The Stability of Iron Carbide and Calculations of Its Heat of Formation from Equilibrium Studies

Harold L. Maxwell

Anson Hayes
between 60° and 90°C. This reaction does not take place under similar conditions with solid sodium hydroxide.

Although Wohl found no organic reduction products and was at a loss to account for the remainder of the nitrobenzene which was lost, it was suggested by R. R. Renshaw that possibly he might have missed any inorganic products of hydrolysis which might have been present.

Consequently the authors have made a number of preparations under various conditions, the standard conditions comprising 5cc of nitrobenzene and 25 grams of powdered potassium hydroxide. These were mixed and heated at 90°C for varying times, water was then added, the unchanged nitrobenzene separated and the aqueous layer extracted with ether to remove the nitrophenols. This aqueous layer was then tested for nitrites and nitrates by the usual standard methods of water analysis for nitrites and nitrates. Nitrophenol interfered with the accuracy of the tests but this factor was eliminated through the use of blanks.

Traces of nitrite and nitrate were observed but not in sufficient amounts to be significant. This would indicate that there had been no appreciable hydrolysis of the nitrobenzene by the alkali. It is of interest to note that about half of the nitrobenzene can be recovered as nitrophenol.

THE STABILITY OF IRON CARBIDE AND CALCULATIONS OF ITS HEAT OF FORMATION FROM EQUILIBRIUM STUDIES

HAROLD L. MAXWELL AND ANSON HAYES

Values of the equilibrium constants for the system:

\[ \text{FeC} + \text{CO} \rightleftharpoons 3\text{Fe} + 2\text{CO} \]

have been determined at temperatures of 650°C and 700°C. The value of \( K \) for this reaction at 650°C is 1.66 and at 700°C is 2.21.

Values of the equilibria constants for the system:

\[ \text{C} + \text{CO}_2 \rightleftharpoons 2\text{CO} \]

as calculated by Juptner and determined experimentally by Bou-douard; Thead and Wheeler; and checked in part in this laboratory, are smaller than the values of \( K \) for reaction (1) at the same temperature. This indicates that iron carbide is metastable with respect to carbon and alpha iron at these temperatures. From the values of the equilibrium constants for reaction (1) its heat effect was calculated and corrected to 20°C. This gave the heat of formation of iron carbide as \(-18,331\) and \(-16,131\), assuming...
graphite in the first case and amorphous carbon in the second. This is in fair agreement with a calorimetric determination made by Ruff.

CHEMICAL ENGINEERING AND AGRICULTURE

JULIAN E. MAC FARLAND

Chemical engineering is finding extensive application in two important phases of agriculture, the preparation of fertilizers to enrich the soil and the better utilization of waste agricultural products. The second phase has been studied at Iowa State College, particularly in regard to corncobs and oat hulls. They contain pentosans, which can be converted to furfural, a potentially valuable product. Cobs may be destructively distilled to yield useful products including a char which can be highly activated. Cobs or oat hulls may be treated with a phenol to form a black resin which can be manipulated into a valuable insulating and decorative material.

SOLUBILITY IN AUSTENITE OF CARBON FROM CARBON AND OF CARBON FROM IRON-CARBIDE

H. L. MAXWELL AND ANSON HAYES

For the well established equilibria:

\[
\begin{align*}
(1) \quad Fe_3C + CO_2 &\rightleftharpoons 3Fe + 2CO + \Delta H_1 \\
(2) \quad C + CO_2 &\rightleftharpoons 2CO + \Delta H_2 \\
(3) \quad [C]_1 + CO_2 &\rightleftharpoons 2CO \\
(4) \quad [C] + CO_2 &\rightleftharpoons 2CO \\
(5) \quad [C] + \text{Fe}_0 &\rightleftharpoons 2CO
\end{align*}
\]

Where \([C]\) is concentration of dissolved carbon in austenite, \([C]_1\) is saturated value of carbon from carbon, \([C]_2\) is saturated value of carbon from iron carbide, and \(K_1, K_2, K_3, \ldots\) are the gaseous equilibrium constants for these reactions. Thermodynamics demands \(K_2 = K_4, K_3 = K_5\) and that \(K_6\) is a function of the concentration of carbon in austenite. Since iron-carbon alloys graphitize down to some 0.9% combined carbon or less, \(Fe_3C\) is metastable with respect to carbon from \(720^\circ\) to \(1130^\circ\) C. Since the heat of formation of \(Fe_3C\) is \(-15100\) calories, it follows from the equation

\[
(d/dT) (\log K) = \Delta H/RT^2
\]

and from the metastability of \(Fe_3C\) that the carbon solubility line of the iron-carbon diagram lies to the left of the cementite solubility line and has a greater slope.

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