

THE RATE OF SOLUTION AND THE POTENTIAL OF DISSOLVED IRON

Ya. V. Durdin and M. A. Oranskaya

In our previous paper [1] we published the results of our investigation of the rate of solution and the potential of dissolving chromium in hydrochloric and sulfuric acids. The present research was undertaken with a view to learning how far the behavior patterns observed in the dissolution of chromium hold good for the dissolution of other metals.

Thanks to the researches of M. Tsentnershver on the rate at which cadmium, tin, and aluminum dissolve,* we were able to assert, at the time this investigation was carried out, that the representative type of relationship derived by us for the rate of solution of chromium as a function of the concentration of hydrochloric acid was qualitatively analogous to the corresponding relationship derived by Tsentnershver for the rates at which the above-mentioned metals dissolve [3].

Tsentnershver's data on the rate of solution of iron carbonyl did not enable one to estimate the variation of this rate with the acid concentration [4].

An exponential equation expressing the variation of the rate at which iron dissolves with the concentration of hydrochloric acid was derived by Conroy [5].

A. Sieverts and P. Lueg [6] made a study of the dissolution of iron wire in 4 N, 5 N, and 6 N hydrochloric acid and in 4 N and 8 N sulfuric acid and came to the conclusion that the rate at which iron dissolves in hydrochloric acid is proportional to $(\text{HCl})^3$, while in sulfuric acid the rate is proportional to somewhat less than the first power of the acid concentration.

Owing to the primitive methods employed, however, we were unable to regard the results of these investigations as any more than rough approximations. S. Ram, in his investigation of the rate at which low-carbon iron dissolves in sulfuric acid, found that the rate of solution of iron rises approximately proportionally to the acid concentration in the region of moderate concentrations of sulfuric acid. At high concentrations (ca. 16 N H_2SO_4) the rate at which the iron dissolves drops sharply, the iron becoming passive [7].

Damon, in his investigation of the dissolution of steels containing various percentages of carbon in sulfuric acid, reached a similar conclusion, [8]. Closest to our research is the investigation made by A. I. Krasilshchikov [9], who made a study of the rate at which commercial sheet iron dissolves in hydrochloric and sulfuric acids at concentrations ranging from 1 N to 10 N.** The general nature of the expression for the variation of the rate of solution of iron with

*This investigation was completed before the war, part of it having been published in the Scientific Papers of Leningrad State University for 1940. [2].

**As well as in nitric acid in which the controlling factor in the kinetics of the dissolution of iron appears to be the diffusion process.

the concentration of hydrochloric or sulfuric acid derived by that author is close to what we derived for chromium as well as for iron.

Unfortunately, in nearly all these investigations of the rate of solution of iron, the rate was determined by the gravimetric method, i.e., by the loss of weight of the metal throughout the experiment, and hence represents merely the average rate applying to the whole test. Owing to the differences in the length of the induction period at various acid concentrations, this rate may differ considerably from the iron solution rate for a stationary state. Moreover, in these researches no investigation was made of the effect of stirring the solution upon the rate at which the iron dissolves, nor (what is particularly vital for us) was the potential of the dissolving iron measured. We therefore believe that the data we obtained on the solution rate and on the potential of dissolving iron are not without interest even today.

1. Experimental method. The experimental method employed in this research was essentially similar to the method described in our previous reports on magnesium [10] and chromium [1]. We might mention that the rate at which the iron dissolved was measured in the same reaction vessel, with a capacity of 1.5 liters, in which the solution rate of chromium had been measured; we shall therefore discuss at this point merely some features that were specifically characteristic of the present research.

In this research we investigated the rate of solution and the dissolution potential of Armco iron containing the following impurities:

C 0.017% Si 0.02% Mn 0.0006% P 0.01% S -

For the sake of comparison we also investigated the rate of solution of commercial light sheet iron.

We prepared plates 1.5 x 2.0 cm in size* for these tests, the plates being affixed to a metal holder by dental cement as described in our paper on chromium. The back and the edges of the plate, as well as the dental cement, were covered with bakelite lacquer, which was polymerized as described in our paper on chromium. The front surface of the plates was cleaned with fine glass paper. It should be noted that the plates of Armco iron were about 7 mm thick. Because of this appreciable thickness, the basic series of tests using Armco iron was performed on a single plate. The plates made of light sheet iron were used up in one or two tests as a rule. Connection to the potentiometer circuit was made at the upper edge of the plate by means of a copper wire soldered to the upper edge of the iron plate, which was under a glass bell and was insulated from the acid solution by the dental cement and bakelite lacquer, the end of the wire being led out through the inner tube of the metal holder as described in our previous paper on chromium.

The solutions were prepared, as in our research on chromium, with chemically pure hydrochloric acid and sulfuric acid "pure, for analysis". All the basic tests were run at a temperature of $60 \pm 0.2^\circ$. We chose so high a temperature because the rate at which Armco iron dissolved at lower temperatures was too low.

The units used in measuring the rate of solution of iron and its potential were the same in this research as in our research on chromium, i.e., the solution rate is expressed in cubic centimeters of hydrogen evolved per sq. cm. of metal surface per minute. The potential is expressed in millivolts against a saturated calomel electrode, its sign being taken as plus (+). The intensity of stirring was indicated by the stirrer rpm (ω).

The Armco iron we used originally had the shape of round rods 12 mm in diameter; in preparing the plates these rods were first flattened out on an anvil, after which the plates were given a rectangular form by means of a file. The surface was given a final treatment with fine glass paper.

2. Variation of the solution rate and of the potential of dissolving iron with the dissolution time. The curves illustrating these functions are given in Figs. 1-4. In these figures, the iron dissolution time, reckoned from the instant the metal was immersed in the solution, is plotted along the axis of abscissas. The values of the dissolution rate, $v \cdot 100$, and the potential of the dissolving iron are plotted along the axis of ordinates.

In all the figures the potential curves are denoted by digits with a prime ('), the solution rate curves being denoted by digits without a prime. Figure 1 illustrates the dissolution of light sheet iron in hydrochloric acid, Curves 1 and 1' representing the dissolution of the light sheet iron in 3.5 N hydrochloric acid, while Curves 2 and 2' represent its dissolution in 10 N hydrochloric acid. Inasmuch as the rate at which iron dissolves in the 10 N hydrochloric acid is much higher than the solution rate in the 3.5 N acid, different scales are employed for Curves 1 and 2 in Fig. 1. The solution rates are laid off as ordinates at the left for Curve 1, those for Curve 2 being laid off at the right; similarly, the scale for Curve 1 is laid off in hours along the axis of abscissas, while that for Curve 2 is laid off in minutes. Figure 2 gives the curves for two tests of the dissolution of the same light sheet iron in sulfuric acid, Curve 1 representing a test in 2 N sulfuric acid, while Curve 2 shows a test using 8 N sulf-

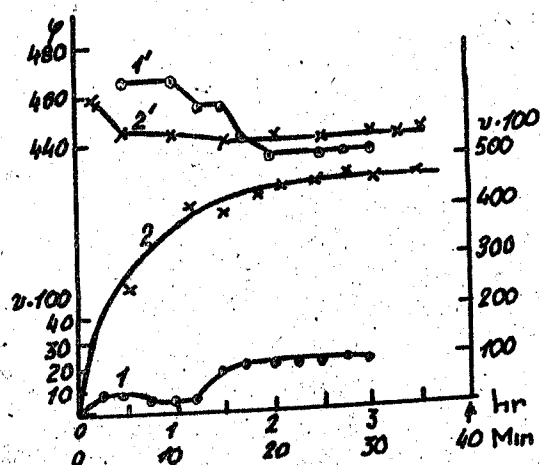


Fig. 1.

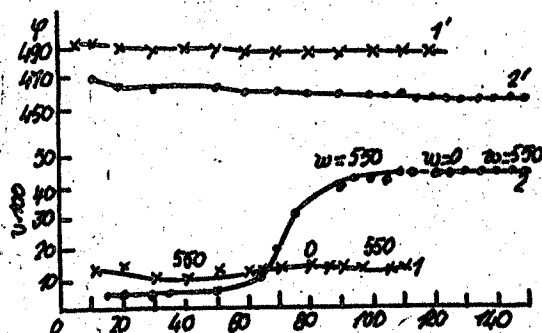


Fig. 2.

uric acid. The curves in Fig. 3 illustrate the dissolution of Armco iron in hydrochloric acid, while the curves in Fig. 4 show the behavior of the same Armco iron in sulfuric acid. When we inspect Figs. 1 and 2, we see that a constant rate of solution is not established at once when light sheet iron is dissolved in hydrochloric or sulfuric acid. At the start of the test there is a characteristic induction period, during which the solution rate rises. The potential of the dissolving light sheet iron, on the other hand, drops during this period by about 20-30 millivolts. Hence, at the beginning of the test, the potential and the rate of solution of light sheet iron move in opposite directions. It might also be noted that in the test represented by the Curves of Fig. 2, the dissolution of the light sheet iron was effected at various stirring speeds, to wit: at $\omega = 550$ rpm. to begin with, then at $\omega = 0$, and again at $\omega = 550$ rpm toward the end of the run. The curves of Fig. 2 indicate that a change in the rate at which the solution is stirred has no perceptible effect upon the rate at which light sheet iron dissolves in sulfuric acid or upon its potential. In general, we may state that the state of affairs observed in the dissolution of light sheet iron in hydrochloric acid as well as in sulfuric acid is comparatively simple. The behavior patterns

exhibited by the Armco iron are more complex.

In Fig. 3, Curve 1 represents a test of the dissolution of Armco iron in 9 N hydrochloric acid, Curve 2 representing its dissolution in 7.5 N hydrochloric acid, and Curve 3 representing its dissolution in the same 7.5 N hydrochloric acid, but at 50°. The curves in Fig. 3 indicate that the length of the induction period may vary very widely for the dissolution of Armco iron in hydrochloric acid, the variation being independent of the acid concentration. Curve 3, for example, exhibits an induction period of the order of 20-30 minutes; in the test represented by Curve 2 the induction period was still shorter; in the test represented by Curve 1, on the other hand, the induction period was very long, some 3 hours, despite the high acid concentration. (The time values laid off on the axis of abscissas must be multiplied by two for this curve.)

When we turn to sulfuric acid, the state of affairs prevailing in the dissolution of Armco iron becomes much more

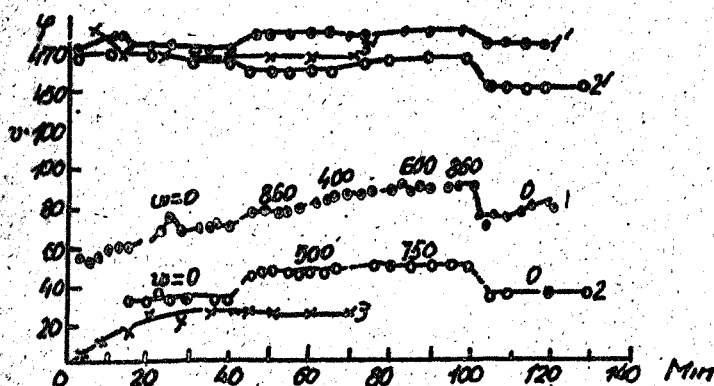


Fig. 3.

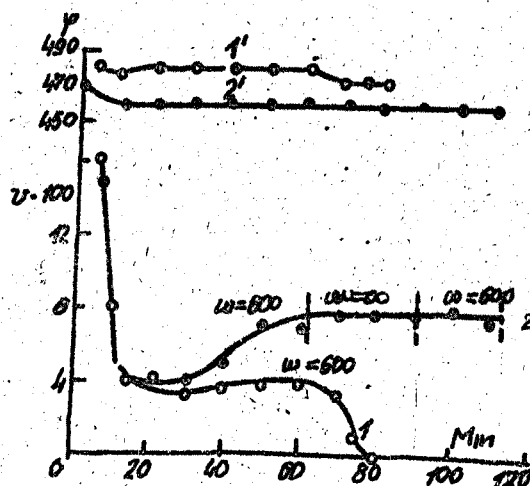


Fig. 4.

complicated. When Armco iron is dissolved in sulfuric acid, the rate of solution drops rather than rises at the start of the test. It usually reaches a constant value after a certain interval of time has passed, but the curve is hard to reproduce. In some tests the solution rate seemed to reach a constant value, but then it suddenly began to drop, falling to zero. Curve 1 in Fig. 4 represents a test of this sort. Curve 2 in that figure represents a test in which no such drop was observed.

It should likewise be observed that the sulfuric acid concentrations were fairly close in the tests represented by Curves 1 and 2 in Fig. 4, being 10 N for Curve 2 and 9 N for Curve 1, which clearly proves that the rate at which the Armco iron dissolved was greatly diminished in the test represented by Curve 1. Thus, phenomena resembling passivation are observed in the dissolution of Armco iron in sulfuric acid, though these phenomena do not involve corresponding abrupt changes in the potential of the dissolving metal. As Curve 2 in Fig. 4 indicates, stirring the solution has no appreciable effect upon the rate of dissolution or upon the potential of the Armco iron as it dissolves in sulfuric acid.

3. Temperature coefficient of the rate at which iron dissolves. The data on the temperature coefficient of the rate of solution of iron are listed in Table 1 and 2, Table 1 referring to the dissolution of Armco iron in hydrochloric acid,* while Table 2 gives the data for the dissolution of light sheet iron in

The temperature coefficient of the rate at which Armco iron dissolves in sulfuric acid was not determined because of the poor reproducibility of our data from the rate solution of Armco iron in sulfuric acid discussed above.

sulfuric acid. In these tables, C denotes the acid concentration; E is the critical increment of the solution rate; $\alpha\%$ is the temperature coefficient of the solution rate, expressed in per cent per degree; v_{t+10}/v_t is the ratio of the solution rates at $t + 10^\circ$ and t° . The values given in these tables for the solution rates at 60° are taken from the curves in Figs. 5 and 6, while the values for the rates at $40, 50$, and 70° represent data obtained in special tests.

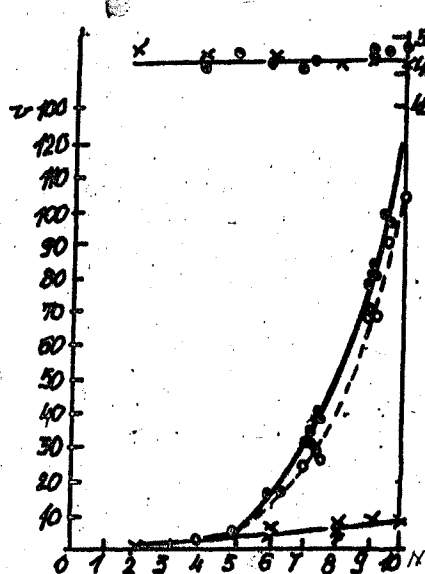


Fig. 5.

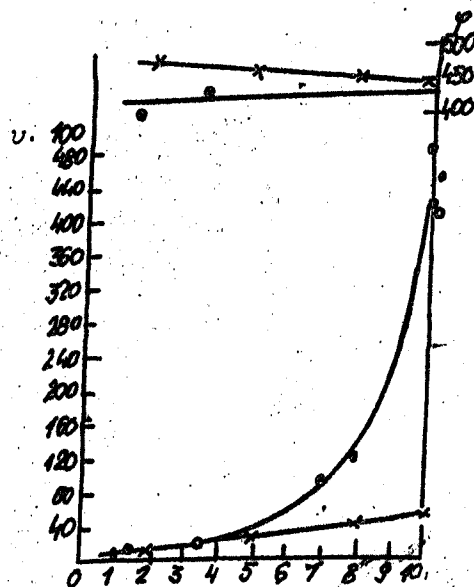


Fig. 6.

TABLE 1
Temperature Coefficient of the Rate of Solution of Armco Iron in HCl

1	2	3	4	5	6	7	8
C	t°	ω	$v \cdot 100$	E	$\alpha\%$	v_{t+10}/v_t	φ_{mv}
9.1	60°	600	80	13200	6.4	1.91	470-480
	40	600	22.1				470
7.5	60	600	38.1	13000	6.3	1.85	470
	50	600	21.0				468
6.0	60	600	15.0	13000	6.3	1.85	470
	50	600	8.1				460

The data in Table 2 indicate that the temperature coefficient of the rate at which light sheet iron dissolves in sulfuric acid is a typical value for the temperature coefficient of the rate of a chemical reaction. The temperature coefficient of the rate at which Armco iron dissolves in hydrochloric acid is somewhat lower, but it is still rather far from the temperature coefficient of processes whose rate is governed by the rate of the diffusion process. Column 8 in Tables 1 and

TABLE 2

Temperature Coefficient of the Rate of Solution of Light Sheet Iron
in H_2SO_4

1	2	3	4	5	6	7	8
C	t°	ω	$v \cdot 100$	E	$\alpha\%$	v_{t+10}/v_t	$\phi mv.$
8	60	550	42.5	16.800	7.9	2.2	455
	50	550	19.2				460
2	60	550	12.4	19.500	8.5	2.3	487
	70	550	28.5				487

2 gives the values of the potential of the iron dissolving at the given temperature. The figures in this column indicate that the potential of the dissolving iron, measured against a saturated calomel electrode, hardly varies with temperature, the fluctuations lying within the limits of experimental error. It may be said that the drop in potential corresponding to a temperature drop of 10° seems to be roughly 10 millivolts.

4. Effect of stirring the solution upon the rate at which iron dissolves in hydrochloric and sulfuric acids. As we stated during our discussion of Figs. 2 and 4, the rate of solution of iron — both the Armco iron and the light sheet iron — in sulfuric acid is wholly independent of the rate at which the solution is stirred. A slight effect of the stirring rate upon the solution rate of the iron was observed, however, in the hydrochloric acid. Table 3 illustrates the extent of this effect.

The first column of this table gives the concentrations of the hydrochloric acid, the others giving the rate at which the iron dissolves in this acid at the stirrer rpm, ω , given in the top line. We see from this table that at high concentrations of hydrochloric acid, 7 N and more, stirring the solution increases the rate of solution of the Armco iron slightly. This increase in the rate is so slight, however, that the only

thing we can remark with any certainty is a difference in the rates of solution between stirring and the absence of any stirring, this change in the rate totaling only 10-15%.

Such a change in the rate is close to the magnitude of experimental error; it may be noted, however, when we compare the solution rates obtained at different values of ω during a single test. In the case of Armco iron, all the figures in Table 3 that lie on the same horizontal line represent the data secured in a single test. Curves 1 and 2 in Fig. 3 represent tests of this sort (the effect of stirring was somewhat more than usual in the test represented by Curve 2).

With the light sheet iron, it was only at moderate concentrations of hydrochloric acid that we were able to measure the solution rate at various values of ω in a single test; as Table 3 indicates, the rate at which light sheet iron dissolved was not affected by the stirring rate. In concentrated solutions of hydrochloric acid the plates of light sheet iron dissolved too fast for us to be able

TABLE 3

	C	ω rpm/min			
		0	400	600	800
Armco iron	4.0	2.3	—	—	2.3
	5.0	5.5	—	—	4.8
	7.2	29	34	—	34
	9.1	68	81	83	80
	9.9	103	117	—	117
Light sheet iron	3.5	19.5	19.5	—	—
	10	(400)	(405)	(445)	—

to measure the rate of solution at more than one value of ω in any single test. When we compared the rates of solution of light sheet iron in 10 N HCl, as obtained in different tests at different values of ω , we found that the rate increased somewhat as ω was raised, as is seen in Table 3. It is possible, however, as we just said, that this effect is the result of nothing but the experimental error. In any case we may state that here, too the effect of stirring, if any, is extremely small.

5. Variation of the rate of solution and of the potential of the dissolving iron with the concentration of hydrochloric and sulfuric acid. The curves representing these functions are shown in Figs. 5 and 6, the curves shown in Fig. 5 representing the dissolution of Armco iron, while the curves in Fig. 6 represent the dissolution of light sheet iron.

Inspection of these curves demonstrates that the rate of solution of the Armco iron and of the light sheet iron rises very rapidly with the concentration of hydrochloric acid, being a modulus, as it were, of this concentration. In the case of sulfuric acid, the increase in the rate of iron solution with the acid concentration is much slower, the rate of dissolution being close to a linear function of the acid concentration. Hence, the underlying nature of the variation of the rate of solution with the concentration of hydrochloric or sulfuric acid is the same in the dissolution of iron as in the dissolution of chromium. Moreover, it must be remembered that in plotting the curve representing the rate at which chromium dissolves as a function of the concentration of sulfuric acid, we found that the curve is slightly convex downward, thus departing from strict linearity. Figure 6 seems to indicate that a similar phenomenon is present in the dissolution of light sheet iron.

In the case of Armco iron, the reproducibility of our results was unsatisfactory for the rate of solution in sulfuric acid, as we have said, so that our only recourse was to draw an approximate straight line, as is shown in Fig. 5. It should be added that we have plotted two curves in Fig. 5 for the dissolution of Armco iron in hydrochloric acid: the solid curve, representing the dots, and the dotted curve, representing the circles. The dotted curve represents the tests made without stirring, at $\omega = 0$, while the solid curve represents the experiments in which stirring was employed.

We see that in both cases we get a curve of the same type; the two curves nearly coincide at hydrochloric acid concentrations below 5-6 N. At higher concentrations the dotted curve is somewhat below the solid one, but this drop is insignificant, averaging some 10-15%. (These facts are, of course, merely a paraphrase of the statements made earlier, in Par. 4). The fact that stirring influences the rate at which iron dissolves in hydrochloric acid enables us to assume that the diffusion process has some influence upon the rate of this reaction. This influence is evidently very small, however, practically disappearing at a rather low stirring rate. In support of this conclusion we may also point out that experiments on the rate of solution of magnesium made by us in similar instruments [10] have shown that the rate at which magnesium dissolves rises about 300% as the stirrer speed is increased from zero to 700 rpm, whereas the change in the rate of solution of iron is only 10-15%.

This conclusion is also supported by the high temperature coefficient of the rate at which iron dissolves.

The values of the rate at which iron dissolves ($v \cdot 100$) in hydrochloric and sulfuric acids of various concentrations are listed in Table 4, obtained by interpolation from the curves reproduced in Figs. 5 and 6.

In accordance with what was set forth on Page 672, the figures obtained

We regard the dissolution of magnesium in hydrochloric acid as a typical example of a reaction in which the factor governing the reaction rate is the diffusion process.

TABLE 4

Normality of the acid		1	2	3	4	5	6	7	8	9	10
		$\bar{v} \cdot 100$									
Armco iron Light sheet iron	HCl	-	-	-	2.3	5.5	15	30	50	77	120
		8.0	13(5)	17	24	36	56	85	135	230	430
Armco iron Light sheet iron	H ₂ SO ₄	-	(1.8)	-	(3.0)	-	(4.5)	-	(6.4)	-	(8.0)
		-	12(5)	16	20	25	30	35	40	46	52

for the rate at which Armco iron dissolves in sulfuric acid fluctuated widely, so that the values given in the table for the rate of solution of Armco iron in sulfuric acid are placed in parentheses, as being merely approximate. Nonetheless, it is obvious that the rate at which Armco iron dissolves in sulfuric acid as well as in hydrochloric acid is much lower than the rate of solution for light sheet iron. The potential of the iron dissolving in hydrochloric and sulfuric acids at different concentrations are given at the top of Figs. 5 and 6, the potentials of iron dissolving in hydrochloric acid being indicated by dots, while those for dissolution in sulfuric acid are shown by crosses. The data in Fig. 5 indicate that the potential of Armco iron varies very little with the acid concentration. The potential of the light sheet iron in sulfuric acid drops slightly as the acid concentration is increased.

We have a total of three points for the potential of light sheet iron in hydrochloric acid, their positions not permitting us to make any definite statement regarding the variation of this potential with the acid concentration. By analogy with the potential of Armco iron, it may be thought that this potential is close to a constant (the horizontally aligned dots shown in Fig. 6).

For the sake of greater clarity, the variation of the potential of dissolving iron with the acid concentration is shown on a larger scale in Fig. 7 (A, B, C). Fig. 7(A) represents the dissolution of light sheet iron in sulfuric acid; Fig. 7(B) represents Armco iron in sulfuric acid; and Fig. 7(C) represents Armco iron in hydrochloric acid. The potentials of the dissolving iron at the beginning of the test are denoted by circles, the crosses denoting the potentials at the end of the test. Figure 7 shows that the difference between the initial and the final values of the potential is much greater for light sheet iron. In sulfuric acid, the potential of dissolving iron, whether light sheet or Armco iron, drops somewhat as the acid concentration increases, the drop being biggest for the potential of light sheet iron as measured at the end of the tests, this drop totaling some 45-50 millivolts, according to Fig. 7(A), between 2 $\bar{N}$ and 10 $\bar{N}$ sulfuric acid. The decrease in the initial values of the potential of light sheet iron during the same concentration range is smaller - of the order of 20 millivolts. As we see in Fig. 7(B), the potential of Armco iron in sulfuric acid drops by about the same amount, though the difference between the initial and final values of the potential is much smaller than in the case of the light sheet iron.

When Armco iron is dissolved in hydrochloric acid, Fig. 7(C), the difference between the initial and terminal values of the potential is again small. In view of the fairly high scattering of the points in Fig. 7(C), we may take the potential of iron dissolving in hydrochloric acid to be a constant, equaling $\phi = 0.47 \pm 0.01$ v. Here too, however, as in the potential of chromium dissolving

TABLE 5

Acid	Potential of Armco iron, mv.	Potential of light sheet iron, mv
H ₂ SO ₄	475	{ 465* 480°
HCl	472	{ 430* 460°

in hydrochloric acid, there is an apparent tendency for the potential to rise somewhat as the acid concentration is increased, as is indicated roughly by the dotted straight line in Fig. 7(C). In general, we see that the behavior of the potential of dissolving Armco iron is rather much like that of the potential of dissolving chromium.

The values of the potential of dissolving iron in a 6 N acid are listed in Table 5 for the sake of comparison. In this table the potentials of light sheet iron are indicated by an asterisk for the start of the run, and by a degree mark (°) for the end of the run. The differences between the initial and terminal potentials of Armco iron were insignificant, so that a single mean value is given in Table 5 for the potential of Armco iron.

We see in Table 5 that the mean values of the potential of Armco and light sheet iron in hydrochloric and sulfuric acids are fairly close together, so that they may all be covered by a single expression, $\phi = 0.47 \pm 0.01$ v.. The sole exception is the potential of light sheet iron in hydrochloric acid at the end of the tests, the value of which was lower: ca. 0.43 volt.

Taking the potential of the calomel electrode with respect to the reference hydrogen electrode as 0.221 volt at 60°, we get a value of 0.25 volt for the potential of dissolving iron, measured against the reference hydrogen electrode, but with a plus sign.

SUMMARY

1. The rate of solution of Armco iron and of commercial light sheet iron in hydrochloric and sulfuric acids at 60° was investigated up to acid concentrations of 10 N.
2. The data on the effect of stirring upon the rate at which iron dissolves and on the temperature coefficient of this rate indicate that the rate of solution of iron in sulfuric or in hydrochloric acid may be regarded as practically independent of the effect of the diffusion process.
3. The rate at which Armco iron dissolves, whether in hydrochloric or in sulfuric acid, is much lower than the rate of solution for light sheet iron.
4. The rate at which Armco and light sheet iron dissolve in hydrochloric acid is an index to the concentration of the acid, the relationship being nearly a linear function in sulfuric acid, however, up to a 10 N concentration. Hence, the variation of the rate at which iron dissolves with the acid concentration (HCl and H₂SO₄) is analogous to the corresponding function described in our previous paper on chromium, the sole difference being, however, that the γ -HCl curve

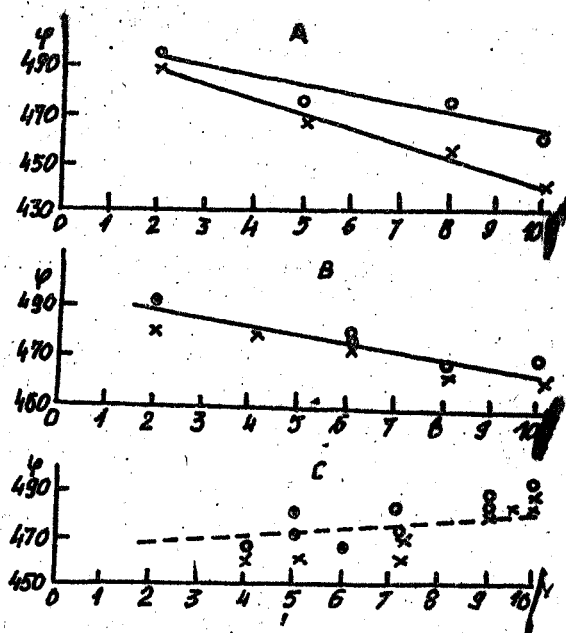


Fig. 7.

for iron at $\omega = 0$ has no maximum, such as it had in chromium, exhibiting practically no difference from the curve obtained for vigorous stirring of the solution.

5. The potential of Armco iron in hydrochloric acid changes very little with the concentration of the acid. The potential of Armco iron in sulfuric acid drops somewhat as the acid concentration is increased, but this drop is small, amounting to some 20 mv in the range from 2 N to 10 N H_2SO_4 . This drop is somewhat greater, ca. 45 mv, in the case of light sheet iron.*

6. The potential of Armco iron is practically the same in average 6 N concentrations of sulfuric or hydrochloric acids.

Measured with respect to a saturated calomel electrode and with its sign taken as plus, it amounts to 0.47 ± 0.01 volt; measured with respect to a reference hydrogen electrode and taken with a plus sign, it is 0.25 volt.

Inasmuch as the normal potential of iron is 0.44 volt, it is evident that the dissolution of iron, like that of chromium, is accompanied by considerable anodic polarization.

It should be noted that the book by Gatty and Spooner [11] gives the potential of iron in 1 N hydrochloric and sulfuric acids as 0.27 volt in a table on p. 312-313, this figure being in close enough agreement with the values we have found.

The problem of the potentials of dissolving iron will be considered in greater detail in one of our forthcoming papers.

LITERATURE CITED

- [1] Ya. Durdin and A. Markevich, J. Gen. Chem. 19, 2131 (1949).**
- [2] M. Oranskaya, Sci. Rep. Leningrad State Univ., Chem. Series, 54, 235 (1940).
- [3] M. Tsentnershver, Trans. Mendeleev Jubilee Congress, II, 241 (1937).
- [4] M. Tsentnershver, Z. phys. Chem. 162, 94 (1932).
- [5] J. T. Conroy, J. Soc. Chem. Ind., 20, 316 (1901).
- [6] A. Sieverts, P. Lueg, Z. allgew. Anorg. Chem., 126, 193 (1923).
- [7] S. Ram, J. Soc. Chem. Ind., 54, 107 (1935).
- [8] G. Damon, Ind. Eng. Chem. 33, 57 (1941).
- [9] A. I. Krasilshchikov, J. Gen. Chem. 14, 261 (1944).
- [10] Ya. Durdin and A. Markevich, J. Gen. Chem. 6, 236 (1936).
- [11] O. Gatty, E. Spooner. The Electrode Potential Behavior of Corroding Metals in Aqueous Solutions (1938).

Received June 11, 1949.

Laboratory of Inorganic Chemistry
Leningrad State University

It should be borne in mind however, that the iron potential measured with respect to a saturated calomel electrode contains the potential jump at the boundary between the hydrochloric acid and the saturated solution of potassium chloride, which may vary with a change in the acid concentration. The feasibility of excluding the resulting difficulties from a theoretical treatment of the problem will be discussed in one of our forthcoming papers.

** See CB translation p. a-605 ff.