (0.3%)	0.2437	0.0019
	323.15	0.1181 (1.1%)	0.1159 (0.8%)	0.1163 (-0.4%)	0.1168	0.0022
Acetic acid	298.15	0.1311 (0.4%)	0.1310 (0.3%)	0.1297 (-0.7%)	0.1306	0.0014
	323.15	0.0560 (0.0%)	0.0561 (0.2%)	0.0559 (-0.2%)	0.0560	0.0002
Carbon	278.15	0.4974 (-0.8%)	0.5049 (0.7%)		0.5012	0.0075
Disulfide	298.15	0.2066 (0.4%)	0.2058 (-0.1%)	0.2055 (-0.2%)	0.2060	0.0011
Dimethyl	298.15	0.1964 (0.3%)	0.1953 (-0.2%)	0.1954 (-0.2%)	0.1957	0.0011
Formamide	323.15	0.0947 (1.3%)	0.0923 (-1.3%)	0.0934 (-0.1%)	0.0935	0.0024
N,N-dimethyl	298.15	0.2305 (-0.1%)	0.2279 (-1.3%)	0.2339 (1.3%)	0.2308	0.006
Acetamide	323.15	0.1083 (-1.2%)	0.1101 (+0.5%)	0.1103 (0.6%)	0.1096	0.002
Ethyl	298.15	0.3291 (-0.8%)	0.3342 (+0.8%)		0.3317	0.0051
Acetate	323.15	0.1633 (-1.3%)	0.1663 (0.5%)	0.1667 (0.8%)	0.1654	0.0034

Table IV

Trans-2-butene Solubility; Mole Fraction, x_2

Solvent	Temp. °K	1	2	3	Avg.	Δx_2
Acetone	298.15	0.1730 (1.0%)	0.1684 (-1.7%)	0.1725 (+0.7%)	0.1713	0.0046
	323.15	0.0874 (-0.3%)	0.0878 (+0.1%)	0.0878 (0.1%)	0.0877	0.0004
Acetic acid	298.15	0.1024 (0.1%)	0.1026 (0.1%)	0.1025 (0%)	0.1025	0.0002
	323.15	0.0429 (%)	0.0423 (-1.4%)	0.0435 (1.4%)	0.0429	0.0012
Carbon	278.15	0.7891 (-0.5%)	0.7977 (+0.5%)		0.7934	0.0086
Disulfide	298.15	0.2423 (0.5%)	0.2399 (-0.5%)		0.2411	0.0024
Dimethyl	298.15	0.1051 (0.5%)	0.1048 (0.2%)	0.1039 (-0.7%)	0.1046	0.0012
Formamide	323.15	0.0533 (0.6%)	0.0524 (-1.1%)	0.0532 (0.4%)	0.0530	0.0009
N,N-dimethyl	298.15	0.1307 (-1.0%)	0.1332 (+0.9%)		0.1320	0.0025
Acetamide	323.15	0.0654 (+0.2%)	0.0652 (-0.2%)		0.0653	0.0002
Ethyl	298.15	0.2996 (-2.0%)	0.3078 (0.7%)	0.3100 (1.4%)	0.3058	0.0104
Acetate	323.15	0.1395 (-0.3%)	0.1402 (0.2%)		0.1399	0.0007

Table V

1,3-Butadiene Solubility, Ostwald coefficient, L

Solvent	Temp. °K	1	2	3	Avg.	ΔL
Acetone	298.15	101.4	102.2	102.5	102.0	1.1
	323.15	45.0	44.1	44.3	44.5	0.9
Acetic acid	298.15	61.8	61.7	60.6	61.4	1.1
	323.15	25.8	25.9	25.8	25.8	0.1
Carbon	278.15	366.2	376.3		371.3	10.1
Disulfide	298.15	99.6	99.1	98.9	99.2	0.7
Dimethyl	298.15	74.0	73.5	73.5	73.7	0.5
Formamide	323.15	33.9	33.0	33.4	33.4	0.9
N,N-dimethyl	298.15	75.8	73.4	76.0	75.1	2.6
Acetamide	323.15	32.9	33.5	33.9	33.4	1.0
Ethyl	298.15	118.8	121.6		120.2	2.8
Acetate	323.15	49.6	50.7	51.2	50.5	1.6

Table VI

Trans-2-butene Solubility, Ostwald Coefficient, L

Solvent	Temp. °K	1	2	3	Avg.	Δ L
Acetone	298.15	66.2	64.0	65.8	65.3	2.2
	323.15	31.9	32.0	32.0	32.0	0.1
Acetic acid	298.15	46.8	47.0	47.1	47.0	0.3
	323.15	19.2	19.0	19.5	19.2	0.5
Carbon	278.15	1374	1440		1407	66
Disulfide	298.15	124.6	123.3		124.0	1.3
Dimethyl	298.15	36.0	35.9	35.6	35.8	0.4
Formamide	323.15	18.2	17.8	18.1	18.0	0.4
N,N-dimethyl	298.15	38.4	39.3		38.9	0.9
Acetamide	323.15	18.8	18.8		18.8	0.0
Ethyl	298.15	102.9	107.0	108.1	106.0	5.2
Acetate	323.15	40.9	41.0		41.0	0.1

Table VII

Ratio Solubility of 1,3-Butadiene to trans-2-butene

Solvent	Temp. ^{o}K	Ratio Solubility
Acetone	298.15	1.423
	323.15	1.332
Acetic acid	298.15	1.274
	323.15	1.305
Dimethyl formamide	298.15	1.871
	323.15	1.764
N,N-dimethyl acetamide	298.15	1.748
	323.15	1.678
Ethyl acetate	298.15	1.085
	323.15	1.182

Table VIII

Additional Properties of Fluids at 298.15°K

Substance	Dipole Moment D	Liquid Mol. Vol. cm^3/mol	Sol. Para. $(J/cm^3)^{1/2}$
1,3-Butadiene	0.0 (26)	88 (17)	14.5 (17)
Trans-2-butene	0.0 (26)	91 (17)	14.3 (17)
Acetone	2.9 (26)		20.5 (17)
Acetic acid	1.3 (26)		21.17 (30)
Carbon disulfide	0.0 (26)		20.5 (17)
Dimethyl formamide	2.0 (31)		24.7 (17)
N,N-dimethyl acetamide	2.0 (31)		22.1 (17)
Ethyl acetate	1.8 (26)		18.6 (17)

Table IX

Comparison of Experimental Solubility of 1,3-Butadiene with those Predicted from Theoretical Correlations

Solvent	Temp. °K	Exp't	Eqn. (15)	Ideal
Acetone	298.15	0.2437		0.3628
	323.15	0.1168		0.1795
Acetic acid	298.15	0.1306	0.0756	0.3628
	323.15	0.0560	0.0422	0.1795
Carbon disulfide	278.15	0.5012	0.1852	0.7067
	298.15	0.2060	0.1040	0.3628
Dimethyl	298.15	0.1957		0.3628
Formamide	323.15	0.0935		0.1795
N,N-dimethyl	298.15	0.2308		0.3628
Acetamide	323.15	0.1096		0.1795
Ethyl acetate	298.15	0.3317	0.2002	0.3628
	323.15	0.1654	0.1037	0.1795

Table X

Comparison of Experimental Solubility of Trans-2-butene with those Predicted from Theoretical Correlations

Solvent	Temp. °K	Exp't	Eqn. (15)	Ideal
Acetone	298.15	0.1713		0.4355
	323.15	0.0877		0.2119
Acetic acid	298.15	0.1025	0.0777	0.4355
	323.15	0.0429	0.0432	0.2119
Carbon disulfide	278.15	0.7934	0.1958	0.8616
	298.15	0.2411	0.1093	0.4355
Dimethyl Formamide	298.15	0.1046		0.4355
	323.15	0.0530		0.2119
N,N, dimethyl Acetamide	298.15	0.1320		0.4355
	323.15	0.0653		0.2119
Ethyl acetate	298.15	0.3058	0.2212	0.4355
	323.15	0.1399	0.1134	0.2119

Table XI

Hydrogen-bonding Factors and Margules Constant for 1,3-Butadiene-solvent system

Solvent	Temp. °K	x_2	x_2^i	α	A_{12}
Acetone	298.15	0.2437	0.3628	0.6717	0.6957
	323.15	0.1168	0.1795	0.6507	0.5509
Acetic acid	298.15	0.1306	0.3628	0.3560	1.366
	323.15	0.0560	0.1795	0.3120	1.307
Carbon Disulfide	278.15	0.5012	0.7067	0.7092	1.381
	298.15	0.2060	0.3628	0.5678	0.8978
Dimethyl Formamide	298.15	0.1957	0.3628	0.5394	0.9542
	323.15	0.0935	0.1795	0.5209	0.7937
N,N-dimethyl Acetamide	298.15	0.2308	0.3628	0.6362	0.7644
	323.15	0.1096	0.1795	0.6106	0.6222
Ethyl acetate	298.15	0.3317	0.3628	0.9143	0.2006
	323.15	0.1654	0.1795	0.9214	0.1175

Table XII

Hydrogen-bonding Factors and Marqules Constant for Trans-2-butene-solvent system

Solvent	Temp. ^{o}K	x_2	x_2^i	α	A_{12}
Acetone	298.15	0.1713	0.4355	0.3933	1.360
	323.15	0.0877	0.2119	0.4139	1.060
Acetic acid	298.15	0.1025	0.4355	0.2354	1.796
	323.15	0.0429	0.2119	0.2025	1.742
Carbon	278.15	0.7934	0.8616	0.9208	1.933
Disulfide	298.15	0.2411	0.4355	0.5536	1.027
Dimethyl	298.15	0.1046	0.4355	0.2402	1.779
Formamide	323.15	0.0530	0.2119	0.2501	1.545
N,N-dimethyl	298.15	0.1320	0.4355	0.3031	1.584
Acetamide	323.15	0.0653	0.2119	0.3082	1.347
Ethyl acetate	298.15	0.3058	0.4355	0.7022	0.7336
	323.15	0.1399	0.2119	0.6602	0.5613

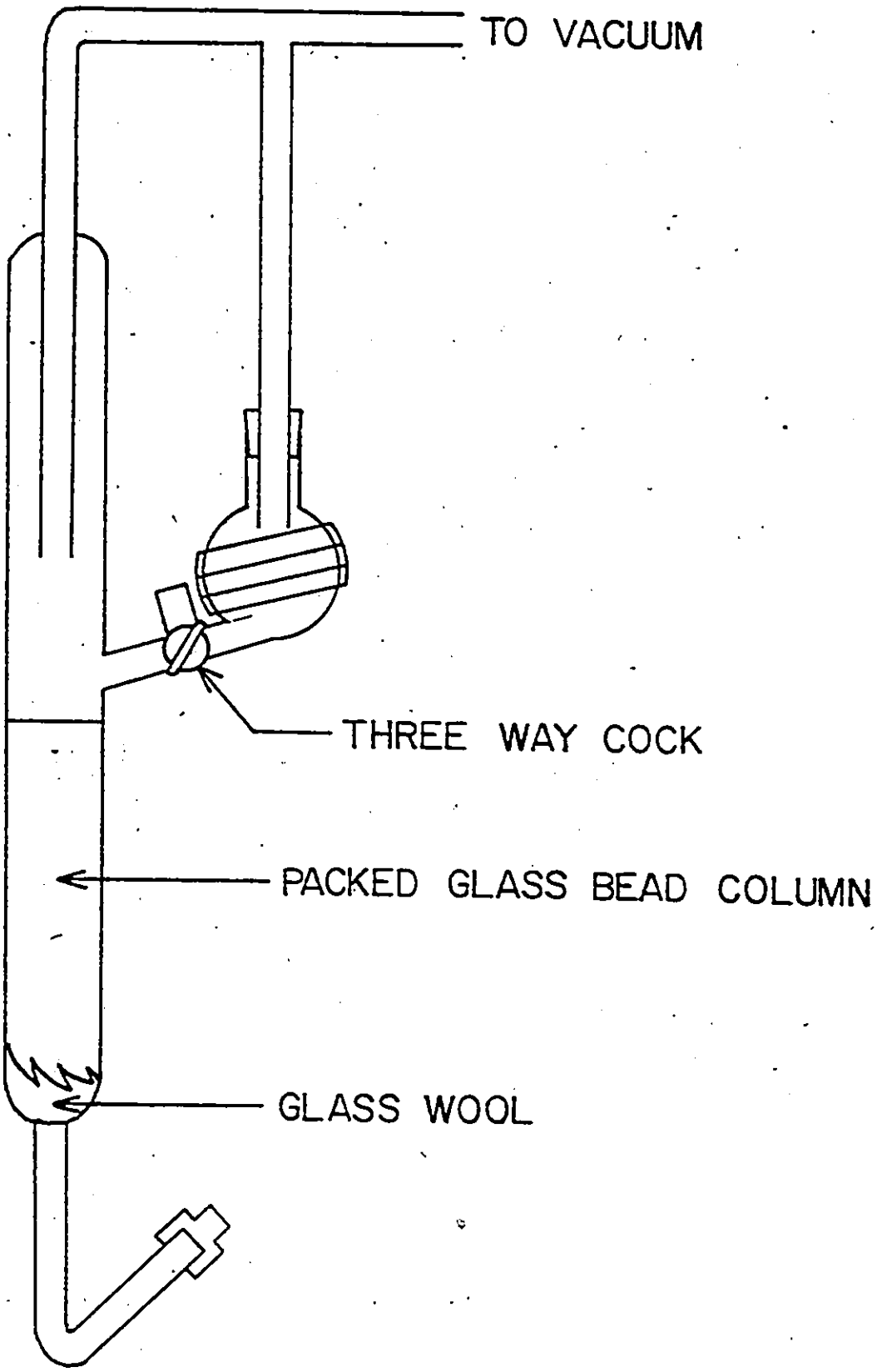

Figure 1

Degassing Apparatus

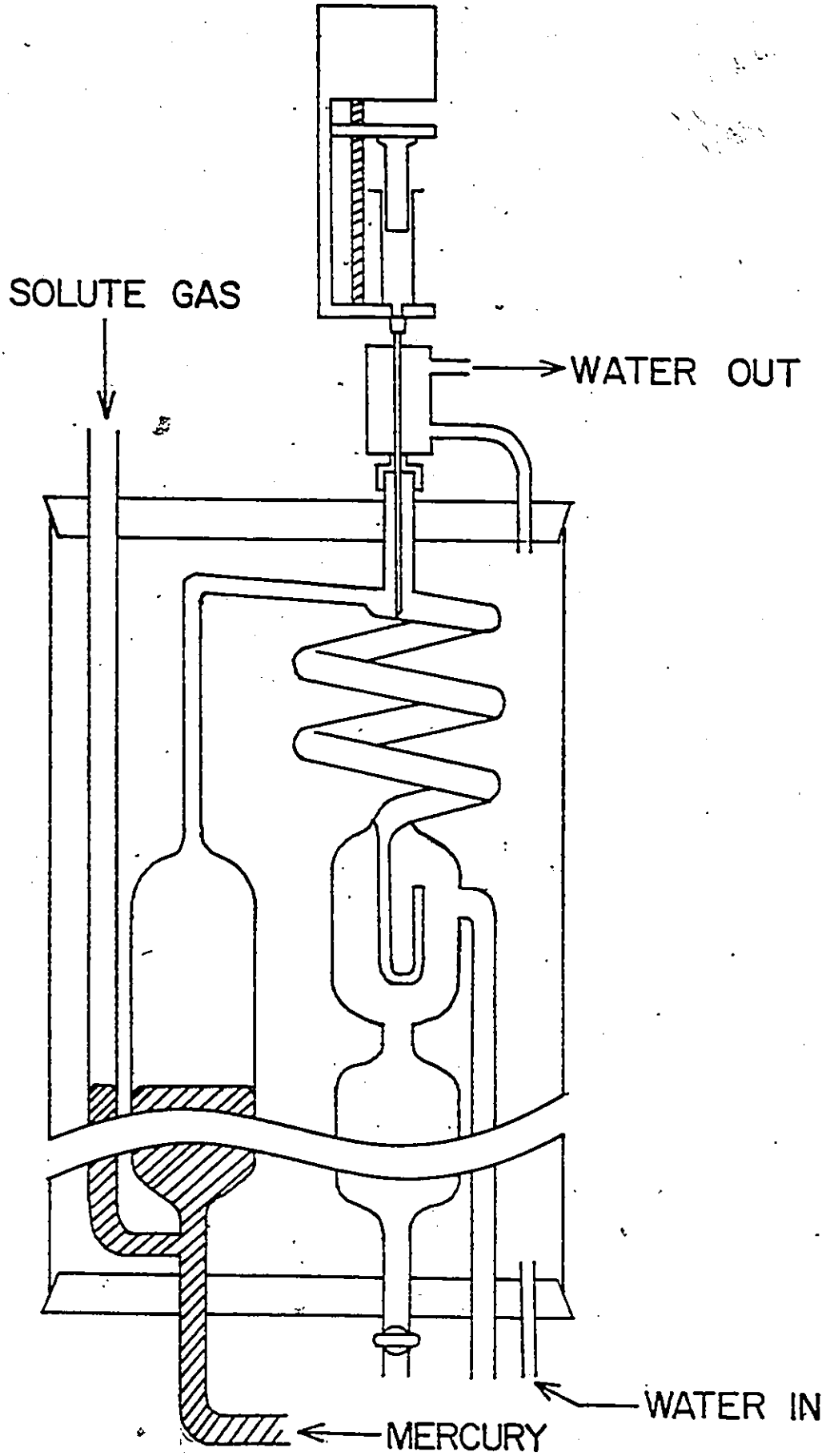

Figure 2

Solubility Apparatus

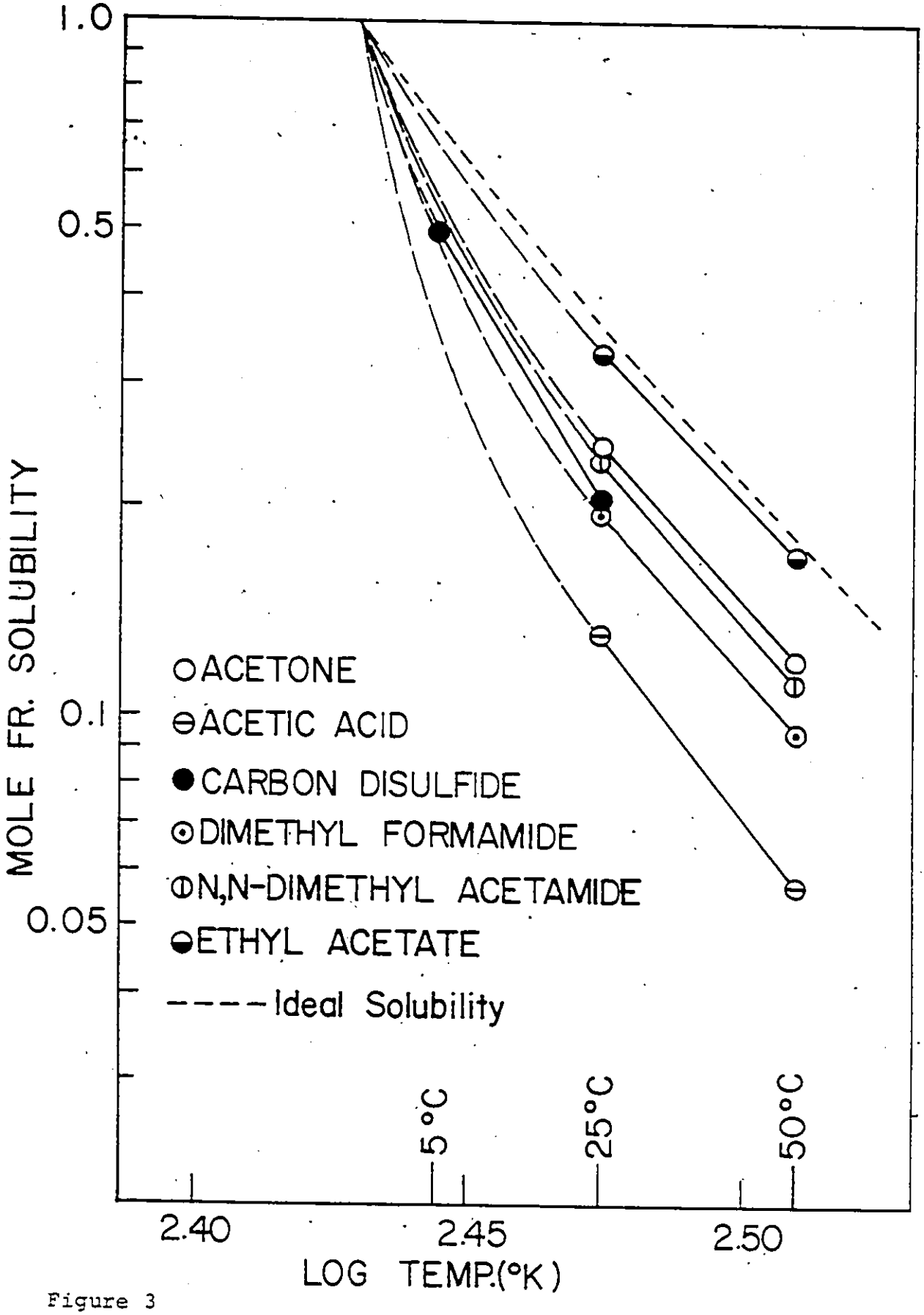

Figure 3

Solubilities of 1,3-Butadiene

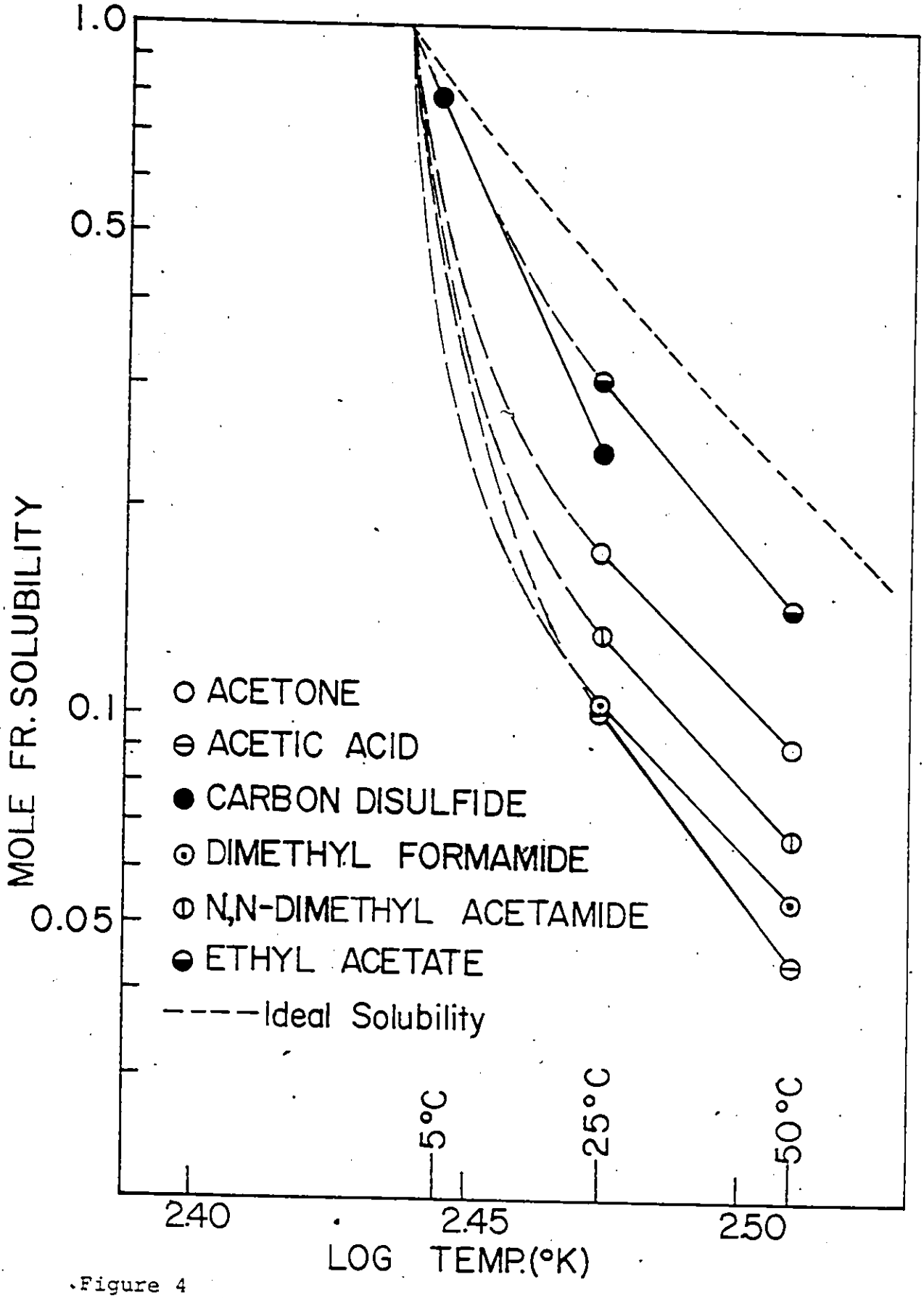

Figure 4

Solubilities of Trans-2-butene

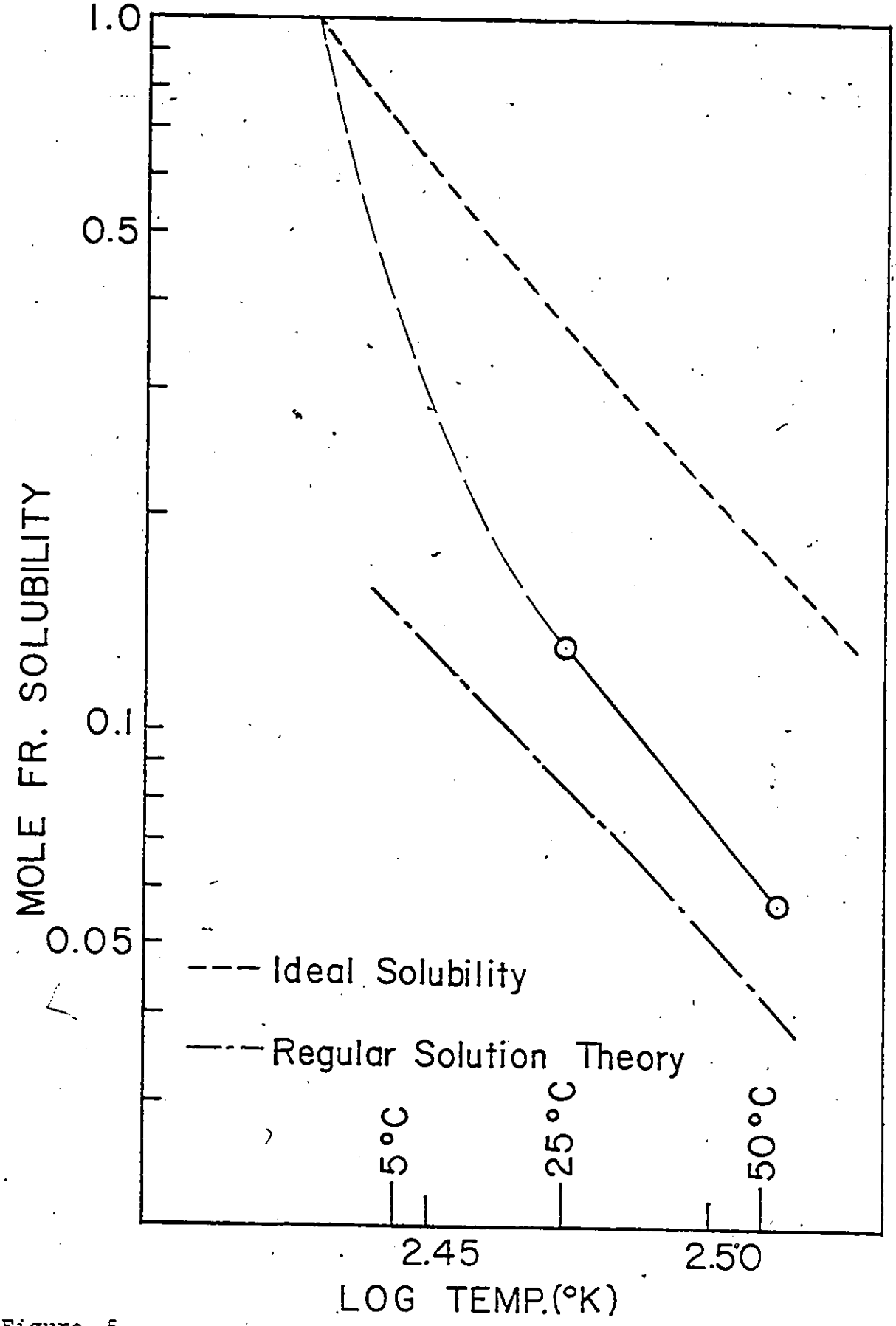

Figure 5

Solubility of 1,3-Butadiene in Acetic acid

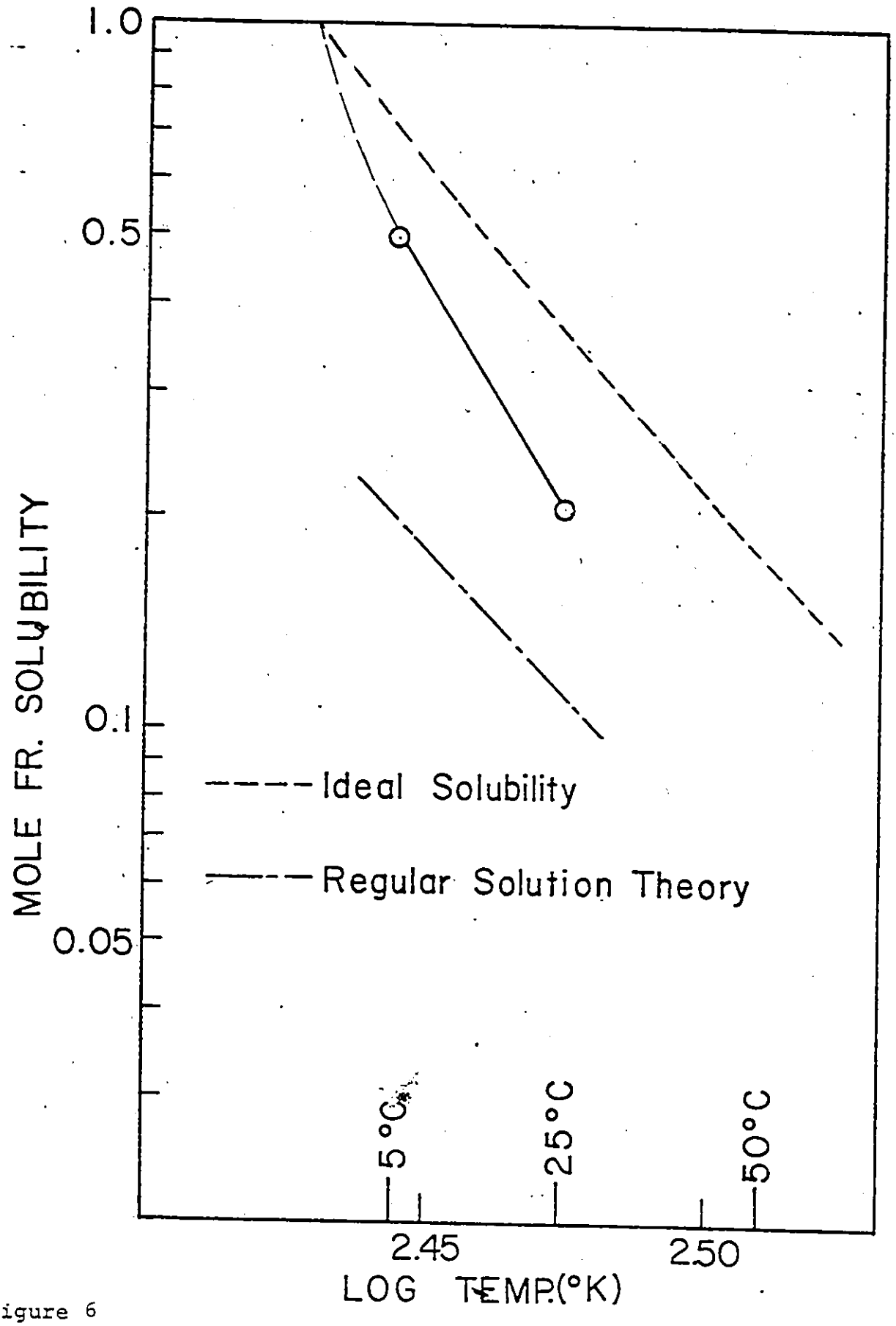

Figure 6

Solubility of 1,3-Butadiene in carbon disulfide

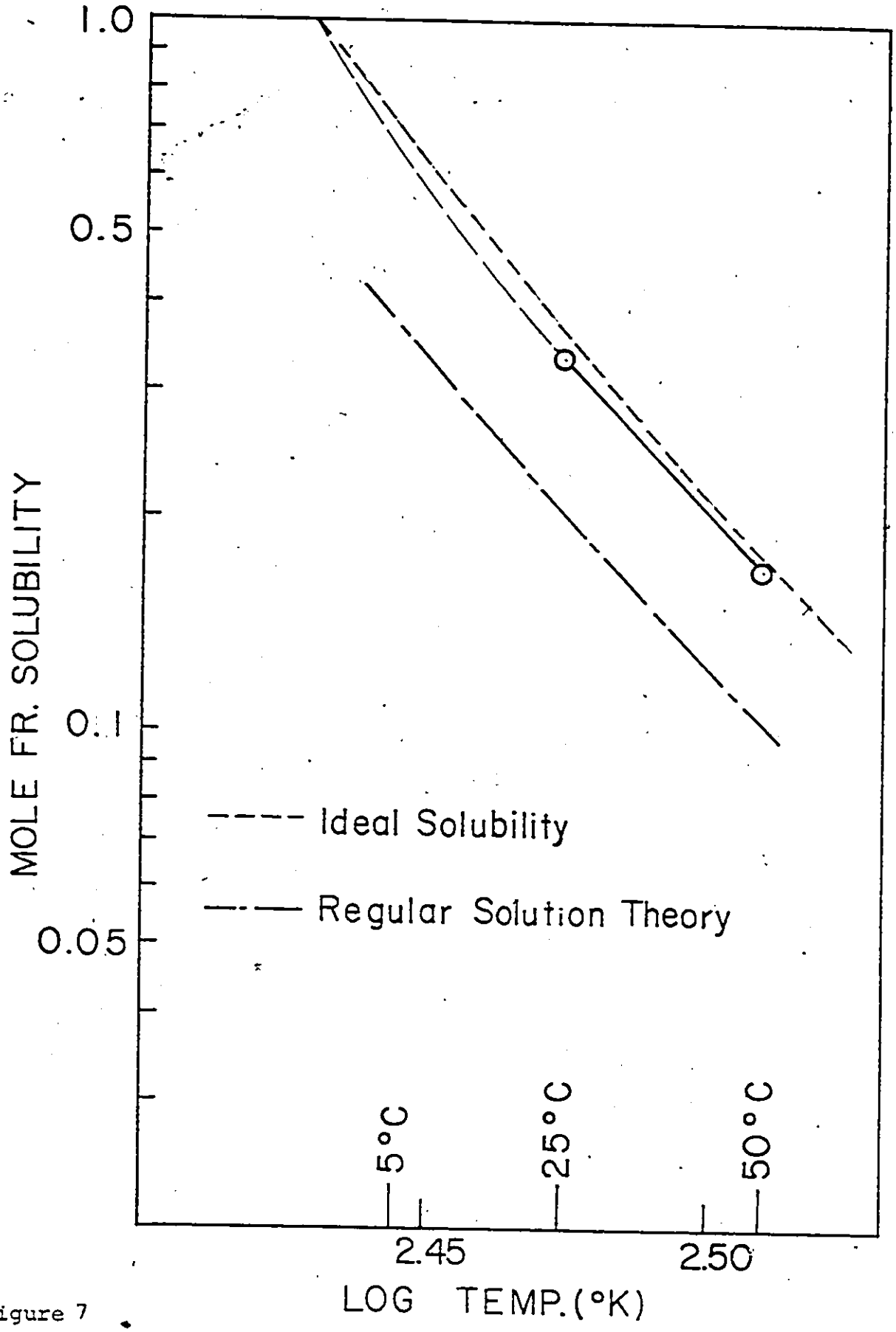

Figure 7

Solubility of 1,3-Butadiene in Ethyl acetate

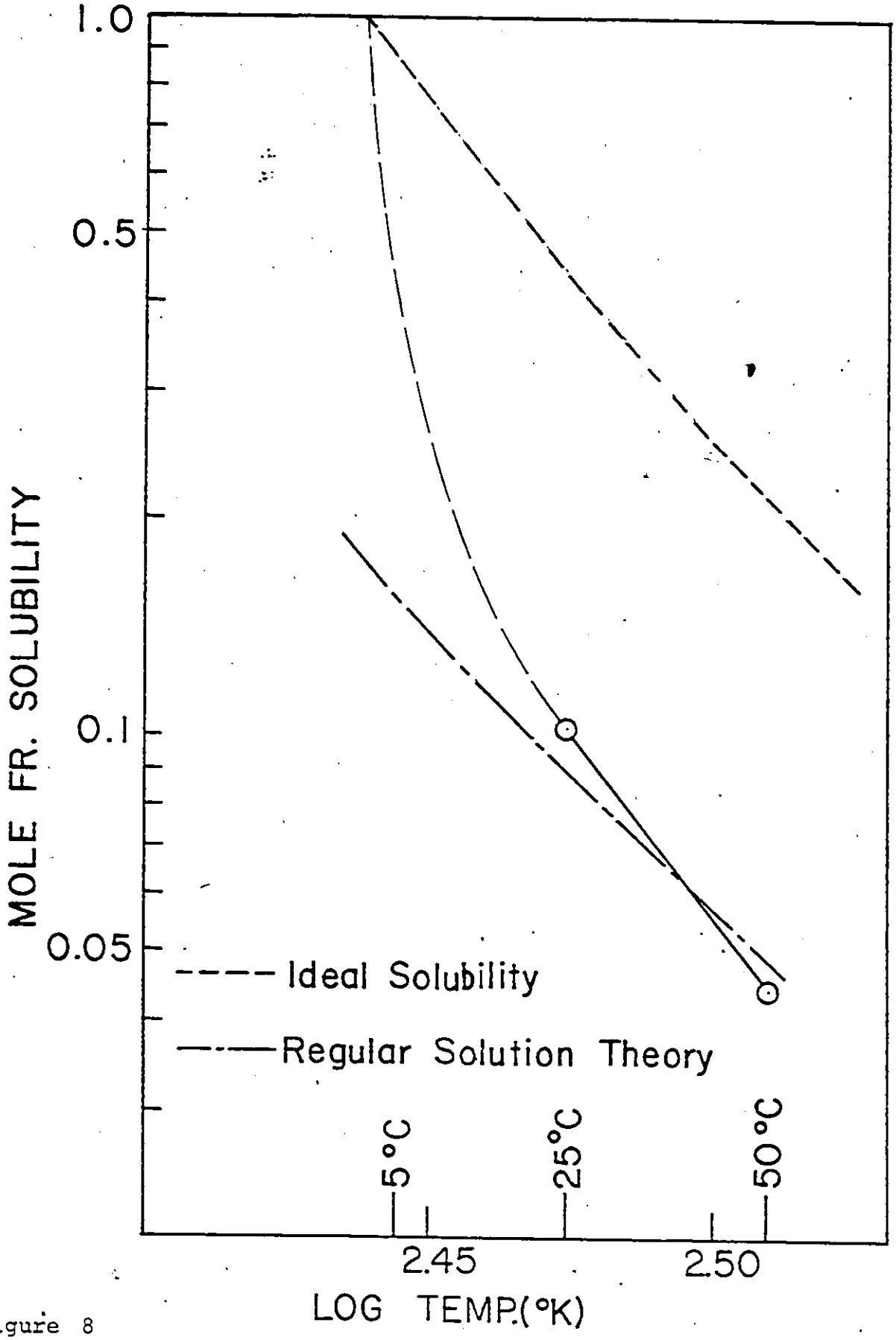

Figure 8

Solubility of Trans-2-butene in Acetic acid

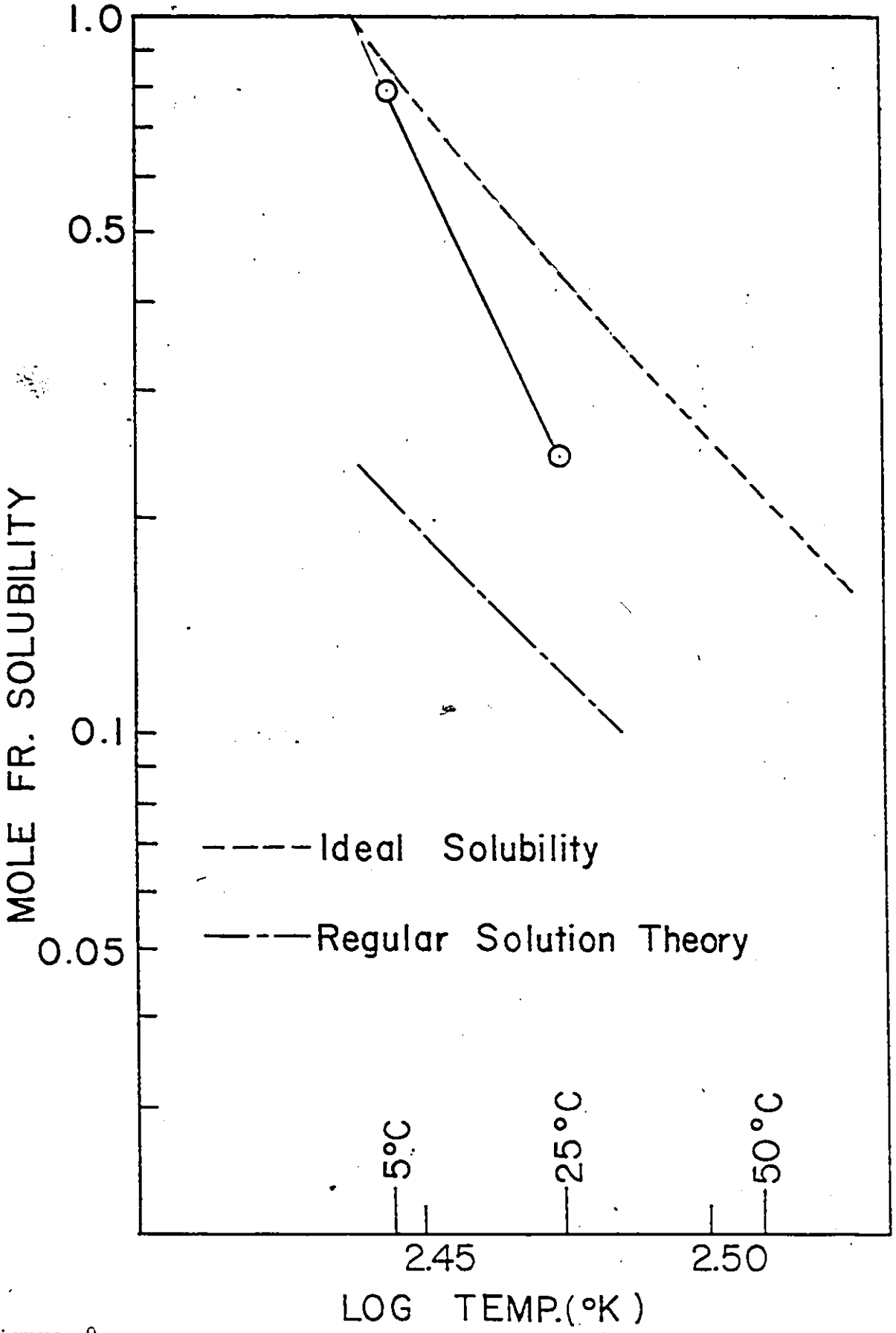

Figure 9

Solubility of Trans-2-butene in carbon disulfide

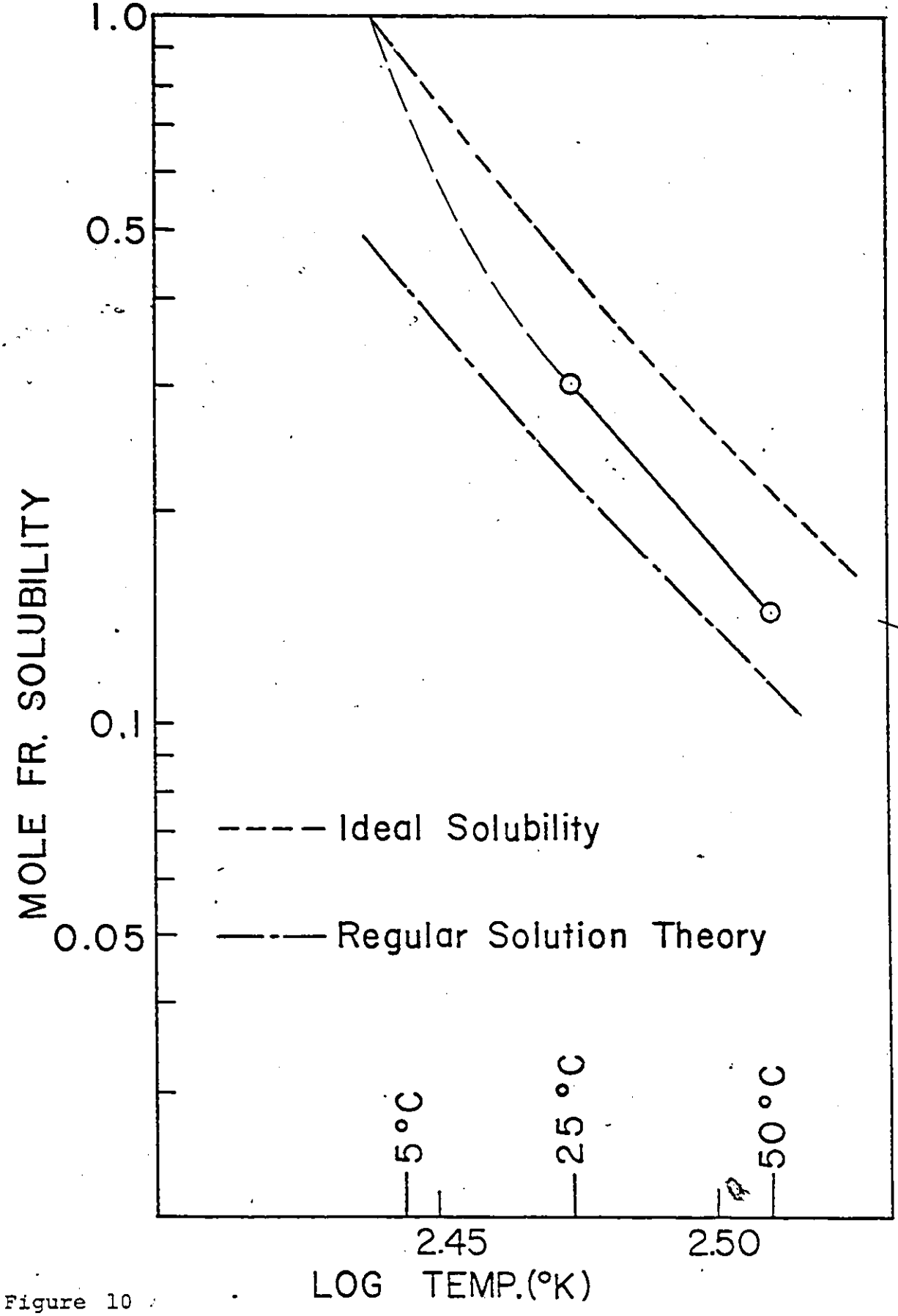

Figure 10

Solubility of Trans-2-butene in Ethyl acetate

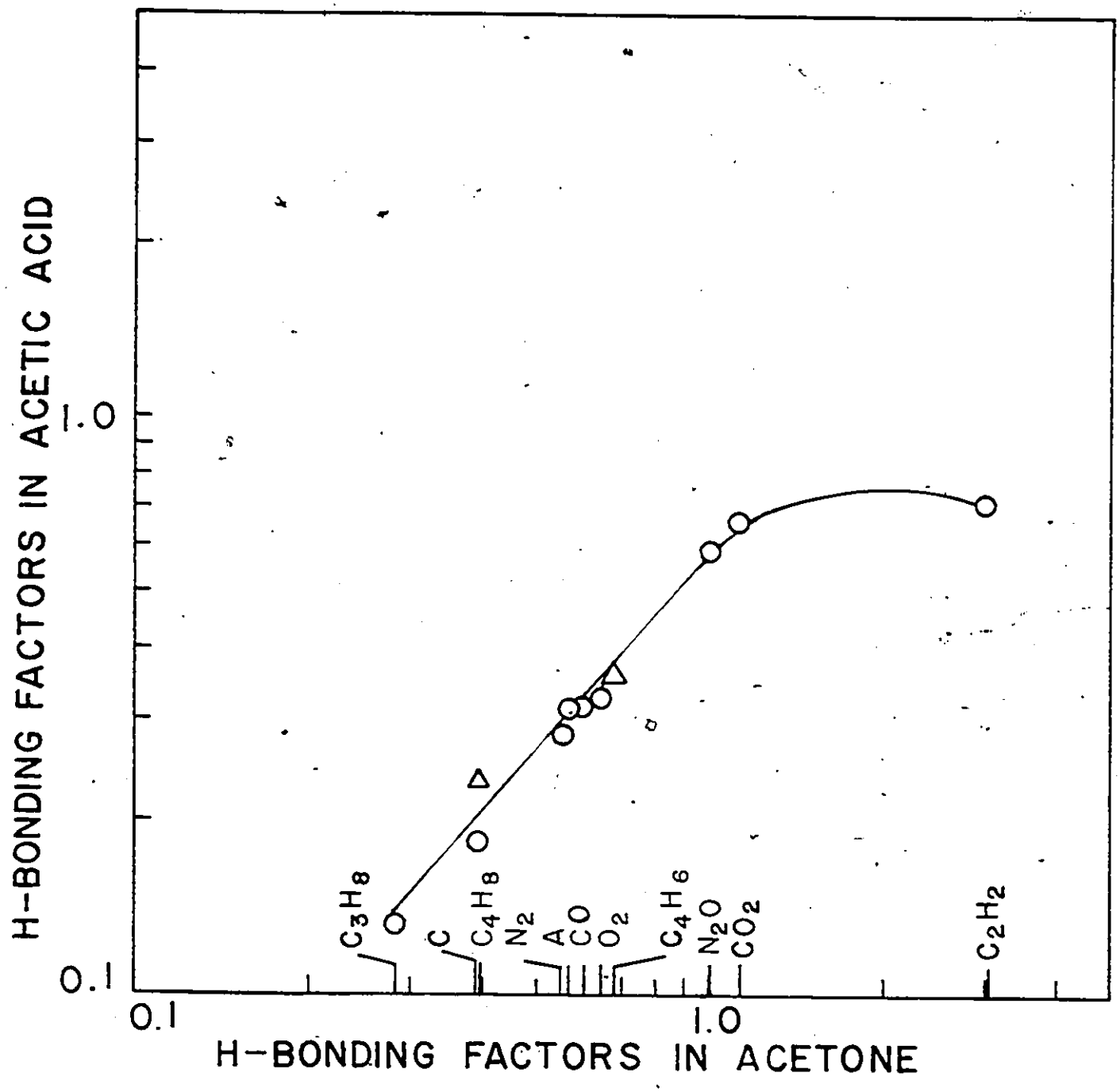

Figure 11

Hydrogen-bonding factor correlation

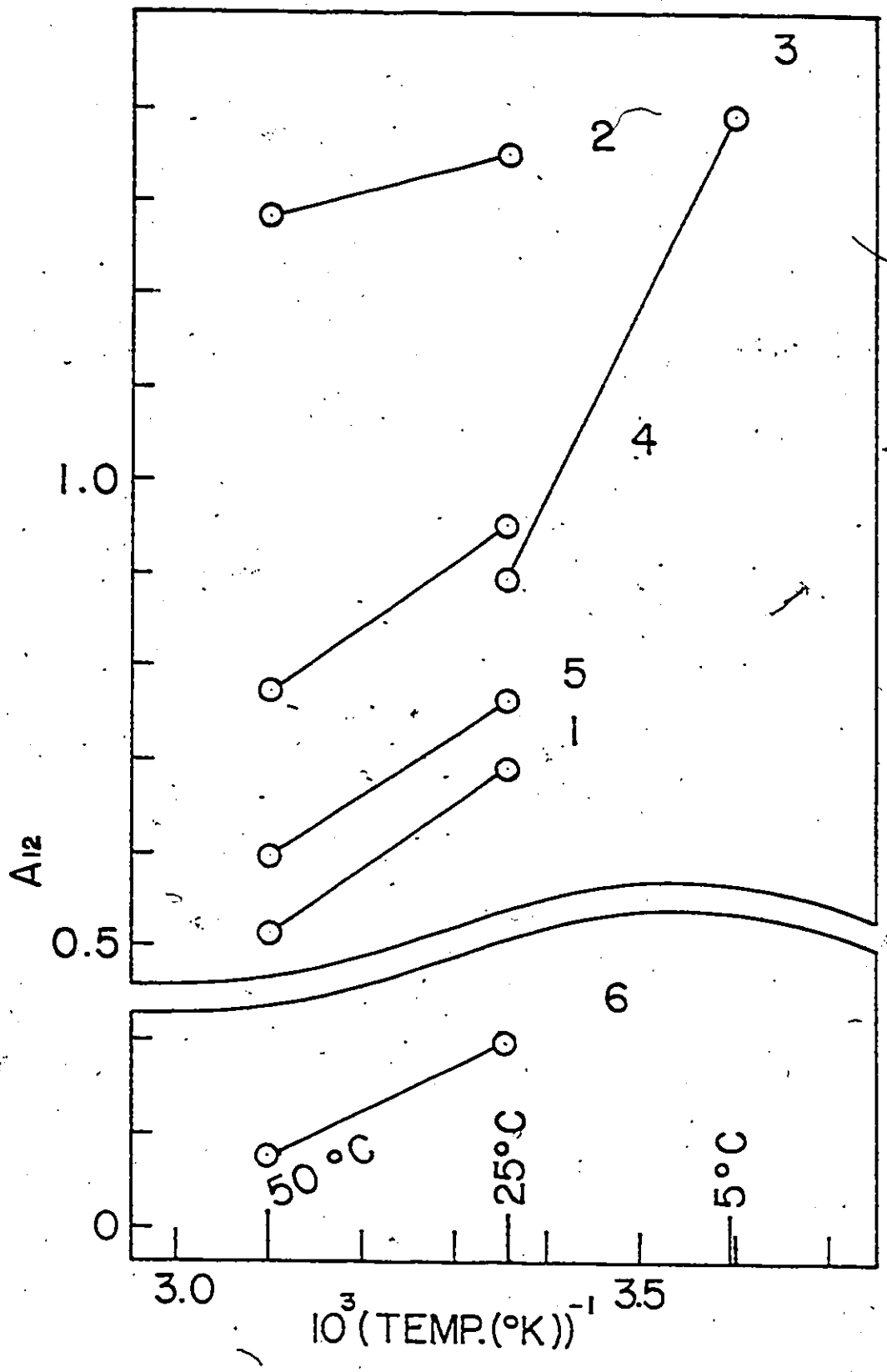

Figure 12

A_{12} values for 1,3-Butatiene in solvents

1 Acetone, 2 Acetic acid, 3 Carbon disulfide, 4 Dimethyl formamide, 5 N,N-dimethyl acetamide, 6 Ethyl acetate.

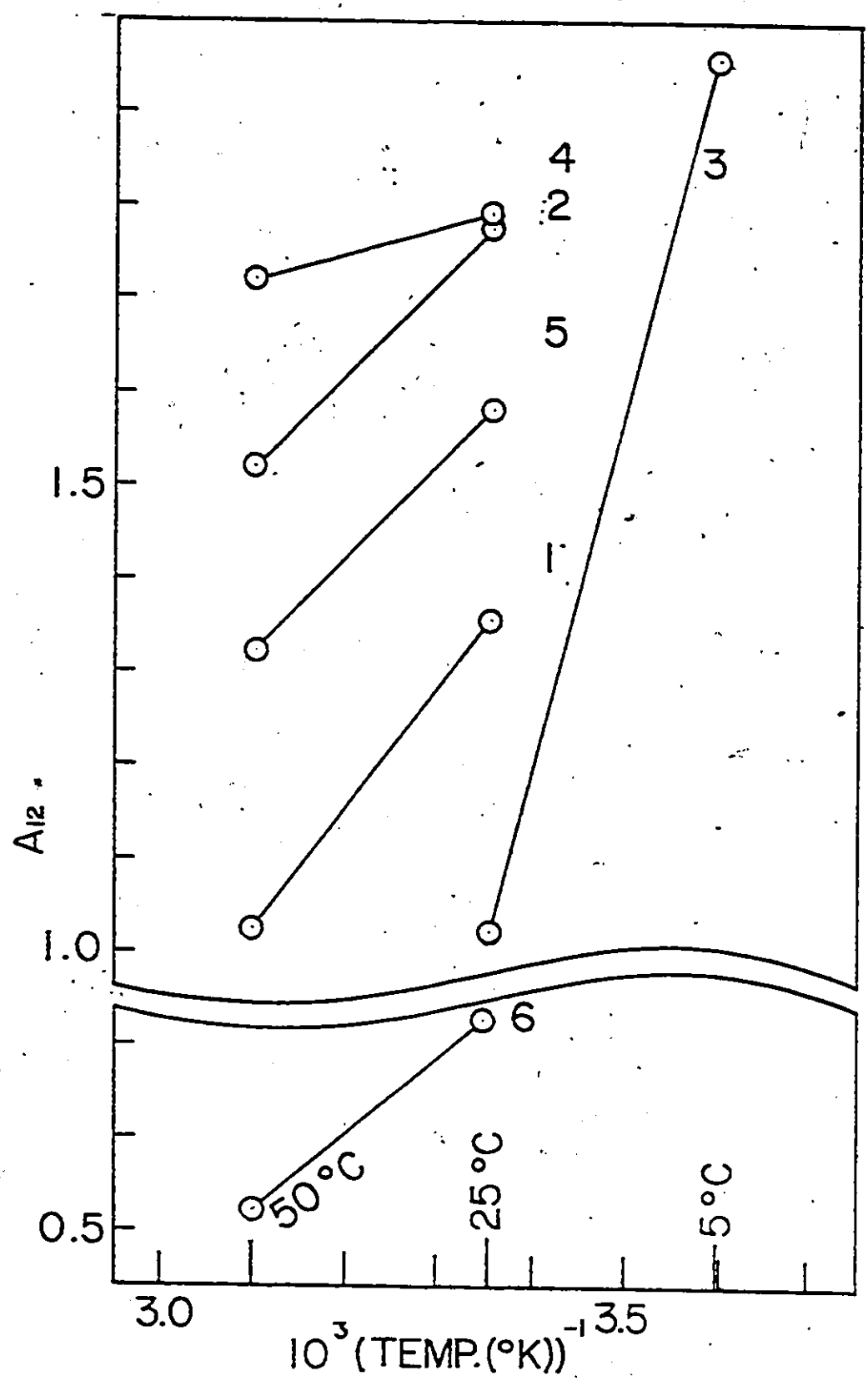

Figure 13

A_{12} values for Trans-2-butene in solvents

1 Acetone, 2 Acetic acid, 3 Carbon disulfide, 4 Dimethy formamide, 5 N,N-dimethyl acetamide, 6 Ethyl acetate.

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APPENDIX

Computer Program and Calculation Printouts

```
FORTRAN IV G LEVEL  21                    MAIN

                C       MAJOR PARAMETERS IN THE PROGRAM
                C       L=OSTWALD COEFFICIENT
                C       T=TIME
                C       V=VOLUME OF SOLUTE GAS DISSOLVED
                C       ST,STT,SV,STV=LEAST SQUARE METHOD PARAMETER
                C       P1O=VAPOR PRESSURE OF SOLVENT
                C       V1=MOLAR VOLUME OF SOLVENT
                C       V2=MOLAR VOLUME OF SOLUTE GAS
                C       PA=ATMOSPHERIC PRESSURE
                C       TEMP=TEMPERATURE
                C       S=SLOPE
                C       F=INFUTION RATE
                C       X=MOLE FRACTION SOLUBILITY
0001                    REAL L
0002                    DIMENSION T(20),V(20),SYSTEM(7)
0003                    WRITE(6,1100)
0004                30  READ(5,999,END=1000) (SYSTEM(I),I=1,70)
0005                    READ(5,100) N
0006                    READ(5,200) (T(I),I=1,N)
0007                    READ(5,300) (V(I),I=1,N)
0008                    READ(5,400) P10,V1,V2,PA,TEMP,F
0009                    ST=0.
0010                    STT=0.
0011                    SV=0.
0012                    STV=0.
0013                    DO 10 I=4,N
0014                    ST=ST+T(I)
0015                    STT=STT+T(I)**2
0016                    SV=SV+V(I)
0017                    STV=STV+T(I)*V(I)
0018                10  CONTINUE
0019                    RN=N-3
0020                    S=(RN*STV-ST*SV)/(RN*STT-ST**2)
0021                    SS=(SV-S*ST)/RN
0022                    WRITE(6,500) (SYSTEM(I),I=1,70)
0023                    WRITE(6,550)
0024                    WRITE(6,600) PA,P10,V1,V2
0025                    WRITE(6,700) ST,STT,SV,STV
0026                    IF(P10.NE.0.) GO TO 11
0027                    L=S/F
0028                    X=1.0/(1.0+PA*V2/(L*760.*V1))
0029                    GO TO 12
0030                11  A=S*PA*P10
0031                    B=-(F*V2*PA*(PA-P10)/V1+S*PA*(760.+P10))
0032                    C=S*PA*760.
0033                    WRITE(6,800) A,B,C,S,SS
0034                    X=(-B-SQRT(B**2-4.*A*C))/2.0/A
0035                    P2=(PA-P10)/(1.0-P10*X/760.)
0036                    L=S*PA/F/(PA-P10*(1.0-P2*X/760.))
0037                12  WRITE(6,850) F
0038                    WRITE(6,900) TEMP,L,X
0039                    WRITE(6,910)
0040                    DO 20 I=1,N
0041                    TI=T(I)
0042                    VI=V(I)
0043                    IF(I.GT.1) GO TO 35
0044                    WRITE(6,920) TI,VI
0045                    GO TO 20
0046                35  VL=S*TI+SS
0047                    IF(VL.EQ.0.0) GO TO 15
0048                    DEV=(VI-VL)/VL*100.
0049                    GO TO 25
```

```
FORTRAN IV G LEVEL  21                          MAIN

0060              15 DEV=0.
0061              25 WRITE(6,950) TI,VI,DEV
0062              20 CONTINUE
0063                 WRITE(6,1100)
0064             100 FORMAT(I2)
0065             200 FORMAT(15F5.0)
0066             300 FORMAT(15F5.0)
0067             400 FORMAT(6F10.0)
0068             500 FORMAT(1X,70A1)
0069             550 FORMAT(1CX,'1=SOLVENT,  2=SOLUTE GAS')
0060             600 FORMAT(10X,'ATM.P=',F8.2,2X,'MMHG',/,
                    110X,'VAP.P=',F8.2,2X,'MMHG',/,
                    210X,'MOL.VOL1=',F15.2,2X,'CC/MOL',/,
                    310X,'MOL.VOL2=',F15.2,2X,'CC/MOL')
0061             700 FORMAT(10X,'ST=',F10.3,5X,'STT=',F10.3,5X,
                   1'SV=',F10.3,/,10X,'STV=',F10.3)
0062             800 FORMAT(10X,'A=',F11.3,5X,'B=',F12.3,5X,'C=',
                    1F15.3,/,10X,'SLOPE=',F10.5,5X,'V0=',F10.5)
0063             850 FORMAT(10X,'INFUSION RATE=',F10.6,3X,'CC/MIN')
0064             900 FORMAT(10X,'TEMP=',F6.3,2X,'KEL.',/,10X,'JST.CO.=',F10.2,/,10X,
                    1'X=',F10.5,5X,'GAS VOL.=SLOPE*TIME+V0',/)
0065             910 FORMAT(14X,'TIME IN MIN.',3X,'VOL. IN CC ',3X,'DEV. IN X',/)
0066             920 FORMAT(10X,2F13.2,3X,'SEE V0')
0067             950 FORMAT(10X,2F13.2,F13.3)
0068             999 FORMAT(70A1)
0069            1100 FORMAT('**********','**********','**********','**********',/)
0070                 GO TO 30
0071            1000 STOP
0072                 END
```

ACETYLENE-CYCLOHEXANE RUN NO.=PREPARATION-1
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 746.70 MMHG
VAP.P= 271.90 MMHG
MOL.VOL1= 112.82 CC/MOL
MOL.VOL2= 26369.10 CC/MOL
ST= 510.000 STT= 25250.000 SV= 10.330
STV= 511.500
A= 4115.898 B=-1525402.000 C= 11504.543
SLOPE= 0.02027 V0= -0.00075
INFUSION RATE= 0.018220 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 1.75
X= 0.00753 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.10	-0.606
10.00	0.21	3.974
15.00	0.31	2.197
20.00	0.40	-1.161
25.00	0.49	-3.174
30.00	0.61	0.424
35.00	0.71	0.171
40.00	0.82	1.216
45.00	0.92	0.931
50.00	1.01	-0.284
55.00	1.12	0.517
60.00	1.21	-0.461
65.00	1.31	-0.529
70.00	1.42	0.118

****

ACETYLENE-CYCLOHEXANE RUN NO.=PREPARATION-2
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 744.10 MMHG
VAP.P= 271.90 MMHG
MOL.VOL1= 112.82 CC/MOL
MOL.VOL2= 26369.10 CC/MOL
ST= 510.000 STT= 25250.000 SV= 10.280
STV= 509.500
A= 4108.641 B=-1511877.000 C= 11484.258
SLOPE= 0.02031 V0= -0.00641
INFUSION RATE= 0.018220 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 1.75
X= 0.00735 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.10	5.117
10.00	0.20	1.693
15.00	0.30	0.601
20.00	0.41	2.565
25.00	0.49	-2.251
30.00	0.60	-0.468
35.00	0.71	0.801
40.00	0.80	-0.732
45.00	0.91	0.283
50.00	1.00	-0.889
55.00	1.11	-0.046
60.00	1.22	0.656
65.00	1.32	0.488
70.00	1.41	-0.362

****

ACETYLENE-BENZENE RUN NO.=PREPARATION-3
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 746.20 MMHG
VAP.P= 269.70 MMHG
MOL.VOL1= 92.11 CC/MOL
MOL.VOL2= 26369.10 CC/MOL
ST= 665.000 STT= 37275.000 SV= 27.680
STV= 1558.549
A= 8625.000 B=-1874316.000 C= 24304.793
SLOPE= 0.04286 V0= -0.05857
INFUSION RATE= 0.018090 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 3.69
X= 0.01299 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.20	28.441
10.00	0.41	10.811
15.00	0.60	2.690
20.00	0.80	0.179
25.00	1.01	-0.282
30.00	1.22	-0.582
35.00	1.44	-0.099
40.00	1.64	-0.949
45.00	1.86	-0.535
50.00	2.10	0.754
55.00	2.31	0.497
60.00	2.52	0.284
65.00	2.71	-0.629
70.00	2.92	-0.728
75.00	3.16	0.136
80.00	3.39	0.594

****

ACETYLENE-BENZENE RUN NO.=PREPARATION-4
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 763.30 MMHG
VAP.P= 269.70 MMHG
MOL.VOL1= 92.11 CC/MOL
MOL.VOL2= 26369.10 CC/MOL
ST= 937.000 STT= 61387.000 SV= 43.410
STV= 2863.908
A= 9472.320 B=-1987342.000 C= 26692.492
SLOPE= 0.04601 V0= 0.01740
INFUSION RATE= 0.018090 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 3.91
X= 0.01346 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.24	-3.016
10.00	0.46	-3.671
15.00	0.70	-1.073
20.00	0.93	-0.817
25.00	1.16	-0.661
30.00	1.40	0.158
35.00	1.60	-1.711
40.00	1.84	-0.964
46.00	2.16	1.219
50.00	2.35	1.378
55.00	2.59	1.644
60.00	2.75	-1.014
65.00	3.04	1.056
70.00	3.22	-0.565
75.00	3.52	1.489
80.00	3.70	0.042
86.00	3.90	-1.875
90.00	4.15	-0.206
95.00	4.40	0.259

****

ACETYLENE-BENZENE RUN NO.=PREPARATION-5
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 763.90 MMHG
VAP.P= 269.70 MMHG
MOL.VOL1= 92.11 CC/MOL
MOL.VOL2= 26369.10 CC/MOL
ST= 940.000 STT= 62282.000 SV= 41.780
STV= 2772.608
A= 9244.582 B=-1990381.000 C= -96050.746
SLOPE= 0.04487 V0= -0.02349
INFUSION RATE= 0.018090 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 3.82
X= 0.01309 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.21	4.544
10.00	0.41	-3.581
15.00	0.64	-1.476
20.00	0.87	-0.451
25.00	1.09	-0.756
30.00	1.33	0.555
36.00	1.61	1.138
40.00	1.78	0.487
45.00	1.99	-0.287
50.00	2.21	-0.454
57.00	2.53	-0.165
60.00	2.67	0.045
65.00	2.91	0.582
70.00	3.12	0.080
75.00	3.35	0.243
80.00	3.57	0.106
86.00	3.80	-0.925
90.00	4.02	0.126
96.00	4.29	0.136

****

ACETYLENE-BENZENE RUN NO.=PREPARATION-6
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 765.80 MMHG
VAP.P= 269.70 MMHG
MOL.VOL1= 92.11 CC/MOL
MOL.VOL2= 26369.10 CC/MOL
ST= 936.000 STT= 61816.000 SV= 41.850
STV= 2765.348
A= 9263.953 B=-2002853.000 C= 26105.332
SLOPE= 0.04485 V0= -0.00784
INFUSION RATE= 0.018090 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 3.81
X= 0.01306 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.21	-2.969
10.00	0.46	4.381
15.00	0.65	-2.250
20.00	0.89	0.086
25.00	1.11	-0.315
30.00	1.34	0.166
35.00	1.56	-0.131
40.00	1.81	1.326
45.00	2.02	0.468
50.00	2.22	-0.665
55.00	2.46	0.036
60.00	2.66	-0.872
65.00	2.94	1.112
70.00	3.15	0.577
75.00	3.35	-0.185
80.00	3.57	-0.292
85.00	3.80	-0.125
90.00	4.02	-0.224
96.00	4.30	0.043

****

ACETYLENE-BENZENE RUN NO.=PREPARATION-7

1=SOLVENT. 2=SOLUTE GAS

ATM.P= 760.00 MMHG

VAP.P= 269.70 MMHG

MOL.VOL1= 92.11 CC/MOL

MOL.VOL2= 26369.10 CC/MOL

ST= 587.000 STT= 31077.000 SV= 25.820

STV= 1367.238

A= 9030.563 B=-1964234.000 C= 25447.543

SLOPE= 0.04406 V0= -0.00322

INFUSION RATE= 0.018090 CC/MIN

TEMP= 323.150 KEL.

OST.CO.= 3.76

X= 0.01296 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.26	19.777
10.00	0.43	-1.682
15.00	0.69	4.920
20.00	0.88	0.235
25.00	1.06	-3.480
31.00	1.38	1.279
35.00	1.52	-1.222
40.00	1.77	0.620
45.00	1.97	-0.474
50.00	2.18	-0.894
55.00	2.41	-0.411
60.00	2.68	1.506
65.00	2.85	-0.368
71.00	3.11	-0.476
75.00	3.32	0.573

****

1,3-BUTADIENE-ACETONE RUN NO.=1
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 748.60 MMHG
VAP.P= 228.42 MMHG
MOL.VOL1= 73.98 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 689.500
STV= 34080.000
A= 228451.875 B=-3188861.000 C= 760106.125
SLOPE= 1.33001 V0= 0.07775
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 101.39
X= 0.24256 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	7.00	-4.863
10.00	14.00	-0.270
15.00	21.00	1.361
20.00	27.00	-1.453
25.00	34.00	-0.229
30.00	41.00	0.593
35.00	48.00	1.184
40.00	54.00	-0.219
45.00	60.50	-0.491
50.00	67.00	-0.709
55.00	74.00	-0.414
60.00	81.00	0.200
65.00	87.50	-0.021
70.00	94.50	0.320

****

1,3-BUTADIENE-ACETONE RUN NO.=2
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 748.60 MMHG
VAP.P= 228.42 MMHG
MOL.VOL1= 73.98 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 679.500
STV= 33697.500
A= 230484.563 B=-3197657.000 C= 760869.313
SLOPE= 1.34790 V0= -0.06079
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 102.24
X= 0.24412 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	7.00	15.156
10.00	13.50	5.319
15.00	20.00	2.261
20.00	26.50	0.771
25.00	33.00	-0.111
30.00	39.50	-0.694
35.00	46.00	-1.109
40.00	53.00	-0.479
45.00	60.00	0.009
50.00	67.00	0.398
55.00	73.50	0.036
60.00	80.00	-0.266
65.00	87.00	0.054
70.00	94.00	0.328

****

1.3-BUTADIENE-ACETONE RUN NO.=3
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 748.60 MMHG
VAP.P= 228.42 MMHG
MOL.VOL1= 73.98 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 693.500
STV= 34302.500
A= 230962.875 B=-3199727.000 C= 768460.750
SLOPE= 1.35070 V0= 0.33698
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 102.45
X= 0.24448 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	8.00	12.037
10.00	14.00	0.763
15.00	21.00	1.707
20.00	27.00	-1.463
25.00	34.00	-0.452
30.00	41.50	1.447
35.00	47.50	-0.339
40.00	54.00	-0.763
45.00	61.00	-0.275
50.00	68.00	0.115
55.00	75.00	0.435
60.00	81.50	0.087
65.00	88.00	-0.207
70.00	95.00	0.068

****

1.3-BUTADIENE-ACETIC ACID RUN NO.=4
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 753.60 MMHG
VAP.P= 15.11 MMHG
MOL.VOL1= 57.58 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 539.500
STV= 26737.500
A= 12131.410 B=-465796?.000 C= 610183.500
SLOPE= 1.06538 V0= -0.32048
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 61.75
X= 0.13111 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	5.00	-0.129
10.00	10.00	-3.226
15.00	16.00	2.169
20.00	21.00	0.061
25.00	26.00	-1.194
30.00	31.50	-0.446
35.00	37.00	0.087
40.00	42.50	0.485
45.00	47.50	-0.256
50.00	53.00	0.097
55.00	58.00	-0.473
60.00	63.50	-0.161
65.00	69.00	0.102
70.00	74.50	0.328

****

1,3-BUTADIENE-ACETIC ACID RUN NO.=5
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 752.70 MMHG
VAP.P= 15.11 MMHG
MOL.VOL1= 57.58 CC/MOL
MOL.VOL2= 23775.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 540.000
STV= 26752.500
A= 12097.043 B=-4645468.000 C= 608454.933
SLOPE= 1.06364 V0= -0.20451
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 61.65
X= 0.13102 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	5.50	7.555
10.00	10.50	0.653
15.00	16.00	1.587
20.00	21.00	-0.324
25.00	26.00	-1.464
30.00	32.00	0.932
35.00	37.00	-0.001
40.00	42.50	0.378
45.00	47.00	-1.383
50.00	53.00	0.043
55.00	58.50	0.351
60.00	64.00	0.607
65.00	69.00	0.099
70.00	74.00	-0.337

****

1,3-BUTADIENE-ACETIC ACID RUN NO.=6
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 749.00 MMHG
VAP.P= 15.11 MMHG
MOL.VOL1= 57.58 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 535.500
STV= 26497.500
A= 11835.770 B=-4593160.000 C= 595313.375
SLOPE= 1.04580 V0= 0.17834
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 60.63
X= 0.12969 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	5.50	1.713
10.00	10.50	-1.282
15.00	15.50	-2.303
20.00	21.50	1.923
25.00	26.50	0.671
30.00	31.50	-0.166
35.00	36.50	-0.765
40.00	42.00	-0.025
45.00	47.00	0.551
50.00	52.50	0.060
55.00	57.50	-0.342
60.00	63.00	0.117
65.00	68.00	-0.228
70.00	73.50	0.157

****

1,3-BUTADIENE-CARBON DISULFIDE RUN NO.=7
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 741.10 MMHG
VAP.P= 358.83 MMHG
MOL.VOL1= 60.62 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 513.000 STT= 25379.000 SV= 513.000
STV= 25379.000
A= 265928.688 B=-2781604.000 C= 5C3235.375
SLOPE= 1.00000 V0= 0.0
INFUSION RATE= 0.017570 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 99.58
X= 0.20656 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	5.00	0.0
10.00	10.00	0.0
15.00	15.00	0.0
20.00	20.00	0.0
25.00	25.00	0.0
30.00	30.00	0.0
35.00	35.00	0.0
40.00	40.00	0.0
45.00	45.00	0.0
50.00	50.00	0.0
55.00	55.00	0.0
60.00	60.00	0.0
65.00	65.00	0.0
70.00	70.00	0.0

****

1,3-BUTADIENE-CARBON DISULFIDE RUN NO.=8
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 741.10 MMHG
VAP.P= 358.83 MMHG
MOL.VOL1= 60.62 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 505.000
STV= 25020.000
A= 264626.875 B=-2777543.000 C= 560478.023
SLOPE= 0.99510 V0= -0.20862
INFUSION RATE= 0.017570 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 99.13
X= 0.20583 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	5.00	4.890
10.00	10.00	2.644
15.00	15.00	1.916
20.00	20.00	1.557
25.00	24.50	-0.685
30.00	29.50	-0.487
35.00	34.50	-0.347
40.00	39.50	-0.241
45.00	44.00	-1.281
50.00	49.50	-0.094
55.00	54.50	-0.041
60.00	60.00	0.843
65.00	64.50	0.042
70.00	69.50	0.074

****

1,3-BUTADIENE-CARBON DISULFIDE RUN NO.=9
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 741.20 MMHG
VAP.P= 358.83 MMHG
MOL.VOL1= 60.62 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 499.000
STV= 24757.500
A= 264104.688 B=-2776692.000 C= 559372.563
SLOPE= 0.99301 V0= -0.61945
INFUSION RATE= 0.017570 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 98.93
X= 0.20547 GAS VOL.=SLOPE*TIME+V0.

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	5.00	15.059
10.00	10.00	7.404
15.00	14.50	1.572
20.00	19.50	1.348
25.00	24.00	-0.850
30.00	29.00	-0.585
35.00	34.00	-0.398
40.00	39.00	-0.258
45.00	44.00	-0.149
50.00	49.00	-0.063
55.00	54.00	0.008
60.00	59.00	0.066
65.00	64.00	0.116
70.00	69.00	0.158

****

1,3-BUTADIENE-DIMETHYL FORMAMIDE RUN NO.=10
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 750.00 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 77.44 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 669.000
STV= 33080.000
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 74.03
X= 0.19635 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	7.50	7.142
10.00	14.00	3.703
15.00	20.00	-0.000
20.00	26.50	-0.000
25.00	33.00	0.0
30.00	39.50	0.0
35.00	46.00	0.0
40.00	52.50	0.0
45.00	59.00	0.000
50.00	65.50	0.000
55.00	72.00	0.000
60.00	78.50	0.000
65.00	85.00	0.000
70.00	91.50	0.000

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1.3-BUTADIENE-DIMETHYL FORMAMIDE RUN NO.=11
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 749.70 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 77.44 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 674.500
STV= 33280.000
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 73.49
X= 0.19526 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE VO
5.00	8.00	2.401
10.00	14.00	-1.859
15.00	20.50	-1.052
20.00	27.00	-0.828
25.00	34.00	1.120
30.00	40.00	-0.190
35.00	46.50	-0.063
40.00	53.00	0.034
45.00	59.50	0.110
50.00	66.00	0.171
55.00	72.50	0.221
60.00	79.00	0.263
65.00	85.00	-0.288
70.00	91.50	-0.217

****

1.3-BUTADIENE-DIMETHYL FORMAMIDE RUN NO.=12
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 749.40 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 77.44 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 656.500
STV= 32517.500
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 73.53
X= 0.19541 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE VO
5.00	6.50	3.402
10.00	13.00	2.021
15.00	19.00	-1.035
20.00	25.50	-0.604
25.00	32.00	-0.347
30.00	39.00	1.121
35.00	45.00	-0.053
40.00	51.50	0.039
45.00	58.00	0.110
50.00	64.50	0.167
55.00	71.00	0.213
60.00	77.50	0.250
65.00	83.50	-0.312
70.00	90.00	-0.242

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1,3-BUTADIENE-N,N-DIMETHYL ACETAMIDE RUN NO.=13
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 750.70 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 92.85 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 682.500
STV= 33762.500
INFUSION RATE= 0.017500 CC/MIN
TEMP= 298.150 KEL.
CST.CO.= 75.76
X= 0.23048 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	7.00	0.225
10.00	13.50	-1.000
15.00	20.50	1.043
20.00	27.00	0.221
25.00	33.50	-0.276
30.00	40.00	-0.608
35.00	47.00	0.220
40.00	53.50	0.091
45.00	60.00	-0.334
50.00	67.00	0.220
55.00	73.50	-0.007
60.00	80.00	-0.196
65.00	87.00	0.220
70.00	93.50	0.041

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1,3-BUTADIENE-N,N-DIMETHYL ACETAMIDE RUN NO.=14
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 738.10 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 92.85 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 510.000 STT= 25250.000 SV= 661.000
STV= 32700.000
INFUSION RATE= 0.017500 CC/MIN
TEMP= 298.150 KEL.
CST.CO.= 73.39
X= 0.22786 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	7.00	3.659
10.00	13.00	-1.493
15.00	19.50	-0.718
20.00	26.00	-0.326
25.00	32.50	-0.090
30.00	39.00	0.069
35.00	45.50	0.182
40.00	52.00	0.267
45.00	58.50	0.334
50.00	65.00	0.387
55.00	71.00	0.272
60.00	77.50	0.177
65.00	84.00	-0.097
70.00	90.50	-0.028

****

1,3-BUTADIENE-N,N-DIMETHYL ACETAMIDE RUN NO.=15

1=SOLVENT, 2=SOLUTE GAS
ATM.P= 738.50 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 92.65 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 509.000 STT= 25141.000 SV= 978.000
STV= 33495.500
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 75.97
X= 0.23388 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	6.50	-1.296
10.00	13.00	-1.927
15.00	20.00	0.374
20.00	26.50	-0.367
25.00	33.50	0.704
30.00	40.00	0.161
35.00	46.50	-0.227
40.00	53.00	-0.518
45.00	60.00	0.090
50.00	66.50	-0.175
54.00	72.00	0.066
60.00	80.00	0.054
65.00	86.50	-0.146
70.00	93.50	0.218

****

1,3-BUTADIENE-ETHYL ACETATE RUN NO.=17

1=SOLVENT, 2=SOLUTE GAS
ATM.P= 762.80 MMHG
VAP.P= 96.12 MMHG
MOL.VOL1= 98.53 CC/MOL
MOL.VOL2= 23778.00 CC/MOL
ST= 509.000 STT= 25141.000 SV= 978.000
STV= 48247.000
A= 139654.563 B=-3401385.000 C= 1104218.000
SLOPE= 1.90472 VC= 0.70817
INFUSION RATE= 0.017530 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 118.81
X= 0.32908 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	10.00	-2.265
10.00	19.50	-1.293
15.00	29.00	-0.953
20.00	38.50	-0.780
25.00	48.00	-0.675
30.00	58.00	0.760
35.00	67.50	0.188
40.00	77.00	0.134
45.00	86.50	0.092
50.00	96.00	0.058
54.00	105.50	1.870
60.00	115.00	0.008
65.00	124.00	-0.414
70.00	133.00	-0.775

****

1,3-BUTADIENE-ETHYL ACETATE RUN NO.=18
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 762.70 MMHG
VAP.P= 95.12 MMHG
MOL.VOL1= 98.53 CC/MOL
MOL.VOL2= 25778.00 CC/MOL
ST= 509.000 STT= 25141.000 SV= 994.000
STV= 49088.000
A= 142987.750 B=-3430466.000 C= 1130672.000
SLOPE= 1.95043 V0= 0.10240
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 121.58
X= 0.33422 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	10.00	1.476
10.00	19.50	0.544
15.00	29.00	1.222
20.00	39.00	0.284
25.00	49.00	0.280
30.00	58.50	-0.197
35.00	68.50	0.194
40.00	78.00	-0.153
45.00	88.00	0.146
50.00	97.50	-0.127
54.00	107.00	1.493
60.00	117.00	-0.110
65.00	126.50	-0.300
70.00	136.00	-0.463

****

1,3-BUTADIENE-ACETONE RUN NO.=19
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 754.60 MMHG
VAP.P= 606.86 MMHG
MOL.VOL1= 76.64 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 565.000 STT= 30875.000 SV= 100.700
STV= 5337.992
A= 81169.750 B= -3703246.88 C= 101652.875
SLOPE= 0.17725 V0= -0.23016
INFUSION RATE= 0.018220 CC/MIN
TEMP= 525.150 KEL.
OST.CO.= 45.00
X= 0.11810 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.60	-8.550
10.00	1.50	-2.746
15.00	2.40	-1.178
20.00	3.30	-0.449
25.00	4.20	-0.027
30.00	5.10	0.248
35.00	6.00	0.441
40.00	6.90	0.585
45.00	7.80	0.695
50.00	8.60	-0.375
55.00	9.50	-0.196
60.00	10.40	-0.047
65.00	11.20	-0.807
70.00	12.20	0.185
75.00	13.10	0.278

****

1,3-BUTADIENE-ACETONE RUN NO.=20
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 756.50 MMHG
VAP.P= 606.86 MMHG
MOL.VOL1= 76.64 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 90.200
STV= 4456.496
A= 79897.625 B= -872473.438 C= 100059.531
SLOPE= 0.17427 V0= 0.11038
INFUSION RATE= 0.018220 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 44.11
X= 0.11592 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.90	-8.323
10.00	1.80	-2.862
15.00	2.70	-0.894
20.00	3.60	0.120
25.00	4.50	0.738
30.00	5.30	-0.718
35.00	6.20	-0.156
40.00	7.10	0.208
45.00	8.00	0.[illegible]
50.00	8.80	-0.266
55.00	9.70	0.052
60.00	10.60	0.319
65.00	11.40	-0.329
70.00	12.30	-0.073

****

1,3-BUTADIENE-ACETONE RUN NO.=21
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 756.30 MMHG
VAP.P= 606.86 MMHG
MOL.VOL1= 76.64 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 91.700
STV= 4525.996
A= 80720.313 B= -878789.875 C= 101090.000
SLOPE= 0.17567 V0= 0.16703
INFUSION RATE= 0.018220 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 44.32
X= 0.11627 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.90	-13.991
10.00	1.80	-6.531
15.00	2.80	-0.183
20.00	3.60	-2.294
25.00	4.60	0.702
30.00	5.40	-0.794
35.00	6.40	1.224
40.00	7.20	-0.027
45.00	8.10	0.231
50.00	9.00	0.438
55.00	9.90	0.609
60.00	10.70	-0.181
65.00	11.60	0.210
70.00	12.40	-0.627

****

1,3-BUTADIENE-ACETIC ACID RUN NO.=22
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 761.80 MMHG
VAP.P= 56.64 MMHG
MOL.VOL1= 59.68 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 565.000 STT= 30875.000 SV= 255.000
STV= 13439.984
A= 18634.238 B=-4466796.000 C= 250035.633
SLOPE= 0.43186 V0= 0.18148
INFUSION RATE= 0.017980 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 25.84
X= 0.05603 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	2.20	-6.014
10.00	4.40	-2.225
15.00	6.60	-0.892
20.00	8.80	-0.213
25.00	11.00	0.200
30.00	13.20	0.476
35.00	15.30	0.021
40.00	17.40	-0.321
45.00	19.60	-0.076
50.00	21.80	0.116
55.00	24.00	0.278
60.00	26.20	0.409
65.00	28.20	-0.186
70.00	30.40	-0.039
75.00	32.50	-0.219

****

1,3-BUTADIENE-ACETIC ACID RUN NO.=23
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 761.80 MMHG
VAP.P= 56.64 MMHG
MOL.VOL1= 59.68 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 511.000 STT= 25331.000 SV= 223.000
STV= 11040.833
A= 18666.250 B=-4467258.000 C= 250465.250
SLOPE= 0.43261 V0= 0.18150
INFUSION RATE= 0.017980 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 25.86
X= 0.05614 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	2.30	-1.055
10.00	4.40	-1.951
15.00	6.60	-0.761
20.00	8.80	-0.155
25.00	11.00	0.213
30.00	13.20	0.459
35.00	15.30	-0.018
41.00	17.90	0.009
45.00	19.60	0.147
50.00	21.80	0.038
55.00	24.00	0.189
60.00	26.10	-0.068
65.00	28.30	0.067
70.00	30.40	-0.144

****

1,3-BUTADIENE-ACETIC ACID RUN NO.=24
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 762.40 MMHG
VAP.P= 56.64 MMHG
MOL.VOL1= 59.68 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 221.200
STV= 10941.980
A= 18013.496 B=-4473380.000 C= 249757.375
SLOPE= 0.43104 V0= 0.11393
INFUSION RATE= 0.017980 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 25.79
X= 0.05590 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	2.10	-7.455
10.00	4.30	-2.811
15.00	6.50	-1.210
20.00	8.70	-0.399
25.00	10.90	0.091
30.00	13.10	0.420
35.00	15.30	0.655
40.00	17.40	0.255
45.00	19.50	-0.056
50.00	21.60	-0.305
55.00	23.90	-0.330
60.00	25.90	-0.295
65.00	28.10	-0.113
70.00	30.30	0.043

****

1,3-BUTADIENE-CARBON DISULFIDE RUN NO=25
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 756.50 MMHG
VAP.P= 158.07 MMHG
MOL.VOL1= 59.22 CC/MOL
MOL.VOL2= 22011.20 CC/MOL
ST= 510.000 STT= 25250.000 SV= 1023.000
STV= 50442.500
A= 232971.813 B=-2367745.000 C= 1120127.000
SLOPE= 1.94825 V0= 2.44932
INFUSION RATE= 0.006030 CC/MIN
TEMP= 278.150 KEL.
OST.CO.= 366.18
X= 0.49742 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	10.50	-13.868
10.00	21.00	-4.249
15.00	31.50	-0.546
20.00	41.00	-1.000
25.00	51.50	0.673
30.00	61.00	0.169
35.00	71.00	0.512
40.00	80.50	0.150
45.00	90.00	-0.134
50.00	100.00	0.138
55.00	109.50	-0.094
60.00	119.00	-0.289
65.00	129.00	-0.066
70.00	139.00	0.125

****

1,3-BUTADIENE-CARBON DISULFIDE RUN NO.=26
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 754.60 MMHG
VAP.P= 158.37 MMHG
MOL.VOL1= 59.22 CC/MOL
MOL.VOL2= 22011.20 CC/MOL
ST= 665.000 STT= 37275.000 SV= 1434.500
STV= 79537.500
A= 239057.125 B=-2397325.000 C= 1149386.000
SLOPE= 2.00418 VO= 7.26597
INFUSION RATE= 0.000030 CC/MIN
TEMP= 278.150 KEL.
OST.CO.= 376.29
X= 0.50430 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC.	DEV. IN %
0.0	0.0	SEE VO
5.00	12.00	-30.563
10.00	24.00	-12.113
15.00	35.50	-4.899
20.00	46.00	-2.850
25.00	57.00	-0.646
30.00	68.00	0.903
35.00	79.00	2.051
40.00	89.00	1.792
45.00	99.00	1.587
50.00	108.00	0.489
55.00	118.00	0.429
60.00	127.00	-0.406
65.00	137.00	-0.391
70.00	147.00	-0.376
75.00	157.00	-0.367
80.00	167.00	-0.358

****

1,3-BUTADIENE-DIMETHYL FORMAMIDE RUN NO.=28
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 754.20 MMHG
VAP.P= 15.51 MMHG
MOL.VOL1= 79.45 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 299.900
STV= 14887.996
A= 7009.582 B=-3628233.000 C= 343474.125
SLOPE= 0.59925 VO= -0.47555
INFUSION RATE= 0.018020 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 33.89
X= 0.09473 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE VO
5.00	2.70	7.121
10.00	5.70	3.323
15.00	8.70	2.199
20.00	11.50	-0.078
25.00	14.30	-1.414
30.00	17.50	-0.007
35.00	20.50	0.013
40.00	23.50	0.027
45.00	26.50	0.039
50.00	29.40	-0.291
55.00	32.50	0.[illegible]95
60.00	35.50	0.[illegible]01
65.00	38.50	0.[illegible]07
70.00	41.50	0.071

****

1.3-BUTADIENE-DIMETHYL FORMAMIDE RUN NO.=29
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 754.40 MMHG
VAP.P= 15.51 MMHG
MOL.VOL1= 79.45 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 296.600
STV= 14773.980
A= 6819.156 B=-3620468.000 C= 334143.188
SLOPE= 0.58280 V0= 0.11444
INFUSION RATE= 0.018020 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 32.96
X= 0.09231 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.00	-0.939
10.00	6.00	0.909
15.00	8.80	-0.637
20.00	11.80	0.252
25.00	14.70	0.106
30.00	17.60	0.009
35.00	20.50	-0.080
40.00	23.40	-0.112
45.00	26.40	0.027
50.00	29.20	-0.150
55.00	32.20	0.099
60.00	35.20	0.330
65.00	38.00	0.010
70.00	40.80	-0.269

****

1.3-BUTADIENE-DIMETHYL FORMAMIDE RUN NO.=30
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 753.90 MMHG
VAP.P= 15.51 MMHG
MOL.VOL1= 79.45 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 302.700
STV= 14972.977
A= 6895.551 B=-3619890.000 C= 337886.563
SLOPE= 0.58972 V0= 0.16201
INFUSION RATE= 0.018020 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 33.35
X= 0.09339 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.00	-3.565
10.00	6.00	-0.977
15.00	9.00	-0.086
20.00	12.00	0.365
25.00	14.80	-0.704
30.00	17.80	-0.300
35.00	20.80	-0.010
40.00	23.80	0.208
45.00	26.80	0.377
50.00	29.70	0.176
55.00	32.60	0.011
60.00	35.60	0.155
65.00	38.40	-0.243
70.00	41.40	-0.102

****

1,3BUTADIENE-N,N-DIMETHYL ACETAMIDE RUN NO.=31

1=SOLVENT, 2=SOLUTE GAS
ATM.P= 753.80 MMHG
VAP.P= 8.27 MMHG
MOL.VOL1= 94.98 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 208.500
STV= 14792.484
A= 3650.540 B=-3095662.000 C= 335478.938
SLOPE= 0.58559 V0= 0.01229
INFUSION RATE= 0.017960 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 32.93
X= 0.10834 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	2.80	-4.770
10.00	5.80	-1.162
15.00	8.80	0.043
20.00	11.60	-1.059
25.00	14.70	0.327
30.00	17.60	0.113
35.00	20.60	0.448
40.00	23.40	-0.154
45.00	26.40	0.137
50.00	29.30	0.022
55.00	32.20	-0.082
60.00	35.20	0.148
65.00	38.00	-0.169
70.00	41.00	-0.009

****

1,3-BUTADIENE-N,N-DIMETHYL ACETAMIDE RUN NO.=32

1=SOLVENT, 2=SOLUTE GAS
ATM.P= 753.80 MMHG
VAP.P= 8.27 MMHG
MOL.VOL1= 94.98 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 305.000
STV= 15093.480
A= 3715.923 B=-3101726.000 C= 341487.500
SLOPE= 0.59608 V0= 0.08321
INFUSION RATE= 0.017960 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 33.52
X= 0.11007 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.00	-2.076
10.00	6.00	-0.728
15.00	9.00	-0.271
20.00	11.90	-0.873
25.00	15.00	0.099
30.00	18.00	0.191
35.00	21.00	0.258
40.00	24.00	0.307
45.00	26.90	-0.025
50.00	30.00	0.377
55.00	32.80	-0.206
60.00	35.80	-0.134
65.00	38.80	-0.073
70.00	41.80	-0.021

****

1,3-BUTADIENE-N,N-DIMETHYL FORMAMIDE RUN NO.=33

1=SOLVENT, 2=SOLUTE GAS
ATM.P= 759.80 MMHG
VAP.P= 8.27 MMHG
MOL.VOL1= 94.98 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 308.600
STV= 15268.477
A= 3784.177 B=-3152369.000 C= 347759.875
SLOPE= 0.60224 V0= 0.12150
INFUSION RATE= 0.017960 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 33.86
X= 0.11033 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.00	-4.238
10.00	6.00	-2.343
15.00	9.10	-0.602
20.00	12.20	0.277
25.00	15.20	0.148
30.00	18.20	0.062
35.00	21.20	0.001
40.00	24.20	-0.046
45.00	27.20	-0.082
50.00	30.30	0.220
55.00	33.20	-0.134
60.00	36.30	0.122
65.00	39.20	-0.171
70.00	42.30	0.052

****

P1,3-BUTADIENE-ETHYL ACETATE RUN NO.=34

1=SOLVENT, 2=SOLUTE GAS
ATM.P= 759.40 MMHG
VAP.P= 285.74 MMHG
MOL.VOL1= 102.07 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 306.200
STV= 15156.996
A= 130103.500 B=-2140768.000 C= 346044.125
SLOPE= 0.59958 V0= 0.03451
INFUSION RATE= 0.016210 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 49.55
X= 0.16327 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.00	-1.069
10.00	5.90	-2.161
15.00	9.00	-0.312
20.00	12.00	-0.217
25.00	15.10	0.506
30.00	18.00	-0.122
35.00	21.00	-0.094
40.00	24.00	-0.074
45.00	27.10	0.312
50.00	30.00	-0.045
55.00	33.00	-0.035
60.00	36.00	-0.026
65.00	39.00	-0.019
70.00	42.00	-0.012

****

1,3-BUTADIENE-ETHYL ACETATE RUN NO.=35
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 759.40 MMHG
VAP.P= 285.74 MMHG
MOL.VOL1= 102.07 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 312.000
STV= 15453.977
A= 133168.313 B=-2151985.000 C= 354195.938
SLOPE= 0.01370 V0= -0.08248
INFUSION RATE= 0.016210 CC/MIN
TEMP= 323.150 KEL.
CST.CO.= 50.65
X= 0.16630 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.00	0.467
10.00	6.00	-0.901
15.00	9.10	-0.253
20.00	12.20	0.069
25.00	15.20	-0.394
30.00	18.40	0.369
35.00	21.40	0.013
40.00	24.40	-0.269
45.00	27.60	0.239
50.00	30.60	0.000
55.00	33.70	0.085
60.00	36.80	0.164
65.00	39.80	-0.021
70.00	42.80	-0.179

****

1,3-BUTADIENE-ETHYL ACETATE RUN NO.=36
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 764.80 MMHG
VAP.P= 285.74 MMHG
MOL.VOL1= 102.07 CC/MOL
MOL.VOL2= 25939.80 CC/MOL
ST= 510.000 STT= 25250.000 SV= 322.700
STV= 15940.977
A= 136086.313 B=-2193612.000 C= 361957.000
SLOPE= 0.02272 V0= 0.42586
INFUSION RATE= 0.016210 CC/MIN
TEMP= 323.150 KEL.
CST.CO.= 51.17
X= 0.16673 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.20	-9.591
10.00	6.40	-3.804
15.00	9.60	-1.707
20.00	12.80	-0.624
25.00	16.00	0.038
30.00	19.20	0.484
35.00	22.20	-0.095
40.00	25.40	0.257
45.00	28.60	0.533
50.00	31.70	0.437
55.00	34.80	0.368
60.00	37.80	0.028
65.00	40.80	-0.252
70.00	43.80	-0.492

****

TRANS-2-BUTENE-ACETONE RUN NO.=37
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 750.60 MMHG
VAP.P= 228.42 MMHG
MOL.VOL1= 73.98 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 443.500
STV= 21902.500
A= 146453.563 B=-2841572.000 C= 487280.938
SLOPE= 0.65420 V0= 0.65503
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 66.21
X= 0.17303 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	5.00	1.502
10.00	9.00	-2.142
15.00	13.50	0.238
20.00	17.50	-1.347
25.00	22.00	-0.045
30.00	26.50	0.834
35.00	30.50	-0.170
40.00	35.00	0.509
45.00	39.00	-0.240
50.00	43.50	0.314
55.00	47.50	-0.285
60.00	52.00	0.180
65.00	56.00	-0.316
70.00	60.50	0.085

****

TRANS-2-BUTENE-ACETONE RUN NO.=38
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 749.20 MMHG
VAP.P= 228.42 MMHG
MOL.VOL1= 73.98 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 422.000
STV= 20877.500
A= 140855.000 B=-2807320.000 C= 468653.313
SLOPE= 0.82308 V0= 0.18591
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 63.95
X= 0.16836 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	4.50	4.620
10.00	8.50	0.990
15.00	12.50	-0.256
20.00	16.50	-0.886
25.00	21.00	1.142
30.00	25.00	0.490
35.00	29.00	0.022
40.00	33.00	-0.329
45.00	37.00	-0.603
50.00	41.50	0.388
55.00	45.50	0.099
60.00	49.50	-0.142
65.00	53.50	-0.346
70.00	58.00	0.344

****

TRANS-2-BUTENE-ACETONE RUN NO.=39
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 749.20 MMHG
VAP.P= 229.42 MMHG
MOL.VOL1= 73.96 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 26250.000 SV= 437.500
STV= 21627.500
A= 145223.000 B=-2826221.000 C= 4831[illegible]
SLOPE= 0.84860 V0= 0.39278
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 65.84
X= 0.17249 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	4.50	-2.929
10.00	9.00	1.365
15.00	13.00	-0.928
20.00	17.50	0.779
25.00	21.50	-0.499
30.00	26.00	0.577
35.00	30.00	-0.312
40.00	34.50	0.476
45.00	38.50	-0.207
50.00	43.00	0.414
55.00	47.00	-0.140
60.00	51.00	-0.602
65.00	55.50	-0.093
70.00	60.00	0.343

****

TRANS-2-BUTENE-ACETIC ACID RUN NO.=40
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 759.10 MMHG
VAP.P= 15.11 MMHG
MOL.VOL1= 57.58 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 26250.000 SV= 409.000
STV= 20270.000
A= 9264.223 B=-4557986.000 C= 465970.313
SLOPE= 0.80769 V0= -0.24357
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 46.83
X= 0.10238 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	4.00	5.405
10.00	8.00	2.127
15.00	12.00	1.080
20.00	16.00	0.564
25.00	20.00	0.257
30.00	24.00	0.053
35.00	28.00	-0.092
40.00	32.00	-0.200
45.00	36.00	-0.284
50.	40.00	-0.351
55.	44.00	-0.406
60.	48.00	-0.452
65.	52.00	-0.491
70.	57.00	1.253

****

TRANS-2-BUTENE-ACETIC ACID RUN NO.=41
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 759.10 MMHG
VAP.P= 15.11 MMHG
MOL.VOL1= 57.58 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 412.500
STV= 20427.500
A= 9292.297 B=-4559426.000 C= 467382.313
SLOPE= 0.81014 V0= -0.05593
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 46.98
X= 0.10261 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	4.00	0.131
10.00	8.00	-0.565
15.00	12.00	-0.795
20.00	16.00	-0.909
25.00	20.00	-0.978
30.00	24.50	1.038
35.00	28.50	0.710
40.00	32.50	0.465
45.00	36.50	0.274
50.00	40.50	0.121
55.00	44.50	-0.004
60.00	48.50	-0.108
65.00	52.00	-1.147
70.00	57.00	0.611

****

TRANS-2-BUTENE-ACETIC ACID RUN NO.=42
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 762.10 MMHG
VAP.P= 15.11 MMHG
MOL.VOL1= 57.58 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 416.500
STV= 20605.000
A= 9353.180 B=-4595212.000 C= 470444.623
SLOPE= 0.81224 V0= 0.18323
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 47.09
X= 0.10248 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	4.00	-5.870
10.00	8.50	2.279
15.00	12.50	1.036
20.00	16.50	0.408
25.00	20.50	0.028
30.00	24.50	-0.225
35.00	28.50	-0.407
40.00	32.50	-0.544
45.00	36.50	-0.650
50.00	41.00	0.490
55.00	45.00	0.309
60.00	49.00	0.158
65.00	53.00	0.031
70.00	57.00	-0.079

****

TR ANS-2-BUTENE-CARBON DISULFIDE RUN NO.=44
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 757.00 MMHG
VAP.P= 358.83 MMHG
MOL.VOL1= 80.62 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 668.000
STV= 33037.500
A= 353124.188 B=-3171917.000 C= 747915.500
SLOPE= 1.30000 V0= 0.41671
INFUSION RATE= 0.017570 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 124.57
X= 0.24233 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	6.50	-3.025
10.00	13.00	-3.106
15.00	19.50	-2.092
20.00	26.50	0.315
25.00	33.00	0.253
30.00	39.50	0.211
35.00	46.00	0.181
40.00	52.50	0.159
45.00	59.00	0.141
50.00	65.50	0.127
55.00	72.00	0.116
60.00	78.50	0.106
65.00	85.00	0.098
70.00	91.00	-0.456

****

TR ANS-2-BUTENE-CARBON DISULFIDE RUN NO.=45
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 759.10 MMHG
VAP.P= 358.83 MMHG
MOL.VOL1= 80.62 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 440.000 STT= 20350.000 SV= 567.000
STV= 26222.500
A= 350864.625 B=-3181630.000 C= 743172.188
SLOPE= 1.23818 V0= 0.01822
INFUSION RATE= 0.017570 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 123.29
X= 0.23993 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	6.50	0.633
10.00	13.00	0.775
15.00	19.50	0.822
20.00	25.50	-1.093
25.00	32.00	-0.691
30.00	38.50	-0.423
35.00	45.00	-0.232
40.00	52.00	0.882
45.00	58.50	0.886
50.00	64.50	0.113
55.00	71.00	0.186
60.00	77.00	-0.400
65.00	83.50	-0.299

****

TRANS-2-BUTENE-DIMETHYL FORMAMIDE RUN NO.=46
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 761.40 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 77.44 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 320.300
STV= 15874.480
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 36.03
X= 0.10513 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.00	1.108
10.00	6.20	1.135
15.00	9.20	-1.008
20.00	12.40	-0.457
25.00	15.60	-0.129
30.00	18.80	0.088
35.00	22.00	0.243
40.00	25.20	0.358
45.00	28.30	0.394
50.00	31.60	0.520
55.00	34.60	0.000
60.00	37.80	0.098
65.00	40.80	-0.009
70.00	44.00	-0.203

****

TRANS-2-BUTENE-DIMETHYL FORMAMIDE RUN NO.=47
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 761.40 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 77.44 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 323.900
STV= 16018.977
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 35.89
X= 0.10478 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.20	-4.656
10.00	6.40	-1.654
15.00	9.50	-1.646
20.00	12.80	-0.281
25.00	16.00	0.239
30.00	19.20	0.454
35.00	22.30	0.159
40.00	25.40	-0.063
45.00	28.60	0.114
50.00	31.80	0.256
55.00	34.90	0.086
60.00	38.10	0.207
65.00	41.10	-0.177
70.00	44.20	-0.280

****

TRANS-2-BUTENE-DIMETHYL FORMAMIDE RUN NO.=48
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 761.40 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 77.44 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 320.600
STV= 15858.480
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
CST.CO.= 35.57
X= 0.10393 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE VO
5.00	3.20	-2.841
10.00	6.40	-0.259
15.00	9.50	-0.416
20.00	12.60	-0.496
25.00	15.80	0.089
30.00	19.00	0.482
35.00	22.00	-0.145
40.00	25.20	0.179
45.00	28.30	0.077
50.00	31.40	-0.004
55.00	34.50	-0.070
60.00	37.70	0.140
65.00	40.80	0.072
70.00	43.80	-0.213

****

TRANS-2-BUTENE-N,N-DIMETHYL ACETAMIDE RUN NO.=5[illegible]
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 760.70 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 92.85 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 348.100
STV=.17205.980
INFUSION RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
CST.CO.= 38.42
X= 0.13069 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE VO
5.00	3.50	-5.670
10.00	6.90	-2.589
15.00	10.40	-0.540
20.00	13.80	-0.214
25.00	17.20	-0.015
30.00	20.60	0.118
35.00	24.00	0.214
40.00	27.30	-0.080
45.00	30.80	0.343
50.00	34.10	0.294
55.00	37.40	-0.109
60.00	40.80	-0.034
65.00	44.20	0.029
70.00	47.50	-0.127

****

TRANS-2-BUTENE-N,N-DIMETHYL ACETAMIDE RUN NO.=S1
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 760.70 MMHG
VAP.P= 0.0 MMHG
MOL.VOL1= 92.85 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 361.000
STV= 17407.484
INFUSION-RATE= 0.017560 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 39.26
X= 0.13317 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	3.40	-1.407
10.00	7.00	1.517
15.00	10.40	0.558
20.00	13.80	0.079
25.00	17.20	-0.209
30.00	20.60	-0.400
35.00	24.10	-0.123
40.00	27.60	0.085
45.00	31.00	-0.075
50.00	34.50	0.086
55.00	38.00	0.219
60.00	41.40	0.087
65.00	44.80	-0.024
70.00	48.20	-0.120

****

TRANS-2-BUTENE-ETHYL ACETATE RUN NO.=S2
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 759.90 MMHG
VAP.P= 96.12 MMHG
MOL.VOL1= 98.53 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 843.300
STV= 41720.000
A= 119956.688 B=-3201792.000 C= 948471.62
SLOPE= 1.64231 V0= 0.49361
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 102.49
X= 0.29960 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	8.00	-8.100
10.00	16.50	-2.463
15.00	25.00	-0.510
20.00	33.50	0.481
25.00	42.00	1.080
30.00	50.00	0.477
35.00	58.00	0.044
40.00	66.00	-0.281
45.00	74.00	-0.534
50.00	82.00	-0.737
55.00	90.50	-0.353
60.00	99.00	-0.032
65.00	107.50	0.239
70.00	116.00	0.472

****

TRANS-2-BUTENE-ETHYL ACETATE RUN NO.=53
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 759.90 MMHG
VAP.P= 96.12 MMHG
MOL.VOL1= 98.53 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 866.000
STV= 42915.000
A= 124834.563 B=-3245238.000 C= 987040.313
SLOPE= 1.70909 V0= -0.46967
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 106.96
X= 0.30780 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	8.00	-0.938
10.00	17.00	2.279
15.00	25.50	1.324
20.00	34.00	0.864
25.00	42.00	-0.610
30.00	50.50	-0.596
35.00	59.00	-0.587
40.00	68.00	0.156
45.00	76.50	0.079
50.00	85.00	0.018
55.00	93.50	-0.032
60.00	102.00	-0.074
65.00	110.50	-0.110
70.00	119.50	0.280

****

TRANS-2-BUTENE-ETHYL ACETATE RUN NO.=54
1=SOLVENT. 2=SOLUTE GAS
ATM.P= 759.90 MMHG
VAP.P= 96.12 MMHG
MOL.VOL1= 98.53 CC/MOL
MOL.VOL2= 23704.70 CC/MOL
ST= 510.000 STT= 25250.000 SV= 876.000
STV= 43490.000
A= 126162.625 B=-3257067.000 C= 997540.812
SLOPE= 1.72727 V0= -0.24239
INFUSION RATE= 0.017580 CC/MIN
TEMP= 298.150 KEL.
OST.CO.= 108.07
X= 0.30999 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	9.00	7.220
10.00	17.50	2.758
15.00	26.00	1.299
20.00	34.50	0.574
25.00	43.00	0.141
30.00	51.50	-0.147
35.00	60.00	-0.352
40.00	68.50	-0.506
45.00	77.00	-0.626
50.00	86.00	-0.141
55.00	95.00	0.256
60.00	103.50	0.103
65.00	112.00	-0.027
70.00	121.00	0.276

****

TRANS-2-BUTENE-ACETONE RUN NO.=55
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 751.40 MMHG
VAP.P= 606.86 MMHG
MOL.VOL1= 76.64 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 61.200
STV= 3029.998
A= 54719.355 B= -788763.688 C= 68527.683
SLOPE= 0.12000 V0= -0.00001
INFUSION RATE= 0.018220 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 31.85
X= 0.08741 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.60	0.001
10.00	1.20	0.001
15.00	1.80	0.000
20.00	2.40	0.000
25.00	3.00	0.000
30.00	3.60	0.000
35.00	4.20	0.000
40.00	4.80	0.000
45.00	5.40	0.000
50.00	6.00	0.000
55.00	6.60	0.000
60.00	7.20	0.000
65.00	7.80	0.000
70.00	8.40	0.000

****

TRANS-2-BUTENE-ACETONE RUN NO.=56
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 750.60 MMHG
VAP.P= 606.86 MMHG
MOL.VOL1= 76.64 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 61.200
STV= 3029.998
A= 54661.094 B= -784244.188 C= 68454.683
SLOPE= 0.12000 V0= -0.00001
INFUSION RATE= 0.018220 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 31.98
X= 0.08783 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.60	0.001
10.00	1.20	0.001
15.00	1.80	0.000
20.00	2.40	0.000
25.00	3.00	0.000
30.00	3.60	0.000
35.00	4.20	0.000
40.00	4.80	0.000
45.00	5.40	0.000
50.00	6.00	0.000
55.00	6.60	0.000
60.00	7.20	0.000
65.00	7.80	0.000
70.00	8.40	0.000

****

TRANS-2-BUTENE-ACETONE RUN NO.=57
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 750.60 MMHG
VAP.P= 606.86 MMHG
MOL.VOL1= 76.64 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 60.000
STV= 2970.998
A= 54661.039 B= -784244.063 C= 68454.625
SLOPE= 0.12000 V0= -0.10000
INFUSION RATE= 0.016220 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 31.96
X= 0.08783 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	0.60	20.000
10.00	1.20	9.091
15.00	1.70	0.000
20.00	2.30	0.000
25.00	2.90	0.000
30.00	3.50	0.000
35.00	4.10	0.000
40.00	4.70	0.000
45.00	5.30	0.000
50.00	5.90	0.000
55.00	6.50	0.000
60.00	7.10	0.000
65.00	7.70	0.000
70.00	8.30	0.000

****

TRANS-2-BUTENE-ACETIC ACID RUN NO.=58
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 756.40 MMHG
VAP.P= 56.64 MMHG
MOL.VOL1= 59.68 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 585.000 STT= 30875.000 SV= 189.300
STV= 9979.488
A= 13756.582 B=-4308593.000 C= 184586.938
SLOPE= 0.32110 V0= 0.11218
INFUSION RATE= 0.017980 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 19.24
X= 0.04289 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	1.70	-1.028.
10.00	3.30	-0.697
15.00	4.90	-0.581
20.00	6.50	-0.522
25.00	8.20	0.742
30.00	9.80	0.564
35.00	11.40	0.436
40.00	12.90	-0.433
45.00	14.50	-0.423
50.00	16.20	0.204
55.00	17.70	-0.408
60.00	19.40	0.114
65.00	21.00	0.079
70.00	22.60	0.049
75.00	24.20	0.023

****

TRANS-2-BUTENE-ACETIC ACID RUN NO.=59
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 756.40 MMHG
VAP.P= 56.64 MMHG
MOL.VOL1= 59.68 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 26250.000 SV= 162.400
STV= 8032.488
A= 13547.664 B=-4306581.000 C= 181783.938
SLOPE= 0.31622 V0= 0.07394
INFUSION RATE= 0.017980 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 18.98
X= 0.04233 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	1.60	-4.480
10.00	3.20	-1.724
15.00	4.80	-0.770
20.00	6.40	-0.286
25.00	8.00	0.007
30.00	9.60	0.203
35.00	11.20	0.343
40.00	12.80	0.449
45.00	14.30	-0.167
50.00	15.90	-0.031
55.00	17.50	0.080
60.00	19.00	-0.352
65.00	20.70	0.250
70.00	22.20	-0.152

****

TRANS-2-BUTENE-ACETIC ACID RUN NO.=60
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 756.40 MMHG
VAP.P= 56.64 MMHG
MOL.VOL1= 59.68 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 26250.000 SV= 164.400
STV= 8148.992
A= 13925.242 B=-4311025.000 C= 180850.000
SLOPE= 0.32503 V0= -0.11393
INFUSION RATE= 0.017980 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 19.48
X= 0.04345 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	1.60	5.873
10.00	3.20	2.028
15.00	4.80	0.807
20.00	6.40	0.208
25.00	8.00	-0.149
30.00	9.60	-0.385
35.00	11.20	-0.553
40.00	12.80	-0.678
45.00	14.60	0.602
50.00	16.20	0.366
55.00	17.80	0.209
60.00	19.40	0.0[illegible]
65.00	21.00	-0.0[illegible]
70.00	22.60	-0.170

****

TRANS-2-BUTENE-CARBON DISULFIDE RUN NO.=61
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 753.30 MMHG
VAP.P= 158.07 MMHG
MOL.VOL1= 59.22 CC/MOL
MOL.VOL2= 21940.40 CC/MOL
ST= 375.000 STT= 16125.000 SV= 600.000
STV= 28850.000
A= 222632.875 B=-1532264.000 C= 1070419.000
SLOPE= 1.86970 VO= -3.46362
INFUSION RATE= 0.001440 CC/MIN
TEMP= 278.150 KEL.
OST.CO.= 1373.54
X= 0.78995 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE VO
5.00	8.50	44.438
10.00	16.50	8.315
15.00	25.00	1.701
20.00	34.00	0.205
25.00	43.00	-0.644
30.00	52.50	-0.242
35.00	62.00	0.039
40.00	71.00	-0.[illegible]
45.00	80.50	-0.214
50.00	90.00	-0.024
55.00	99.50	0.151
60.00	109.00	0.259

****

TRANS-2-BUTENE-CARBON DISULFIDE RUN NO.=62
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 748.80 MMHG
VAP.P= 158.07 MMHG
MOL.VOL1= 59.22 CC/MOL
MOL.VOL2= 21940.40 CC/MOL
ST= 510.000 STT= 25250.000 SV= 1008.000
STV= 49850.000
A= 232090.188 B=-1533968.000 C= 1115389.000
SLOPE= 1.96084 VO= 0.66439
INFUSION RATE= 0.001440 CC/MIN
TEMP= 278.150 KEL.
OST.CO.= 1439.68
X= 0.79774 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE VO
5.00	10.50	0.300
10.00	21.00	3.587
15.00	30.50	1.407
20.00	39.50	-0.956
25.00	49.50	-0.373
30.00	59.50	0.018
35.00	69.50	0.298
40.00	79.50	0.508
45.00	89.00	0.110
50.00	98.00	-0.716
55.00	108.00	-0.470
60.00	118.50	0.157
65.00	128.50	0.297
70.00	138.00	0.056

****

TRANS-2-BUTENE-DIMETHYL FORMAMIDE RUN NO.=64
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 756.40 MMHG
VAP.P= 15.51 MMHG
MOL.VOL1= 79.45 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 164.600
STV= 8152.996
A= 3770.571 B=-346474E.000 C= 180760.375
SLOPE= 0.32140 V0= 0.07369
INFUSION RATE= 0.018020 CC/MIN
TEMP= 323.150 KEL.
CST.CO.= 18.19
X= 0.05231 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	1.60	-4.812
10.00	3.20	-2.673
15.00	4.80	-1.938
20.00	6.50	-0.029
25.00	8.10	-0.109
30.00	9.70	-0.163
35.00	11.40	0.681
40.00	13.00	0.543
45.00	14.60	0.435
50.00	16.20	0.344
55.00	17.70	-0.286
60.00	19.30	-0.299
65.00	21.00	0.168
70.00	22.50	-0.318

****

TRANS-2-BUTENE-DIMETHYL FORMAMIDE RUN NO.=65
1=SOLVENT, 2=SOLUTE GAS
ATM.P= 754.70 MMHG
VAP.P= 15.51 MMHG
MOL.VOL1= 79.45 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 162.600
STV= 8034.988
A= 3681.844 B=-3445449.000 C= 180412.750
SLOPE= 0.31454 V0= 0.18194
INFUSION RATE= 0.018020 CC/MIN
TEMP= 323.150 KEL.
CST.CO.= 17.80
X= 0.05242 GAS.VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	1.60	-8.814
10.00	3.20	-3.828
15.00	4.90	-0.002
20.00	6.50	0.420
25.00	8.00	-0.566
30.00	9.60	-0.189
35.00	11.30	0.975
40.00	12.70	-0.499
45.00	14.30	-0.254
50.00	15.90	-0.057
55.00	17.50	0.104
60.00	19.10	0.239
65.00	20.60	-0.132
70.00	22.20	0.000

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TRANS-2-BUTENE-DIMETHYL FORMAMIDE RUN NO.=66

1=SOLVENT. 2=SOLUTE GAS
ATM.P= 754.70 MMHG
VAP.P= 15.51 MMHG
MOL.VOL1= 79.45 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 183.300
STV= 8084.988
A= 3748.147 B=-3448764.000 C= 183561.525
SLOPE= 0.32021 V0= -0.00046
INFUSION RATE= 0.018020 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 18.12
X= 0.05323 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	1.60	-0.036
10.00	3.20	-0.050
15.00	4.80	-0.055
20.00	6.40	-0.057
25.00	8.00	-0.059
30.00	9.60	-0.060
35.00	11.20	-0.060
40.00	12.80	-0.061
45.00	14.40	-0.061
50.00	16.10	0.563
55.00	17.60	-0.062
60.00	19.20	-0.062
65.00	20.80	-0.062
70.00	22.40	-0.062

****

TRANS-2-BUTENE-N,N-DIMETHYL ACETAMIDE RUN NO.=67

1=SOLVENT. 2=SOLUTE GAS
ATM.P= 754.70 MMHG
VAP.P= 8.27 MMHG
MOL.VOL1= 94.98 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 173.400
STV= 8564.988
A= 2087.130 B=-2939535.000 C= 191803.933
SLOPE= 0.33440 V0= 0.23788
INFUSION RATE= 0.017960 CC/MIN
TEMP= 323.150 KEL.
OST.CO.= 18.81
X= 0.06540 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	1.80	-5.754
10.00	3.60	0.505
15.00	5.20	-1.026
20.00	6.90	-0.374
25.00	8.60	0.024
30.00	10.40	1.266
35.00	11.90	-0.351
40.00	13.60	-0.103
45.00	15.30	0.092
50.00	17.00	0.246
55.00	18.60	-0.161
60.00	20.30	-0.010
65.00	22.00	0.118
70.00	23.60	-0.195

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TRANS-2-BUTENE-N,N-DIMETHYL ACETAMIDE RUN NO.=69

1=SOLVENT, 2=SOLUTE GAS
ATM.P= 754.70 MMHG
VAP.P= 8.27 MMHG
MOL.VOL1= 94.98 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 172.200
STV= 8512.963
A= 2085.364 B=-2939372.000 C= 191648.300
SLOPE= 0.33412 V0= 0.14977
INFUSION RATE= 0.017960 CC/MIN
TEMP= 323.150 KEL.
CST.CO.= 18.80
X= 0.06522 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	1.70	-6.613
10.00	3.40	-2.607
15.00	5.20	0.744
20.00	6.80	-0.472
25.00	8.50	-0.033
30.00	10.20	0.261
35.00	11.80	-0.372
40.00	13.50	-0.109
45.00	15.20	0.097
50.00	16.80	-0.332
55.00	18.60	0.497
60.00	20.20	0.014
65.00	21.90	0.147
70.00	23.50	-0.163

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TRANS-2-BUTENE-ETHYL ACETATE RUN NO.=71

1=SOLVENT, 2=SOLUTE GAS
ATM.P= 758.80 MMHG
VAP.P= 285.74 MMHG
MOL.VOL1= 102.07 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 251.300
STV= 12431.484
A= 106210.500 B=-2039381.000 C= 282494.500
SLOPE= 0.46980 V0= 0.12273
INFUSION RATE= 0.018210 CC/MIN
TEMP= 323.150 KEL.
CST.CO.= 40.89
X= 0.13953 GAS VOL.=SLOPE*TIME+V0

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE V0
5.00	2.40	-6.688
10.00	4.90	-2.416
15.00	7.50	0.394
20.00	9.90	-0.200
25.00	12.30	-0.559
30.00	14.80	-0.124
35.00	17.30	0.187
40.00	19.70	-0.086
45.00	22.20	0.152
50.00	24.70	0.343
55.00	27.10	0.130
60.00	29.50	-0.048
65.00	31.90	-0.198
70.00	34.40	-0.037

****

TRANS-2-BUTENE-ETHYL ACETATE RUN NO.=72

1=SOLVENT. 2=SOLUTE GAS
ATM.P= 757.60 MMHG
VAP.P= 285.74 MMHG
MOL.VOL1= 102.07 CC/MOL
MOL.VOL2= 25775.50 CC/MOL
ST= 510.000 STT= 25250.000 SV= 253.800
STV= 12543.480
A= 106418.500 B=-2054482.000 C= 283047.313
SLOPE= 0.49146 VO= 0.26277
INFUSION RATE= 0.018210 CC/MIN.
TEMP= 323.150 KEL.
BST.CO.= 41.04
X= 0.14015 GAS VOL.=SLOPE*TIME+VO

TIME IN MIN.	VOL. IN CC	DEV. IN %
0.0	0.0	SEE VO
5.00	2.50	-8.091
10.00	5.10	-1.495
15.00	7.50	-1.765
20.00	10.10	0.079
25.00	12.60	0.403
30.00	15.00	-0.045
35.00	17.50	0.206
40.00	20.00	-0.395
45.00	22.40	0.095
50.00	24.90	0.258
55.00	27.30	0.025
60.00	29.70	-0.170
65.00	32.20	-0.025
70.00	34.60	-0.180

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