

Optimization through School Geometry

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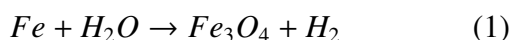
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Abstract—This manual shows how to balance chemical equations using matrices.

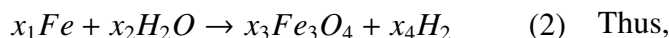
Download python codes using

svn co <https://github.com/gadepall/school/trunk/training/chemistry/codes>

Balance the following chemical equation



Solution: Let the balanced version of (1) be



which results in the following equations

$$\begin{aligned} (x_1 - 3x_3) Fe &= 0 \\ (2x_2 - 2x_4) H &= 0 \end{aligned} \quad (3)$$

$$\begin{aligned} (x_2 - 4x_3) H &= 0 \\ x_1 - 3x_3 &= 0 \\ \implies 2x_2 - 2x_4 &= 0 \\ x_2 - 4x_3 &= 0 \end{aligned} \quad (4)$$

resulting in the matrix equation

$$\begin{pmatrix} 1 & 0 & -3 & 0 \\ 0 & 2 & 0 & -2 \\ 0 & 1 & -4 & 0 \end{pmatrix} \mathbf{x} = \mathbf{0} \quad (5)$$

where

$$\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} \quad (6)$$

The matrix in (6) can be row reduced as follows

$$\begin{pmatrix} 1 & 0 & -3 & 0 \\ 0 & 2 & 0 & -2 \\ 0 & 1 & -4 & 0 \end{pmatrix} \xrightarrow{R_2 \leftrightarrow \frac{R_2}{2}} \begin{pmatrix} 1 & 0 & -3 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 1 & -4 & 0 \end{pmatrix} \quad (7)$$

$$\xrightarrow{R_3 \leftarrow R_3 - R_2} \begin{pmatrix} 1 & 0 & -3 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & -4 & 1 \end{pmatrix} \xrightarrow{R_1 \leftarrow 4R_1 - 3R_3} \begin{pmatrix} -4 & 0 & 0 & -3 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & -4 & 1 \end{pmatrix} \quad (8)$$

$$\xrightarrow{\begin{matrix} R_1 \leftarrow -\frac{1}{4} \\ R_3 \leftarrow -\frac{1}{4}R_3 \end{matrix}} \begin{pmatrix} 1 & 0 & 0 & \frac{3}{4} \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & \frac{1}{4} \end{pmatrix} \quad (9)$$

$$\mathbf{x} = x_4 \begin{pmatrix} \frac{3}{4} \\ -1 \\ \frac{1}{4} \\ 1 \end{pmatrix} \quad (10)$$

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