

Data Analysis (DAS)

CHEM445 – 025L

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RESULTS AND DISCUSSION

Table 1a: Vapor Pressure of 2-propanol from First Experiment

t (°C)	T (K)	$\frac{1}{T}$ (K⁻¹)	P (Torr)	log(P)	ln(P)
25.0	298.2	0.003354	44.4	-1.233	-2.840
26.7	299.9	0.003335	48.9	-1.192	-2.744
27.3	300.5	0.003328	50.7	-1.176	-2.707
30.3	303.5	0.003295	60.1	-1.102	-2.537
34.6	307.8	0.003249	76.2	-0.999	-2.300
37.5	310.7	0.003219	91.3	-0.920	-2.119
40.9	314.1	0.003184	109.8	-0.840	-1.935
45.5	318.7	0.003138	138.1	-0.741	-1.705
50.7	323.9	0.003088	182.6	-0.619	-1.426
54.5	327.7	0.003052	222.8	-0.533	-1.227
59.7	332.9	0.003004	284.9	-0.426	-0.981
65.7	338.9	0.002951	373.1	-0.309	-0.711
70.4	343.6	0.002911	461.6	-0.217	-0.499
74.5	347.7	0.002876	553.7	-0.138	-0.317
79.4	352.6	0.002836	675.3	-0.051	-0.118
82.5	355.7	0.002812	750.3	-0.006	-0.013

Table 1b: Vapor Pressure of 2-propanol from Second Experiment

t (°C)	T (K)	$\frac{1}{T}$ (K⁻¹)	P (Torr)	log(P)	ln(P)
25.0	298.2	0.003354	44.3	-1.234	-2.842
27.2	300.4	0.003329	50.1	-1.181	-2.719
28.7	301.9	0.003313	55.1	-1.140	-2.624
30.8	304.0	0.003290	62.1	-1.088	-2.505
35.7	308.9	0.003238	82.4	-0.965	-2.222
39.8	313.0	0.003195	103.5	-0.866	-1.994
46.6	319.8	0.003127	147.7	-0.711	-1.638
50.8	324.0	0.003087	182.4	-0.620	-1.427
55.3	328.5	0.003045	232.2	-0.515	-1.186
60.4	333.6	0.002998	292.9	-0.414	-0.953
65.4	338.6	0.002954	369.0	-0.314	-0.723
69.2	342.4	0.002921	439.1	-0.238	-0.549
74.6	347.8	0.002876	551.4	-0.139	-0.321
79.4	352.6	0.002836	671.2	-0.054	-0.124
81.6	354.8	0.002819	736.8	-0.013	-0.031
82.0	355.2	0.002816	746.4	-0.008	-0.018

Based on Table 1a and 1b, the following data such as T (K), log(P) and ln(P) were obtained based on the following formula listed below. log(P) and ln(P) were dimensionless because the pressure was referenced to the standard pressure in normal room condition, 760 Torr.

$$T(K) = T(^{\circ}C) + 273.15$$

$$\log P = \text{LOG10}\left(\frac{P \text{ Torr}}{760 \text{ Torr}}\right) \text{ function in Excel}$$

$$\ln P = \text{LN}\left(\frac{P \text{ Torr}}{760 \text{ Torr}}\right) \text{ function in Excel}$$

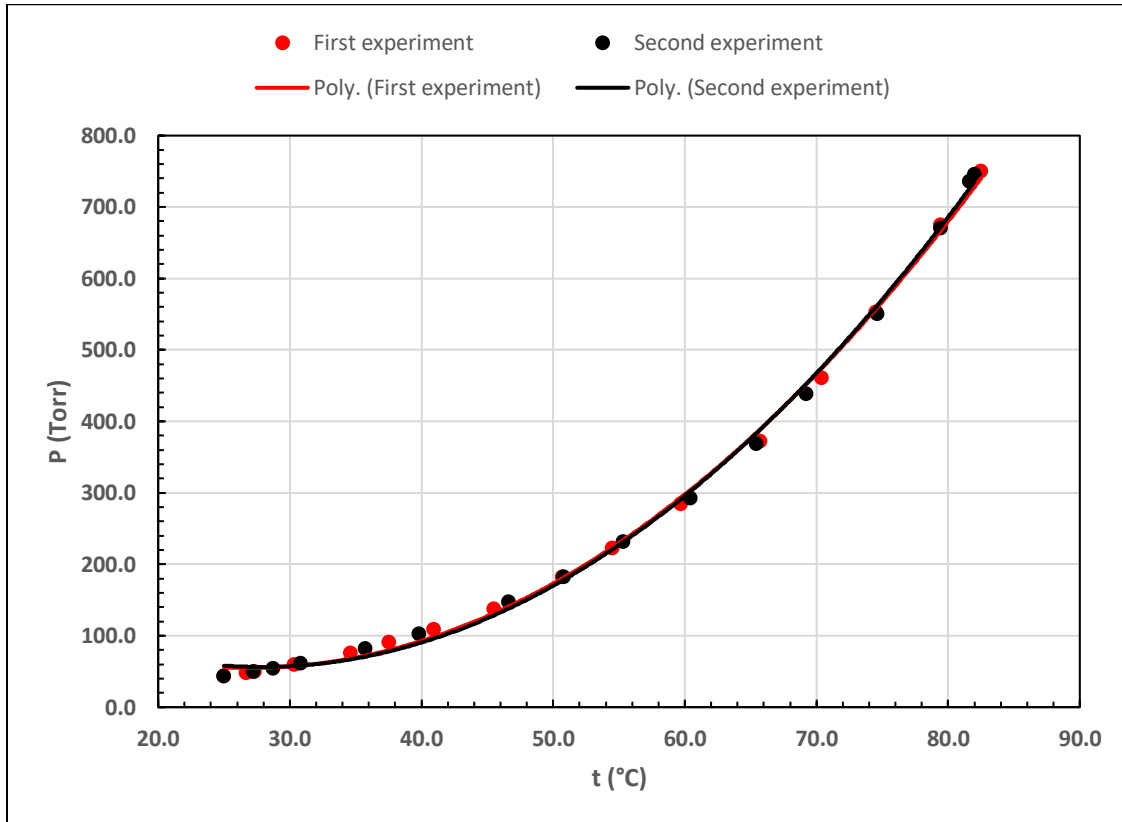


Figure 1: Plot of pressure (Torr) versus temperature (°C) for both experiments

By referring to Figure 1, the data points for both experiments were fitted by second-degree polynomial fitting line. The data points seemed to follow the trend of the fitting and it was said that pressure (Torr) increased as temperature (°C) increased, at least within the temperature range of where this data was collected. The equation of the fitting line for both experiments were as shown below, with their corresponding squared of correlation coefficient, R^2 value.

$$\text{Experiment 1: } P = 0.2220t^2 - 11.96t + 216.09, R^2 = 0.9985 \text{ (Eq. 1)}$$

$$\text{Experiment 2: } P = 0.2316t^2 - 12.90t + 235.91, R^2 = 0.9985 \text{ (Eq. 2)}$$

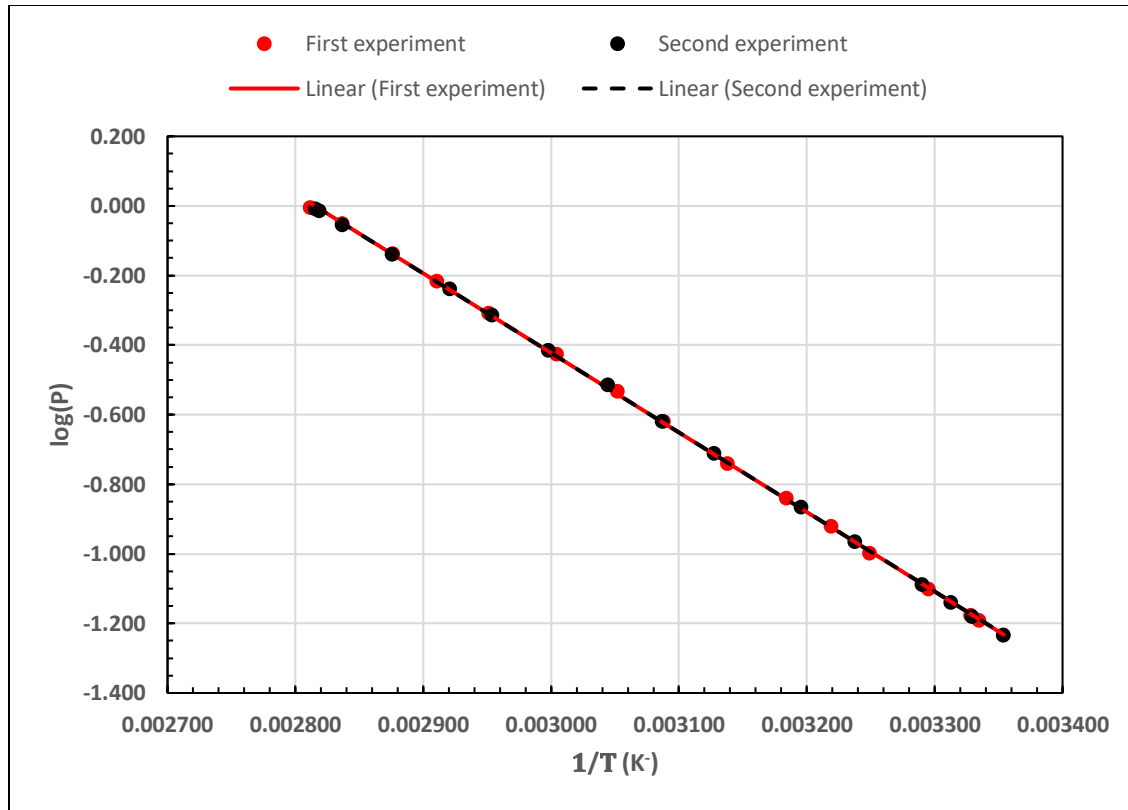


Figure 2: Plot of $\log(P)$ versus $\frac{1}{T}$ (K⁻¹) for both experiments

Based on Figure 2, the data points for both experiments were fitted with a linear trendline. They seemed to follow the fitting trendline as most of the data points laid on/were close to the trendline. From this, it was said that $\log P$ was decreasing linearly as $\frac{1}{T}$ increased, at least within the temperature range that this data was acquired.

Table 3a: LINEST value for Experiment 1 for trendline in Figure 2

m	-2287.31	6.439	b
u_m	7.620	0.02368	u_b
R²	0.9998	0.005532	s_y
Fisher value	90105.76	14	df
Regression SOS	2.758	0.0004285	Residual SOS

Table 3b: LINEST value for Experiment 2 for trendline in Figure 2

m	-2284.78	6.432	b
u_m	6.057	0.01866	u_b
R²	0.9999	0.004549	s_y
Fisher value	142300.29	14	df
Regression SOS	2.944	0.0002897	Residual SOS

The linear trendline plotted in Figure 2 for experiment 1 and 2 had their LINEST outputs as shown in Table 3a and 3b respectively. The equation of the fitting line and its corresponding R^2 value could be written as shown below:

$$\text{Experiment 1: } \log P = 6.439 - \frac{2287.31}{T}, R^2 = 0.9998 \text{ (Eq. 3)}$$

$$\text{Experiment 2: } \log P = 6.432 - \frac{2284.78}{T}, R^2 = 0.9999 \text{ (Eq. 4)}$$

By using the information generated from LINEST in Table 3a and 3b, the propagation of errors for both Eq. 3 and 4 could be obtained by using the formula listed below. The errors were calculated by using 95 % confidence interval.

$$\log P = A' - \frac{\Delta H_{\text{vap}}}{2.3025RT}, R = 8.314 \frac{\text{J}}{\text{mol.K}}, T = \text{temperature in Kelvin, } P = \text{pressure in Torr (Eq. 5)}$$

$$(\log P \pm tu_y) = (A' \pm tu_b) - \left(\frac{\Delta H_{\text{vap}}}{2.3025R} \pm tu_m \right) \left(\frac{1}{T} \pm tu_x \right) \text{ (Eq. 6)}$$

$$u_y = \frac{s_y}{\sqrt{n}}, u_y = \text{standard error of } y, s_y = \text{standard deviation of } y, n = \text{number of data (Eq. 7)}$$

Table 4: Uncertainties in the parameters of Eq. 6 within 95% confidence interval

Experiment	t-value, t (95% CI)	tu_m (K)	tu_b	tu_y
First	2.145	16.34	0.051	0.0030
Second	2.145	12.99	0.040	0.0024

In this error propagation analysis, only the standard error, u , were used, instead of the standard deviation, s . Table 4 shows the values of uncertainties within 95 % confidence interval (t-value = TINV(0.05,df) function in Excel) for the constants and variables in Eq. 6. tu_y were obtained by using Eq.7 based on s_y value from Table 3a and 3b.

By using the uncertainties in Table 4, the average heat of vaporization and its uncertainties of 2-propanol could be calculated by using the integrated equation of Clausius-Clapeyron equation, Eq. 5. By using the data in Table 3a, 3b and 4, it could be concluded that:

$$m \pm tu_m = \frac{\Delta H_{\text{vap}} \pm tu_h}{2.3025R}, tu_m = tu_h$$

Table 5: ΔH_{vap} for both experiments

Experiment	ΔH_{vap} ($\frac{\text{kJ}}{\text{mol}}$)	t value, t (95% CI)	tu_m ($\frac{\text{kJ}}{\text{mol}}$)	tu_h ($\frac{\text{kJ}}{\text{mol}}$)
First	43.786	2.145	0.016	0.016
Second	43.738	2.145	0.013	0.013

The average heat of vaporization, ΔH_{vap} for both experiments were calculated and tabulated in Table 5. ΔH_{vap} from the first experiment was $43.786 \pm 0.016 \frac{\text{kJ}}{\text{mol}}$ (95% CI, $n = 16$), while the ΔH_{vap} for the second experiment was $43.738 \pm 0.013 \frac{\text{kJ}}{\text{mol}}$ (95% CI, $n = 16$). The two values were close to each other, with a reasonably small standard error, within 95% confidence interval. The difference between these two ΔH_{vap} values were only $0.048 \frac{\text{kJ}}{\text{mol}}$, in relative to experiment 1, which was marginally small. The values for the two experiments in agreement with each other.

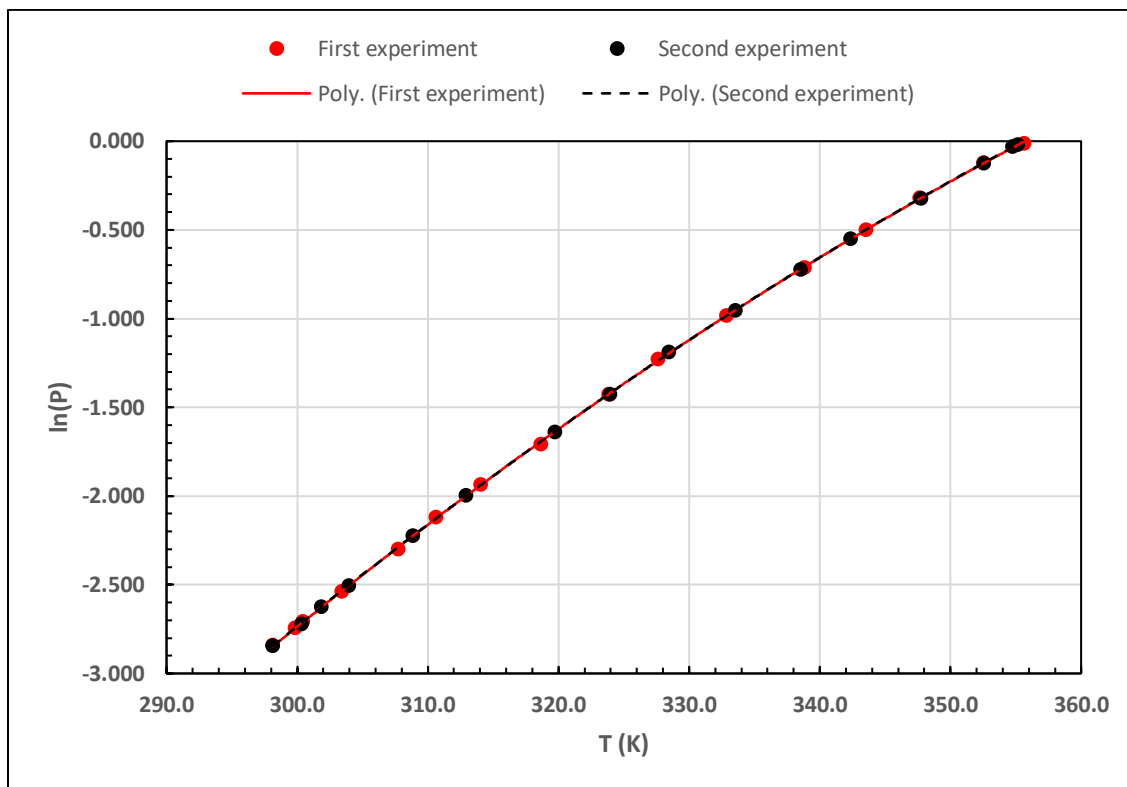


Figure 3: Plot of $\ln(P)$ versus T (K) for both experiment

As shown in Figure 3, the data points from both experiments would not be fitted perfectly with a linear trendline. In fact, most of the data points laid on the fitted line where it was fitted with a second-degree polynomial fit. It was reflected that the heat of vaporization was not temperature independent. The equation of the fitted line for both experiments were as listed below:

$$\text{Experiment 1: } \ln P = -1.836 \times 10^{-4}T^2 + 0.1695T - 37.06 \text{ (Eq. 8)}$$

$$\text{Experiment 2: } \ln P = -1.809 \times 10^{-4}T^2 + 0.1678T - 36.79 \text{ (Eq. 9)}$$

From Eq. 8 and 9, the heat of vaporization for each temperature could be computed by using the derivation of equation below:

$$\frac{d}{dT} \ln P = \frac{\Delta H_{\text{vap}}}{RT^2}$$

From Eq. 8: $\frac{d}{dT} \ln P = -3.672 \times 10^{-4}T + 0.1695 = \frac{\Delta H_{\text{vap}}}{RT^2}$ (Eq. 10)

From Eq. 9: $\frac{d}{dT} \ln P = -3.618 \times 10^{-4}T + 0.1678 = \frac{\Delta H_{\text{vap}}}{RT^2}$ (Eq. 11)

Table 6: The ΔH_{vap} for each temperature for both experiments

First Experiment		Second Experiment	
T (K)	$\Delta H_{\text{vap}} \left(\frac{\text{kJ}}{\text{mol}} \right)$	T (K)	$\Delta H_{\text{vap}} \left(\frac{\text{kJ}}{\text{mol}} \right)$
298.2	44.36	298.2	44.29
299.9	44.40	300.4	44.35
300.5	44.41	301.9	44.38
303.5	44.46	304.0	44.42
307.8	44.48	308.9	44.46
310.7	44.47	313.0	44.44
314.1	44.43	319.8	44.30
318.7	44.31	324.0	44.14
323.9	44.11	328.5	43.92
327.7	43.90	333.6	43.59
332.9	43.55	338.6	43.18
338.9	43.03	342.4	42.81
343.6	42.54	347.8	42.21
347.7	42.05	352.6	41.59
352.6	41.38	354.8	41.28
355.7	40.91	355.2	41.22
Average	43.55	Average	43.41

The ΔH_{vap} data values for each temperature for both experiments were observed as tabulated in Table 6. As the temperature increased, ΔH_{vap} also slowly increased. At some point, the ΔH_{vap} started to decrease as the temperature continue to increase. This trend could also be seen from Figure 3, as the fitted curve line concaved down as temperature increased. The values were not constant in comparison to itself as temperature changed, but it was relatively constant with one another at the same temperature, when the two experiments were compared with each other. The average ΔH_{vap} from Table 6 for both experiments (43.55 and $43.41 \frac{\text{kJ}}{\text{mol}}$ for Exp. 1 & 2 respectively)

were relatively lower than the values obtained from the integrated Clausius-Clayperon equation (43.786 & $43.738 \frac{\text{kJ}}{\text{mol}}$ for Exp. 1 & 2 respectively), as tabulated in Table 5. This was because the data in table 5 were computed by assuming that ΔH_{vap} were constants throughout the temperature range, where in fact it was changing as temperature increases or decreases.

A better fit to the data of vapor pressure for both experiments could be obtained by using the Antoine equation. The equation could be written as shown below:

$$\log P = A - \frac{B}{t + C}, P = \text{pressure dimensionless, } t = \text{temperature in } ^\circ\text{C} \text{ (Eq. 12)}$$

The parameters value A, B and C were determined by using two different methods: Multiple Linear Regression (MLR) and Solver function in Excel. In order to use the MLR function in excel, Eq. 12 could be rearranged as shown below:

$$t \log P = (AC - B) + At - C * \log P \text{ (Eq. 13)}$$

Table 7: Antoine parameters from Multiple Linear Regression function

First Experiment			Second Experiment		
Parameters	Value	tu (95% CI)	Parameters	Value	tu (95% CI)
A	5.10	0.55	A	5.23	0.30
B	1498.52	175.06	B	1569.70	96.92
C	211.48	25.35	C	217.62	13.71

The value of Antoine parameters generated from MLR were as tabulated in Table 7 for both experiments. The uncertainties within 95% confidence interval for each of the parameters were also calculated and tabulated in the same table.

Table 8: Antoine parameters from Solver function

Experiment	A	B	C
First	5.304	1608.37	220.85
Second	5.022	1460.98	208.40

By using Solver function, the Antoine parameters for both experiments were as tabulated in Table 8. The solver function was set to have a fixed sum of zero of the difference between the left-hand side and the right-hand side of Eq. 12. The values were automatically generated in Excel after setting up those constraints.

Table 9a: Data of pressure computed from Eq. 5 and Eq. 12 (parameters in Table 7 and 8) for experiment 1

P_{exp} (Torr)	$P_{calc\ 1}$ (Torr)*	$P_{calc\ 2}$ (Torr)**	$P_{calc\ 3}$ (Torr)***	$\frac{P_{exp} - P_{calc\ 1}}{P_{exp}}$	$\frac{P_{exp} - P_{calc\ 2}}{P_{exp}}$	$\frac{P_{exp} - P_{calc\ 3}}{P_{exp}}$
44.4	44.5	43.8	43.9	-0.00241	0.01270	0.01044
48.9	49.2	48.6	48.7	-0.00603	0.00516	0.00358
50.7	51.0	50.5	50.5	-0.00496	0.00491	0.00355
60.1	60.6	60.4	60.4	-0.00819	-0.00431	-0.00463
76.2	77.2	77.5	77.4	-0.01341	-0.01646	-0.01560
91.3	90.6	91.2	91.1	0.00768	0.00114	0.00257
109.8	108.9	109.9	109.7	0.00864	-0.00105	0.00088
138.1	138.7	140.4	140.1	-0.00411	-0.01660	-0.01425
182.6	180.8	183.2	182.8	0.00978	-0.00346	-0.00109
222.8	218.3	221.1	220.7	0.01999	0.00747	0.00963
284.9	280.7	283.6	283.1	0.01482	0.00458	0.00624
373.1	371.4	373.5	373.3	0.00445	-0.00113	-0.00043
461.6	459.4	459.7	459.8	0.00467	0.00415	0.00385
553.7	550.5	547.9	548.6	0.00579	0.01053	0.00923
675.3	679.5	671.4	673.2	-0.00624	0.00585	0.00317
750.3	774.0	760.8	763.6	-0.03161	-0.01400	-0.01771

* Pressure value obtained from Eq. 5 (Integrated form of Clausius-Clayperon Equation)

** Pressure value obtained from Eq. 12 (Antoine Equation with MLR parameters)

*** Pressure value obtained from Eq. 12 (Antoine Equation with Solver parameters)

Table 9b: Data of pressure computed from Eq. 5 and Eq. 12 (parameters in Table 7 and 8) for experiment 2

P_{exp} (Torr)	$P_{\text{calc 1}}$ (Torr)*	$P_{\text{calc 2}}$ (Torr)**	$P_{\text{calc 3}}$ (Torr)***	$\frac{P_{\text{exp}} - P_{\text{calc 1}}}{P_{\text{exp}}}$	$\frac{P_{\text{exp}} - P_{\text{calc 2}}}{P_{\text{exp}}}$	$\frac{P_{\text{exp}} - P_{\text{calc 3}}}{P_{\text{exp}}}$
44.3	44.6	44.0	44.0	-0.00662	0.00750	0.00762
50.1	50.7	50.3	50.3	-0.01289	-0.00331	-0.00391
55.1	55.4	55.0	55.1	-0.00473	0.00193	0.00090
62.1	62.4	62.3	62.4	-0.00555	-0.00252	-0.00408
82.4	82.2	82.5	82.7	0.00269	-0.00109	-0.00355
103.5	102.7	103.5	103.8	0.00749	-0.00035	-0.00321
147.7	146.9	148.6	149.0	0.00561	-0.00610	-0.00907
182.4	181.8	184.1	184.6	0.00332	-0.00914	-0.01184
232.2	227.1	229.8	230.3	0.02198	0.01023	0.00812
292.9	290.1	293.0	293.4	0.00951	-0.00041	-0.00166
369.0	366.2	368.7	368.7	0.00755	0.00089	0.00076
439.1	435.2	436.6	436.3	0.00899	0.00562	0.00648
551.4	552.4	551.1	549.7	-0.00187	0.00051	0.00300
671.2	678.8	673.1	670.3	-0.01130	-0.00277	0.00136
736.8	744.6	736.1	732.4	-0.01058	0.00102	0.00592
746.4	757.1	748.0	744.2	-0.01439	-0.00217	0.00290

* Pressure value obtained from Eq. 5 (Integrated form of Clausius-Clayperon Equation)

** Pressure value obtained from Eq. 12 (Antoine Equation with MLR parameters)

*** Pressure value obtained from Eq. 12 (Antoine Equation with Solver parameters)

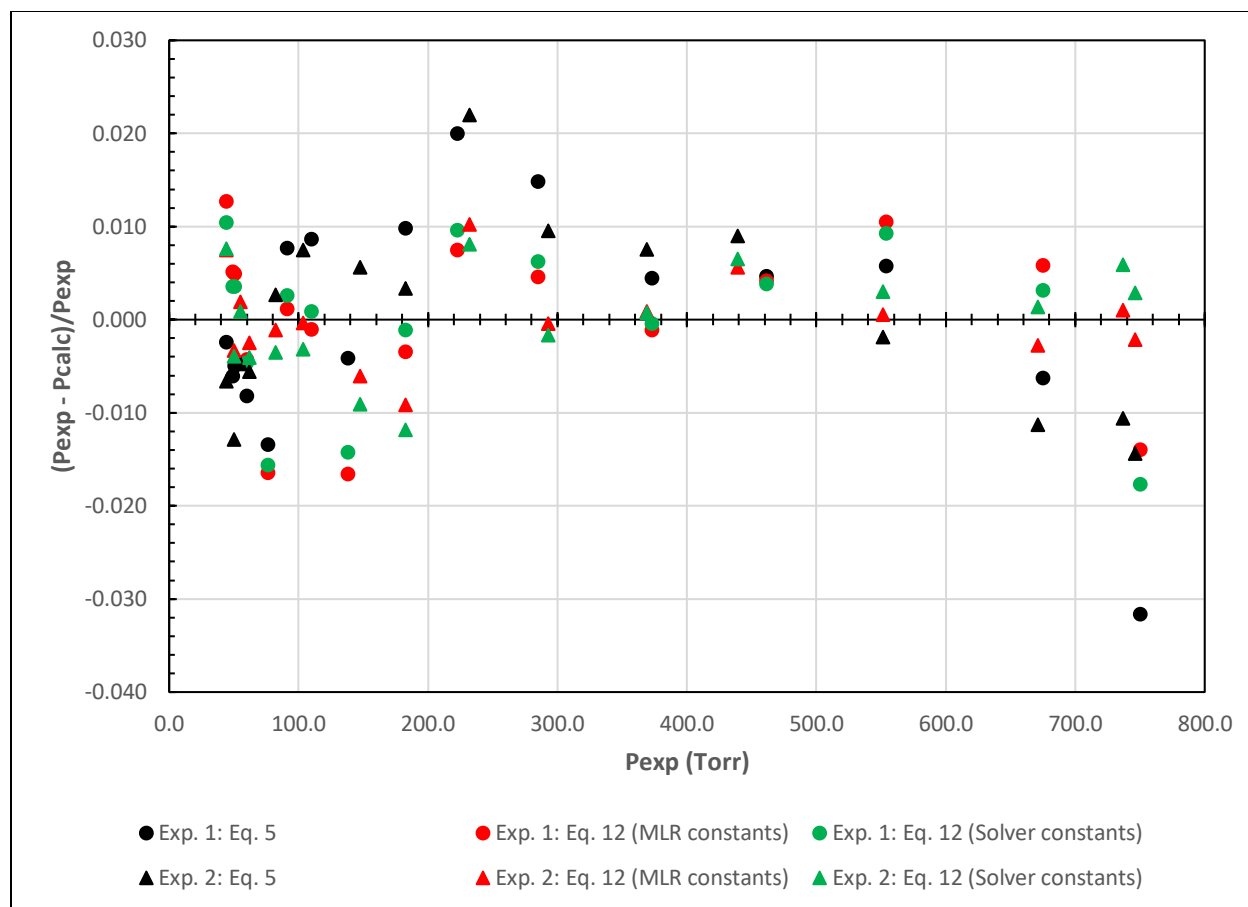


Figure 4: Plot of fractional error, $\frac{P_{exp} - P_{calc}}{P_{exp}}$ versus P_{exp} for three different equations for both experiments

As shown in Figure 4, plotted by using the data tabulated in Table 9a and 9b, the fractional error calculated from Eq. 5 were greater than the other 2 equations (Eq. 12 with MLR and Solver parameters). This was illustrated by how much the data points deviate from the x-axis ($y = 0$) in the y-direction. The data points for Eq. 5 for both sets of experiments (black) spread out more, unlike the other two equations, where the data points were clustered more around $y = 0$. In relative to the other two equations, the fractional error computed from using Eq. 12 with MLR parameters to calculate the pressure (red) was much lower than that of Solver parameters (green). It could be said that the MLR parameters could be used to describe the vapor pressure of 2-propanol as the pressure calculated was more precise as it produced values that were close to the experimental data.

The normal boiling point of 2-propanol with its uncertainty could be determined by using the constant values tabulated in Table 3a and 3b and Eq. 5. The standard pressure in normal room condition was 1 atm, or 760 Torr. Eq. 5 could be rewritten, re-generalized and rearranged as shown below:

$$\log P = b + \frac{m}{T}, m = \frac{\Delta H_{\text{vap}}}{2.3025R}, b = A' \text{ (Eq. 5')}$$

$$T \pm tu_T = \frac{m \pm tu_m}{(\log P \pm tu_y) - (b \pm tu_b)} \text{ (Eq. 14)}$$

The normal boiling point was calculated by using Eq. 14. The uncertainty in the normal boiling point was determined in three different methods: 1) the normal standard propagation of error analysis, 2) the propagation of error analysis with partial derivatives, assuming m and b were independent to each other, and 3) the propagation of error analysis by using covariance, assuming m and b were dependent to each other. All of these uncertainties were being calculated by using the values of its standard error within 95% confidence interval.

$$(\log P \pm tu_y) - (b \pm tu_b) = (\log P - b) \pm tu_d$$

$$tu_d = \sqrt{(tu_b)^2 + (tu_y)^2}$$

$$tu_T = T \sqrt{\left(\frac{tu_m}{m}\right)^2 + \left(\frac{tu_d}{\log P - b}\right)^2} \text{ (Eq. 15)}$$

Table 10a: Uncertainties in normal boiling point by using Method 1 for both experiments

Experiment	T _B (K)	tu _d	tu _T (K)	t-value, t (95% CI)
First	355.21	0.0509	3.78	2.145
Second	355.24	0.0401	3.00	2.145

The boiling point and its uncertainties for both experiments were as tabulated in Table 10a, obtained by using Eq. 15. The normal boiling point determined from the first and second experiment were 355.21 ± 3.78 K (95% CI, n = 16) and 355.24 ± 3.00 K (95% CI, n = 16) respectively.

The second method of propagation of error analysis involved partial derivative, assuming that m and b were independent of each other.

$$tu_T = t \sqrt{\left(\frac{\partial T}{\partial b}\right)^2 s_b^2 + \left(\frac{\partial T}{\partial m}\right)^2 s_m^2} \text{ (Eq. 16)}$$

$$\text{Based on Eq. 14: } \frac{\partial T}{\partial b} = \frac{m}{(\log P - b)^2}, \frac{\partial T}{\partial m} = \frac{1}{\log P - b}$$

Table 10b: Uncertainties in normal boiling point by using Method 2 for both experiments

Experiment	T _B (K)	$\frac{\partial T}{\partial b}$ (K)	$\frac{\partial T}{\partial m}$	t-value, t (95% CI)	tu _T (K)
First	355.21	-55.16	-0.155	2.145	15.12
Second	355.24	-55.23	-0.155	2.145	11.98

From Eq. 16, the standard error within 95% confidence interval for both sets of experiments were as tabulated in Table 10b. The normal boiling point for the first and second experiments was 355.21 ± 15.12 K and 355.24 ± 11.98 K respectively.

Last but not least, the uncertainties of the normal boiling point were calculated by using Method 3, by using the formula listed below:

$$tu_T = t \sqrt{\left(\frac{\partial T}{\partial b}\right)^2 s_b^2 + \left(\frac{\partial T}{\partial m}\right)^2 s_m^2 + 2\left(\frac{\partial T}{\partial m}\right)\left(\frac{\partial T}{\partial b}\right)s_{mb}} \quad (\text{Eq. 17})$$

$$s_{mb} = -s_b^2 \frac{\sum x_i}{\sum x_i^2}, \quad x_i = \frac{1}{T_i}$$

Table 10ci: Uncertainties in normal boiling point by using Method 3 for Experiment 1

x_i (K ⁻¹)	x_i^2 (K ⁻²)	$\frac{\partial T}{\partial m}$	$\frac{\partial T}{\partial b}$ (K)	s_{mb} (K)	t-value, t (95% CI)	tu _T (K)
0.003354	1.125E-05	-0.1553	-55.16	-2.8819	2.145	1.22
0.003335	1.112E-05					
0.003328	1.108E-05					
0.003295	1.086E-05					
0.003249	1.056E-05					
0.003219	1.036E-05					
0.003184	1.014E-05					
0.003138	9.849E-06					
0.003088	9.535E-06					
0.003052	9.315E-06					
0.003004	9.026E-06					
0.002951	8.709E-06					
0.002911	8.473E-06					
0.002876	8.274E-06					
0.002836	8.046E-06					
0.002812	7.906E-06					
0.049635	0.00015450	SUM				

Table 10cii: Uncertainties in normal boiling point by using Method 3 for Experiment 2

x_i (K)	x_i^2 (K ²)	$\frac{\partial T}{\partial m}$	$\frac{\partial T}{\partial b}$ (K)	s_{mb} (K)	t-value, t (95% CI)	tu_T (K)
0.003354	1.125E-05	-0.1555	-55.23	-1.8048	2.145	0.92
0.003329	1.109E-05					
0.003313	1.098E-05					
0.003290	1.082E-05					
0.003238	1.048E-05					
0.003195	1.021E-05					
0.003127	9.781E-06					
0.003087	9.529E-06					
0.003045	9.270E-06					
0.002998	8.988E-06					
0.002954	8.725E-06					
0.002921	8.532E-06					
0.002876	8.269E-06					
0.002836	8.046E-06					
0.002819	7.946E-06					
0.002816	7.928E-06					
0.049198	0.00015184	SUM				

The uncertainties computed within 95% confidence interval by using Eq. 17 were as tabulated in Table 10ci and 10cii for experiment 1 and 2 respectively. The normal boiling point for the first and second experiment was 355.21 ± 1.22 K (95% CI, n = 16) and 355.24 ± 0.92 K (95% CI, n = 16).

By comparing all these uncertainties, it was indeed true that method 2 (propagation of error analysis with partial derivatives, assuming m and b were independent to each other) results in disconcertingly large uncertainties, in comparison with the other 2 methods. The standard propagation of error analysis (Method 1) produced smaller uncertainties than Method 2, but it was still relatively larger than that produced from Method 3. By making sure that m and b of the equations were dependent to each other, the uncertainties could be calculated correctly and result in smaller values than those obtained from other methods. It gave a reasonable estimate in the uncertainty of the normal boiling point.

CONCLUSIONS

The vapor pressure of 2-propanol, given the temperature range of which it was to be measured, could be computed from various type of equations, such as integrated Clausius-Clapeyron Equation and Antoine Equation. The temperature ($^{\circ}\text{C}$) and pressure (Torr) of 2-propanol had a strong, positive and non-linear relationship (quadratic) between themselves while inverse of temperature (K^{-1}) and logarithmic of pressure had a strong, negative, and linear relationship. Moreover, temperature (K) and natural logarithmic of pressure had a strong, negative, non-linear relationship, by Clausius-Clapeyron equation, which indicated the heat of vaporization was temperature dependent, as increasing temperature did not result in constant value of slope (slope represented the heat of vaporization). To use Antoine equation to find the vapor pressure at desired temperature, its parameters were determined from Multiple Linear Regression (MLR) and Solver function in Excel. By comparing the vapor pressure obtained from integrated Clausius-Clapeyron, and Antoine equation with both sets of parameters from MLR and Solver, the fractional error of pressure calculated relative to the pressure obtained experimentally was the lowest for Antoine equation with MLR parameters, followed by Solver parameters, and the greatest for integrated Clausius-Clapeyron equation. The uncertainties in determining the boiling point of 2-propanol at standard room temperature and pressure were best to be determined by using the propagation of error analysis with covariance, as it took into account the slope and the y-intercept of the plotted set of data to be dependent to each other, which would result in smaller uncertainties within 95% confidence interval.