PROBLEMS

Problem 6-1

The rate at which a substance passes through a semi-permeable membrane is determined by the diffusivity D,(cm^2/s) of the gas. D varies with the temperature $T(K)$ according to the following law:

$$D = D_0 \exp(-E/RT)$$

where D_0 is the pre-exponential factor, E is the activation energy for diffusion, and R = 1.987 cal/mol K. Diffusivities of SO_2 in a certain membrane are measured at several temperatures with the data listed in Table P6.1. Determine the values of D_0 and E.

Table P6.1: Data for Problem 6-1

$T(K)$	347	374.2	396.2	420.7	447.7	471.2
$D(cm^2/s)\times 10^6$	1.34	2.5	4.55	8.52	14.07	19.99

Problem 6-2

According to Stafen-Boltzman law, the total energy radiated per second, (Q_R), from a hot object varies as the absolute temperature to the fourth power

$$Q_R = \sigma (T^4 - T_0^4)$$

where T_0 is the room temperature in (K) and σ is called the Stafen-Boltzman constant. From the data below (Table P6-2) determine the value for σ.

Table P6.2: Data for Problem 6-2

T(K)	300	350	400	450	500	550
R	40	430	1050	1920	3150	4750

Problem 6-3

Using the thermodynamic data below (Table P6-3) determine the values of the constants A,B, C of the virial equation of state

$$\frac{PV}{RT} = A + \frac{B}{V} + \frac{C}{V^2}$$

Table P6-3: Data for Problem 6-3

T(^oF)	130	160	190	220	250
P (psia)			V (ft^3/lbmol)		
250	0.031	0.03265	0.03499		
500	0.03066	0.03215	0.03421	0.03678	0.04112
1000	0.03009	0.03139	0.03300	0.03484	0.03730
1500	0.02966	0.03079	0.03212	0.03370	0.03529

Problem 6-4

The specific heat data vs. temperature for carbon dioxide is shown below in Table P6-4. It is required to fit this data to a polynomial equation of order 4:

$$c_p(T) = a + bT + cT^2 + dT^4$$

Table P6-4: data for Problem 6-4

T (^oC)	cp (J/kg.K)
170	1101
225	1110
275	1123
330	1136
390	1153
445	1170
500	1185
555	1200
610	1216
670	1230
725	1243
775	1256

Problem 6-5

The reactions of ozone (A) were studied in the presence of cis-2butene (B). The reaction was carried out isothermally at 297°K. Determine the values of the rate law constant ($kC_A^{\alpha}C_B^{\beta}$) using the data in Table P6-5.

Table P6.5: Data for Problem 6-5

Run	Ozone rate (mol/scm^3)$\times 10^7$	C_A	C_B
1	1.5	0.01	10^{-12}
2	3.2	0.02	10^{-11}
3	3.5	0.015	10^{-10}
4	5.0	0.005	10^{-9}
5	8.8	0.001	10^{-8}
6	4.7	0.018	10^{-9}

Problem 6-6

Using the data below (Table P6-6), determine the reaction-rate law parameters (k_0, E, n):

$$r = k_0\, e^{-E/RT}\, C_A^{\,n}$$

Table P6-6: Data for Problem 6-6

Run	Rate (mol/s cm^3)	C_A (mol/cm^3)	T (K)
1	4.90×10^{-4}	0.2	700
2	1.10×10^{-4}	0.02	750
3	2.40×10^{-4}	0.05	800
4	2.20×10^{-4}	0.08	850
5	1.18×10^{-4}	0.1	900
6	1.82×10^{-4}	0.06	950

Problem 6.7

Table (P6.7) gives the observed values of the independent variables (x) and the function (y) over six lab experiments. It is supposed that (x) and (y) may be correlated by the 2nd order polynomial

$$y = a_1 + a_2\, x + a_3\, x^2$$

You are requested to calculate the optimum values of a_1, a_2 and a_3 using the least square approximation technique.

Table P6,7: Data for Problem 6.7

x	1	2	3	4	5	6
y	10	21	38	61	90	125

Problem 6.8

The experimental data tabulated below (Table P6.8) are suggested to be correlated by the equation,

$$y = A\,e^{Bx}$$

Determine the optimum values of A and B using the least square technique

Table P6.8: data for Problem 6.8

x	0.1	0.2	0.3	0.4	0.5	0.6
y	1.82212	2.01375	2.22554	2.4596	2.71828	3.0047

Problem 6.9

In modeling the effect of an impurity on crystal growth, the following equation is obtained:

$$\frac{G - G_L}{G_o - G} = \frac{1}{K_L C^m}$$

where C is impurity concentration, G_L is a limiting growth rate, G_0 is the growth rate of the crystal with no impurity present, and K_L and M are model parameters.

In a particular experiment, $G_0 = 3\times10^{-3}$ mm/min and $G_L = 1.8\times10^{-3}$ mm/min. Growth rates are measured for several impurity concentrations C (ppm), with the following result

Table P6.9: Data for Problem 6.9

C (ppm)	50.0	75.0	100.0	125.0	150.0
G (mm/min)$\times10^3$	2.50	2.20	2.04	1.95	1.90

Determine K_L and m.

Problem 6.10

Data for the viscosity of molten solid as a function of temperature are given below (Table P6.10). Use the following data to determine the coefficient *A*, and *B* of the equation:

$$\mu = Ae^{B/T}$$

Table P6.10: Data for Problem 6.10

T (^{o}C)	200	300	430	550
μ (Pa.s)$\times 10^4$	5.4	4.5	3.9	3.4