Experiment Title:

Author's Name:

Submitting Author's Partner:

TA (Demonstrator)'s Name:

Ogadimma Okagu

Date Experiment Performed:

October, 31st 2019

Date Experiment Submitted:

Introduction:

There are two main theories used to define Acid and base. The Arhenius theory and the Bronsted-Lowry theory. Arrhenius theory was introduced in 1887 by the Swedish scientist Svante Arrhenius, acids are compounds that dissociate in water to produce electrically charged atoms or molecules, known as ions, one of which is a hydrogen ion (H+), bases ionise in water to produce hydroxide ions (OH−).

Although the theory of Arrhenius was a crucial step in understanding acid-base chemistry, it was considered inadequate because it allows only bases containing the hydroxide ion (OH-) and implies that all acid base reactions occur only in aqueous solutions (DiGiussipe&Maurice, 488). Bronsted-Lowry theory was introduced in 1923 by a Danish chemist, Johannes Nicolaus Bronsted and the English chemist Thomas Martin Lowry. It was also called the proton theory. **"**Bronsted-Lowry acid is defined as a substance that gives up or donates hydrogen ions during a chemical reaction, [while] a Bronsted-Lowry base accepts hydrogen ions" (thoughtCo.com). Each Bronsted-Lowry acid gives its proton to a species that is its conjugate base. Similarly, each Bronsted-Lowry base accepts a proton from its conjugate acid.

For example, in the reaction

$HCl\ (aq) + NH_3\ (aq) \rightarrow NH_4^+\ (aq) + Cl^-\ (aq)$

In the above reaction "Hydrochloric acid (HCl) donates a proton to ammonia (NH_3) to form the ammonium cation (NH_4^+) and the chloride anion (Cl^-). Hydrochloric acid is a Bronsted-Lowry acid; the chloride ion is its conjugate base. Ammonia is a Bronsted-Lowry base; its conjugate acid is the ammonium ion" (thoughtCo.com).

Acid and base react to form a solution of a salt and water, this is known as a neutralization reaction. An acid-base titration is used to determine the unknown concentration of an acid or base by neutralizing it with an acid or base of known concentration(courses.lumenlearning.com). In a titration, the solution being analyzed is called the sample, and it is placed in a receiving flask. Drops of a solution called a titrant are slowly added from the burette to the sample (DiGiussipe&Maurice, 540). At the start of a titration, an indicator, which is "any substance that gives a visible sign, usually by a colour change, of the presence or absence of a threshold concentration of a chemical species, such as an acid or an alkali in a solution"(The Editors of Encyclopaedia Britannica, 2019). The endpoint or equivalent point of the titration is reached when the indicator changes color and the titration is stopped at this point.

In this experiment, a solution of sodium hydroxide NaOH was prepared and the solution was standardized. The standardized solution was then used to determine the concentration of an unknown acid by titration. The standard acid used for this lab is hydrochloric acid (HCl). The indicator used in this experiment is phenolphthalein.

Procedure:

Refer to the lab manual ("Oh How Bitter a Thing It Is", Dr. Rashmi Venkateswaran, 2017, Experiment 4).

Observation

Part 1: Preparing a solution of NaOH by dilution

Volume of 6.0M of NaOH - 6.0 ml

Volume of distilled water - 250 ml

Part 2: Calibrating the drop counter

Volume of NaOH used - 60 drops - 3.0 ml

Part 3: Titration with 0.100M of HCl

Volume of 0.100M HCl - 10.00ml

Drops of phenolphthalein - 3 drops

Volume of solution when H2O was added - 100 ml

Part 4: Titration with unknown diprotic acid

Volume of unknown acid - 10.00 ml

Drops of phenolphthalein - 3 drops

Volume of solution when H2O was added - 100 ml

Standardization of the diluted NaOH:

	Trial 1	Trial 2	Trial 3
Initial volume of HCL (ml)	13.0	4.10	1.00
Final Volume of HCL (ml)	22.9	14.1	11.0
Volume of HCL used (ml)	9.90	10.0	10.0
Initial volume of NaOH (ml)	40.0	40.0	40.0
Final Volume of NaOH (ml)	31.1	33.0	33.0
Volume of NaOH used (ml)	8.90	7.00	7.00

Average Volume of NaOH = (8.90 + 7.00 + 7.00) / 3 = 7.63 ml

Titration of Unknown Acid

	Trial 1	Trial 2	Trial 3
Initial volume of HCL (ml)	4.00	4.00	1.00
Final Volume of HCL (ml)	14.0	14.0	11.0
Volume of HCL used (ml)	10.0	10.0	10.0
Initial volume of NaOH (ml)	40.0	40.0	40.0
Final Volume of NaOH (ml)	32.0	31.1	31.4
Volume of NaOH used (ml)	8.00	8.90	8.60

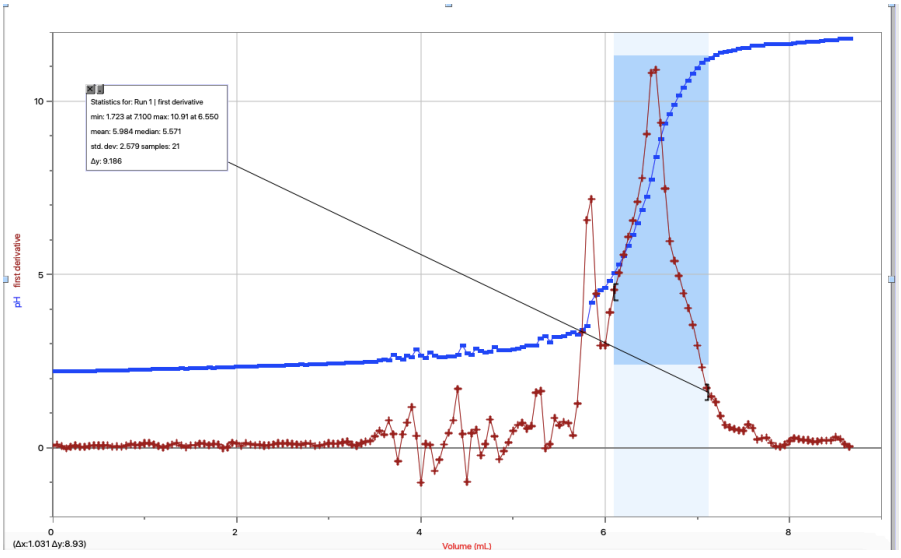
Average Volume of NaOH = (8.00 + 8.90 + 8.60) / 3 = 8.50

Graph

Standardization of the diluted NaOH:

Trial 1

Titration of HCl with NaOH

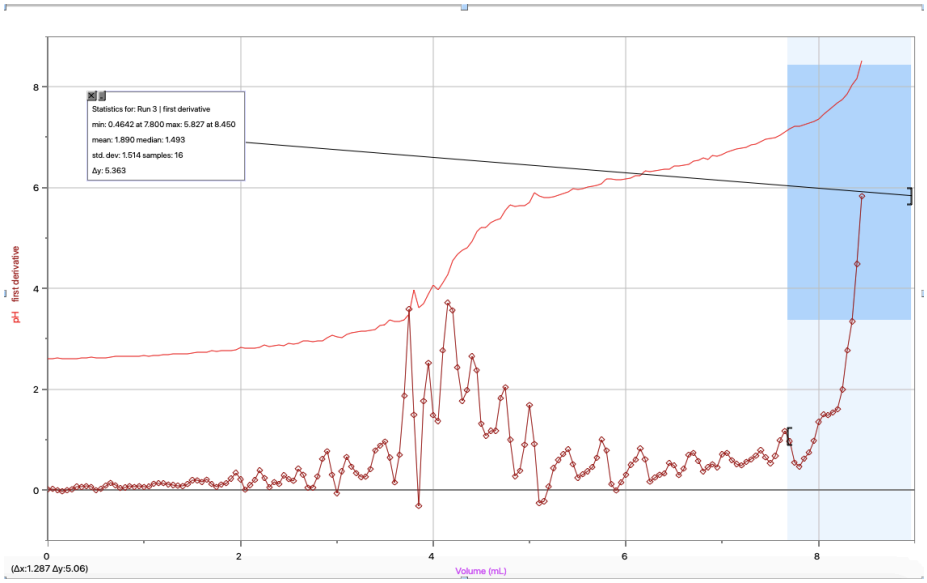


The volume of the NaOH observed here was 6.55 ml

Titration of Unknown Acid

Trial 1

Titration of unknown acid with NaOH



The volume of the NaOH observed here was 8.45 ml

Observation:

HCL, NaOH, and the unknown acids, were colourless.

In all areas of the experiment, where the phenolphthalein indicator was used, a colour change fro m colourless to pink was observed. Equivalence points were observed for the HCL acid, and the unknown acid respectively.

Discussion:

The purpose of this experiment was to determine the concentration of an unknown substance, as well as observe what happens during an acid-base neutralization titration.
The end point was clearly observed in all three experimental trials as a result of the addition of three drops of the phenolphthalein indicator.

Phenolphthalein, is a weak acid, that is colorless when hydrogen ions are added and turns pink when hydroxide ions is added (DiGiussipe&Maurice, 542). This the reason why it remains colourless when added to the acid and eventually turns pink when drops of the base is added. For the standardization distilled water was used instead of tap water. This is because distilled water is very neutral compared total water and it would have an insignificant effect on the titration result.

The concentration of the NaOH, using the volume obtained from the LoggerPro was 0.159 M while the concentration of the NaOH obtained from the visual recorded volume is 0.131 M. In the second part, the concentration of the unknown acid, using the volume obtained from the LoggerPro was 0.0660 M while the concentration of the unknown acid obtained from the visual recorded volume is 0.0557.

The percentage error of the concentration can not be calculated because the actual value was not given. Irrespective of this, the two concentrations obtained are similar but not exact because of some errors observed.

This errors can include:

- The same beaker was used through out all trials. Even though the beaker was rinsed after each trials, acid or bases residue that remained in the beaker can affect the rate at which the titration reaches its equivalence point .
- While taking the reading on the LabQuest 2, the titration was not set to plateau which did made it difficult to know where exactly to analyze the first derivative point.

This errors will result to an inaccurate curve which will result to inaccurate calculations.

Conclusion:

In the first part of the experiment, the concentration of diluted NaOH was found to be 0.159 mol/L using values from the LoggerPro. In the second part, the concentration of the unknown acid was found to be 0.0660 mol/L using values from the LoggerPro .

Reference(s):

The Editors of Encyclopaedia Britannica. (2019, July 26). Chemical indicator. Retrieved from https://www.britannica.com/science/chemical-indicator.

DiGiuseppe, Maurice. *Nelson chemistry 12: university preparation*. Thomson/Nelson,2012.

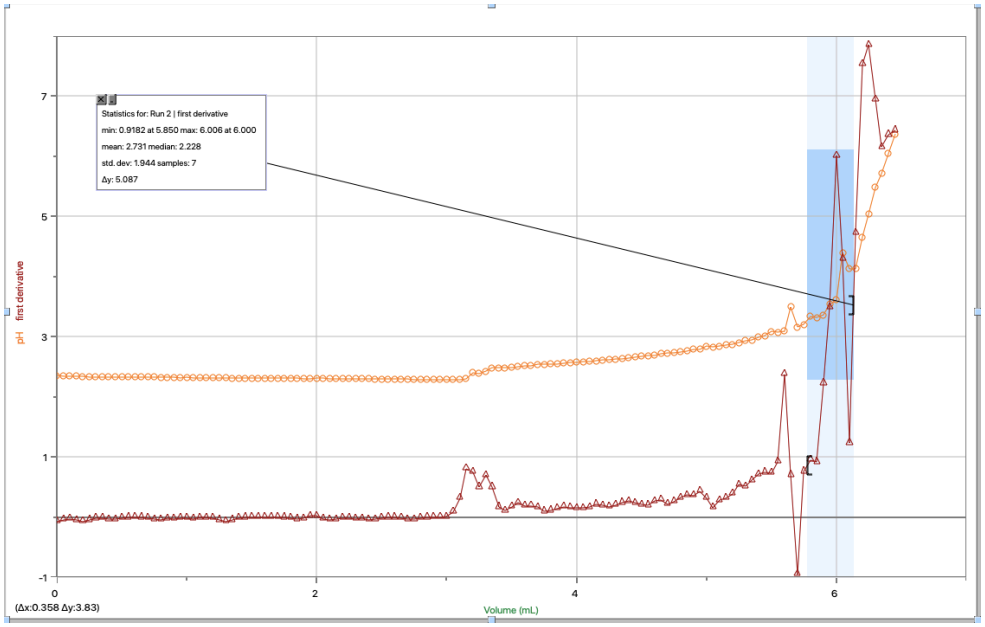
Appendix:

Additional Graphs

Standardization of the diluted NaOH:

Trial 2

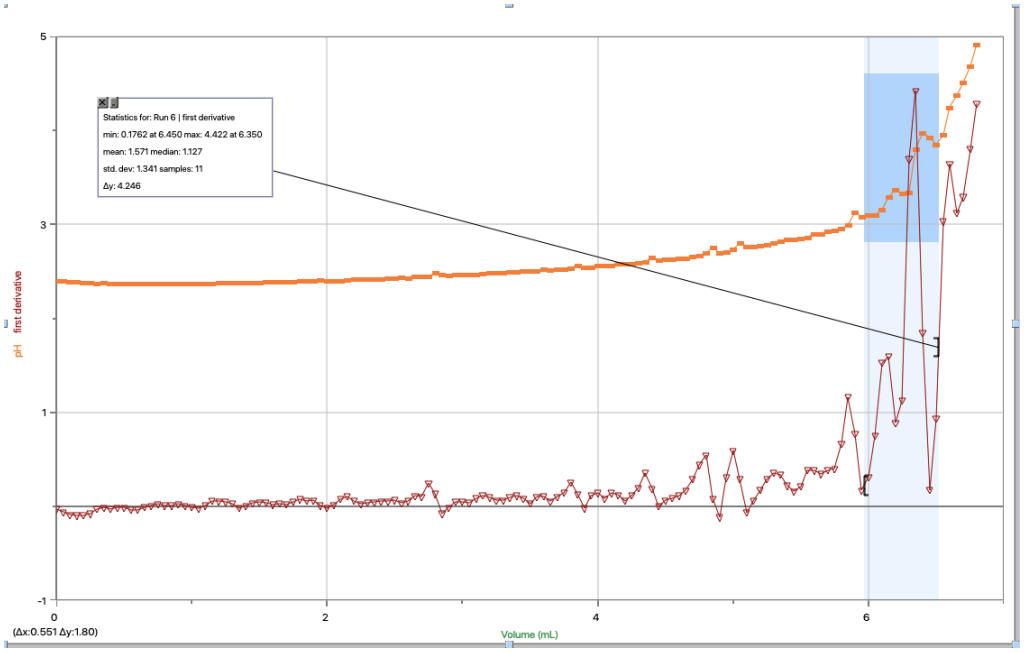
Titration of HCl with NaOH



The volume of the NaOH observed here was 6.55 ml

Trial 3

Titration of HCl with NaOH

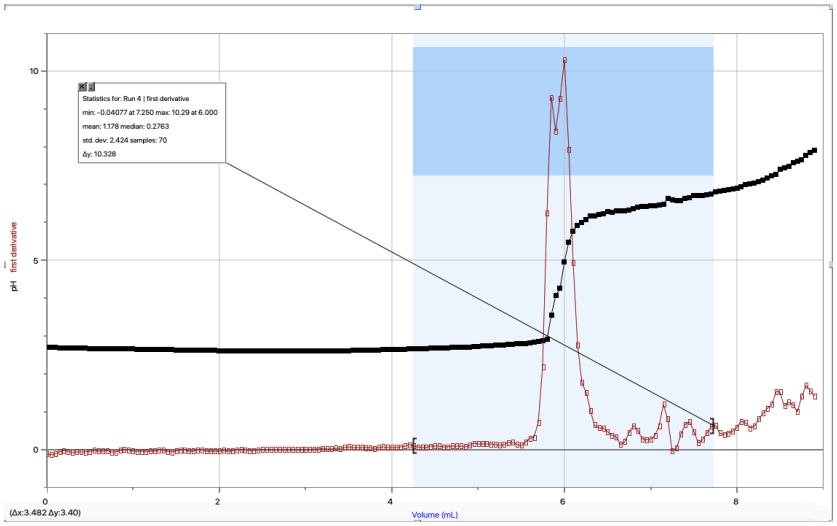


The volume of the NaOH observed here was 6.35 ml

Titration of Unknown Acid

Trial 2

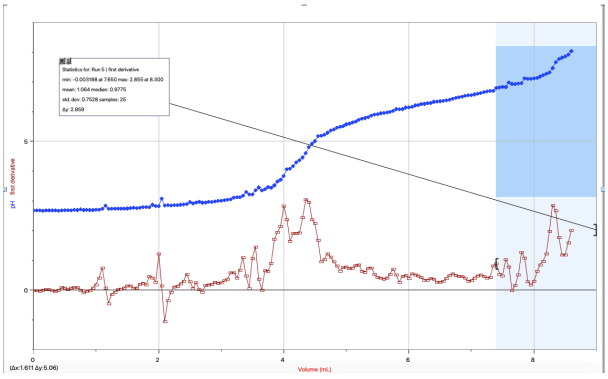
Titration of unknown acid with NaOH



The volume of the NaOH observed here was 6.00 ml

Trial 3

Titration of unknown acid with NaOH



The volume of the NaOH observed here was 8.30 ml

Sample Calculations

Concentration of NaOH solution (approximately)

$C_1V_1 = C_2V_2$

(6.00M) * (0.006L) = C_2 * (0.250)L

C_2 = 0.144 M

Calculating concentration from the graph

Concentration of NaOH

Trial 1

$C_{NaOH}\ V_{NaOH} = C_{HCl}\ V_{HCL}$

C_{NaOH}* (0.00655L) = (0.100M)*(0.01)

C_{NaOH} = 0.153 M

Trial 2

$C_{NaOH}\ V_{NaOH} = C_{HCl}\ V_{HCL}$

C_{NaOH}* (0.006L) = (0.100M)*(0.01)

C_{NaOH} = 0.167 M

Trial 3

$C_{NaOH}\ V_{NaOH} = C_{HCl}\ V_{HCL}$

C_{NaOH}* (0.00635L) = (0.100M)*(0.01)

C_{NaOH} = 0.157 M

Average Concentration for NaOH = (0.153 + 0.167 + 0.157) / 3 = 0.159

Concentration of unknown acid (For diprotic acid)

$C_{NaOH}\ V_{NaOH} = C_{acid}\ V_{acid}$

Trial 1

(0.159 M) * (0.00845L) = 2* C_{acid}*(0.01)

C_{NaOH} = 0.0672 M

Trial 2

(0.159 M) * (0.0060L) = 2* C_{acid}*(0.01)

C_{NaOH} = 0.0477 M

Trial 3

(0.159 M) * (0.00830L) = 2* C_{acid}*(0.01)

C_{NaOH} = 0.0660 M

Average Concentration for the unknown acid = (0.0672 + 0.0477 + 0.0660) / 3 = 0.0603 M

Calculating concentration from the visual collected data

Concentration of NaOH

Average volume of NaOH used from the three trials

(8.90 + 7.00 + 7.00) / 3 = 7.63 ml

$C_{NaOH}\ V_{NaOH} = C_{HCl}\ V_{HCL}$

C_{NaOH}* (0.00763L) = (0.100M)*(0.01)

C_{NaOH} = 0.131 M

Concentration of unknown acid (For diprotic acid)

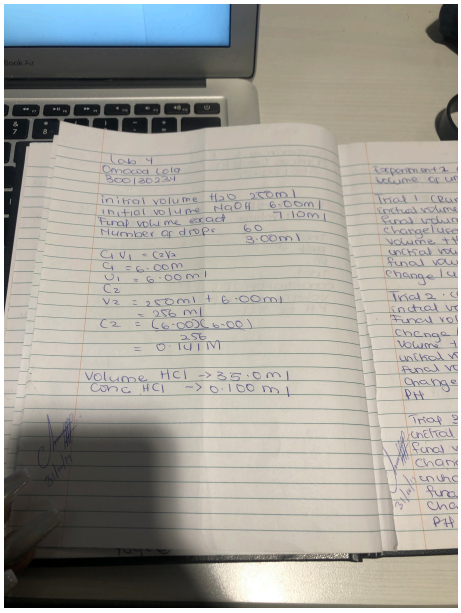
Average volume of NaOH used from the three trials = (8.00 + 8.90 + 8.60) / 3 = 8.50

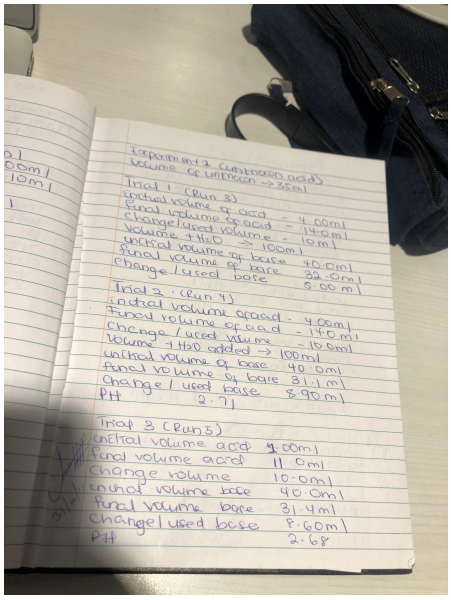
$C_{NaOH}\ V_{NaOH} = C_{acid}\ V_{acid}$

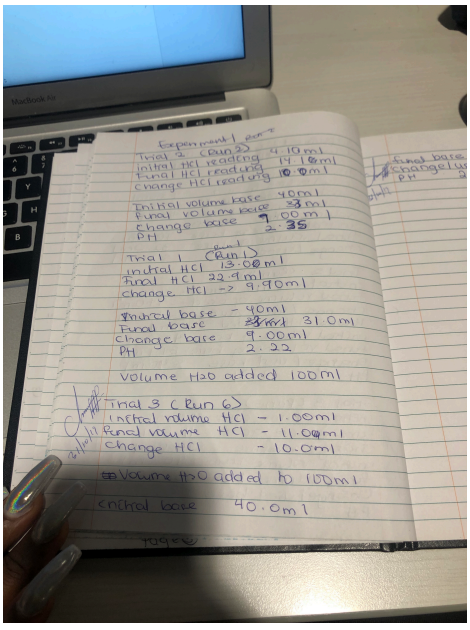
$(0.131\ M) * (0.00850\ L) = 2 * C_{acid} * (0.01)$

$C_{NaOH} = 0.0557\ M$

Raw Data







	Run 1			Run 2			Run 3			Run 4			Run 5			Run 6		
	Volume (mL)	pH	fd	Volume (mL)	pH	fd	Volume (mL)	pH	fd	Volume (mL)	pH	fd	Volume (mL)	pH	fd	Volume (mL)	pH	fd
1	0.000	2.22	0.055	0.000	2.35	-0.070	0.000	2.61	0.016	0.000	2.71	-0.119	0.000	2.68	-0.005	0.000	2.40	-0.028
2	0.050	2.22	0.089	0.050	2.35	-0.043	0.050	2.61	0.024	0.050	2.70	-0.134	0.050	2.68	-0.011	0.050	2.40	-0.060
3	0.100	2.23	0.039	0.100	2.35	-0.026	0.100	2.62	0.000	0.100	2.69	-0.120	0.100	2.68	-0.024	0.100	2.39	-0.088
4	0.150	2.22	-0.026	0.150	2.35	-0.050	0.150	2.61	-0.024	0.150	2.69	-0.062	0.150	2.67	0.003	0.150	2.39	-0.095
5	0.200	2.22	0.030	0.200	2.34	-0.072	0.200	2.61	-0.003	0.200	2.69	-0.030	0.200	2.68	0.033	0.200	2.38	-0.094
6	0.250	2.23	0.058	0.250	2.34	-0.046	0.250	2.61	0.016	0.250	2.69	-0.049	0.250	2.68	0.031	0.250	2.38	-0.077
7	0.300	2.23	0.022	0.300	2.34	-0.016	0.300	2.61	0.067	0.300	2.68	-0.075	0.300	2.68	-0.005	0.300	2.37	-0.025
8	0.350	2.23	0.019	0.350	2.34	-0.013	0.350	2.62	0.065	0.350	2.68	-0.061	0.350	2.68	-0.044	0.350	2.38	-0.014
9	0.400	2.23	0.047	0.400	2.34	-0.035	0.400	2.62	0.083	0.400	2.68	-0.060	0.400	2.67	0.014	0.400	2.37	-0.027
10	0.450	2.23	0.073	0.450	2.33	-0.035	0.450	2.63	0.067	0.450	2.67	-0.073	0.450	2.68	0.091	0.450	2.37	-0.011
11	0.500	2.24	0.060	0.500	2.33	-0.011	0.500	2.63	0.001	0.500	2.67	-0.048	0.500	2.69	0.078	0.500	2.37	-0.013
12	0.550	2.24	0.059	0.550	2.33	-0.003	0.550	2.63	0.025	0.550	2.67	-0.025	0.550	2.69	0.020	0.550	2.37	-0.035
13	0.600	2.25	0.069	0.600	2.33	0.000	0.600	2.63	0.091	0.600	2.67	-0.040	0.600	2.68	0.077	0.600	2.37	-0.035
14	0.650	2.25	0.028	0.650	2.33	-0.003	0.650	2.64	0.142	0.650	2.66	-0.042	0.650	2.70	0.092	0.650	2.37	-0.008
15	0.700	2.25	0.035	0.700	2.33	-0.011	0.700	2.65	0.095	0.700	2.66	-0.033	0.700	2.69	0.096	0.700	2.37	0.005
16	0.750	2.25	0.024	0.750	2.33	-0.037	0.750	2.65	0.041	0.750	2.66	-0.073	0.750	2.71	0.005	0.750	2.37	0.027
17	0.800	2.25	0.057	0.800	2.33	-0.040	0.800	2.65	0.053	0.800	2.65	-0.070	0.800	2.69	-0.077	0.800	2.37	0.011
18	0.850	2.26	0.102	0.850	2.33	-0.019	0.850	2.65	0.078	0.850	2.65	-0.021	0.850	2.70	-0.028	0.850	2.37	0.011
19	0.900	2.26	0.072	0.900	2.33	-0.030	0.900	2.66	0.066	0.900	2.65	-0.008	0.900	2.69	-0.015	0.900	2.37	0.027
20	0.950	2.26	0.077	0.950	2.32	-0.011	0.950	2.66	0.080	0.950	2.65	-0.011	0.950	2.69	0.080	0.950	2.37	0.005
21	1.000	2.27	0.123	1.000	2.33	-0.011	1.000	2.67	0.062	1.000	2.65	-0.040	1.000	2.70	0.193	1.000	2.37	-0.005
22	1.050	2.28	0.129	1.050	2.32	-0.027	1.050	2.66	0.073	1.050	2.65	-0.048	1.050	2.70	0.409	1.050	2.37	-0.021
23	1.100	2.28	0.094	1.100	2.32	-0.008	1.100	2.67	0.126	1.100	2.65	-0.049	1.100	2.73	0.744	1.100	2.37	0.011
24	1.150	2.29	0.047	1.150	2.32	-0.005	1.150	2.68	0.140	1.150	2.64	-0.048	1.150	2.83	0.085	1.150	2.37	0.062
25	1.200	2.29	-0.001	1.200	2.32	-0.014	1.200	2.69	0.137	1.200	2.64	-0.046	1.200	2.73	-0.442	1.200	2.38	0.054
26	1.250	2.28	0.049	1.250	2.32	-0.046	1.250	2.69	0.110	1.250	2.64	-0.038	1.250	2.74	-0.133	1.250	2.38	0.048
27	1.300	2.29	0.096	1.300	2.32	-0.072	1.300	2.70	0.099	1.300	2.64	-0.014	1.300	2.74	-0.060	1.300	2.38	0.031
28	1.350	2.29	0.134	1.350	2.31	-0.048	1.350	2.70	0.089	1.350	2.64	-0.017	1.350	2.74	0.032	1.350	2.38	-0.014
29	1.400	2.31	0.063	1.400	2.31	-0.014	1.400	2.71	0.079	1.400	2.64	-0.048	1.400	2.74	0.051	1.400	2.38	0.006
30	1.450	2.30	0.011	1.450	2.31	-0.003	1.450	2.71	0.121	1.450	2.63	-0.072	1.450	2.74	0.081	1.450	2.38	0.036
31	1.500	2.31	0.066	1.500	2.31	0.000	1.500	2.72	0.196	1.500	2.63	-0.046	1.500	2.75	0.153	1.500	2.38	0.043
32	1.550	2.31	0.074	1.550	2.31	0.000	1.550	2.73	0.191	1.550	2.63	-0.016	1.550	2.76	0.146	1.550	2.39	0.040
33	1.600	2.31	0.120	1.600	2.31	0.000	1.600	2.74	0.157	1.600	2.63	-0.014	1.600	2.77	0.061	1.600	2.39	0.019
34	1.650	2.32	0.118	1.650	2.31	0.000	1.650	2.74	0.209	1.650	2.63	-0.037	1.650	2.76	0.077	1.650	2.39	0.032
35	1.700	2.33	0.066	1.700	2.31	0.000	1.700	2.77	0.118	1.700	2.62	-0.037	1.700	2.77	0.211	1.700	2.39	0.022
36	1.750	2.32	0.110	1.750	2.31	-0.003	1.750	2.75	0.063	1.750	2.62	-0.014	1.750	2.79	0.247	1.750	2.39	0.050