

GAS CHROMATOGRAPHIC STUDY OF HYDROCARBON  
ADSORPTION ON PLATINUM/ALUMINA  
CATALYST

by

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## ABSTRACT

The adsorption of three normal paraffins (n-pentane, n-hexane and n-heptane) and one isoparaffin (i-octane) on the commercial 0.3 % wt Pt/Al<sub>2</sub>O<sub>3</sub> reforming catalyst were investigated using the elution (or the pulse) technique in a gas-solid chromatograph in the temperature range 185-235 °C.

Adsorption isotherms were constructed from chromatographic data at various temperatures using helium as carrier. Average heats of adsorption were determined using the isosteres obtained from the adsorption isotherms, and the values were found to be 28.6 kJ/gmol for n-pentane, 36.4 kJ/gmol for n-hexane, 42.0 kJ/gmol for n-heptane and 41.6 kJ/gmol for i-octane. The experiments for n-pentane and n-hexane were repeated using hydrogen carrier, and the average heats of adsorption were determined to be 23.8 kJ/gmol and 36.7 kJ/gmol respectively.

It was found that the heat of adsorption increases linearly with increasing carbon number for normal paraffins, and that all the hydrocarbons studied were chemically adsorbed under the operating conditions used.

## ÖZET

Bu çalışmada n-pentan, n-hekzan, n-heptan ve i-oktan'ın % 0.3 Pt/Al<sub>2</sub>O<sub>3</sub> endüstriyel reformlama katalizörü üzerindeki adsorplanması gaz katı kromatografisi yöntemi ve darbe tekniği kullanılarak incelenmiştir. 185 °C - 235 °C arasında değişik sıcaklıklarda elde edilen eş sıcaklık eğrilerinden sabit yüzey derişim değerleri kullanılarak hidrokarbonların ortalama adsorplanma ısıları hesaplanmıştır.

Taşıyıcı gaz olarak helyum kullanılmış ve n-pentan n-hekzan, n-heptan ve i-oktan için ortalama adsorplanma ısıları sırasıyla 28.6 kJ/gmol, 36.4 kJ/gmol, 42.0 kJ/gmol ve 41.6 kJ/gmol olarak bulunmuştur. n-Pentan ve n-hexan için deneyler hidrojen taşıyıcı gazı kullanılarak ta gerçekleştirilmiş ve ortalama adsorplama ısıları sırasıyla 23.8 kJ/gmol ve 36.7 kJ/gmol olarak elde edilmiştir.

Bulunan değerlerden ve çalışılan sıcaklık aralığından her durumda kimyasal adsorplanmanın gerçekleştiği sonucuna varılmış, normal parafinlerin adsorplanma ısılarının karbon sayısı ile doğrusal olarak arttığı gözlemlenmiştir.

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FIGURE A.4.10 Sample Chromatogram for i-Octane at  
0.4  $\mu$ l with Helium

## LIST OF SYMBOLS

|              |   |
|--------------|---|
| A            | constant of adsorption isotherm (mmHg gcat/gmol)  |
| $A_p$        | area under the elution peak (mm <sup>2</sup> )  |
| B            | constant of adsorption isotherm (gcat/gmol)   |
| C            | integration constant for Eq(2.17)   |
| $C_s$        | amount of gas adsorbed (gmol/g cat)   |
| c            | gas phase concentration of the sample (gmol sample/cm <sup>3</sup> gas)   |
| c(t)         | ordinate of the chromatographic peak corresponding to time t (cm)   |
| $E_p$        | correction for partial pressure (mm Hg)   |
| $F_c$        | volumetric carrier gas flowrate corrected to column temperature and according to the pressure drop in the column (cm <sup>3</sup> /min) |
| $F_D$        | volumetric carrier gas flowrate in the detector (cm <sup>3</sup> /min)  |
| $F_r$        | volumetric carrier gas flowrate at the room temperature (cm <sup>3</sup> /min)  |
| f'(c)        | derivative of the adsorption isotherm   |
| $\Delta H_v$ | heat of vaporization (kJ/gmol)  |
| J            | pressure gradient correction factor   |
| N            | amount of gas adsorbed (gmol/g)   |
| n            | number of moles of sample injected (gmol)   |
| p            | partial pressure of the adsorbate (mm Hg)   |
| $p_1$        | pressure at the inlet of the column (mm Hg)   |
| $p_2$        | pressure at the outlet of the column (mm Hg)  |
| $Q_{ads}$    | heats of adsorption (kJ/gmol, kcal/gmol)  |
| R            | gas constant (cm <sup>3</sup> mmHg/gmol <sup>o</sup> K, kJ/gmol <sup>o</sup> C)   |

|        |  |
|--------|--|
| $T_b$  | boiling point of the adsorbate ( $^{\circ}\text{C}$ , $^{\circ}\text{K}$ ) |
| $T_c$  | column temperature ( $^{\circ}\text{C}$ , $^{\circ}\text{K}$ )             |
| $T_D$  | dedector temperature ( $^{\circ}\text{C}$ , $^{\circ}\text{K}$ )           |
| $T_r$  | room temperature ( $^{\circ}\text{C}$ , $^{\circ}\text{K}$ )               |
| $T_r$  | reduced temperature  |
| $t$    | time (sec)   |
| $t_c$  | time corresponding to any concentration at the rear of the peak (sec)      |
| $t_M$  | retention time of the inert gas (sec)                                      |
| $t_R$  | total retention time of the sample (sec)                                   |
| $t_R'$ | retention time of the sample on the catalyst (sec)                         |
| $V$    | volume of sample injected ( $\mu\text{l}$ )                                |
| $V_g$  | specific retention volume ( $\text{cm}^3/\text{g cat}$ )                   |
| $V_M$  | mobile gas hold-up ( $\text{cm}^3$ )                                       |
| $V_N$  | net retention volume ( $\text{cm}^3$ )                                     |
| $V_R$  | retention volume ( $\text{cm}^3$ )   |
| $V_R'$ | adjusted retention volume ( $\text{cm}^3$ )                                |
| $v$    | chart speed (mm/sec)   |
| $w_c$  | weight of catalyst (g)   |

## I. INTRODUCTION

Catalytic reactions are the basis of the entire chemical industry. Since adsorption is one of the basic stages of heterogeneous catalysis, studying adsorption is a prerequisite to the understanding of heterogeneous catalysis.

Gas chromatography has been used to investigate the physicochemical and kinetic parameters of the catalytic systems recently. The particular features of gas chromatography are its simplicity and its rapidity. Since this technique provides low contact time between adsorbate and adsorbent, it can be used under normal operating temperatures. With static methods, the temperature has to be far below the operating temperature. Gas chromatography also has many other advantages such as better temperature control, the use of wider range of compositions with no loss of precision at the low concentrations.

In this study, the adsorption of four paraffinic hydrocarbons, namely, n-pentane, n-hexane, n-heptane and i-octane were investigated by direct gas chromatography. The elution technique was used. The adsorption isotherms were obtained from the chromatographic data and used to determine the heats of adsorption.

Chapter II contains general information about the conventional experimental techniques on adsorption and a short description of the gas chromatographic method. The experimental studies carried out are given in Chapter III and results are discussed in Chapter IV. The conclusions and recommendations for future works are presented in Chapter V.

## II. ADSORPTION AND GAS CHROMATOGRAPHY

When a fluid phase comes into contact with a solid phase, the concentration of the fluid at the interface is greater than in the bulk phase. The accumulation of the fluid molecules on the surface is called adsorption.

### 2.1 CONVENTIONAL EXPERIMENTAL METHODS ON ADSORPTION

Various conventional experimental methods of studying adsorption have been developed. These methods can be classified into two groups as the methods involving the study of adsorption phenomena and the methods of investigation of the properties of the adsorbent.

#### 2.1.1 Methods Involving the Adsorption Phenomena

- i) The amount of gas adsorbed can be determined by volumetric and gravimetric methods and by the radioactive tracer technique. In the volumetric method, the gas pressure in a known volume both in the absence and in the presence of the adsorbent is measured and the amount of gas

adsorbed is calculated from the variation of the pressure. The amount of gas adsorbed can be calculated gravimetrically from the variations of the weight of adsorbent during the course of adsorption. In some cases a radioactive chemisorbed gas can be used and the amount adsorbed on the adsorbent surface is measured (Hayward and Trapnell, 1964; Thomas and Thomas, 1967; Ponec, Knor and Cerny, 1974).

- ii) It is possible to measure the heat of adsorption in two ways; calorimetrically and isosterically. A calorimeter is a vessel surrounded by a jacket. The calorimetric measurement can be carried out under adiabatic, isothermal and diathermal conditions. In the adiabatic method, the calorimeter is isolated and heat of adsorption is derived from the temperature change of the adsorbate. In isothermal case, the heat liberated by adsorption is used to produce a phase change in the surrounding substance. The heat of adsorption is calculated from the volume change of the surrounding. Diathermic calorimeter is also called isoperibol calorimeter or constant temperature environment calorimeter. It operates on the basis of a finite and defined rate of dissipation of the heat evolved in the vessel to the

thermostate. The vessel temperature rises first and decreases to the initial value after the completion of the heat liberating process (Hayward and Trapnell, 1964; Ponec, Knor and Cerny, 1974; Beler, 1981).

iii) The activation energy of desorption can be determined by measuring the desorption rate as a function of temperature on heating the adsorbent. The measurement can be carried out in a static volumetric apparatus or in a flow system (Ponec, Knor and Cerny, 1974).

#### 2.1.2 The Methods of Examining the Properties of the Solid Catalyst

- i) The particle size of the solid can be determined by sieve classification, microscopy, sedimentation, the motion of the particles in the stream of a carrier gas and their diffraction of electromagnetic radiation. (Ponec, Knor and Cerny, 1974)
- ii) The most important methods for measurement of porosity are mercury porosimetry, electron microscopy, x-ray diffraction and from density measurement (Ponec, Knor and Cerny, 1974).
- iii) Total surface area can be determined from physical adsorption and active surface area can

be estimated from chemisorption (Thomas and Thomas, 1967).

- iv) There are some methods to study changes in the electrical and magnetic properties of solids during adsorption (Ponec, Knor and Cerny, 1974; Gönenç, 1985).

## 2.2 GAS CHROMATOGRAPHIC STUDY OF ADSORPTION

In recent years, gas chromatography has been used for adsorption measurements. This method is superior to other techniques in many respects. The most important feature of the method is that the measurement can be carried out under actual operating conditions of catalyst (Choudhary and Doraiswamy, 1971). In addition, gas chromatography has great advantages as a simple and rapid technique.

Many physicochemical properties such as energetics of adsorption, surface area of the solid, pore size and pore size distribution, effective diffusivity, surface activity, surface acidity and acid strength distribution, effects of electric field, magnetic field and irradiation on active sites and catalyst deactivation can be measured by gas chromatography. Application of gas chromatography in catalysis have been reviewed by Choudhary and Doraiswamy (1971). The methods are presented by Conder (1979).

Gas chromatographic measurement can be applied in two ways. In the first, the chromatographic column is packed with catalyst and chromatographic parameters such as retention time, retention volume and the shape of the chromatographic peak are used to estimate the adsorption parameters. In the second, a microreactor is connected to the chromatograph, and feed and the product of the reactor are analyzed by the chromatograph (Choudhary and Doraiswamy, 1971). The temperature programmed adsorption-desorption chromatography can also be applied. In this study, the former method was used and experiments were carried out under isothermal conditions.

Gas chromatographic determinations can be performed using four basic procedures; elution chromatography, frontal method, combined frontal-elution method and displacement technique (Choudhary and Doraiswamy, 1971). In the present study, elution chromatography was used. Hence only this technique is discussed here.

In elution chromatography, a discrete sample of solute is injected into the carrier gas stream. While the solute sample passes through the column, it is distributed in a constant ratio between the mobile and the immobile phase. This ratio is governed by the partition coefficient which is a fundamental physical quantity. If partition coefficients are different, each component emerges from the column as a separate peak. At fixed column conditions, the time of emergence of the

peak is characteristic of the system. Therefore all chromatographic measurements are taken as time value (Choudhary and Doraiswamy, 1971).

### 2.2.1 Retention Time and Retention Volume

The retention time,  $t_R$  is the time that it takes from solute injection to solute detection, and is measured from the injection to the midpoint of the elution peak as shown in Figure 2.1.

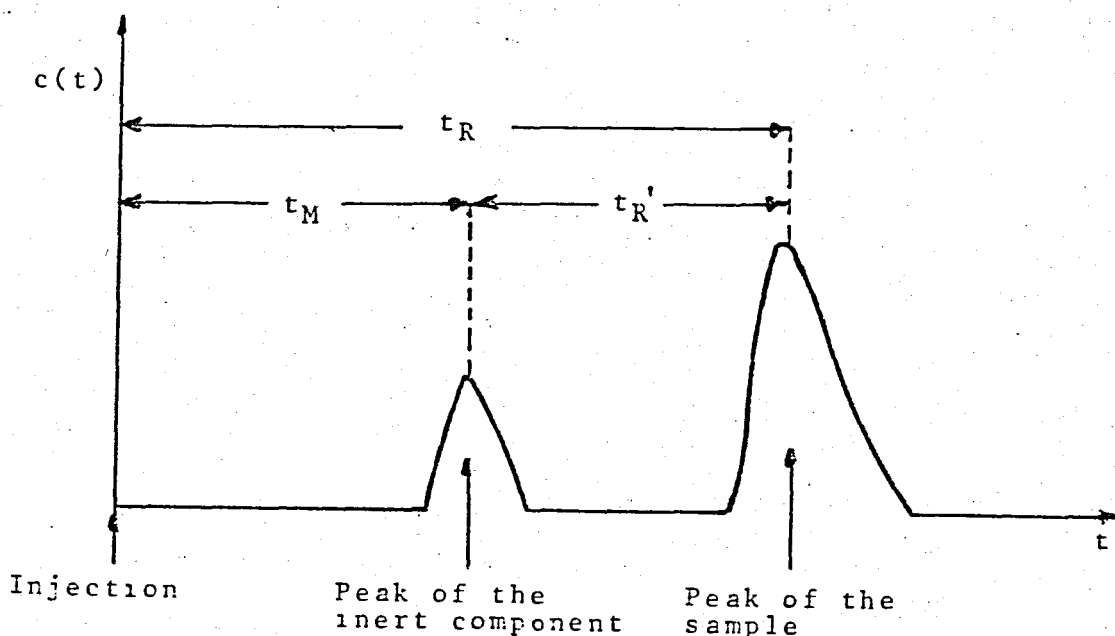


FIGURE 2.1 Chromatogram Obtained by Elution Chromatography

Retention time consists of two distinct values:  $t_M$ , the time required for the solute to pass through the

column and  $t_R'$ , the time spent on the surface of the catalyst. Therefore the following equation can be written:

$$t_R' = t_R - t_M \quad (2.1)$$

If  $t_R'$ ,  $t_R$  and  $t_M$  are multiplied by the flowrate,  $F_F$  observed at the column outlet, adjusted retention volume,  $V_R'$ , retention volume,  $V_R$  and mobile gas hold-up,  $V_M$  are obtained respectively and Equation (2.1) becomes:

$$F_F t_R' = (t_R - t_M) F_F \quad (2.2)$$

or

$$V_R' = V_R - V_M \quad (2.3)$$

Since the flowrate is measured at the outlet, and the pressure drop through the column must be taken into account, and the volumes obtained must be corrected to the mean column pressure by multiplying with a pressure gradient correction factor  $j$  given as follows (Littlewood, 1972; Conder, 1979; Beler, 1981; Gönenç, 1985):

$$j = \frac{3}{2} \left[ \frac{(p_1/p_0)^2 - 1}{(p_1/p_0)^3 - 1} \right] \quad (2.4)$$

where  $p_1$  and  $p_0$  are column inlet and outlet pressures respectively. Therefore net retention volume  $V_N$  is obtained:

$$V_N = jV_R' \quad (2.5)$$

Since the flowrate is measured at room temperature, the net retention volume,  $V_N$ , must be further corrected for the column temperature:

$$V_N = jV_R' \frac{T_f}{T_c} \quad (2.6)$$

By considering the dependence of the net retention volume on the amount of catalyst, the specific retention volume,  $V_g$  per unit weight of catalyst is obtained as:

$$V_g = \frac{V_N}{w_k} \quad (2.7)$$

where  $w_k$  is the weight of catalyst. In summary:

$$V_g = F_c(t_R - t_M) / w_k \quad (2.8)$$

where  $F_c$  is volumetric carrier gas flowrate corrected to column conditions and defined as:

$$F_c = F_f \frac{T_c}{T_f} \frac{3}{2} \left[ \frac{(p_1/p_0)^{2-1}}{(p_1/p_0)^{3-1}} \right] \quad (2.9)$$

### 2.2.2 The Adsorption Isotherm

Adsorption isotherms show the dependence of the amount of adsorbate upon the partial pressure of the gas at constant temperature and equilibrium conditions (Thomas and Thomas, 1967). Adsorption isotherms can be obtained from the shape of the diffuse rear boundary of an elution peak (Huber and Keulemans, 1962; Gönenç, 1985).

Huber and Keulemans (1962) treated one-dimensional transport of a sample of a single component by an inert fluid carrier through a column containing stationary sorption material. They derived an expression relating the concentration of the sample in the effluent to the volume of carrier fluid which has passed through the column since the injection of the sample, with the following simplifying assumptions:

- i) A segment of the column containing a given

amount of stationary phase also contains a volume of moving phase which is invariant with time and with position of the segment.

- ii) The temperature of the column is constant and uniform along its length.
- iii) The volume velocity of the carrier fluid, averaged over any cross section of the column, is constant.
- iv) The volume velocity of the moving phase is equal to the volume velocity of the carrier gas.
- v) All axial transport is due to convection.
- vi) Equilibrium is maintained at all times within any cross section.

Cremer and Huber (1961) described the same method to obtain the adsorption isotherm from a single elution peak. From simplified mass balance equation (Baumgarten, Weinstrauch and Höffkes, 1977) :

$$\frac{dN}{dc} = V_g \quad (2.15)$$

where  $N$  is amount of adsorbed gas (gmole/g).  $c$  is the concentration in the gas phase (gmole/cm<sup>3</sup>) and  $V_g$  is the specific retention volume (cm<sup>3</sup>). Equation (2.15) can be written as:

$$V_g = f'(c) \quad (2.16)$$

Equation (2.16) shows the relation between specific retention volume and the derivative of the adsorption isotherm (Cremer and Huber, 1961; Gönenç, 1985).

The relation between partial pressure and the height of chromatographic peak,  $c(t)$  at any point on the abscissa,  $t$  is given as (Cremer and Huber, 1961; Gönenç, 1985):

$$p = \frac{c(t)}{E_p} \quad (2.10)$$

where  $c(t)$  is in mm and

$$E_p = \frac{A_p F_D}{vnRT_D} \quad (2.11)$$

where  $A_p$  is the area of the chromatographic peak in  $\text{mm}^2$ ,  $v$  is the chart speed in mm/sec,  $n$  is the number of moles of sample injected in gmol,  $T_D$  is the detector temperature in K and  $F_D$  is the flowrate in  $\text{cm}^3/\text{sec}$  and is defined as:

$$F_D = F_r \frac{T_D}{T_r} \quad (2.12)$$

where  $F_r$  is the flowrate of the carrier gas at room temperature,  $T_r$ . Equation (2.10) can be written as:

$$p = \frac{c(t)}{A_p F_r / v n R T_r} \quad (2.13)$$

The retention volume,  $V_g$  ( $\text{cm}^3/\text{g}$ ) for a time on abscissa,  $t_e$  can be determined as (Gonenc, 1985):

$$V_g = (t_e - t_M) F_c / w_k \quad (2.14)$$

where  $t_e$  is in sec,  $t_M$  is the retention time of an inert gas in sec,  $F_c$  is the flowrate of the carrier gas in  $\text{cm}^3/\text{sec}$  as given in Equation (2.9) and  $w_k$  is the weight of catalyst in g.

In order to calculate  $V_g$  and  $p$  values,  $t_e$  and  $c(t)$  data can be obtained from a chromatographic peak as shown in Figure 2.2.

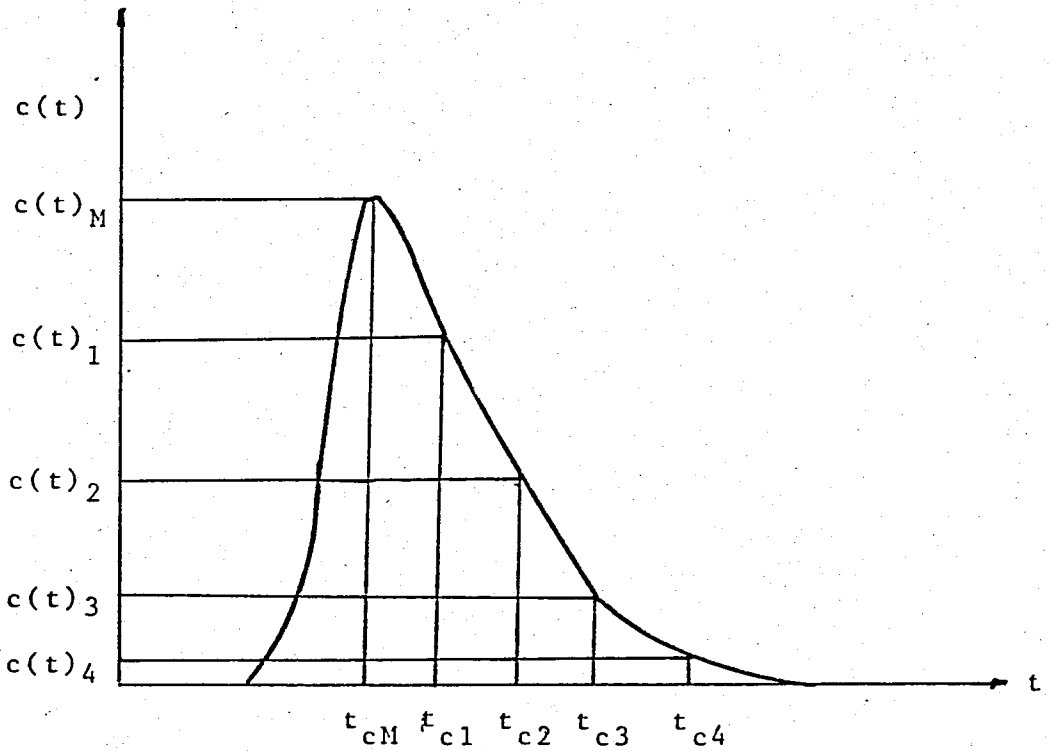


FIGURE 2.2. Examples of Evaluation of Peak to Obtain  $t_c$  and  $c(t)$  values.

At zero surface coverage, the heat of adsorption can be determined from the chromatographic data at infinite dilution by applying the equation given by Kiselev and Yashin (1969):

$$\ln V_g = \frac{Q_{ads}}{R} (1/T_c) + C \quad (2.17)$$

where  $V_g$  is the retention volume at infinite dilution.  $Q_{ads}$  is the heat of adsorption,  $R$  is the gas constant,  $T_c$  is the column temperature and  $C$  is the integration

constant. The slope of  $\ln V_g$  vs  $1/T_c$  gives  $Q_{ads}/R$  (Eberly, 1961; Choudhary and Menon, 1976; Önsan, 1979; Beler, 1981).

At higher surface coverages, on the other hand, the heats of adsorption are calculated using isosteres obtained from adsorption isotherm data i.e using plots of partial pressure  $p$  versus temperature  $T$ , at constant surface coverage (Conder, 1979). The Clausius-Clapeyron equation can then be applied (Shen and Smith, 1968; Kiselev and Yashin, 1969; Ponec, Knor and Cerny, 1974; Conder, 1979; Smith, 1981; Gönenç, 1985):

$$\left[ \frac{d(\ln p)}{dT} \right]_N = - \frac{Q_{ads}}{R} \quad (2.18)$$

where  $N$  is the amount of gas adsorbed (gmol/g cat). Making use of this equation and plots of  $\ln p$  vs  $1/T_c$ , average  $Q_{ads}$  values are obtained from the slope for particular values of surface concentration.

### III. EXPERIMENTAL WORK

#### 3.1 EXPERIMENTAL SET-UP

The experimental set-up consists of a gas chromatograph, a strip chart recorder, a data processor, a quartz thermometer, gas cylinders with sensitive regulators, a soap bubble flowmeter, a mercury manometer and a barometer. The experimental set-up is shown in Figure 3.1.

##### - Gas Chromatograph

A Varian Aerograph Moduline Series 2800 gas chromatograph, with possibilities of flame ionization or thermal conductivity detectors and temperature programming, was used. The chromatograph which contains the adsorption column in its oven has the following specifications:

Detector : Thermal conductivity dedector  
4 filament tungsten-rhenium(wx)  
usage up to 400 °C

Detector Control Unit: Current: 0-300 mA  
Control: %  $\pm$  0.02

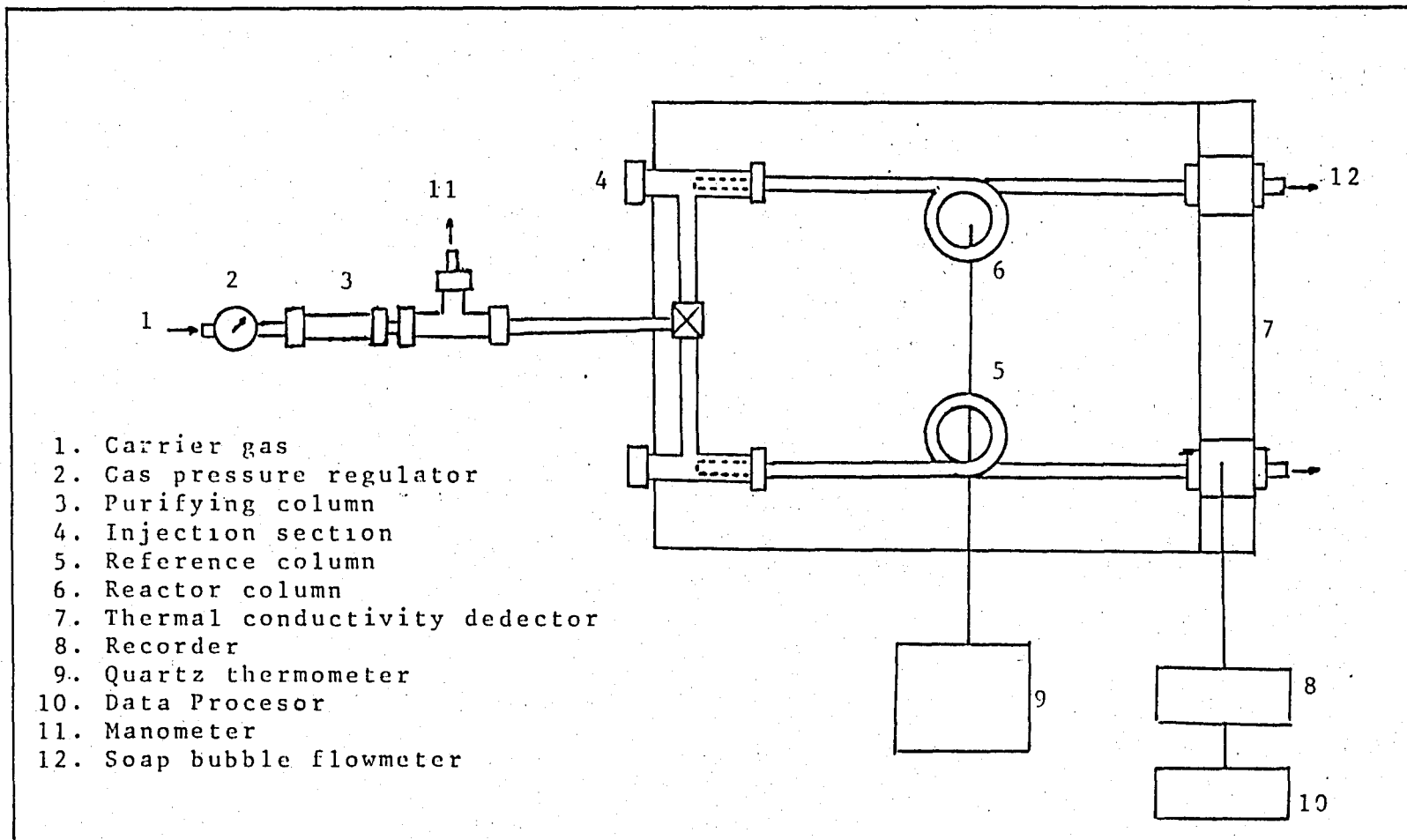


FIGURE 3.1 Experimental Set-up

Attenuation: 1-1024

Column Oven

: Usage up to 400 °C

Control: max ± 0.5 °C

The following specifications were used in this study:

Detector Temperature : 250 °C

Column Temperature : Isothermal operation at the  
range of 185-235 °C

Injector Temperature : Same as column temperature

Detector Current : 125 mA

Attenuation : 32-64

-Strip Chart Recorder

The specifications of Varian Aerograph recorder are as below:

Full Scale Range : 1 mV-1 V

Chart Speed Range : 2-2000 cm/hr, 0.02-20 cm/min

The specification used during the experiment :

Full Scale Range : 1 V

Chart speed : 20 cm/min

- Data Processor

The data processor used is Shimadzu Data Processor Chromatopac C-R1B with the following specifications :

Input Voltage Range : -5 mV to 1 V

Recording Span : 1 mV

Integration Sensitivity: 1  $\mu$ V.sec (= 1 digit of area)

- Quartz Thermometer

The temperature of the column was measured with a Hewlett Packard quartz thermometer. The specifications of the thermometer are :

Usage : up to 250 °C

Sensitivity : 0.01 to 0.0001 °C

In these experiments a sensitivity of 0.01 °C was used.

- Adsorption Column

1.66 mm ID stainless steel tubing was used. The length of the column was 103 cm.

### 3.2 MATERIALS

Industrial 0.3 % wt Pt/Al<sub>2</sub>O<sub>3</sub> reforming catalyst was used. Hydrogen, helium, nitrogen gases were obtained from HABAS A.S.

The hydrocarbons used are shown in Table 3.1

TABLE 3.1 - Hydrocarbon Used in the Experiments

| Compound  | Company    | Grade | Molecular Weight | Specific Gravity |
|-----------|------------|-------|------------------|------------------|
| n-Pentane | Carlo Erba | GC    | 72.15            | 0.626            |
| n-Hexane  | Merck      | GC    | 86.18            | 0.660            |
| n-Heptane | Merck      | GC    | 100.21           | 0.683            |
| i-Octane  | Merck      | GC    | 114.23           | 0.690            |

### 3.3 PREPARATION OF EXPERIMENTAL SET-UP

The stainless steel column was first washed with dilute HCl, distilled water, ethanol and acetone and then dried by passing nitrogen through it. The catalyst particles sieved to 0.177-0.250 mm (60-80 mesh) were filled into the column and the two ends were closed by means of glass wool. After being filled, the column was fitted into the oven of the chromatograph.

Carrier gas cylinders were connected to the chromatograph by 1/8 inch copper tubing. Before entering the chromatograph, the carrier gas was dried by passing it through a trap of molecular sieve and silica gel. A mercury manometer was connected to the carrier gas stream line by polyethylene tubing. The polyethylene tubing was also used to discharge the exit hydrogen to the open air.

### 3.4 EXPERIMENTAL PROCEDURE

The experiments were carried out at different temperatures from 185 °C to 235 °C. The carrier gas used was helium. The measurements for n-pentane and n-hexane were also performed using hydrogen as the carrier gas.

The 103 cm-long stainless steel column was packed 1.99 grams of catalyst for n-pentane and i-octane and 2.00 grams for n-hexane and n-heptane.

Before each experiment was performed, hydrogen was passed over the catalyst for 2  $\frac{1}{2}$  hours at 287 °C and at a flowrate of about 10 cm<sup>3</sup>/min in order to have the same activation level of the catalyst at the start of each experiment. Then the hydrogen stream was replaced with the helium and any adsorbed hydrogen was desorbed by passing helium over the catalyst for half an hour at the same temperature and flowrate. At the end of this period, the column was cooled down to the temperature at which the experiment was to be performed. The flowrate of the carrier gas was adjusted to about 10 cm<sup>3</sup>/min for n-pentane and n-hexane and 15 cm<sup>3</sup>/min for n-heptane and i-octane.

After steady state temperature was reached, 1-2  $\mu$ l of hydrocarbon were introduced into the column to saturate the very active irreversible sites. After that,

the main pulse of hydrocarbon sample was injected. The peak corresponding the hydrocarbon was recorded by the strip chart recorder and the data processor.

Nitrogen was also injected into the column at the same conditions as an inert gas to measure the dead time.

During the experiments, the column temperature was measured by a quartz thermometer with the fluctuations remaining between  $\pm 0.05$  °C. The flowrate was held constant measuring with the soap bubble flowmeter and adjusting the pressure regulator continuously. The inlet pressure was measured with a mercury manometer and the outlet pressure was read from a mercury barometer.

### 3.5 EVALUATION OF DATA

The adsorption isotherm was obtained from single reproducible elution peak for each adsorbate at each operating temperature. The specific retention volume,  $V_g$  and the partial pressure,  $p$  were calculated from Equation (2.14) and Equation (2.13) respectively as discussed in Section (2.2.2).

The plot of  $V_g/RT_c$  vs  $p$  was integrated using Simpson's Approximation. The computer program used to carry out the integration is given in Appendix IV.

The adsorption isotherm was curve fitted to the following equation by using the Least Squares Curve Fitting Program (Calderbank, 1983) in Appendix V :

$$C_s = \frac{p}{A+Bp} \quad (3.1)$$

where  $C_s$  is amount adsorbed in gmol/gcat,  $p$  is partial pressure in mmHg,  $A$  and  $B$  are constants for each operating temperature in mmHg gcat/gmol and gcat/gmol respectively.

Isosteres were obtained from the adsorption isotherms by using the rearranged form of Equation (3.1):

$$p = \frac{AC_s}{1-BC_s} \quad (3.2)$$

The  $A$  and  $B$  values corresponding to each column temperature  $T_c$  were used to calculate  $p$ , keeping the surface concentration  $C_s$  constant. The heat of adsorption,  $Q_{ads}$ , was calculated from the slope of  $\ln p$  vs  $1/T_c$  plots by using Equation (2.18) and least squares. The calculation procedure was repeated for different  $C_s$  and the  $Q_{ads}$  values obtained were later averaged.

An example for calculation of the adsorption isotherm is given for n-hexane at 211.11°C and 0.4  $\mu$ l sample size. Table 3.2 shows the retention time-height data. The  $V_g/RT_c$  vs  $p$  values are plotted in Figure 3.3 and the adsorption isotherm is obtained by integrating this curve. Data for the adsorption isotherm are given in the first two columns of Table 3.3. The set of  $C_s$  and  $p$  values are curve fitted to Equation (3.1) and  $A$  and  $B$

are found as  $5.846 \times 10^4$  mmHg gcat/gmol and  $4.278 \times 10^4$  gcat/gmol respectively. The isotherm obtained by curve fitting is shown as the solid line in Figure 3.4 while the experimental values of  $C_s$  and  $p$  are presented as points in the same figure.

TABLE 3.2 Retention Time-Height Data for n-Hexane  
at 211.11°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 67.80          | 3.689                      | 1.221  | 146.5          | 27.621        |
| 71.40          | 3.969                      | 1.313  | 120.0          | 22.624        |
| 72.90          | 4.085                      | 1.352  | 103.0          | 19.419        |
| 74.40          | 4.202                      | 1.391  | 85.5           | 16.120        |
| 77.40          | 4.436                      | 1.468  | 54.0           | 10.181        |
| 78.90          | 4.552                      | 1.507  | 41.0           | 7.730         |
| 80.40          | 4.669                      | 1.545  | 30.0           | 5.656         |
| 81.90          | 4.786                      | 1.584  | 21.5           | 4.054         |
| 83.40          | 4.903                      | 1.622  | 15.0           | 2.828         |
| 84.90          | 5.019                      | 1.661  | 10.5           | 1.980         |
| 86.40          | 5.136                      | 1.700  | 7.0            | 1.320         |
| 87.90          | 5.253                      | 1.738  | 5.0            | 0.943         |
| 89.40          | 5.369                      | 1.777  | 3.5            | 0.660         |
| 90.90          | 5.486                      | 1.816  | 2.5            | 0.471         |
| 92.40          | 5.603                      | 1.854  | 2.0            | 0.377         |
| 96.90          | 5.953                      | 1.970  | 1.0            | 0.189         |
| 113.40         | 7.237                      | 2.395  | 0.0            | 0.000         |

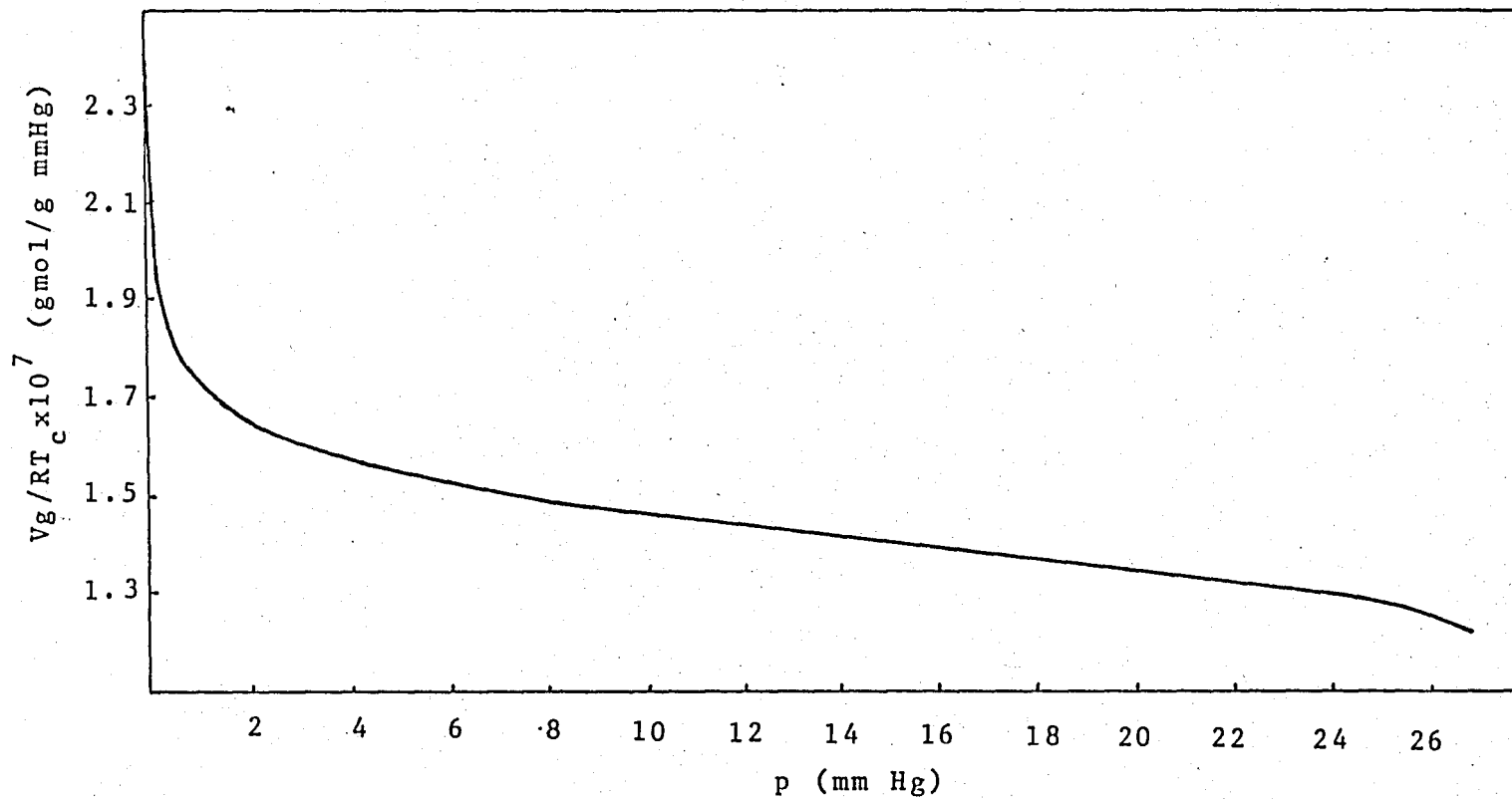


FIGURE 3.2 Derivative of the Adsorption Isotherm of n-Hexane at 0.4  $\mu$ l and 211.11  $^{\circ}$ C

TABLE 3.3 Adsorption Isotherm of n-Hexane at 0.4  $\mu$ l and 211.11  $^{\circ}$ C with Helium

| p (mm Hg) | $C_s \times 10^7$ (gmol/g cat) |           |
|-----------|--------------------------------|-----------|
| 2         | 3.672                          | (3.372)*  |
| 4         | 6.912                          | (6.648)*  |
| 6         | 10.042                         | (9.832)*  |
| 8         | 13.088                         | (12.928)* |
| 10        | 16.067                         | (15.939)* |
| 12        | 18.981                         | (18.870)* |
| 14        | 21.840                         | (21.723)* |
| 16        | 24.642                         | (24.500)* |
| 18        | 27.406                         | (27.206)* |
| 20        | 30.126                         | (29.843)* |
| 22        | 32.796                         | (32.414)* |
| 24        | 35.418                         | (34.921)* |

\* isotherm obtained by curve fitting

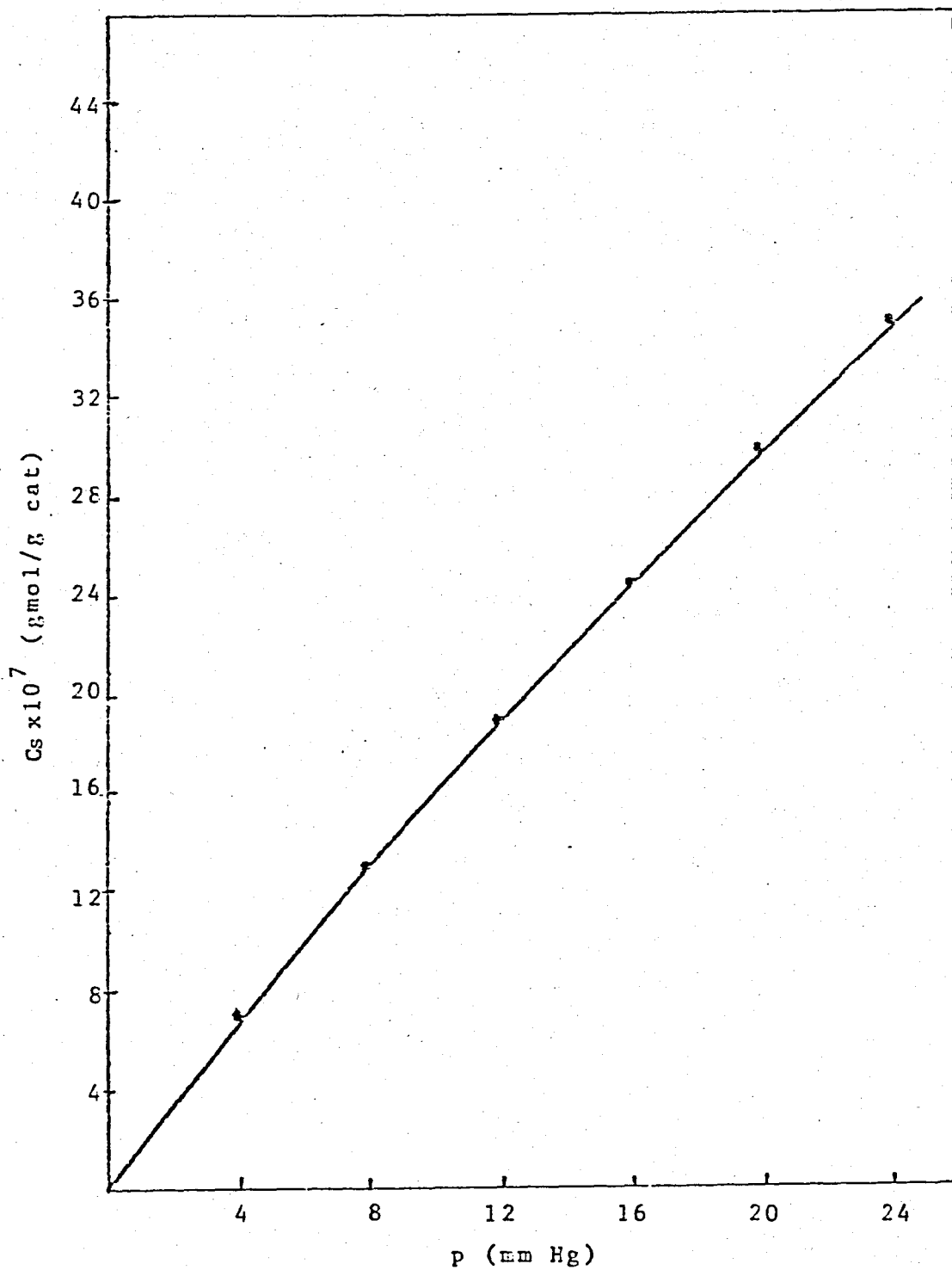


FIGURE 3.3 Adsorption Isotherm of n-Hexane at 0.4  $\mu$ l and 211.11  $^{\circ}$ C with Helium

### 3.4 DISCUSSION OF EXPERIMENTAL CONDITIONS

In this study, adsorption of four different hydrocarbons were investigated in the absence of any chemical reaction. The presence of a chemical reaction may cause complications arising from the interference or overlapping of reactant and product peaks. Hence the experimental conditions were chosen so as to prevent any possible reactions. The absence of a chemical reaction was verified by the single chromatographic peak obtained for each experiment.

Precise temperature control is also essential in direct chromatographic measurement. For reliable results, the fluctuations must be within the range of  $\pm 0.1$  °C (Conder, 1968). In this study, the column temperature was measured with a quartz thermometer and held constant within the range of  $\pm 0.05$  °C in majority of runs, but at no time did the fluctuation reaches  $\pm 0.1$  °C.

Helium was used as the carrier gas because of its inert characteristics. The experiments for n-pentane and n-hexane were also carried out with hydrogen to investigate the effects of hydrogen on the adsorption of the hydrocarbon.

The flowrate of the carrier gas was continuously measured by a soap-bubble flowmeter at the column exit and held constant so that the retention parameters were not affected by flowrate fluctuations. The flowrate was

chosen low enough to allow sufficient contact time between the catalyst and the hydrocarbon. A flowrate of about 10 cm<sup>3</sup>/min was used for n-pentane and n-hexane. The flowrate for n-hexane and i-octane was about 15 cm<sup>3</sup>/min to prevent peak tailing which occurred at 10 cm<sup>3</sup>/min.

The sample size is also an important parameter. It must be high enough to obtain sufficiently high partial pressures and low enough to avoid peak tailing. In this study the sample size chosen was the highest value allowable for each hydrocarbon. The values used are 0.8  $\mu$ l and 0.4  $\mu$ l for n-pentane and n-hexane, and 0.4  $\mu$ l and 0.2  $\mu$ l for n-heptane and i-octane.

At low flowrates, the particle size of the catalyst must be sufficiently small to minimize diffusion effects. In this study, very small particle size (60 -80 mesh ) was used.

#### IV. RESULTS AND DISCUSSIONS

In this work, the adsorption isotherms and the heats of adsorption of n-pentane, n-hexane, n-heptane and i-octane on the commercial 0.3 % wt Pt/Al<sub>2</sub>O<sub>3</sub> reforming catalyst were determined. The experiments were carried out in the temperature range 185-235 °C by using elution chromatography, and the information was obtained from the retention data and the shape of a single elution peak for each temperature and each adsorbate. The adsorption isotherms and isosteres were constructed, and the heats of adsorption of these hydrocarbons were calculated from the isosteres. The experimental data are tabulated in the Appendices cited while the results obtained are presented and discussed in this Chapter.

The adsorption isotherms were evaluated as described in Section 3.3. Data on the chromatographic peaks, retention time-height data and data for adsorption isotherms are given in Appendix I, Appendix II and Appendix III respectively. The isotherms are curve fitted to Equation (3.1) and the results are given in Tables 4.1.a through 4.4.b. The isotherms are drawn in Figures 4.1, 4.3, 4.5, 4.7, 4.9, 4.11, 4.13, 4.15, 4.17 and 4.19. The adsorption isosteres were obtained from the adsorption isotherms as discussed in Section 3.3. The

isosteres are tabulated in Table 4.5 through 4.14 and plotted in Figures 4.2, 4.4, 4.6, 4.8, 4.10, 4.12, 4.14, 4.16, 4.18, 4.20. The heats of adsorption were obtained from the slopes of isosteres at constant adsorbate concentration,  $C_s$ , assuming that the heat of adsorption is constant in the temperature of 185-235 °C. Since a definite trend was not observed in the  $Q_{ads}$  values obtained at different  $C_s$ , a global average  $Q_{ads}$  was also calculated for each hydrocarbon. The heats of adsorption of the hydrocarbons at different  $C_s$  values are tabulated in Table 4.15, while the global averages are given in Table 4.16

As may be observed in Figures 4.2, 4.4 and 4.6 and, later in Table 4.15, the percentage error in the heat of adsorption calculated for n-pentane is greater than the error limit for the other hydrocarbons. This arises from the fact that the boiling point of n-pentane is very low (36.0 °C) which leads to experimental error since evaporation occurs during the injection of the sample. Even though several injections are made until reproducible peaks are obtained, the partial pressure,  $p$ , predicted by using Equation 2.13 still gives an overestimated value. Since the degree of overestimation may change for different column temperatures and can not quantitatively be determined, sufficient number of experiments were carried out with n-pentane to determine  $Q_{ads}$  values with acceptable accuracy.

TABLE 4.1.a Constants of Adsorption Isotherms for  
n-Pentane  
Carrier Gas: Hydrogen V = 0.4  $\mu$ l

| T<br>( $^{\circ}$ C) | A $\times 10^{-6}$<br>(mmHg gcat/gmol) | B $\times 10^{-4}$<br>(gcat/gmol) | $\pm$ Error in Cs*<br>(gmol/g cat) |
|----------------------|--|-----------------------------------|------------------------------------|
| 187.39               | 8.284                                  | 8.706                             | 0.20                               |
| 193.37               | 7.473                                  | 6.617                             | 0.28                               |
| 210.74               | 9.640                                  | 8.468                             | 0.27                               |
| 226.91               | 12.167                                 | 13.415                            | 0.20                               |
| 234.94               | 12.678                                 | 12.946                            | 0.19                               |

TABLE 4.1.b Constants of Adsorption Isotherms for  
n-Pentane  
Carrier Gas: Helium V = 0.4  $\mu$ l

| T<br>( $^{\circ}$ C) | A $\times 10^{-6}$<br>(mmHg gcat/gmol) | B $\times 10^{-4}$<br>(gcat/gmol) | $\pm$ Error in Cs*<br>(gmol/g cat) |
|----------------------|--|-----------------------------------|------------------------------------|
| 186.17               | 6.824                                  | 4.942                             | 0.27                               |
| 198.00               | 8.120                                  | 6.094                             | 0.25                               |
| 205.51               | 8.844                                  | 7.945                             | 0.25                               |
| 211.18               | 8.693                                  | 9.373                             | 0.27                               |
| 218.18               | 9.315                                  | 9.726                             | 0.28                               |
| 225.45               | 11.173                                 | 10.572                            | 0.23                               |
| 230.75               | 12.323                                 | 14.420                            | 0.21                               |
| 235.25               | 12.221                                 | 12.335                            | 0.21                               |

TABLE 4.1.c Constants of Adsorption Isotherms for  
n-Pentane  
Carrier Gas: Helium V = 0.8  $\mu$ l

| T<br>( $^{\circ}$ C) | A $\times 10^{-6}$<br>(mmHg gcat/gmol) | B $\times 10^{-4}$<br>(gcat/gmol) | $\pm$ Error in Cs*<br>(gmol/g cat) |
|----------------------|--|-----------------------------------|------------------------------------|
| 185.71               | 7.193                                  | 3.361                             | 0.55                               |
| 197.08               | 8.383                                  | 4.499                             | 0.42                               |
| 203.37               | 8.607                                  | 6.097                             | 0.35                               |
| 211.08               | 9.621                                  | 6.228                             | 0.60                               |
| 218.14               | 9.838                                  | 6.344                             | 0.43                               |
| 225.52               | 11.565                                 | 7.620                             | 0.50                               |
| 230.75               | 13.028                                 | 9.137                             | 0.40                               |
| 235.31               | 14.685                                 | 9.438                             | 0.32                               |

\* Errors in moles of adsorbed were calculated using the the method given by Mickley, et. al. (1957)

TABLE 4.2.a Constants of Adsorption Isotherms for  
n-Hexane  
Carrier Gas: Hydrogen V = 0.4  $\mu$ l

| T<br>(°C) | Ax10 <sup>-6</sup><br>(mmHg gcat/gmol) | Bx10 <sup>-4</sup><br>(gcat/gmol) | ±Error in Cs*<br>(gmol/g cat) |
|-----------|--|-----------------------------------|-------------------------------|
| 187.39    | 3.993                                  | 2.036                             | 0.39                          |
| 204.99    | 5.575                                  | 2.876                             | 0.27                          |
| 210.73    | 6.010                                  | 4.160                             | 0.26                          |
| 226.97    | 8.046                                  | 7.464                             | 0.20                          |
| 234.98    | 8.955                                  | 7.516                             | 0.20                          |

TABLE 4.2.b Constants of Adsorption Isotherms for  
n-Hexane  
Carrier Gas: Helium V = 0.4  $\mu$ l

| T<br>(°C) | Ax10 <sup>-6</sup><br>(mmHg gcat/gmol) | Bx10 <sup>-4</sup><br>(gcat/gmol) | ±Error in Cs*<br>(gmol/g cat) |
|-----------|--|-----------------------------------|-------------------------------|
| 186.05    | 3.454                                  | 4.088                             | 0.52                          |
| 197.93    | 4.839                                  | 3.692                             | 0.33                          |
| 205.59    | 5.437                                  | 3.807                             | 0.29                          |
| 211.11    | 5.846                                  | 4.278                             | 0.28                          |
| 218.17    | 6.746                                  | 3.918                             | 0.23                          |
| 225.64    | 7.671                                  | 4.892                             | 0.22                          |
| 230.82    | 8.261                                  | 6.470                             | 0.23                          |
| 235.31    | 8.465                                  | 6.761                             | 0.24                          |

TABLE 4.2.c Constants of Adsorption Isotherms for  
n-Hexane  
Carrier Gas: Helium V = 0.8  $\mu$ l

| T<br>(°C) | Ax10 <sup>-6</sup><br>(mmHg gcat/gmol) | Bx10 <sup>-4</sup><br>(gcat/gmol) | ±Error in Cs*<br>(gmol/g cat) |
|-----------|--|-----------------------------------|-------------------------------|
| 185.81    | 3.675                                  | 2.130                             | 0.41                          |
| 196.99    | 4.831                                  | 2.383                             | 0.31                          |
| 203.35    | 5.440                                  | 2.614                             | 0.29                          |
| 211.07    | 5.884                                  | 3.113                             | 0.28                          |
| 218.26    | 7.000                                  | 3.331                             | 0.26                          |
| 225.49    | 7.981                                  | 3.715                             | 0.23                          |
| 230.83    | 8.555                                  | 4.490                             | 0.28                          |
| 235.21    | 9.333                                  | 4.448                             | 0.24                          |

\* Errors in moles of adsorbed were calculated using the  
the method given by Mickley, et. al. (1957)

TABLE 4.3.a Constants of Adsorption Isotherms for  
n-Heptane  
Carrier Gas: Helium V = 0.2  $\mu$ l

| T<br>( $^{\circ}$ C) | $A \times 10^{-6}$<br>(mmHg gcat/gmol) | $B \times 10^{-4}$<br>(gcat/gmol) | $\pm$ Error in $C_s^*$<br>(gmol/g cat) |
|----------------------|--|-----------------------------------|--|
| 185.24               | 1.858                                  | 4.179                             | 0.30                                   |
| 193.34               | 2.285                                  | 4.056                             | 0.25                                   |
| 201.51               | 2.667                                  | 3.359                             | 0.21                                   |
| 207.39               | 3.205                                  | 4.722                             | 0.22                                   |
| 217.49               | 3.783                                  | 3.847                             | 0.36                                   |
| 224.97               | 4.294                                  | 4.686                             | 0.19                                   |
| 229.87               | 4.760                                  | 4.691                             | 0.17                                   |
| 234.29               | 5.216                                  | 5.864                             | 0.16                                   |

TABLE 4.3.b Constants of Adsorption Isotherms for  
n-Heptane  
Carrier Gas: Helium V = 0.4  $\mu$ l

| T<br>( $^{\circ}$ C) | $A \times 10^{-6}$<br>(mmHg gcat/gmol) | $B \times 10^{-4}$<br>(gcat/gmol) | $\pm$ Error in $C_s^*$<br>(gmol/g cat) |
|----------------------|--|-----------------------------------|--|
| 185.24               | 1.862                                  | 2.119                             | 0.43                                   |
| 193.32               | 2.204                                  | 4.789                             | 0.34                                   |
| 201.62               | 2.658                                  | 3.021                             | 0.30                                   |
| 207.40               | 3.337                                  | 3.062                             | 0.73                                   |
| 217.47               | 3.820                                  | 2.991                             | 0.41                                   |
| 225.01               | 4.416                                  | 3.407                             | 0.36                                   |
| 229.90               | 4.963                                  | 3.292                             | 0.32                                   |
| 234.31               | 5.380                                  | 3.739                             | 0.29                                   |

\* Errors in moles of adsorbed were calculated using the  
the method given by Mickley, et. al. (1957)

TABLE 4.4.a Constants of Adsorption Isotherms for  
i-Octane  
Carrier Gas: Helium V = 0.2  $\mu$ l

| T<br>( $^{\circ}$ C) | A $\times 10^{-6}$<br>(mmHg gcat/gmol) | B $\times 10^{-4}$<br>(gcat/gmol) | $\pm$ Error in Cs<br>(gmol/g cat) |
|----------------------|--|-----------------------------------|-----------------------------------|
| 185.25               | 1.577                                  | 5.751                             | 0.26                              |
| 193.33               | 1.879                                  | 4.534                             | 0.21                              |
| 201.59               | 2.134                                  | 5.681                             | 0.20                              |
| 209.91               | 2.630                                  | 3.767                             | 0.31                              |
| 217.47               | 3.157                                  | 4.356                             | 0.26                              |
| 224.87               | 3.573                                  | 5.361                             | 0.23                              |
| 229.84               | 3.931                                  | 6.555                             | 0.13                              |
| 234.26               | 4.330                                  | 5.897                             | 0.19                              |

TABLE 4.4.b Constants of Adsorption Isotherms for  
i-Octane  
Carrier Gas: Helium V = 0.4  $\mu$ l

| T<br>( $^{\circ}$ C) | A $\times 10^{-6}$<br>(mmHg gcat/gmol) | B $\times 10^{-4}$<br>(gcat/gmol) | $\pm$ Error in Cs<br>(gmol/g cat) |
|----------------------|--|-----------------------------------|-----------------------------------|
| 185.27               | 1.606                                  | 4.005                             | 0.50                              |
| 193.30               | 1.934                                  | 3.622                             | 0.40                              |
| 201.65               | 2.201                                  | 3.925                             | 0.35                              |
| 209.99               | 2.660                                  | 3.518                             | 0.29                              |
| 217.44               | 3.144                                  | 3.637                             | 0.25                              |
| 224.48               | 3.646                                  | 3.817                             | 0.21                              |
| 229.84               | 4.229                                  | 4.093                             | 0.37                              |
| 234.34               | 4.583                                  | 4.288                             | 0.35                              |

\* Errors in moles of adsorbed were calculated using the  
the method given by Mickley, et. al. (1957)

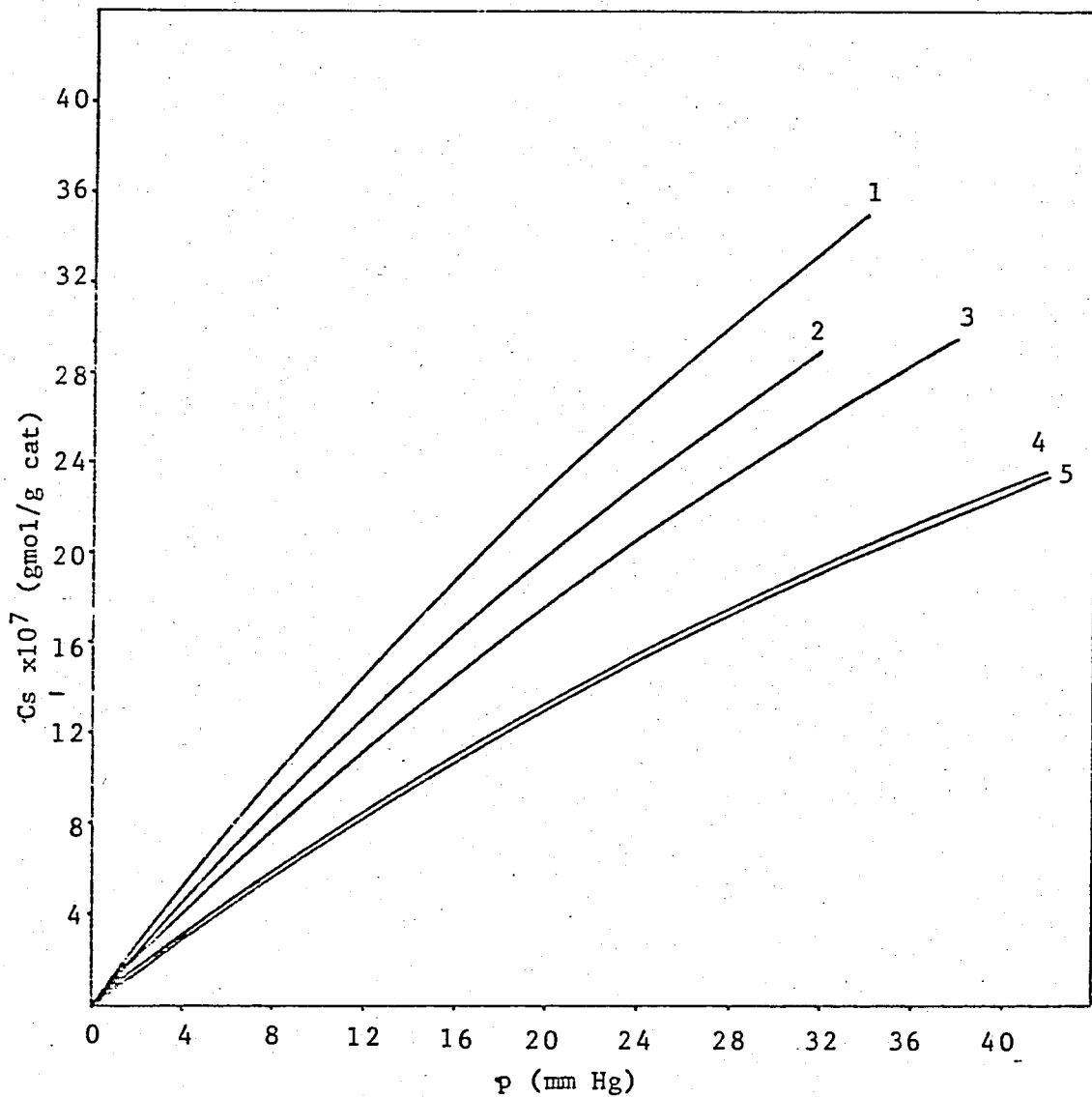


FIGURE 4.1 Adsorption Isotherms of n-Pentane at 0.4  $\mu$ l with Hydrogen

- |    |           |    |           |
|----|-----------|----|-----------|
| 1. | 187.39 °C | 4. | 226.91 °C |
| 2. | 193.37 °C | 5. | 234.94 °C |
| 3. | 210.74 °C |    |           |

TABLE 4.5 Adsorption Isotherms for n-Pentane at 0.4  $\mu$ l with  $H_2$

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |       | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>e</sub> (°C) | 10 <sup>3</sup> /T <sub>e</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 187.39              | 2.171   | 4.331             | 1.465 | 9.074              | 2.205 | 14.293             | 2.660 | 20.062             | 2.999 |
| 193.37              | 2.144   | 3.865             | 1.352 | 8.485              | 2.138 | 13.796             | 2.624 | 17.226             | 2.846 |
| 210.74              | 2.067   | 5.033             | 1.616 | 10.532             | 2.354 | 16.563             | 2.807 | 23.210             | 3.145 |
| 226.91              | 2.000   | 6.521             | 1.875 | 14.052             | 2.643 | 22.848             | 3.129 | 33.256             | 3.504 |
| 234.94              | 1.968   | 6.778             | 1.914 | 14.563             | 2.679 | 23.599             | 3.161 | 34.214             | 3.523 |

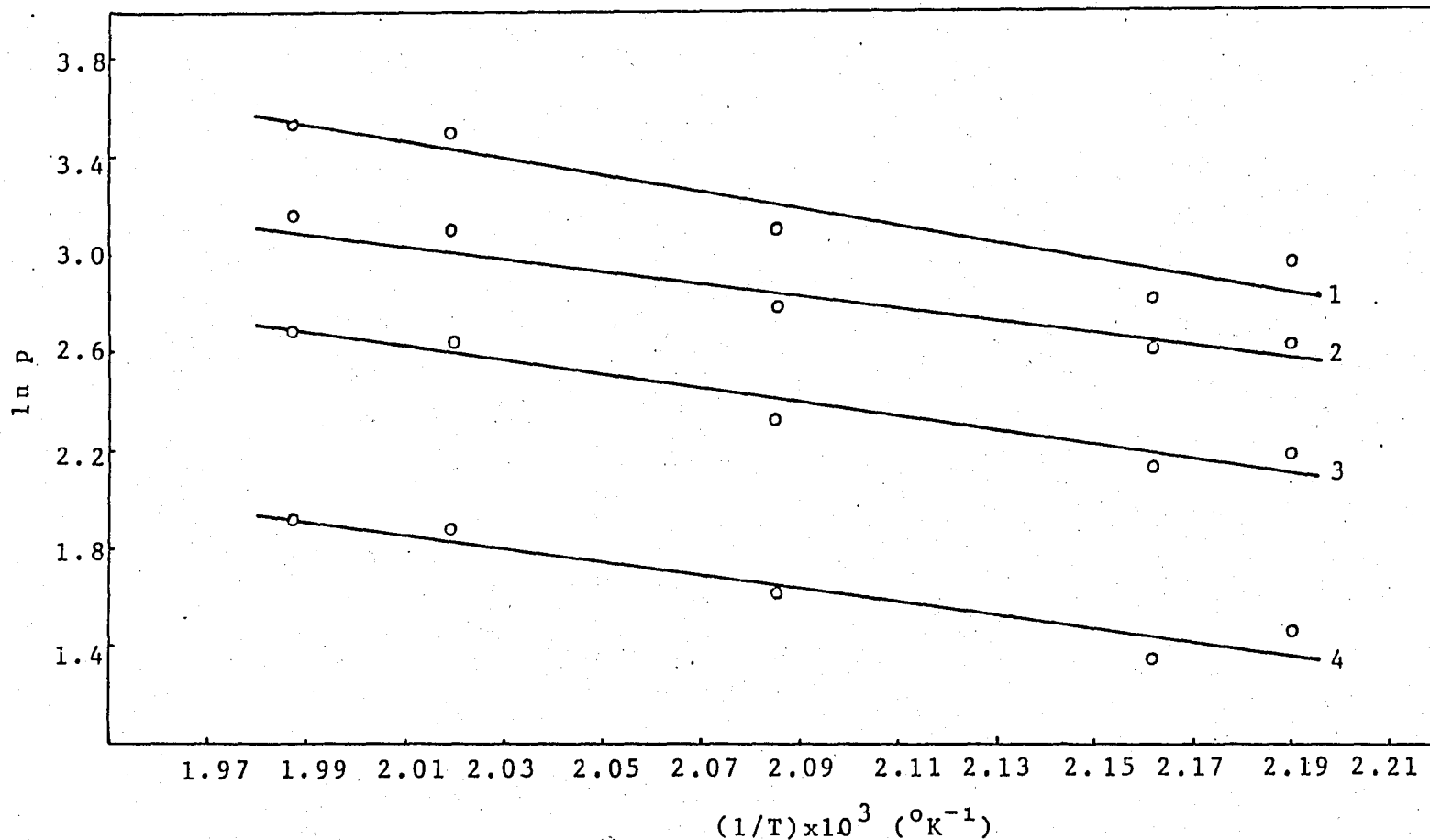


FIGURE 4.2 Adsorption Isosteres of n-Pentane at 0.4  $\mu$ l with Hydrogen

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. At $20 \times 10^7$ gmol/g cat | 3. At $10 \times 10^7$ gmol/g cat |
| 2. At $15 \times 10^7$ gmol/g cat | 4. At $5 \times 10^7$ gmol/g cat  |

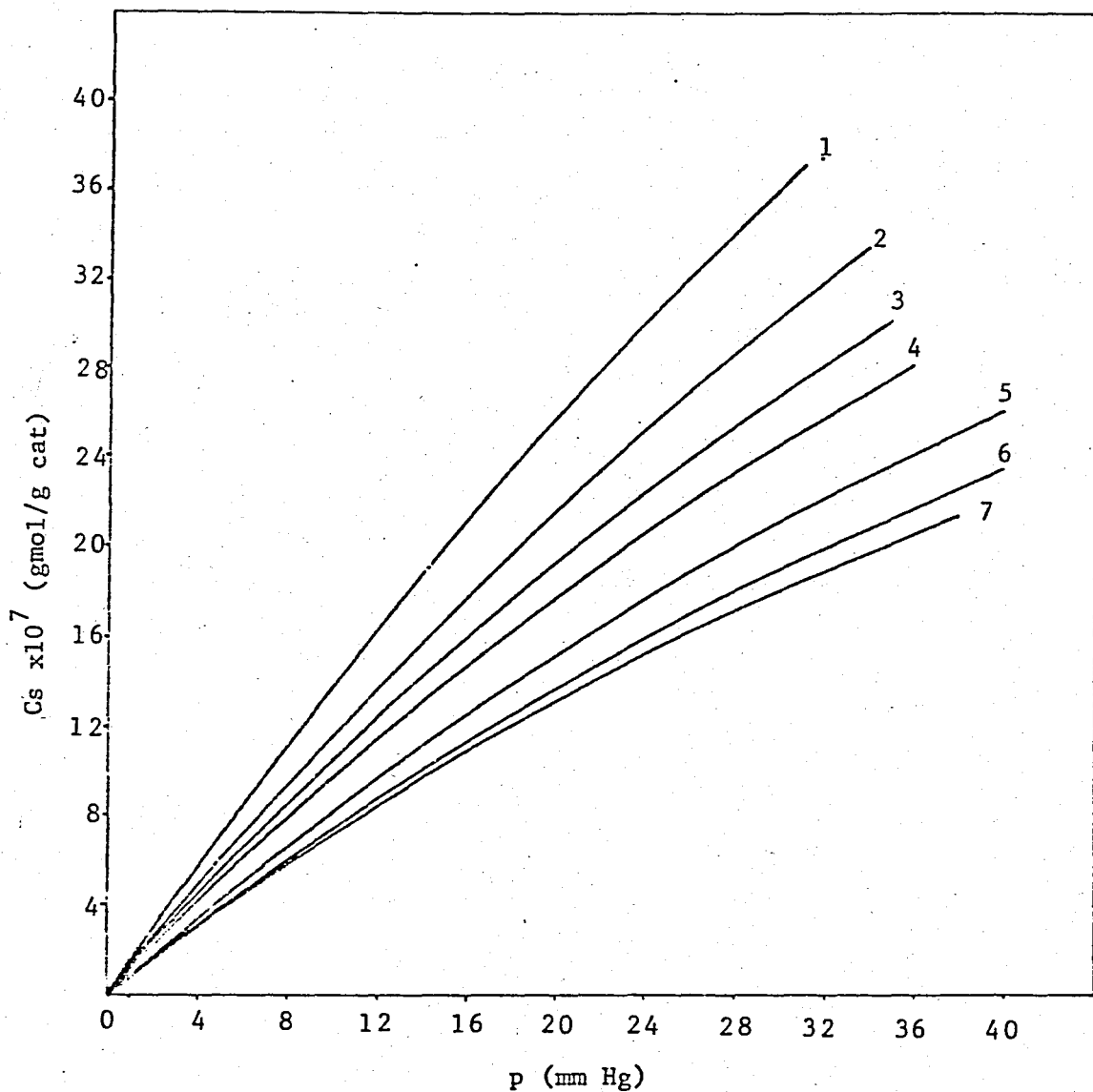


FIGURE 4.3 Adsorption Isotherms of n-Pentane at 0.4  $\mu$ l with Helium

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 186.17 °C | 5. | 225.45 °C |
| 2. | 198.00 °C | 6. | 230.75 °C |
| 3. | 205.51 °C | 7. | 235.25 °C |
| 4. | 218.18 °C |    |           |

TABLE 4.6 Adsorption Isosteres for n-Pentane at 0.4  $\mu$ l with He

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |       | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>e</sub> (°C) | 10 <sup>3</sup> /T <sub>e</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 186.17              | 2.177   | 3.498             | 1.252 | 7.179              | 1.971 | 11.055             | 2.403 | 15.145             | 2.718 |
| 198.00              | 2.123   | 4.188             | 1.432 | 8.648              | 2.157 | 13.405             | 2.596 | 18.494             | 2.917 |
| 205.51              | 2.089   | 4.605             | 1.527 | 9.607              | 2.263 | 14.803             | 2.695 | 21.029             | 3.046 |
| 211.12              | 2.065   | 4.560             | 1.517 | 9.592              | 2.261 | 15.060             | 2.712 | 21.396             | 3.063 |
| 218.18              | 2.035   | 4.896             | 1.588 | 10.319             | 2.334 | 16.359             | 2.795 | 23.129             | 3.141 |
| 225.45              | 2.006   | 5.898             | 1.775 | 12.494             | 2.525 | 19.918             | 2.992 | 28.337             | 3.344 |
| 230.75              | 1.985   | 6.640             | 1.893 | 14.399             | 2.667 | 23.586             | 3.161 | 34.634             | 3.545 |
| 235.25              | 1.968   | 6.512             | 1.874 | 13.941             | 2.635 | 22.494             | 3.113 | 32.447             | 3.480 |

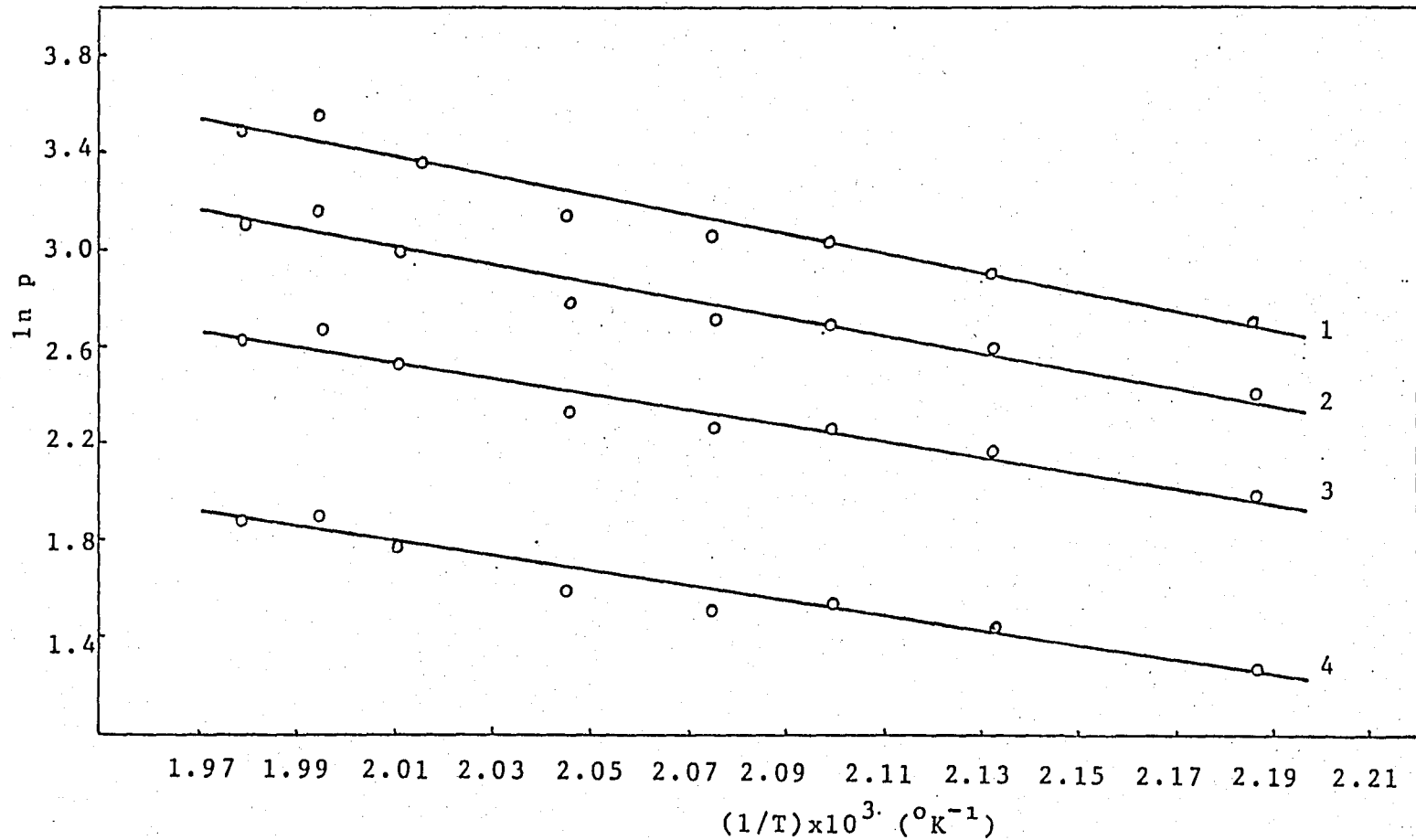


FIGURE 4.4 Adsorption Isosteres of n-Pentane at 0.4  $\mu$ l with Helium

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. At $20 \times 10^7$ gmol/g cat | 3. At $10 \times 10^7$ gmol/g cat |
| 2. At $15 \times 10^7$ gmol/g cat | 4. At $5 \times 10^7$ gmol/g cat  |

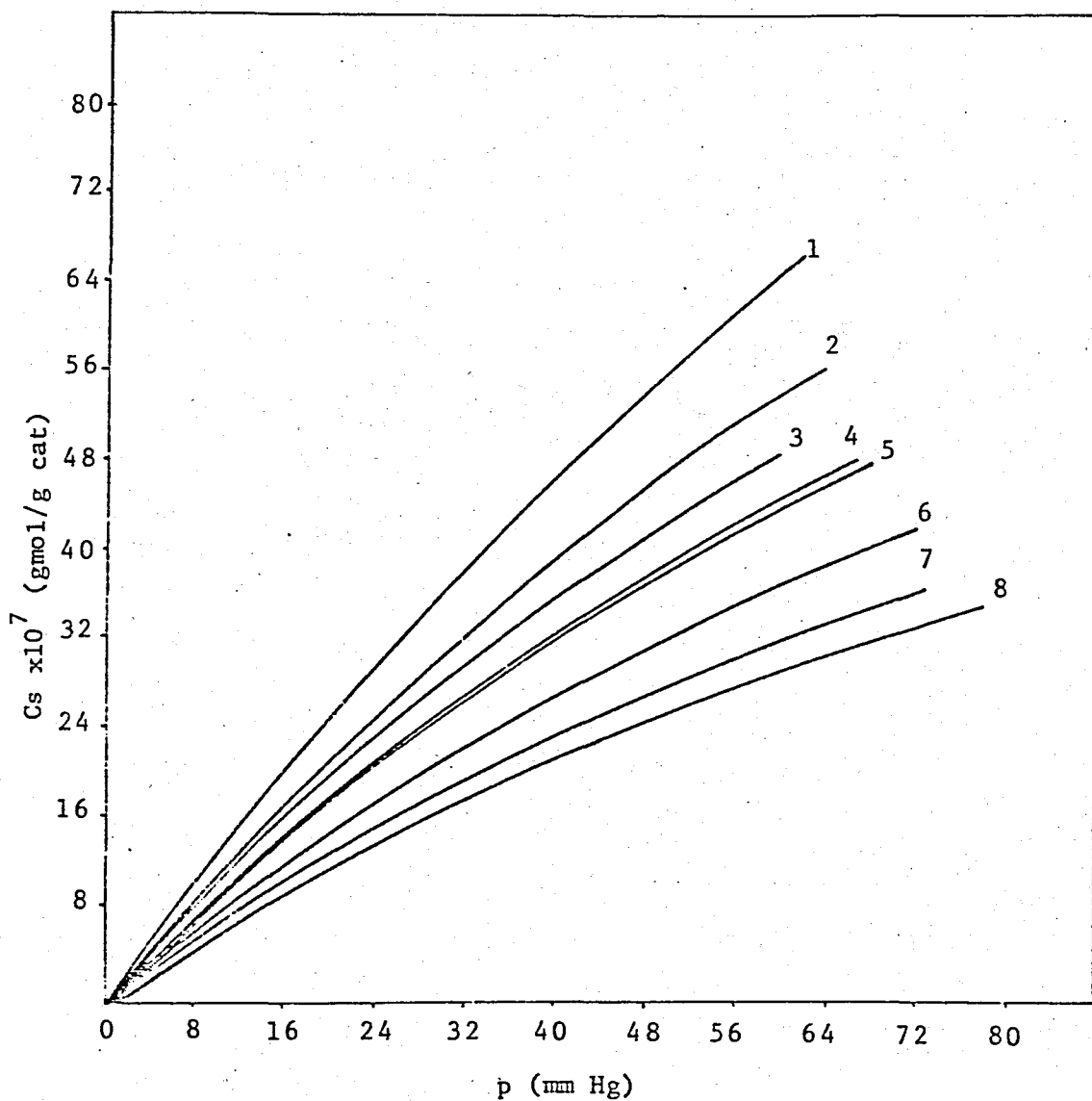


FIGURE 4.5 Adsorption Isotherms of n-Pentane at 0.8  $\mu$ l with Helium

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 185.71 °C | 5. | 218.14 °C |
| 2. | 197.08 °C | 6. | 225.52 °C |
| 3. | 203.37 °C | 7. | 230.75 °C |
| 4. | 211.08 °C | 8. | 235.25 °C |

TABLE 4.7 Adsorption Isosteres for n-Pentane at 0.8  $\mu$ l with He

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |       | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>e</sub> (°C) | 10 <sup>3</sup> /T <sub>e</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 185.71              | 2.179   | 3.658             | 1.297 | 7.443              | 2.007 | 11.363             | 2.430 | 15.423             | 2.736 |
| 197.08              | 2.127   | 4.288             | 1.456 | 8.778              | 2.172 | 13.484             | 2.602 | 18.424             | 2.914 |
| 203.37              | 2.099   | 4.439             | 1.490 | 9.166              | 2.216 | 14.211             | 2.654 | 19.605             | 2.976 |
| 211.08              | 2.065   | 4.965             | 1.602 | 10.260             | 2.328 | 15.918             | 2.768 | 21.979             | 3.090 |
| 218.14              | 2.036   | 5.080             | 1.625 | 10.504             | 2.352 | 16.309             | 2.792 | 22.535             | 3.115 |
| 225.52              | 2.005   | 6.012             | 1.794 | 12.520             | 2.523 | 19.587             | 2.975 | 27.290             | 3.307 |
| 230.75              | 1.985   | 6.826             | 1.921 | 14.338             | 2.663 | 22.645             | 3.120 | 31.881             | 3.462 |
| 235.31              | 1.967   | 7.706             | 2.042 | 16.216             | 2.786 | 25.661             | 3.245 | 36.205             | 3.589 |

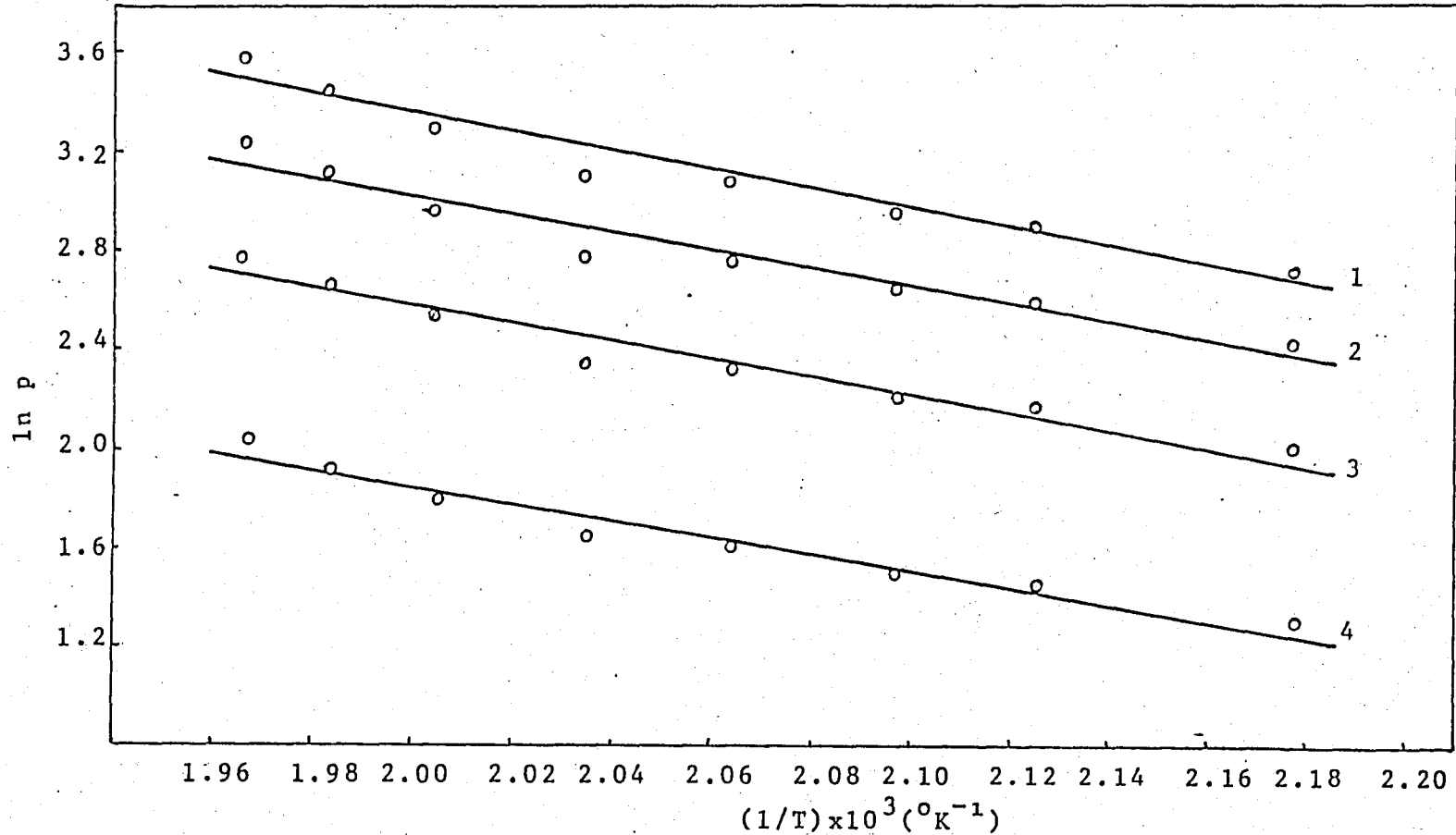


FIGURE 4.6 Adsorption Isosteres of n-Pentane at 0.8  $\mu$ l with Helium

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. At $20 \times 10^7$ gmol/g cat | 3. At $10 \times 10^7$ gmol/g cat |
| 2. At $15 \times 10^7$ gmol/g cat | 4. At $5 \times 10^7$ gmol/g cat  |

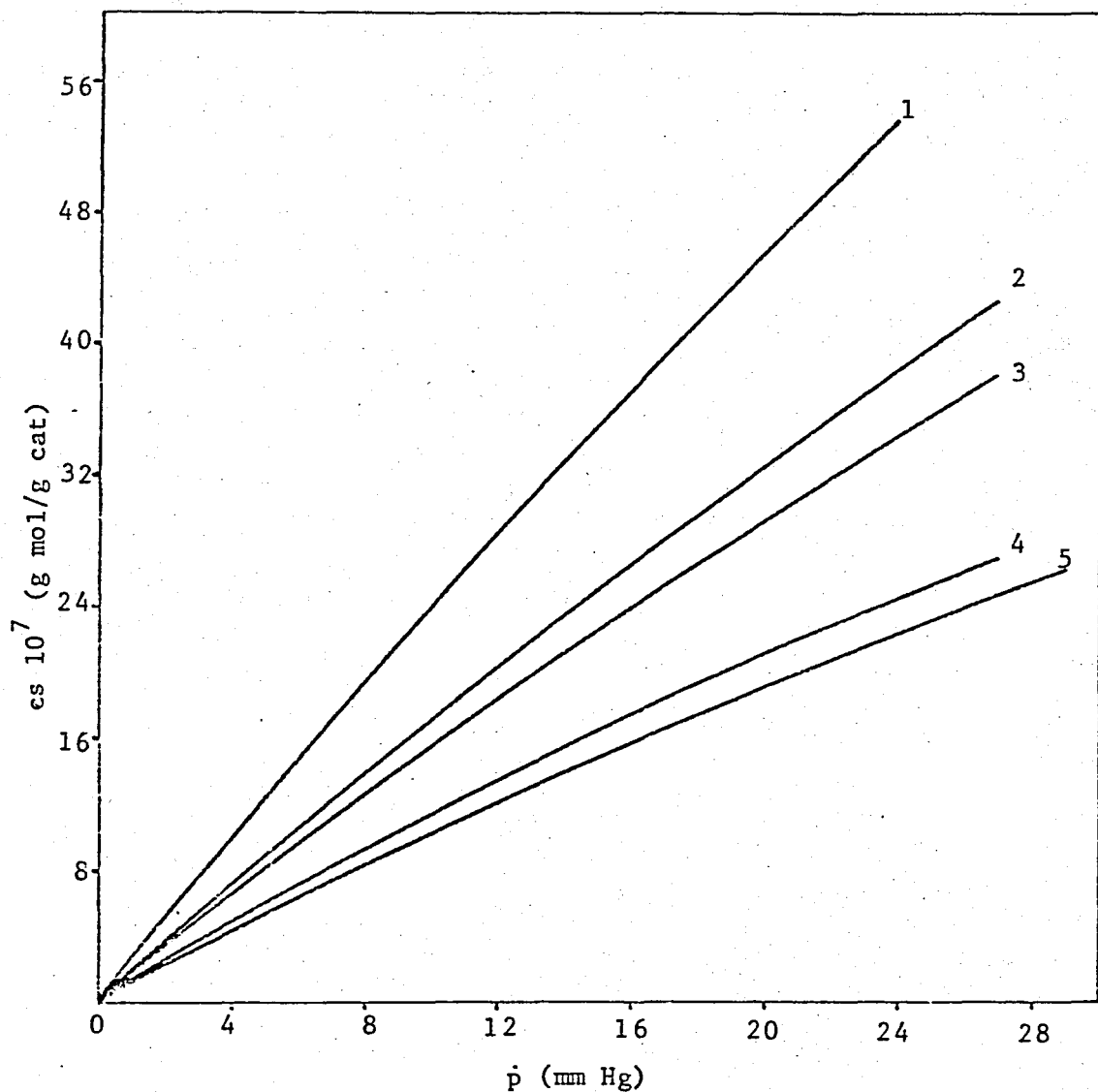


FIGURE 4.7 Adsorption Isotherms of n-Hexane at 0.4  $\mu$ l with Hydrogen

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 187.39 °C | 4. | 226.97 °C |
| 2. | 204.99 °C | 5. | 234.98 °C |
| 3. | 210.73 °C |    |           |

TABLE 4.8 Adsorption Isotherms for n-Hexane at 0.4  $\mu$ l with  $H_2$

| Cs (gmol/g cat)       |                                     | $5 \times 10^7$ |       | $10 \times 10^7$ |       | $15 \times 10^7$ |       | $20 \times 10^7$ |       |
|-----------------------|-------------------------------------|-----------------|-------|------------------|-------|------------------|-------|------------------|-------|
| $T_e$ ( $^{\circ}$ C) | $10^3/T_e$ ( $^{\circ}$ K $^{-1}$ ) | p(mmHg)         | ln p  | p(mmHg)          | ln p  | p(mmHg)          | ln p  | p(mmHg)          | ln p  |
| 187.39                | 2.171                               | 2.017           | 0.702 | 4.076            | 1.405 | 6.179            | 1.821 | 8.326            | 2.119 |
| 204.99                | 2.0.9                               | 2.828           | 1.040 | 5.740            | 1.748 | 8.740            | 2.168 | 11.811           | 2.471 |
| 210.73                | 2.067                               | 3.069           | 1.121 | 6.271            | 1.836 | 9.616            | 2.263 | 13.112           | 2.574 |
| 226.97                | 2.000                               | 4.179           | 1.430 | 8.695            | 2.163 | 13.591           | 2.609 | 18.916           | 2.940 |
| 234.98                | 1.968                               | 4.652           | 1.537 | 9.682            | 2.270 | 15.139           | 2.717 | 21.078           | 3.048 |

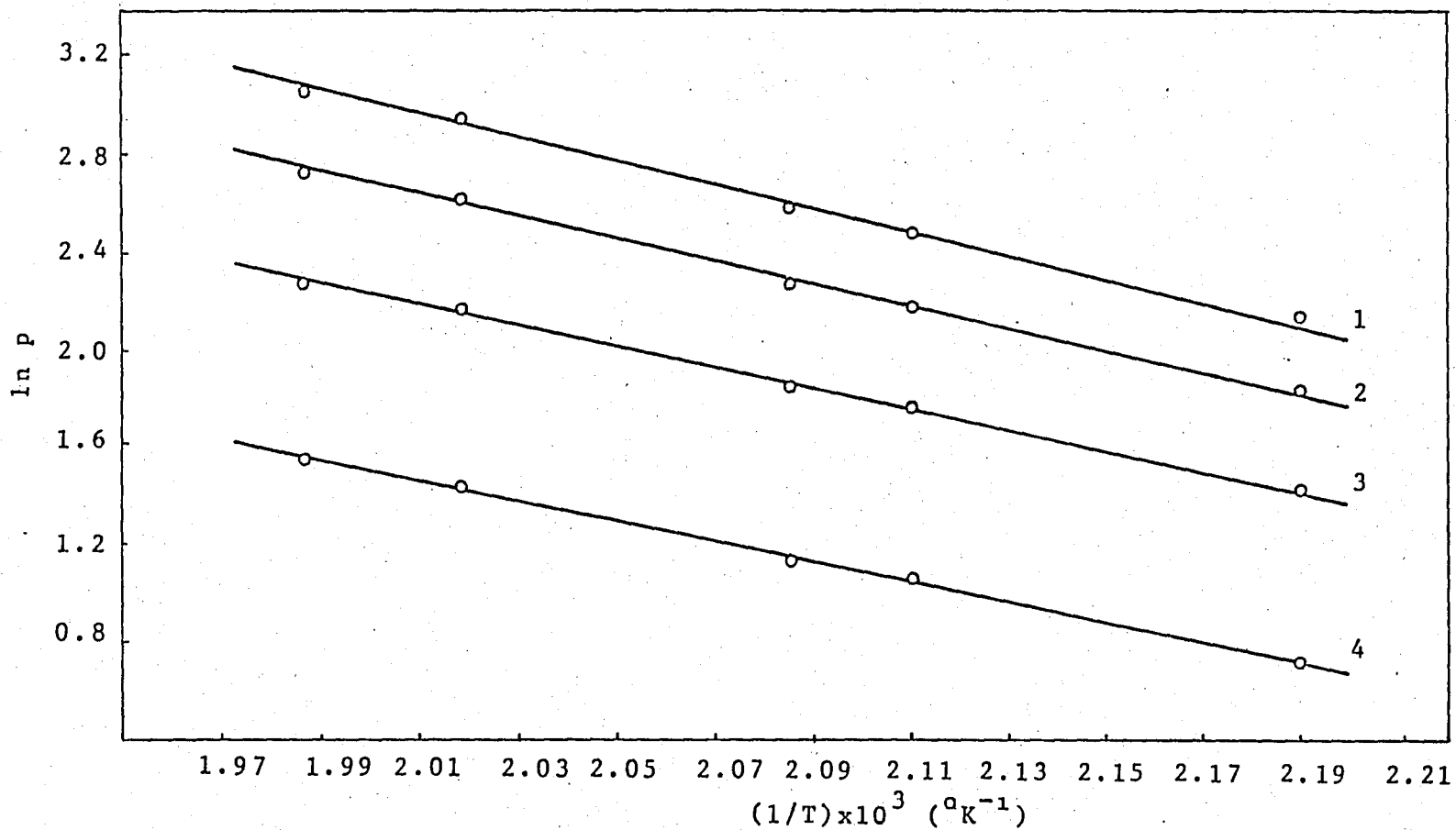


FIGURE 4.8 Adsorption Isotherms of n-Hexane at 0.4  $\mu\text{l}$  with Hydrogen

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. At $20 \times 10^7$ gmol/g cat | 3. At $10 \times 10^7$ gmol/g cat |
| 2. At $15 \times 10^7$ gmol/g cat | 4. At $5 \times 10^7$ gmol/g cat  |

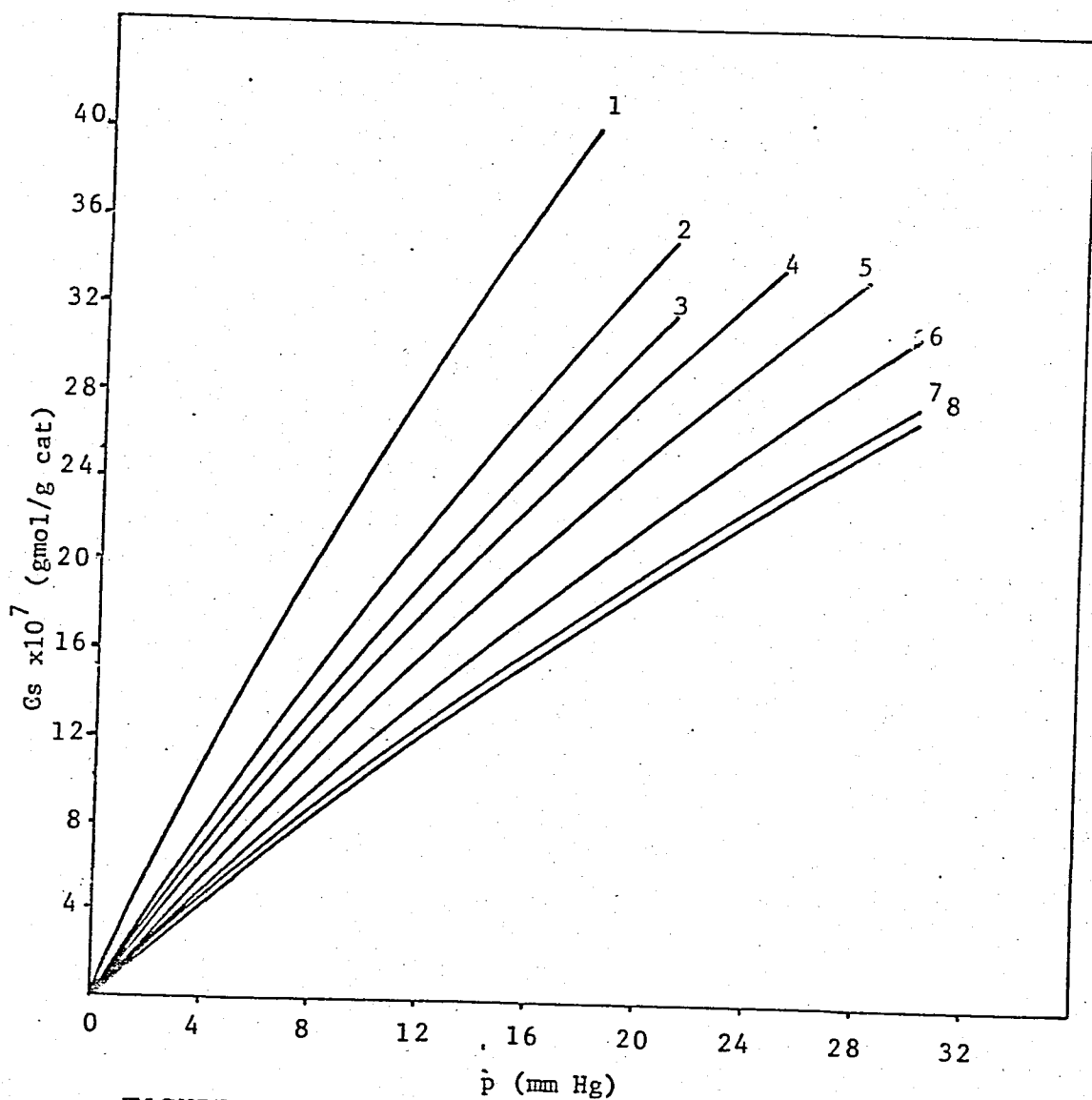


FIGURE 4.9 Adsorption Isotherms of n-Hexane at  $0.4 \mu\text{l}$  with Helium

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 186.05 °C | 5. | 218.17 °C |
| 2. | 197.93 °C | 6. | 225.64 °C |
| 3. | 205.59 °C | 7. | 230.82 °C |
| 4. | 211.11 °C | 8. | 235.31 °C |

TABLE 4.9 Adsorption Isotheres for n-Hexane at 0.4  $\mu$ l with He

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |       | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>e</sub> (°C) | 10 <sup>3</sup> /T <sub>e</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 186.05              | 2.178   | 1.763             | 0.567 | 3.601              | 1.281 | 5.519              | 1.708 | 7.523              | 2.018 |
| 197.93              | 2.123   | 2.465             | 0.902 | 5.024              | 1.614 | 7.683              | 2.039 | 10.449             | 2.347 |
| 205.59              | 2.089   | 2.771             | 1.019 | 5.652              | 1.732 | 8.650              | 2.158 | 11.771             | 2.466 |
| 211.11              | 2.065   | 2.987             | 1.094 | 6.107              | 1.810 | 9.370              | 2.238 | 12.786             | 2.548 |
| 218.17              | 2.035   | 3.441             | 1.236 | 7.021              | 1.949 | 10.751             | 2.375 | 14.640             | 2.684 |
| 225.64              | 2.005   | 3.932             | 1.369 | 8.065              | 2.088 | 12.418             | 2.519 | 17.006             | 2.834 |
| 230.82              | 1.984   | 4.269             | 1.451 | 8.833              | 2.179 | 13.724             | 2.619 | 18.978             | 2.943 |
| 235.31              | 1.967   | 4.381             | 1.447 | 9.079              | 2.206 | 14.131             | 2.648 | 19.578             | 2.974 |

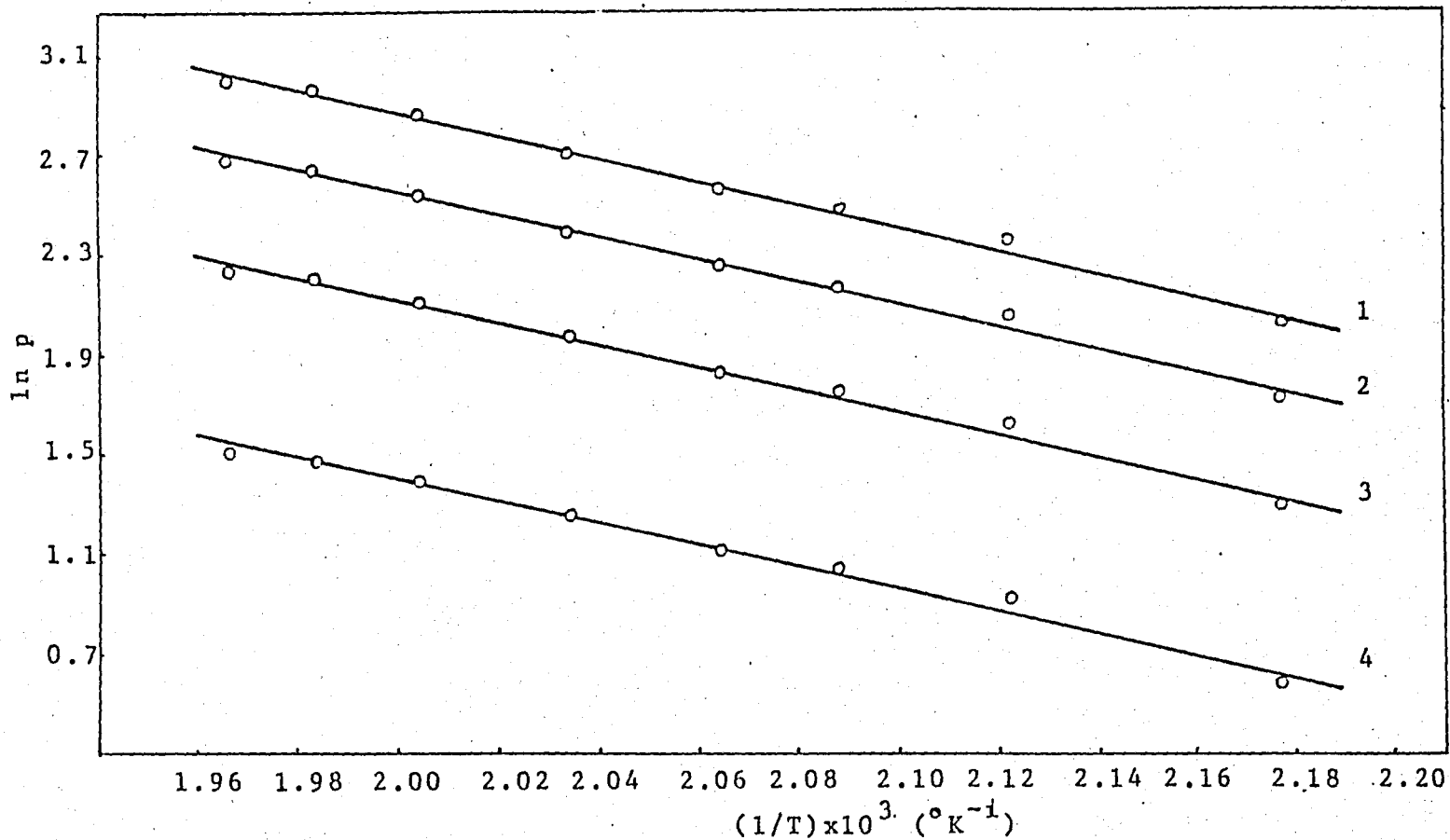


FIGURE 4.10 Adsorption Isosteres of n-Hexane at 0.4  $\mu$ l with Helium

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. At $20 \times 10^7$ gmol/g cat | 3. At $10 \times 10^7$ gmol/g cat |
| 2. At $15 \times 10^7$ gmol/g cat | 4. At $5 \times 10^7$ gmol/g cat  |

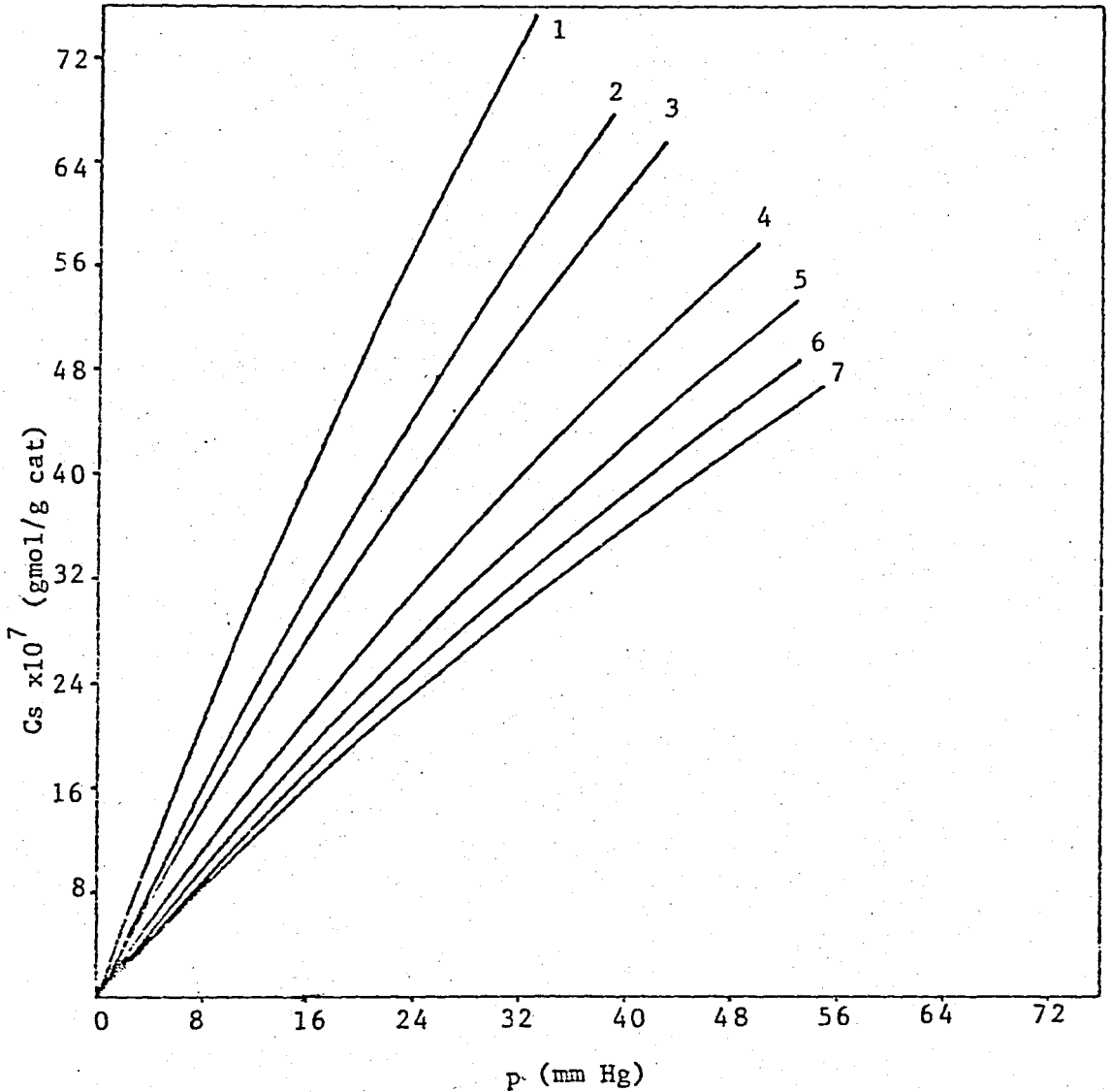


FIGURE 4.11 Adsorption Isotherms of n-Hexane at 0.8  $\mu$ l with Helium

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 185.81 °C | 5. | 225.49 °C |
| 2. | 196.99 °C | 6. | 230.83 °C |
| 3. | 203.35 °C | 7. | 235.21 °C |
| 4. | 218.26 °C |    |           |

TABLE 4.10 Adsorption Isotheres for n-Hexane at 0.8  $\mu$ l with He

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |       | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>e</sub> (°C) | 10 <sup>3</sup> /T <sub>e</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 185.81              | 2.179   | 1.857             | 0.619 | 3.755              | 1.323 | 5.695              | 1.740 | 7.678              | 2.038 |
| 196.99              | 2.127   | 2.445             | 0.894 | 4.949              | 1.599 | 7.156              | 2.017 | 10.146             | 2.317 |
| 203.35              | 2.099   | 2.756             | 1.014 | 5.586              | 1.720 | 8.492              | 2.139 | 11.479             | 2.441 |
| 211.07              | 2.065   | 2.988             | 1.095 | 6.073              | 1.804 | 9.258              | 2.225 | 12.548             | 2.530 |
| 218.26              | 2.035   | 3.559             | 1.270 | 7.241              | 1.980 | 11.052             | 2.403 | 14.998             | 2.708 |
| 225.49              | 2.006   | 4.066             | 1.403 | 8.289              | 2.115 | 12.678             | 2.540 | 17.243             | 2.847 |
| 230.83              | 1.984   | 4.376             | 1.476 | 8.958              | 2.193 | 13.760             | 2.622 | 18.799             | 2.934 |
| 235.21              | 1.967   | 4.773             | 1.563 | 9.768              | 2.279 | 15.001             | 2.708 | 20.490             | 3.020 |

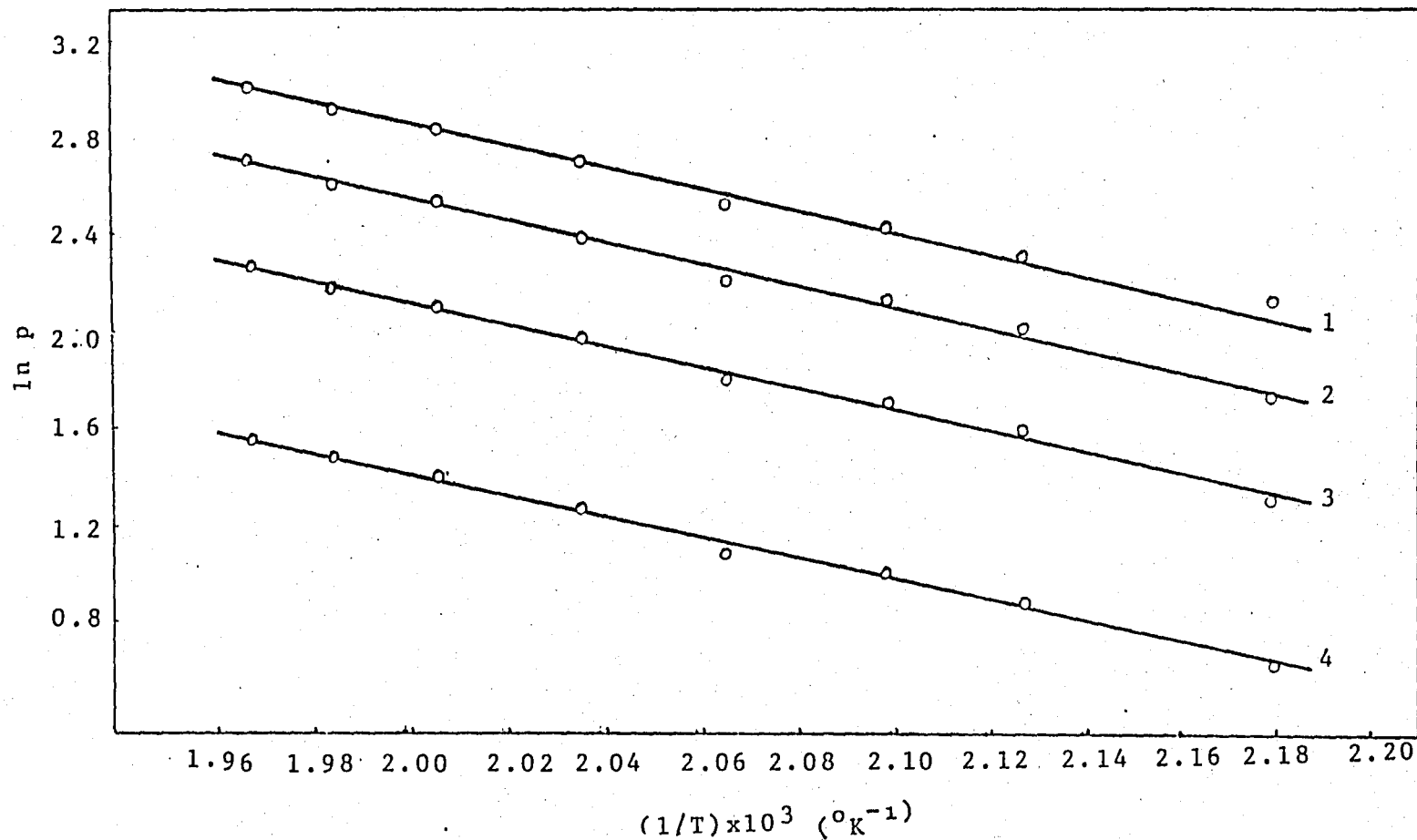


FIGURE 4.12 Adsorption Isosteres of n-Hexane at 0.8  $\mu$ l with Helium

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. At $20 \times 10^7$ gmol/g cat | 3. At $10 \times 10^7$ gmol/g cat |
| 2. At $15 \times 10^7$ gmol/g cat | 4. At $5 \times 10^7$ gmol/g cat  |

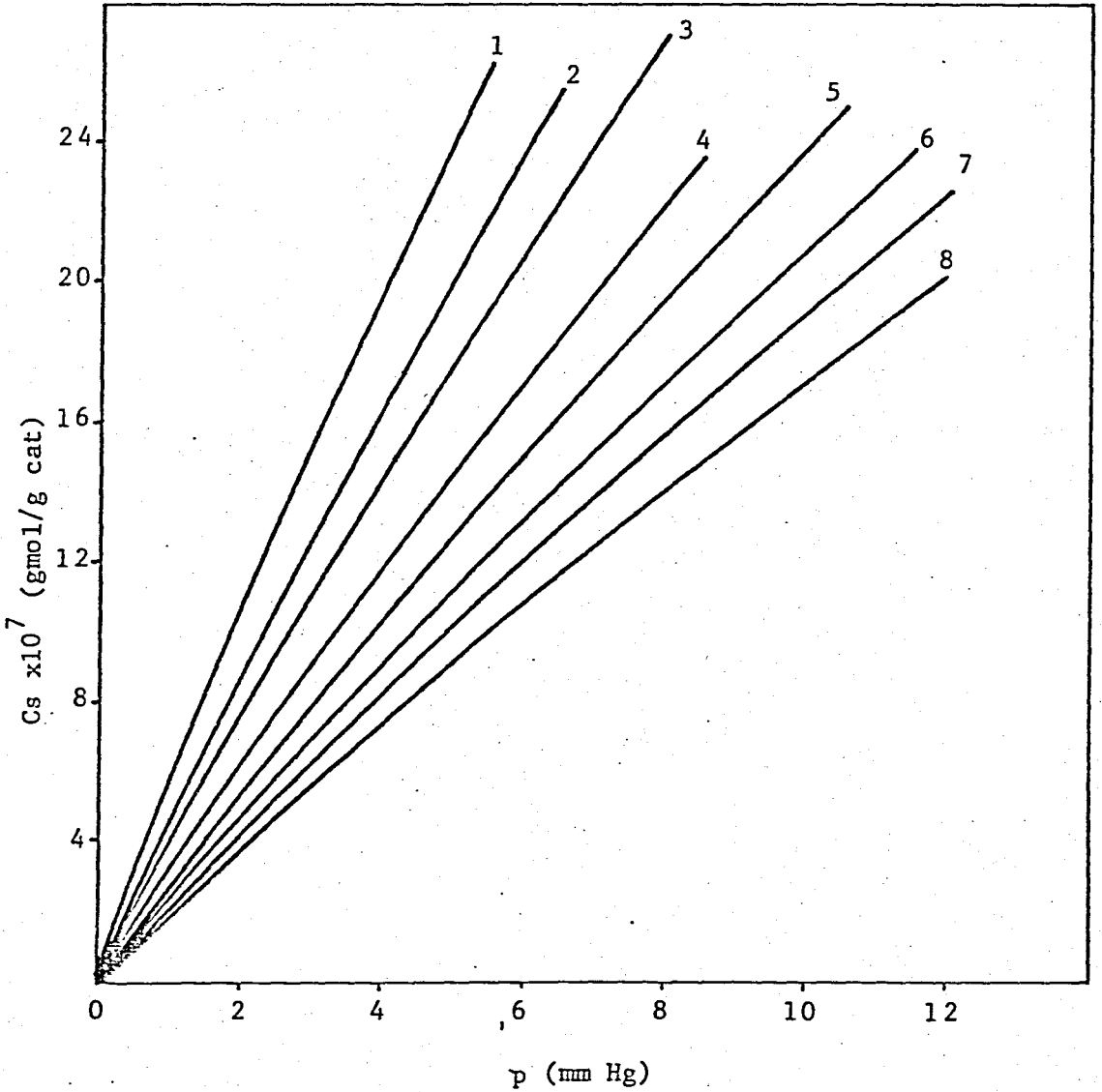


FIGURE 4.13 Adsorption Isotherms of n-Heptane at 0.2  $\mu$ l with Helium

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 185.24 °C | 5. | 217.49 °C |
| 2. | 193.34 °C | 6. | 224.97 °C |
| 3. | 201.51 °C | 7. | 229.87 °C |
| 4. | 207.39 °C | 8. | 234.29 °C |

TABLE 4.11 Adsorption Isosteres for n-Heptane at 0.2  $\mu$ l with He

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |        | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|--------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>c</sub> (°C) | 10 <sup>3</sup> /T <sub>c</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p   | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 185.24              | 2.182   | 0.949             | -0.053 | 1.939              | 0.662 | 2.973              | 1.090 | 4.055              | 1.400 |
| 193.34              | 2.144   | 1.166             | 0.154  | 2.381              | 0.868 | 3.649              | 1.295 | 4.973              | 1.604 |
| 201.51              | 2.107   | 1.356             | 0.305  | 2.759              | 1.015 | 4.212              | 1.438 | 5.718              | 1.744 |
| 207.39              | 2.081   | 1.641             | 0.495  | 3.364              | 1.213 | 5.174              | 1.644 | 7.078              | 1.957 |
| 217.49              | 2.038   | 1.929             | 0.657  | 3.935              | 1.370 | 6.023              | 1.796 | 8.198              | 2.104 |
| 224.97              | 2.008   | 2.199             | 0.788  | 4.506              | 1.505 | 6.929              | 1.936 | 9.477              | 2.249 |
| 229.87              | 1.988   | 2.437             | 0.891  | 4.994              | 1.608 | 7.680              | 2.039 | 10.506             | 2.352 |
| 234.29              | 1.971   | 2.687             | 0.988  | 5.541              | 1.712 | 8.578              | 2.149 | 11.817             | 2.470 |

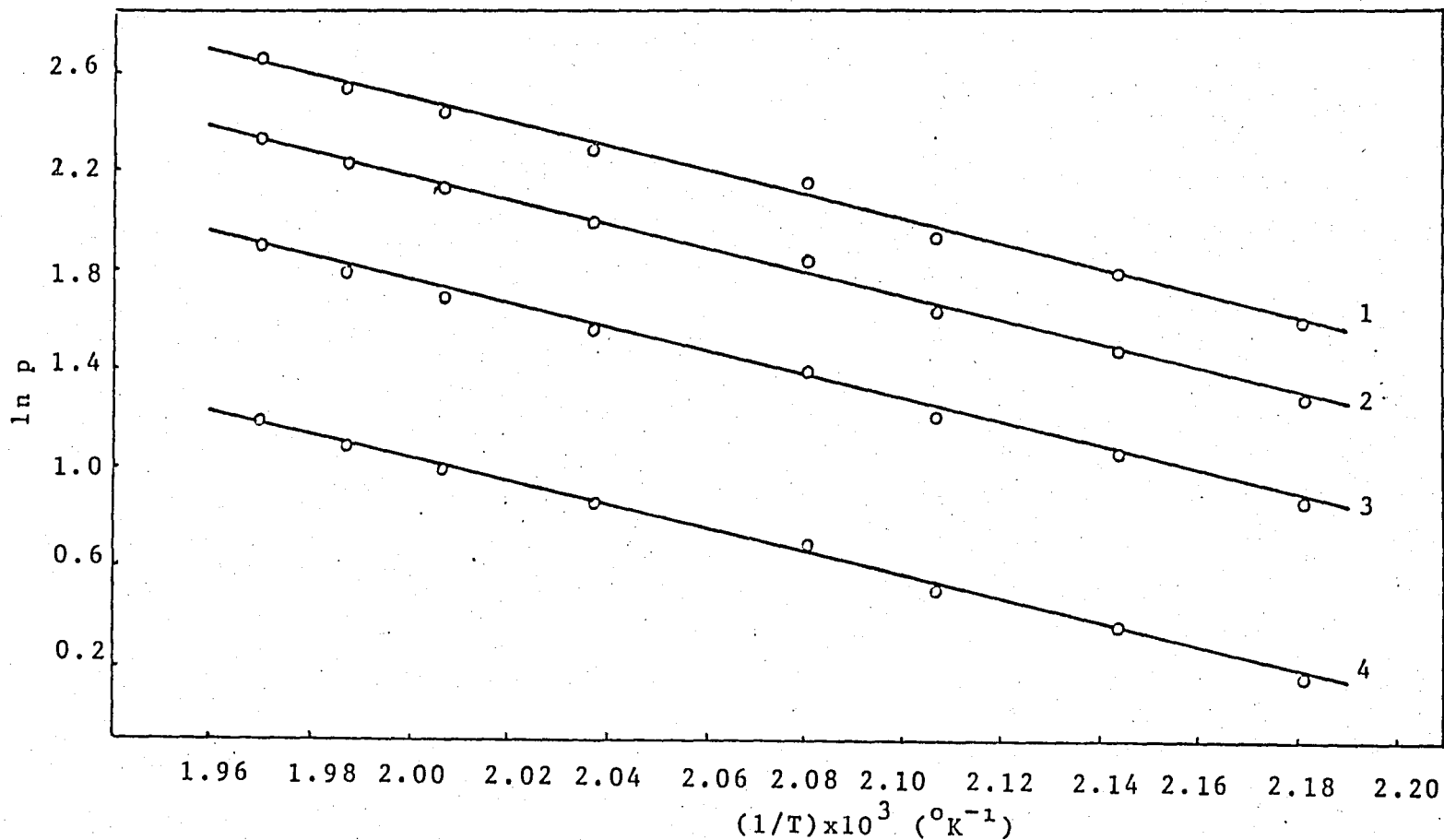


FIGURE 4.14 Adsorption Isosteres of n-Heptane at 0.2  $\mu$ l with Helium

- |                                       |                                       |
|---------------------------------------|---------------------------------------|
| 1. At 20 x 10 <sup>7</sup> gmol/g cat | 3. At 10 x 10 <sup>7</sup> gmol/g cat |
| 2. At 15 x 10 <sup>7</sup> gmol/g cat | 4. At 5 x 10 <sup>7</sup> gmol/g cat  |

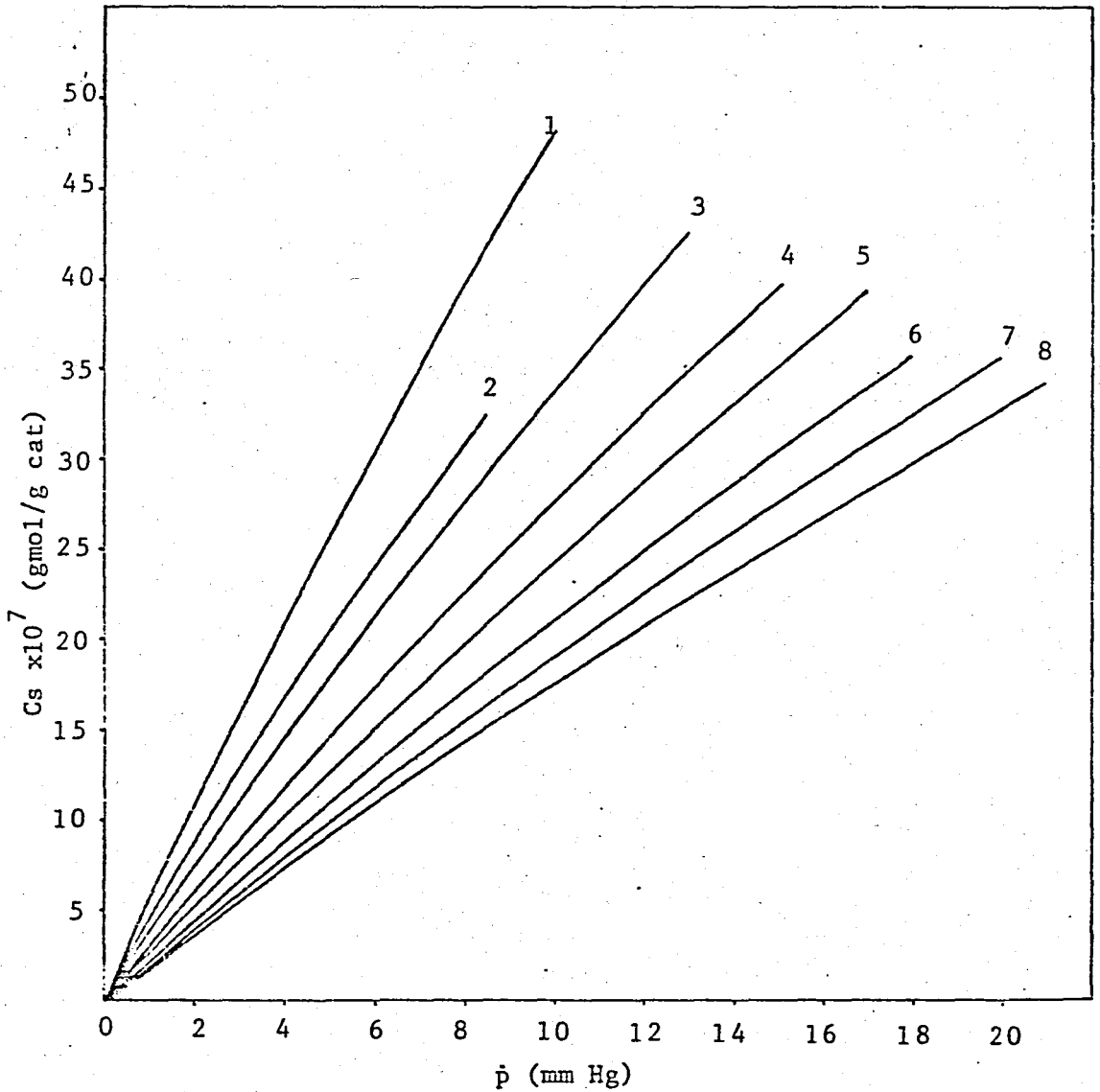


FIGURE 4.15 Adsorption Isotherms of n-Heptane at 0.4  $\mu$ l with Helium

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 185.24 °C | 5. | 217.47 °C |
| 2. | 193.32 °C | 6. | 225.01 °C |
| 3. | 201.62 °C | 7. | 229.90 °C |
| 4. | 207.40 °C | 8. | 234.31 °C |

TABLE 4.12 Adsorption Isotherms for n-Heptane at 0.4  $\mu$ l with He

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |        | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|--------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>e</sub> (°C) | 10 <sup>3</sup> /T <sub>e</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p   | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 185.24              | 2.182   | 0.941             | -0.061 | 1.902              | 0.643 | 2.885              | 1.060 | 3.889              | 1.358 |
| 193.32              | 2.144   | 1.129             | 0.121  | 2.315              | 0.894 | 3.562              | 1.270 | 4.875              | 1.584 |
| 201.62              | 2.106   | 1.349             | 0.300  | 2.741              | 1.008 | 4.176              | 1.429 | 5.657              | 1.733 |
| 207.40              | 2.081   | 1.695             | 0.527  | 3.443              | 1.236 | 5.247              | 1.658 | 7.110              | 1.962 |
| 217.47              | 2.038   | 1.939             | 0.662  | 3.938              | 1.371 | 5.999              | 1.792 | 8.126              | 2.095 |
| 225.01              | 2.007   | 2.246             | 0.809  | 4.572              | 1.520 | 6.981              | 1.943 | 9.478              | 2.249 |
| 229.90              | 1.988   | 2.523             | 0.925  | 5.132              | 1.635 | 7.831              | 2.058 | 10.625             | 2.363 |
| 234.31              | 1.971   | 2.741             | 1.008  | 5.589              | 1.721 | 8.549              | 2.146 | 11.629             | 2.454 |

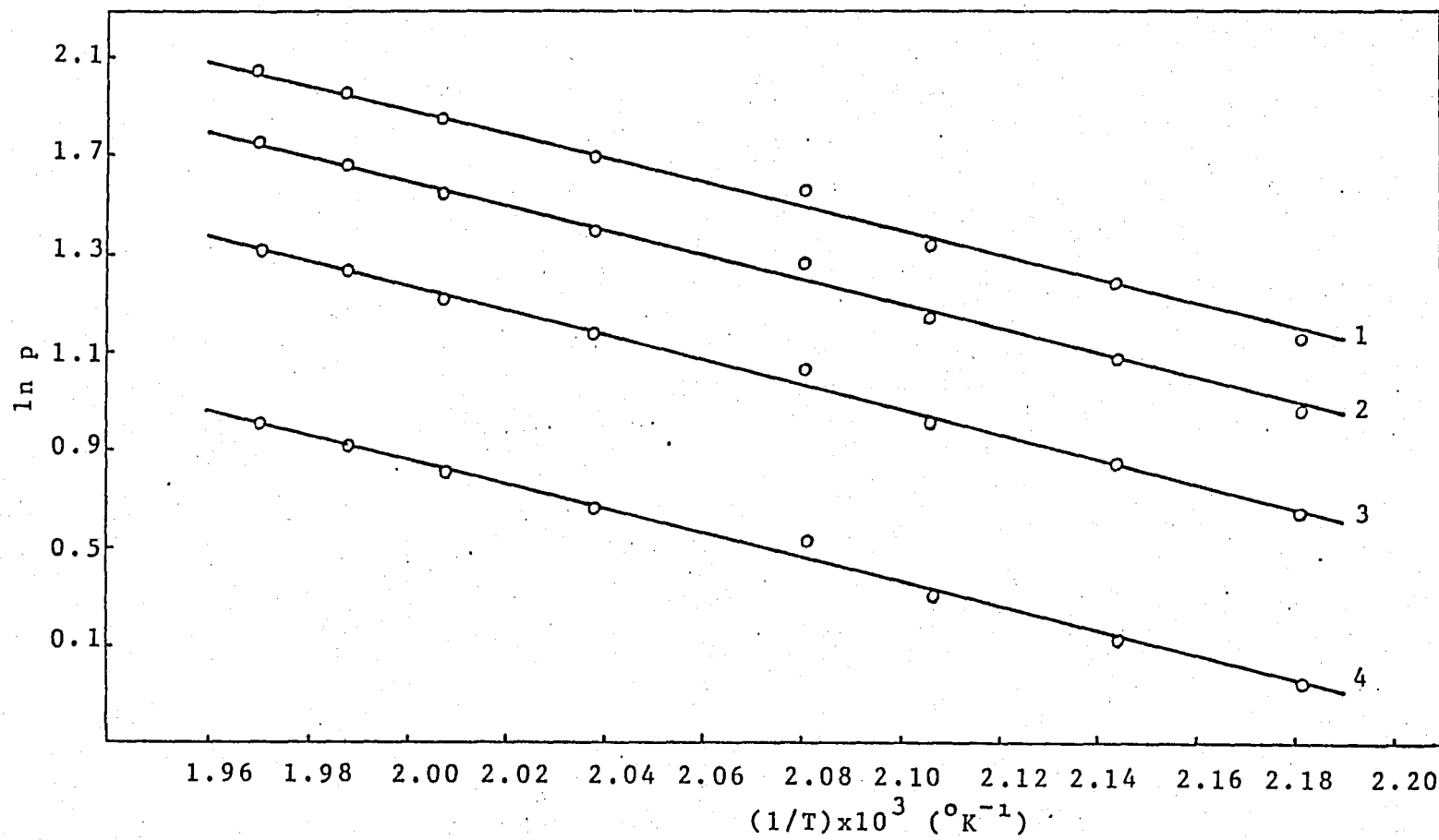


FIGURE 4.16 Adsorption Isosteres of n-Heptane at 0.4 μl with Helium

- |                                       |                                       |
|---------------------------------------|---------------------------------------|
| 1. At 20 x 10 <sup>7</sup> gmol/g cat | 3. At 10 x 10 <sup>7</sup> gmol/g cat |
| 2. At 15 x 10 <sup>7</sup> gmol/g cat | 4. At 5 x 10 <sup>7</sup> gmol/g cat  |

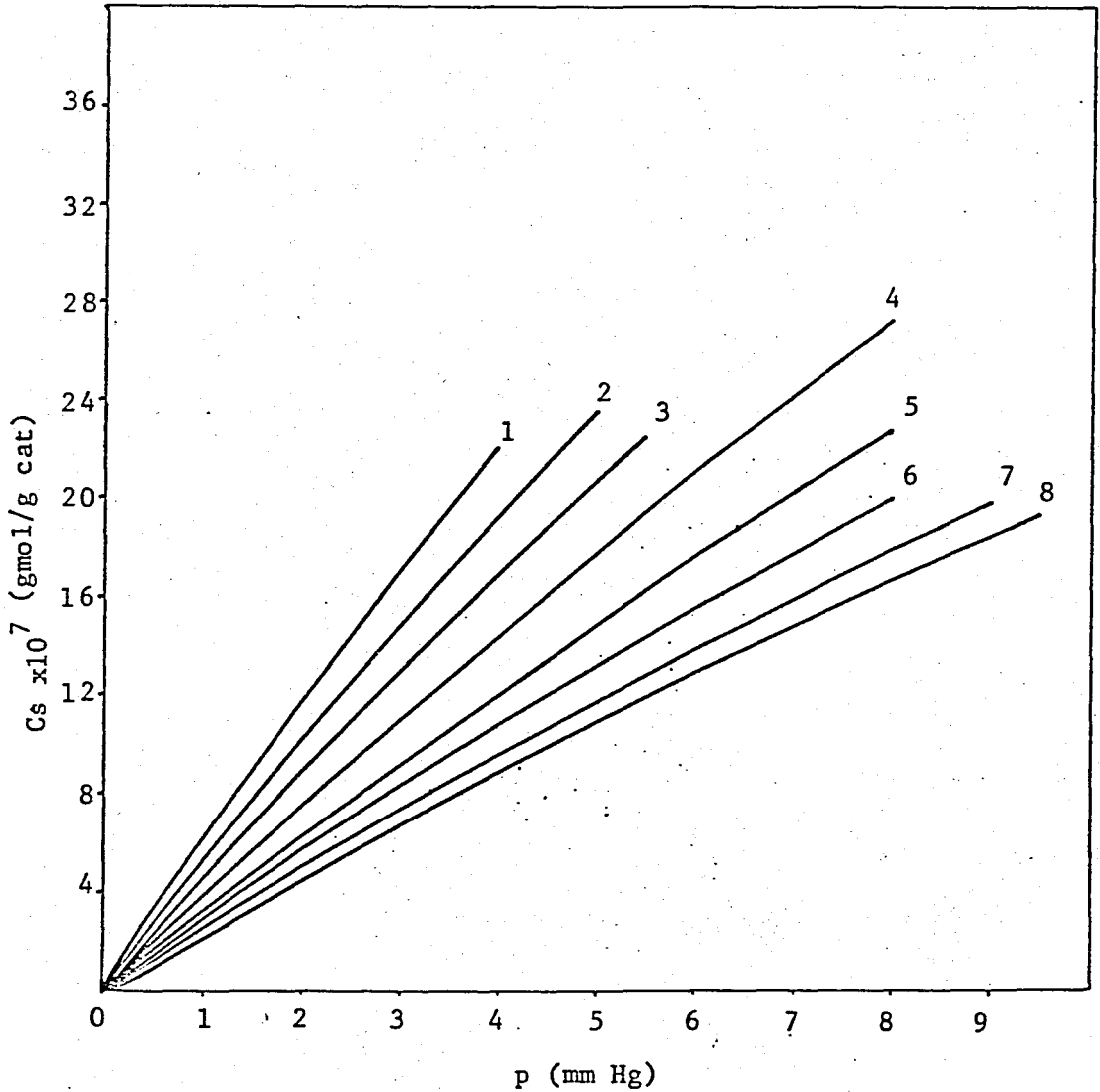


FIGURE 4.17 Adsorption Isotherms of *i*-Octane  
at 0.2  $\mu$ l with Helium

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 185.25 °C | 5. | 217.47 °C |
| 2. | 193.33 °C | 6. | 224.87 °C |
| 3. | 201.59 °C | 7. | 229.84 °C |
| 4. | 209.91 °C | 8. | 234.26 °C |

TABLE 4.13 Adsorption Isotherms for i-Octane at 0.2  $\mu$ l with He

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |        | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|--------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>e</sub> (°C) | 10 <sup>3</sup> /T <sub>e</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p   | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 185.25              | 2.182   | 0.812             | -0.208 | 1.673              | 0.515 | 2.589              | 0.951 | 3.564              | 1.271 |
| 193.33              | 2.144   | 0.961             | -0.040 | 1.968              | 0.677 | 3.024              | 1.107 | 4.133              | 1.419 |
| 201.59              | 2.106   | 1.098             | 0.094  | 2.263              | 0.817 | 3.499              | 1.253 | 4.815              | 1.572 |
| 209.91              | 2.070   | 1.340             | 0.293  | 2.733              | 1.005 | 4.181              | 1.431 | 5.688              | 1.738 |
| 217.47              | 2.038   | 1.614             | 0.479  | 3.301              | 1.194 | 5.066              | 1.623 | 6.916              | 1.934 |
| 224.87              | 2.008   | 1.836             | 0.607  | 3.775              | 1.329 | 5.828              | 1.763 | 8.004              | 2.800 |
| 229.84              | 1.988   | 2.032             | 0.709  | 4.207              | 1.437 | 6.539              | 1.878 | 9.048              | 2.203 |
| 234.26              | 1.971   | 2.231             | 0.802  | 4.602              | 1.526 | 7.126              | 1.964 | 9.819              | 2.284 |

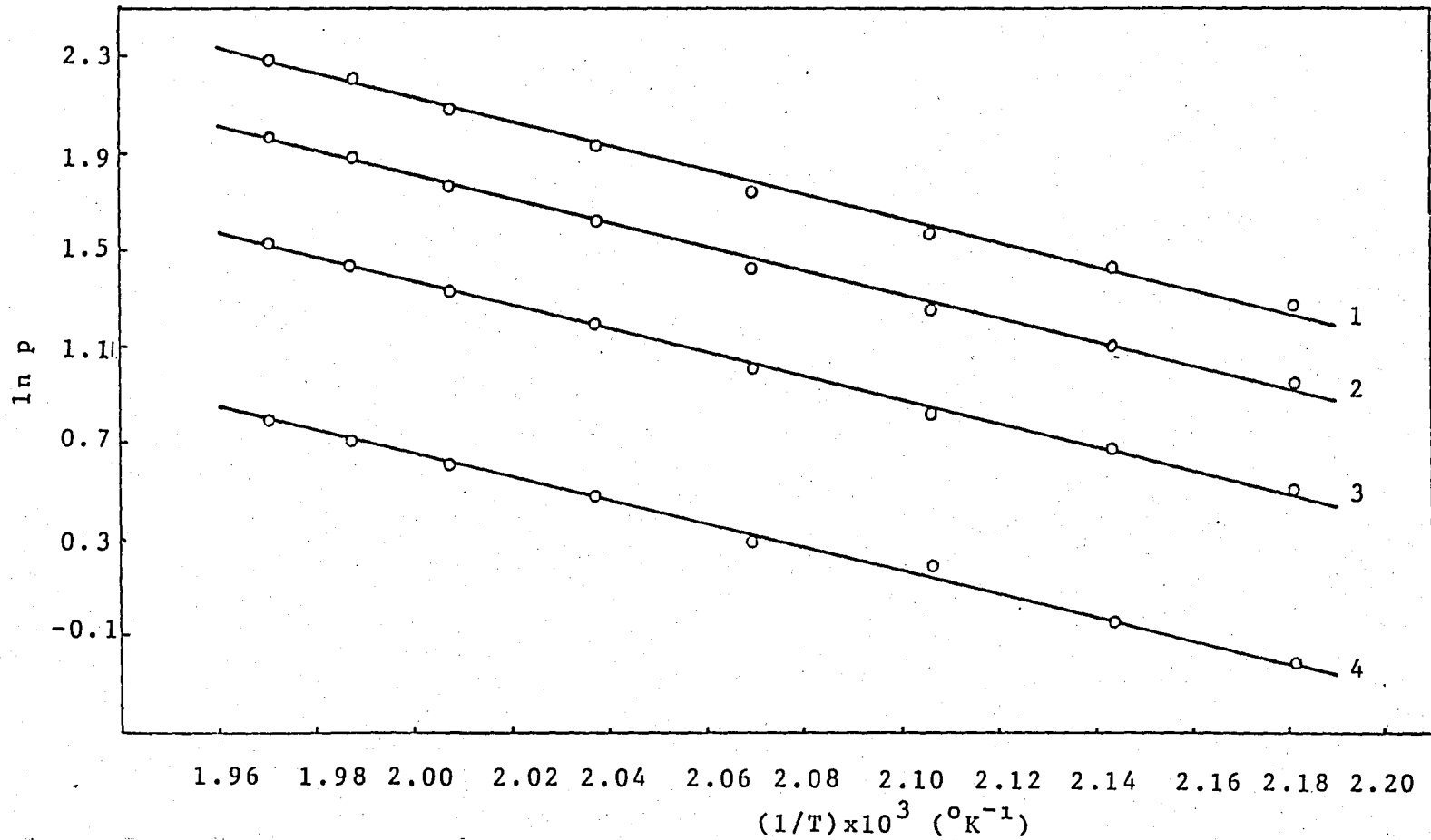


FIGURE 4.18 Adsorption Isosteres of i-Octane at 0.2  $\mu$ l with Helium

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. At $20 \times 10^7$ gmol/g cat | 3. At $10 \times 10^7$ gmol/g cat |
| 2. At $15 \times 10^7$ gmol/g cat | 4. At $5 \times 10^7$ gmol/g cat  |

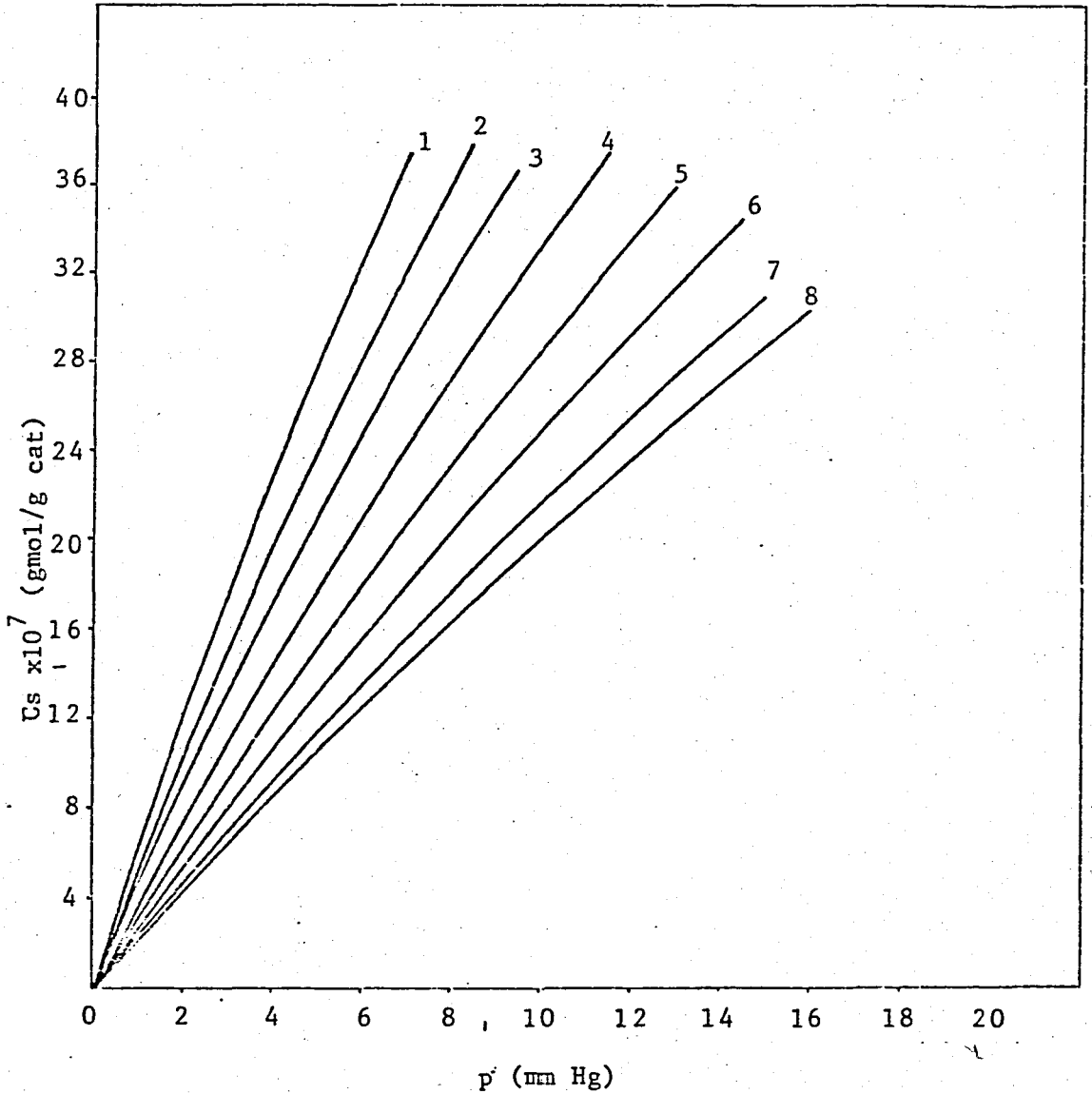


FIGURE 4.19 Adsorption Isotherms of *i*-Octane at 0.4  $\mu$ l with Helium

|    |           |    |           |
|----|-----------|----|-----------|
| 1. | 185.27 °C | 5. | 217.44 °C |
| 2. | 193.30 °C | 6. | 224.48 °C |
| 3. | 201.65 °C | 7. | 229.84 °C |
| 4. | 209.99 °C | 8. | 234.34 °C |

TABLE 4.14 Adsorption Isotherms for i-Octane at 0.4  $\mu$ l with He

| Cs (gmol/g cat)     |   | 5x10 <sup>7</sup> |        | 10x10 <sup>7</sup> |       | 15x10 <sup>7</sup> |       | 20x10 <sup>7</sup> |       |
|---------------------|---|-------------------|--------|--------------------|-------|--------------------|-------|--------------------|-------|
| T <sub>e</sub> (°C) | 10 <sup>3</sup> /T <sub>e</sub> (°K <sup>-1</sup> ) | p(mmHg)           | ln p   | p(mmHg)            | ln p  | p(mmHg)            | ln p  | p(mmHg)            | ln p  |
| 185.27              | 2.181   | 0.819             | -0.199 | 1.673              | 0.515 | 2.563              | 0.941 | 3.492              | 1.250 |
| 193.30              | 2.144   | 0.985             | -0.002 | 2.007              | 0.697 | 3.068              | 1.121 | 4.170              | 1.428 |
| 201.65              | 2.106   | 1.123             | 0.116  | 2.291              | 0.829 | 3.508              | 1.255 | 4.777              | 1.564 |
| 209.99              | 2.070   | 1.354             | 0.303  | 2.757              | 1.014 | 4.213              | 1.438 | 5.723              | 1.745 |
| 217.44              | 2.038   | 1.601             | 0.471  | 3.263              | 1.183 | 4.989              | 1.607 | 6.782              | 1.914 |
| 224.48              | 2.010   | 1.859             | 0.620  | 3.791              | 1.333 | 5.802              | 1.758 | 7.896              | 2.006 |
| 229.84              | 1.988   | 2.159             | 0.770  | 4.410              | 1.484 | 6.759              | 1.911 | 9.212              | 2.221 |
| 234.34              | 1.971   | 2.342             | 0.851  | 4.791              | 1.567 | 7.347              | 1.994 | 10.025             | 2.305 |

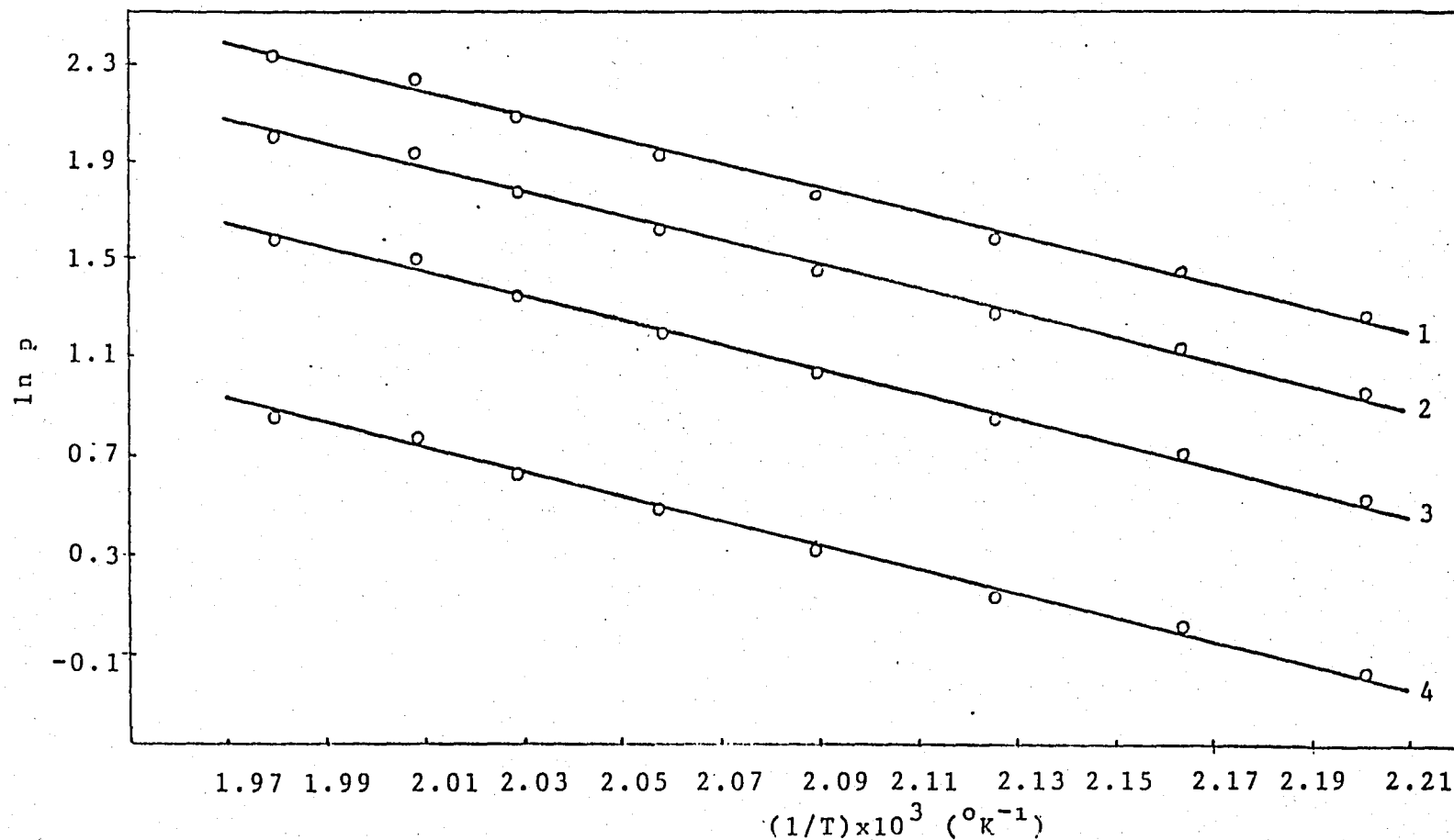


FIGURE 4.20 Adsorption Isosteres of i-Octane at 0.4  $\mu\text{l}$  with Helium

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. At $20 \times 10^7$ gmol/g cat | 3. At $10 \times 10^7$ gmol/g cat |
| 2. At $15 \times 10^7$ gmol/g cat | 4. At $5 \times 10^7$ gmol/g cat  |

TABLE 4.15 Heats of Adsorption of Hydrocarbons

| Compound                                       | Temperature Range (°C) | Cs $\times 10^7$ gmol/gcat) | Q <sub>ads</sub> (kJ/gmol) |
|--|------------------------|-----------------------------|----------------------------|
| n-Pentane<br>(0.4 $\mu$ l and H <sub>2</sub> ) | 187.39-234.94          | 5                           | 22.3( $\pm 3.9$ )*         |
|  |                        | 10                          | 22.6( $\pm 3.3$ )*         |
|  |                        | 15                          | 23.3( $\pm 3.4$ )*         |
|  |                        | 20                          | 27.2( $\pm 4.6$ )*         |
| n-Pentane<br>(0.4 $\mu$ l and He)              | 186.17-235.25          | 5                           | 25.4( $\pm 2.3$ )*         |
|  |                        | 10                          | 27.3( $\pm 2.5$ )*         |
|  |                        | 15                          | 29.7( $\pm 2.7$ )*         |
|  |                        | 20                          | 32.0( $\pm 3.0$ )*         |
| n-Pentane<br>(0.8 $\mu$ l and He)              | 185.71-235.31          | 5                           | 27.4( $\pm 2.6$ )*         |
|  |                        | 10                          | 28.7( $\pm 3.6$ )*         |
|  |                        | 15                          | 30.0( $\pm 3.0$ )*         |
|  |                        | 20                          | 31.5( $\pm 2.9$ )*         |
| n-Hexane<br>(0.4 $\mu$ l and H <sub>2</sub> )  | 187.39-234.98          | 5                           | 34.5( $\pm 0.7$ )*         |
|  |                        | 10                          | 35.9( $\pm 0.8$ )*         |
|  |                        | 15                          | 37.3( $\pm 1.0$ )*         |
|  |                        | 20                          | 38.9( $\pm 1.3$ )*         |
| n-Hexane<br>(0.4 $\mu$ l and He)               | 186.05-235.3           | 5                           | 35.5( $\pm 1.5$ )*         |
|  |                        | 10                          | 36.1( $\pm 1.4$ )*         |
|  |                        | 15                          | 36.7( $\pm 1.3$ )*         |
|  |                        | 20                          | 37.4( $\pm 1.3$ )*         |
| n-Hexane<br>(0.8 $\mu$ l and He)               | 185.81-235.21          | 5                           | 36.1( $\pm 1.1$ )*         |
|  |                        | 10                          | 36.7( $\pm 1.0$ )*         |
|  |                        | 15                          | 37.2( $\pm 1.0$ )*         |
|  |                        | 20                          | 37.7( $\pm 1.4$ )*         |
| n-Heptane<br>(0.2 $\mu$ l and He)              | 185.24-234.29          | 5                           | 40.3( $\pm 0.9$ )*         |
|  |                        | 10                          | 40.5( $\pm 1.0$ )*         |
|  |                        | 15                          | 40.8( $\pm 1.1$ )*         |
|  |                        | 20                          | 41.1( $\pm 1.2$ )*         |
| n-Heptane<br>(0.4 $\mu$ l and He)              | 185.24-234.31          | 5                           | 42.1( $\pm 1.4$ )*         |
|  |                        | 10                          | 42.2( $\pm 1.4$ )*         |
|  |                        | 15                          | 42.3( $\pm 1.4$ )*         |
|  |                        | 20                          | 41.2( $\pm 1.6$ )*         |
| i-Octane<br>(0.2 $\mu$ l and He)               | 185.25-234.26          | 5                           | 40.3( $\pm 0.9$ )*         |
|  |                        | 10                          | 40.5( $\pm 1.0$ )*         |
|  |                        | 15                          | 40.6( $\pm 1.0$ )*         |
|  |                        | 20                          | 40.8( $\pm 1.2$ )*         |
| i-Octane<br>(0.4 $\mu$ l and He)               | 185.27-234.34          | 5                           | 41.3( $\pm 1.3$ )*         |
|  |                        | 10                          | 41.6( $\pm 1.3$ )*         |
|  |                        | 15                          | 41.6( $\pm 1.3$ )*         |
|  |                        | 20                          | 41.7( $\pm 1.3$ )*         |

\* Errors in heats of adsorption were calculated using the method given by Mickley, et.al.(1957)

TABLE 4.16 Average Heats of Adsorption of Hydrocarbons

| Compound                                       | Temperature Range (°C) | $Q_{ads}$ (kcal/gmol) | $Q_{ads}$ (kJ/gmol) |
|--|------------------------|-----------------------|---------------------|
| n-Pentane<br>(0.4 $\mu$ l and H <sub>2</sub> ) | 187.39-234.94          | 5.7                   | 23.8                |
| n-Pentane<br>(0.4 $\mu$ l and He)              | 186.17-235.25          | 6.8                   | 28.6                |
| n-Pentane<br>(0.8 $\mu$ l and He)              | 185.71-235.31          | 7.0                   | 29.4                |
| n-Hexane<br>(0.4 $\mu$ l and H <sub>2</sub> )  | 187.39-234.98          | 8.8                   | 36.7                |
| n-Hexane<br>(0.4 $\mu$ l and He)               | 186.05-235.31          | 8.7                   | 36.4                |
| n-Hexane<br>(0.8 $\mu$ l and He)               | 185.81-235.21          | 8.8                   | 36.9                |
| n-Heptane<br>(0.2 $\mu$ l and He)              | 185.24-234.29          | 9.7                   | 40.7                |
| n-Heptane<br>(0.4 $\mu$ l and He)              | 185.24-234.31          | 10.0                  | 42.0                |
| i-Octane<br>(0.2 $\mu$ l and He)               | 185.25-234.26          | 9.7                   | 40.6                |
| i-Octane<br>(0.4 $\mu$ l and He)               | 185.27-234.34          | 10.0                  | 41.6                |

Elution peaks with a sharp front and a tailing rear boundary give isotherms which are concave to the pressure axis (Gregg and Stock, 1958). The same result is observed in this study but this curvature of the isotherms are not clearly seen because of the small curvature of the isotherms at the low partial pressures used.

In order to investigate the effects of sample size, the experiments were carried out at two different sample sizes for each hydrocarbon. The sample sizes were chosen large enough to obtain as high partial pressures as possible. The sample size for n-pentane and n-hexane are 0.8  $\mu\text{l}$  and 0.4  $\mu\text{l}$ , but for n-heptane and i-octane, the sample size of 0.8  $\mu\text{l}$  caused peak tailing. Sample sizes of 0.4  $\mu\text{l}$  and 0.2  $\mu\text{l}$  were used for these hydrocarbons to prevent the peak tailing and to compare the heats of adsorption of all hydrocarbons at the same sample size (0.4  $\mu\text{l}$ ). The heats of adsorption obtained at different sample sizes are very close to each other as seen in Table 4.16. This result shows that the effect of sample size is not too significant within this range. Accordingly, the results obtained with 0.4  $\mu\text{l}$  samples are discussed and compared in the following paragraphs.

The heats of adsorption of n-pentane and n-hexane were also determined using hydrogen as the carrier gas. The heat of adsorption found with hydrogen is about 4.8 kJ/gmol smaller than that found with helium for n-pentane and 0.3 kJ/gmol greater for n-hexane. It is difficult to draw a conclusion about the effect of hydrogen adsorption on the basis of this result. Although two values are very close for n-hexane, the difference is relatively large for n-pentane.

There are several criteria to determine the nature of the adsorbed state (Hayward and Trapnell, 1964, Thomas

and Thomas, 1967). The heat of adsorption and the temperature range involved are the most important among them. Physical adsorption generally occurs only at temperatures close to the boiling point of the adsorbate and heat of adsorption is not greater than the heat of condensation. Chemisorption, on the other hand, occurs at higher temperatures with higher heats of adsorption.

The boiling points and corresponding heats of vaporization of the hydrocarbons investigated are listed with the average heats of adsorption obtained at 0.4  $\mu$ l in Table 4.17. The heats of vaporization were extrapolated to the operating temperatures by Watson Equation (Reid, Prausnitz and Sherwood, 1977):

$$(\Delta H_v)_2 = (\Delta H_v)_1 \left[ \frac{(1-T_{r2})}{(1-T_{r1})} \right]^{0.38} \quad (4.1)$$

where  $(\Delta H_v)_1$  is the heat of vaporization and  $T_{r1}$  is the reduced temperature at the boiling point and  $(\Delta H_v)_2$  and  $T_{r2}$  are the values at any higher temperature. Since the Watson equation does not give good results at high reduced temperatures, i.e.  $T_r > 0.84$ , scaling of  $H_v$  with temperature has been restricted to the temperatures corresponding to  $T_r$  values lower than 0.84. For example for n-pentane, when  $T_2 = 121.3$  °C,  $T_r = 0.84$ ; in this case,  $H_v$  has been extrapolated to 120 °C although this

temperature is well below the adsorption temperatures used. However, the heat of vaporization decreases with increasing temperature (Reid, Prausnitz and Sherwood, 1979), the actual  $\Delta H_v$  value for n-pentane is somewhat smaller than the value at 120 °C.

As shown in Table 4.17, the average heats of adsorption are sufficiently larger than the corresponding heats of vaporization. Furthermore the temperature range involved is well above the boiling points of all the samples used indicating the occurrence of chemisorption. The result is in agreement with the result obtained for the same hydrocarbons on the same catalyst by Beler (1981).

Adsorption studies on graphitized carbon black (Kiselev et al., 1968; Kiselev and Yashin, 1969), on macroporous silica gel (Kiselev and Yashin, 1969), on zeolites (Kiselev and Yashin, 1969; Attonucci et al., 1978) on 0.6 % wt Pt/Al<sub>2</sub>O<sub>3</sub> (Choudhary and Menon, 1976) and on the same 0.3 %wt Pt/Al<sub>2</sub>O<sub>3</sub> catalyst used in this study (Beler, 1981) have shown that the heat of adsorption increases with increasing carbon number in a homologous series and that the linear increase is obtained for normal paraffins.

The heats of adsorption of three normal paraffins (n-pentane, n-hexane and n-heptane) used in the present study are plotted against the carbon number, n, in Figure 4.21 and the result is the same with the results of the

TABLE 4.17 Comparison of Heats of Adsorption and Heats of Condensation

| Compound  | $T_b$<br>(°C) | $-\Delta H_v$ at $T_b$<br>(kJ/gmol) | T<br>(°C) | $-\Delta H_v$ at T<br>(kJ/gmol) | Temperature<br>Range (°C) | $Q_{ads}$<br>(kJ/gmol) |
|-----------|---------------|-------------------------------------|-----------|---------------------------------|---------------------------|------------------------|
| n-Pentane | 36.0          | 25.8                                | 120.0     | 19.4                            | 186.17-235.25             | 28.6                   |
| n-Hexane  | 68.7          | 28.9                                | 150.0     | 22.3                            | 186.05-235.31             | 36.4                   |
| n-Heptane | 98.4          | 31.7                                | 180.0     | 24.6                            | 185.24-234.31             | 42.0                   |
| i-Octane  | 99.2          | 31.0                                | 180.0     | 24.4                            | 185.27-234.34             | 41.6                   |

authors mentioned above. A straight line is obtained from the least squares fit. Since the only i-octane is investigated as isoparaffin, it is impossible to make a general statement about isoparaffins.

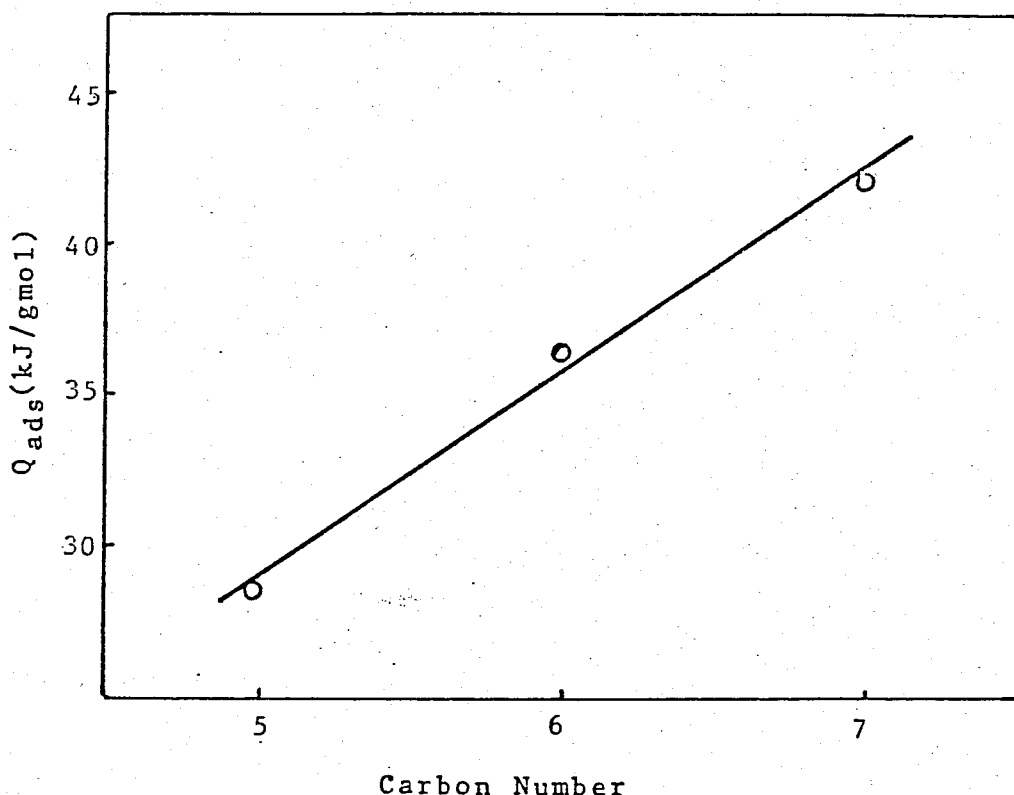


FIGURE 4.21 Relation Between Heats of Adsorption and Carbon Number

The heats of adsorption found in this study are greater than those obtained by Choudhary and Menon (1976) and Beler (1981) who have studied for the same hydrocarbons using infinite retention volumes. This difference may come from the difference between the techniques used. A comparison of the results obtained by the same authors above and Önsan (1979), who have all used the infinite dilution technique, with the results of Gönenc (1985) who has used the present technique yields a

similar result for cycloparaffins and aromatics. The results obtained in different studies are summarized in Table 4.18.

TABLE 4.18 Comparison of Heats of Adsorption on Pt/Al<sub>2</sub>O<sub>3</sub>

| Compound          | Q <sub>ads</sub> (kcal/gmol) |                  |                  |                   |                                  |
|-------------------|------------------------------|------------------|------------------|-------------------|----------------------------------|
|                   | Present Study *              | Gönenç (1985) ** | Belçer (1981) ** | Önsan (1979) **** | Choudhary and Menon (1976) ***** |
| n-Pentane         | 6.8                          | -                | 6.84             | -                 | 5.2                              |
| n-Hexane          | 8.7                          | -                | 8.16             | -                 | 7.7                              |
| n-Heptane         | 10.0                         | -                | 8.95             | -                 | 10.8                             |
| i-Octane          | 10.0                         | -                | 9.61             | -                 | -                                |
| Cyclohexane       | -                            | 7.48             | 4.68             | 5.11              | -                                |
| Methylcyclohexane | -                            | 7.45             | 4.93             | 5.53              | -                                |
| Benzene           | -                            | 13.11            | -                | 10.58             | 11.2                             |
| Toluene           | -                            | 13.90            | -                | 11.65             | 14.4                             |

\* at the sample size of 0.4 µl

\*\* on 0.3 wt % Pt/Al<sub>2</sub>O<sub>3</sub> and in the range of 187-235 °C

\*\*\* on 0.3 wt % Pt/Al<sub>2</sub>O<sub>3</sub> and in the range of 185-235 °C

\*\*\*\* on 0.3 wt % Pt/Al<sub>2</sub>O<sub>3</sub> and in the range of 195-240 °C

\*\*\*\*\* on 0.6 wt % Pt/Al<sub>2</sub>O<sub>3</sub> and in the range of 185-380 °C

## V. CONCLUSIONS AND RECOMMENDATIONS

The conclusions that can be drawn from the literature survey and the experimental work are summarized below together with recommendations for further work.

1. Elution peaks with a sharp front and tailing rear boundary give adsorption isotherms that are concave to the pressure axis.
2. Adsorption isotherm can be obtained from a single reproducible elution peak using  $c(t)$  versus  $t$  profiles.
3. Heats of adsorptions can be determined from the isosteres obtained from these adsorption isotherms.
4. The average heats of adsorption were found to be 28.6 kJ/gmol for n-pentane, 36.4 kJ/gmol for n-hexane, 42.0 kJ/gmol for n-heptane and 41.6 kJ/gmol for i-octane(0.4  $\mu$ l samples). Similarly the average heats of adsorption of n-pentane and n-hexane were determined to be 23.8 kJ/gmol and 36.7 kJ/gmol respectively.
5. The effect of the sample size on the heat of adsorption is not significant.

6. The heat of adsorption increases linearly with increasing carbon number for normal paraffins.
7. The average heats of adsorption for all hydrocarbons are larger than the corresponding heats of vaporization at the operating temperature. In addition, the temperature range used is far above the boiling points of the hydrocarbons. These results support the occurrence of chemisorption.
8. The result obtained may be verified by using other chromatographic techniques such as frontal analysis, temperature-programmed adsorption desorption chromatography or using a microreactor system coupled to the chromatograph.

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## APPENDIX I

TABLE A.1.1 Data for Adsorption Isotherms of n-Pentane

| $T_c$<br>(°C) | $T_r$<br>(°C) | $F_r$<br>(cm <sup>3</sup> /sec) | $P_1$<br>(mmHg) | $P_2$<br>(mmHg) | $V$<br>(μl) | $t_M$<br>(sec) | $A_D$<br>(mm <sup>2</sup> ) | $v$<br>(mm/sec) | Carrier<br>Gas |
|---------------|---------------|---------------------------------|-----------------|-----------------|-------------|----------------|-----------------------------|-----------------|----------------|
| 187.39        | 18.9          | 0.1842                          | 1357.0          | 755.0           | 0.4         | 26.1           | 6761.67                     | 3.33            | H <sub>2</sub> |
| 193.37        | 21.6          | 0.1792                          | 1359.0          | 757.0           | 0.4         | 17.7           | 6538.33                     | 3.33            | H <sub>2</sub> |
| 204.95        | 23.5          | 0.1838                          | 1394.5          | 752.5           | 0.4         | 17.7           | 6666.67                     | 3.33            | H <sub>2</sub> |
| 210.75        | 24.7          | 0.1712                          | 1419.0          | 755.0           | 0.4         | 17.6           | 7051.00                     | 3.33            | H <sub>2</sub> |
| 226.91        | 19.8          | 0.1786                          | 1426.9          | 758.9           | 0.4         | 17.4           | 6140.00                     | 3.33            | H <sub>2</sub> |
| 234.94        | 19.3          | 0.1723                          | 1402.0          | 758.0           | 0.4         | 16.6           | 3408.33                     | 3.33            | H <sub>2</sub> |
| 186.17        | 17.8          | 0.1488                          | 1609.0          | 759.0           | 0.4         | 21.6           | 6281.00                     | 3.33            | He             |
| 198.00        | 19.8          | 0.1642                          | 1579.5          | 751.5           | 0.4         | 18.9           | 5537.33                     | 3.33            | He             |
| 205.62        | 20.8          | 0.1597                          | 1656.8          | 752.8           | 0.4         | 19.2           | 6222.33                     | 3.33            | He             |
| 211.12        | 25.4          | 0.1650                          | 1613.5          | 749.5           | 0.4         | 18.9           | 6222.67                     | 3.33            | He             |
| 218.18        | 24.7          | 0.1656                          | 1630.7          | 744.7           | 0.4         | 18.0           | 6483.67                     | 3.33            | He             |
| 225.45        | 22.5          | 0.1718                          | 1613.0          | 753.0           | 0.4         | 18.0           | 5551.67                     | 3.33            | He             |
| 230.75        | 23.7          | 0.1626                          | 1704.0          | 752.0           | 0.4         | 19.2           | 6425.83                     | 3.33            | He             |
| 235.29        | 24.0          | 0.1695                          | 1703.7          | 752.7           | 0.4         | 18.0           | 6175.00                     | 3.33            | He             |
| 185.71        | 24.7          | 0.1656                          | 1559.0          | 753.0           | 0.8         | 19.2           | 5406.67                     | 3.33            | He             |
| 197.08        | 24.9          | 0.1639                          | 1608.6          | 754.6           | 0.8         | 19.2           | 5449.33                     | 3.33            | He             |
| 203.37        | 25.0          | 0.1558                          | 1599.0          | 751.0           | 0.8         | 21.0           | 6299.33                     | 3.33            | He             |
| 211.08        | 25.3          | 0.1565                          | 1613.5          | 749.5           | 0.8         | 19.5           | 5956.33                     | 3.33            | He             |
| 218.14        | 25.0          | 0.1577                          | 1630.7          | 744.7           | 0.8         | 18.0           | 6538.00                     | 3.33            | He             |
| 225.52        | 22.6          | 0.1721                          | 1613.0          | 753.0           | 0.8         | 18.0           | 5616.67                     | 3.33            | He             |
| 230.75        | 23.7          | 0.1626                          | 1704.0          | 752.0           | 0.8         | 19.2           | 6018.33                     | 3.33            | He             |
| 235.31        | 24.3          | 0.1587                          | 1703.7          | 752.7           | 0.8         | 18.6           | 5938.33                     | 3.33            | He             |

TABLE A.1.2 Data for Adsorption Isotherms of n-Hexane

| $T_m$<br>(°C) | $T_r$<br>(°C) | $F_r$<br>(cm <sup>3</sup> /sec) | $P_1$<br>(mmHg) | $P_0$<br>(mmHg) | $V$<br>( $\mu$ l) | $t_m$<br>(sec) | $A_D$<br>(mm <sup>2</sup> ) | $v$<br>(mm/sec) | Carrier<br>Gas |
|---------------|---------------|---------------------------------|-----------------|-----------------|-------------------|----------------|-----------------------------|-----------------|----------------|
| 187.39        | 18.90         | 0.1789                          | 1357.0          | 755.0           | 0.4               | 18.6           | 5593.00                     | 3.33            | H <sub>2</sub> |
| 204.99        | 23.60         | 0.1887                          | 1394.2          | 752.2           | 0.4               | 17.4           | 6228.00                     | 3.33            | H <sub>2</sub> |
| 210.73        | 24.50         | 0.1667                          | 1419.0          | 755.0           | 0.4               | 19.8           | 7352.00                     | 3.33            | H <sub>2</sub> |
| 226.97        | 19.90         | 0.1818                          | 1426.9          | 758.9           | 0.4               | 18.0           | 7260.00                     | 3.33            | H <sub>2</sub> |
| 234.98        | 19.30         | 0.1650                          | 1402.0          | 758.0           | 0.4               | 18.6           | 3533.00                     | 3.33            | H <sub>2</sub> |
| 186.05        | 17.00         | 0.1550                          | 1609.0          | 759.0           | 0.4               | 22.2           | 12839.33                    | 3.33            | He             |
| 192.93        | 19.8          | 0.1613                          | 1689.2          | 751.5           | 0.4               | 21.6           | 12018.67                    | 3.33            | He             |
| 205.59        | 20.8          | 0.1650                          | 1656.8          | 752.8           | 0.4               | 20.4           | 7167.00                     | 3.33            | He             |
| 211.11        | 24.9          | 0.1580                          | 1613.5          | 749.5           | 0.4               | 20.4           | 6360.00                     | 3.33            | He             |
| 218.17        | 24.8          | 0.1650                          | 1630.7          | 744.7           | 0.4               | 20.1           | 6272.00                     | 3.33            | He             |
| 225.64        | 22.5          | 0.1504                          | 1643.0          | 753.0           | 0.4               | 21.0           | 6589.50                     | 3.33            | He             |
| 230.82        | 23.6          | 0.1639                          | 1704.0          | 752.0           | 0.4               | 21.0           | 6153.33                     | 3.33            | He             |
| 235.31        | 24.1          | 0.1637                          | 1734.7          | 752.7           | 0.4               | 19.5           | 6103.00                     | 3.33            | He             |
| 185.81        | 24.9          | 0.1647                          | 1559.0          | 739.0           | 0.8               | 21.6           | 12283.33                    | 3.33            | He             |
| 196.99        | 25.1          | 0.1613                          | 1608.6          | 754.6           | 0.8               | 21.6           | 6229.67                     | 3.33            | He             |
| 203.35        | 25.2          | 0.1600                          | 1599.9          | 751.9           | 0.8               | 20.1           | 6070.33                     | 3.33            | He             |
| 211.07        | 24.7          | 0.1597                          | 1613.5          | 749.5           | 0.8               | 20.4           | 12587.00                    | 3.33            | He             |
| 218.26        | 24.9          | 0.1658                          | 1630.7          | 744.7           | 0.8               | 20.1           | 5993.17                     | 3.33            | He             |
| 225.49        | 22.3          | 0.1605                          | 1643.0          | 753.0           | 0.8               | 21.0           | 5971.33                     | 3.33            | He             |
| 230.83        | 23.6          | 0.1603                          | 1704.0          | 752.0           | 0.8               | 21.0           | 5944.67                     | 3.33            | He             |
| 235.21        | 24.1          | 0.1587                          | 1734.7          | 752.7           | 0.8               | 19.5           | 5890.50                     | 3.33            | He             |

TABLE A.1.3 Data for Adsorption Isotherms of n-Heptane

| $T_c$<br>(°C) | $T_r$<br>(°C) | $F_r$<br>(cm <sup>3</sup> /sec) | $P_i$<br>(mmHg) | $P_e$<br>(mmHg) | $V$<br>(μl) | $t_m$<br>(sec) | $A_p$<br>(mm <sup>2</sup> ) | $v$<br>(mm/sec) | Carrier<br>Gas |
|---------------|---------------|---------------------------------|-----------------|-----------------|-------------|----------------|-----------------------------|-----------------|----------------|
| 185.24        | 28.2          | 0.2786                          | 1921.0          | 748.0           | 0.2         | 13.8           | 8156.00                     | 3.33            | He             |
| 193.34        | 26.4          | 0.2421                          | 1955.5          | 741.5           | 0.2         | 15.0           | 8815.00                     | 3.33            | He             |
| 201.51        | 25.7          | 0.2326                          | 1797.0          | 743.0           | 0.2         | 15.0           | 9034.00                     | 3.33            | He             |
| 207.38        | 30.2          | 0.2564                          | 1879.5          | 756.5           | 0.2         | 14.4           | 9189.67                     | 3.33            | He             |
| 217.49        | 23.0          | 0.2326                          | 1875.0          | 754.0           | 0.2         | 14.4           | 4343.33                     | 3.33            | He             |
| 224.97        | 28.8          | 0.2538                          | 1925.8          | 753.8           | 0.2         | 13.8           | 4079.00                     | 3.33            | He             |
| 229.87        | 28.0          | 0.2591                          | 1969.0          | 756.0           | 0.2         | 13.2           | 4056.00                     | 3.33            | He             |
| 234.29        | 26.9          | 0.2577                          | 1951.0          | 755.0           | 0.2         | 13.8           | 4068.00                     | 3.33            | He             |
| 185.24        | 28.2          | 0.2786                          | 1921.0          | 748.0           | 0.4         | 13.8           | 8073.00                     | 3.33            | He             |
| 193.32        | 26.4          | 0.2398                          | 1855.5          | 741.5           | 0.4         | 15.0           | 8976.67                     | 3.33            | He             |
| 201.72        | 25.5          | 0.2326                          | 1797.0          | 743.0           | 0.4         | 15.0           | 9349.67                     | 3.33            | He             |
| 207.40        | 30.0          | 0.2591                          | 1879.5          | 756.5           | 0.4         | 14.4           | 8473.00                     | 3.33            | He             |
| 217.47        | 23.1          | 0.2336                          | 1875.0          | 754.0           | 0.4         | 14.4           | 4223.33                     | 3.33            | He             |
| 225.01        | 29.0          | 0.2545                          | 1925.8          | 753.8           | 0.4         | 15.0           | 4134.00                     | 3.33            | He             |
| 229.90        | 28.2          | 0.2571                          | 1969.0          | 756.0           | 0.4         | 13.2           | 4004.00                     | 3.33            | He             |
| 234.31        | 27.0          | 0.2591                          | 1951.0          | 755.0           | 0.4         | 13.8           | 4088.67                     | 3.33            | He             |

TABLE A.1.4 Data for Adsorption Isotherms of *i*-Octane

| $T_c$<br>(°C) | $T_r$<br>(°C) | $F_r$<br>(cm <sup>3</sup> /sec) | $P_i$<br>(mmHg) | $P_o$<br>(mmHg) | $V$<br>(μl) | $t_M$<br>(sec) | $A_p$<br>(mm <sup>2</sup> ) | $v$<br>(mm/sec) | Carrier<br>Gas |
|---------------|---------------|---------------------------------|-----------------|-----------------|-------------|----------------|-----------------------------|-----------------|----------------|
| 185.25        | 28.9          | 0.2421                          | 1921.0          | 748.0           | 0.2         | 15.0           | 8163.00                     | 3.33            | He             |
| 193.37        | 25.7          | 0.2488                          | 1855.5          | 741.5           | 0.2         | 13.8           | 7785.67                     | 3.33            | He             |
| 201.59        | 25.6          | 0.2273                          | 1797.0          | 743.0           | 0.2         | 15.0           | 8866.67                     | 3.33            | He             |
| 209.91        | 25.2          | 0.2439                          | 1857.5          | 751.5           | 0.2         | 13.8           | 6718.33                     | 3.33            | He             |
| 217.47        | 23.1          | 0.2288                          | 1875.0          | 754.0           | 0.2         | 15.0           | 3803.00                     | 3.33            | He             |
| 224.87        | 28.0          | 0.2404                          | 1925.8          | 753.8           | 0.2         | 13.8           | 4077.33                     | 3.33            | He             |
| 229.84        | 28.0          | 0.2506                          | 1969.0          | 756.0           | 0.2         | 13.8           | 4055.33                     | 3.33            | He             |
| 234.26        | 27.0          | 0.2421                          | 1951.0          | 755.0           | 0.2         | 13.2           | 3994.67                     | 3.33            | He             |
| 185.27        | 22.2          | 0.2433                          | 1921.0          | 748.0           | 0.4         | 15.0           | 8284.67                     | 3.33            | He             |
| 193.30        | 26.0          | 0.2481                          | 1855.5          | 741.5           | 0.4         | 13.8           | 7825.00                     | 3.33            | He             |
| 201.65        | 26.0          | 0.2278                          | 1797.0          | 743.0           | 0.4         | 15.0           | 8770.00                     | 3.33            | He             |
| 209.99        | 25.5          | 0.2439                          | 1857.5          | 751.5           | 0.4         | 13.8           | 7876.00                     | 3.33            | He             |
| 217.44        | 23.3          | 0.2238                          | 1875.0          | 754.0           | 0.4         | 15.0           | 8259.00                     | 3.33            | He             |
| 224.86        | 28.9          | 0.2421                          | 1925.8          | 753.8           | 0.4         | 13.8           | 4064.67                     | 3.33            | He             |
| 229.83        | 28.4          | 0.2421                          | 1969.0          | 756.0           | 0.4         | 13.8           | 3903.00                     | 3.33            | He             |
| 234.26        | 27.0          | 0.2421                          | 1951.0          | 755.0           | 0.4         | 13.2           | 4060.00                     | 3.33            | He             |

## APPENDIX II

TABLE A.2.1 Retention Time-Height Data for n-Pentane at 187.39°C and 0.4  $\mu$ l with Hydrogen

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 45.00          | 1.919                      | 0.668  | 195.0          | 33.188        |
| 48.00          | 2.224                      | 0.774  | 157.0          | 26.720        |
| 49.50          | 2.376                      | 0.827  | 126.0          | 21.444        |
| 52.50          | 2.681                      | 0.933  | 72.0           | 12.254        |
| 54.00          | 2.833                      | 0.986  | 53.0           | 9.020         |
| 55.50          | 2.986                      | 1.039  | 38.0           | 6.467         |
| 57.00          | 3.138                      | 1.092  | 26.0           | 4.425         |
| 58.50          | 3.290                      | 1.145  | 17.0           | 2.893         |
| 60.00          | 3.443                      | 1.198  | 11.0           | 1.872         |
| 61.50          | 3.595                      | 1.251  | 7.0            | 1.191         |
| 63.00          | 3.747                      | 1.304  | 5.0            | 0.851         |
| 64.50          | 3.900                      | 1.357  | 4.0            | 0.681         |
| 66.00          | 4.052                      | 1.410  | 3.0            | 0.511         |
| 67.50          | 4.204                      | 1.463  | 2.0            | 0.340         |
| 69.00          | 4.357                      | 1.516  | 1.0            | 0.170         |
| 70.50          | 4.509                      | 1.569  | 0.5            | 0.085         |
| 73.50          | 4.814                      | 1.675  | 0.0            | 0.000         |

TABLE A.2.2 Retention Time-Height Data for n-Pentane at 193.37°C and 0.4  $\mu$ l with Hydrogen

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 41.40          | 2.348                      | 0.806  | 195.0          | 35.605        |
| 42.75          | 2.481                      | 0.852  | 188.0          | 34.327        |
| 44.25          | 2.630                      | 0.903  | 157.0          | 28.667        |
| 45.75          | 2.779                      | 0.955  | 129.0          | 23.554        |
| 47.25          | 2.927                      | 1.006  | 99.0           | 18.076        |
| 48.75          | 3.076                      | 1.057  | 73.0           | 13.329        |
| 50.25          | 3.224                      | 1.108  | 49.0           | 8.947         |
| 51.75          | 3.373                      | 1.159  | 35.0           | 6.391         |
| 53.25          | 3.522                      | 1.210  | 23.0           | 4.200         |
| 54.75          | 3.670                      | 1.261  | 15.0           | 2.739         |
| 56.25          | 3.819                      | 1.312  | 10.0           | 1.826         |
| 57.75          | 3.967                      | 1.363  | 6.0            | 1.096         |
| 59.25          | 4.116                      | 1.414  | 4.0            | 0.730         |
| 60.75          | 4.265                      | 1.465  | 2.0            | 0.365         |
| 62.25          | 4.413                      | 1.516  | 1.5            | 0.274         |
| 63.75          | 4.562                      | 1.567  | 1.0            | 0.183         |
| 66.75          | 4.859                      | 1.669  | 0.0            | 0.000         |

TABLE A.2.3 Retention Time-Height Data for n-Pentane at 204.94°C and 0.4  $\mu$ l with Hydrogen

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 35.40          | 1.789                      | 0.600  | 221.0          | 38.834        |
| 37.20          | 1.971                      | 0.661  | 195.0          | 34.265        |
| 38.70          | 2.123                      | 0.712  | 159.0          | 27.939        |
| 40.20          | 2.274                      | 0.762  | 121.0          | 21.262        |
| 41.70          | 2.426                      | 0.813  | 87.0           | 15.288        |
| 43.20          | 2.578                      | 0.864  | 61.0           | 10.719        |
| 44.70          | 2.729                      | 0.915  | 38.0           | 6.677         |
| 46.20          | 2.881                      | 0.966  | 27.0           | 4.744         |
| 47.70          | 3.032                      | 1.016  | 17.0           | 2.987         |
| 49.20          | 3.184                      | 1.067  | 11.0           | 1.933         |
| 50.70          | 3.336                      | 1.118  | 6.0            | 1.054         |
| 52.20          | 3.487                      | 1.169  | 4.0            | 0.703         |
| 53.70          | 3.639                      | 1.220  | 3.0            | 0.527         |
| 55.20          | 3.790                      | 1.271  | 2.0            | 0.351         |
| 56.70          | 3.942                      | 1.321  | 1.0            | 0.176         |
| 59.70          | 4.245                      | 1.423  | 0.0            | 0.000         |

TABLE A.2.4 Retention Time-Height Data for n-Pentane at 210.75°C and 0.4  $\mu$ l with Hydrogen

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 36.60          | 1.779                      | 0.589  | 223.0          | 39.984        |
| 39.30          | 2.032                      | 0.673  | 180.0          | 32.274        |
| 40.80          | 2.173                      | 0.720  | 140.0          | 25.102        |
| 42.30          | 2.313                      | 0.766  | 106.0          | 19.006        |
| 43.80          | 2.454                      | 0.813  | 74.5           | 13.358        |
| 45.30          | 2.595                      | 0.859  | 51.5           | 9.234         |
| 46.80          | 2.736                      | 0.906  | 35.0           | 6.275         |
| 48.30          | 2.876                      | 0.953  | 23.0           | 4.124         |
| 49.80          | 3.017                      | 0.999  | 15.5           | 2.779         |
| 51.30          | 3.158                      | 1.046  | 10.0           | 1.793         |
| 52.80          | 3.299                      | 1.092  | 6.5            | 1.165         |
| 54.30          | 3.439                      | 1.139  | 4.0            | 0.717         |
| 55.80          | 3.580                      | 1.186  | 3.0            | 0.538         |
| 57.30          | 3.721                      | 1.232  | 2.5            | 0.448         |
| 58.80          | 3.861                      | 1.279  | 1.8            | 0.323         |
| 60.30          | 4.002                      | 1.325  | 1.0            | 0.179         |
| 63.30          | 4.284                      | 1.419  | 0.0            | 0.000         |

TABLE A.2.5 Retention Time-Height Data for n-Pentane at 226.91°C and 0.4  $\mu$ l with Hydrogen

| $t_e$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_e) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 29.40          | 1.235                      | 0.396  | 223.0          | 43.239        |
| 31.50          | 1.451                      | 0.465  | 181.0          | 35.095        |
| 33.00          | 1.606                      | 0.515  | 132.0          | 25.594        |
| 34.50          | 1.760                      | 0.564  | 96.0           | 18.614        |
| 36.00          | 1.914                      | 0.613  | 65.0           | 12.603        |
| 37.50          | 2.069                      | 0.663  | 42.0           | 8.144         |
| 39.00          | 2.223                      | 0.712  | 29.0           | 5.623         |
| 40.50          | 2.377                      | 0.762  | 17.0           | 3.296         |
| 42.00          | 2.532                      | 0.811  | 10.0           | 1.939         |
| 43.50          | 2.686                      | 0.861  | 7.0            | 1.357         |
| 45.00          | 2.841                      | 0.910  | 4.0            | 0.776         |
| 46.50          | 2.995                      | 0.960  | 3.0            | 0.582         |
| 48.00          | 3.149                      | 1.009  | 2.0            | 0.388         |
| 49.50          | 3.304                      | 1.059  | 1.5            | 0.291         |
| 51.00          | 3.458                      | 1.108  | 1.0            | 0.194         |
| 52.50          | 3.612                      | 1.158  | 0.5            | 0.097         |
| 54.00          | 3.767                      | 1.207  | 0.0            | 0.000         |

TABLE A.2.6 Retention Time-Height Data for n-Pentane at 234.94°C and 0.4  $\mu$ l with Hydrogen

| $t_e$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_e) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 28.20          | 1.193                      | 0.376  | 124.0          | 44.716        |
| 29.10          | 1.286                      | 0.406  | 119.0          | 42.913        |
| 30.60          | 1.440                      | 0.454  | 100.0          | 36.062        |
| 32.10          | 1.593                      | 0.503  | 77.0           | 27.767        |
| 33.60          | 1.747                      | 0.551  | 54.0           | 19.473        |
| 35.10          | 1.901                      | 0.600  | 36.0           | 12.982        |
| 36.60          | 2.055                      | 0.648  | 24.0           | 8.655         |
| 38.10          | 2.208                      | 0.697  | 14.0           | 5.049         |
| 39.60          | 2.362                      | 0.745  | 9.0            | 3.246         |
| 41.10          | 2.516                      | 0.794  | 6.0            | 2.164         |
| 42.60          | 2.670                      | 0.842  | 3.5            | 1.262         |
| 44.10          | 2.824                      | 0.891  | 2.0            | 0.721         |
| 45.60          | 2.977                      | 0.939  | 1.0            | 0.361         |
| 47.10          | 3.131                      | 0.988  | 0.5            | 0.180         |
| 48.60          | 3.285                      | 1.036  | 0.0            | 0.000         |

TABLE A.2.7 Retention Time-Height Data for n-Pentane at 186.17°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 60.60          | 2.823                      | 0.985  | 143.0          | 32.311        |
| 63.60          | 3.040                      | 1.061  | 125.0          | 28.244        |
| 65.10          | 3.149                      | 1.099  | 108.0          | 24.403        |
| 68.10          | 3.366                      | 1.174  | 72.0           | 16.268        |
| 69.60          | 3.474                      | 1.212  | 56.0           | 12.653        |
| 71.10          | 3.583                      | 1.250  | 42.5           | 9.603         |
| 74.10          | 3.800                      | 1.326  | 24.0           | 5.423         |
| 75.60          | 3.909                      | 1.364  | 17.5           | 3.954         |
| 78.60          | 4.126                      | 1.439  | 9.5            | 2.147         |
| 81.60          | 4.343                      | 1.515  | 5.5            | 1.243         |
| 83.10          | 4.451                      | 1.553  | 4.0            | 0.904         |
| 84.60          | 4.560                      | 1.591  | 3.0            | 0.678         |
| 86.10          | 4.669                      | 1.629  | 2.5            | 0.565         |
| 87.60          | 4.777                      | 1.667  | 2.0            | 0.452         |
| 92.10          | 5.103                      | 1.780  | 1.0            | 0.226         |
| 95.10          | 5.320                      | 1.856  | 0.0            | 0.000         |

TABLE A.2.8 Retention Time-Height Data for n-Pentane at 198.00°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 47.40          | 2.335                      | 0.794  | 151.2          | 35.359        |
| 49.05          | 2.470                      | 0.840  | 145.0          | 33.909        |
| 50.55          | 2.593                      | 0.882  | 124.0          | 28.998        |
| 52.05          | 2.715                      | 0.924  | 100.0          | 23.386        |
| 53.55          | 2.838                      | 0.965  | 76.0           | 17.773        |
| 56.55          | 3.084                      | 1.049  | 41.0           | 9.588         |
| 58.05          | 3.207                      | 1.091  | 29.0           | 6.782         |
| 61.05          | 3.453                      | 1.174  | 14.0           | 3.274         |
| 62.55          | 3.576                      | 1.216  | 10.0           | 2.339         |
| 64.05          | 3.698                      | 1.258  | 7.0            | 1.637         |
| 65.55          | 3.821                      | 1.300  | 5.0            | 1.169         |
| 67.05          | 3.944                      | 1.342  | 3.0            | 0.702         |
| 68.55          | 4.067                      | 1.383  | 2.1            | 0.491         |
| 70.05          | 4.190                      | 1.425  | 1.5            | 0.351         |
| 71.55          | 4.313                      | 1.467  | 1.0            | 0.234         |
| 73.05          | 4.436                      | 1.509  | 0.5            | 0.117         |
| 74.55          | 4.559                      | 1.551  | 0.0            | 0.000         |

TABLE A.2.9 Retention Time-Height Data for n-Pentane at 205.62°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 45.00          | 2.007                      | 0.672  | 169.5          | 36.393        |
| 45.90          | 2.077                      | 0.696  | 166.0          | 35.641        |
| 47.40          | 2.194                      | 0.735  | 150.0          | 32.206        |
| 48.90          | 2.311                      | 0.774  | 126.0          | 27.053        |
| 50.40          | 2.428                      | 0.813  | 101.0          | 21.685        |
| 51.90          | 2.544                      | 0.852  | 78.0           | 16.747        |
| 53.40          | 2.661                      | 0.891  | 59.0           | 12.668        |
| 54.90          | 2.778                      | 0.930  | 43.0           | 9.232         |
| 56.40          | 2.894                      | 0.969  | 31.0           | 6.656         |
| 57.90          | 3.011                      | 1.008  | 22.5           | 4.831         |
| 59.40          | 3.128                      | 1.047  | 16.0           | 3.435         |
| 60.90          | 3.245                      | 1.086  | 11.0           | 2.362         |
| 62.40          | 3.361                      | 1.125  | 8.0            | 1.718         |
| 63.90          | 3.478                      | 1.164  | 6.0            | 1.288         |
| 65.40          | 3.595                      | 1.203  | 4.0            | 0.859         |
| 66.90          | 3.711                      | 1.243  | 3.0            | 0.644         |
| 68.40          | 3.828                      | 1.282  | 2.0            | 0.429         |
| 72.90          | 4.178                      | 1.399  | 1.0            | 0.215         |
| 80.40          | 4.762                      | 1.594  | 0.0            | 0.000         |

TABLE A.2.10 Retention Time-Height Data for n-Pentane at 211.12°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 43.20          | 1.976                      | 0.654  | 168.5          | 35.626        |
| 44.73          | 2.101                      | 0.695  | 155.0          | 32.772        |
| 46.23          | 2.223                      | 0.736  | 132.0          | 27.909        |
| 49.23          | 2.467                      | 0.816  | 83.0           | 17.549        |
| 50.73          | 2.589                      | 0.857  | 65.0           | 13.743        |
| 52.23          | 2.711                      | 0.897  | 48.0           | 10.149        |
| 55.23          | 2.955                      | 0.978  | 26.0           | 5.497         |
| 56.73          | 3.077                      | 1.018  | 19.0           | 4.017         |
| 58.23          | 3.199                      | 1.059  | 14.0           | 2.960         |
| 59.73          | 3.321                      | 1.099  | 10.0           | 2.114         |
| 61.23          | 3.443                      | 1.139  | 7.5            | 1.586         |
| 62.73          | 3.565                      | 1.180  | 5.5            | 1.163         |
| 64.23          | 3.687                      | 1.220  | 4.5            | 0.951         |
| 67.23          | 3.931                      | 1.301  | 3.0            | 0.634         |
| 68.73          | 4.053                      | 1.341  | 2.5            | 0.529         |
| 70.23          | 4.175                      | 1.382  | 2.0            | 0.423         |
| 80.23          | 4.988                      | 1.651  | 0.0            | 0.000         |

TABLE A.2.11 Retention Time-Height Data for n-Pentane at 218.18°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 40.80          | 1.849                      | 0.603  | 182.5          | 37.172        |
| 43.20          | 2.044                      | 0.667  | 155.0          | 31.571        |
| 44.70          | 2.166                      | 0.706  | 126.0          | 25.664        |
| 47.70          | 2.409                      | 0.786  | 72.0           | 14.665        |
| 49.20          | 2.531                      | 0.825  | 53.0           | 10.795        |
| 52.20          | 2.774                      | 0.905  | 27.5           | 5.601         |
| 53.70          | 2.896                      | 0.945  | 20.0           | 4.074         |
| 55.20          | 3.018                      | 0.984  | 14.0           | 2.852         |
| 58.20          | 3.261                      | 1.064  | 8.0            | 1.629         |
| 59.70          | 3.383                      | 1.103  | 6.0            | 1.222         |
| 62.70          | 3.626                      | 1.183  | 3.5            | 0.713         |
| 64.20          | 3.748                      | 1.222  | 3.0            | 0.611         |
| 65.70          | 3.869                      | 1.262  | 2.5            | 0.509         |
| 67.20          | 3.991                      | 1.302  | 2.0            | 0.407         |
| 70.20          | 4.234                      | 1.381  | 1.5            | 0.306         |
| 74.70          | 4.599                      | 1.500  | 1.0            | 0.204         |
| 77.70          | 4.843                      | 1.580  | 0.0            | 0.000         |

TABLE A.2.12 Retention Time-Height Data for n-Pentane at 225.45°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 35.40          | 1.584                      | 0.509  | 182.5          | 39.944        |
| 36.75          | 1.707                      | 0.549  | 170.0          | 37.208        |
| 38.25          | 1.843                      | 0.592  | 140.0          | 30.642        |
| 39.75          | 1.980                      | 0.636  | 103.0          | 22.544        |
| 41.25          | 2.116                      | 0.680  | 73.0           | 15.978        |
| 42.75          | 2.253                      | 0.724  | 50.0           | 10.944        |
| 44.25          | 2.389                      | 0.768  | 34.0           | 7.442         |
| 45.75          | 2.526                      | 0.812  | 23.0           | 5.034         |
| 47.25          | 2.662                      | 0.856  | 15.0           | 3.283         |
| 48.75          | 2.799                      | 0.900  | 10.0           | 2.189         |
| 50.25          | 2.936                      | 0.944  | 7.0            | 1.532         |
| 51.75          | 3.072                      | 0.987  | 4.0            | 0.875         |
| 53.25          | 3.209                      | 1.031  | 3.0            | 0.657         |
| 54.75          | 3.345                      | 1.075  | 2.0            | 0.438         |
| 56.25          | 3.482                      | 1.119  | 1.5            | 0.328         |
| 57.75          | 3.618                      | 1.163  | 1.0            | 0.219         |
| 62.25          | 4.028                      | 1.295  | 0.0            | 0.000         |

TABLE A.2.13 Retention Time-Height Data for n-Pentane at 230.75°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 34.80          | 1.246                      | 0.396  | 192.5          | 40.090        |
| 37.50          | 1.462                      | 0.465  | 158.0          | 32.905        |
| 39.00          | 1.582                      | 0.503  | 124.0          | 25.824        |
| 40.50          | 1.702                      | 0.541  | 93.0           | 19.368        |
| 42.00          | 1.822                      | 0.579  | 67.0           | 13.954        |
| 43.50          | 1.941                      | 0.617  | 48.0           | 9.997         |
| 46.50          | 2.181                      | 0.694  | 23.0           | 4.790         |
| 48.00          | 2.301                      | 0.732  | 16.0           | 3.332         |
| 49.50          | 2.421                      | 0.770  | 11.5           | 2.395         |
| 51.00          | 2.541                      | 0.808  | 8.0            | 1.666         |
| 52.50          | 2.661                      | 0.846  | 5.5            | 1.145         |
| 54.00          | 2.780                      | 0.884  | 4.0            | 0.833         |
| 55.50          | 2.900                      | 0.922  | 3.0            | 0.625         |
| 57.00          | 3.020                      | 0.960  | 2.5            | 0.521         |
| 58.50          | 3.140                      | 0.999  | 1.5            | 0.312         |
| 60.00          | 3.260                      | 1.037  | 1.0            | 0.208         |
| 63.00          | 3.499                      | 1.113  | 0.0            | 0.000         |

TABLE A.2.14 Retention Time-Height Data for n-Pentane at 235.29°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 34.20          | 1.373                      | 0.433  | 202.0          | 41.674        |
| 35.10          | 1.449                      | 0.457  | 195.0          | 40.229        |
| 36.60          | 1.577                      | 0.497  | 166.0          | 34.247        |
| 38.10          | 1.704                      | 0.537  | 122.0          | 25.169        |
| 39.60          | 1.831                      | 0.577  | 90.0           | 18.567        |
| 41.10          | 1.958                      | 0.617  | 63.0           | 12.997        |
| 42.60          | 2.085                      | 0.657  | 43.0           | 8.871         |
| 44.10          | 2.212                      | 0.697  | 29.0           | 5.983         |
| 45.60          | 2.339                      | 0.737  | 20.0           | 4.126         |
| 47.10          | 2.467                      | 0.777  | 13.0           | 2.682         |
| 48.60          | 2.594                      | 0.818  | 9.0            | 1.857         |
| 50.10          | 2.721                      | 0.858  | 6.0            | 1.238         |
| 51.60          | 2.848                      | 0.898  | 4.0            | 0.825         |
| 53.10          | 2.975                      | 0.938  | 3.0            | 0.619         |
| 54.60          | 3.102                      | 0.978  | 2.0            | 0.413         |
| 57.60          | 3.357                      | 1.058  | 1.0            | 0.206         |
| 62.10          | 3.738                      | 1.178  | 0.0            | 0.000         |

TABLE A.2.15 Retention Time-Height Data for n-Pentane at 185.71°C and 0.8  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 51.00          | 2.546                      | 0.889  | 132.0          | 63.738        |
| 53.25          | 2.726                      | 0.952  | 111.0          | 53.598        |
| 54.75          | 2.846                      | 0.994  | 96.0           | 46.355        |
| 57.75          | 3.086                      | 1.078  | 67.0           | 32.352        |
| 59.25          | 3.207                      | 1.120  | 53.0           | 25.592        |
| 62.25          | 3.447                      | 1.204  | 22.0           | 10.623        |
| 63.75          | 3.567                      | 1.246  | 16.0           | 7.726         |
| 66.75          | 3.807                      | 1.330  | 8.0            | 3.863         |
| 68.25          | 3.927                      | 1.372  | 6.0            | 2.897         |
| 69.75          | 4.047                      | 1.413  | 4.5            | 2.173         |
| 71.25          | 4.167                      | 1.455  | 3.0            | 1.449         |
| 72.75          | 4.287                      | 1.497  | 2.5            | 1.207         |
| 74.25          | 4.407                      | 1.539  | 2.0            | 0.966         |
| 75.75          | 4.528                      | 1.581  | 1.5            | 0.724         |
| 78.75          | 4.768                      | 1.665  | 1.0            | 0.483         |
| 92.25          | 5.849                      | 2.043  | 0.0            | 0.000         |

TABLE A.2.16 Retention Time-Height Data for n-Pentane at 197.08°C and 0.8  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 44.40          | 1.999                      | 0.681  | 135.0          | 65.391        |
| 45.45          | 2.082                      | 0.710  | 132.0          | 63.938        |
| 46.95          | 2.201                      | 0.750  | 120.5          | 58.368        |
| 48.45          | 2.320                      | 0.791  | 104.0          | 50.376        |
| 49.95          | 2.439                      | 0.831  | 87.0           | 42.141        |
| 51.45          | 2.558                      | 0.872  | 69.0           | 33.422        |
| 52.95          | 2.677                      | 0.912  | 53.0           | 25.672        |
| 54.45          | 2.796                      | 0.953  | 39.0           | 18.891        |
| 55.95          | 2.915                      | 0.994  | 28.0           | 13.563        |
| 57.45          | 3.034                      | 1.034  | 20.0           | 9.688         |
| 58.95          | 3.153                      | 1.075  | 14.5           | 7.024         |
| 60.45          | 3.272                      | 1.115  | 10.0           | 4.844         |
| 61.95          | 3.391                      | 1.156  | 7.0            | 3.391         |
| 63.45          | 3.510                      | 1.196  | 5.0            | 2.422         |
| 64.95          | 3.629                      | 1.237  | 4.0            | 1.938         |
| 67.95          | 3.867                      | 1.318  | 2.0            | 0.969         |
| 70.95          | 4.105                      | 1.399  | 1.0            | 0.484         |
| 79.95          | 4.819                      | 1.642  | 0.0            | 0.000         |

TABLE A.2.17 Retention Time-Height Data for n-Pentane  
at 203.37°C and 0.8  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 43.80          | 1.743                      | 0.586  | 138.5          | 61.072        |
| 46.80          | 1.973                      | 0.663  | 120.0          | 52.914        |
| 48.30          | 2.087                      | 0.702  | 104.0          | 45.859        |
| 51.30          | 2.317                      | 0.779  | 73.0           | 32.190        |
| 52.80          | 2.432                      | 0.818  | 60.0           | 26.457        |
| 55.80          | 2.661                      | 0.895  | 38.0           | 16.756        |
| 57.30          | 2.776                      | 0.933  | 30.0           | 13.229        |
| 60.30          | 3.005                      | 1.011  | 17.0           | 7.496         |
| 61.80          | 3.120                      | 1.049  | 13.0           | 5.732         |
| 63.30          | 3.234                      | 1.088  | 10.0           | 4.410         |
| 64.80          | 3.349                      | 1.126  | 7.0            | 3.087         |
| 66.30          | 3.464                      | 1.165  | 5.0            | 2.205         |
| 67.80          | 3.579                      | 1.203  | 4.0            | 1.764         |
| 70.80          | 3.808                      | 1.281  | 2.5            | 1.102         |
| 73.80          | 4.037                      | 1.358  | 1.5            | 0.661         |
| 75.30          | 4.152                      | 1.396  | 1.0            | 0.441         |
| 78.30          | 4.381                      | 1.474  | 0.0            | 0.000         |

TABLE A.2.18 Retention Time-Height Data for n-Pentane  
at 210.08°C and 0.8  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 40.20          | 1.600                      | 0.530  | 147.5          | 68.547        |
| 42.15          | 1.751                      | 0.579  | 136.0          | 63.203        |
| 43.65          | 1.867                      | 0.618  | 120.0          | 55.767        |
| 45.15          | 1.983                      | 0.656  | 101.0          | 46.938        |
| 48.15          | 2.215                      | 0.733  | 63.0           | 29.278        |
| 49.65          | 2.331                      | 0.771  | 48.0           | 22.307        |
| 52.65          | 2.563                      | 0.848  | 27.0           | 12.548        |
| 54.15          | 2.679                      | 0.886  | 19.5           | 9.062         |
| 57.15          | 2.910                      | 0.963  | 10.5           | 4.880         |
| 60.15          | 3.142                      | 1.040  | 5.5            | 2.556         |
| 61.65          | 3.258                      | 1.078  | 4.0            | 1.859         |
| 64.65          | 3.490                      | 1.155  | 2.5            | 1.162         |
| 66.15          | 3.606                      | 1.193  | 1.5            | 0.697         |
| 69.15          | 3.838                      | 1.270  | 1.0            | 0.465         |
| 72.15          | 4.070                      | 1.347  | 0.5            | 0.232         |
| 76.65          | 4.418                      | 1.462  | 0.0            | 0.000         |

TABLE A.2.19 Retention Time-Height Data for n-Pentane at 218.14°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 38.40          | 1.592                      | 0.519  | 165.0          | 69.257        |
| 40.20          | 1.733                      | 0.565  | 155.0          | 65.059        |
| 41.70          | 1.850                      | 0.603  | 138.0          | 57.924        |
| 43.20          | 1.967                      | 0.642  | 116.0          | 48.690        |
| 46.20          | 2.201                      | 0.718  | 71.0           | 29.801        |
| 47.70          | 2.318                      | 0.756  | 52.5           | 22.036        |
| 49.20          | 2.435                      | 0.794  | 38.0           | 15.950        |
| 52.20          | 2.670                      | 0.871  | 19.5           | 8.185         |
| 53.70          | 2.787                      | 0.909  | 14.0           | 5.876         |
| 55.20          | 2.904                      | 0.947  | 10.0           | 4.197         |
| 56.70          | 3.021                      | 0.985  | 7.0            | 2.938         |
| 58.20          | 3.138                      | 1.024  | 5.0            | 2.099         |
| 59.70          | 3.255                      | 1.062  | 4.0            | 1.679         |
| 61.20          | 3.372                      | 1.100  | 3.0            | 1.259         |
| 64.20          | 3.606                      | 1.176  | 1.5            | 0.630         |
| 75.70          | 4.504                      | 1.469  | 1.0            | 0.420         |
| 86.20          | 5.324                      | 1.737  | 0.0            | 0.000         |

TABLE A.2.20 Retention Time-Height Data for n-Pentane at 225.52°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 32.40          | 1.277                      | 0.410  | 165.5          | 73.499        |
| 33.90          | 1.410                      | 0.453  | 154.0          | 68.392        |
| 35.40          | 1.543                      | 0.496  | 132.0          | 58.622        |
| 36.90          | 1.676                      | 0.539  | 105.0          | 46.631        |
| 39.90          | 1.942                      | 0.624  | 55.0           | 24.426        |
| 41.40          | 2.075                      | 0.667  | 37.0           | 16.432        |
| 42.90          | 2.208                      | 0.710  | 25.0           | 11.103        |
| 44.40          | 2.341                      | 0.752  | 16.5           | 7.328         |
| 47.40          | 2.607                      | 0.838  | 7.0            | 3.109         |
| 48.90          | 2.740                      | 0.881  | 5.0            | 2.221         |
| 50.40          | 2.873                      | 0.923  | 3.5            | 1.554         |
| 51.90          | 3.007                      | 0.966  | 2.5            | 1.110         |
| 53.40          | 3.140                      | 1.009  | 2.0            | 0.888         |
| 54.90          | 3.273                      | 1.052  | 1.5            | 0.666         |
| 56.40          | 3.406                      | 1.094  | 1.0            | 0.444         |
| 57.90          | 3.539                      | 1.137  | 0.5            | 0.222         |
| 62.40          | 3.938                      | 1.265  | 0.0            | 0.000         |

TABLE A.2.21 Retention Time-Height Data for n-Pentane at 230.75°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 32.40          | 1.065                      | 0.339  | 168.5          | 74.193        |
| 35.70          | 1.331                      | 0.423  | 135.0          | 59.442        |
| 37.20          | 1.452                      | 0.462  | 108.0          | 47.554        |
| 38.70          | 1.573                      | 0.500  | 81.0           | 35.665        |
| 40.20          | 1.695                      | 0.539  | 60.0           | 26.419        |
| 41.70          | 1.816                      | 0.577  | 42.0           | 18.493        |
| 44.70          | 2.058                      | 0.654  | 20.0           | 8.806         |
| 46.20          | 2.179                      | 0.693  | 13.5           | 5.944         |
| 47.70          | 2.300                      | 0.731  | 9.0            | 3.963         |
| 49.20          | 2.421                      | 0.770  | 6.0            | 2.642         |
| 50.70          | 2.542                      | 0.808  | 4.0            | 1.761         |
| 52.20          | 2.663                      | 0.847  | 3.0            | 1.321         |
| 53.70          | 2.784                      | 0.885  | 2.0            | 0.881         |
| 55.20          | 2.905                      | 0.924  | 1.5            | 0.660         |
| 56.70          | 3.026                      | 0.962  | 1.0            | 0.440         |
| 59.70          | 3.268                      | 1.039  | 0.5            | 0.220         |
| 62.70          | 3.510                      | 1.116  | 0.0            | 0.000         |

TABLE A.2.22 Retention Time-Height Data for n-Pentane at 235.21°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 30.60          | 0.953                      | 0.300  | 173.0          | 79.257        |
| 33.00          | 1.143                      | 0.360  | 150.0          | 68.720        |
| 34.50          | 1.262                      | 0.398  | 122.0          | 55.892        |
| 36.00          | 1.381                      | 0.435  | 92.0           | 42.148        |
| 37.50          | 1.500                      | 0.473  | 65.0           | 29.779        |
| 39.00          | 1.619                      | 0.510  | 44.0           | 20.158        |
| 40.50          | 1.738                      | 0.548  | 30.0           | 13.744        |
| 42.00          | 1.857                      | 0.585  | 19.0           | 8.705         |
| 43.50          | 1.977                      | 0.623  | 13.0           | 5.956         |
| 45.00          | 2.096                      | 0.660  | 8.0            | 3.665         |
| 46.50          | 2.215                      | 0.698  | 5.0            | 2.291         |
| 48.00          | 2.334                      | 0.736  | 3.5            | 1.603         |
| 49.50          | 2.453                      | 0.773  | 2.0            | 0.916         |
| 51.00          | 2.572                      | 0.811  | 1.5            | 0.687         |
| 52.50          | 2.691                      | 0.848  | 1.0            | 0.458         |
| 54.00          | 2.810                      | 0.886  | 0.5            | 0.229         |
| 55.50          | 2.929                      | 0.923  | 0.0            | 0.000         |

TABLE A.2.23 Retention Time-Height Data for n-Hexane at 187.39°C and 0.4  $\mu$ l with Hydrogen

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 74.40          | 5.470                      | 1.903  | 138.0          | 25.604        |
| 76.20          | 5.646                      | 1.965  | 130.0          | 24.119        |
| 77.70          | 5.793                      | 2.016  | 120.0          | 22.264        |
| 79.20          | 5.940                      | 2.067  | 106.0          | 19.667        |
| 80.70          | 6.087                      | 2.118  | 91.0           | 16.884        |
| 83.70          | 6.381                      | 2.221  | 64.0           | 11.874        |
| 85.20          | 6.528                      | 2.272  | 52.0           | 9.648         |
| 86.70          | 6.675                      | 2.323  | 41.0           | 7.607         |
| 88.20          | 6.822                      | 2.374  | 32.0           | 5.937         |
| 89.70          | 6.969                      | 2.425  | 24.5           | 4.546         |
| 91.20          | 7.117                      | 2.476  | 13.0           | 2.412         |
| 92.70          | 7.264                      | 2.528  | 9.0            | 1.670         |
| 94.20          | 7.411                      | 2.579  | 6.0            | 1.113         |
| 95.70          | 7.558                      | 2.630  | 4.0            | 0.742         |
| 97.20          | 7.705                      | 2.681  | 3.0            | 0.557         |
| 98.70          | 7.852                      | 2.732  | 1.0            | 0.186         |
| 101.70         | 8.146                      | 2.835  | 0.0            | 0.000         |

TABLE A.2.24 Retention Time-Height Data for n-Hexane at 204.99°C and 0.4  $\mu$ l with Hydrogen

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 55.80          | 3.966                      | 1.329  | 178.0          | 28.570        |
| 57.45          | 4.137                      | 1.387  | 165.5          | 26.564        |
| 58.95          | 4.292                      | 1.438  | 145.0          | 23.273        |
| 60.45          | 4.447                      | 1.490  | 122.0          | 19.582        |
| 61.95          | 4.602                      | 1.542  | 97.0           | 15.569        |
| 63.45          | 4.757                      | 1.594  | 72.5           | 11.637        |
| 64.95          | 4.911                      | 1.646  | 51.5           | 8.266         |
| 66.45          | 5.066                      | 1.698  | 34.0           | 5.457         |
| 67.95          | 5.221                      | 1.750  | 22.0           | 3.531         |
| 69.45          | 5.376                      | 1.802  | 13.0           | 2.087         |
| 70.95          | 5.531                      | 1.854  | 7.5            | 1.204         |
| 72.45          | 5.686                      | 1.906  | 4.0            | 0.642         |
| 73.95          | 5.841                      | 1.958  | 2.0            | 0.321         |
| 75.45          | 5.996                      | 2.010  | 1.0            | 0.161         |
| 76.95          | 6.151                      | 2.062  | 0.0            | 0.000         |

TABLE A.2.25 Retention Time-Height Data for n-Hexane at 210.73°C and 0.4  $\mu$ l with Hydrogen

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 58.20          | 3.499                      | 1.159  | 182.0          | 28.097        |
| 61.20          | 3.772                      | 1.249  | 160.0          | 24.701        |
| 62.70          | 3.909                      | 1.295  | 138.0          | 21.304        |
| 65.70          | 4.182                      | 1.385  | 91.0           | 14.048        |
| 67.20          | 4.319                      | 1.430  | 71.0           | 10.961        |
| 68.70          | 4.456                      | 1.476  | 53.0           | 8.182         |
| 70.20          | 4.592                      | 1.521  | 39.0           | 6.021         |
| 71.70          | 4.729                      | 1.566  | 28.0           | 4.323         |
| 73.20          | 4.866                      | 1.612  | 19.0           | 2.933         |
| 74.70          | 5.003                      | 1.657  | 13.0           | 2.007         |
| 76.20          | 5.139                      | 1.702  | 9.0            | 1.389         |
| 77.70          | 5.276                      | 1.747  | 6.0            | 0.926         |
| 79.20          | 5.413                      | 1.793  | 4.0            | 0.618         |
| 80.70          | 5.549                      | 1.838  | 3.0            | 0.463         |
| 82.20          | 5.686                      | 1.883  | 2.0            | 0.309         |
| 83.70          | 5.823                      | 1.928  | 1.0            | 0.154         |
| 85.20          | 5.959                      | 1.974  | 0.0            | 0.000         |

TABLE A.2.26 Retention Time-Height Data for n-Hexane at 226.97°C and 0.4  $\mu$ l with Hydrogen

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 42.00          | 2.503                      | 0.802  | 199.0          | 28.086        |
| 43.95          | 2.706                      | 0.867  | 175.0          | 24.699        |
| 45.45          | 2.863                      | 0.917  | 141.0          | 19.900        |
| 46.95          | 3.019                      | 0.967  | 109.0          | 15.384        |
| 48.45          | 3.176                      | 1.018  | 77.0           | 10.867        |
| 49.95          | 3.332                      | 1.068  | 50.5           | 7.127         |
| 51.45          | 3.489                      | 1.118  | 32.5           | 4.587         |
| 52.95          | 3.645                      | 1.168  | 21.0           | 2.964         |
| 54.45          | 3.801                      | 1.218  | 14.0           | 1.976         |
| 55.95          | 3.958                      | 1.268  | 8.0            | 1.129         |
| 57.45          | 4.114                      | 1.318  | 5.0            | 0.706         |
| 58.95          | 4.271                      | 1.368  | 3.0            | 0.423         |
| 60.45          | 4.427                      | 1.419  | 1.5            | 0.212         |
| 61.95          | 4.584                      | 1.469  | 1.0            | 0.141         |
| 66.45          | 5.053                      | 1.619  | 0.0            | 0.000         |

TABLE A.2.27 Retention Time-Height Data for n-Hexane  
at 234.97°C and 0.4  $\mu$ l with Hydrogen

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 41.40          | 2.224                      | 0.701  | 109.0          | 34.759        |
| 43.65          | 2.443                      | 0.771  | 93.0           | 29.657        |
| 45.15          | 2.590                      | 0.817  | 76.0           | 24.236        |
| 46.65          | 2.736                      | 0.863  | 56.0           | 17.858        |
| 48.15          | 2.882                      | 0.909  | 40.0           | 12.756        |
| 49.65          | 3.029                      | 0.955  | 27.5           | 8.770         |
| 51.15          | 3.175                      | 1.001  | 17.0           | 5.421         |
| 52.65          | 3.321                      | 1.048  | 12.0           | 3.827         |
| 54.15          | 3.468                      | 1.094  | 7.0            | 2.232         |
| 55.65          | 3.614                      | 1.140  | 4.5            | 1.435         |
| 57.15          | 3.760                      | 1.186  | 3.0            | 0.957         |
| 58.65          | 3.907                      | 1.232  | 2.0            | 0.638         |
| 60.15          | 4.053                      | 1.278  | 1.0            | 0.319         |
| 64.65          | 4.492                      | 1.417  | 0.0            | 0.000         |

TABLE A.2.28 Retention Time-Height Data for n-Hexane  
at 186.05°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 100.20         | 5.870                      | 2.049  | 208.5          | 19.323        |
| 103.20         | 6.096                      | 2.127  | 194.0          | 17.979        |
| 106.20         | 6.322                      | 2.206  | 163.5          | 15.153        |
| 107.70         | 6.435                      | 2.246  | 146.0          | 13.531        |
| 110.70         | 6.661                      | 2.324  | 114.0          | 10.565        |
| 112.20         | 6.773                      | 2.364  | 98.0           | 9.082         |
| 115.20         | 6.999                      | 2.443  | 70.0           | 6.487         |
| 116.70         | 7.112                      | 2.482  | 58.5           | 5.422         |
| 124.20         | 7.677                      | 2.679  | 20.0           | 1.854         |
| 125.70         | 7.790                      | 2.718  | 15.5           | 1.436         |
| 128.70         | 8.015                      | 2.797  | 10.0           | 0.927         |
| 130.20         | 8.128                      | 2.837  | 8.0            | 0.741         |
| 133.20         | 8.354                      | 2.915  | 5.0            | 0.463         |
| 139.70         | 8.843                      | 3.086  | 3.0            | 0.278         |
| 143.70         | 9.144                      | 3.191  | 2.0            | 0.185         |
| 182.70         | 12.079                     | 4.216  | 1.0            | 0.093         |
| 199.70         | 13.359                     | 4.662  | 0.0            | 0.000         |

TABLE A.2.29 Retention Time-Height Data for n-Hexane  
at 197.73°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 80.40          | 4.468                      | 1.520  | 246.0          | 23.630        |
| 82.50          | 4.628                      | 1.574  | 229.0          | 21.997        |
| 84.00          | 4.742                      | 1.613  | 208.0          | 19.980        |
| 87.00          | 4.970                      | 1.691  | 148.0          | 14.216        |
| 88.50          | 5.084                      | 1.729  | 135.0          | 12.968        |
| 91.50          | 5.312                      | 1.807  | 91.0           | 8.741         |
| 93.00          | 5.426                      | 1.846  | 73.0           | 7.012         |
| 96.00          | 5.654                      | 1.923  | 43.0           | 4.130         |
| 97.50          | 5.768                      | 1.962  | 32.0           | 3.074         |
| 100.50         | 5.996                      | 2.040  | 17.0           | 1.633         |
| 103.50         | 6.224                      | 2.117  | 8.5            | 0.816         |
| 106.50         | 6.452                      | 2.195  | 4.8            | 0.461         |
| 109.50         | 6.679                      | 2.272  | 3.0            | 0.288         |
| 112.50         | 6.907                      | 2.350  | 1.8            | 0.173         |
| 117.00         | 7.249                      | 2.466  | 1.0            | 0.096         |
| 127.50         | 8.047                      | 2.738  | 0.0            | 0.000         |

TABLE A.2.30 Retention Time-Height Data for n-Hexane  
at 205.59°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 71.40          | 4.083                      | 1.367  | 143.5          | 22.674        |
| 74.70          | 4.347                      | 1.455  | 122.0          | 19.277        |
| 76.20          | 4.467                      | 1.495  | 107.0          | 16.907        |
| 79.20          | 4.707                      | 1.576  | 75.0           | 11.850        |
| 80.70          | 4.827                      | 1.616  | 60.0           | 9.480         |
| 82.20          | 4.947                      | 1.656  | 47.0           | 7.426         |
| 83.70          | 5.068                      | 1.696  | 35.0           | 5.530         |
| 85.20          | 5.188                      | 1.737  | 26.0           | 4.108         |
| 86.70          | 5.308                      | 1.777  | 18.0           | 2.844         |
| 88.20          | 5.428                      | 1.817  | 13.0           | 2.054         |
| 89.70          | 5.548                      | 1.857  | 8.5            | 1.343         |
| 91.20          | 5.668                      | 1.897  | 6.0            | 0.948         |
| 92.70          | 5.788                      | 1.938  | 4.0            | 0.632         |
| 94.20          | 5.908                      | 1.978  | 2.5            | 0.395         |
| 95.70          | 6.028                      | 2.018  | 2.0            | 0.316         |
| 97.20          | 6.148                      | 2.058  | 1.0            | 0.158         |
| 104.70         | 6.749                      | 2.259  | 0.0            | 0.000         |

TABLE A.2.31 Retention Time-Height Data for n-Hexane  
at 211.11°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 67.80          | 3.689                      | 1.221  | 146.5          | 27.621        |
| 71.40          | 3.969                      | 1.313  | 120.0          | 22.624        |
| 72.90          | 4.085                      | 1.352  | 103.0          | 19.419        |
| 74.40          | 4.202                      | 1.391  | 85.5           | 16.120        |
| 77.40          | 4.436                      | 1.468  | 54.0           | 10.181        |
| 78.90          | 4.552                      | 1.507  | 41.0           | 7.730         |
| 80.40          | 4.669                      | 1.545  | 30.0           | 5.656         |
| 81.90          | 4.786                      | 1.584  | 21.5           | 4.054         |
| 83.40          | 4.903                      | 1.622  | 15.0           | 2.828         |
| 84.90          | 5.019                      | 1.661  | 10.5           | 1.980         |
| 86.40          | 5.136                      | 1.700  | 7.0            | 1.320         |
| 87.90          | 5.253                      | 1.738  | 5.0            | 0.943         |
| 89.40          | 5.369                      | 1.777  | 3.5            | 0.660         |
| 90.90          | 5.486                      | 1.816  | 2.5            | 0.471         |
| 92.40          | 5.603                      | 1.854  | 2.0            | 0.377         |
| 96.90          | 5.953                      | 1.970  | 1.0            | 0.189         |
| 113.40         | 7.237                      | 2.395  | 0.0            | 0.000         |

TABLE A.2.32 Retention Time-Height Data for n-Hexane  
at 218.17°C and 0.4  $\mu$ l with Helium

| $t_e$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_e) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 60.60          | 3.296                      | 1.075  | 160.0          | 29.282        |
| 62.85          | 3.479                      | 1.135  | 145.0          | 26.537        |
| 64.35          | 3.601                      | 1.175  | 127.5          | 23.334        |
| 65.85          | 3.723                      | 1.214  | 106.0          | 19.399        |
| 67.35          | 3.845                      | 1.254  | 84.0           | 15.373        |
| 68.85          | 3.967                      | 1.294  | 64.0           | 11.713        |
| 70.35          | 4.089                      | 1.334  | 49.0           | 8.968         |
| 71.85          | 4.211                      | 1.374  | 31.0           | 5.673         |
| 73.35          | 4.334                      | 1.413  | 22.0           | 4.026         |
| 74.85          | 4.456                      | 1.453  | 14.0           | 2.562         |
| 76.35          | 4.578                      | 1.493  | 9.5            | 1.739         |
| 77.85          | 4.700                      | 1.533  | 6.0            | 1.098         |
| 79.35          | 4.822                      | 1.573  | 4.0            | 0.732         |
| 80.85          | 4.944                      | 1.613  | 2.5            | 0.458         |
| 83.85          | 5.188                      | 1.692  | 1.0            | 0.183         |
| 101.85         | 6.653                      | 2.170  | 0.0            | 0.000         |

TABLE A.2.33 Retention Time-Height Data for n-Hexane  
at 225.64°C and 0.4  $\mu$ l with Helium

| $t_e$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_e) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 58.20          | 2.831                      | 0.910  | 166.0          | 31.478        |
| 60.00          | 2.968                      | 0.954  | 156.0          | 29.582        |
| 61.50          | 3.082                      | 0.990  | 137.0          | 25.979        |
| 63.00          | 3.197                      | 1.027  | 116.0          | 21.997        |
| 64.50          | 3.311                      | 1.064  | 94.0           | 17.825        |
| 66.00          | 3.425                      | 1.100  | 72.0           | 13.653        |
| 67.50          | 3.539                      | 1.137  | 52.0           | 9.861         |
| 69.00          | 3.653                      | 1.174  | 37.2           | 7.054         |
| 70.50          | 3.767                      | 1.210  | 26.0           | 4.930         |
| 72.00          | 3.882                      | 1.247  | 18.0           | 3.413         |
| 73.50          | 3.996                      | 1.284  | 12.0           | 2.276         |
| 75.00          | 4.110                      | 1.320  | 8.0            | 1.517         |
| 76.50          | 4.224                      | 1.357  | 5.0            | 0.948         |
| 78.00          | 4.338                      | 1.394  | 3.5            | 0.664         |
| 79.50          | 4.452                      | 1.430  | 2.2            | 0.417         |
| 82.50          | 4.681                      | 1.504  | 1.0            | 0.190         |
| 88.50          | 5.137                      | 1.651  | 0.0            | 0.000         |

TABLE A.2.34 Retention Time-Height Data for n-Hexane  
at 230.82°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 52.20          | 2.528                      | 0.804  | 170.5          | 31.890        |
| 53.25          | 2.613                      | 0.831  | 164.0          | 30.674        |
| 54.75          | 2.735                      | 0.870  | 147.0          | 27.494        |
| 56.25          | 2.856                      | 0.908  | 122.0          | 22.818        |
| 57.75          | 2.978                      | 0.947  | 96.0           | 17.955        |
| 59.25          | 3.099                      | 0.986  | 72.0           | 13.467        |
| 60.75          | 3.221                      | 1.024  | 51.0           | 9.539         |
| 62.25          | 3.342                      | 1.063  | 35.0           | 6.546         |
| 63.75          | 3.464                      | 1.101  | 24.0           | 4.489         |
| 65.25          | 3.585                      | 1.140  | 15.0           | 2.806         |
| 66.75          | 3.707                      | 1.179  | 10.5           | 1.964         |
| 68.25          | 3.828                      | 1.217  | 7.0            | 1.309         |
| 69.75          | 3.950                      | 1.256  | 4.5            | 0.842         |
| 71.25          | 4.072                      | 1.295  | 2.8            | 0.524         |
| 72.75          | 4.193                      | 1.333  | 2.0            | 0.374         |
| 74.25          | 4.315                      | 1.372  | 1.1            | 0.206         |
| 92.25          | 5.773                      | 1.836  | 0.0            | 0.000         |

TABLE A.2.35 Retention Time-Height Data for n-Hexane  
at 235.31°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 50.40          | 2.485                      | 0.783  | 171.5          | 32.435        |
| 51.90          | 2.605                      | 0.821  | 161.0          | 30.449        |
| 53.40          | 2.726                      | 0.859  | 139.0          | 26.289        |
| 54.90          | 2.847                      | 0.897  | 111.0          | 20.993        |
| 56.40          | 2.967                      | 0.935  | 85.0           | 16.076        |
| 57.90          | 3.088                      | 0.973  | 62.0           | 11.726        |
| 59.40          | 3.208                      | 1.011  | 42.0           | 7.943         |
| 60.90          | 3.329                      | 1.049  | 30.0           | 5.674         |
| 62.40          | 3.450                      | 1.087  | 20.0           | 3.783         |
| 63.90          | 3.570                      | 1.125  | 13.8           | 2.610         |
| 65.40          | 3.691                      | 1.163  | 9.0            | 1.702         |
| 66.90          | 3.812                      | 1.201  | 6.0            | 1.135         |
| 68.40          | 3.932                      | 1.239  | 4.0            | 0.757         |
| 69.90          | 4.053                      | 1.277  | 3.0            | 0.567         |
| 71.40          | 4.173                      | 1.315  | 2.0            | 0.378         |
| 74.40          | 4.415                      | 1.391  | 1.0            | 0.189         |
| 89.40          | 5.621                      | 1.772  | 0.0            | 0.000         |

TABLE A.2.36 Retention Time-Height Data for n-Hexane  
at 185.81°C and 0.3  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 91.20          | 5.436                      | 1.898  | 186.0          | 34.837        |
| 93.90          | 5.647                      | 1.972  | 174.0          | 32.589        |
| 95.40          | 5.764                      | 2.013  | 162.5          | 30.435        |
| 98.40          | 5.999                      | 2.095  | 138.0          | 25.847        |
| 99.90          | 6.116                      | 2.135  | 126.0          | 23.599        |
| 102.90         | 6.350                      | 2.217  | 101.0          | 18.917        |
| 104.40         | 6.467                      | 2.258  | 90.0           | 16.856        |
| 107.40         | 6.701                      | 2.340  | 69.5           | 13.017        |
| 108.90         | 6.819                      | 2.381  | 60.0           | 11.238        |
| 111.90         | 7.053                      | 2.463  | 43.5           | 8.147         |
| 113.40         | 7.170                      | 2.504  | 36.0           | 6.743         |
| 116.40         | 7.404                      | 2.585  | 24.0           | 4.495         |
| 120.90         | 7.756                      | 2.708  | 11.0           | 2.060         |
| 123.90         | 7.990                      | 2.790  | 7.0            | 1.311         |
| 129.90         | 8.459                      | 2.954  | 2.0            | 0.375         |
| 132.90         | 8.693                      | 3.035  | 1.0            | 0.187         |
| 141.90         | 9.396                      | 3.281  | 0.0            | 0.000         |

TABLE A.2.37 Retention Time-Height Data for n-Hexane  
at 196.99°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 75.00          | 4.148                      | 1.414  | 108.5          | 40.941        |
| 77.70          | 4.357                      | 1.485  | 101.5          | 38.299        |
| 79.20          | 4.474                      | 1.525  | 94.0           | 35.469        |
| 82.20          | 4.707                      | 1.604  | 76.5           | 28.866        |
| 83.70          | 4.823                      | 1.644  | 67.5           | 25.470        |
| 86.70          | 5.056                      | 1.724  | 52.0           | 19.621        |
| 88.20          | 5.173                      | 1.763  | 44.0           | 16.603        |
| 91.20          | 5.406                      | 1.843  | 30.5           | 11.509        |
| 92.70          | 5.522                      | 1.882  | 25.0           | 9.433         |
| 94.20          | 5.639                      | 1.922  | 20.0           | 7.547         |
| 95.70          | 5.755                      | 1.962  | 15.0           | 5.660         |
| 97.20          | 5.872                      | 2.002  | 11.0           | 4.151         |
| 100.20         | 6.105                      | 2.081  | 6.0            | 2.264         |
| 101.70         | 6.221                      | 2.121  | 4.0            | 1.509         |
| 103.20         | 6.338                      | 2.160  | 3.0            | 1.132         |
| 109.20         | 6.804                      | 2.319  | 1.0            | 0.377         |
| 110.70         | 6.920                      | 2.359  | 0.0            | 0.000         |

TABLE A.2.38 Retention Time-Height Data for n-Hexane at 203.35°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 67.20          | 3.682                      | 1.238  | 115.5          | 45.105        |
| 70.20          | 3.916                      | 1.317  | 105.0          | 41.004        |
| 73.20          | 4.151                      | 1.396  | 85.0           | 33.194        |
| 74.70          | 4.268                      | 1.435  | 75.0           | 29.289        |
| 76.20          | 4.385                      | 1.475  | 65.0           | 25.384        |
| 79.20          | 4.620                      | 1.554  | 46.0           | 17.964        |
| 80.70          | 4.737                      | 1.593  | 38.0           | 14.840        |
| 82.20          | 4.855                      | 1.633  | 30.0           | 11.715        |
| 83.70          | 4.972                      | 1.672  | 24.0           | 9.372         |
| 85.20          | 5.089                      | 1.712  | 18.0           | 7.029         |
| 86.70          | 5.206                      | 1.751  | 13.0           | 5.077         |
| 88.20          | 5.324                      | 1.790  | 9.5            | 3.710         |
| 89.70          | 5.441                      | 1.830  | 6.5            | 2.538         |
| 92.70          | 5.675                      | 1.909  | 3.0            | 1.172         |
| 94.20          | 5.793                      | 1.948  | 2.0            | 0.781         |
| 98.70          | 6.144                      | 2.066  | 1.0            | 0.391         |
| 106.20         | 6.731                      | 2.264  | 0.0            | 0.000         |

TABLE A.2.39 Retention Time-Height Data for n-Hexane at 211.07°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 64.20          | 3.447                      | 1.141  | 245.5          | 46.245        |
| 67.50          | 3.707                      | 1.227  | 197.0          | 37.109        |
| 69.00          | 3.825                      | 1.266  | 175.0          | 32.965        |
| 72.00          | 4.061                      | 1.344  | 130.0          | 24.488        |
| 73.50          | 4.179                      | 1.383  | 108.0          | 20.344        |
| 76.50          | 4.415                      | 1.461  | 70.0           | 13.186        |
| 78.00          | 4.533                      | 1.500  | 54.0           | 10.172        |
| 81.00          | 4.769                      | 1.578  | 30.5           | 5.745         |
| 82.50          | 4.887                      | 1.618  | 22.0           | 4.144         |
| 84.00          | 5.005                      | 1.657  | 15.5           | 2.920         |
| 85.50          | 5.123                      | 1.696  | 11.0           | 2.072         |
| 87.00          | 5.242                      | 1.735  | 8.0            | 1.507         |
| 90.00          | 5.478                      | 1.813  | 4.0            | 0.753         |
| 91.50          | 5.596                      | 1.852  | 3.0            | 0.565         |
| 94.50          | 5.832                      | 1.930  | 1.8            | 0.339         |
| 99.00          | 6.186                      | 2.047  | 1.0            | 0.188         |
| 108.00         | 6.894                      | 2.282  | 0.0            | 0.000         |

TABLE A.2.40 Retention Time-Height Data for n-Hexane  
at 218.16°C and 0.8  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 55.80          | 2.919                      | 0.952  | 135.5          | 51.669        |
| 57.90          | 3.091                      | 1.008  | 116.0          | 44.234        |
| 59.40          | 3.213                      | 1.048  | 101.0          | 38.514        |
| 60.90          | 3.336                      | 1.088  | 87.0           | 33.175        |
| 62.40          | 3.459                      | 1.128  | 72.5           | 27.646        |
| 63.90          | 3.581                      | 1.168  | 59.0           | 22.498        |
| 65.40          | 3.704                      | 1.208  | 46.0           | 17.541        |
| 66.90          | 3.827                      | 1.248  | 35.0           | 13.346        |
| 68.40          | 3.949                      | 1.288  | 25.5           | 9.724         |
| 69.90          | 4.072                      | 1.328  | 17.5           | 6.673         |
| 71.40          | 4.194                      | 1.368  | 12.0           | 4.576         |
| 72.90          | 4.317                      | 1.408  | 7.5            | 2.860         |
| 74.40          | 4.440                      | 1.448  | 5.0            | 1.907         |
| 75.90          | 4.562                      | 1.488  | 3.0            | 1.144         |
| 77.40          | 4.685                      | 1.528  | 2.0            | 0.763         |
| 80.40          | 4.930                      | 1.608  | 1.0            | 0.381         |
| 89.40          | 5.666                      | 1.848  | 0.0            | 0.000         |

TABLE A.2.41 Retention Time-Height Data for n-Hexane  
at 225.49°C and 0.8  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 51.00          | 2.437                      | 0.783  | 138.5          | 54.288        |
| 53.85          | 2.669                      | 0.858  | 124.0          | 48.605        |
| 55.35          | 2.790                      | 0.897  | 110.0          | 43.117        |
| 56.85          | 2.912                      | 0.936  | 93.0           | 36.454        |
| 58.35          | 3.034                      | 0.975  | 78.0           | 30.574        |
| 59.35          | 3.115                      | 1.001  | 62.0           | 24.302        |
| 61.35          | 3.278                      | 1.053  | 48.0           | 18.815        |
| 62.85          | 3.400                      | 1.093  | 35.0           | 13.719        |
| 64.35          | 3.522                      | 1.132  | 25.0           | 9.799         |
| 65.85          | 3.643                      | 1.171  | 17.0           | 6.664         |
| 67.35          | 3.765                      | 1.210  | 11.0           | 4.312         |
| 68.85          | 3.887                      | 1.249  | 7.0            | 2.744         |
| 70.35          | 4.009                      | 1.288  | 4.0            | 1.568         |
| 71.85          | 4.131                      | 1.328  | 2.5            | 0.980         |
| 74.85          | 4.375                      | 1.406  | 1.0            | 0.392         |
| 79.35          | 4.740                      | 1.523  | 0.0            | 0.000         |

TABLE A.2.42 Retention Time-Height Data for n-Hexane  
at 230.83°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 48.60          | 2.212                      | 0.703  | 141.0          | 55.201        |
| 51.00          | 2.404                      | 0.764  | 129.0          | 50.503        |
| 52.50          | 2.524                      | 0.803  | 114.0          | 44.630        |
| 54.00          | 2.645                      | 0.841  | 98.0           | 38.366        |
| 55.50          | 2.765                      | 0.879  | 80.0           | 31.320        |
| 57.00          | 2.885                      | 0.917  | 64.0           | 25.056        |
| 58.50          | 3.005                      | 0.956  | 49.0           | 19.183        |
| 60.00          | 3.125                      | 0.994  | 36.0           | 14.094        |
| 61.50          | 3.246                      | 1.032  | 25.0           | 9.787         |
| 63.00          | 3.366                      | 1.070  | 18.0           | 7.047         |
| 64.50          | 3.486                      | 1.108  | 12.0           | 4.698         |
| 66.00          | 3.606                      | 1.147  | 7.5            | 2.936         |
| 67.50          | 3.726                      | 1.185  | 5.0            | 1.957         |
| 69.00          | 3.847                      | 1.223  | 3.0            | 1.174         |
| 70.50          | 3.967                      | 1.261  | 2.0            | 0.783         |
| 73.50          | 4.207                      | 1.338  | 1.0            | 0.391         |
| 84.00          | 5.049                      | 1.605  | 0.0            | 0.000         |

TABLE A.2.43 Retention Time-Height Data for n-Hexane  
at 235.21°C and 0.8  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 46.20          | 2.081                      | 0.656  | 141.5          | 57.200        |
| 48.00          | 2.221                      | 0.700  | 137.0          | 55.381        |
| 49.50          | 2.338                      | 0.737  | 122.0          | 49.317        |
| 51.00          | 2.455                      | 0.774  | 104.0          | 42.041        |
| 52.50          | 2.572                      | 0.811  | 85.5           | 34.562        |
| 54.00          | 2.689                      | 0.848  | 67.0           | 27.084        |
| 55.50          | 2.806                      | 0.885  | 50.0           | 20.212        |
| 57.00          | 2.923                      | 0.921  | 36.0           | 14.553        |
| 58.50          | 3.040                      | 0.958  | 24.5           | 9.904         |
| 60.00          | 3.157                      | 0.995  | 15.5           | 6.266         |
| 61.50          | 3.274                      | 1.032  | 10.0           | 4.042         |
| 63.00          | 3.390                      | 1.069  | 6.5            | 2.628         |
| 64.50          | 3.507                      | 1.106  | 3.5            | 1.415         |
| 66.00          | 3.624                      | 1.143  | 2.2            | 0.889         |
| 67.50          | 3.741                      | 1.179  | 1.1            | 0.445         |
| 76.50          | 4.443                      | 1.401  | 0.0            | 0.000         |

TABLE A.2.44 Retention Time-Height Data for n-Heptane at 185.24°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 124.80         | 12.365                     | 4.323  | 148.5          | 5.587         |
| 128.10         | 12.732                     | 4.451  | 131.0          | 4.929         |
| 129.60         | 12.899                     | 4.510  | 118.0          | 4.440         |
| 132.60         | 13.234                     | 4.627  | 95.0           | 3.574         |
| 135.60         | 13.568                     | 4.743  | 75.0           | 2.822         |
| 138.60         | 13.902                     | 4.860  | 57.0           | 2.145         |
| 140.10         | 14.069                     | 4.919  | 49.5           | 1.862         |
| 143.10         | 14.403                     | 5.035  | 36.5           | 1.373         |
| 146.10         | 14.737                     | 5.152  | 26.0           | 0.978         |
| 149.10         | 15.072                     | 5.269  | 18.0           | 0.677         |
| 152.10         | 15.406                     | 5.386  | 12.5           | 0.470         |
| 153.60         | 15.573                     | 5.444  | 10.0           | 0.376         |
| 139.60         | 14.013                     | 4.899  | 5.0            | 0.188         |
| 161.10         | 16.408                     | 5.736  | 4.0            | 0.150         |
| 167.10         | 17.077                     | 5.970  | 2.0            | 0.075         |
| 171.60         | 17.578                     | 6.145  | 1.0            | 0.038         |
| 179.10         | 18.413                     | 6.437  | 0.0            | 0.000         |

TABLE A.2.45 Retention Time-Height Data for n-Heptane at 193.34°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 117.60         | 10.389                     | 3.569  | 170.5          | 6.789         |
| 120.30         | 10.662                     | 3.663  | 154.0          | 6.132         |
| 121.80         | 10.814                     | 3.715  | 139.0          | 5.535         |
| 124.80         | 11.118                     | 3.819  | 109.0          | 4.340         |
| 126.30         | 11.270                     | 3.872  | 95.0           | 3.783         |
| 129.30         | 11.573                     | 3.976  | 71.0           | 2.827         |
| 130.80         | 11.725                     | 4.028  | 60.0           | 2.389         |
| 133.80         | 12.029                     | 4.132  | 43.0           | 1.712         |
| 138.30         | 12.485                     | 4.289  | 24.0           | 0.956         |
| 139.80         | 12.637                     | 4.341  | 20.0           | 0.796         |
| 144.30         | 13.092                     | 4.498  | 10.5           | 0.418         |
| 147.30         | 13.396                     | 4.602  | 7.0            | 0.279         |
| 148.80         | 13.548                     | 4.654  | 6.0            | 0.239         |
| 151.80         | 13.852                     | 4.759  | 4.0            | 0.159         |
| 153.30         | 14.004                     | 4.811  | 3.0            | 0.119         |
| 165.30         | 15.219                     | 5.228  | 1.0            | 0.040         |
| 168.30         | 15.522                     | 5.333  | 0.0            | 0.000         |

TABLE A.2.46 Retention Time-Height Data for n-Heptane at 201.51°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 105.00         | 9.182                      | 3.100  | 198.5          | 8.009         |
| 108.00         | 9.489                      | 3.204  | 170.0          | 6.859         |
| 109.50         | 9.642                      | 3.255  | 150.0          | 6.052         |
| 111.00         | 9.795                      | 3.307  | 130.0          | 5.245         |
| 112.50         | 9.948                      | 3.359  | 112.0          | 4.519         |
| 115.50         | 10.254                     | 3.462  | 79.0           | 3.187         |
| 117.00         | 10.407                     | 3.514  | 64.5           | 2.602         |
| 120.00         | 10.713                     | 3.617  | 41.5           | 1.674         |
| 121.50         | 10.866                     | 3.669  | 33.0           | 1.331         |
| 124.50         | 11.172                     | 3.772  | 19.0           | 0.767         |
| 127.50         | 11.478                     | 3.875  | 10.5           | 0.424         |
| 130.50         | 11.784                     | 3.979  | 5.5            | 0.222         |
| 132.00         | 11.937                     | 4.030  | 4.0            | 0.161         |
| 133.50         | 12.090                     | 4.082  | 3.0            | 0.121         |
| 135.00         | 12.243                     | 4.134  | 2.5            | 0.101         |
| 139.50         | 12.702                     | 4.289  | 1.0            | 0.040         |
| 145.50         | 13.315                     | 4.495  | 0.0            | 0.000         |

TABLE A.2.47 Retention Time-Height Data for n-Heptane at 207.39°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 82.80          | 7.505                      | 2.503  | 246.0          | 8.985         |
| 85.80          | 7.835                      | 2.613  | 202.0          | 7.378         |
| 87.30          | 7.999                      | 2.668  | 170.0          | 6.209         |
| 90.30          | 8.328                      | 2.777  | 112.0          | 4.091         |
| 91.80          | 8.493                      | 2.832  | 86.0           | 3.141         |
| 93.30          | 8.658                      | 2.887  | 66.0           | 2.411         |
| 96.30          | 8.987                      | 2.997  | 35.0           | 1.278         |
| 97.80          | 9.151                      | 3.052  | 25.0           | 0.913         |
| 99.30          | 9.316                      | 3.107  | 18.0           | 0.657         |
| 100.80         | 9.481                      | 3.162  | 13.0           | 0.475         |
| 103.80         | 9.810                      | 3.271  | 7.0            | 0.256         |
| 105.30         | 9.974                      | 3.326  | 5.5            | 0.201         |
| 106.80         | 10.139                     | 3.381  | 4.0            | 0.146         |
| 108.30         | 10.303                     | 3.436  | 3.2            | 0.117         |
| 111.30         | 10.633                     | 3.546  | 2.0            | 0.073         |
| 118.80         | 11.456                     | 3.820  | 1.0            | 0.037         |
| 127.80         | 12.443                     | 4.150  | 0.0            | 0.000         |

TABLE A.2.48 Retention Time-Height Data for n-Heptane at 217.48°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 78.00          | 6.616                      | 2.161  | 126.5          | 10.520        |
| 81.30          | 6.959                      | 2.273  | 100.0          | 8.316         |
| 82.80          | 7.115                      | 2.324  | 82.0           | 6.819         |
| 84.30          | 7.271                      | 2.375  | 65.5           | 5.447         |
| 85.80          | 7.427                      | 2.426  | 50.5           | 4.200         |
| 87.30          | 7.583                      | 2.477  | 38.0           | 3.160         |
| 88.80          | 7.740                      | 2.528  | 27.5           | 2.287         |
| 90.30          | 7.896                      | 2.579  | 19.0           | 1.580         |
| 91.80          | 8.052                      | 2.630  | 13.0           | 1.081         |
| 93.30          | 8.208                      | 2.681  | 8.5            | 0.707         |
| 94.80          | 8.364                      | 2.732  | 5.5            | 0.457         |

TABLE A.2.49 Retention Time-Height Data for n-Heptane at 224.97°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 66.60          | 5.836                      | 1.878  | 139.0          | 11.502        |
| 68.85          | 6.085                      | 1.958  | 116.0          | 9.599         |
| 70.35          | 6.251                      | 2.011  | 93.0           | 7.695         |
| 71.85          | 6.416                      | 2.064  | 70.0           | 5.792         |
| 73.35          | 6.582                      | 2.118  | 50.5           | 4.179         |
| 74.85          | 6.748                      | 2.171  | 34.0           | 2.813         |
| 76.35          | 6.914                      | 2.224  | 22.0           | 1.820         |
| 77.85          | 7.080                      | 2.278  | 14.0           | 1.158         |
| 79.35          | 7.245                      | 2.331  | 8.5            | 0.703         |
| 80.85          | 7.411                      | 2.384  | 5.5            | 0.455         |
| 82.35          | 7.577                      | 2.438  | 3.5            | 0.290         |
| 83.85          | 7.743                      | 2.491  | 2.0            | 0.165         |
| 85.35          | 7.909                      | 2.544  | 1.2            | 0.099         |
| 86.85          | 8.074                      | 2.598  | 1.0            | 0.083         |
| 101.85         | 9.732                      | 3.131  | 0.0            | 0.000         |

TABLE A.2.50 Retention Time-Height Data for n-Heptane at 229.87°C and 0.2  $\mu$ l with Helium

| $t_e$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_e) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 60.60          | 5.330                      | 1.698  | 148.0          | 12.032        |
| 62.85          | 5.583                      | 1.779  | 121.0          | 9.837         |
| 64.35          | 5.751                      | 1.832  | 94.0           | 7.642         |
| 65.85          | 5.920                      | 1.886  | 69.0           | 5.609         |
| 67.35          | 6.088                      | 1.940  | 48.0           | 3.902         |
| 68.85          | 6.257                      | 1.993  | 31.0           | 2.520         |
| 70.35          | 6.426                      | 2.047  | 19.0           | 1.545         |
| 71.85          | 6.594                      | 2.101  | 10.5           | 0.854         |
| 73.35          | 6.763                      | 2.155  | 6.0            | 0.488         |
| 74.85          | 6.932                      | 2.208  | 3.5            | 0.285         |
| 76.35          | 7.100                      | 2.262  | 1.8            | 0.146         |
| 77.85          | 7.269                      | 2.316  | 1.0            | 0.081         |
| 88.35          | 8.450                      | 2.692  | 0.0            | 0.000         |

TABLE A.2.51 Retention Time-Height Data for n-Heptane at 234.29°C and 0.2  $\mu$ l with Helium

| $t_e$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_e) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 55.80          | 4.787                      | 1.512  | 155.5          | 12.627        |
| 57.30          | 4.958                      | 1.566  | 138.0          | 11.206        |
| 58.80          | 5.129                      | 1.620  | 109.0          | 8.851         |
| 60.30          | 5.300                      | 1.674  | 77.0           | 6.252         |
| 61.80          | 5.471                      | 1.728  | 153.0          | 12.424        |
| 63.30          | 5.642                      | 1.782  | 133.0          | 10.800        |
| 64.80          | 5.812                      | 1.836  | 20.0           | 1.624         |
| 66.30          | 5.983                      | 1.890  | 12.0           | 0.974         |
| 67.80          | 6.154                      | 1.944  | 7.0            | 0.568         |
| 69.30          | 6.325                      | 1.998  | 4.0            | 0.325         |
| 70.80          | 6.496                      | 2.052  | 2.5            | 0.203         |
| 72.30          | 6.667                      | 2.106  | 2.0            | 0.162         |
| 73.80          | 6.838                      | 2.160  | 1.5            | 0.122         |
| 75.30          | 7.009                      | 2.214  | 1.0            | 0.081         |
| 85.80          | 8.206                      | 2.592  | 0.0            | 0.000         |

TABLE A.2.52 Retention Time-Height Data for n-Heptane at 185.24°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 124.80         | 12.365                     | 4.323  | 148.5          | 11.289        |
| 127.80         | 12.699                     | 4.440  | 132.5          | 10.073        |
| 129.30         | 12.866                     | 4.498  | 120.0          | 9.122         |
| 132.30         | 13.200                     | 4.615  | 96.5           | 7.336         |
| 133.80         | 13.367                     | 4.673  | 86.0           | 6.538         |
| 136.80         | 13.701                     | 4.790  | 66.5           | 5.055         |
| 138.30         | 13.869                     | 4.849  | 58.0           | 4.409         |
| 141.30         | 14.203                     | 4.965  | 43.0           | 3.269         |
| 142.80         | 14.370                     | 5.024  | 37.0           | 2.813         |
| 145.80         | 14.704                     | 5.141  | 26.5           | 2.015         |
| 150.30         | 15.205                     | 5.316  | 15.0           | 1.140         |
| 151.80         | 15.372                     | 5.374  | 10.0           | 0.760         |
| 154.80         | 15.707                     | 5.491  | 8.0            | 0.608         |
| 157.80         | 16.041                     | 5.608  | 5.5            | 0.418         |
| 162.30         | 16.542                     | 5.783  | 3.0            | 0.228         |
| 165.30         | 16.876                     | 5.900  | 2.0            | 0.152         |
| 178.80         | 18.380                     | 6.426  | 0.0            | 0.000         |

TABLE A.2.53 Retention Time-Height Data for n-Heptane at 193.34°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 110.40         | 9.564                      | 3.286  | 117.0          | 9.241         |
| 112.95         | 9.820                      | 3.374  | 108.5          | 8.569         |
| 115.95         | 10.121                     | 3.477  | 93.0           | 7.345         |
| 118.95         | 10.422                     | 3.580  | 78.0           | 6.160         |
| 121.95         | 10.722                     | 3.684  | 65.0           | 5.134         |
| 123.45         | 10.873                     | 3.735  | 59.5           | 4.699         |
| 126.45         | 11.173                     | 3.839  | 49.0           | 3.870         |
| 127.95         | 11.324                     | 3.890  | 44.0           | 3.475         |
| 130.95         | 11.625                     | 3.994  | 36.0           | 2.843         |
| 136.95         | 12.226                     | 4.200  | 22.0           | 1.738         |
| 141.45         | 12.677                     | 4.355  | 15.0           | 1.185         |
| 144.45         | 12.978                     | 4.459  | 11.5           | 0.908         |
| 150.45         | 13.580                     | 4.665  | 6.0            | 0.474         |
| 156.45         | 14.181                     | 4.872  | 3.0            | 0.237         |
| 168.45         | 15.384                     | 5.285  | 1.0            | 0.079         |
| 171.45         | 15.685                     | 5.389  | 0.0            | 0.000         |

TABLE A.2.54 Retention Time-Height Data for n-Heptane at 201.62°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 98.40          | 8.517                      | 2.875  | 178.0          | 13.869        |
| 101.40         | 8.823                      | 2.978  | 159.0          | 12.389        |
| 104.40         | 9.130                      | 3.082  | 129.5          | 10.090        |
| 105.90         | 9.283                      | 3.133  | 115.0          | 8.960         |
| 108.90         | 9.589                      | 3.237  | 88.5           | 6.896         |
| 110.40         | 9.742                      | 3.288  | 76.5           | 5.961         |
| 111.90         | 9.895                      | 3.340  | 66.0           | 5.142         |
| 114.90         | 10.202                     | 3.444  | 47.0           | 3.662         |
| 116.40         | 10.355                     | 3.495  | 39.5           | 3.078         |
| 119.40         | 10.661                     | 3.599  | 26.0           | 2.026         |
| 120.90         | 10.814                     | 3.650  | 21.0           | 1.636         |
| 123.90         | 11.121                     | 3.754  | 12.5           | 0.974         |
| 126.90         | 11.427                     | 3.857  | 7.0            | 0.545         |
| 128.40         | 11.580                     | 3.909  | 5.5            | 0.429         |
| 131.40         | 11.887                     | 4.012  | 2.5            | 0.195         |
| 135.90         | 12.346                     | 4.167  | 1.0            | 0.078         |
| 149.40         | 13.725                     | 4.633  | 0.0            | 0.000         |

TABLE A.2.55 Retention Time-Height Data for n-Heptane at 207.40°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 76.80          | 6.924                      | 2.309  | 211.0          | 16.531        |
| 79.80          | 7.257                      | 2.420  | 177.0          | 13.867        |
| 81.30          | 7.423                      | 2.476  | 153.0          | 11.987        |
| 84.30          | 7.756                      | 2.587  | 110.0          | 8.618         |
| 85.80          | 7.922                      | 2.642  | 90.0           | 7.051         |
| 87.30          | 8.089                      | 2.698  | 73.0           | 5.719         |
| 88.80          | 8.255                      | 2.753  | 58.0           | 4.544         |
| 90.30          | 8.422                      | 2.809  | 45.0           | 3.526         |
| 91.80          | 8.588                      | 2.864  | 34.0           | 2.664         |
| 93.30          | 8.755                      | 2.920  | 25.0           | 1.959         |
| 94.80          | 8.921                      | 2.975  | 17.5           | 1.371         |
| 96.30          | 9.088                      | 3.031  | 12.0           | 0.940         |
| 97.80          | 9.254                      | 3.086  | 8.0            | 0.627         |
| 99.30          | 9.420                      | 3.142  | 5.5            | 0.431         |
| 100.80         | 9.587                      | 3.197  | 3.5            | 0.274         |
| 102.30         | 9.753                      | 3.253  | 2.2            | 0.172         |
| 105.80         | 10.142                     | 3.382  | 1.0            | 0.078         |

TABLE A.2.56 Retention Time-Height Data for n-Heptane  
at 217.47°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 73.80          | 6.203                      | 2.026  | 109.0          | 18.571        |
| 76.80          | 6.517                      | 2.129  | 91.0           | 15.504        |
| 78.30          | 6.673                      | 2.180  | 78.0           | 13.289        |
| 81.30          | 6.987                      | 2.282  | 54.0           | 9.200         |
| 82.80          | 7.143                      | 2.333  | 43.5           | 7.411         |
| 84.30          | 7.300                      | 2.384  | 34.5           | 5.878         |
| 85.80          | 7.457                      | 2.436  | 26.5           | 4.515         |
| 87.30          | 7.613                      | 2.487  | 19.5           | 3.322         |
| 88.80          | 7.770                      | 2.538  | 14.0           | 2.385         |
| 90.30          | 7.927                      | 2.589  | 10.0           | 1.704         |
| 91.80          | 8.083                      | 2.640  | 7.0            | 1.193         |
| 93.30          | 8.240                      | 2.692  | 5.0            | 0.852         |
| 94.80          | 8.397                      | 2.743  | 3.5            | 0.596         |
| 96.30          | 8.553                      | 2.794  | 2.0            | 0.341         |
| 97.80          | 8.710                      | 2.845  | 1.5            | 0.256         |
| 99.30          | 8.867                      | 2.896  | 1.0            | 0.170         |
| 109.80         | 9.963                      | 3.254  | 0.0            | 0.000         |

TABLE A.2.57 Retention Time-Height Data for n-Heptane  
at 225.01°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 63.60          | 5.384                      | 1.732  | 121.5          | 19.798        |
| 65.10          | 5.550                      | 1.785  | 112.5          | 18.331        |
| 66.60          | 5.716                      | 1.839  | 97.0           | 15.805        |
| 68.10          | 5.882                      | 1.892  | 80.0           | 13.035        |
| 69.60          | 6.048                      | 1.946  | 65.0           | 10.591        |
| 71.10          | 6.214                      | 1.999  | 50.0           | 8.147         |
| 72.60          | 6.381                      | 2.053  | 38.0           | 6.192         |
| 74.10          | 6.547                      | 2.106  | 27.5           | 4.481         |
| 75.60          | 6.713                      | 2.160  | 19.0           | 3.096         |
| 77.10          | 6.879                      | 2.213  | 12.5           | 2.037         |
| 78.60          | 7.045                      | 2.266  | 7.5            | 1.222         |
| 80.10          | 7.211                      | 2.320  | 5.5            | 0.896         |
| 81.60          | 7.378                      | 2.373  | 3.5            | 0.570         |
| 83.10          | 7.544                      | 2.427  | 2.1            | 0.342         |
| 84.60          | 7.710                      | 2.480  | 1.5            | 0.244         |
| 86.10          | 7.876                      | 2.534  | 1.0            | 0.163         |
| 96.60          | 9.039                      | 2.908  | 0.0            | 0.000         |

TABLE A.2.58 Retention Time-Height Data for n-Heptane  
at 229.90°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>(cm <sup>3</sup> ) | $(V_g/RT_r) \times 10^7$<br>(gmol/g mmHg) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|-----------------------------|---|----------------|---------------|
| 57.00          | 4.884                       | 1.556                                     | 128.0          | 21.260        |
| 58.50          | 5.051                       | 1.609                                     | 117.0          | 19.433        |
| 60.00          | 5.218                       | 1.662                                     | 98.5           | 16.360        |
| 61.50          | 5.386                       | 1.716                                     | 79.5           | 13.204        |
| 63.00          | 5.553                       | 1.769                                     | 61.5           | 10.215        |
| 64.50          | 5.720                       | 1.822                                     | 46.0           | 7.640         |
| 66.00          | 5.887                       | 1.876                                     | 32.5           | 5.398         |
| 67.50          | 6.055                       | 1.929                                     | 22.0           | 3.654         |
| 69.00          | 6.222                       | 1.982                                     | 13.5           | 2.242         |
| 70.50          | 6.389                       | 2.035                                     | 8.0            | 1.329         |
| 72.00          | 6.556                       | 2.089                                     | 4.5            | 0.747         |
| 73.50          | 6.724                       | 2.142                                     | 2.5            | 0.415         |
| 75.00          | 6.891                       | 2.195                                     | 1.2            | 0.199         |
| 76.50          | 7.058                       | 2.248                                     | 0.8            | 0.133         |
| 84.00          | 7.894                       | 2.515                                     | 0.0            | 0.000         |

TABLE A.2.59 Retention Time-Height Data for n-Heptane  
at 234.31°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>(cm <sup>3</sup> ) | $(V_g/RT_r) \times 10^7$<br>(gmol/g mmHg) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|-----------------------------|---|----------------|---------------|
| 52.80          | 4.468                       | 1.411                                     | 138.5          | 22.264        |
| 54.30          | 4.639                       | 1.465                                     | 125.5          | 20.175        |
| 55.80          | 4.811                       | 1.519                                     | 104.0          | 16.718        |
| 57.30          | 4.983                       | 1.574                                     | 81.0           | 13.021        |
| 58.80          | 5.155                       | 1.628                                     | 61.0           | 9.806         |
| 60.30          | 5.327                       | 1.682                                     | 43.0           | 6.912         |
| 61.80          | 5.499                       | 1.736                                     | 29.5           | 4.742         |
| 63.50          | 5.693                       | 1.798                                     | 18.5           | 2.974         |
| 64.80          | 5.842                       | 1.845                                     | 11.0           | 1.768         |
| 66.30          | 6.014                       | 1.899                                     | 6.5            | 1.045         |
| 67.80          | 6.186                       | 1.954                                     | 3.5            | 0.563         |
| 69.30          | 6.358                       | 2.008                                     | 2.0            | 0.322         |
| 70.80          | 6.530                       | 2.062                                     | 1.1            | 0.177         |
| 72.30          | 6.701                       | 2.116                                     | 1.0            | 0.161         |
| 79.80          | 7.561                       | 2.388                                     | 0.0            | 0.000         |

TABLE A.2.60 Retention Time-Height Data for i-Octane at 185.25°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 161.40         | 14.200                     | 4.964  | 108.5          | 4.175         |
| 164.40         | 14.491                     | 5.066  | 101.0          | 3.887         |
| 167.40         | 14.782                     | 5.168  | 88.0           | 3.386         |
| 170.40         | 15.073                     | 5.269  | 75.5           | 2.905         |
| 173.40         | 15.364                     | 5.371  | 64.0           | 2.463         |
| 176.40         | 15.655                     | 5.473  | 53.5           | 2.059         |
| 179.40         | 15.946                     | 5.575  | 44.5           | 1.712         |
| 185.40         | 16.528                     | 5.778  | 30.5           | 1.174         |
| 188.40         | 16.819                     | 5.880  | 24.5           | 0.943         |
| 191.40         | 17.110                     | 5.982  | 20.0           | 0.770         |
| 197.40         | 17.692                     | 6.185  | 12.5           | 0.481         |
| 200.40         | 17.983                     | 6.287  | 9.8            | 0.377         |
| 206.40         | 18.565                     | 6.490  | 6.0            | 0.231         |
| 209.40         | 18.856                     | 6.592  | 4.7            | 0.181         |
| 215.40         | 19.438                     | 6.795  | 3.0            | 0.115         |
| 231.90         | 21.038                     | 7.355  | 1.0            | 0.038         |
| 255.90         | 23.366                     | 8.169  | 0.0            | 0.000         |

TABLE A.2.61 Retention Time-Height Data for i-Octane at 193.33°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 133.20         | 12.508                     | 4.297  | 129.5          | 5.030         |
| 133.95         | 12.587                     | 4.324  | 128.0          | 4.972         |
| 138.45         | 13.058                     | 4.486  | 102.0          | 3.962         |
| 139.95         | 13.215                     | 4.540  | 93.0           | 3.613         |
| 142.95         | 13.529                     | 4.648  | 75.0           | 2.913         |
| 145.95         | 13.844                     | 4.756  | 60.0           | 2.331         |
| 148.95         | 14.158                     | 4.863  | 47.0           | 1.826         |
| 151.95         | 14.472                     | 4.971  | 36.5           | 1.418         |
| 154.95         | 14.787                     | 5.079  | 28.0           | 1.088         |
| 159.45         | 15.258                     | 5.241  | 17.5           | 0.680         |
| 162.45         | 15.572                     | 5.349  | 12.5           | 0.486         |
| 165.45         | 15.886                     | 5.457  | 9.0            | 0.350         |
| 168.45         | 16.201                     | 5.565  | 6.0            | 0.233         |
| 174.45         | 16.829                     | 5.781  | 2.5            | 0.097         |
| 177.45         | 17.144                     | 5.889  | 1.8            | 0.070         |
| 180.45         | 17.458                     | 5.997  | 1.0            | 0.039         |
| 183.45         | 17.772                     | 6.105  | 0.0            | 0.000         |

TABLE A.2.62 Retention Time-Height Data for i-Octane at 201.59°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 123.60         | 10.880                     | 3.673  | 154.5          | 5.766         |
| 126.60         | 11.180                     | 3.774  | 139.5          | 5.207         |
| 128.10         | 11.331                     | 3.825  | 128.0          | 4.777         |
| 129.60         | 11.481                     | 3.876  | 115.5          | 4.311         |
| 132.60         | 11.782                     | 3.977  | 92.0           | 3.434         |
| 134.10         | 11.932                     | 4.028  | 81.5           | 3.042         |
| 137.10         | 12.232                     | 4.129  | 63.0           | 2.351         |
| 138.60         | 12.383                     | 4.180  | 55.0           | 2.053         |
| 143.10         | 12.833                     | 4.332  | 35.0           | 1.306         |
| 147.60         | 13.284                     | 4.484  | 20.5           | 0.765         |
| 150.60         | 13.585                     | 4.586  | 15.0           | 0.560         |
| 155.10         | 14.036                     | 4.738  | 8.0            | 0.299         |
| 156.60         | 14.186                     | 4.789  | 7.0            | 0.261         |
| 159.60         | 14.486                     | 4.890  | 4.5            | 0.168         |
| 165.60         | 15.088                     | 5.093  | 2.0            | 0.075         |
| 173.10         | 15.839                     | 5.347  | 1.0            | 0.037         |
| 197.10         | 18.243                     | 6.158  | 0.0            | 0.000         |

TABLE A.2.63 Retention Time-Height Data for i-Octane at 209.91°C and 0.2  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 100.20         | 9.297                      | 3.084  | 177.0          | 8.114         |
| 103.20         | 9.619                      | 3.191  | 152.0          | 6.968         |
| 104.70         | 9.781                      | 3.245  | 135.0          | 6.189         |
| 107.70         | 10.104                     | 3.352  | 100.5          | 4.607         |
| 109.20         | 10.265                     | 3.405  | 85.5           | 3.920         |
| 112.20         | 10.588                     | 3.512  | 60.0           | 2.751         |
| 113.70         | 10.749                     | 3.566  | 49.5           | 2.269         |
| 115.20         | 10.910                     | 3.620  | 40.0           | 1.834         |
| 116.70         | 11.072                     | 3.673  | 30.0           | 1.375         |
| 119.70         | 11.395                     | 3.780  | 19.5           | 0.894         |
| 121.20         | 11.556                     | 3.834  | 15.0           | 0.688         |
| 124.20         | 11.879                     | 3.941  | 8.0            | 0.367         |
| 125.70         | 12.040                     | 3.994  | 5.5            | 0.252         |
| 128.70         | 12.363                     | 4.101  | 2.5            | 0.115         |
| 130.20         | 12.524                     | 4.155  | 2.0            | 0.092         |
| 133.20         | 12.847                     | 4.262  | 1.0            | 0.046         |
| 146.70         | 14.300                     | 4.744  | 0.0            | 0.000         |

TABLE A.2.64 Retention Time-Height Data for i-Octane  
at 217.47°C and 0.2  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 92.40          | 7.898                      | 2.580  | 94.0           | 8.112         |
| 95.40          | 8.204                      | 2.680  | 79.0           | 6.818         |
| 96.90          | 8.357                      | 2.730  | 68.0           | 5.869         |
| 98.40          | 8.510                      | 2.780  | 58.5           | 5.049         |
| 99.90          | 8.663                      | 2.830  | 48.5           | 4.186         |
| 102.90         | 8.969                      | 2.930  | 32.5           | 2.805         |
| 104.40         | 9.123                      | 2.980  | 26.0           | 2.244         |
| 105.90         | 9.276                      | 3.030  | 20.5           | 1.769         |
| 107.40         | 9.429                      | 3.080  | 15.5           | 1.338         |
| 108.90         | 9.582                      | 3.130  | 12.0           | 1.036         |
| 110.40         | 9.735                      | 3.180  | 8.5            | 0.734         |
| 111.90         | 9.888                      | 3.230  | 6.2            | 0.535         |
| 113.40         | 10.041                     | 3.280  | 4.5            | 0.388         |
| 114.90         | 10.194                     | 3.330  | 3.0            | 0.259         |
| 116.40         | 10.347                     | 3.380  | 2.0            | 0.173         |
| 117.90         | 10.500                     | 3.430  | 1.0            | 0.086         |
| 131.40         | 11.878                     | 3.880  | 0.0            | 0.000         |

TABLE A.2.65 Retention Time-Height Data for i-Octane  
at 224.87°C and 0.2  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 79.80          | 6.957                      | 2.239  | 110.0          | 8.509         |
| 82.80          | 7.273                      | 2.340  | 91.0           | 7.039         |
| 84.30          | 7.431                      | 2.391  | 77.0           | 5.956         |
| 85.80          | 7.589                      | 2.442  | 63.0           | 4.873         |
| 87.30          | 7.747                      | 2.493  | 50.5           | 3.906         |
| 88.80          | 7.906                      | 2.544  | 40.0           | 3.094         |
| 90.30          | 8.064                      | 2.595  | 30.5           | 2.359         |
| 93.30          | 8.380                      | 2.697  | 16.5           | 1.276         |
| 94.80          | 8.538                      | 2.747  | 11.5           | 0.890         |
| 96.30          | 8.696                      | 2.798  | 8.0            | 0.619         |
| 97.80          | 8.854                      | 2.849  | 5.5            | 0.425         |
| 99.30          | 9.012                      | 2.900  | 3.5            | 0.271         |
| 100.80         | 9.170                      | 2.951  | 2.5            | 0.193         |
| 102.30         | 9.329                      | 3.002  | 2.0            | 0.155         |
| 103.80         | 9.487                      | 3.053  | 1.2            | 0.093         |
| 105.30         | 9.645                      | 3.104  | 1.0            | 0.077         |
| 118.80         | 11.068                     | 3.561  | 0.0            | 0.000         |

TABLE A.2.66 Retention Time-Height Data for i-Octane  
at 229.84°C and 0.2  $\mu$ l with Helium

| $t_e$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_e) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 70.80          | 6.225                      | 1.983  | 121.5          | 9.065         |
| 72.30          | 6.389                      | 2.036  | 113.0          | 8.431         |
| 73.80          | 6.553                      | 2.088  | 97.0           | 7.237         |
| 75.30          | 6.716                      | 2.140  | 79.5           | 5.932         |
| 78.30          | 7.044                      | 2.244  | 48.5           | 3.619         |
| 79.80          | 7.208                      | 2.296  | 36.5           | 2.723         |
| 82.80          | 7.536                      | 2.401  | 18.5           | 1.380         |
| 84.30          | 7.699                      | 2.453  | 12.5           | 0.933         |
| 85.80          | 7.863                      | 2.505  | 8.5            | 0.634         |
| 87.30          | 8.027                      | 2.557  | 5.5            | 0.410         |
| 88.80          | 8.191                      | 2.610  | 4.0            | 0.298         |
| 90.30          | 8.355                      | 2.662  | 3.0            | 0.224         |
| 91.80          | 8.518                      | 2.714  | 2.0            | 0.149         |
| 93.30          | 8.682                      | 2.766  | 1.8            | 0.134         |
| 94.80          | 8.846                      | 2.818  | 1.5            | 0.112         |
| 99.30          | 9.338                      | 2.975  | 1.0            | 0.075         |
| 118.80         | 11.467                     | 3.654  | 0.0            | 0.000         |

TABLE A.2.67 Retention Time-Height Data for i-Octane  
at 234.26°C and 0.2  $\mu$ l with Helium

| $t_e$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_e) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 67.20          | 5.804                      | 1.833  | 127.0          | 9.924         |
| 68.70          | 5.966                      | 1.884  | 118.5          | 9.260         |
| 70.20          | 6.127                      | 1.935  | 100.0          | 7.814         |
| 71.70          | 6.288                      | 1.986  | 80.5           | 6.290         |
| 73.20          | 6.449                      | 2.037  | 62.0           | 4.845         |
| 74.70          | 6.611                      | 2.088  | 46.0           | 3.595         |
| 76.20          | 6.772                      | 2.139  | 33.0           | 2.579         |
| 77.70          | 6.933                      | 2.190  | 22.5           | 1.758         |
| 79.20          | 7.094                      | 2.241  | 14.5           | 1.133         |
| 80.70          | 7.256                      | 2.292  | 9.5            | 0.742         |
| 82.20          | 7.417                      | 2.342  | 6.0            | 0.469         |
| 83.70          | 7.578                      | 2.393  | 4.0            | 0.313         |
| 85.20          | 7.739                      | 2.444  | 2.5            | 0.195         |
| 86.70          | 7.901                      | 2.495  | 2.0            | 0.156         |
| 88.20          | 8.062                      | 2.546  | 1.2            | 0.094         |
| 89.70          | 8.223                      | 2.597  | 1.0            | 0.078         |
| 104.70         | 9.835                      | 3.106  | 0.0            | 0.000         |

TABLE A.2.68 Retention Time-Height Data for *i*-Octane at 185.27°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 151.20         | 13.264                     | 4.637  | 100.0          | 7.553         |
| 154.20         | 13.556                     | 4.739  | 93.0           | 7.025         |
| 160.20         | 14.140                     | 4.943  | 72.0           | 5.438         |
| 163.20         | 14.432                     | 5.045  | 62.5           | 4.721         |
| 169.20         | 15.016                     | 5.249  | 46.0           | 3.475         |
| 172.20         | 15.309                     | 5.352  | 39.0           | 2.946         |
| 175.20         | 15.601                     | 5.454  | 33.5           | 2.530         |
| 181.20         | 16.185                     | 5.658  | 24.5           | 1.851         |
| 184.20         | 16.477                     | 5.760  | 19.5           | 1.473         |
| 190.20         | 17.061                     | 5.964  | 13.2           | 0.997         |
| 193.20         | 17.354                     | 6.067  | 11.0           | 0.831         |
| 199.20         | 17.938                     | 6.271  | 7.0            | 0.529         |
| 202.20         | 18.230                     | 6.373  | 5.5            | 0.415         |
| 208.20         | 18.814                     | 6.577  | 3.5            | 0.264         |
| 211.20         | 19.106                     | 6.679  | 2.8            | 0.211         |
| 230.70         | 21.005                     | 7.343  | 1.0            | 0.076         |
| 248.70         | 22.758                     | 7.956  | 0.0            | 0.000         |

TABLE A.2.69 Retention Time-Height Data for *i*-Octane at 193.30°C and 0.4  $\mu$ l with Helium

| $t_c$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_c) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 123.00         | 11.394                     | 3.915  | 117.5          | 9.117         |
| 129.00         | 12.020                     | 4.130  | 92.0           | 7.139         |
| 132.00         | 12.333                     | 4.237  | 77.0           | 5.975         |
| 135.00         | 12.646                     | 4.345  | 64.5           | 5.005         |
| 138.00         | 12.959                     | 4.452  | 52.5           | 4.074         |
| 144.00         | 13.585                     | 4.667  | 34.5           | 2.677         |
| 147.00         | 13.898                     | 4.775  | 27.5           | 2.134         |
| 150.00         | 14.211                     | 4.883  | 21.5           | 1.668         |
| 153.00         | 14.524                     | 4.990  | 16.5           | 1.280         |
| 156.00         | 14.837                     | 5.098  | 12.5           | 0.970         |
| 159.00         | 15.151                     | 5.205  | 9.0            | 0.698         |
| 165.00         | 15.777                     | 5.420  | 4.5            | 0.349         |
| 168.00         | 16.090                     | 5.528  | 3.0            | 0.233         |
| 171.00         | 16.403                     | 5.635  | 2.0            | 0.155         |
| 174.00         | 16.716                     | 5.743  | 1.9            | 0.147         |
| 177.00         | 17.029                     | 5.850  | 1.0            | 0.078         |
| 183.50         | 17.707                     | 6.083  | 0.0            | 0.000         |

TABLE A.2.70 Retention Time-Height Data for i-Octane at 201.65°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 115.20         | 10.048                     | 3.392  | 138.5          | 10.443        |
| 118.20         | 10.349                     | 3.493  | 125.0          | 9.425         |
| 121.20         | 10.650                     | 3.595  | 106.0          | 7.993         |
| 127.20         | 11.252                     | 3.798  | 71.5           | 5.391         |
| 130.20         | 11.552                     | 3.899  | 57.5           | 4.336         |
| 133.20         | 11.853                     | 4.001  | 45.0           | 3.393         |
| 136.20         | 12.154                     | 4.102  | 35.5           | 2.677         |
| 142.10         | 12.746                     | 4.302  | 20.0           | 1.508         |
| 145.20         | 13.057                     | 4.407  | 14.5           | 1.093         |
| 148.20         | 13.358                     | 4.508  | 10.0           | 0.754         |
| 151.20         | 13.658                     | 4.610  | 6.5            | 0.490         |
| 154.20         | 13.959                     | 4.712  | 4.5            | 0.339         |
| 157.20         | 14.260                     | 4.813  | 3.0            | 0.226         |
| 160.20         | 14.561                     | 4.915  | 2.0            | 0.151         |
| 163.20         | 14.862                     | 5.016  | 1.5            | 0.113         |
| 166.20         | 15.163                     | 5.118  | 1.0            | 0.075         |
| 188.70         | 17.419                     | 5.879  | 0.0            | 0.000         |

TABLE A.2.71 Retention Time-Height Data for i-Octane at 209.99°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 94.20          | 8.644                      | 2.867  | 154.5          | 12.096        |
| 95.70          | 8.805                      | 2.921  | 147.5          | 11.548        |
| 97.20          | 8.966                      | 2.974  | 135.5          | 10.608        |
| 100.20         | 9.289                      | 3.081  | 109.0          | 8.533         |
| 101.70         | 9.450                      | 3.135  | 96.0           | 7.516         |
| 103.20         | 9.611                      | 3.188  | 84.5           | 6.615         |
| 106.20         | 9.934                      | 3.295  | 64.0           | 5.010         |
| 109.20         | 10.256                     | 3.402  | 47.0           | 3.680         |
| 110.70         | 10.418                     | 3.455  | 39.5           | 3.092         |
| 113.70         | 10.740                     | 3.562  | 27.5           | 2.153         |
| 118.20         | 11.224                     | 3.723  | 14.5           | 1.135         |
| 119.70         | 11.385                     | 3.776  | 11.0           | 0.861         |
| 122.70         | 11.708                     | 3.883  | 6.5            | 0.509         |
| 124.20         | 11.869                     | 3.937  | 4.5            | 0.352         |
| 127.20         | 12.191                     | 4.044  | 2.5            | 0.196         |
| 131.70         | 12.675                     | 4.204  | 1.0            | 0.078         |
| 140.70         | 13.643                     | 4.525  | 0.0            | 0.000         |

TABLE A.2.72 Retention Time-Height Data for i-Octane at 217.44°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 88.80          | 7.399                      | 2.417  | 170.0          | 13.736        |
| 91.80          | 7.700                      | 2.515  | 150.0          | 12.120        |
| 93.30          | 7.850                      | 2.564  | 135.0          | 10.908        |
| 96.30          | 8.151                      | 2.663  | 104.0          | 8.403         |
| 97.80          | 8.301                      | 2.712  | 89.5           | 7.232         |
| 99.30          | 8.452                      | 2.761  | 76.5           | 6.181         |
| 100.80         | 8.602                      | 2.810  | 64.5           | 5.212         |
| 103.80         | 8.903                      | 2.908  | 45.0           | 3.636         |
| 105.30         | 9.053                      | 2.957  | 37.0           | 2.990         |
| 108.30         | 9.354                      | 3.056  | 24.0           | 1.939         |
| 109.80         | 9.504                      | 3.105  | 18.5           | 1.495         |
| 112.80         | 9.805                      | 3.203  | 11.0           | 0.889         |
| 114.30         | 9.956                      | 3.252  | 8.0            | 0.646         |
| 117.30         | 10.256                     | 3.350  | 4.0            | 0.323         |
| 118.80         | 10.407                     | 3.399  | 3.0            | 0.242         |
| 123.30         | 10.858                     | 3.547  | 1.0            | 0.081         |
| 132.30         | 11.760                     | 3.842  | 0.0            | 0.000         |

TABLE A.2.73 Retention Time-Height Data for i-Octane at 224.86°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 75.00          | 6.477                      | 2.084  | 97.5           | 15.070        |
| 78.00          | 6.795                      | 2.186  | 83.0           | 12.829        |
| 79.50          | 6.953                      | 2.238  | 72.0           | 11.129        |
| 81.00          | 7.112                      | 2.289  | 62.0           | 9.583         |
| 84.00          | 7.430                      | 2.391  | 43.0           | 6.646         |
| 85.50          | 7.588                      | 2.442  | 35.0           | 5.410         |
| 87.00          | 7.747                      | 2.493  | 28.0           | 4.328         |
| 90.00          | 8.065                      | 2.595  | 17.0           | 2.628         |
| 91.50          | 8.223                      | 2.646  | 13.0           | 2.009         |
| 93.00          | 8.382                      | 2.697  | 9.0            | 1.391         |
| 96.00          | 8.700                      | 2.799  | 4.5            | 0.696         |
| 97.50          | 8.858                      | 2.851  | 3.2            | 0.495         |
| 99.00          | 9.017                      | 2.902  | 2.0            | 0.309         |
| 100.50         | 9.176                      | 2.953  | 1.5            | 0.232         |
| 102.00         | 9.335                      | 3.004  | 1.0            | 0.155         |
| 111.00         | 10.287                     | 3.310  | 0.0            | 0.000         |

TABLE A.2.74 Retention Time-Height Data for i-Octane  
at 229.83°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 67.20          | 5.626                      | 1.793  | 104.5          | 16.793        |
| 70.20          | 5.943                      | 1.893  | 86.0           | 13.820        |
| 71.70          | 6.101                      | 1.944  | 73.0           | 11.731        |
| 73.20          | 6.259                      | 1.994  | 60.5           | 9.722         |
| 74.70          | 6.417                      | 2.044  | 49.5           | 7.955         |
| 77.70          | 6.733                      | 2.145  | 30.5           | 4.901         |
| 79.20          | 6.891                      | 2.196  | 23.0           | 3.696         |
| 80.70          | 7.049                      | 2.246  | 17.0           | 2.732         |
| 82.20          | 7.207                      | 2.296  | 12.5           | 2.009         |
| 83.70          | 7.365                      | 2.347  | 8.5            | 1.366         |
| 85.20          | 7.523                      | 2.397  | 6.0            | 0.964         |
| 86.70          | 7.681                      | 2.447  | 4.0            | 0.643         |
| 88.20          | 7.839                      | 2.498  | 2.8            | 0.450         |
| 89.70          | 7.997                      | 2.548  | 2.0            | 0.321         |
| 91.20          | 8.155                      | 2.598  | 1.2            | 0.193         |
| 92.70          | 8.313                      | 2.649  | 1.0            | 0.161         |
| 103.20         | 9.420                      | 3.001  | 0.0            | 0.000         |

TABLE A.2.75 Retention Time-Height Data for i-Octane  
at 234.26°C and 0.4  $\mu$ l with Helium

| $t_r$<br>(sec) | $V_g$<br>( $\text{cm}^3$ ) | $(V_g/RT_r) \times 10^7$<br>( $\text{gmol/g mmHg}$ ) | $c(t)$<br>(mm) | $p$<br>(mmHg) |
|----------------|----------------------------|--|----------------|---------------|
| 63.00          | 5.353                      | 1.691  | 116.0          | 17.837        |
| 64.50          | 5.514                      | 1.742  | 93.0           | 14.301        |
| 66.00          | 5.675                      | 1.792  | 78.0           | 11.994        |
| 67.50          | 5.837                      | 1.843  | 63.5           | 9.764         |
| 69.00          | 5.998                      | 1.894  | 50.0           | 7.688         |
| 70.50          | 6.159                      | 1.945  | 39.0           | 5.997         |
| 72.00          | 6.320                      | 1.996  | 29.0           | 4.459         |
| 73.50          | 6.482                      | 2.047  | 21.0           | 3.229         |
| 75.00          | 6.643                      | 2.098  | 15.0           | 2.307         |
| 76.50          | 6.804                      | 2.149  | 10.0           | 1.538         |
| 78.00          | 6.965                      | 2.200  | 6.5            | 1.000         |
| 79.50          | 7.127                      | 2.251  | 4.0            | 0.615         |
| 81.00          | 7.288                      | 2.302  | 2.5            | 0.384         |
| 82.50          | 7.449                      | 2.353  | 1.8            | 0.277         |
| 84.00          | 7.610                      | 2.404  | 1.1            | 0.169         |
| 97.50          | 9.061                      | 2.862  | 0.0            | 0.000         |

APPENDIX III

TABLE A.3.1 Adsorption Isotherms of n-Pentane  
Carrier Gas: HYDROGEN V = 0.4  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)  | 187.39 | 197.37 | 210.74 | 226.91 | 234.94 |
|------------------------------|--|--------|--------|--------|--------|--------|
|                              | (Moles of n-Pentane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |
| 2                            |  | 2.590  | 2.943  | 2.277  | 1.823  | 1.744  |
| 4                            |  | 4.855  | 5.448  | 4.251  | 3.362  | 3.248  |
| 6                            |  | 6.993  | 7.820  | 6.103  | 4.789  | 4.629  |
| 8                            |  | 9.033  | 10.102 | 7.879  | 6.145  | 5.933  |
| 10                           |  | 10.999 | 12.323 | 9.589  | 7.441  | 7.193  |
| 12                           |  | 12.901 | 14.495 | 11.249 | 8.692  | 8.413  |
| 14                           |  | 14.743 | 16.617 | 12.869 | 9.907  | 9.597  |
| 16                           |  | 16.533 | 18.695 | 14.458 | 11.087 | 10.755 |
| 18                           |  | 18.273 | 20.730 | 16.017 | 12.232 | 11.880 |
| 20                           |  | 19.973 | 22.717 | 17.550 | 13.351 | 12.979 |
| 22                           |  | 21.637 | 24.665 | 19.059 | 14.441 | 14.057 |
| 24                           |  | 23.267 | 26.576 | 20.540 | 15.510 | 15.113 |
| 26                           |  | 24.855 | 28.455 | 21.992 | 16.552 | 16.150 |
| 28                           |  | 26.388 | 30.295 | 23.420 | 17.570 | 17.164 |
| 30                           |  | 27.866 | 32.095 | 24.819 | 18.567 | 18.154 |
| 32                           |  | 29.282 | 33.865 | 26.184 | 19.542 | 19.124 |
| 34                           |  |        | 35.605 | 27.523 | 20.492 | 20.069 |
| 36                           |  |        |        | 28.823 | 21.422 | 20.989 |
| 38                           |  |        |        | 30.066 | 22.323 | 21.879 |
| 40                           |  |        |        |        | 23.196 | 22.740 |
| 42                           |  |        |        |        | 24.036 | 23.570 |

TABLE A.3.2 Adsorption Isotherms of n-Pentane  
Carrier Gas: HELIUM V = 0.4  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)  | 187.17 | 198.00 | 205.51 | 211.12 | 218.18 | 225.45 | 230.75 | 235.29 |
|------------------------------|--|--------|--------|--------|--------|--------|--------|--------|--------|
|                              | (Moles of n-Pentane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |        |        |        |
| 2                            |  | 3.166  | 2.666  | 2.488  | 2.552  | 2.399  | 1.981  | 1.800  | 1.827  |
| 4                            |  | 5.971  | 5.033  | 4.615  | 4.668  | 4.383  | 3.675  | 3.305  | 3.352  |
| 6                            |  | 8.637  | 7.276  | 6.618  | 6.659  | 6.234  | 5.256  | 4.704  | 4.779  |
| 8                            |  | 11.221 | 9.438  | 8.541  | 8.560  | 8.013  | 6.760  | 6.025  | 6.143  |
| 10                           |  | 13.751 | 11.538 | 10.406 | 10.390 | 9.728  | 8.215  | 7.287  | 7.456  |
| 12                           |  | 16.229 | 13.588 | 12.223 | 12.170 | 11.390 | 9.627  | 8.507  | 8.736  |
| 14                           |  | 18.651 | 15.589 | 13.999 | 13.901 | 13.010 | 11.007 | 9.687  | 9.976  |
| 16                           |  | 21.031 | 17.558 | 15.739 | 15.590 | 14.590 | 12.347 | 10.828 | 11.178 |
| 18                           |  | 23.371 | 19.496 | 17.441 | 17.232 | 16.130 | 13.657 | 11.947 | 12.356 |
| 20                           |  | 25.671 | 21.398 | 19.119 | 18.841 | 17.639 | 14.939 | 13.037 | 13.506 |
| 22                           |  | 27.942 | 23.276 | 20.760 | 20.419 | 19.119 | 16.197 | 14.098 | 14.636 |
| 24                           |  | 30.179 | 25.124 | 22.371 | 21.964 | 20.569 | 17.427 | 15.138 | 15.738 |
| 26                           |  | 32.379 | 26.943 | 23.952 | 23.485 | 21.999 | 18.637 | 16.158 | 16.818 |
| 28                           |  | 34.539 | 28.733 | 25.504 | 24.983 | 23.409 | 19.827 | 17.158 | 17.878 |
| 30                           |  | 36.657 | 30.498 | 27.029 | 26.451 | 24.790 | 20.997 | 18.139 | 18.918 |
| 32                           |  |        | 32.238 | 28.529 | 27.881 | 26.149 | 22.147 | 19.101 |        |
| 34                           |  |        | 33.937 | 29.989 | 29.263 | 27.469 | 23.277 | 20.042 |        |
| 36                           |  |        |        |        |        | 28.740 | 24.385 | 20.960 |        |
| 38                           |  |        |        |        |        |        | 25.464 | 21.840 |        |
| 40                           |  |        |        |        |        |        | 26.504 |        |        |

TABLE A.3.3 Adsorption Isotherms of n-Pentane  
Carrier Gas: HELIUM V = 0.8  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)  | 187.71 | 197.08 | 203.37 | 211.08 | 218.14 | 225.52 | 230.75 | 235.31 |
|------------------------------|--|--------|--------|--------|--------|--------|--------|--------|--------|
|                              | (Moles of n-Pentane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |        |        |        |
| 4                            | 5.946  | 5.040  | 4.876  | 4.424  | 4.395  | 3.736  | 3.310  | 2.931  |        |
| 8                            | 11.041   | 9.426  | 9.048  | 8.180  | 8.015  | 6.826  | 6.045  | 5.402  |        |
| 12                           | 15.865   | 13.576 | 12.933 | 11.694 | 11.404 | 9.698  | 8.591  | 7.709  |        |
| 16                           | 20.515   | 17.545 | 16.633 | 15.020 | 14.633 | 12.440 | 11.011 | 9.880  |        |
| 20                           | 25.075   | 21.381 | 20.182 | 18.216 | 17.728 | 15.067 | 13.317 | 11.960 |        |
| 24                           | 29.560   | 25.109 | 23.605 | 21.296 | 20.721 | 17.608 | 15.537 | 13.962 |        |
| 28                           | 33.979   | 28.732 | 26.899 | 24.278 | 23.646 | 20.083 | 17.676 | 15.904 |        |
| 32                           | 38.328   | 32.270 | 30.076 | 27.178 | 26.505 | 22.483 | 19.731 | 17.784 |        |
| 36                           | 42.604   | 35.745 | 33.152 | 30.007 | 29.288 | 24.817 | 21.717 | 19.592 |        |
| 40                           | 46.794   | 39.145 | 36.152 | 32.756 | 31.999 | 27.081 | 23.650 | 21.360 |        |
| 44                           | 50.872   | 42.450 | 39.052 | 35.442 | 34.662 | 29.292 | 25.539 | 23.095 |        |
| 48                           | 54.863   | 45.677 | 41.852 | 38.073 | 37.265 | 31.460 | 27.388 | 24.795 |        |
| 52                           | 58.766   | 48.849 | 44.560 | 40.652 | 39.792 | 33.555 | 29.208 | 26.452 |        |
| 56                           | 62.590   | 51.948 | 47.200 | 43.173 | 42.266 | 35.594 | 31.004 | 28.064 |        |
| 60                           | 66.360   | 54.965 | 49.751 | 45.602 | 44.680 | 37.574 | 32.749 | 29.644 |        |
| 64                           |  | 57.864 |        | 47.949 | 47.019 | 39.498 | 34.433 | 31.172 |        |
| 68                           |  |        |        |        | 49.238 | 41.357 | 36.048 | 32.646 |        |
| 72                           |  |        |        |        |        | 43.124 | 37.552 | 34.075 |        |
| 76                           |  |        |        |        |        |        |        | 35.454 |        |

TABLE A.3.4 Adsorption Isotherms of n-Hexane  
Carrier Gas: HYDROGEN V = 0.4  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)   | 187.39 | 204.99 | 210.73 | 226.97 | 234.98 |
|------------------------------|---|--------|--------|--------|--------|--------|
|                              | (Moles of n-Hexane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |
| 2                            |   | 5.248  | 3.778  | 3.525  | 2.664  | 2.405  |
| 4                            |   | 10.174 | 7.303  | 6.739  | 5.002  | 4.525  |
| 6                            |   | 14.974 | 10.706 | 9.825  | 7.223  | 6.543  |
| 8                            |   | 19.654 | 14.036 | 12.821 | 9.362  | 8.474  |
| 10                           |   | 24.220 | 17.298 | 15.741 | 11.442 | 10.351 |
| 12                           |   | 28.691 | 20.500 | 18.593 | 13.472 | 12.191 |
| 14                           |   | 33.081 | 23.650 | 21.393 | 15.447 | 13.997 |
| 16                           |   | 37.400 | 26.749 | 24.077 | 17.378 | 15.773 |
| 18                           |   | 41.639 | 29.789 | 26.778 | 19.270 | 17.511 |
| 20                           |   | 45.792 | 32.778 | 29.437 | 21.117 | 19.212 |
| 22                           |   | 49.827 | 35.712 | 32.040 | 22.920 | 20.882 |
| 24                           |   | 53.860 | 38.615 | 34.593 | 24.681 | 22.523 |
| 26                           |   |        | 41.452 | 37.077 | 26.403 | 24.135 |
| 28                           |   |        |        |        |        | 25.716 |

TABLE A.3.5 Adsorption Isotherms of n-Hexane  
Carrier Gas: HELIUM V = 0.4  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)   | 187.05 | 197.93 | 205.59 | 211.11 | 218.17 | 225.64 | 230.82 | 235.31 |
|------------------------------|---|--------|--------|--------|--------|--------|--------|--------|--------|
|                              | (Moles of n-Hexane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |        |        |        |
| 2                            |   | 6.230  | 4.390  | 3.878  | 3.672  | 3.160  | 2.795  | 2.648  | 2.586  |
| 4                            |   | 11.426 | 8.318  | 7.425  | 6.912  | 6.030  | 5.310  | 4.913  | 4.808  |
| 6                            |   | 16.428 | 12.109 | 10.840 | 10.042 | 8.802  | 7.722  | 7.093  | 6.921  |
| 8                            |   | 21.286 | 15.795 | 14.160 | 13.088 | 11.506 | 10.067 | 9.204  | 8.967  |
| 10                           |   | 26.012 | 19.399 | 17.404 | 16.067 | 14.161 | 12.363 | 11.273 | 10.967 |
| 12                           |   | 30.635 | 22.929 | 20.572 | 18.981 | 16.772 | 14.613 | 13.285 | 12.927 |
| 14                           |   | 35.160 | 26.381 | 23.681 | 21.840 | 19.331 | 16.828 | 15.265 | 14.849 |
| 16                           |   | 39.579 | 29.771 | 26.731 | 24.642 | 21.842 | 19.001 | 17.209 | 16.739 |
| 18                           |   | 43.879 | 33.095 | 24.726 | 27.406 | 24.318 | 21.140 | 19.119 | 18.598 |
| 20                           |   |        | 36.355 | 32.653 | 30.126 | 26.739 | 23.240 | 21.004 | 20.425 |
| 22                           |   |        |        |        | 32.796 | 29.133 | 25.301 | 22.857 | 22.225 |
| 24                           |   |        |        |        | 35.418 | 31.486 | 27.340 | 24.667 | 23.991 |
| 26                           |   |        |        |        |        | 33.798 | 29.343 | 26.439 | 25.736 |
| 28                           |   |        |        |        |        | 36.049 | 31.306 | 28.189 | 27.450 |
| 30                           |   |        |        |        |        |        | 33.224 | 29.907 | 29.125 |

TABLE A.3.6 Adsorption Isotherms of n-Hexane  
Carrier Gas: HELIUM V = 0.8  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)   | 185.81 | 196.99 | 203.35 | 211.07 | 218.26 | 225.49 | 230.83 | 235.21 |
|------------------------------|---|--------|--------|--------|--------|--------|--------|--------|--------|
|                              | (Moles of n-Hexane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |        |        |        |
| 4                            |   | 11.073 | 8.448  | 7.539  | 7.006  | 5.893  | 5.178  | 4.858  | 4.464  |
| 8                            |   | 21.196 | 16.260 | 14.452 | 13.273 | 11.236 | 9.879  | 9.162  | 8.442  |
| 12                           |   | 30.831 | 23.740 | 21.066 | 19.275 | 16.357 | 14.370 | 13.277 | 12.255 |
| 16                           |   | 40.091 | 30.937 | 27.448 | 25.107 | 21.311 | 18.717 | 17.246 | 15.941 |
| 20                           |   | 49.013 | 37.879 | 33.646 | 30.762 | 26.111 | 22.940 | 21.094 | 19.502 |
| 24                           |   | 57.650 | 44.605 | 39.685 | 36.222 | 30.784 | 27.044 | 24.824 | 22.972 |
| 28                           |   | 66.011 | 51.145 | 45.526 | 41.538 | 35.339 | 31.037 | 28.452 | 26.381 |
| 32                           |   | 74.110 | 57.522 | 51.207 | 46.698 | 39.755 | 34.936 | 31.992 | 29.721 |
| 36                           |   |        | 63.703 | 56.754 | 51.707 | 44.058 | 38.729 | 35.436 | 32.972 |
| 40                           |   |        |        | 62.154 | 56.587 | 48.250 | 42.429 | 38.800 | 36.127 |
| 44                           |   |        |        |        | 61.305 | 52.341 | 46.042 | 42.089 | 39.187 |
| 48                           |   |        |        |        |        | 56.318 | 49.553 | 45.284 | 42.188 |
| 52                           |   |        |        |        |        |        | 52.920 | 48.364 | 45.157 |

TABLE A.3.7 Adsorption Isotherms of n-Heptane  
Carrier Gas: HELIUM V = 0.2  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)  | 185.24 | 193.34 | 201.51 | 207.39 | 217.49 | 224.97 | 229.87 | 234.29 |
|------------------------------|--|--------|--------|--------|--------|--------|--------|--------|--------|
|                              | (Moles of n-Heptane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |        |        |        |
| 1                            |  | 5.467  | 4.571  | 3.940  | 3.299  | 2.787  | 2.487  | 2.230  | 2.054  |
| 2                            |  | 10.476 | 8.739  | 7.582  | 6.274  | 5.374  | 4.730  | 4.278  | 3.901  |
| 3                            |  | 15.284 | 12.752 | 11.103 | 9.151  | 7.885  | 6.911  | 6.274  | 5.689  |
| 4                            |  | 19.926 | 16.652 | 14.534 | 11.957 | 10.341 | 9.052  | 8.229  | 7.439  |
| 5                            |  | 24.428 | 20.453 | 17.894 | 14.708 | 12.753 | 11.157 | 10.141 | 9.159  |
| 6                            |  |        | 24.167 | 21.187 | 17.416 | 15.125 | 13.229 | 12.014 | 10.851 |
| 7                            |  |        |        | 24.418 | 20.077 | 17.461 | 15.270 | 13.864 | 12.521 |
| 8                            |  |        |        | 27.575 | 22.686 | 19.761 | 17.285 | 15.699 | 14.170 |
| 9                            |  |        |        |        |        | 22.027 | 19.277 | 17.514 | 15.799 |
| 10                           |  |        |        |        |        | 24.256 | 21.238 | 19.303 | 17.407 |
| 11                           |  |        |        |        |        |        | 23.163 | 21.056 | 18.994 |
| 12                           |  |        |        |        |        |        |        | 22.773 | 20.549 |

TABLE A.3.8 Adsorption Isotherms of n-Heptane  
Carrier Gas: HELIUM V = 0.4  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)  | 185.24 | 193.32 | 201.62 | 207.40 | 217.47 | 225.01 | 229.90 | 234.31 |
|------------------------------|--|--------|--------|--------|--------|--------|--------|--------|--------|
|                              | (Moles of n-Heptane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |        |        |        |
| 2                            |  | 10.895 | 9.009  | 7.653  | 6.274  | 5.502  | 4.778  | 4.249  | 3.928  |
| 3                            |  | 15.965 | 13.060 | 11.200 | 8.192  | 7.191  | 6.237  | 5.563  | 5.132  |
| 4                            |  | 20.910 | 16.956 | 14.651 | 11.957 | 10.510 | 9.103  | 8.150  | 7.502  |
| 5                            |  | 25.751 | 20.716 | 18.026 | 13.793 | 12.135 | 10.506 | 9.411  | 8.663  |
| 6                            |  | 30.502 | 24.364 | 21.332 | 17.417 | 15.345 | 13.278 | 11.899 | 10.959 |
| 7                            |  | 35.175 | 27.911 | 24.586 | 19.193 | 16.920 | 14.638 | 13.126 | 12.083 |
| 8                            |  | 39.761 | 31.373 | 27.784 | 22.708 | 20.038 | 17.329 | 15.560 | 14.306 |
| 9                            |  | 44.283 |        | 30.928 | 24.436 | 21.571 | 18.652 | 16.760 | 15.406 |
| 10                           |  | 48.753 |        | 34.027 | 27.858 | 24.610 | 21.274 | 19.140 | 17.586 |
| 11                           |  |        |        | 37.086 | 29.541 | 26.108 | 22.568 | 20.313 | 18.662 |
| 12                           |  |        |        | 40.106 | 32.875 | 29.081 | 25.135 | 22.641 | 20.801 |
| 13                           |  |        |        | 43.080 | 34.516 | 30.550 | 26.401 | 23.791 | 21.857 |
| 14                           |  |        |        |        | 37.768 | 33.464 | 28.916 | 26.076 | 23.954 |
| 15                           |  |        |        |        | 39.369 | 34.902 | 30.161 | 27.204 | 24.989 |
| 16                           |  |        |        |        |        | 37.756 | 32.635 | 29.443 | 27.044 |
| 17                           |  |        |        |        |        | 39.164 | 33.854 | 30.548 | 28.059 |
| 18                           |  |        |        |        |        |        | 36.296 | 32.740 | 30.074 |
| 19                           |  |        |        |        |        |        |        | 33.820 | 31.068 |
| 20                           |  |        |        |        |        |        |        | 35.962 | 33.038 |
| 21                           |  |        |        |        |        |        |        |        | 34.008 |

TABLE A.3.9: Adsorption Isotherms of i-Octane  
Carrier Gas: HELIUM V = 0.2  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)   | 185.25 | 193.33 | 201.59 | 209.91 | 217.47 | 224.87 | 229.84 | 234.26 |
|------------------------------|---|--------|--------|--------|--------|--------|--------|--------|--------|
|                              | (Moles of i-Octane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |        |        |        |
| 1                            |   | 6.333  | 5.396  | 4.742  | 4.001  | 3.329  | 2.953  | 2.710  | 2.450  |
| 2                            |   | 11.985 | 10.342 | 9.021  | 7.657  | 6.389  | 5.625  | 5.094  | 4.655  |
| 3                            |   | 17.346 | 15.053 | 13.117 | 11.190 | 9.341  | 8.207  | 7.404  | 6.796  |
| 4                            |   | 22.490 | 19.597 | 17.074 | 14.626 | 12.212 | 10.727 | 9.655  | 8.888  |
| 5                            |   |        | 24.001 | 20.926 | 17.987 | 15.021 | 13.187 | 11.853 | 10.938 |
| 6                            |   |        |        |        | 21.275 | 17.774 | 15.598 | 14.010 | 12.948 |
| 7                            |   |        |        |        | 24.500 | 20.475 | 17.962 | 16.125 | 14.922 |
| 8                            |   |        |        |        | 27.649 | 23.108 | 20.275 | 18.203 | 16.868 |
| 9                            |   |        |        |        |        |        | 20.229 | 18.758 |        |

TABLE A.3.10 Adsorption Isotherms of i-Octane  
Carrier Gas: HELIUM V = 0.4  $\mu$ l

| Partial Pressure<br>p(mm Hg) | T ( $^{\circ}$ C)   | 185.27 | 193.30 | 201.65 | 209.99 | 217.44 | 224.48 | 229.84 | 234.34 |
|------------------------------|---|--------|--------|--------|--------|--------|--------|--------|--------|
|                              | (Moles of i-Octane Adsorbed per gram of Catalyst) $\times 10^7$ |        |        |        |        |        |        |        |        |
| 2                            |   | 12.269 | 10.331 | 9.096  | 7.605  | 6.466  | 5.590  | 4.954  | 4.589  |
| 3                            |   | 17.718 | 15.027 | 13.227 | 11.118 | 9.459  | 8.193  | 6.460  | 5.979  |
| 4                            |   | 22.955 | 19.553 | 17.213 | 14.533 | 12.377 | 10.726 | 9.415  | 8.708  |
| 5                            |   | 28.030 | 23.944 | 21.085 | 17.864 | 15.227 | 13.201 | 10.854 | 10.038 |
| 6                            |   | 32.965 | 28.224 | 24.869 | 21.119 | 18.016 | 15.632 | 13.696 | 12.663 |
| 7                            |   | 37.766 | 32.405 | 28.569 | 24.304 | 20.752 | 18.022 | 15.088 | 13.947 |
| 8                            |   |        | 36.495 | 32.194 | 27.429 | 23.444 | 20.375 | 17.840 | 16.483 |
| 9                            |   |        |        | 35.748 | 30.500 | 26.095 | 22.698 | 19.191 | 17.730 |
| 10                           |   |        |        |        | 33.521 | 28.708 | 24.987 | 21.870 | 20.202 |
| 11                           |   |        |        |        | 36.500 | 31.286 | 27.240 | 23.188 | 21.417 |
| 12                           |   |        |        |        |        | 33.828 | 29.462 | 25.800 | 23.823 |
| 13                           |   |        |        |        |        | 36.327 | 31.654 | 27.086 | 25.009 |
| 14                           |   |        |        |        |        |        | 33.817 | 29.634 | 27.359 |
| 15                           |   |        |        |        |        |        |        | 30.887 | 28.516 |
| 16                           |   |        |        |        |        |        |        |        | 30.813 |

## APPENDIX IV

## PROGRAM FOR SIMPSON'S NUMERICAL INTEGRATION METHOD

```

C
C H = SUBINTERVALS
C YA = INITIAL VALUE OF Y(I)
C N = NUMBER OF POINTS
C X(I)= EVALUATION POINTS
C Y(I)= VALUES OF THE FUNCTION AT X(I)
C
DIMENSION X(100),Y(100)
READ(4,*) H,YA,N
X(1)=H
DO 11 I=2,N
11 X(I)=X(I-1)+H
DO 5 I=1,N
5 READ(4,*) Y(I)
M=N-1
L=1
WRITE(5,*) L,M
K=1
30 K=K+1
SUMODD=0.
SUMEVN=0.
SUMEND=YA*1.0E-7+Y(K)
I=1
50 SUMODD=SUMODD+4*Y(I)
I=I+1
IF(I.EQ.K) GO TO 10
SUMEVN=SUMEVN+2*Y(I)
I=I+1
IF(I.NE.K) GO TO 50
10 SIMP=H*(SUMEND+SUMODD+SUMEVN)/3
WRITE (5,*) X(I),Y(I),SIMP
STOP
END

```

## APPENDIX V

```

C*****
C
C A LEAST-SQUARES CURVE FITTING PROGRAM
C
C*****
C
C THIS IS THE MAIN PROGRAM. IT CALLS ONE SUBROUTINE
C CALLED NORMEQ. THE MAXIMUM NUMBER OF DATA POINTS
C IS 100 AND THE MAXIMUM DEGREE IS 10.
C
      DIMENSION X(100),Y(100),COEF(100),V(100),AD1(100),
      +AD(100)
      INTEGER DEGREE,DEGP1
C
C READ DATA
C
      OPEN(4,FILE='SIMRES')
      REWIND 4
      OPEN(5,FILE='CFRES',STATUS='NEW')
      REWIND 5
      READ(4,*) DEGREE,NOPTS
      DO 11 I=1,NOPTS
111 READ(4,*) X(I),V(I),AD(I),Y(I)
      DEGP1=DEGREE+1
C
C CALL SUBROUTINE NORMEQ
C
      CALL NORMEQ(DEGREE,DEGP1,NOPTS,X,Y,COEF)
C
C PRINTS RESULTS
C
      WRITE(5,*) NOPTS
      DO 111 I=1,NOPTS
      AD1(I)=X(I)/(COEF(1)+COEF(2)*X(I))
1111 WRITE(5,*) X(I),V(I),AD(I),AD1(I)
      WRITE(5,*) (I,COEF(I),I=1,DEGP1)
      END
C
C*****
C
CSUBROUTINE NORMEQ TO SET UP THE NORMAL EQUAT
C
C*****
C
      SUBROUTINE NORMEQ(DEGREE,DEGP1,NOPTS,X,Y,COEF)
C

```

```

C
C THIS SUBROUTINE CALLS SUBROUTINE GAUSS.
C
      INTEGER DEGT2,DEGREE,DEGP1
      DIMENSION POWX(200),X(NOPTS),Y(NOPTS),SUM(11,11),
      +RHS(11),COEF(DEGP1)
      DEGT2=DEGREE*2
C
C COMPUTE SUMS OF POWERS
C
      DO 10 I=1,DEGT2
      POWX(I)=0.0
      DO 10 J=1,NOPTS
      POWX(I)=POWX(I)+X(J)**I
10 CONTINUE
C
C FROM THE SUMS OF POWERS COMPUTE THE LHS OF THE
C EQUATION IN THE TWO DIMENSIONAL ARRAY 'SUM'
C
      DO 30 I=1,DEGP1
      DO 30 J=1,DEGP1
      K=I+J-2
      IF(K.LE.0) GO TO 20
      SUM(I,J)=POWX(K)
      GO TO 30
20 SUM(I,J)=NOPTS
30 CONTINUE
C
C SET UP THE RHS OF THE EQUATIONS
C
      RHS(1)=0.0
      DO 40 J=1,NOPTS
      RHS(1)=RHS(1)+Y(J)
40 CONTINUE
      DO 50 I=2,DEGP1
      RHS(I)=0.0
      DO 50 J=1,NOPTS
      RHS(I)=RHS(I)+Y(J)*X(J)**(I-1)
50 CONTINUE
C
C CALL SUBROUTINE GAUS TO SOLVE THE EQUATIONS
C
      CALL GAUSS(DEGREE,DEGP1,RHS,COEF,SUM)
      RETURN
      END
C
C*****
C
C SUBROUTINE GAUSS. SOLVES THE SET OF EQUATIONS
C SUM(I,J)=RHS(I)
C
C*****
C
      SUBROUTINE GAUSS(DEGREE,DEGP1,RHS,COEF,SUM)

```

```

      INTEGER DEGREE,DEGP1
      DIMENSION RHS(DEGP1),COEF(DEGP1),SUM(11,11)
      DO 50 K=1,DEGREE
C
C   CARRY OUT THE ELIMINATION PROCESS 'DEGREE' TIMES
C
      KPLUS1=K+1
      L=K
C
C   FIND TERMS OF GREATEST MAGNITUDE
C
      DO 10 I=KPLUS1,DEGP1
      IF(ABS(SUM(I,K)).LE.ABS(SUM(L,K))) GO TO 10
      L=I
10  CONTINUE
C
C   IF TERMS ARE SUITABLY ORDERED THEN OMIT INTERCHANGE.
C
      IF(L.LE.K) GO TO 30
C
C   INTERCHANGE ROWS TO OBTAIN TERMS OF DECREASING
C   MAGNITUDES.
C
      DO 20 J=K,DEGP1
      DUMP=SUM(K,J)
      SUM(K,J)=SUM(L,J)
      SUM(L,J)=DUMP
20  CONTINUE
      DUMP=RHS(K)
      RHS(K)=RHS(L)
      RHS(L)=DUMP
30  DO 50 I=KPLUS1,DEGP1
C
C   FIND FACTOR WHICH WILL ELIMINATE TERM AFTER
C   SUBTRACTION
C
      FACTOR=SUM(I,K)/SUM(K,K)
C
C   SET THIS TERM=0
C
      SUM(I,K)=0.0
      DO 40 J=KPLUS1,DEGP1
C
C   COMPUTE OTHER TERM
C
      SUM(I,J)=SUM(I,J)-FACTOR*SUM(K,J)
40  CONTINUE
      RHS(I)=RHS(I)-FACTOR*RHS(K)
50  CONTINUE
C
C   COMPUTE SOLUTION OF SINGLE EQUATION REMAINING
C
      COEF(DEGP1)=RHS(DEGP1)/SUM(DEGP1,DEGP1)
      I=DEGREE

```

```
60 IPLUS1=I+1
   TOTAL=0.0
C
C COMPUTE OTHER SOLUTION BY SUBSTITUTION
C
   DO 70 J=IPLUS1,DEGP1
   TOTAL=TOTAL+SUM(I,J)*COEF(J)
70 CONTINUE
C
C RETURN SOLUTIONS IN THE VECTOR 'COEF'
C
   COEF(I)=(RHS(I)-TOTAL)/SUM(I,I)
   I=I-1
   IF(I.GT.0) GO TO 60
   RETURN
   END
```

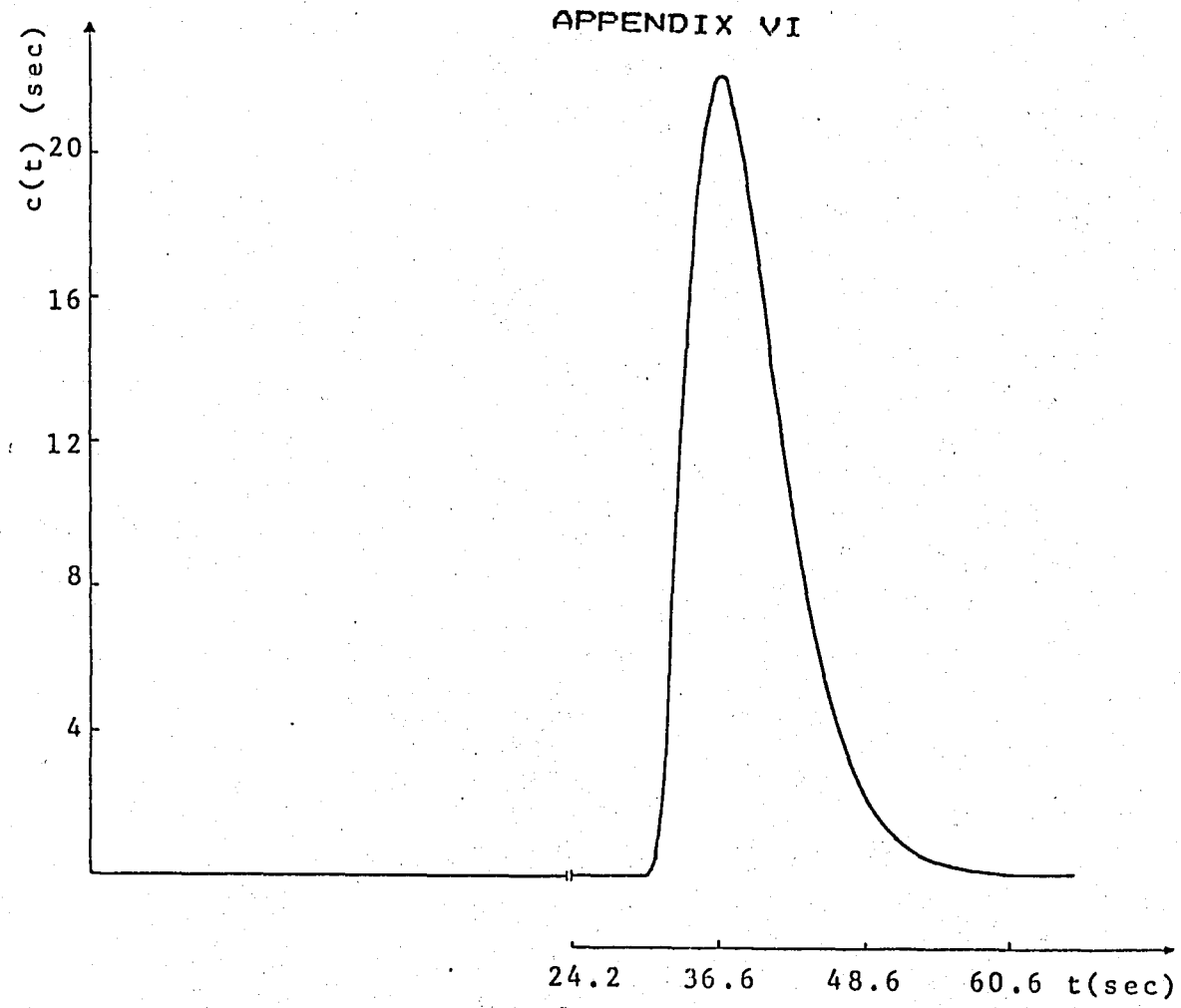


FIGURE A.6.1 Sample Chromatogram for n-Pentane at 0.4  $\mu$ l with  $H_2$   
T=210.75°C Attenuation=32 Chart Speed=20 cm/min

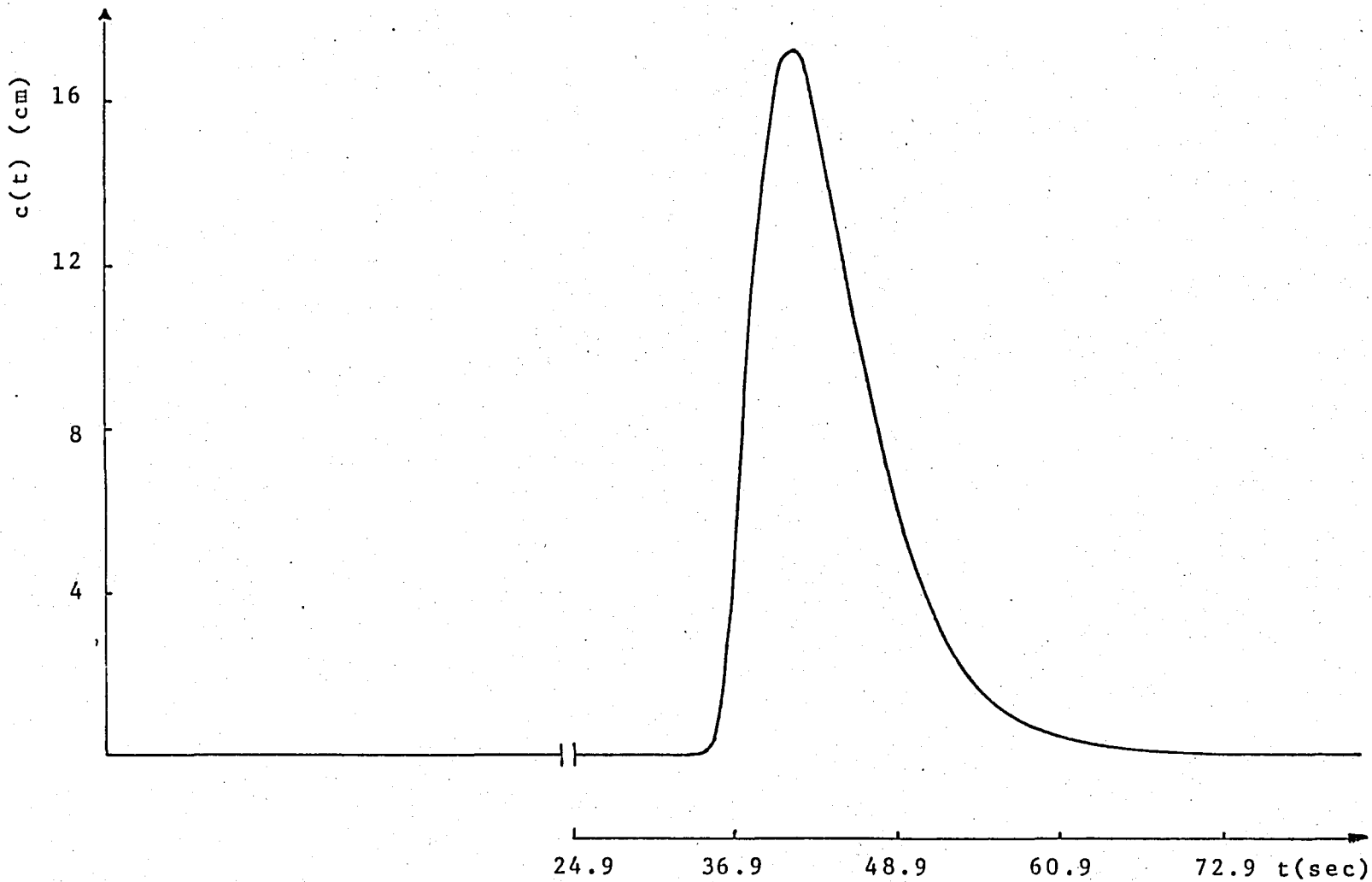


FIGURE A.6.2 Sample Chromatogram for n-Pentane at 0.4  $\mu$ l with He  
T=218.18°C Attenuation=64 Chart Speed=20 cm/min

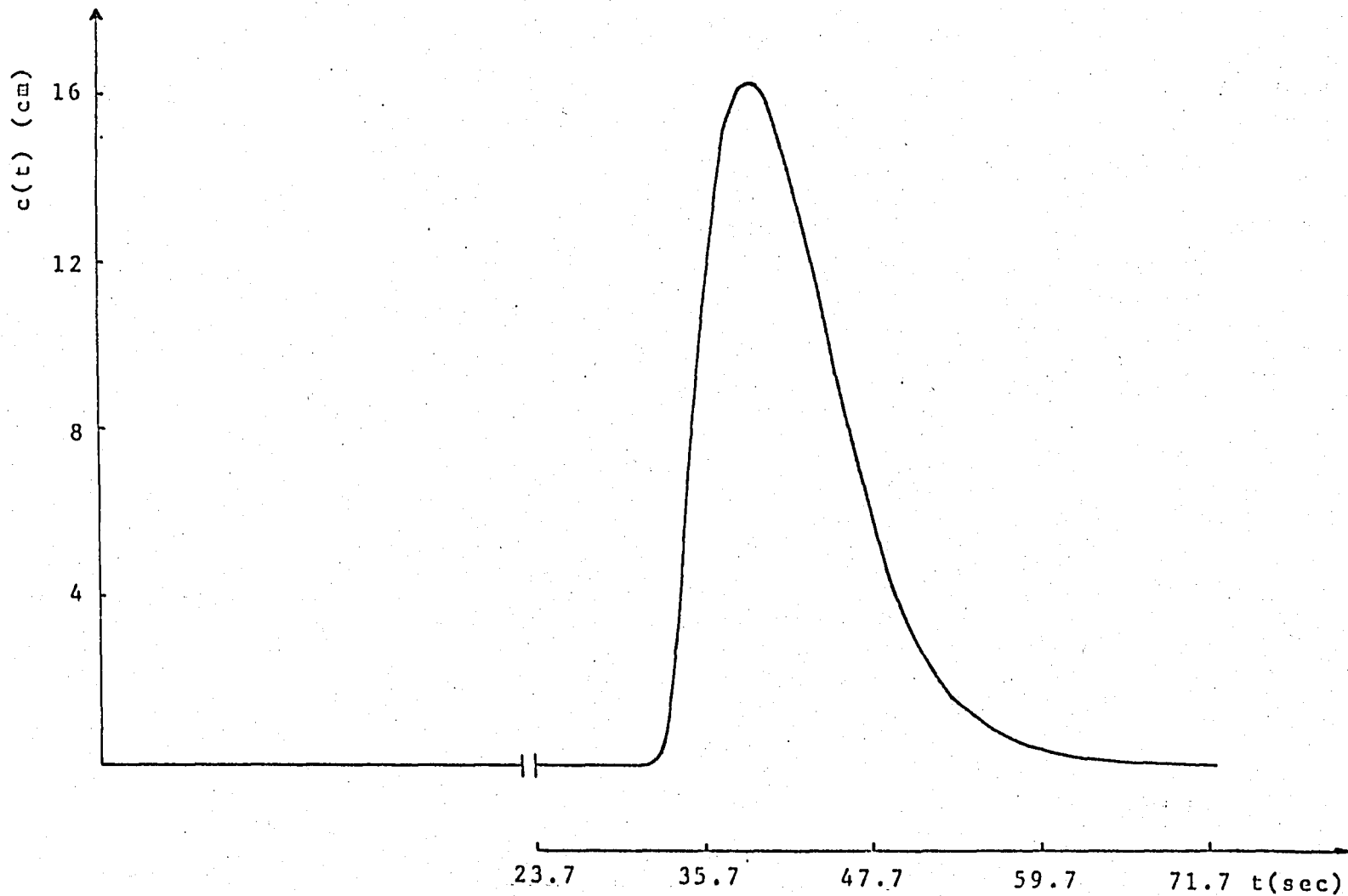


FIGURE A.6.3 Sample Chromatogram for n-Pentane at 0.8  $\mu$ l with He  
T=218.14°C Attenuation=128 Chart Speed=20 cm/min

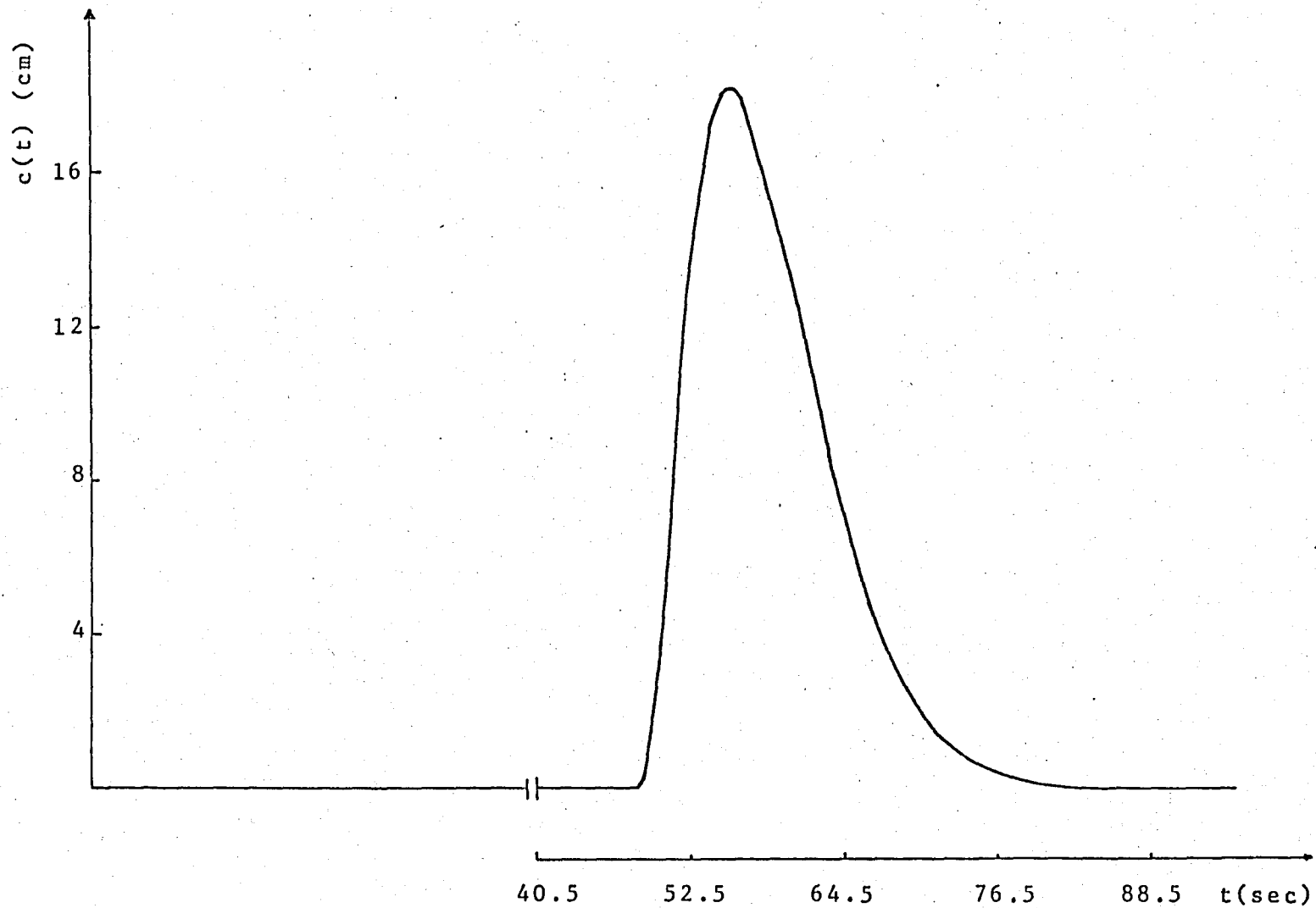


FIGURE A.6.4 Sample Chromatogram for n-Hexane at 0.4  $\mu\text{l}$  with  $\text{H}_2$   
 $T=210.73^\circ\text{C}$  Attenuation=32 Chart Speed=20 cm/min

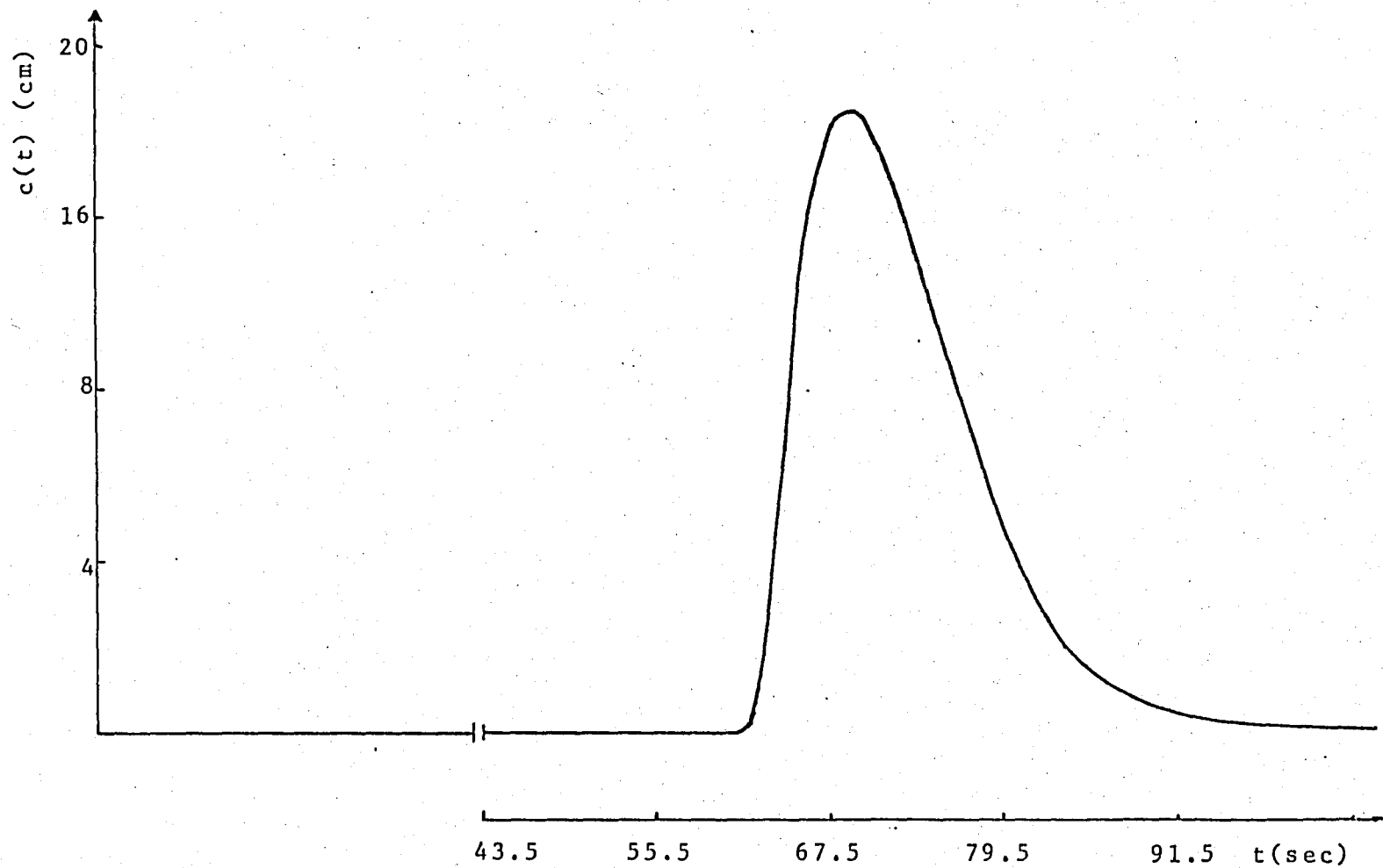


FIGURE A.6.5 Sample Chromatogram for n-Hexane at 0.4  $\mu$ l with He  
T=211.11°C Attenuation=32 Chart Speed=20 cm/min

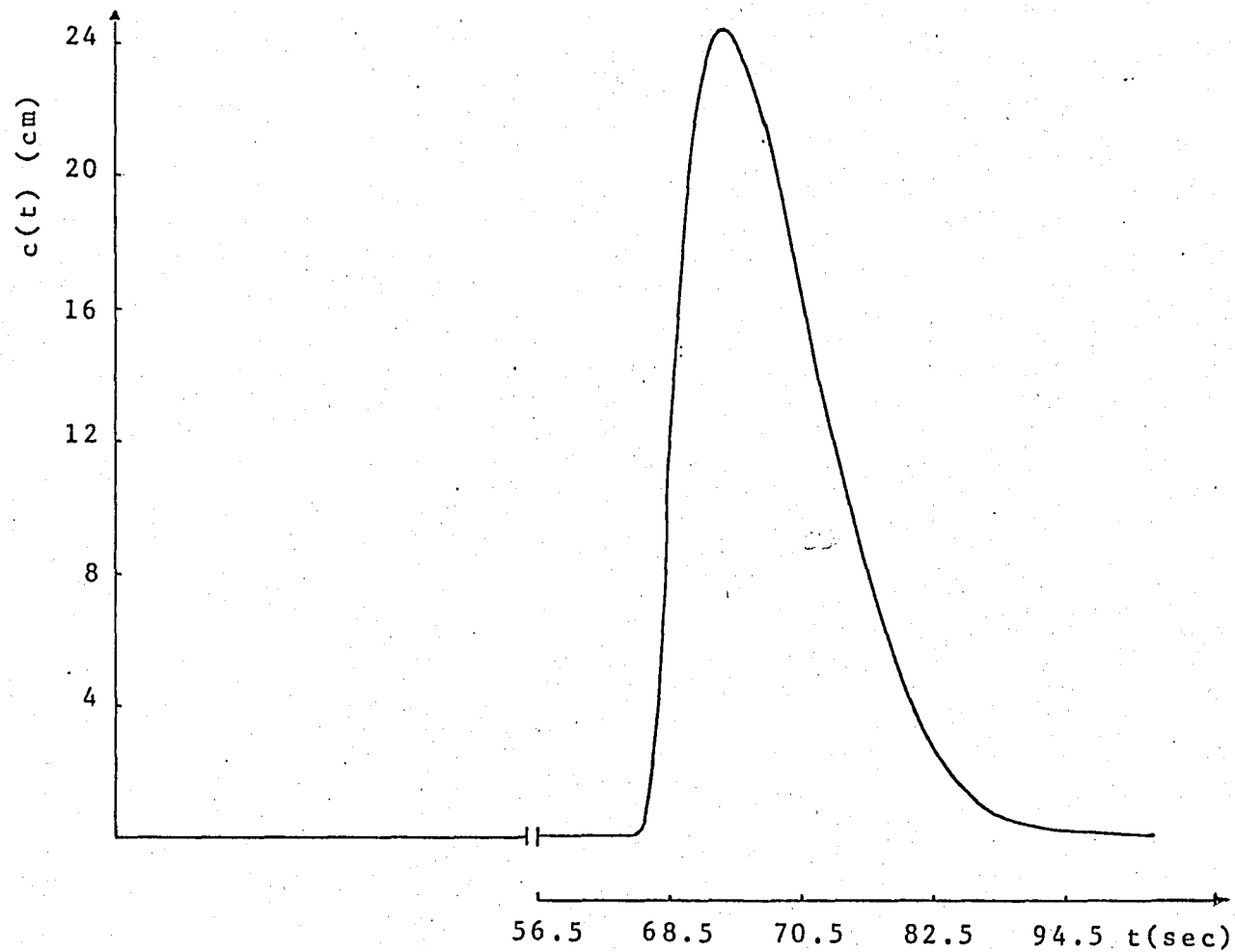


FIGURE A.6.6 Sample Chromatogram for n-Hexane at 0.8  $\mu\text{l}$  with He  
 $T=211.07^{\circ}\text{C}$  Attenuation=64 Chart Speed=20 cm/min

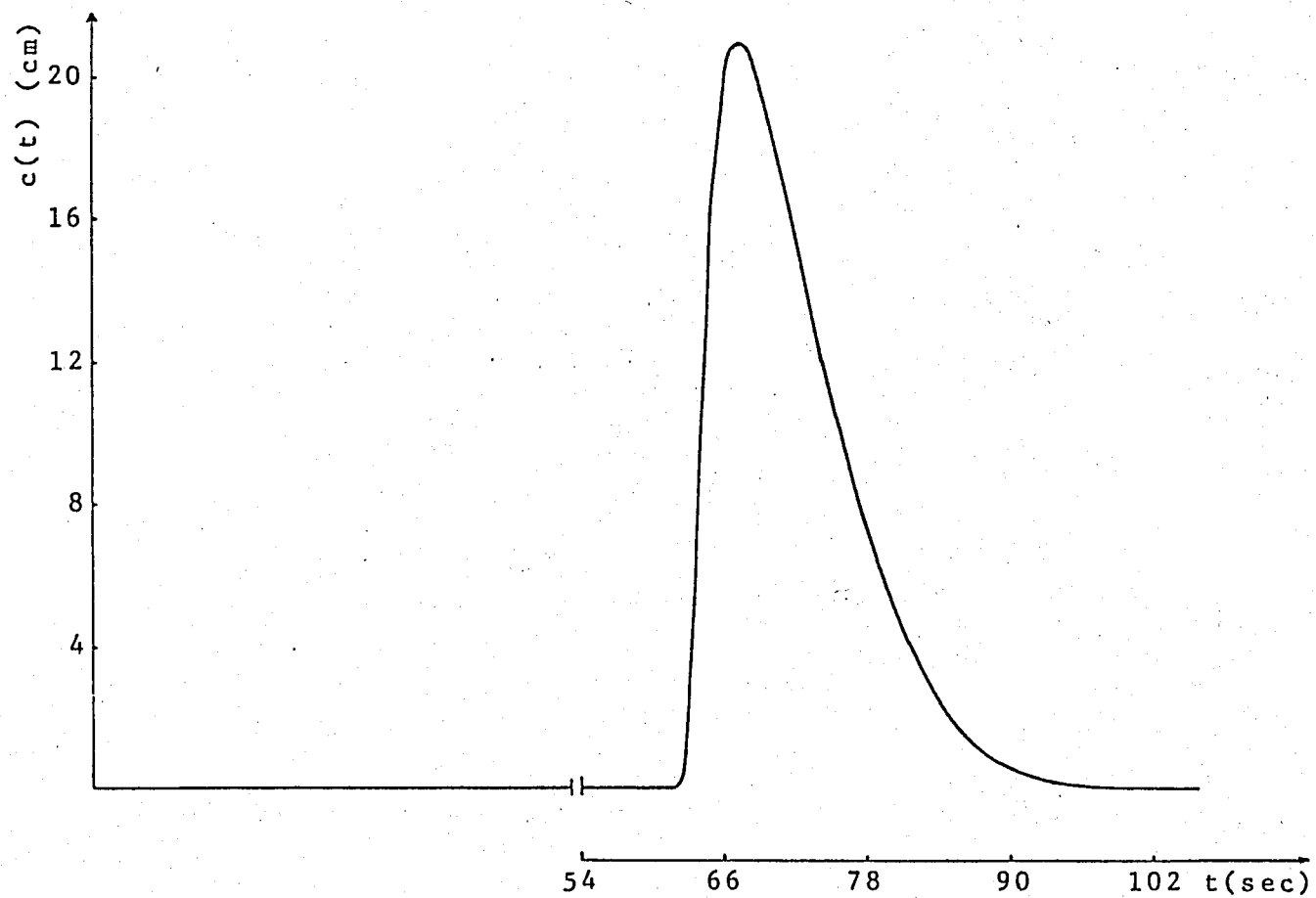


FIGURE A.6.7 Sample Chromatogram for n-Heptane at 0.2  $\mu$ l with He  
T=207.39°C Attenuation=32 Chart Speed=20 cm/min

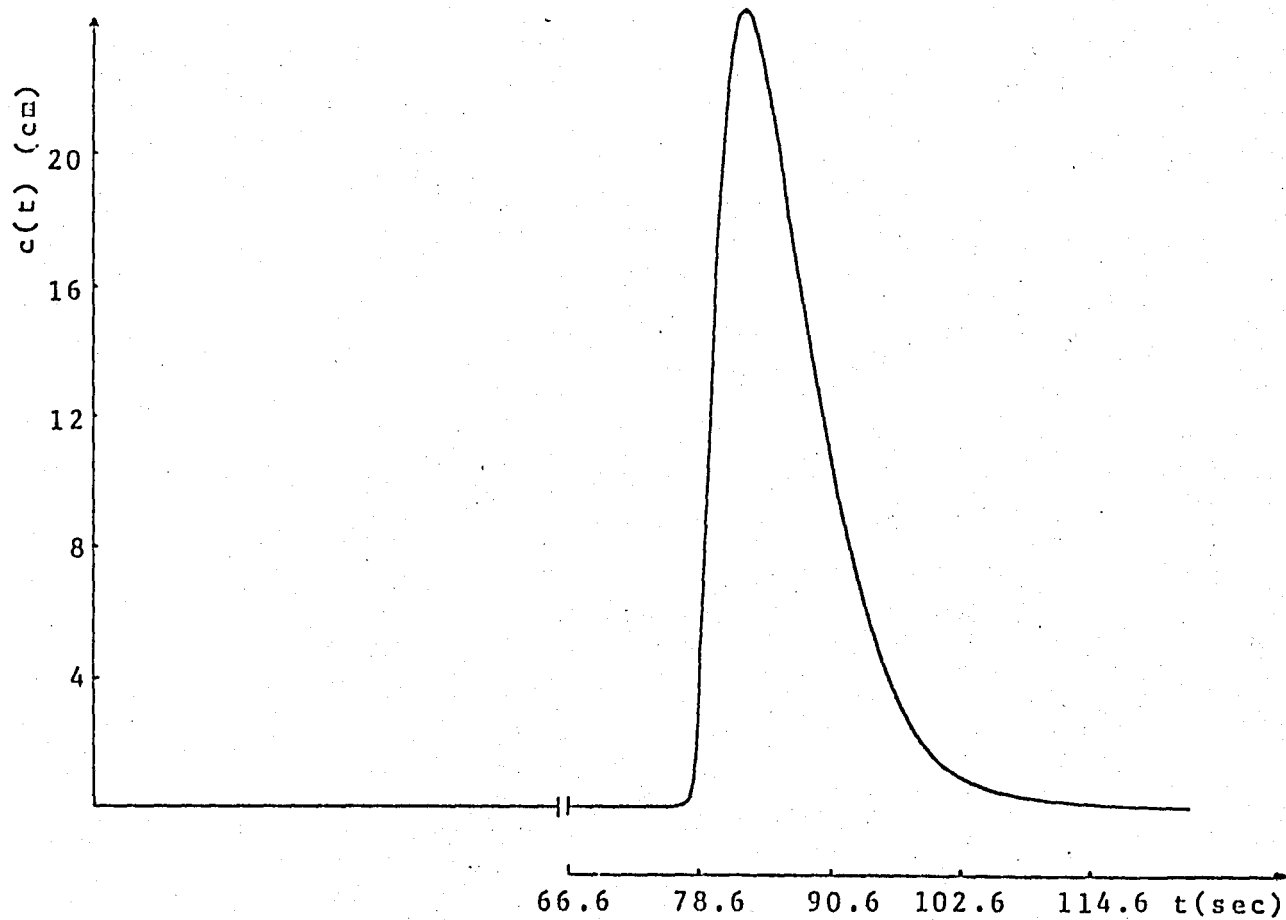


FIGURE A.6.8 Sample Chromatogram for n-Heptane at 0.4  $\mu$ l with He  
T=207.40°C Attenuation=16 Chart Speed=20 cm/min

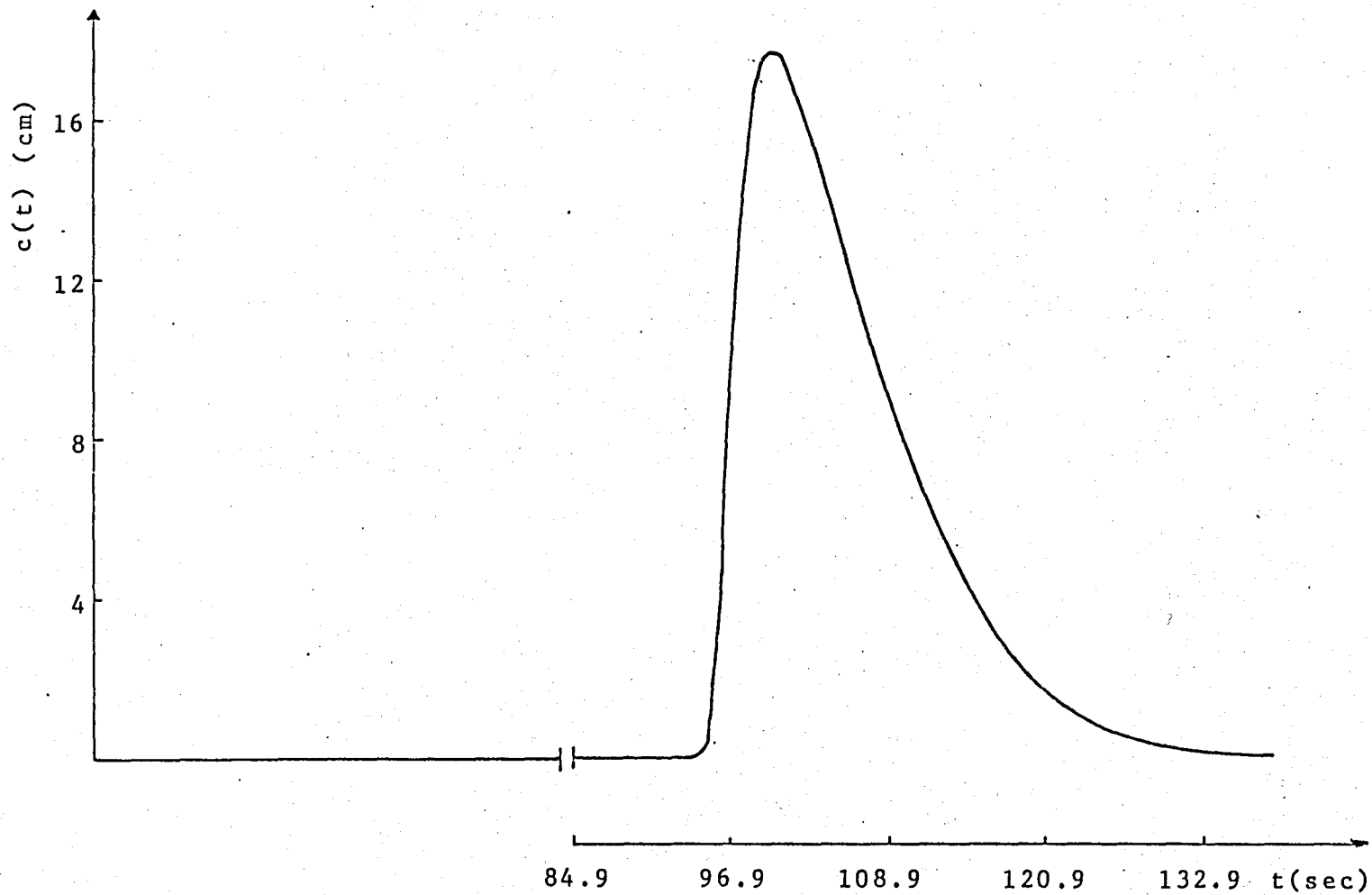


FIGURE A.6.9 Sample Chromatogram for i-Octane at 0.2  $\mu$ l with He  
T=209.91°C Attenuation=16 Chart Speed=20 cm/min

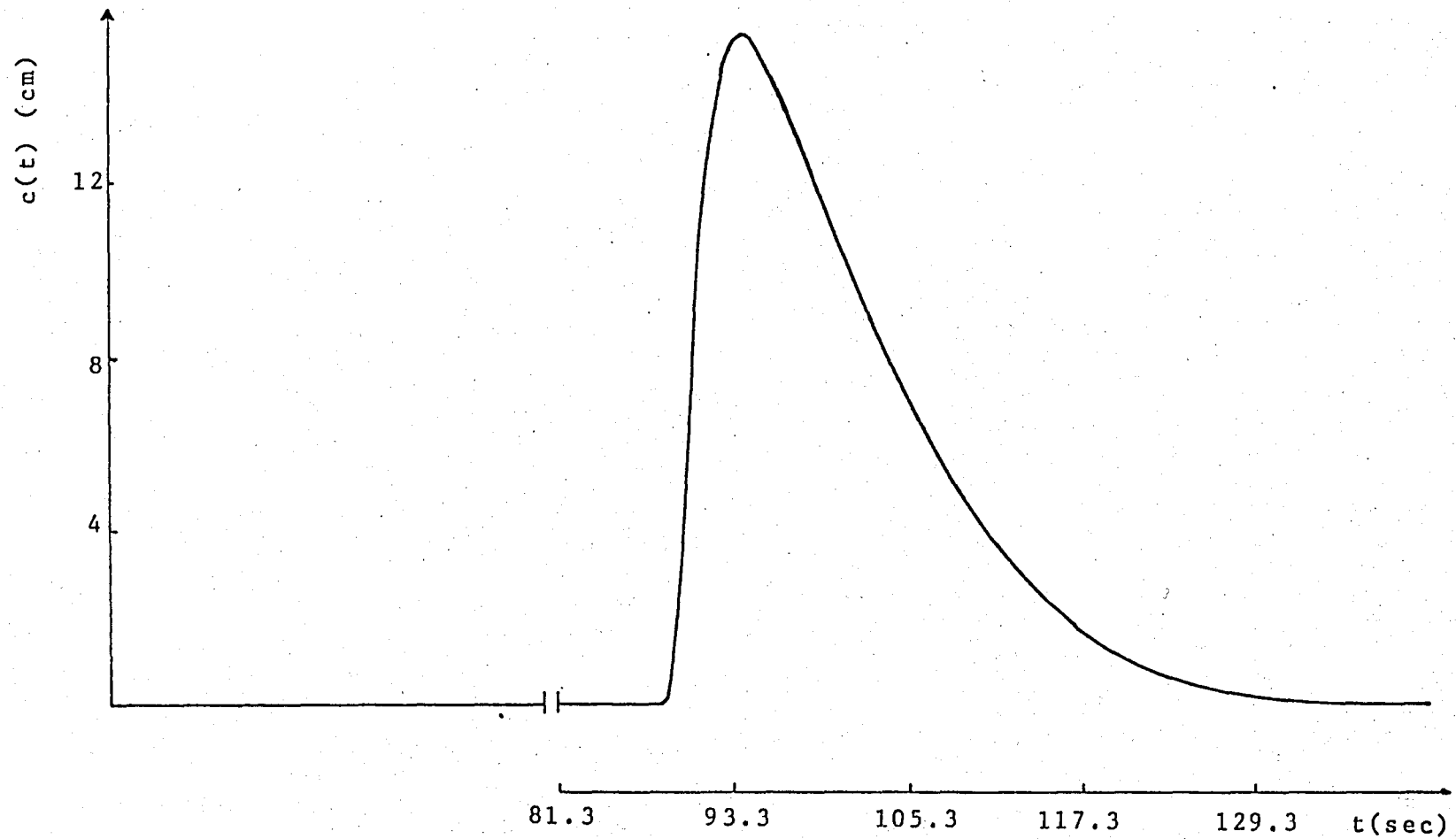


FIGURE A.6.10 Sample Chromatogram for i-Octane at 0.4  $\mu$ l with He  
T=209.99°C Attenuation=32 Chart Speed=20 cm/min