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_2O_3 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-heksan, n-heptan ve i-oktan'ın % 0.3 Pt/Al_2O_3 endustriyel reformlama katalizörü üzerindeki adsorplanması gaz katı kromatografisi yöntemi ve darbe tekniği kullanılarak incelenmiştir. 185 °C - 235 °C arasında değisik 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-heksan, n-heptan ve i-oktan için ortalama adsorplanma ısıları sirasiyla 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 sıcaklik aralığından her durumda kimyasal adsorplanmanın gerçekleştigi sonucuna varılmış, normal parafinlerin adsorplanma ısılarının karbon sayısıyla doğrusal olarak arttığı gözlemlenmiştir.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	constant of adsorption isotherm (mmHg gcat/gmol)
A_p	area under the elution peak (mm^2)
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 concenration of the sample (gmol sample/cm^3 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 colum temperature and according to the pressure drop in the column (cm^3/min)
F_D	volumetric carrier gas flowrate in the dedector (cm^3/min)
F_r	volumetric carrier gas flowrate at the room temperature (cm^3/min)
$f'(c)$	derivative of the adsorption isotherm
ΔH_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_i	pressure at the inlet of the column (mm Hg)
p_o	pressure at the outlet of the column (mm Hg)
Q_{ads}	heats of adsorption (kJ/gmol, kcal/gmol)
R	gas constant (cm^3 mmHg/gmol°K, kJ/gmol°C)

T_b	boiling point of the adsorbate (°C, °K)
T_c	column temperature (°C, °K)
T_D	dedector temperature (°C, °K)
T_r	room temperature (°C, °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 (μl)
V_g	specific retention volume (cm^3/g cat)
V_M	mobile gas hold-up (cm^3)
V_N	net retention volume (cm^3)
V_R	retention volume (cm^3)
V_R'	adjusted retention volume (cm^3)
v	chart speed (mm/sec)
w_c	weight of catalyst (g)

I. INTRODUCTION

Catalitic 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 isopreribol 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 Doroiswamy (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.

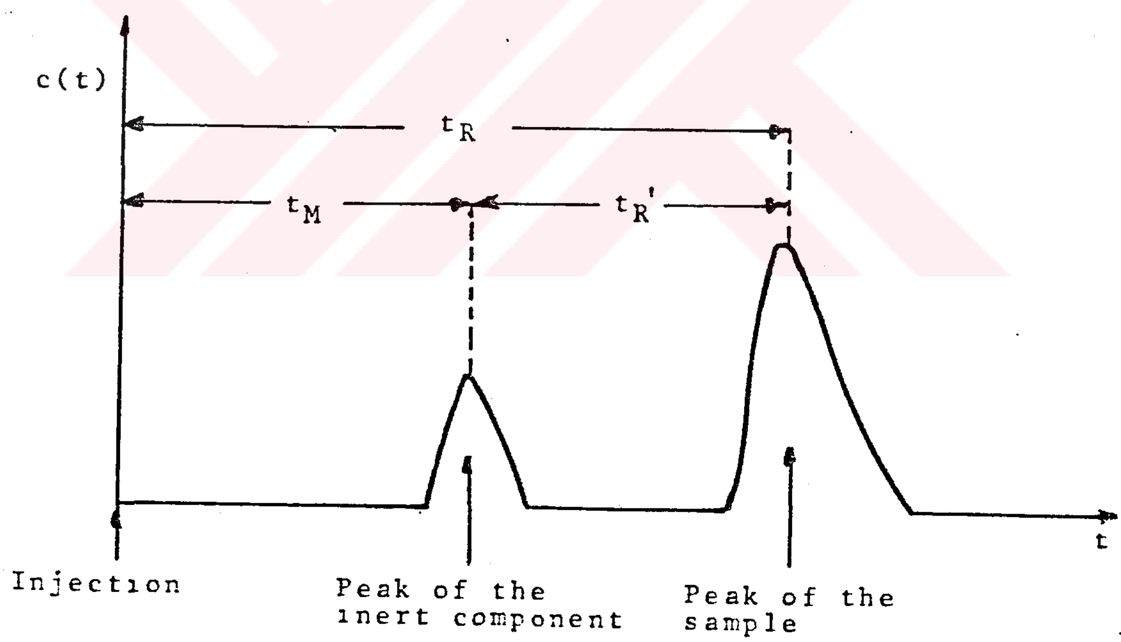

FIGURE 2.1 Chromatogram Obtained by Elution Chromatography

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:

$$t_R' = t_R - t_M \tag{2.1}$$

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:

$$F_f t_R' = (t_R - t_M) F_f \tag{2.2}$$

or

$$V_R' = V_R - V_M \tag{2.3}$$

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):

$$j = \frac{3}{2}\left[\frac{(p_i/p_o)^2-1}{(p_i/p_o)^3-1}\right] \tag{2.4}$$

where p_i and p_o are column inlet and outlet pressures respectively. Therefore net retention volume V_N is obtained:

$$V_N = jV_R' \tag{2.5}$$

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

$$V_N = jV_R'\frac{Tf}{Tc} \tag{2.6}$$

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

$$Vg = \frac{V_N}{w_K} \tag{2.7}$$

where w_K is the weight of catalyst. In summary:

$$Vg = F_c(t_R - t_M)/w_k \tag{2.8}$$

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

$$F_c = F_f \frac{T_c}{T_f} \frac{3}{2} \left[\frac{(p_i/p_o)2-1}{(p_i/p_o)3-1} \right] \tag{2.9}$$

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) :

$$\frac{dN}{dc} = Vg \tag{2.15}$$

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

$$Vg = f'(c) \tag{2.16}$$

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):

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

where c(t) is in mm and

$$E_p = \frac{A_p F_D}{vnRT_D} \tag{2.11}$$

where A_p is the area of the chromatographic peak in 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 cm^3/sec and is defined as:

$$F_D = F_f \frac{T_D}{T_f} \tag{2.12}$$

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

$$p = \frac{c(t)}{A_p F_r / vnRT_r} \tag{2.13}$$

The retention volume, Vg (cm^3/g) for a time on abscissa, t_c can be determined as (Gonenc,1985):

$$Vg = (t_c - t_M)F_c / w_k \tag{2.14}$$

where t_c 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 cm^3/sec as given in Equation(2.9) and w_k is the weight of catalyst in g.

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

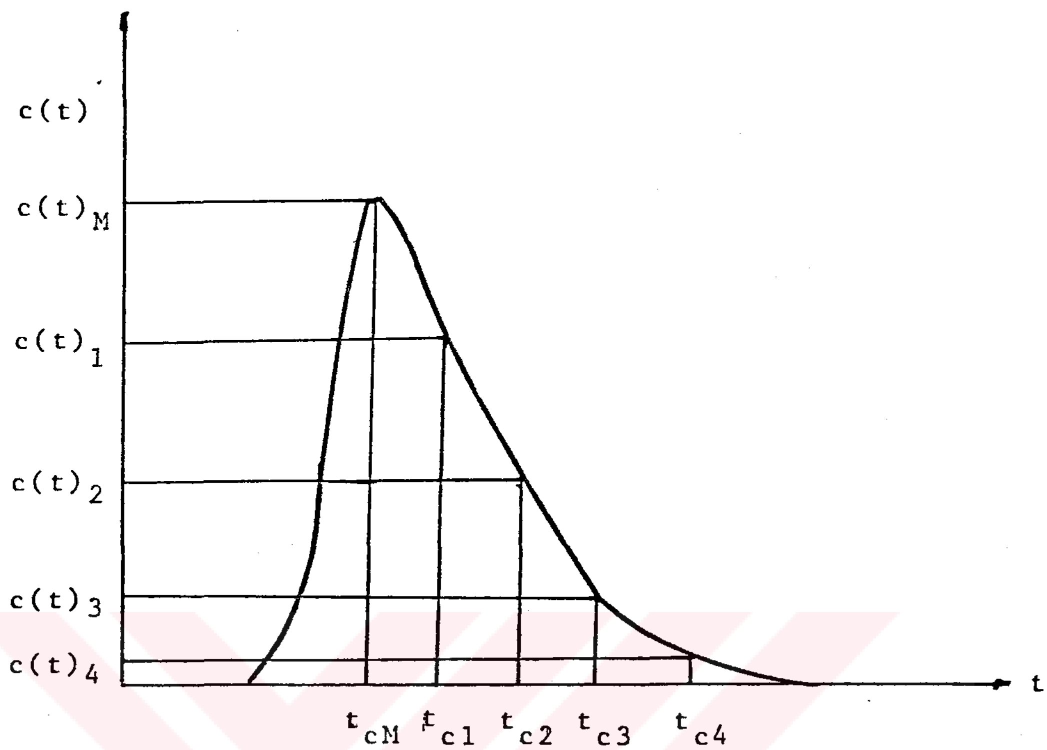

FIGURE 2.2. Examples of Evaluation of Peak to Obtain t_c and c(t) values.

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):

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

where Vg 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):

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

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 slop 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:

<u>Detector</u>	: Thermal conductivity dedector 4 filament tungsten-rhenium(wx) usage up to 400 °C
<u>Detector Control Unit</u>	: Current: 0-300 mA Control: % ± 0.02

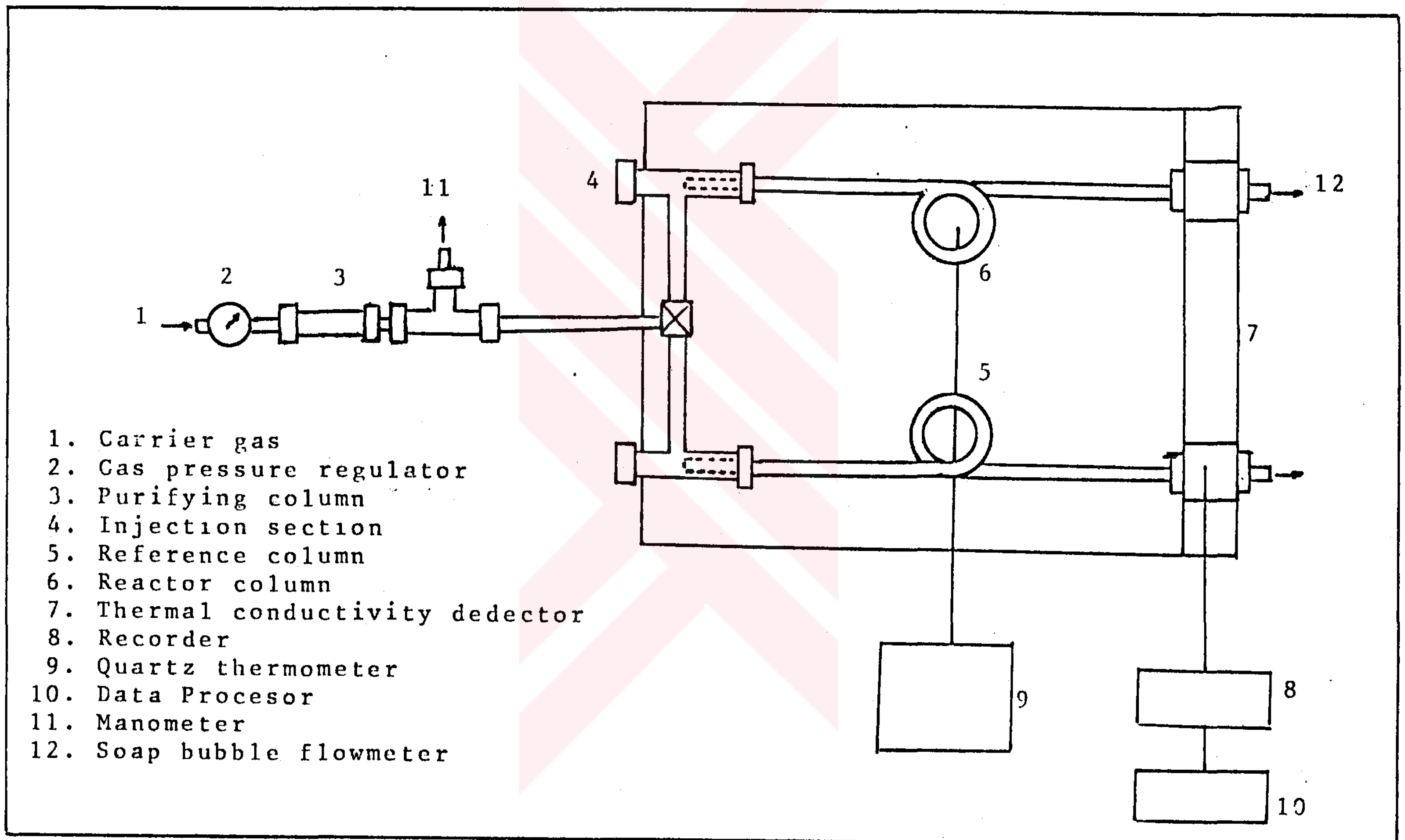

FIGURE 3.1 Experimental Set-up

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 μV.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_2O_3 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	Moleculer 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 steal 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 $^1/_2$ hours at 287 °C and at a flowrate of about 10 cm^3/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^3/min for n-pentane and n-hexane and 15 cm^3/min for n-heptane and i-octane.

After steady state temperature was reached, 1-2 µl 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 ± 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, Vg 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 Vg/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 :

$$Cs = \frac{p}{A+Bp} \tag{3.1}$$

where Cs 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):

$$p = \frac{ACs}{1-BCs} \tag{3.2}$$

The A and B values corresponding to each column temperature T_c were used to calculate p, keeping the surface concentration Cs 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 Cs 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 µl sample size. Table 3.2 shows the retention time-height data. The Vg/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 Cs and p values are curve fitted to Equation (3.1) and A and B are found as 5.846 $\times 10^{6}$ 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 Cs 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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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

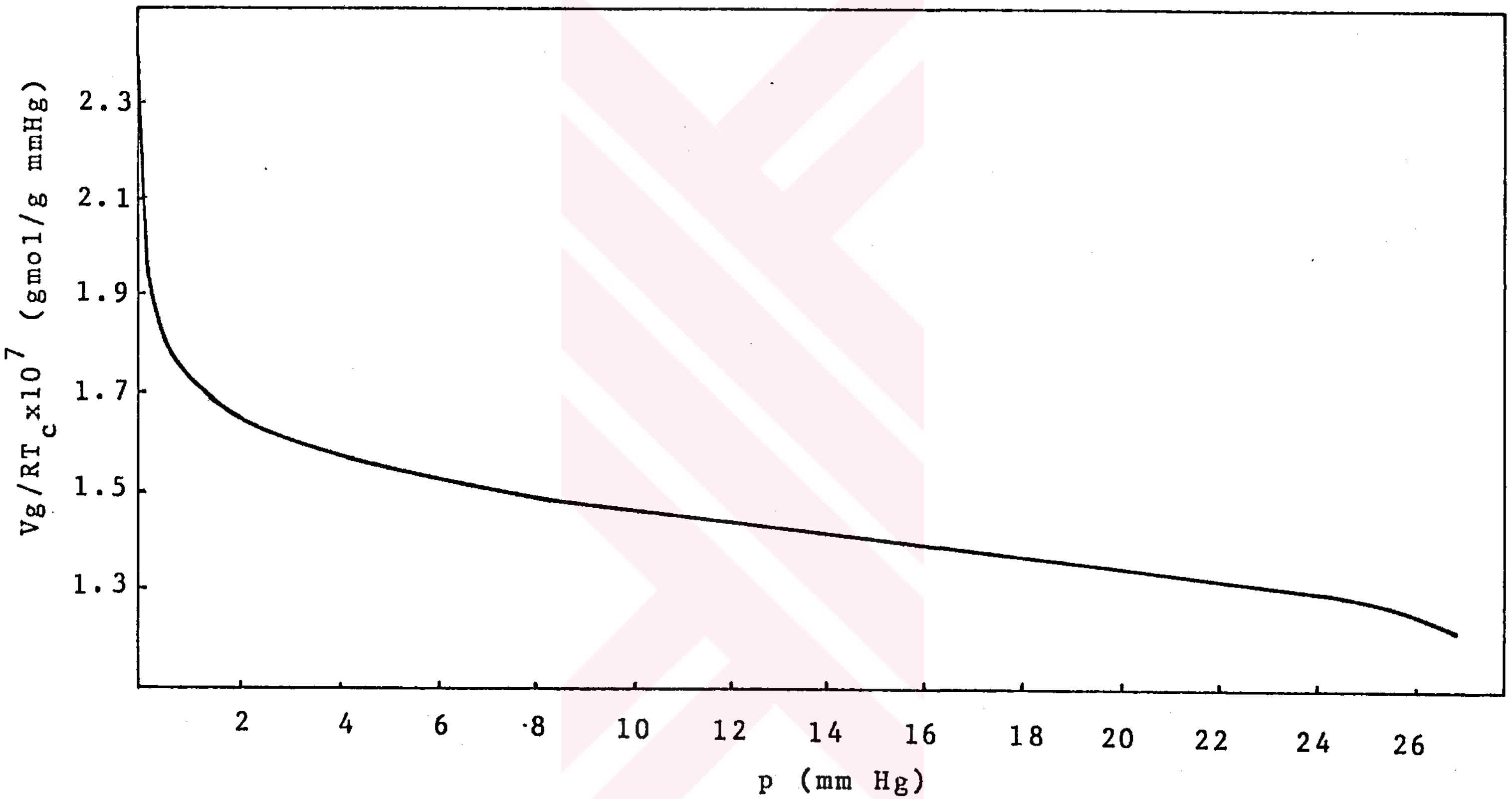

FIGURE 3.2 Derivative of the Adsorption Isotherm of n-Hexane at 0.4 µl and 211.11 °C

TABLE 3.3 Adsorption Isotherm of n-Hexane at 0.4 µl and 211.11 °C with Helium

p (mm Hg)	$C_s x10^7$ (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

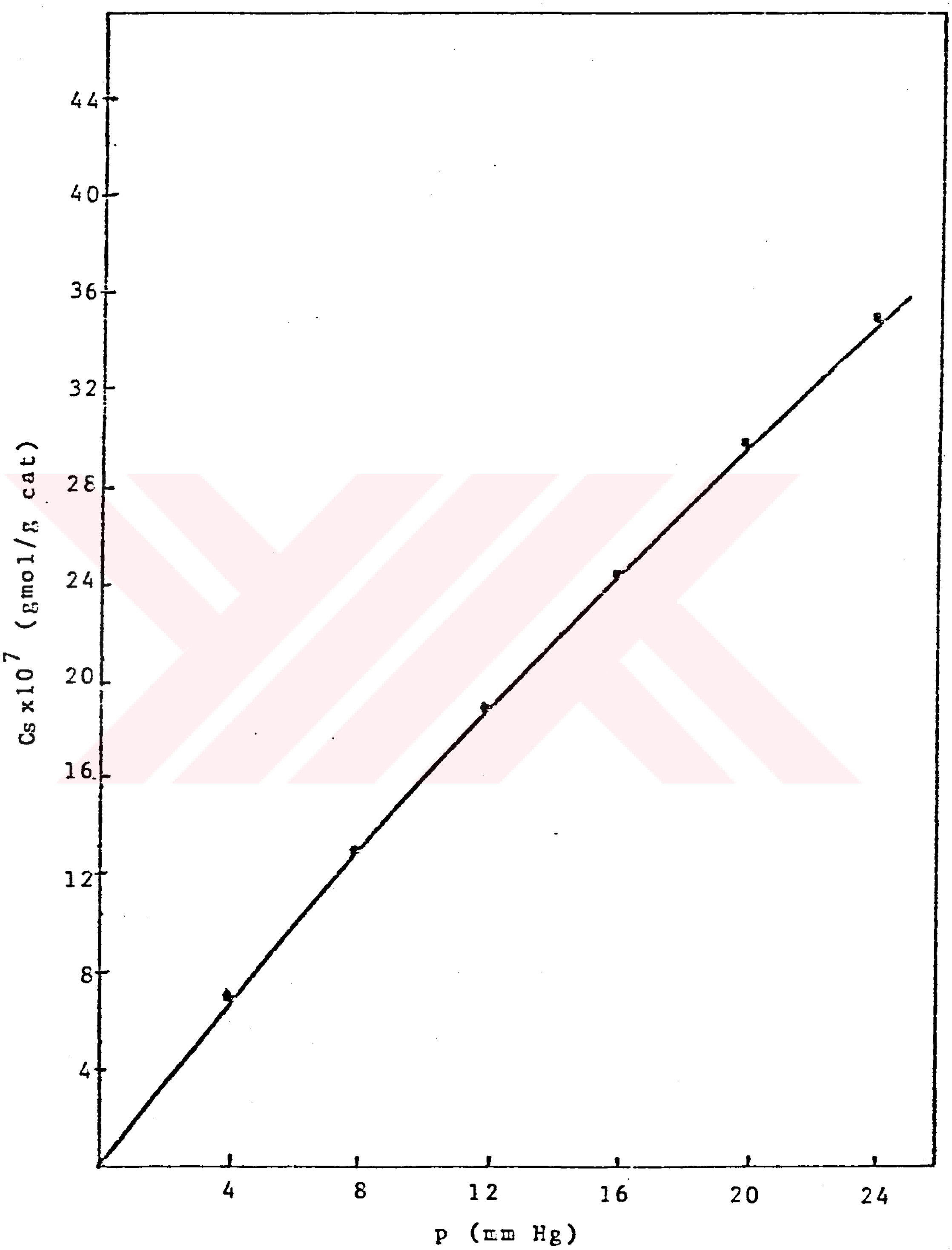

FIGURE 3.3 Adsorption Isotherm of n-Hexane at 0.4 μl and 211.11 °C with Helium

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 ±0.1 °C (Conder,1968). In this study, the column temperature was measured with a quartz thermometer and held constant within the range of ±0.05 °C in majority of runs, but at no time did the fluctuation reachs ±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^3/min was used for n-pentane and n-hexane. The flowrate for n-hexane and i-octane was about 15 cm^3/min to prevent peak tailing which occured at 10 cm^3/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 µl and 0.4 µl for n-pentane and n-hexane, and 0.4 µl and 0.2 µl for n-heptane and i-octane.

At low flowrates, the particle size of the catalyst must be sufficiently small to minimize diffussion 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_2O_3 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, Cs, 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 Cs, a global average Q_{ads} was also calculated for each hydrocarbon. The heats of adsorption of the hydrocarbons at diferent Cs 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 (°C)	$A \times 10^{-6}$ (mmHg gcat/gmol)	$B \times 10^{-4}$ (gcat/gmol)	±Error in Cs* (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 (°C)	$A \times 10^{-6}$ (mmHg gcat/gmol)	$B \times 10^{-4}$ (gcat/gmol)	±Error in Cs* (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 (°C)	$A \times 10^{-6}$ (mmHg gcat/gmol)	$B \times 10^{-4}$ (gcat/gmol)	±Error in Cs* (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 μl

T (°C)	$A \times 10^{-6}$ (mmHg gcat/gmol)	$B \times 10^{-4}$ (gcat/gmol)	±Error in Cs* (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 μl

T (°C)	$A \times 10^{-6}$ (mmHg gcat/gmol)	$B \times 10^{-4}$ (gcat/gmol)	±Error in Cs* (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 μl

T (°C)	$A \times 10^{-6}$ (mmHg gcat/gmol)	$B \times 10^{-4}$ (gcat/gmol)	±Error in Cs* (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 µl

T (°C)	$A \times 10^{-6}$ (mmHg gcat/gmol)	$B \times 10^{-4}$ (gcat/gmol)	±Error in Cs* (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 µl

T (°C)	$A \times 10^{-6}$ (mmHg gcat/gmol)	$B \times 10^{-4}$ (gcat/gmol)	±Error in Cs* (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 µl

T (°C)	$A\times10^{-6}$ (mmHg gcat/gmol)	$B\times10^{-4}$ (gcat/gmol)	±Error in Cs (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 µl

T (°C)	$A\times10^{-6}$ (mmHg gcat/gmol)	$B\times10^{-4}$ (gcat/gmol)	±Error in Cs (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)

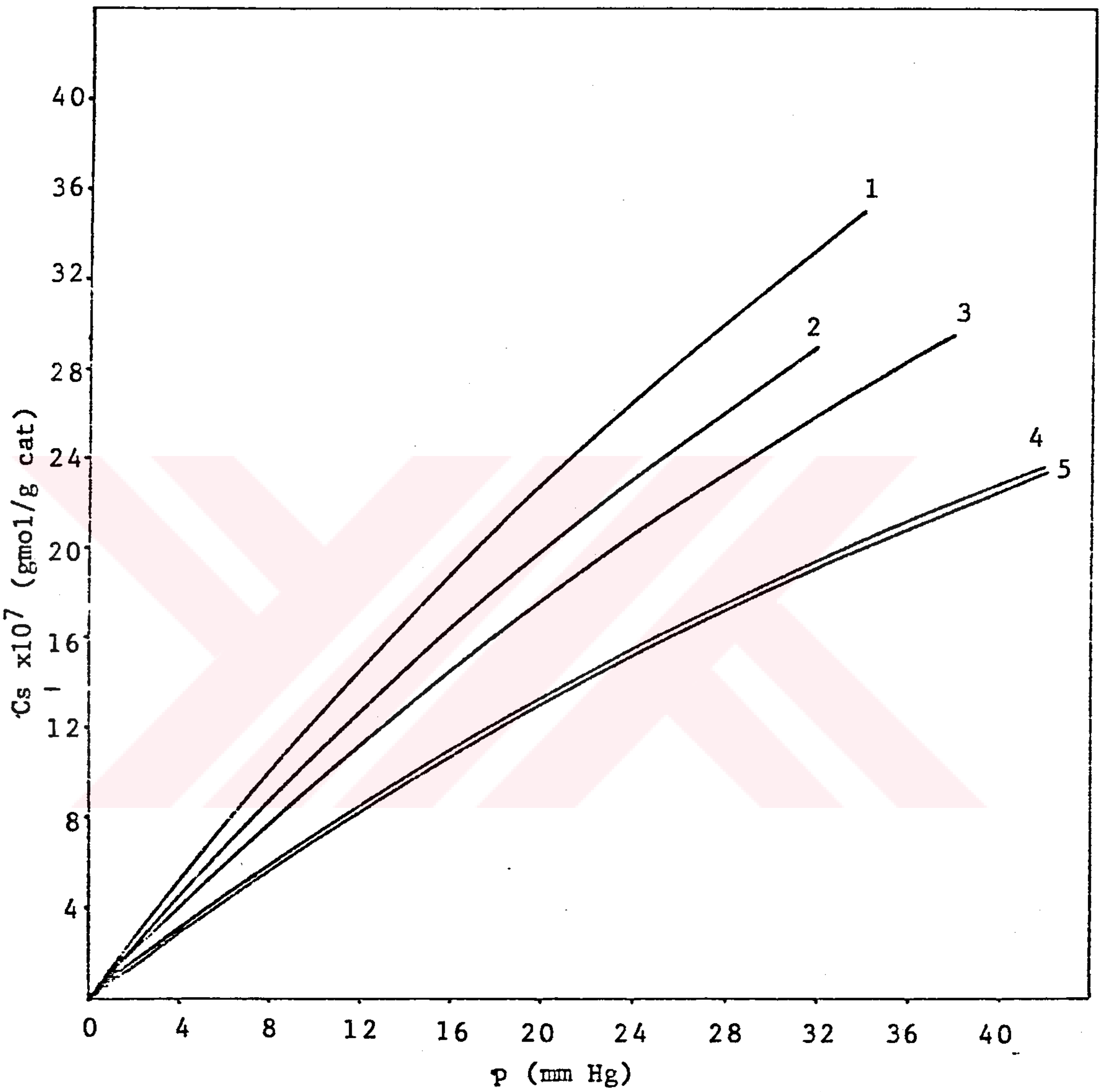

FIGURE 4.1 Adsorption Isotherms of n-Pentane at 0.4 μl with Hydrogen

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

TABLE 4.5 Adsorption Isosteres for n-Pentane at 0.4 μl with H_2

Cs (gmol/g cat)		$5x10^{7}$		$10x10^{7}$		$15x10^{7}$		$20x10^{7}$	
T_c(°C)	$10^3/T_c$(°K^{-1})	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

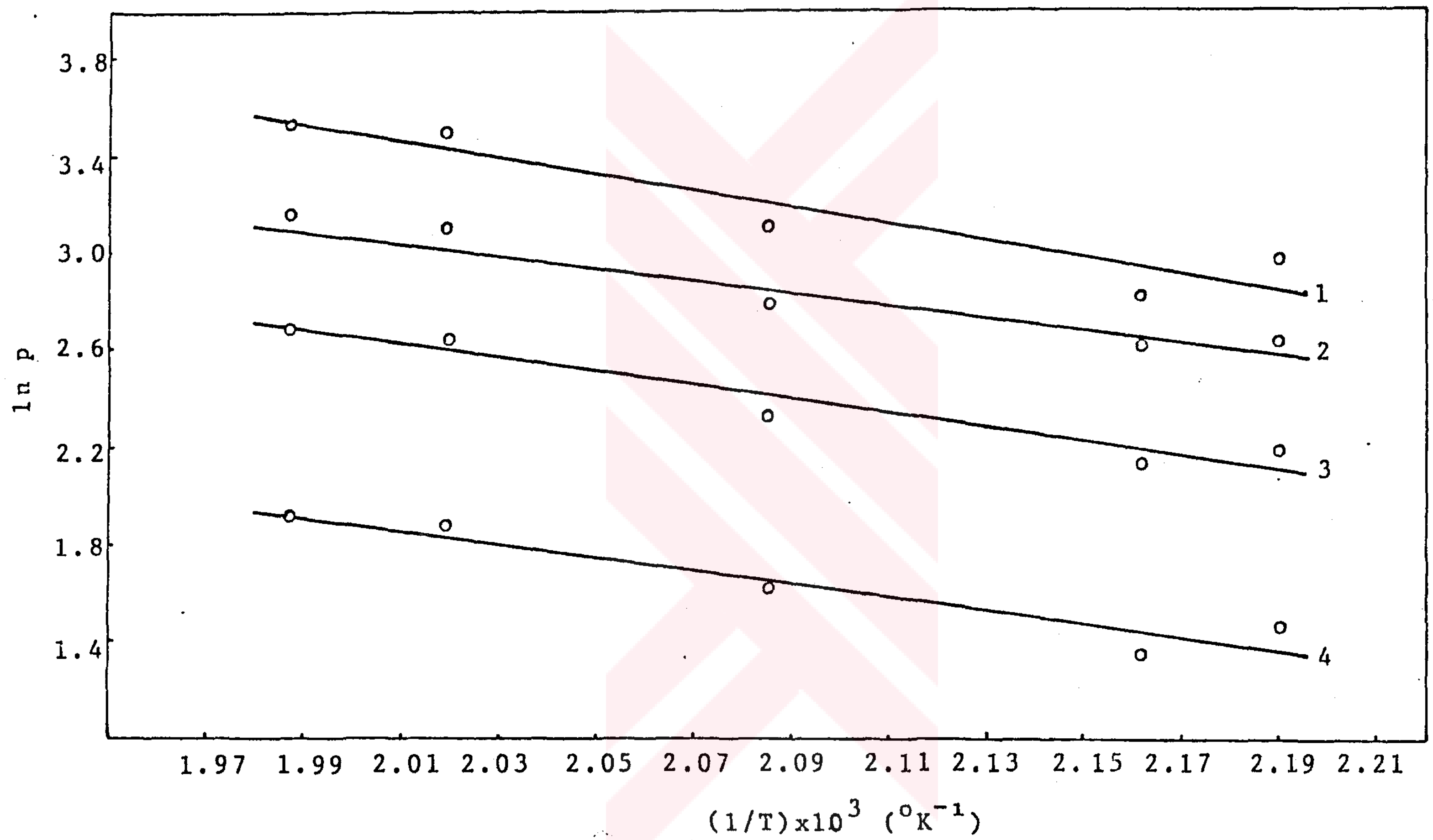

FIGURE 4.2 Adsorption Isosteres of n-Pentane at 0.4 μl with Hydrogen

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

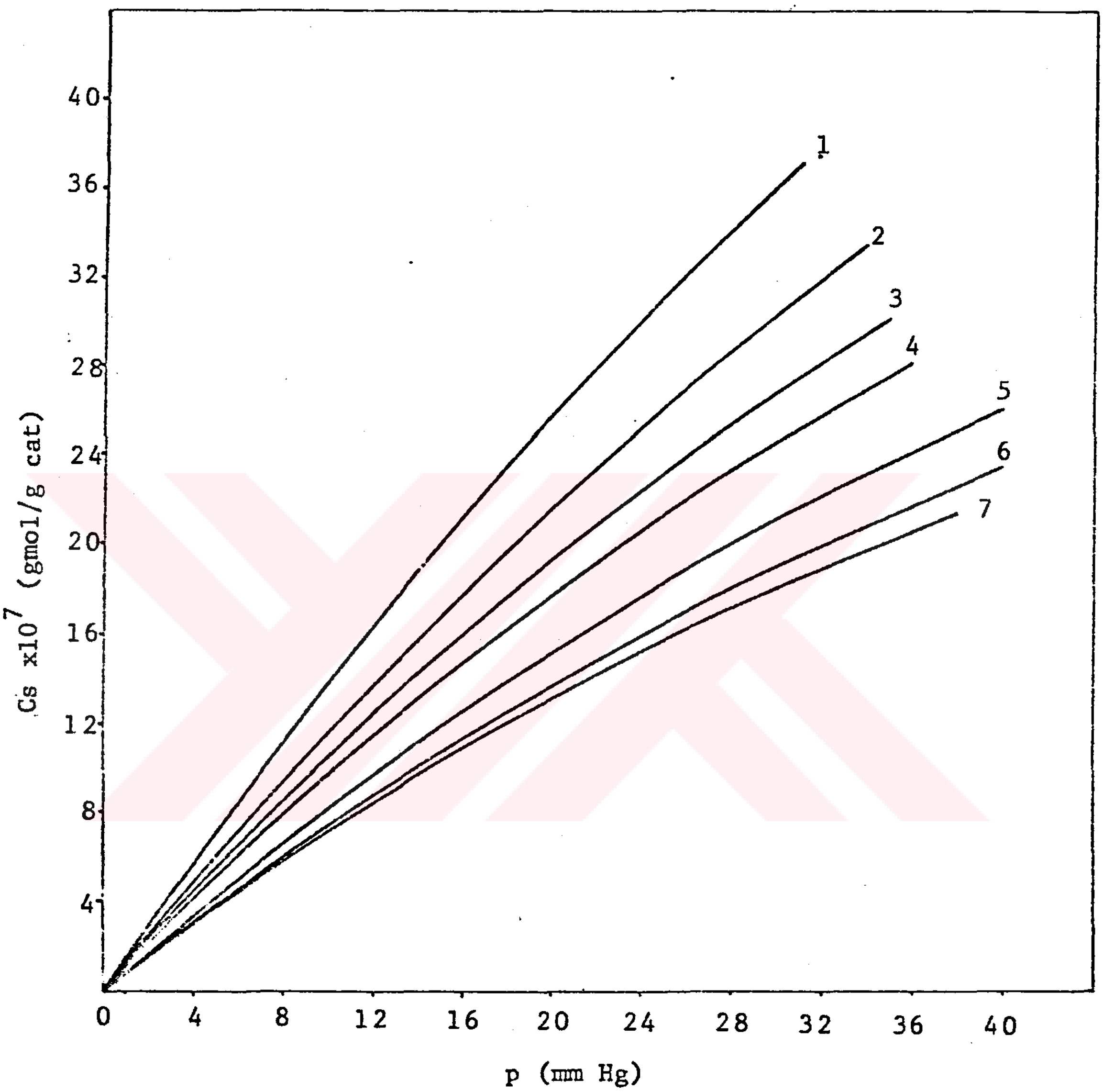

FIGURE 4.3 Adsorption Isotherms of n-Pentane at 0.4 μl with Helium

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

TABLE 4.6 Adsorption Isosteres for n-Pentane at 0.4 μl with He

Cs (gmol/g cat)		5×10^{-7}		10×10^{-7}		15×10^{-7}		20×10^{-7}	
T_c (°C)	$10^3/T_c$ (°K^{-1})	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

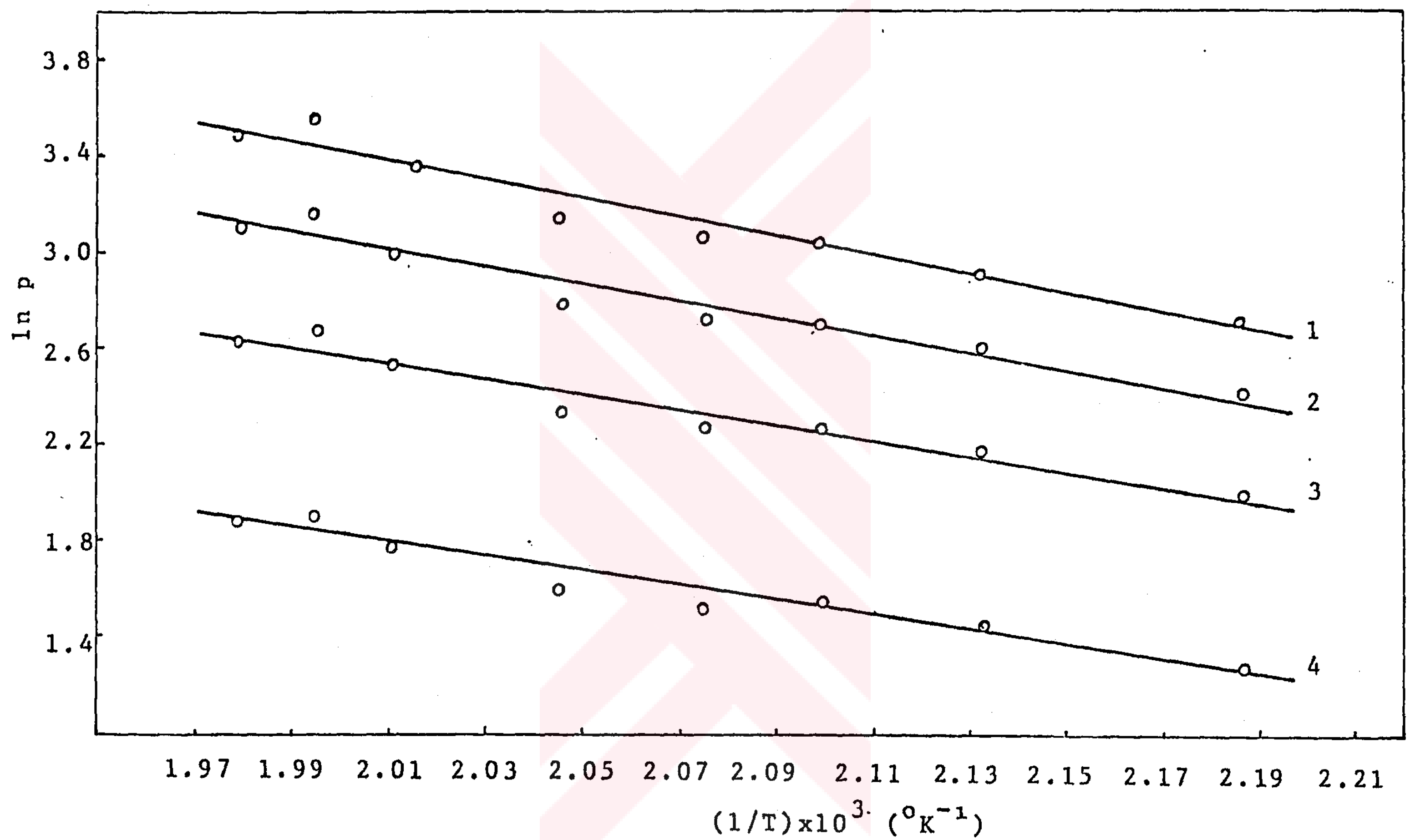

FIGURE 4.4 Adsorption Isosteres of n-Pentane at 0.4 μl with Helium

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

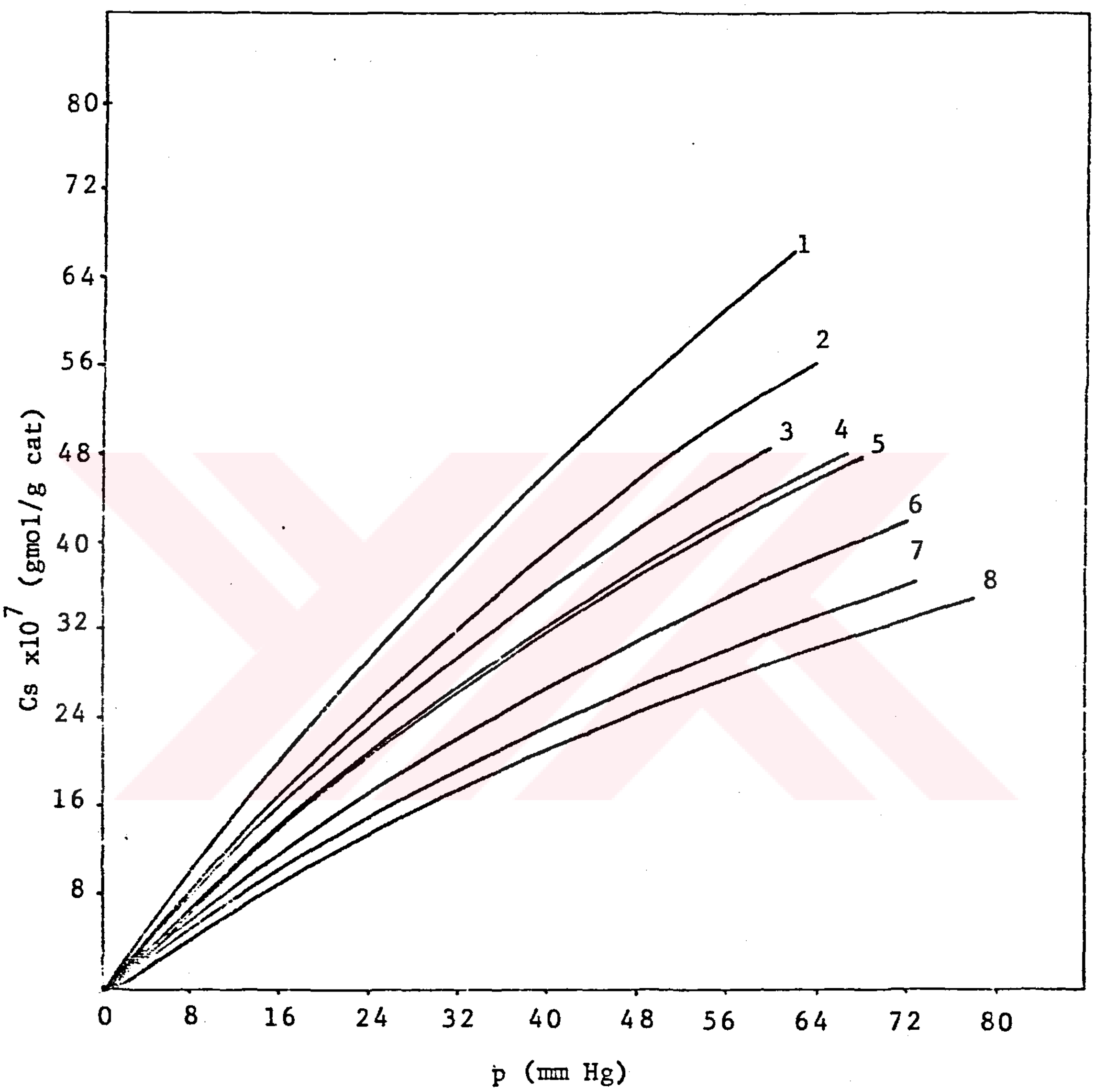

FIGURE 4.5 Adsorption Isotherms of n-Pentane at 0.8 μl with Helium

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 μl with He

Cs (gmol/g cat)		5×10^{7}		10×10^{7}		15×10^{7}		20×10^{7}	
T_s(°C)	$10^3/T_s$(°K^{-1})	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

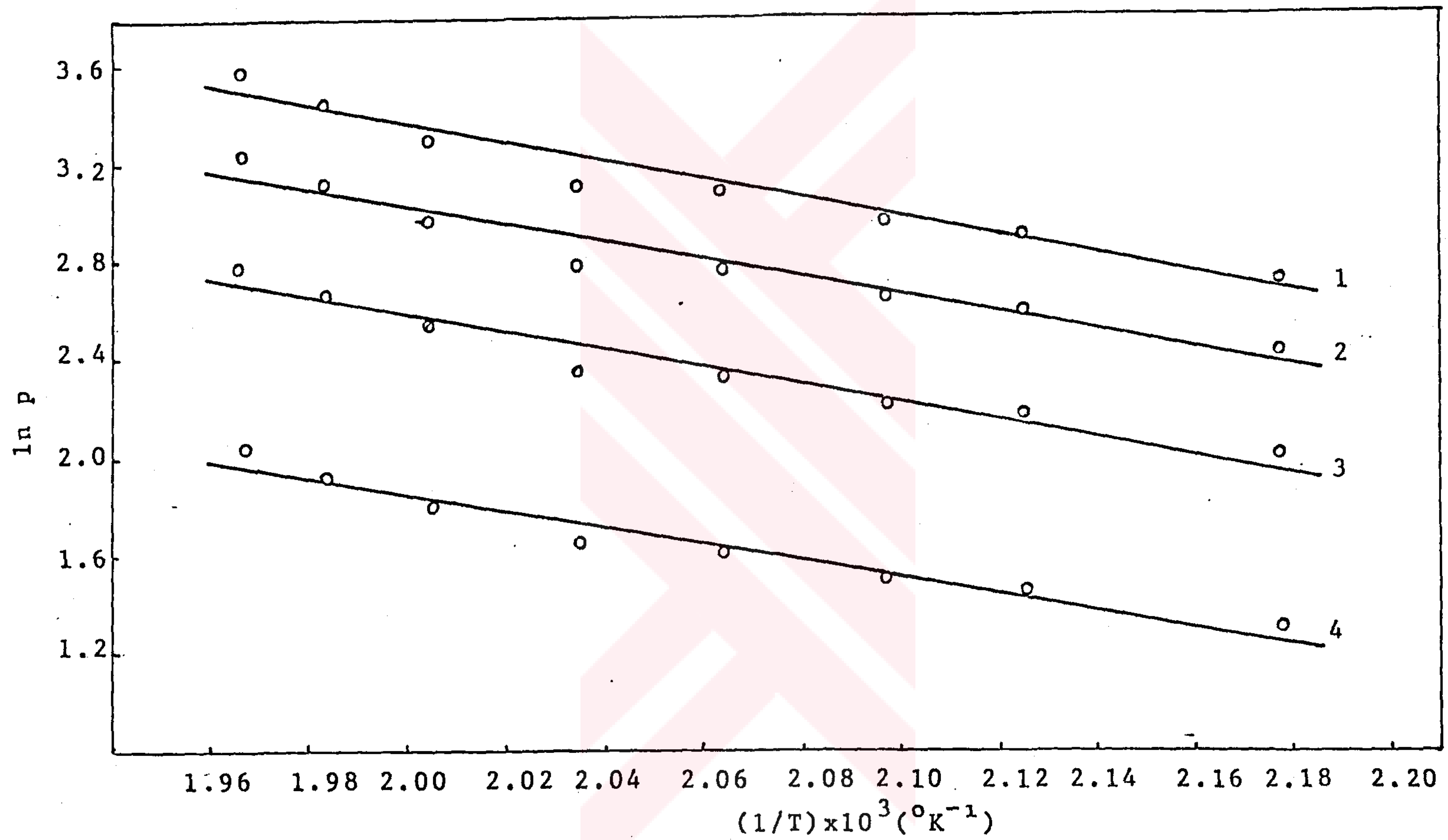

FIGURE 4.6 Adsorption Isosteres of n-Pentane at 0.8 μl with Helium

1. At 20×10^{7} gmol/g cat
2. At 15×10^{7} gmol/g cat
3. At 10×10^{7} gmol/g cat
4. At 5×10^{7} gmol/g cat

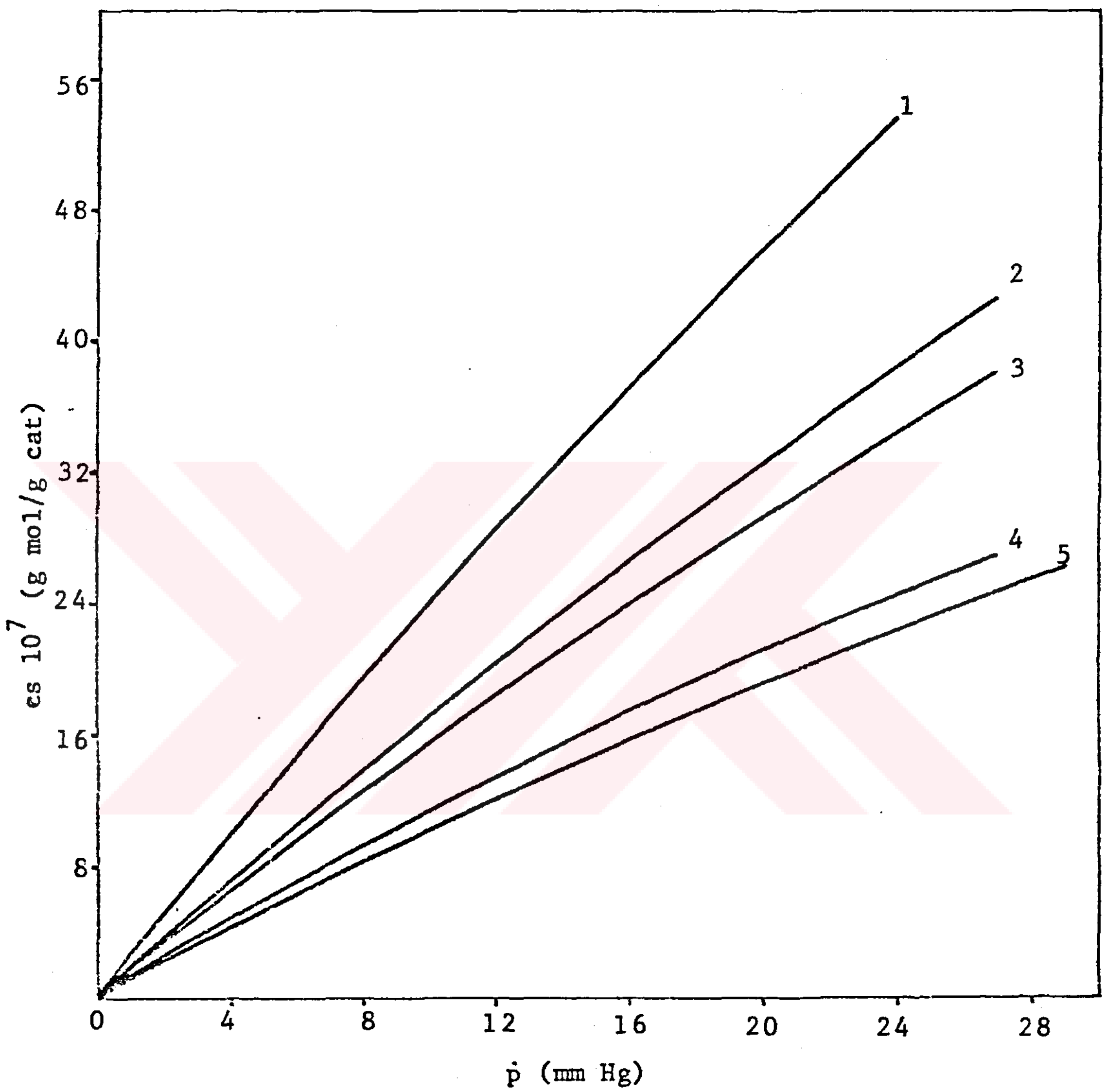

FIGURE 4.7 Adsorption Isotherms of n-Hexane at 0.4 µl with Hydrogen

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

TABLE 4.8 Adsorption Isosteres for n-Hexane at 0.4 µl with H_2

Cs (gmol/g cat)		5×10^{7}		10×10^{7}		15×10^{7}		20×10^{7}	
T_s(°C)	$10^3/T_s$(°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

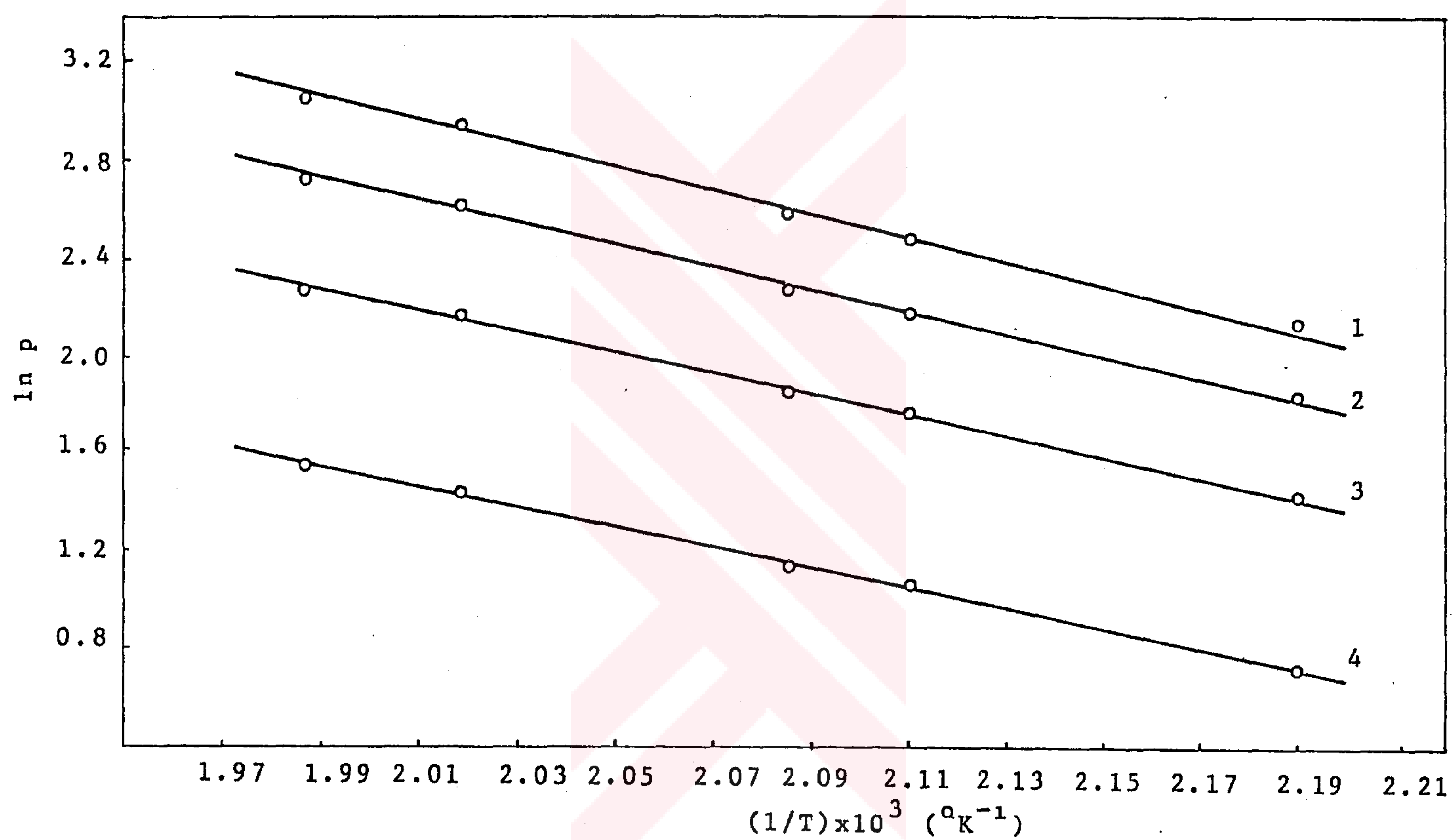

FIGURE 4.8 Adsorption Isosteres of n-Hexane at 0.4 µl with Hydrogen

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

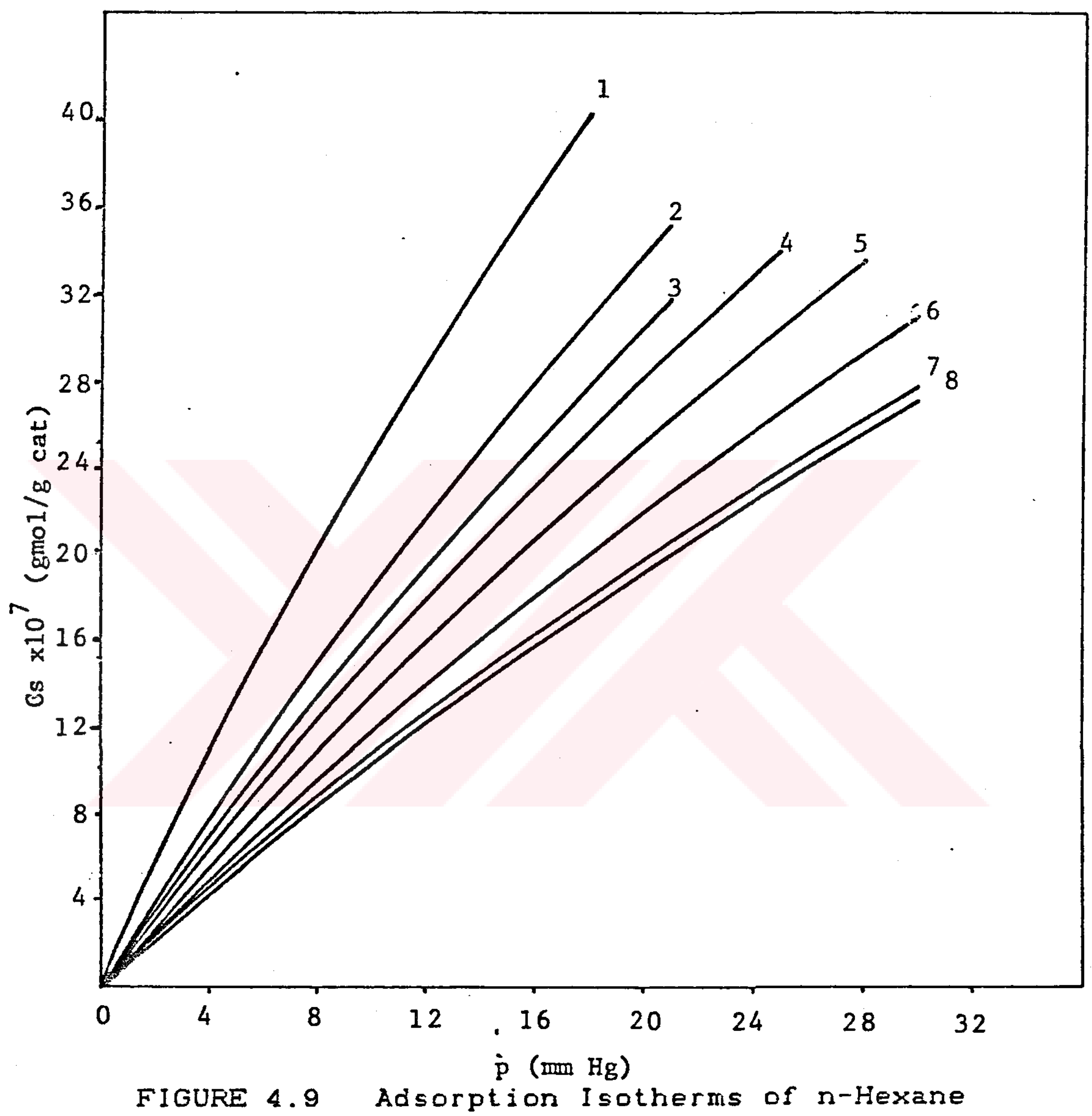

FIGURE 4.9 Adsorption Isotherms of n-Hexane at 0.4 µl with Helium

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 Isosteres for n-Hexane at 0.4 μl with He

Cs (gmol/g cat)		$5x10^{7}$		$10x10^{7}$		$15x10^{7}$		$20x10^{7}$	
T_s(°C)	$10^3/T_s$(°K^{-1})	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

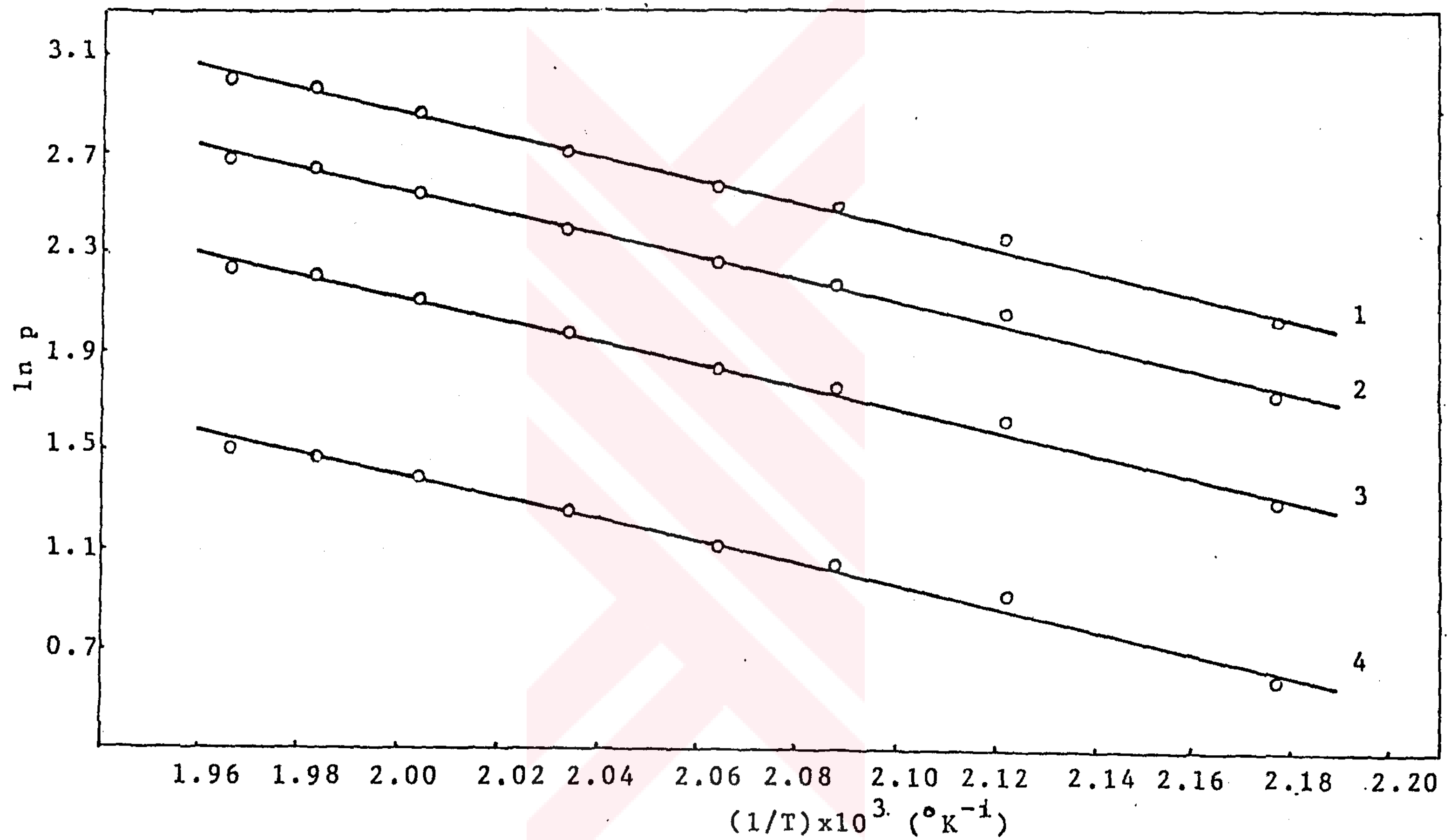

FIGURE 4.10 Adsorption Isosteres of n-Hexane at 0.4 µl with Helium

1. At 20×10^{7} gmol/g cat
2. At 15×10^{7} gmol/g cat
3. At 10×10^{7} gmol/g cat
4. At 5×10^{7} gmol/g cat

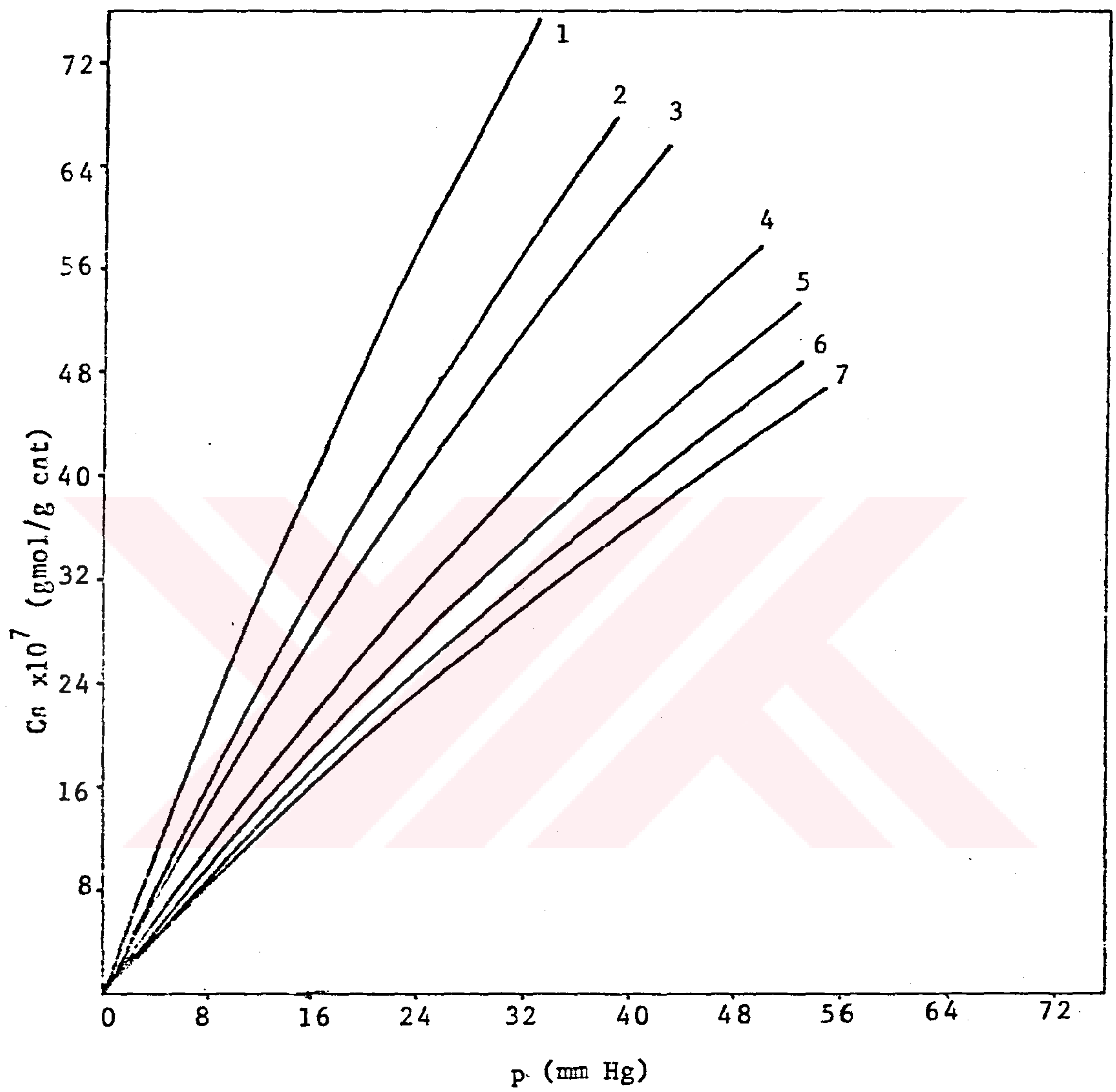

FIGURE 4.11 Adsorption Isotherms of n-Hexane at 0.8 μl with Helium

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

TABLE 4.10 Adsorption Isosteres for n-Hexane at 0.8 μl with He

Cs (gmol/g cat)		5x10^{-7}		10x10^{-7}		15x10^{-7}		20x10^{-7}	
T_s (°C)	$10^3/T_s$ (°K^{-1})	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

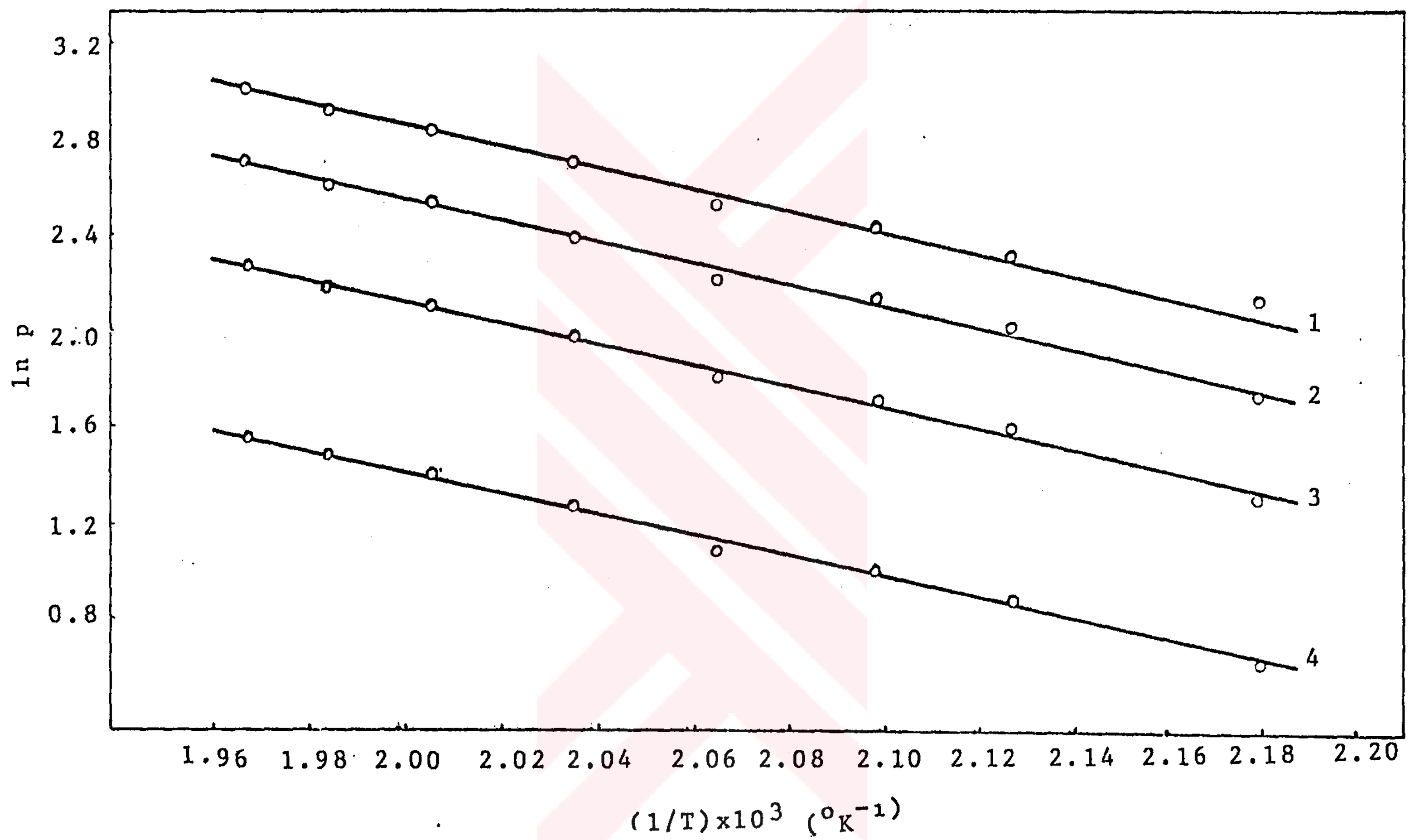

FIGURE 4.12 Adsorption Isosteres of n-Hexane at 0.8 μl with Helium

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

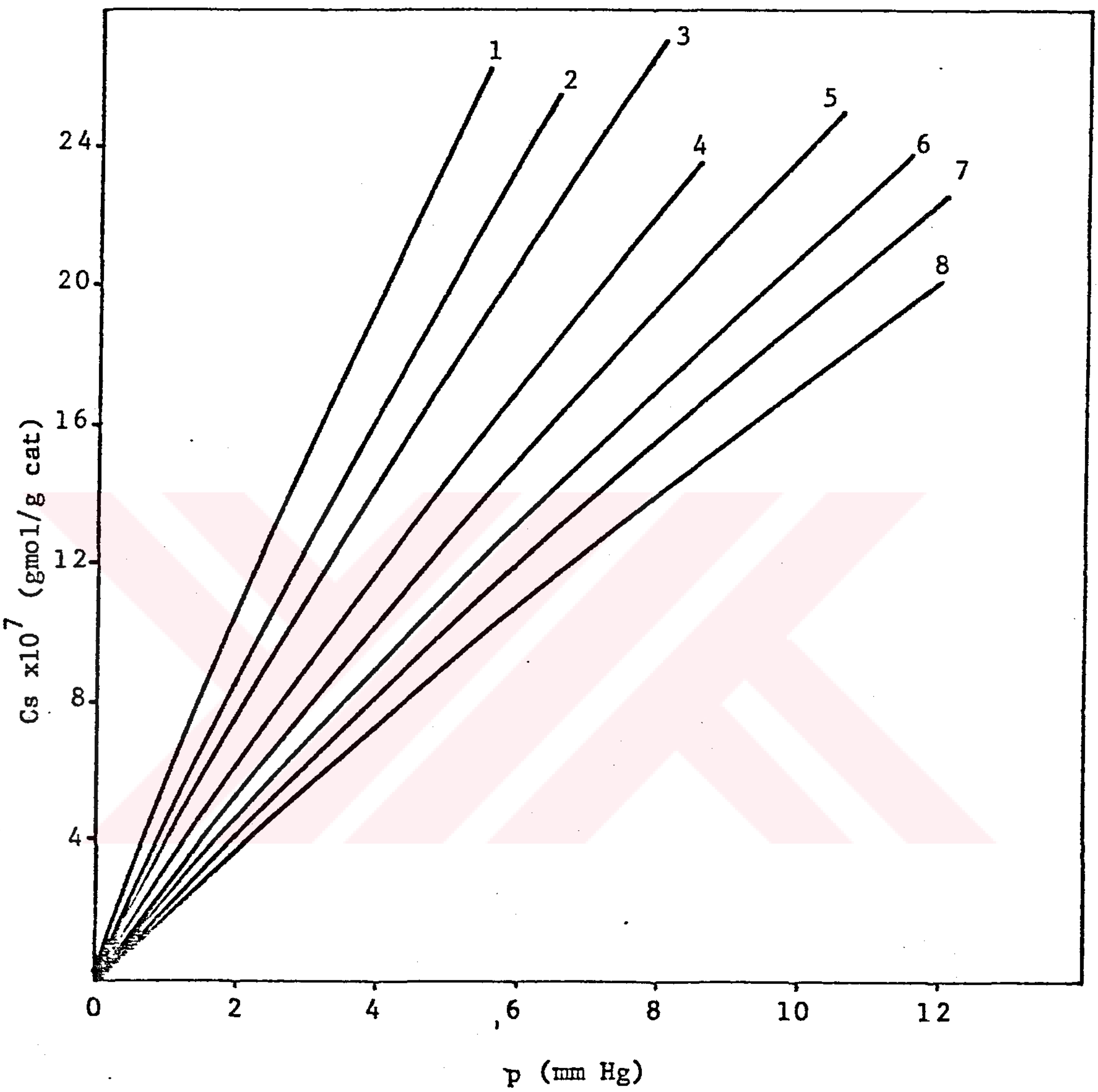

FIGURE 4.13 Adsorption Isotherms of n-Heptane at 0.2 μl with Helium

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 µl with He

Cs (gmol/g cat)		5×10^{-7}		10×10^{-7}		15×10^{-7}		20×10^{-7}	
T_c (°C)	$10^3/T_c$ (°K^{-1})	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

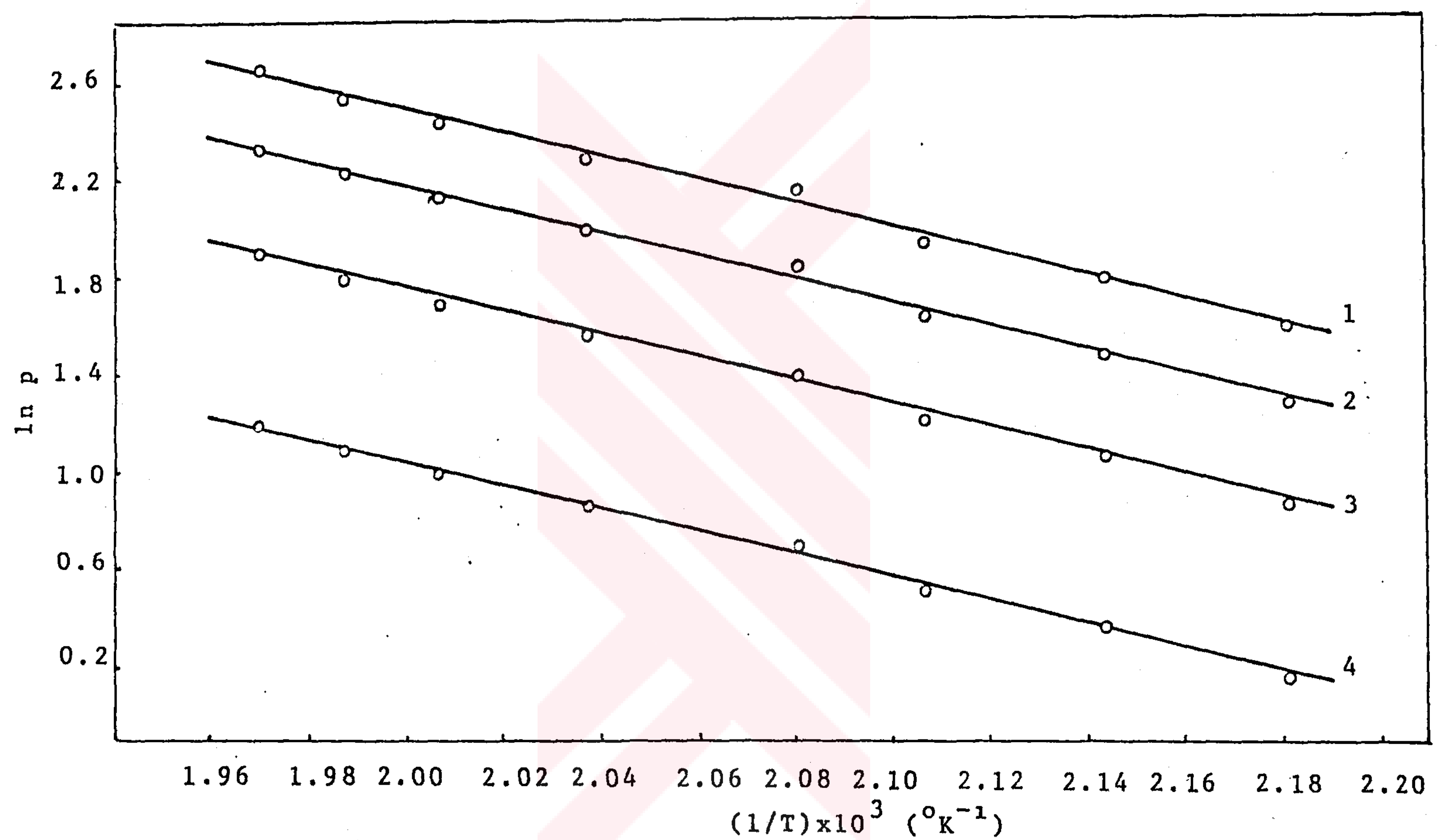

FIGURE 4.14 Adsorption Isosteres of n-Heptane at 0.2 µl with Helium

1. At 20×10^7 gmol/g cat
2. At 15×10^7 gmol/g cat
3. At 10×10^7 gmol/g cat
4. At 5×10^7 gmol/g cat

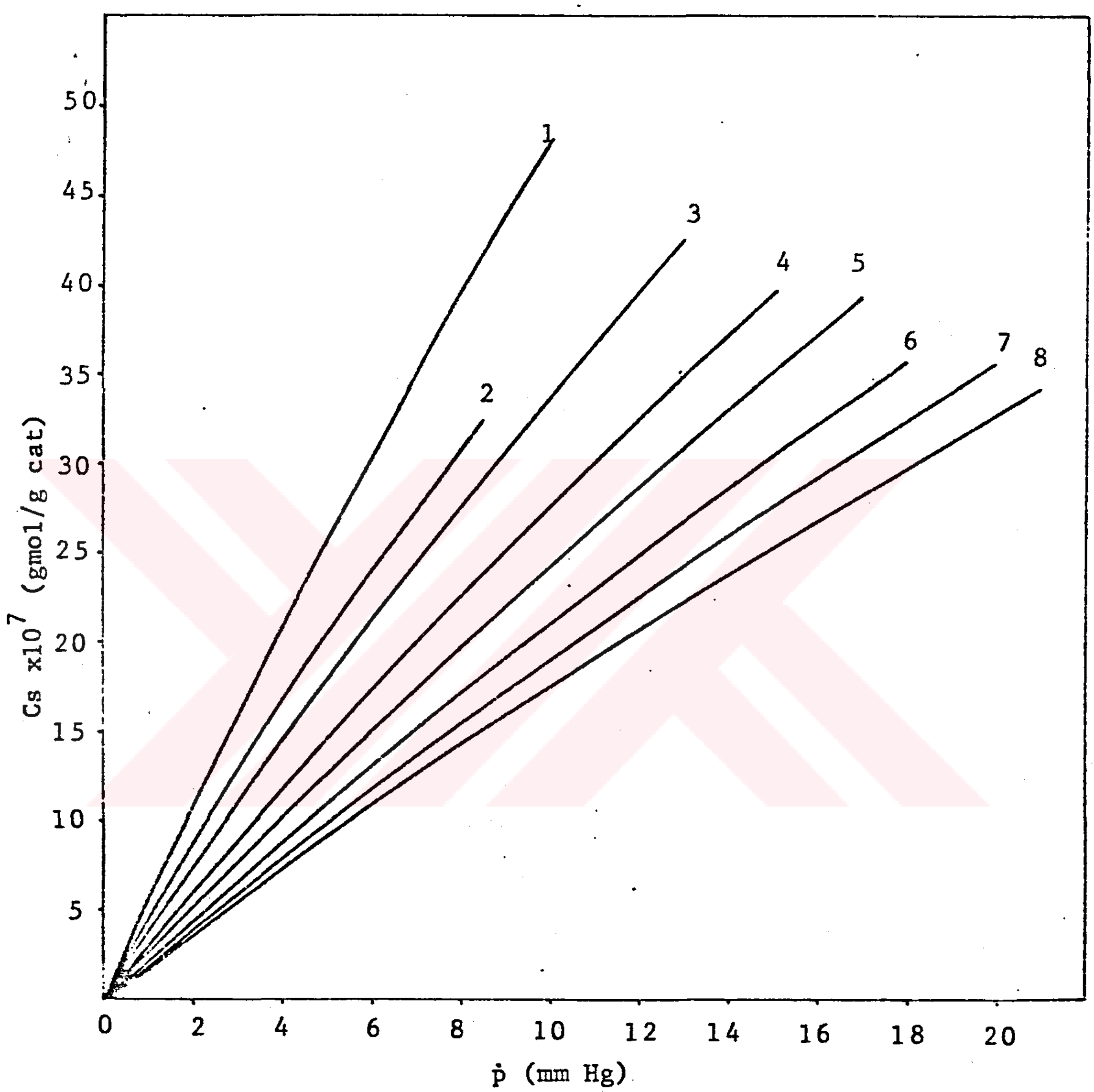

FIGURE 4.15 Adsorption Isotherms of n-Heptane at 0.4 μl with Helium

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 Isosteres for n-Heptane at 0.4 μl with He

Cs (gmol/g cat)		5×10^{-7}		10×10^{-7}		15×10^{-7}		20×10^{-7}	
T_c (°C)	$10^3/T_c$ (°K^{-1})	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

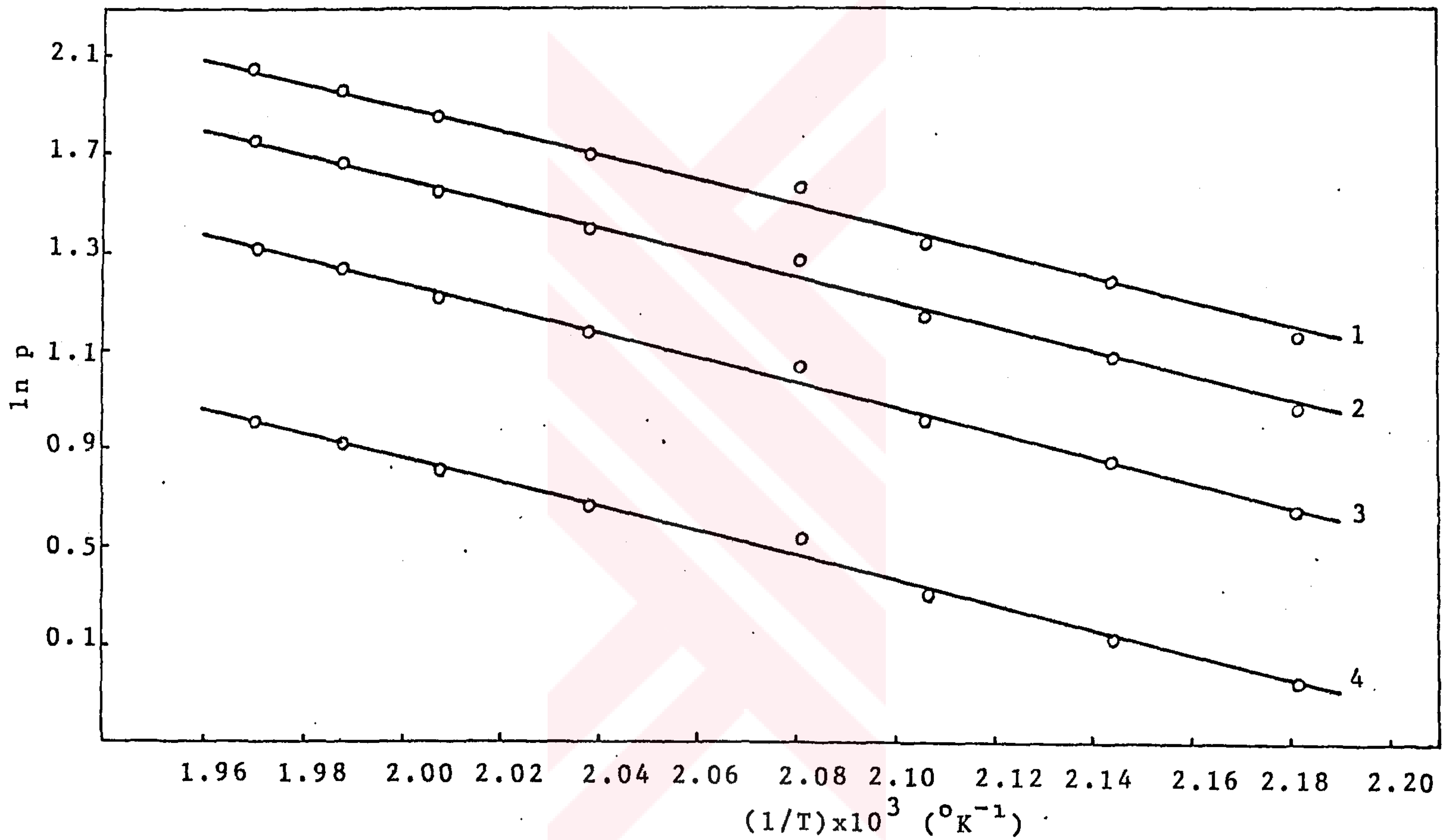

FIGURE 4.16 Adsorption Isosteres of n-Heptane at 0.4 μl with Helium

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

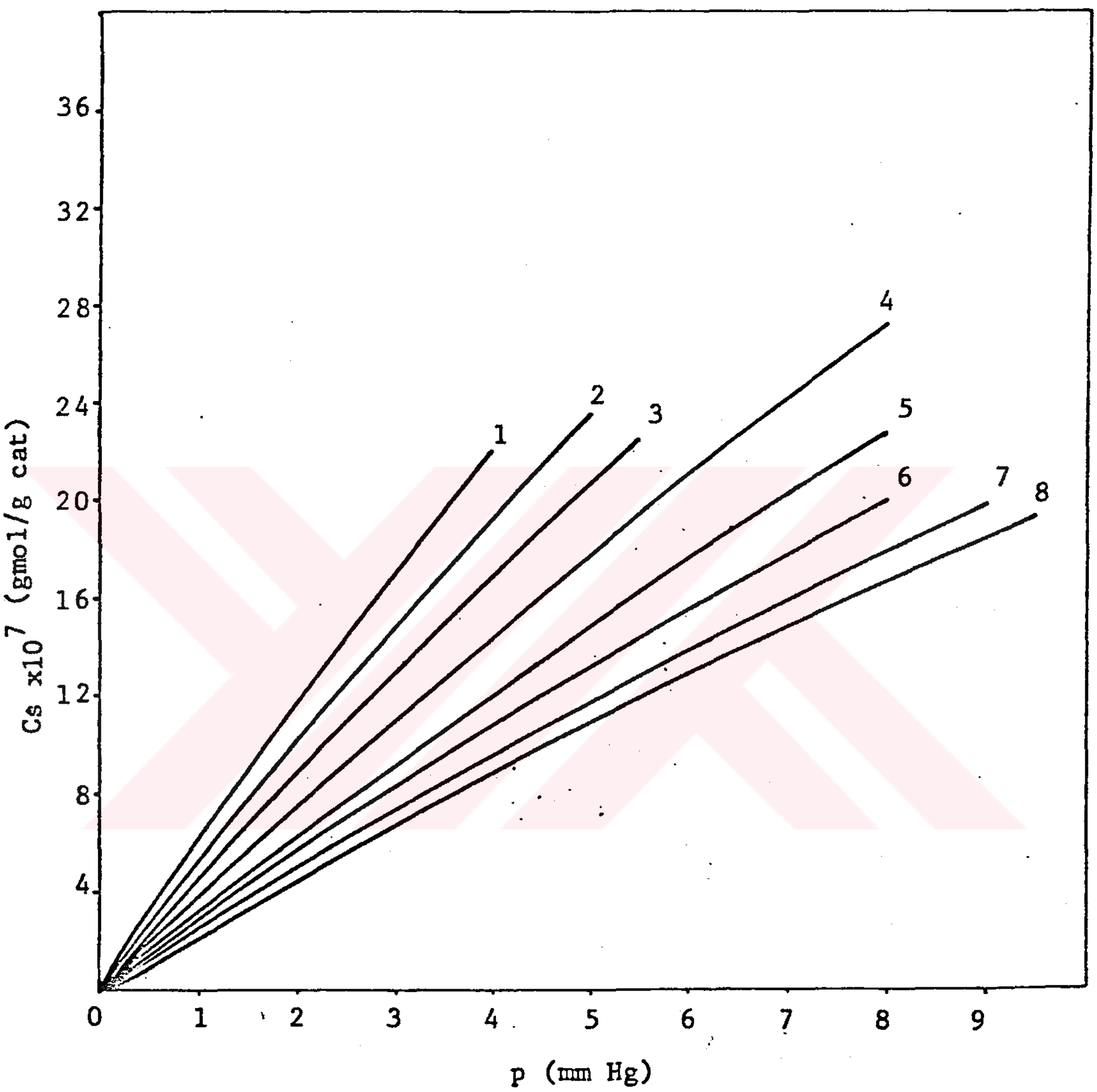

FIGURE 4.17 Adsorption Isotherms of i-Octane at 0.2 μl with Helium

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

TABLE 4.13 Adsorption Isosteres for i-Octane at 0.2 μl with He

Cs (gmol/g cat)		5×10^{7}		10×10^{7}		15×10^{7}		20×10^{7}	
T_s (°C)	$10^3/T_s$ (°K^{-1})	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

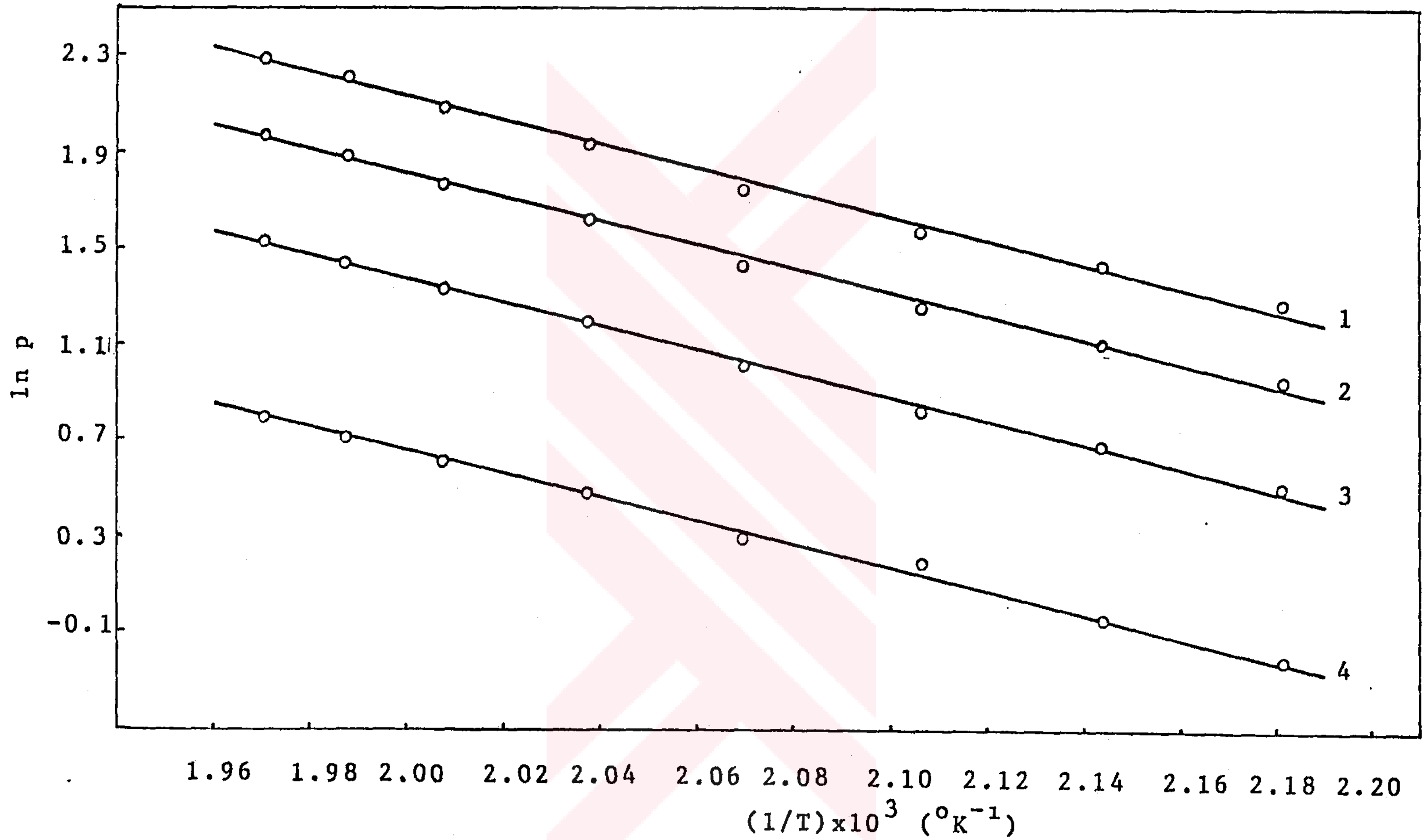

FIGURE 4.18 Adsorption Isosteres of i-Octane at 0.2 µl with Helium

1. At 20 $\times 10^{7}$ gmol/g cat
2. At 15×10^{7} gmol/g cat
3. At 10×10^{7} gmol/g cat
4. At 5×10^{7} gmol/g cat

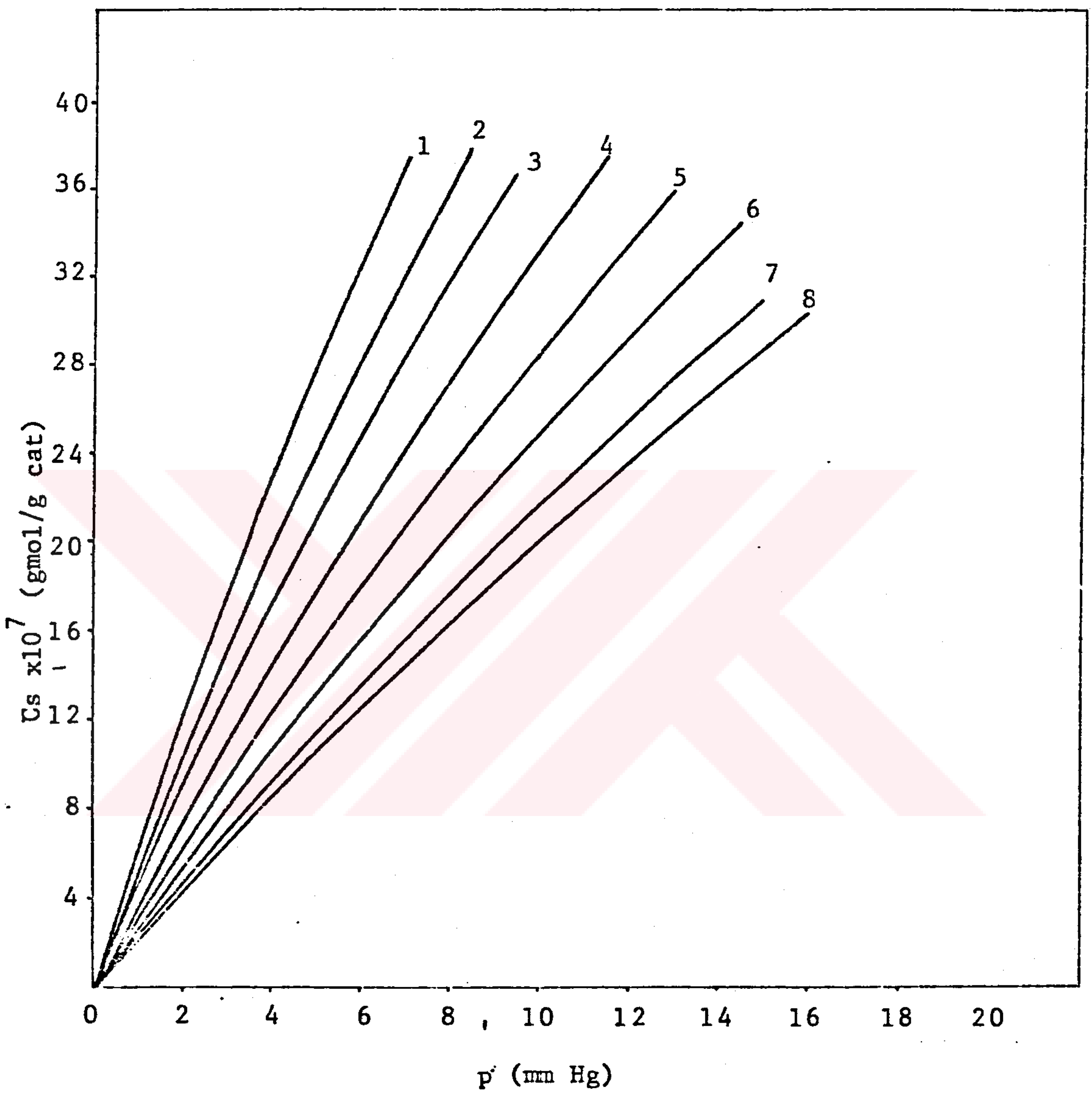

FIGURE 4.19 Adsorption Isotherms of i-Octane at 0.4 µl with Helium

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

TABLE 4.14 Adsorption Isosteres for i-Octane at 0.4 μl with He

Cs (gmol/g cat)		5×10^{-7}		10×10^{-7}		15×10^{-7}		20×10^{-7}	
T_c(°C)	$10^3/T_c$(°K^{-1})	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

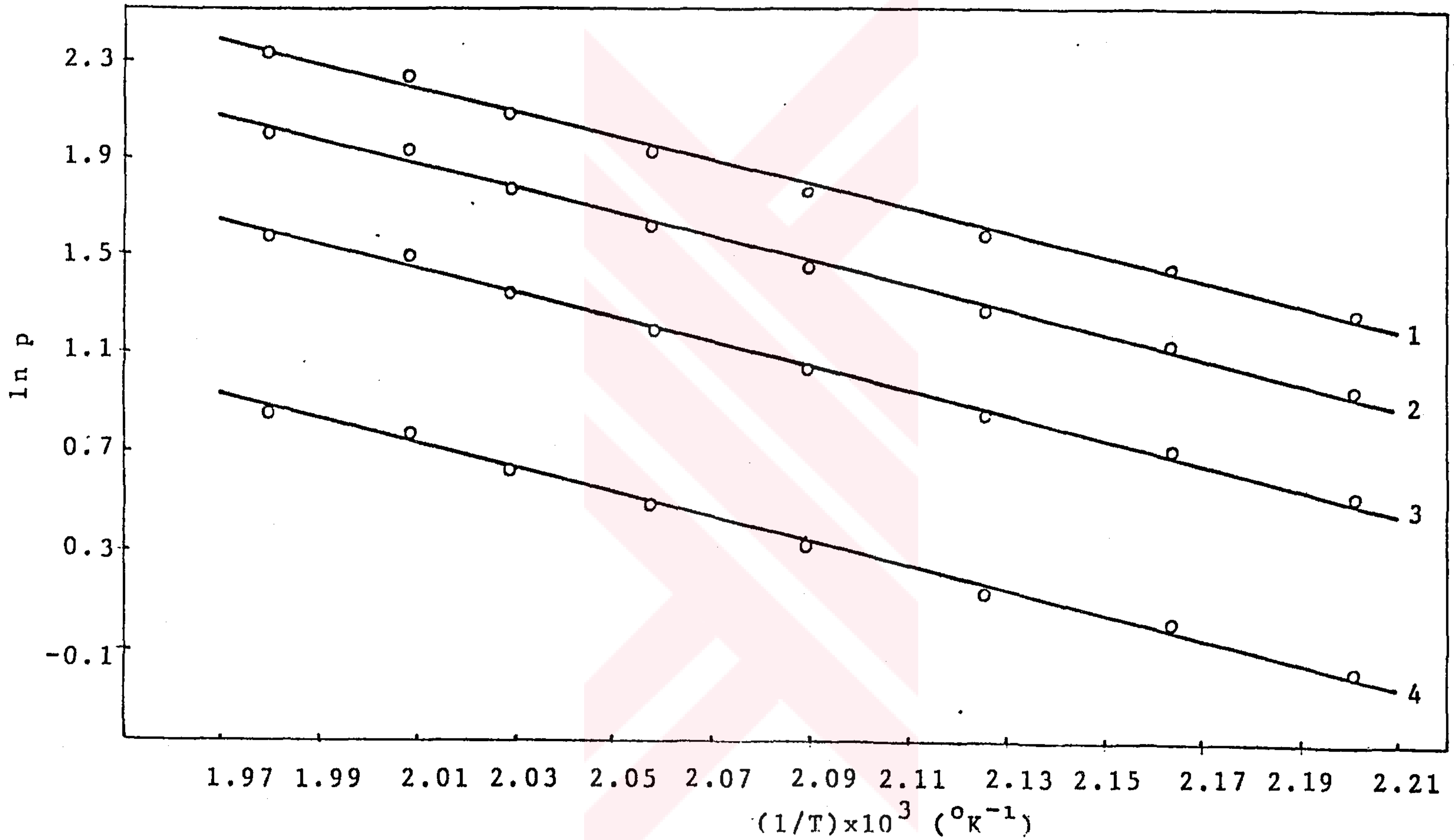

FIGURE 4.20 Adsorption Isosteres of i-Octane at 0.4 μl with Helium

1. At 20×10^{7} gmol/g cat
2. At 15×10^{7} gmol/g cat
3. At 10×10^{7} gmol/g cat
4. At 5×10^{7} gmol/g cat

TABLE 4.15 Heats of Adsorption of Hydrocarbons

Compound	Temperature Range (°C)	Csx10^7 gmol/gcat)	Q_{ads} (kJ/gmol)
n-Pentane		5	22.3(±3.9)*
(0.4 µl and H_2)	187.39-234.94	10	22.6(±3.3)*
		15	23.3(±3.4)*
		20	27.2(±4.6)*
n-Pentane		5	25.4(±2.3)*
(0.4 µl and He)	186.17-235.25	10	27.3(±2.5)*
		15	29.7(±2.7)*
		20	32.0(±3.0)*
n-Pentane		5	27.4(±2.6)*
(0.8 µl and He)	185. 71-235.31	10	28.7(±3.6)*
		15	30.0(±3.0)*
		20	31.5(±2.9)*
n-Hexane		5	34.5(±0.7)*
(0.4 µl and H_2)	187.39-234.98	10	35.9(±0.8)*
		15	37.3(±1.0)*
		20	38.9(±1.3)*
n-Hexane		5	35.5(±1.5)*
(0.4 µl and He)	186.05-235.3	10	36.1(±1.4)*
		15	36.7(±1.3)*
		20	37.4(±1.3)*
n-Hexane		5	36.1(±1.1)*
(0.8 µl and He)	185.81-235.21	10	36.7(±1.0)*
		15	37.2(±1.0)*
		20	37.7(±1.4)*
n-Heptane		5	40.3(±0.9)*
(0.2 µl and He)	185.24-234.29	10	40.5(±1.0)*
		15	40.8(±1.1)*
		20	41.1(±1.2)*
n-Heptane		5	42.1(±1.4)*
(0.4 µl and He)	185.24-234.31	10	42.2(±1.4)*
		15	42.3(±1.4)*
		20	41.2(±1.6)*
i-Octane		5	40.3(±0.9)*
(0.2 µl and He)	185.25-234.26	10	40.5(±1.0)*
		15	40.6(±1.0)*
		20	40.8(±1.2)*
i-Octane		5	41.3(±1.3)*
(0.4 µl and He)	185.27-234.34	10	41.6(±1.3)*
		15	41.6(±1.3)*
		20	41.7(±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 (0.4 µl and H_2)	187.39-234.94	5.7	23.8
n-Pentane (0.4 µl and He)	186.17-235.25	6.8	28.6
n-Pentane (0.8 µl and He)	185.71-235.31	7.0	29.4
n-Hexane (0.4 µl and H_2)	187.39-234.98	8.8	36.7
n-Hexane (0.4 µl and He)	186.05-235.31	8.7	36.4
n-Hexane (0.8 µl and He)	185.81-235.21	8.8	36.9
n-Heptane (0.2 µl and He)	185.24-234.29	9.7	40.7
n-Heptane (0.4 µl and He)	185.24-234.31	10.0	42.0
i-Octane (0.2 µl and He)	185.25-234.26	9.7	40.6
i-Octane (0.4 µl 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 μl and 0.4 μl, but for n-heptane and i-octane,the sample size of 0.8 μl caused peak tailing. Sample sizes of 0.4 μl and 0.2 μl 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 μl). 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 μl 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 diffucult 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 μl in Table 4.17. The heats of vaporization were extrapolated to the operating temperatures by Watson Equation (Reid, Prausnitz and Sherwood, 1977):

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

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 ΔH_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_2O_3 (Choudhary and Menon, 1976) and on the same 0.3 %wt Pt/Al_2O_3 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 Comperision of Heats of Adsorption and Heats of Condensation

Compound	T_b (°C)	$-\Delta H_v$ at T_b (kJ/gmol)	T (°C)	$-\Delta H_v$ at T (kJ/gmol)	Temperature Range (°C)	Q_{ads} (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.

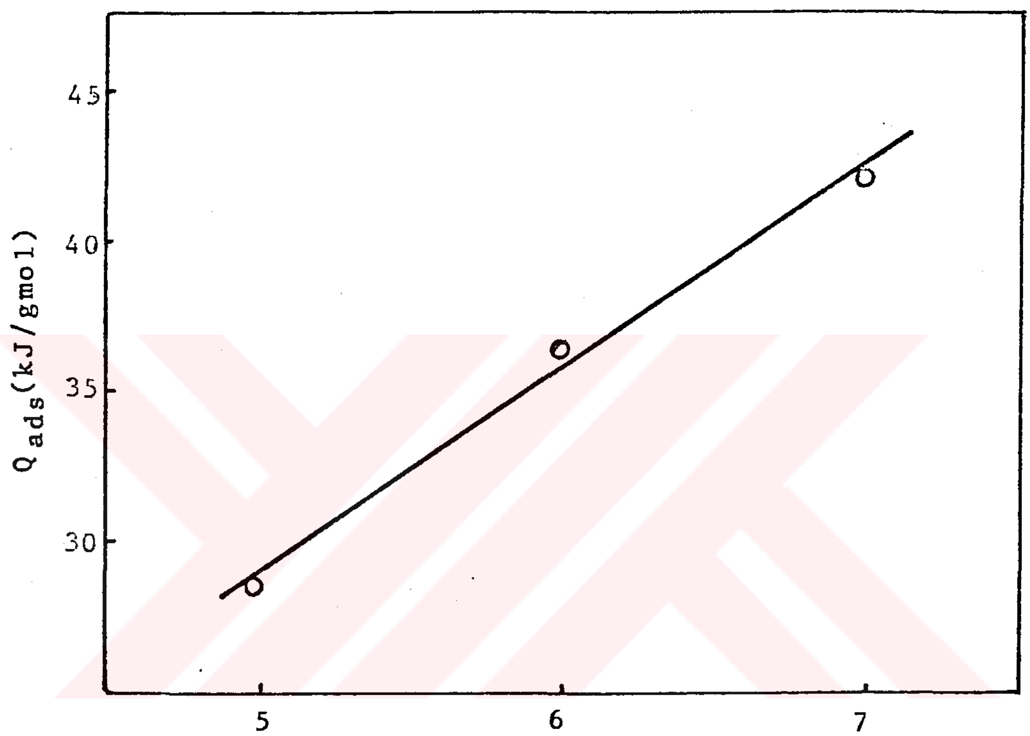

FIGURE 4.21 Relation Between Heats of Adsorption and Carbon Number

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 Gönenç (1985) who has used the present technique yields a similar result for cycloparaffins and aromatics. The results obtained in diferent studies are summarized in Table 4.18.

TABLE 4.18 Comparison of Heats of Adsorption on Pt/Al_2O_3

Compound	Q_{ads} (kcal/gmol)				
	Present Study *	Gönenç (1985) **	Beler (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	-
Methylcyclo-hexane	-	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_2O_3 and in the range of 187-235 °C

*** on 0.3 wt % Pt/Al_2O_3 and in the range of 185-235 °C

**** on 0.3 wt % Pt/Al_2O_3 and in the range of 195-240 °C

***** on 0.6 wt % Pt/Al_2O_3 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 µl 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 the chromatograph.

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APPENDIX I

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

T_c (°C)	T_f (°C)	F_f (cm^3/sec)	P_i (mmHg)	P_o (mmHg)	V (µl)	t_M (sec)	A_p (mm^2)	v (mm/sec)	Carrier Gas
187.39	18.9	0.1842	1357.0	755.0	0.4	26.1	6761.67	3.33	H_2
193.37	21.6	0.1792	1359.0	757.0	0.4	17.7	6538.33	3.33	H_2
204.95	23.5	0.1838	1394.5	752.5	0.4	17.7	6666.67	3.33	H_2
210.75	24.7	0.1712	1419.0	755.0	0.4	17.6	7051.00	3.33	H_2
226.91	19.8	0.1786	1426.9	758.9	0.4	17.4	6140.00	3.33	H_2
234.94	19.3	0.1723	1402.0	758.0	0.4	16.6	3408.33	3.33	H_2
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_c (°C)	T_f (°C)	F_f (cm^3/sec)	P_i (mmHg)	P_o (mmHg)	V (µl)	t_M (sec)	A_p (mm^2)	v (mm/sec)	Carrier Gas
187.39	18.90	0.1789	1357.0	755.0	0.4	18.6	5593.00	3.33	H_2
204.99	23.60	0.1887	1394.2	752.2	0.4	17.4	6228.00	3.33	H_2
210.73	24.50	0.1667	1419.0	755.0	0.4	19.8	7352.00	3.33	H_2
226.97	19.90	0.1818	1426.9	758.9	0.4	18.0	7260.00	3.33	H_2
234.98	19.30	0.1650	1402.0	758.0	0.4	18.6	3533.00	3.33	H_2
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 (°C)	T_f (°C)	F_f (cm^3/sec)	P_i (mmHg)	P_o (mmHg)	V (μl)	t_M (sec)	A_p (mm^2)	v (mm/sec)	Carrier 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 (°C)	T_f (°C)	F_f (cm^3/sec)	P_i (mmHg)	P_o (mmHg)	V (μl)	t_M (sec)	A_p (mm^2)	v (mm/sec)	Carrier 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 µl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_R (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_R (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_R (sec)	Vg (cm^3)	$(Vg/RT_R)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_R (sec)	Vg (cm^3)	$(Vg/RT_R)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Hydrogen

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c) \times 10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c) \times 10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_r (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_r (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_r (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_r (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_r (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_r (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_R (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_R (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_R (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 μl with Helium

t_R (sec)	Vg (cm^3)	$(Vg/RT_c)x10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 µl with Helium

t_c (sec)	Vg (cm^3)	$(Vg/RT_c)\times10^7$ (gmol/g mmHg)	c(t) (mm)	p (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 p(mm Hg)	T (°C)	187.39	197.37	210.74	226.91	234.94
	(Moles of n-Pentane Adsorbed per gram of Catalyst)x10^7					
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 µl

Partial Pressure p(mm Hg)	T (°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)x10^7								
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 p(mm Hg)	T (°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)x10^7								
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 μl

Partial Pressure p(mm Hg)	T (°C) 187.39	204.99	210.73	226.97	234.98
	(Moles of n-Hexane Adsorbed per gram of Catalyst)x10⁷				
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 p(mm Hg)	T (°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)x10^7							
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 p(mm Hg)	T (°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)x10^{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 p(mm Hg)	T (°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)x10^7							
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 p(mm Hg)	T (°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)x10[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 µl

Partial Pressure p(mm Hg)	T (°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)x10^7								
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 μl

Partial Pressure p(mm Hg)	T (°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)x10^7								
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
   11 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))
  111 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
```

APPENDIX VI

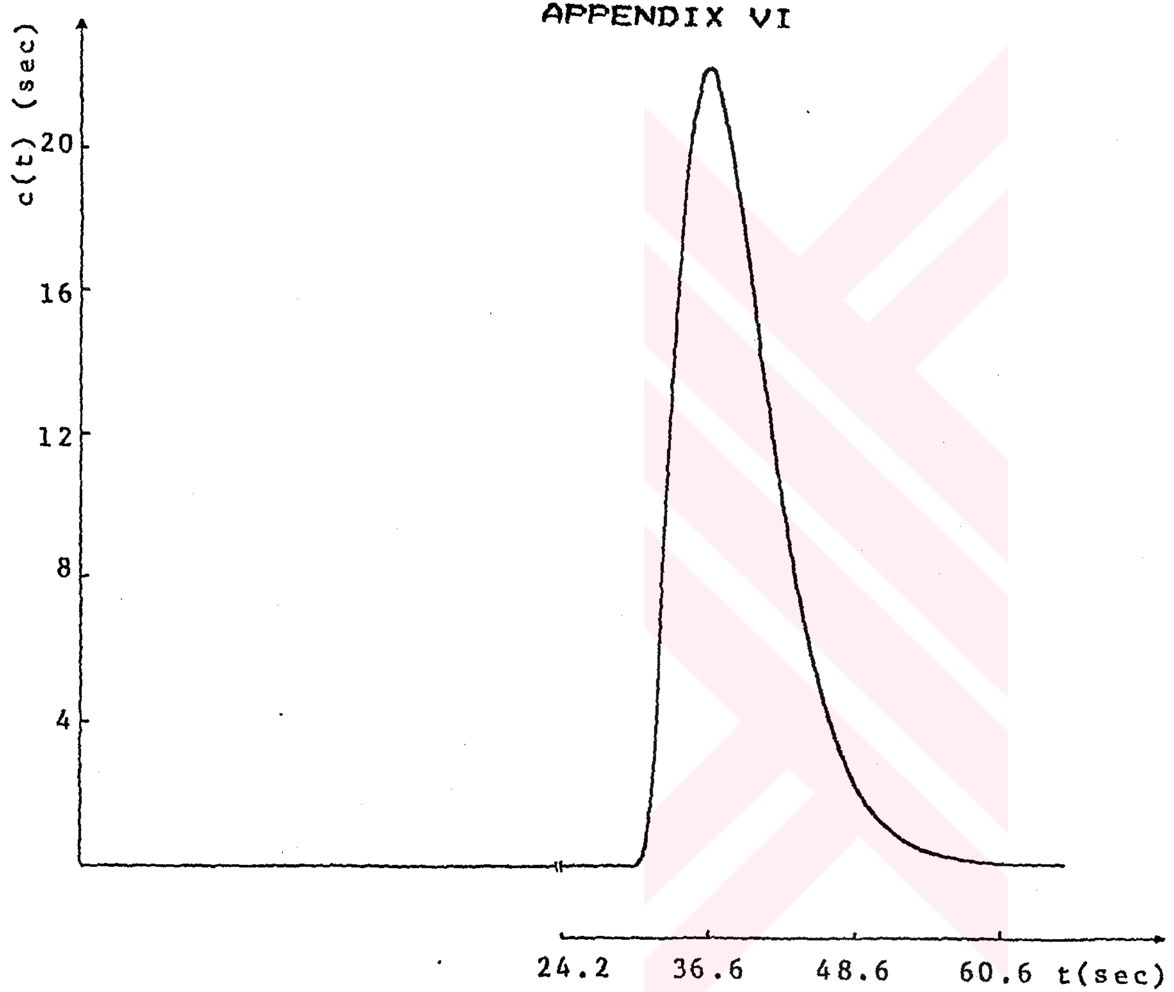

FIGURE A.6.1 Sample Chromatogram for n-Pentane at 0.4 μl with H_2
T=210.75°C Attenuation=32 Chart Speed=20 cm/min

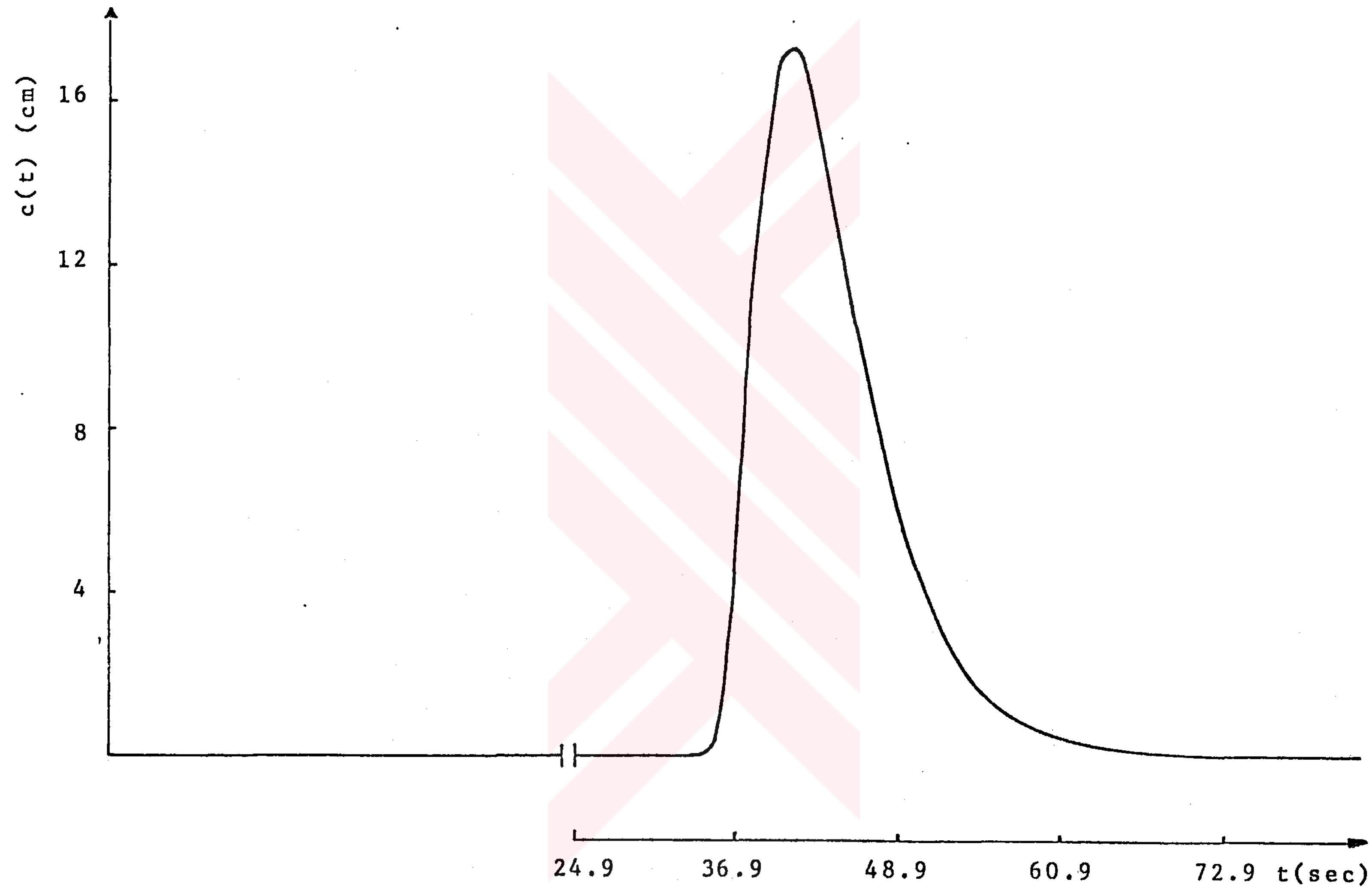

FIGURE A.6.2 Sample Chromatogram for n-Pentane at 0.4 μl with He
T=218.18°C Attenuation=64 Chart Speed=20 cm/min

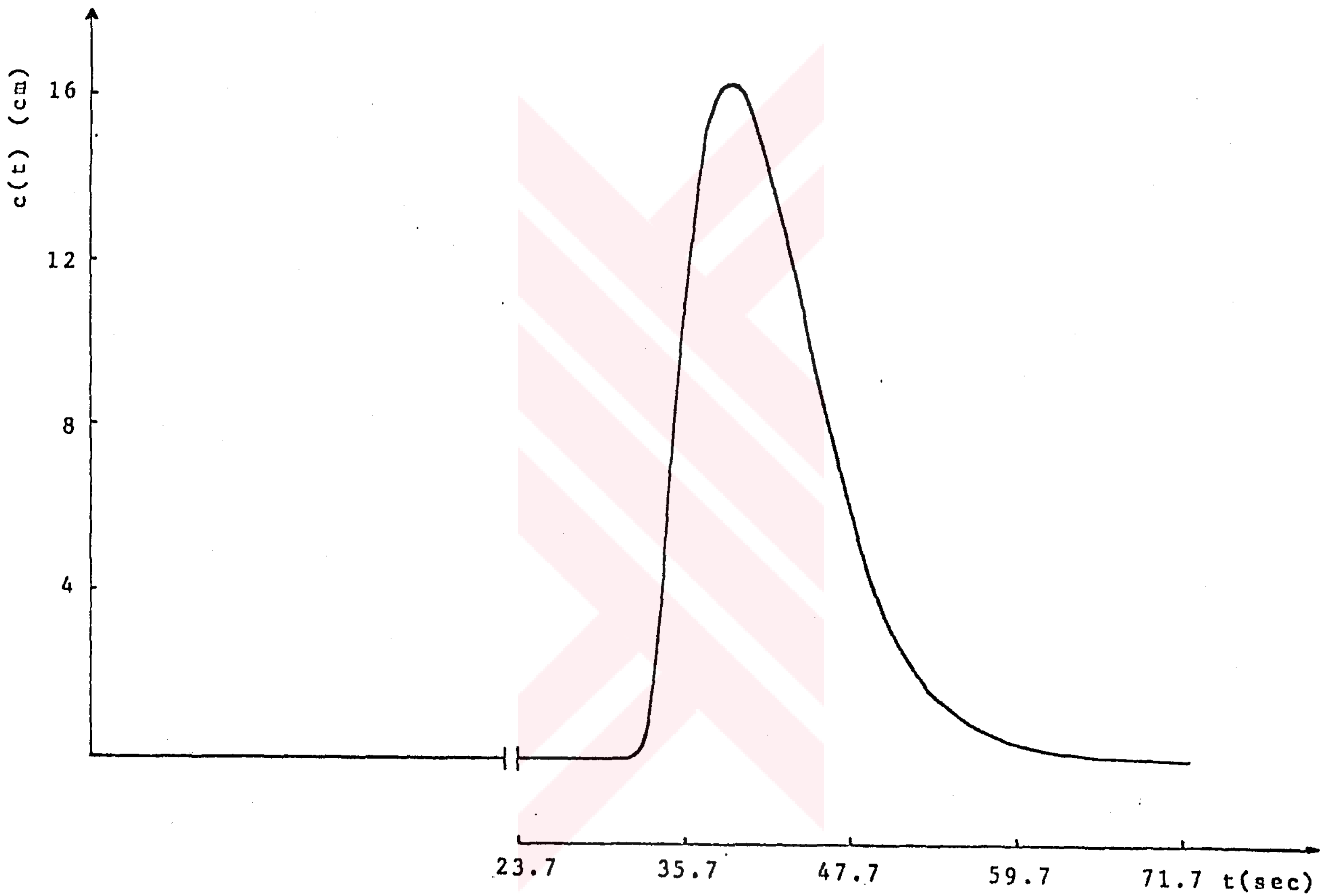

FIGURE A.6.3 Sample Chromatogram for n-Pentane at 0.8 µl with He
T=218.14°C Attenuation=128 Chart Speed=20 cm/min

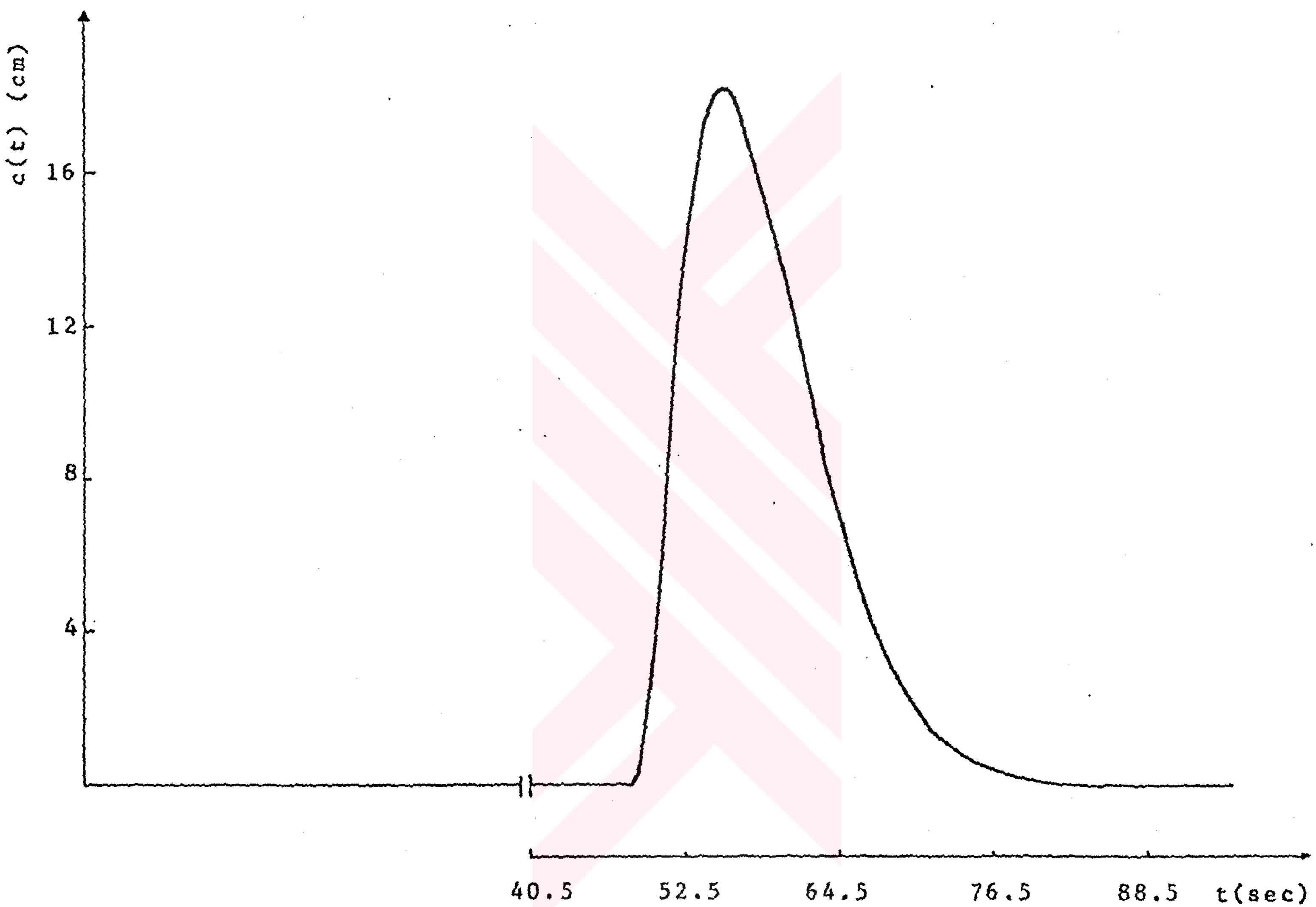

FIGURE A.6.4 Sample Chromatogram for n-Hexane at 0.4 μl with H_2
T=210.73°C Attenuation=32 Chart Speed=20 cm/min

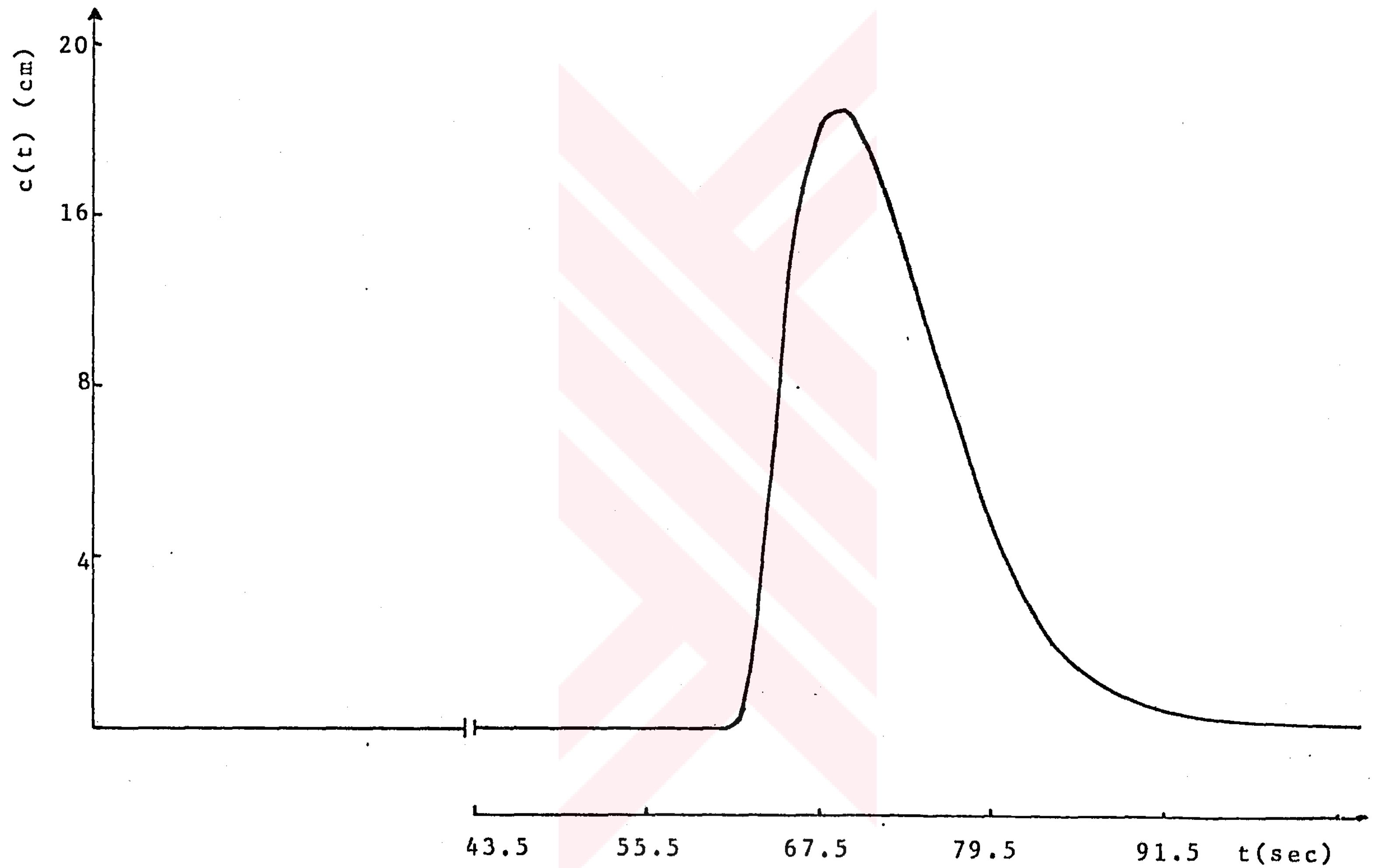

FIGURE A.6.5 Sample Chromatogram for n-Hexane at 0.4 µl with He
T=211.11°C Attenuation=32 Chart Speed=20 cm/min

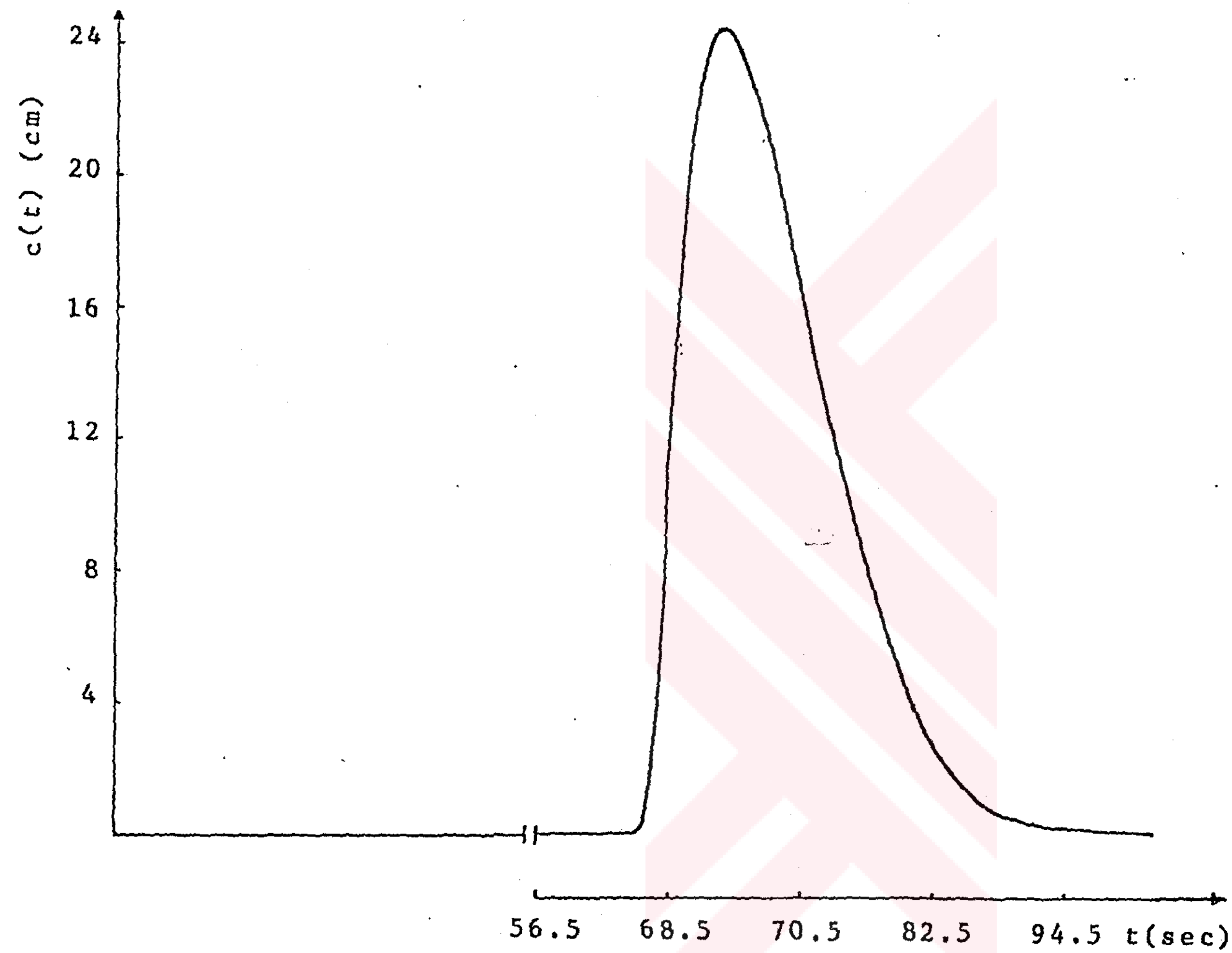

FIGURE A.6.6 Sample Chromatogram for n-Hexanee at 0.8 μl with He
T=211.07°C Attenuation=64 Chart Speed=20 cm/min

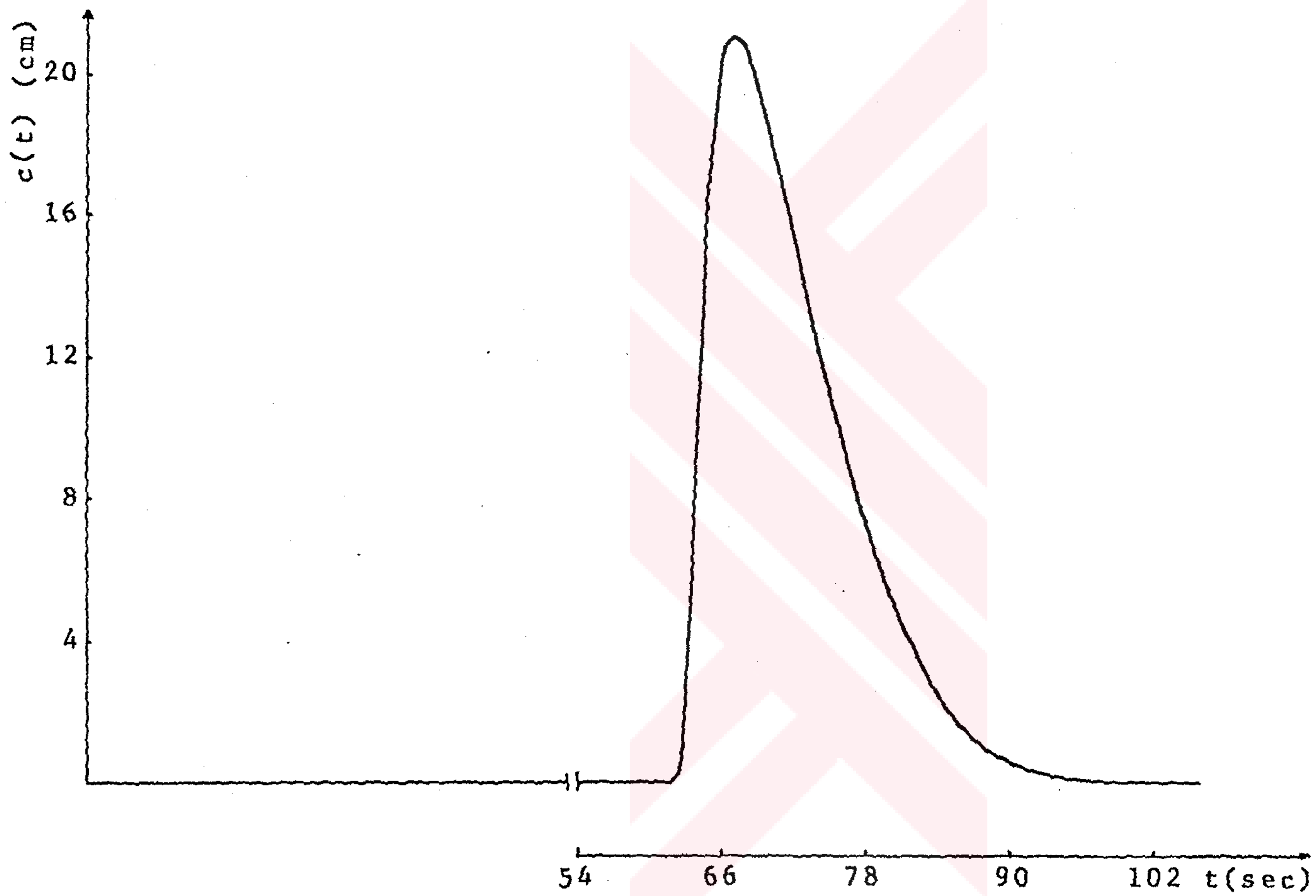

FIGURE A.6.7 Sample Chromatogram for n-Heptane at 0.2 μl with He
T=207.39°C Attenuation=32 Chart Speed=20 cm/min

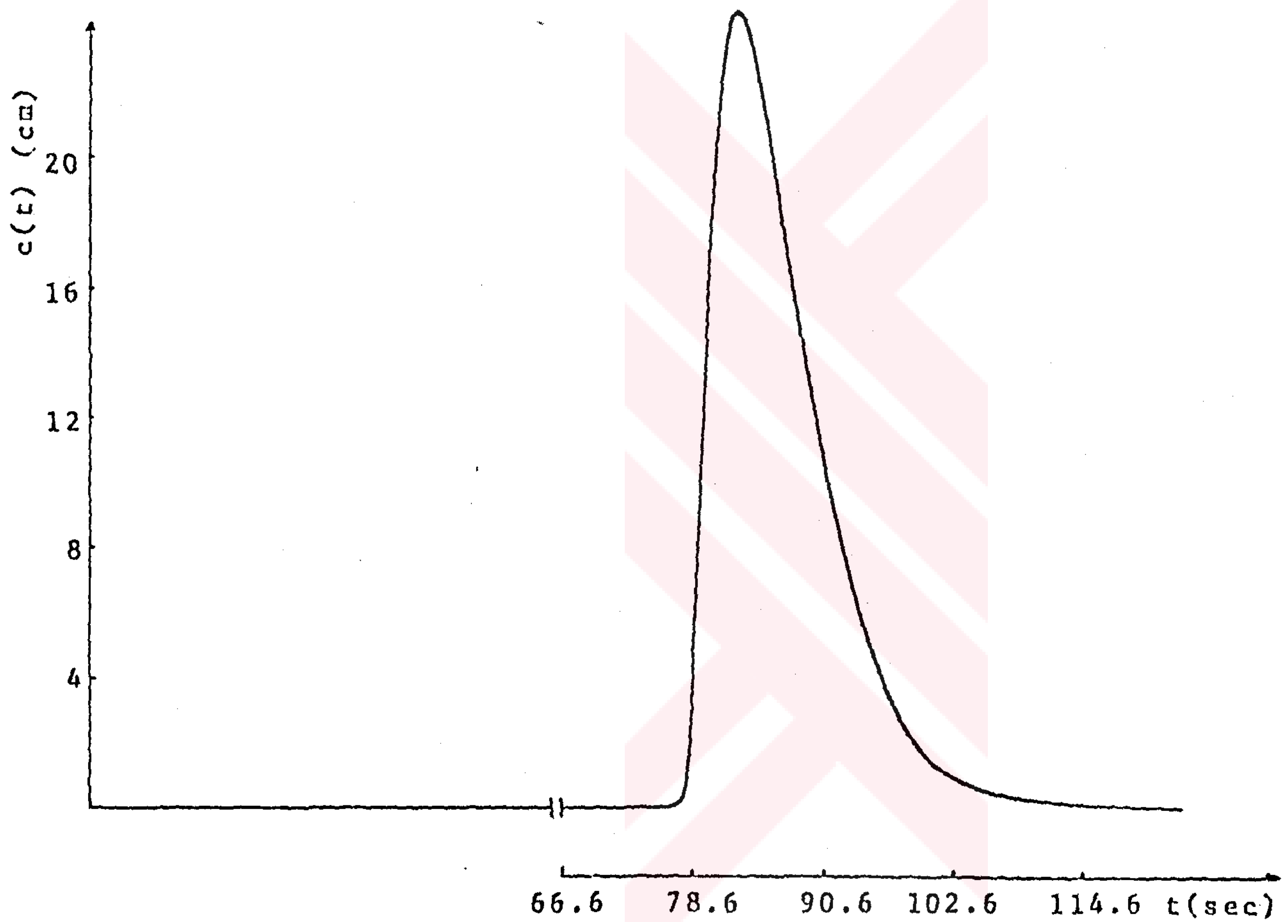

FIGURE A.6.8 Sample Chromatogram for n-Heptane at 0.4 µl with He
T=207.40°C Attenuation=16 Chart Speed=20 cm/min

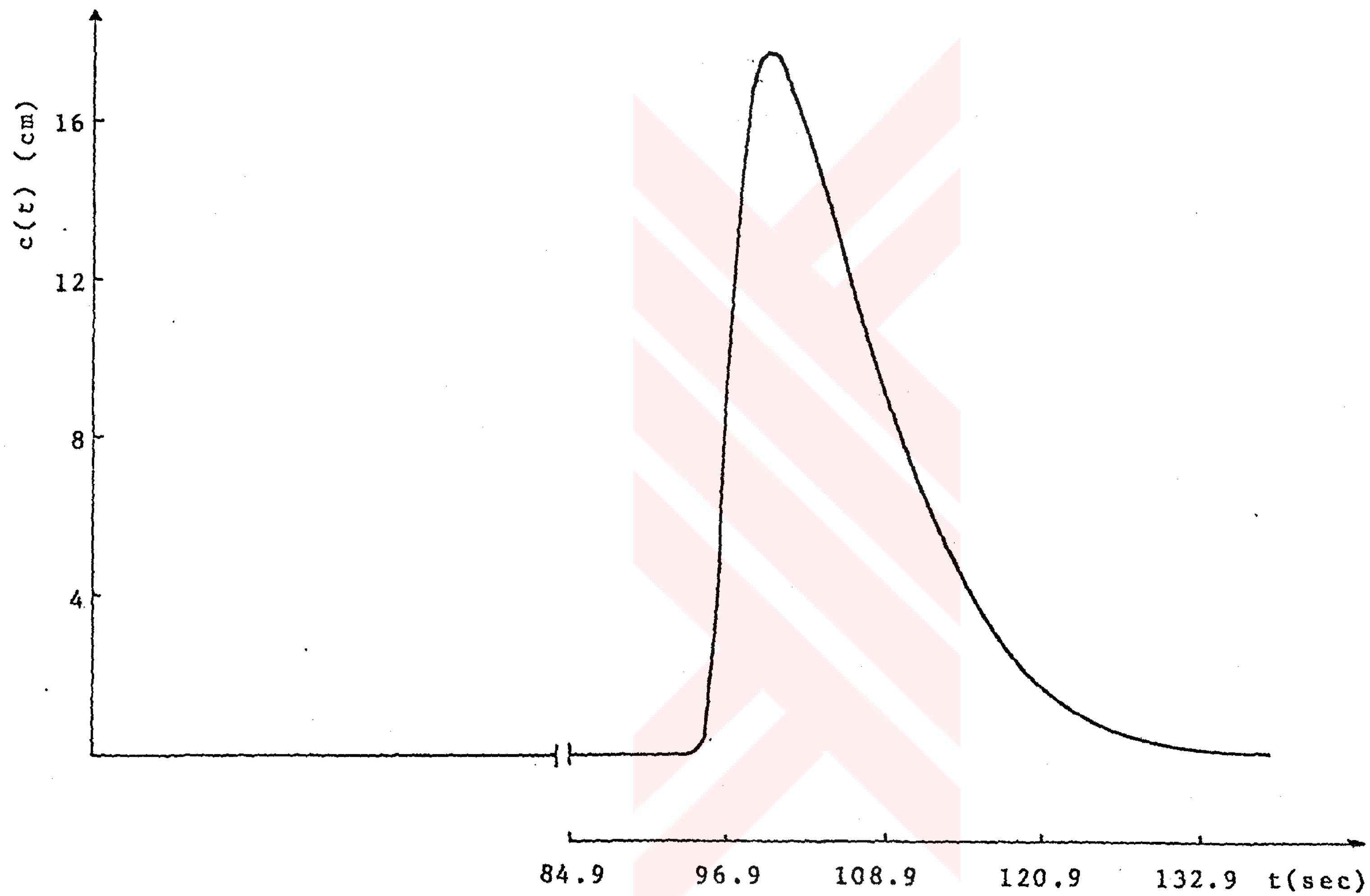

FIGURE A.6.9 Sample Chromatogram for i-Octane at 0.2 μl with He
T=209.91°C Attenuation=16 Chart Speed=20 cm/min

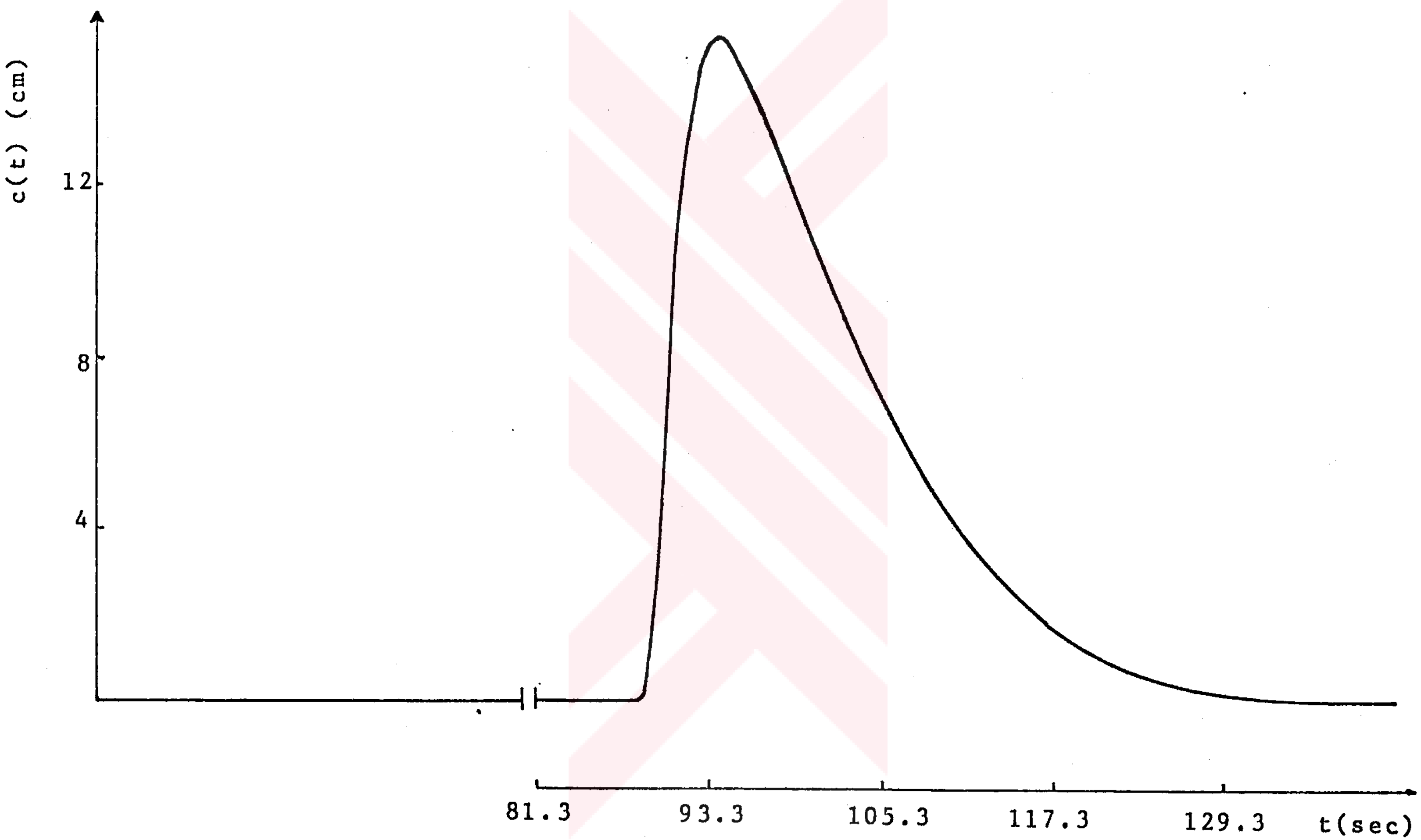

FIGURE A.6.10 Sample Chromatogram for i-Octane at 0.4 μl with He
T=209.99°C Attenuation=32 Chart Speed=20 cm/min