The Chromium(IV) Oxide–Hydrogen Reaction

WILLIAM D. HILL, Jr.

Department of Chemistry, North Carolina Central University, Durham, N.C. 27707, U.S.A.

(Received March 31, 1987)

The thermal decomposition of iron(III) nitrate nonahydrate followed by reaction with hydrogen [1] prompted the idea to execute a reaction involving chromium(IV) oxide and hydrogen in light of the fact that chromium(IV) oxide was obtained by the thermal decomposition of chromium(III) nitrate nonhydrate [2].

Six supplies of chromium(IV) oxide each weighing 8.4000 g (0.10 mol) were subjected to reaction with hydrogen in the same way as iron(III) oxide [1] and other metal oxides [3]. Green solids weighing 7.5996 g on average were obtained (99.991% based on chromium(IV) oxide). The products of each reaction were combined into one sample.

A sample of the combined products was found to be insoluble in water at any temperature, the mineral acids and alkali metal hydroxide solutions. The product was shown to be non-ferromagnetic.

The color, the yields and the solubility tests were enough to show that chromium(III) oxide is obtained when chromium(IV) oxide is subjected to reaction with hydrogen. However, the magnetic test is also proof of chromium(III) oxide production. Chromium(IV) oxide is black and ferromagnetic but chromium(III) oxide is green and non-ferromagnetic.

$2CrO_2 + H_2 \rightarrow Cr_2O_3 + H_2O\uparrow$ is the equation for the reaction involving chromium(IV) oxide and hydrogen and based on the above stated observations, it can be stated that the reaction falls in the category of the manganese dioxide–hydrogen reaction [3] as opposed to the copper(II) oxide–hydrogen reaction [3]. Chromium instead of chromium(III) oxide would have been produced if the chromium(IV) oxide–hydrogen reaction had been in the category of the copper(II) oxide–hydrogen reaction.

All of the weighings were executed on a cantilever, a modified form of the triple beam balance.

In addition to the thermal decomposition of chromium(III) hydroxide which is characteristic of all hydroxides, chromium(III) oxide is also prepared by: reacting chromium with oxygen [4], the thermal decomposition of ammonium dichromate [5–7], a reaction involving sodium dichromate and sulfur [6, 7], heating chromium(II) hydroxide in air [8], heating sodium dichromate and ammonium chloride [8] and executing a reaction involving molybdenum, potassium perchlorate and barium chromate [9].

The production of chromium(III) oxide by reacting chromium(IV) oxide with hydrogen is supplemented by the above reactions.

Acknowledgements

Thanks and appreciation are given to Mesdames Debra Dixon, Stephanie Ellis, Vernall Fletcher, Allyson Fenderson and Brenda Smith for their assistance in this project.

References

1 W. D. Hill Jr., *Inorg. Chim. Acta, 121,* L33 (1986).
2 W. D. Hill Jr., *Inorg. Chim. Acta, 65,* L100 (1982).
3 W. D. Hill Jr., *J. Chem. Educ., 59,* 920 (1982).
4 F. A. Cotton and G. Wilkerson, 'Advanced Inorganic Chemistry: A Comprehensive Text', 3rd edn., Wiley, New York, 1972, p. 833.
5 W. D. Hill Jr., *Chem. Eng. News,* July 21, 1986, p. 6.
6 L. Pauling and P. Pauling, 'Chemistry', Freeman, San Francisco, Calif., 1975, p. 663.
7 W. H. Nebergall, H. F. Holtzclaw Jr. and W. R. Robinson, 'College Chemistry with Qualitative Analysis', 7th edn., Heath, Lexington, Mass., 1984, p. 893.
8 W. M. Latimer and J. H. Hildebrand, 'Reference Book of Inorganic Chemistry', New York, 1951, pp. 374–375.
9 I. Matsuzaki, *Chem. Abstr., 95,* 670 (1981).