

Summarizing this calculation of the potential of iron and this discussion of the effect of the probable experimental errors on the final result, we may say:

(1) That the calculated potential of iron against a molecular normal solution of ferrous ions, taking the calomel electrode as  $-0.564$  volt, is **0.192**, in excellent agreement with the experimental results of Richards and Behr;

(2) That, in so far as errors in the experimental data involved are concerned, this result can scarcely be in error by more than three centivolts, and that it is probably too low, rather than too high.

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[CONTRIBUTION FROM THE BUREAU OF CHEMISTRY, U. S. DEPT. OF AGRICULTURE.]  
**THE INVERSION OF CANE SUGAR BY INVERTASE. VI. A THEORY  
 OF THE INFLUENCE OF ACIDS AND ALKALIS ON THE  
 ACTIVITY OF INVERTASE.**

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In alkaline solutions invertase shows no activity, in weakly acid solutions its enzymotic power reaches a maximum from which it decreases with increasing acidity. The simplest theoretical interpretation of this striking fact is that acids and alkalis combine with invertase by the principles of the law of mass action and prevent it from inverting cane sugar. In the following calculations this hypothesis will be tested. If invertase combines with both acids and alkalis it is an amphoteric electrolyte and may be assumed to dissociate as follows:

(1) Invertase  $\rightleftharpoons \dot{H} + \text{anion}$  (acidic dissociation).

(2) Invertase  $\rightleftharpoons OH' + \text{cation}$  (basic dissociation).

If  $a$  units of invertase are dissolved in a unit volume of a solution containing hydrogen and hydroxyl ions in the fixed concentrations ( $\dot{H}$ ) and ( $OH$ ), it will form  $x$  units of anion and  $y$  units of cation, leaving  $a - x - y$  units of undissociated invertase. The mass-action law requires the fulfilment of the following conditions when equilibrium is attained:

$$(3) \frac{(x)(\dot{H})}{(a-x-y)} = K_1, \text{ and } (4) \frac{(y)(OH')}{(a-x-y)} = K_2$$

The quantity  $a - x - y$  is the concentration of uncombined or undissociated invertase, and it is here assumed that the enzymotic activity is caused by this substance and is proportional to its concentration.

difference, however, must be small, since, from the properties of ferrous oxide, we know that the heat of hydration is probably very small. Since the solubility of ferrous oxide, could it be measured, would be greater than that of ferrous hydroxide, this inaccuracy also tends to make the true potential higher.

Solving (3) and (4) for  $a - x - y$  gives

$$\text{Activity (i. e., } a - x - y) = \frac{a}{1 + \frac{K_2(\dot{H})}{K_w} + \frac{K_1}{(\dot{H})}} \quad (5)$$

where  $K_w$  is the dissociation constant for water. This formula contains the three coefficients  $a$ ,  $K_1$ , and  $K_2$ , which are of unknown values; in order to determine the values of these coefficients the data which were found for the activity of invertase in three solutions containing small concentrations of hydrochloric acid are used; namely:<sup>1</sup>

HCl concentration Normal.	Activity of invertase.
0.0005.....	62
0.0015.....	61
0.008.....	37

These data when introduced in equation (5) give the values  $a = 77$ ,  $K_2/K_w = 133$ , and  $K_1 = 0.000086$ , and formula (5) becomes

$$\text{Activity} = \frac{77}{1 + 133(\dot{H}) + \frac{0.000086}{\dot{H}}} \quad (6)$$

From this formula the activities of invertase over a considerable range of acidity and alkalinity have been calculated and are recorded in Table I in comparison with the activities which were found experimentally

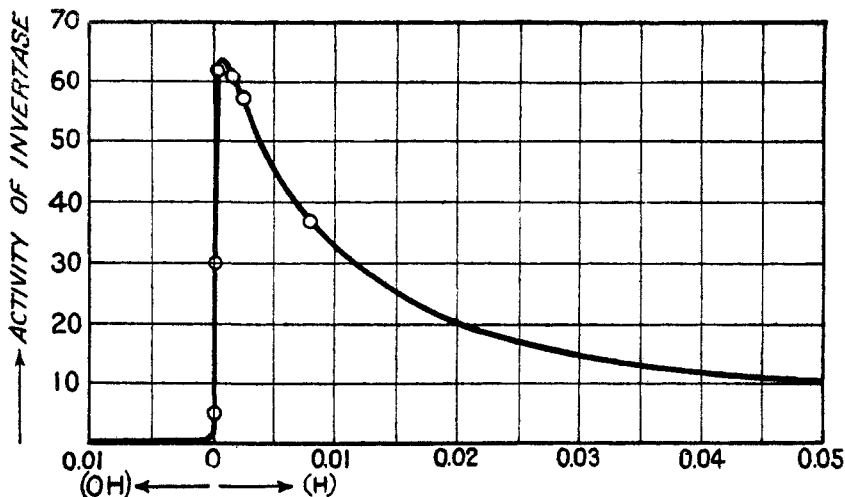
TABLE I.—CALCULATED AND OBSERVED ACTIVITIES OF INVERTASE.

HCl concentration.	Calculated activity.	Observed activity.
(10) <sup>-9</sup> (alkaline).....	0.001	0.0
(10) <sup>-7</sup> (pure water).....	0.1	5.0
(10) <sup>-6</sup> .....	0.9	....
(10) <sup>-5</sup> .....	8.0	....
0.00009.....	39	30
0.0005.....	(62)	(62)
0.0015.....	(61)	(61)
0.002.....	59	....
0.003.....	58	58
0.005.....	45	....
0.008.....	(37)	(37)
0.01.....	33	....
0.02.....	21	....
0.03.....	15	....
0.05.....	10	....

By reference to the figure it will be seen that there is a remarkably close agreement between the calculated and observed activities: the calculated values are shown by the smooth curve, the observed activi-

<sup>1</sup> THIS JOURNAL, 32, 777. In line 7 of the page referred to, the word printed "acidity" should be "activity."

ties by the circles. On account of the rapid destruction of invertase at  $30^\circ$  by acid above 0.01 normal the relation can not well be tested beyond that concentration, but it is probable that at  $0^\circ$  such measurements can be made, and this will be attempted in the near future.



Graph of the formula for the activity of invertase.

The concentration of acid for which the enzymatic activity is a maximum can be calculated from equation (5). Writing its first differential with respect to  $(\dot{H})$  equal to zero and solving gives

$$(\dot{H})_{\max} = \sqrt{\frac{K_1 K_w}{K_2}}. \quad (7)$$

Substituting in this the values previously found for these constants gives  $(\dot{H})_{\max} = 0.8(10)^{-3}$  at  $30^\circ$ . Sørensen,<sup>1</sup> from his experiments at  $52^\circ$ , has found this value to be approximately  $(10)^{-4}$ ; our results are thus in fair agreement with his, but they can not be strictly compared because of the different temperatures used, namely,  $52^\circ$  and  $32^\circ$ .

[CONTRIBUTION FROM THE JOHN HARRISON LABORATORY OF CHEMISTRY.]

### METALLIC STRONTIUM.<sup>2</sup>

BY BEN L. GLASCOCK.

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In no case has strontium been obtained in sufficient amount to admit of a thorough study of its properties. The most complete investiga-

<sup>1</sup> *Comptes rendus des travaux du Laboratoire de Carlsberg*, 8, 132 (1909).

<sup>2</sup> From the author's doctoral thesis, 1909.