

izes the wood. An extraction of some of the shavings with alcohol yielded some resinous matter, but other solvents failed to remove appreciable amounts of soluble constituents. Some six kilos of shavings of the dry wood were then treated with steam till about fifty liters of distillate had been obtained. The latter was turbid and retained the peculiar odor of the wood. On standing, no oil separated, but on shaking with petroleum ether and allowing the latter to evaporate some two grams of white crystals, which possessed the odor of the wood in a marked degree, were obtained. Recrystallization of these gave a pure white compound, which melted at 80° . It is soluble in a great variety of organic solvents, but does not crystallize readily. A single combustion gave $C = 73.23$, $H = 7.72$. The molecular weight obtained by the freezing point method using glacial acetic acid as solvent was 157. Apparently the formula of the compound is $C_{10}H_{12}O_2$. The small amount of material available made further study of it impracticable.

UNIVERSITY OF CALIFORNIA, BERKELEY, JAN. 14, 1907.

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THE UNIFICATION OF REDUCING SUGAR METHODS.

BY PERCY H. WALKER.

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Munson and Walker have recently published¹ uniform methods and tables for the determination of *d*-glucose and invert sugar alone, and invert sugar when mixed with sucrose. The authors hoped to take up the study of maltose and lactose. It is regretted that Mr. Munson was unable to continue the work, and the writer, therefore, undertook to complete the work alone.

Commercial lactose was repeatedly recrystallized by dissolving in hot water and pouring into alcohol with constant stirring. The fine crystals were dried at first by drawing air over them for three days, and then dried for five days over calcium chloride.

Von Lippman² states that lactose prepared in this manner has the formula, $5C_{12}H_{22}O_{11} + 2H_2O$. The product obtained, however, had a composition represented by the formula, $C_{12}H_{22}O_{11} + \frac{1}{2}H_2O$. A water determination made according to the method used by Brown, Morris and Miller³ gave 2.43 per cent. This determination was made as follows: The powdered lactose was placed in a small flask connected by a T tube with another small flask containing P_2O_5 , and the remaining limb of the tube connected with an exhaust pump. The system was exhausted and the flask containing the lactose kept at 30° for two hours, cooled to room tem-

¹ This Journal, 28, 663 (1906).

² Die Chemie der Zuckerarten, 3 Auflage—1526.

³ J. Chem. Soc. Trans., 71., 76.

perature, and weighed. It had not changed in weight, proving the absence of moisture. The apparatus was again connected up, exhausted, the flask containing the lactose placed in a paraffin bath at 80° , kept at that temperature for one hour, then heated slowly to 130° , kept at that temperature for one hour, cooled and weighed. The product was still perfectly white; but on heating for another hour at 140° , the powder became somewhat tinged with brown. Carbon determinations were made yielding 40.80 per cent. and 40.98 per cent., theory being 41.02 per cent. The specific rotation of the lactose was 52.93° .

The maltose used was prepared by recrystallizing Merck's C. P. maltose three times, and drying below 80° *in vacuo*. This gave a specific rotation of 130.48° , corresponding to 137.2 for the anhydrous maltose, which showed it to be a very pure preparation.

Some of the same crucibles used in the former work were used in weighing the cuprous oxide, and the method of manipulation previously described was followed. No difficulty was encountered in getting concordant results with lactose by the two-minute boiling, and this method can be relied upon to give as accurate results as the ordinary method of boiling six minutes.

As in the previous work, blanks were run each day and corrections applied to all weighings. In Table I the blanks of each set of determinations are given.

TABLE I.

Number of Set.	Individual blanks mgs.	Average mgs.
1	0.7 0.0	0.4
2	0.0 --0.8	-0.4
3	0.0	0.0
4	0.4 1.6	1.0
5	0.6 0.8	0.7
6	0.3 1.0	0.6
7	0.4 0.6	0.5
8	0.6 0.2	0.4
9	0.4 -0.2	0.1

TABLE II.

Reducing Sugar mgs.	Lactose $C_{12}H_{22}O_{11} \cdot \frac{1}{2}H_2O$		Maltose $C_{12}H_{22}O_{11}H_2O$		
	found	accepted average.	found	accepted average.	
20	33.2	33.0	26.7	26.6	
	32.8		26.5		
40	62.9	63.2	51.7	51.2	
	63.4		50.7		
60	92.2	92.9	75.3	74.7	
	93.6		73.9		
80	123.8	123.9	98.5	98.1	
	124.0		97.7		
100	154.4	154.1	122.9	122.6	
	153.8		122.3		
120	180.2	180.6	145.6	146.3	
	181.0		147.0		
140	210.2	210.7	170.4	170.6	
	211.2		170.8		
	239.4		192.0		
160	239.4	239.4	193.2	192.6	
	265.7*		216.4		
	268.4		217.2		
180	268.1	268.0		216.8	
	267.6				
	296.4		297.1		243.0
	297.8				242.6
220	327.0	326.8	266.4	266.6	
	326.6		268.4*		
			268.3*		
			266.7		
240	355.2	356.1	290.0	289.7	
	356.9		289.4		
	384.2		312.6*		
260	384.6	384.4	315.0	314.7	
			315.1		
			314.1		
			340.4		
280	412.4*	413.9	340.2	340.3	
	414.6				
	413.1				
	413.9				
300	443.6	443.1	362.4	362.4	
	442.6		362.4		
320	470.4	470.3	388.2	387.9	
	470.1		387.6		
340			411.9	411.7	
			411.5		
360			435.9	435.4	
			434.9		
380			458.2	458.4	
			458.5		
			481.3		
400			481.7	481.5	

Table II gives the corrected weights of cuprous oxide found for varying weights of the sugars. The first column gives the number of milligrams of sugar taken, the second and fourth columns give the milligrams of cuprous oxide found, and the third and fifth columns give the average results accepted. The starred values in the second and fourth columns were discarded in taking the averages.

By taking x = reducing sugar, and
 y = cuprous oxide, the relation between the two may be expressed by the equation :

$$y = a + bx + cx^2.$$

The values of a , b , and c can be calculated by the method of least squares from the determined values.

Taking the accepted values for lactose we get the following :

$$\begin{aligned} a &= 4.1759 \\ b &= 1.148697 \\ c &= 0.00009. \end{aligned}$$

Taking the accepted values for maltose we get the following :

$$\begin{aligned} a &= 2.5795 \\ b &= 1.19694 \\ c &= 0.000106. \end{aligned}$$

By substituting these values in the above equation we can calculate the values distributing any experimental errors over the whole range. In Table III are given in parallel columns the found and calculated values of Cu_2O for each point determined.

The agreement of values determined and calculated is good, the maximum variation being 2.1 milligrams.

TABLE III.

Milligrams Sugar.	Lactose			Maltose		
	$\text{C}_{12}\text{H}_{22}\text{O}_{11} \cdot \frac{1}{2}\text{H}_2\text{O}$ Milligrams found	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$ calculated	difference	$\text{C}_{12}\text{H}_{22}\text{O}_{11}\text{H}_2\text{O}$ Milligrams found	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$ calculated	difference
20	33.0	33.9	+0.9	26.6	26.5	-0.1
40	63.2	63.5	+0.3	51.2	50.5	-0.7
60	92.9	93.1	-0.2	74.7	74.4	-0.3
80	123.9	122.6	-1.3	98.1	98.4	+0.3
100	154.1	152.0	-2.1	122.6	122.4	-0.2
120	180.6	181.3	+0.7	146.3	146.4	+0.1
140	210.7	210.6	-0.1	170.6	170.4	-0.2
160	239.4	239.8	+0.4	192.6	194.4	+1.8
180	268.0	269.0	+1.0	216.8	218.4	+1.6
200	297.1	298.0	+0.9	242.8	242.4	-0.4
220	326.8	327.0	+0.2	266.6	266.4	-0.2
240	356.1	355.9	-0.2	289.7	290.5	+0.8
260	384.4	384.7	+0.3	314.7	314.5	-0.2
280	413.9	413.5	-0.4	340.3	338.6	-1.7
300	443.1	442.2	-0.9	362.4	362.6	+0.2
320	470.3	470.8	+0.5	387.9	386.7	-1.2
340				411.7	410.8	-0.9
360				435.4	434.9	-0.5
380				458.4	459.0	+0.6
400				481.5	483.1	+1.6

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ ½H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
10	8.9	3.8	3.9	4.0	5.9	6.2
11	9.8	4.5	4.6	4.7	6.7	7.0
12	10.7	5.1	5.3	5.4	7.5	7.9
13	11.5	5.8	5.9	6.1	8.3	8.7
14	12.4	6.4	6.6	6.8	9.1	9.5
15	13.3	7.1	7.3	7.5	9.9	10.4
16	14.2	7.7	8.0	8.2	10.6	11.2
17	15.1	8.4	8.6	8.8	11.4	12.0
18	16.0	9.1	9.3	9.5	12.2	12.9
19	16.9	9.7	10.0	10.2	13.0	13.7
20	17.8	10.4	10.6	10.9	13.8	14.6
21	18.7	11.0	11.3	11.6	14.6	15.4
22	19.5	11.7	12.0	12.3	15.4	16.2
23	20.4	12.3	12.7	13.0	16.2	17.1
24	21.3	13.0	13.3	13.7	17.0	17.9
25	22.2	13.6	14.0	14.4	17.8	18.7
26	23.1	14.3	14.7	15.1	18.6	19.6
27	24.0	15.0	15.3	15.7	19.4	20.4
28	24.9	15.6	16.0	16.4	20.2	21.2
29	25.8	16.3	16.7	17.1	21.0	22.1
30	26.6	16.9	17.4	17.8	21.8	22.9
31	27.5	17.6	18.0	18.5	22.6	23.7
32	28.4	18.2	18.7	19.2	23.3	24.6
33	29.3	18.9	19.4	19.9	24.1	25.4
34	30.2	19.5	20.1	20.6	24.9	26.2
35	31.1	20.2	20.7	21.3	25.7	27.1
36	32.0	20.9	21.4	22.0	26.5	27.9
37	32.9	21.5	22.1	22.7	27.3	28.7
38	33.8	22.2	22.8	23.3	28.1	29.6
39	34.6	22.8	23.4	24.0	28.9	30.4
40	35.5	23.5	24.1	24.7	29.7	31.3
41	36.4	24.1	24.8	25.4	30.5	32.1
42	37.3	24.8	25.4	26.1	31.3	32.9
43	38.2	25.4	26.1	26.8	32.1	33.8
44	39.1	26.1	26.8	27.5	32.9	34.6
45	40.0	26.8	27.5	28.2	33.7	35.4
46	40.9	27.4	28.1	28.8	34.4	36.3
47	41.7	28.1	28.8	29.5	35.2	37.1
48	42.6	28.7	29.5	30.2	36.0	37.9
49	43.5	29.4	30.1	30.9	36.8	38.8
50	44.4	30.0	30.8	31.6	37.6	39.6
51	45.3	30.7	31.5	32.3	38.4	40.4
52	46.2	31.3	32.1	33.0	39.2	41.3
53	47.1	32.0	32.8	33.6	40.0	42.1
54	48.0	32.6	33.5	34.3	40.8	42.9
55	48.9	33.3	34.1	35.0	41.6	43.8
56	49.7	33.9	34.8	35.7	42.4	44.6
57	50.6	34.6	35.5	36.4	43.2	45.4
58	51.5	35.2	36.1	37.1	44.0	46.3

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ ½H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ M ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
59	52.4	35.9	36.8	37.7	44.8	47.1
60	53.3	36.5	37.5	38.4	45.6	48.0
61	54.2	37.2	38.2	39.1	46.3	48.8
62	55.1	37.8	38.8	39.8	47.1	49.6
63	56.0	38.5	39.5	40.5	47.9	50.5
64	56.8	39.2	40.2	41.2	48.7	51.3
65	57.7	39.8	40.9	41.9	49.5	52.1
66	58.6	40.5	41.6	42.6	50.3	53.0
67	59.5	41.1	42.2	43.3	51.1	53.8
68	60.4	41.8	42.9	44.0	51.9	54.6
69	61.3	42.5	43.6	44.7	52.7	55.5
70	62.2	43.1	44.3	45.4	53.5	56.3
71	63.1	43.8	44.9	46.1	54.3	57.1
72	64.0	44.4	45.6	46.8	55.1	58.0
73	64.8	45.1	46.3	47.5	55.9	58.8
74	65.7	45.7	47.0	48.2	56.7	59.6
75	66.6	46.4	47.6	48.8	57.5	60.5
76	67.5	47.0	48.3	49.5	58.2	61.3
77	68.4	47.7	49.0	50.2	59.0	62.1
78	69.3	48.4	49.6	50.9	59.8	63.0
79	70.2	49.0	50.3	51.6	60.6	63.8
80	71.1	49.7	51.0	52.3	61.4	64.6
81	71.9	50.3	51.6	53.0	62.2	65.5
82	72.8	51.0	52.3	53.7	63.0	66.3
83	73.7	51.6	53.0	54.4	63.8	67.1
84	74.6	52.3	53.7	55.0	64.6	68.0
85	75.5	52.9	54.3	55.7	65.4	68.8
86	76.4	53.6	55.0	56.4	66.2	69.7
87	77.3	54.3	55.7	57.1	67.0	70.5
88	78.2	54.9	56.4	57.8	67.8	71.3
89	79.1	55.6	57.0	58.5	68.5	72.2
90	79.9	56.2	57.7	59.2	69.3	73.0
91	80.8	56.9	58.4	59.9	70.1	73.8
92	81.7	57.5	59.0	60.6	70.9	74.7
93	82.6	58.2	59.7	61.3	71.7	75.5
94	83.5	58.8	60.4	61.9	72.5	76.3
95	84.4	59.5	61.1	62.6	73.3	77.2
96	85.3	60.2	61.7	63.3	74.1	78.0
97	86.2	60.8	62.4	64.0	74.9	78.8
98	87.1	61.5	63.1	64.7	75.7	79.7
99	87.9	62.1	63.8	65.4	76.5	80.5
100	88.8	62.8	64.4	66.1	77.3	81.3
101	89.7	63.4	65.1	66.8	78.1	82.2
102	90.6	64.1	65.8	67.5	78.8	83.0
103	91.5	64.7	66.4	68.1	79.6	83.8
104	92.4	65.4	67.1	68.8	80.4	84.7
105	93.3	66.1	67.8	69.5	81.2	85.5
106	94.2	66.7	68.5	70.2	82.0	86.3
107	95.0	67.4	69.1	70.9	82.8	87.2

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ ½H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
108	95.9	68.0	69.8	71.6	83.6	88.0
109	96.8	68.7	70.5	72.3	84.4	88.8
110	97.7	69.3	71.1	73.0	85.2	89.7
111	98.6	70.0	71.8	73.6	86.0	90.5
112	99.5	70.6	72.5	74.3	86.8	91.3
113	100.4	71.3	73.1	75.0	87.6	92.2
114	101.3	71.9	73.8	75.7	88.4	93.0
115	102.2	72.6	74.5	76.4	89.2	93.9
116	103.0	73.2	75.2	77.1	90.0	94.7
117	103.9	73.9	75.8	77.8	90.7	95.5
118	104.8	74.5	76.5	78.5	91.5	96.4
119	105.7	75.2	77.2	79.1	92.3	97.2
120	106.6	75.8	77.8	79.8	93.1	98.0
121	107.5	76.5	78.5	80.5	93.9	98.9
122	108.4	77.1	79.2	81.2	94.7	99.7
123	109.3	77.8	79.9	81.9	95.5	100.5
124	110.1	78.5	80.5	82.6	96.3	101.4
125	111.0	79.1	81.2	83.3	97.1	102.2
126	111.9	79.8	81.9	84.0	97.9	103.0
127	112.8	80.4	82.5	84.7	98.7	103.9
128	113.7	81.1	83.2	85.4	99.4	104.7
129	114.6	81.7	83.9	86.0	100.2	105.5
130	115.5	82.4	84.6	86.7	101.0	106.4
131	116.4	83.1	85.2	87.4	101.8	107.2
132	117.3	83.7	85.9	88.1	102.6	108.0
133	118.1	84.4	86.6	88.8	103.4	108.9
134	119.0	85.0	87.3	89.5	104.2	109.7
135	119.9	85.7	87.9	90.2	105.0	110.5
136	120.8	86.3	88.6	90.9	105.8	111.4
137	121.7	87.0	89.3	91.6	106.6	112.2
138	122.6	87.7	90.0	92.3	107.4	113.0
139	123.5	88.3	90.6	93.0	108.2	113.9
140	124.4	89.0	91.3	93.6	109.0	114.7
141	125.2	89.6	92.0	94.3	109.8	115.5
142	126.1	90.3	92.6	95.0	110.5	116.4
143	127.0	90.9	93.3	95.7	111.3	117.2
144	127.9	91.6	94.0	96.4	112.1	118.0
145	128.8	92.2	94.7	97.1	112.9	118.9
146	129.7	92.9	95.3	97.8	113.7	119.7
147	130.6	93.5	96.0	98.4	114.5	120.5
148	131.5	94.2	96.7	99.1	115.3	121.4
149	132.4	94.8	97.3	99.8	116.1	122.2
150	133.2	95.5	98.0	100.5	116.9	123.0
151	134.1	96.2	98.7	101.2	117.7	123.9
152	135.0	96.8	99.3	101.9	118.5	124.7
153	135.9	97.5	100.0	102.6	119.3	125.5
154	136.8	98.1	100.7	103.3	120.0	126.4
155	137.7	98.8	101.4	104.0	120.8	127.2
156	138.6	99.4	102.0	104.7	121.6	128.0

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ · $\frac{1}{2}$ H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
157	139.5	100.1	102.7	105.3	122.4	128.9
158	104.3	100.7	103.4	105.0	123.2	129.7
159	141.2	101.4	104.1	106.7	124.0	130.5
160	142.1	102.0	104.7	107.4	124.8	131.4
161	143.0	102.7	105.4	108.1	125.6	132.2
162	143.9	103.4	106.1	108.8	126.4	133.0
163	144.8	104.0	106.7	109.5	127.2	133.9
164	145.7	104.7	107.4	110.2	128.0	134.7
165	146.6	105.3	108.1	110.9	128.8	135.5
166	147.5	106.0	108.8	111.5	129.6	136.4
167	148.3	106.6	109.4	112.2	130.3	137.2
168	149.2	107.3	110.1	112.9	131.1	138.0
169	150.1	107.9	110.8	113.6	131.9	138.9
170	151.0	108.6	111.4	114.3	132.7	139.7
171	151.9	109.2	112.1	115.0	133.5	140.5
172	152.8	109.9	112.8	115.7	134.3	141.4
173	153.7	110.5	113.5	116.4	135.1	142.2
174	154.6	111.2	114.1	117.1	135.9	143.0
175	155.5	111.9	114.8	117.7	136.7	143.9
176	156.3	112.5	115.5	118.4	137.5	144.7
177	157.2	113.2	116.1	119.1	138.3	145.5
178	158.1	113.8	116.8	119.8	139.1	146.4
179	159.0	114.5	117.5	120.5	139.8	147.2
180	159.9	115.1	118.2	121.2	140.6	148.0
181	160.8	115.8	118.8	121.9	141.4	148.9
182	161.7	116.5	119.5	122.6	142.2	149.7
183	162.6	117.1	120.2	123.3	143.0	150.5
184	163.4	117.8	120.9	123.9	143.8	151.4
185	164.3	118.4	121.5	124.6	144.6	152.2
186	165.2	119.1	122.2	125.3	145.4	153.0
187	166.1	119.7	122.9	126.0	146.2	153.9
188	167.0	120.4	123.5	126.7	147.0	154.7
189	167.9	121.0	124.2	127.4	147.8	155.5
190	168.8	121.7	124.9	128.1	148.6	156.4
191	169.7	122.3	125.5	128.8	149.3	157.2
192	170.5	123.0	126.2	129.5	150.1	158.0
193	171.4	123.6	126.9	130.1	150.9	158.9
194	172.3	124.3	127.6	130.8	151.7	159.7
195	173.2	125.0	128.2	131.5	152.5	160.5
196	174.1	125.6	128.9	132.2	153.3	161.4
197	175.0	126.3	129.6	132.9	154.1	162.2
198	175.9	126.9	130.3	133.6	154.9	163.0
199	176.8	127.6	130.9	134.3	155.7	163.9
200	177.7	128.2	131.6	135.0	156.5	164.7
201	178.5	128.9	132.3	135.7	157.3	165.5
202	179.4	129.5	132.9	136.3	158.1	166.4
203	180.3	130.2	133.6	137.0	158.8	167.2
204	181.2	130.8	134.3	137.7	159.6	168.0
205	182.1	131.5	135.0	138.4	160.4	168.9

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ ½H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ A ₂₂ O ₁₁ H ₂ O)
206	183.0	132.1	135.6	139.1	161.2	169.7
207	183.9	132.8	136.3	139.8	162.0	170.5
208	184.8	133.4	137.0	140.5	162.8	171.4
209	185.6	134.1	137.6	141.2	163.6	172.2
210	186.5	134.8	138.3	141.9	164.4	173.0
211	187.4	135.4	139.0	142.5	165.2	173.8
212	188.3	136.1	139.6	143.2	166.0	174.7
213	189.2	136.7	140.3	143.9	166.8	175.5
214	190.1	137.4	141.0	144.6	167.5	176.4
215	191.0	138.0	141.7	145.3	168.3	177.2
216	191.9	138.7	142.3	146.0	169.1	178.0
217	192.8	139.3	143.0	146.7	169.9	178.9
218	193.6	140.0	143.7	147.3	170.7	179.7
219	194.5	140.6	144.3	148.0	171.5	180.5
220	195.4	141.3	145.0	148.7	172.3	181.4
221	196.3	141.9	145.7	149.4	173.1	182.2
222	197.2	142.6	146.3	150.1	173.9	183.0
223	198.1	143.2	147.0	150.8	174.7	183.9
224	199.0	143.9	147.7	151.5	175.5	184.7
225	199.9	144.6	148.4	152.2	176.2	185.5
226	200.7	145.2	149.0	152.9	177.0	186.4
227	201.6	145.9	149.7	153.6	177.8	187.2
228	202.5	146.5	150.4	154.2	178.6	188.0
229	203.4	147.2	151.1	154.9	179.4	188.8
230	204.3	147.8	151.7	155.6	180.2	189.7
231	205.2	148.5	152.4	156.3	181.0	190.5
232	206.1	149.1	153.1	157.0	181.8	191.3
233	207.0	149.8	153.7	157.7	182.6	192.2
234	207.9	150.5	154.4	158.4	183.4	193.0
235	208.7	151.1	155.1	159.1	184.2	193.8
236	209.6	151.8	155.8	159.7	184.9	194.7
237	210.5	152.4	156.4	160.4	185.7	195.5
238	211.4	153.1	157.1	161.1	186.5	196.3
239	212.3	153.7	157.8	161.8	187.3	197.2
240	213.2	154.4	158.4	162.5	188.1	198.0
241	214.1	155.0	159.1	163.2	188.9	198.8
242	215.0	155.7	159.8	163.9	189.7	199.7
243	215.8	156.3	160.5	164.6	190.5	200.5
244	216.7	157.0	161.1	165.3	191.3	201.3
245	217.6	157.7	161.8	166.0	192.1	202.2
246	218.5	158.3	162.5	166.6	192.9	203.0
247	219.4	159.0	163.1	167.3	193.6	203.8
248	220.3	159.6	163.8	168.0	194.4	204.7
249	221.2	160.3	164.5	168.7	195.2	205.5
250	222.1	160.9	165.2	169.4	196.0	206.3
251	223.0	161.6	165.8	170.1	196.8	207.2
252	223.8	162.2	166.5	170.8	197.6	208.0
253	224.7	162.9	167.2	171.5	198.4	208.8
254	225.6	163.5	167.9	172.2	199.2	209.7

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ ½H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
255	226.5	164.2	168.5	172.8	200.0	210.5
256	227.4	164.8	169.2	173.5	200.8	211.3
257	228.3	165.5	169.9	174.2	201.6	212.2
258	229.2	166.2	170.5	174.9	202.3	213.0
259	230.1	166.8	171.2	175.6	203.1	213.8
260	231.0	167.5	171.9	176.3	203.9	214.7
261	231.8	168.1	172.5	177.0	204.7	215.5
262	232.7	168.8	173.2	177.7	205.5	216.3
263	233.6	169.4	173.9	178.3	206.3	217.2
264	234.5	170.1	174.6	179.0	207.1	218.0
265	235.4	170.7	175.2	179.7	207.9	218.8
266	236.3	171.4	175.9	180.4	208.7	219.7
267	237.2	172.0	176.6	181.1	209.5	220.5
268	238.1	172.7	177.2	181.8	210.3	221.3
269	238.9	173.3	177.9	182.5	211.0	222.1
270	239.8	174.0	178.6	183.2	211.8	223.0
271	240.7	174.6	179.2	183.8	212.6	223.8
272	241.6	175.3	179.9	184.5	213.4	224.6
273	242.5	176.0	180.6	185.2	214.2	225.5
274	243.4	176.6	181.3	185.9	215.0	226.3
275	244.3	177.3	181.9	186.6	215.8	227.1
276	245.2	177.9	182.6	187.3	216.6	228.0
277	246.1	178.6	183.3	188.0	217.4	228.8
278	246.9	179.2	184.0	188.7	218.2	229.6
279	247.8	179.9	184.6	189.4	218.9	230.5
280	248.7	180.6	185.3	190.1	219.7	231.3
281	249.6	181.2	186.0	190.7	220.5	232.1
282	250.5	181.9	186.6	191.4	221.3	233.0
283	251.4	182.5	187.3	192.1	222.1	233.8
284	252.3	183.2	188.0	192.8	222.9	234.6
285	253.2	183.8	188.7	193.5	223.7	235.5
286	254.0	184.5	189.3	194.2	224.5	236.3
287	254.9	185.1	190.0	194.9	225.3	237.1
288	255.8	185.8	190.7	195.5	226.1	238.0
289	256.7	186.4	191.3	196.2	226.9	238.8
290	257.6	187.1	192.0	196.9	227.6	239.6
291	258.5	187.7	192.7	197.6	228.4	240.5
292	259.4	188.4	193.3	198.3	229.2	241.3
293	260.3	189.0	194.0	199.0	230.0	242.1
294	261.2	189.7	194.7	199.7	230.8	242.9
295	262.0	190.3	195.4	200.4	231.6	243.8
296	262.9	191.0	196.0	201.0	232.4	244.6
297	263.8	191.7	196.7	201.7	233.2	245.4
298	264.7	192.3	197.4	202.4	234.0	246.3
299	265.6	193.0	198.0	203.1	234.8	247.1
300	266.5	193.6	198.7	203.8	235.5	247.9
301	267.4	194.3	199.4	204.5	236.3	248.8
302	268.3	194.9	200.0	205.2	237.1	249.6
303	269.1	195.6	200.7	205.9	237.9	250.4

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ ½H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
304	270.0	196.2	201.4	206.5	238.7	251.3
305	270.9	196.9	202.1	207.2	239.5	252.1
306	271.8	197.5	202.7	207.9	240.3	252.9
307	272.7	198.2	203.4	208.6	241.1	253.8
308	273.6	198.8	204.1	209.3	241.9	254.6
309	274.5	199.5	204.7	210.0	242.7	255.4
310	275.4	200.1	205.4	210.7	243.5	256.3
311	276.3	200.8	206.1	211.4	244.2	257.1
312	277.1	201.4	206.7	212.1	245.0	257.9
313	278.0	202.1	207.4	212.7	245.8	258.8
314	278.9	202.8	208.1	213.4	246.6	259.6
315	279.8	203.4	208.8	214.1	247.4	260.4
316	280.7	204.1	209.4	214.8	248.2	261.2
317	281.6	204.7	210.1	215.5	249.0	262.1
318	282.5	205.4	210.8	216.2	249.8	262.9
319	283.4	206.0	211.5	216.9	250.6	263.7
320	284.2	206.7	212.1	217.6	251.3	264.6
321	285.1	207.3	212.8	218.3	252.1	265.4
322	286.0	208.0	213.5	218.9	252.9	266.2
323	286.9	208.6	214.1	219.6	253.7	267.1
324	287.8	209.3	214.8	220.3	254.5	267.9
325	288.7	210.0	215.5	221.0	255.3	268.7
326	289.6	210.6	216.2	221.7	256.1	269.6
327	290.5	211.3	216.8	222.4	256.9	270.4
328	291.4	211.9	217.5	223.1	257.7	271.2
329	292.2	212.6	218.2	223.8	258.5	272.1
330	293.1	213.2	218.8	224.4	259.3	272.9
331	294.0	213.9	219.5	225.1	260.0	273.7
332	294.9	214.5	220.2	225.8	260.8	274.6
333	295.8	215.2	220.8	226.5	261.6	275.4
334	296.7	215.8	221.5	227.2	262.4	276.2
335	297.6	216.5	222.2	227.9	263.2	277.0
336	298.5	217.1	222.9	228.6	264.0	277.9
337	299.3	217.8	223.5	229.2	264.8	278.7
338	300.2	218.4	224.2	229.9	265.6	279.5
339	301.1	219.1	224.9	230.6	266.4	280.4
340	302.0	219.8	225.5	231.3	267.1	281.2
341	302.9	220.4	226.2	232.0	267.9	282.0
342	303.8	221.1	226.9	232.7	268.7	282.9
343	304.7	221.7	227.5	233.4	269.5	283.7
344	305.6	222.4	228.2	234.1	270.3	284.5
345	306.5	223.0	228.9	234.7	271.1	285.4
346	307.3	223.7	229.6	235.4	271.9	286.2
347	308.2	224.3	230.2	236.1	272.7	287.0
348	309.1	225.0	230.9	236.8	273.5	287.9
349	310.0	225.6	231.6	237.5	274.3	288.7
350	310.9	226.3	232.2	238.2	275.0	289.5
351	311.8	226.9	232.9	238.9	275.8	290.4
352	312.7	227.6	233.6	239.6	276.6	291.2

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ · $\frac{1}{2}$ H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ A ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
353	313.6	228.2	234.2	240.2	277.4	292.0
354	314.4	228.9	234.9	240.9	278.2	292.8
355	315.3	229.5	235.6	241.6	279.0	293.7
356	316.2	230.2	236.3	242.3	279.8	294.5
357	317.1	230.8	236.9	243.0	280.6	295.3
358	318.0	231.5	237.6	243.7	281.4	296.2
359	318.9	232.1	238.3	244.4	282.2	297.0
360	319.8	232.8	238.9	245.1	282.9	297.8
361	320.7	233.5	239.6	245.8	283.7	298.7
362	321.6	234.1	240.3	246.4	284.5	299.5
363	322.4	234.8	241.0	247.1	285.3	300.3
364	323.3	235.4	241.6	247.8	286.1	301.2
365	324.2	236.1	242.3	248.5	286.9	302.0
366	325.1	236.7	243.0	249.2	287.7	302.8
367	326.0	237.4	243.6	249.9	288.5	303.6
368	326.9	238.1	244.3	250.6	289.3	304.5
369	327.8	238.7	245.0	251.3	290.0	305.3
370	328.7	239.4	245.7	252.0	290.8	306.1
371	329.5	240.0	246.3	252.7	291.6	307.0
372	330.4	240.7	247.0	253.3	292.4	307.8
373	331.3	241.3	247.7	254.0	293.2	308.6
374	332.2	242.0	248.4	254.7	294.0	309.5
375	333.1	242.6	249.0	255.4	294.8	310.3
376	334.0	243.3	249.7	256.1	295.6	311.1
377	334.9	243.9	250.4	256.8	296.4	312.0
378	335.8	244.6	251.0	257.5	297.2	312.8
379	336.7	245.2	251.7	258.2	297.9	313.6
380	337.5	245.9	252.4	258.8	298.7	314.5
381	338.4	246.6	253.0	259.5	299.5	315.3
382	339.3	247.2	253.7	260.2	300.3	316.1
383	340.2	247.9	254.4	260.9	301.1	316.9
384	341.1	248.5	255.1	261.6	301.9	317.8
385	342.0	249.2	255.7	262.3	302.7	318.6
386	342.9	249.8	256.4	263.0	303.5	319.4
387	343.8	250.5	257.1	263.6	304.2	320.3
388	344.6	251.1	257.7	264.3	305.0	321.1
389	345.5	251.8	258.4	265.0	305.8	321.9
390	346.4	252.4	259.1	265.7	306.6	322.8
391	347.3	253.1	259.7	266.4	307.4	323.6
392	348.2	253.7	260.4	267.1	308.2	324.4
393	349.1	254.4	261.1	267.8	309.0	325.2
394	350.0	255.0	261.8	268.5	309.8	326.1
395	350.9	255.7	262.4	269.1	310.6	326.9
396	351.8	256.3	263.1	269.8	311.4	327.7
397	352.6	257.0	263.8	270.5	312.1	328.6
398	353.5	257.7	264.4	271.2	312.9	329.4
399	354.4	258.3	265.1	271.9	313.7	330.2
400	355.3	259.0	265.8	272.6	314.5	331.1
401	356.2	259.6	266.4	273.3	315.3	331.9

Milligrams Cuprous Oxide (C ₁₂ H ₂₂ O ₁₁)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ ½H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
402	357.1	260.3	267.1	274.0	316.1	332.7
403	358.0	260.9	267.8	274.6	316.9	333.6
404	358.9	261.6	268.5	275.3	317.7	334.4
405	359.7	262.2	269.1	276.0	318.5	335.2
406	360.6	262.9	269.8	276.7	319.2	336.0
407	361.5	263.5	270.5	277.4	320.0	336.9
408	362.4	264.2	271.1	278.1	320.8	337.7
409	363.3	264.8	271.8	278.8	321.6	338.5
410	364.2	265.5	272.5	279.5	322.4	339.4
411	365.1	266.1	273.1	280.1	323.2	340.2
412	366.0	266.8	273.8	280.8	324.0	341.0
413	366.9	267.4	274.5	281.5	324.8	341.9
414	367.7	268.1	275.2	282.2	325.6	342.7
415	368.6	268.7	275.8	282.9	326.3	343.5
416	369.5	269.4	276.5	283.6	327.1	344.4
417	370.4	270.1	277.2	284.3	327.9	345.2
418	371.3	270.7	277.8	285.0	328.7	346.0
419	372.2	271.4	278.5	285.6	329.5	346.8
420	373.1	272.0	279.2	286.3	330.3	347.7
421	374.0	272.7	279.8	287.0	331.1	348.5
422	374.8	273.3	280.5	287.7	331.9	349.3
423	375.7	274.0	281.2	288.4	332.7	350.2
424	376.6	274.6	281.9	289.1	333.4	351.0
425	377.5	275.3	282.5	289.8	334.2	351.8
426	378.4	275.9	283.2	290.5	335.0	352.7
427	379.3	276.6	283.9	291.1	335.8	353.5
428	380.2	277.2	284.5	291.8	336.6	354.3
429	381.1	277.9	285.2	292.5	337.4	355.1
430	382.0	278.5	285.9	293.2	338.2	356.0
431	382.8	279.2	286.5	293.9	339.0	356.8
432	383.7	279.8	287.2	294.6	339.7	357.6
433	384.6	280.5	287.9	295.3	340.5	358.5
434	385.5	281.2	288.6	295.9	341.3	359.3
435	386.4	281.8	289.2	296.6	342.1	360.1
436	387.3	282.5	289.9	297.3	342.9	361.0
437	388.2	283.1	290.6	298.0	343.7	361.8
438	389.1	283.8	291.2	298.7	344.5	362.6
439	390.0	284.4	291.9	299.4	345.3	363.4
440	390.8	285.1	292.6	300.1	346.1	364.3
441	391.7	285.7	293.2	300.8	346.8	365.1
442	392.6	286.4	293.9	301.4	347.6	365.9
443	393.5	287.0	294.6	302.1	348.4	366.8
444	394.4	287.7	295.3	302.8	349.2	367.6
445	395.3	288.3	295.9	303.5	350.0	368.4
446	396.2	289.0	296.6	304.2	350.8	369.3
447	397.1	289.6	297.3	304.9	351.6	370.1
448	397.9	290.3	297.9	305.6	352.4	370.9
449	398.8	290.9	298.6	306.3	353.2	371.7
450	399.7	291.6	299.3	306.9	353.9	372.6

Milligrams Cuprous Oxide (Cu ₂ O)	Milligrams Copper (Cu)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ ½H ₂ O)	Milligrams Lactose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁)	Milligrams Maltose (C ₁₂ H ₂₂ O ₁₁ H ₂ O)
451	400.6	292.3	299.0	307.6	354.7	373.4
452	401.5	292.9	300.6	308.3	355.5	374.2
453	402.4	293.6	301.3	309.0	356.3	375.1
454	403.3	294.2	302.0	309.7	357.1	375.9
455	404.2	294.9	302.6	310.4	357.9	376.7
456	405.1	295.5	303.3	311.1	358.7	377.6
457	405.9	296.2	304.0	311.8	359.5	378.4
458	406.8	296.8	304.6	312.4	360.3	379.2
459	407.7	297.5	305.3	313.1	361.0	380.0
460	408.6	298.1	306.0	313.8	361.8	380.9
461	409.5	298.8	306.6	314.5	362.6	381.7
462	410.4	299.4	307.3	315.2	363.4	382.5
463	411.3	300.1	308.0	315.9	364.2	383.4
464	412.2	300.7	308.7	316.6	365.0	384.2
465	413.0	301.4	309.3	317.3	365.8	385.0
466	413.9	302.0	310.0	317.9	366.6	385.9
467	414.8	302.7	310.7	318.6	367.3	386.7
468	415.7	303.3	311.3	319.3	368.1	387.5
469	416.6	304.0	312.0	320.0	368.9	388.3
470	417.5	304.7	312.7	320.7	369.7	389.2
471	418.4	305.3	313.3	321.4	370.5	390.0
472	419.3	306.0	314.0	322.1	371.3	390.8
473	420.2	306.6	314.7	322.8	372.1	391.7
474	421.0	307.3	315.4	323.4	372.9	392.5
475	421.9	307.9	316.0	324.1	373.7	393.3
476	422.8	308.6	316.7	324.8	374.4	394.2
477	423.7	309.2	317.4	325.5	375.2	395.0
478	424.6	309.9	318.0	326.2	376.0	395.8
479	425.5	310.5	318.7	326.9	376.8	396.6
480	426.4	311.2	319.4	327.6	377.6	397.5
481	427.3	311.8	320.0	328.2	378.4	398.3
482	428.1	312.5	320.7	328.9	379.2	399.1
483	429.0	313.1	321.4	329.6	380.0	400.0
484	429.9	313.8	322.1	330.3	380.7	400.8
485	430.8	314.4	322.7	331.0	381.5	401.6
486	431.7	315.1	323.4	331.7	382.3	402.4
487	432.6	315.8	324.1	332.4	383.1	403.3
488	433.5	316.4	324.7	333.1	383.9	404.1
489	434.4	317.1	325.4	333.7	384.7	404.9
490	435.3	317.7	326.1	334.4	385.5	405.8

The published tables for lactose and maltose do not state clearly whether the values are for the anhydrous or hydrated sugars. In Table IV the values for copper, anhydrous lactose, crystallized lactose of the formula C₁₂H₂₂O₁₁½H₂O, crystallized lactose of the formula C₁₂H₂₂O₁₁H₂O, anhydrous maltose, and crystallized maltose for each milligram of cuprous oxide from 10 to 490 are given. The table is simply a completion of the table of Munson and Walker, the two tables together giving the necessary data for all of the more common reducing sugars.