Math 221: LINEAR ALGEBRA

Chapter 1. Systems of Linear Equations

§1-6. Application to Chemical Reactions

Le Chen[1]

Emory University, 2021 Spring

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[1] Slides are adapted from those by Karen Seyffarth from University of Calgary.

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Chemical Reactions

Linear Algebra with Applications

Lecture Notes

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Chemical Reactions

Balancing Chemical Reactions

Problem

Balance the chemical reaction given below involving tin (Sn), hydrogen (H), and oxygen (0).

$$\mathrm{xSnO_2 + yH_2 \rightarrow zSn + wH_2O}$$

Solution

Setting up a system of equations in $\mathrm{x, y, z, w}$ gives

$$\begin{aligned} \mathrm{Sn} &: \quad \mathrm{x = z \text{ or } x - z = 0} \\ \mathrm{O} &: \quad \mathrm{2x = w \text{ or } 2x - w = 0} \\ \mathrm{H} &: \quad \mathrm{2y = 2w \text{ or } 2y - 2w = 0} \end{aligned}$$

The augmented matrix is $\left[\begin{array}{cccc|c} 1 & 0 & -1 & 0 & 0 \\ 2 & 0 & 0 & -1 & 0 \\ 0 & 2 & 0 & -2 & 0 \end{array}\right]$

Solution (continued)

The reduced row-echelon matrix is

$$\left[\begin{array}{cccc|c} 1 & 0 & 0 & -\frac{1}{2} & 0 \\ 0 & 1 & 0 & -1 & 0 \\ 0 & 0 & 1 & -\frac{1}{2} & 0 \end{array}\right]$$

Letting $w = t$, the solution is

$$\begin{aligned} x &= \frac{1}{2}t \\ y &= t \\ z &= \frac{1}{2}t \\ w &= t \end{aligned}$$

We can choose any values for $w = t$. Suppose we choose $w = 4$, then $x = 2, y = 4, z = 2$ and the balanced reaction is

$$2Sn0_2 + 4H_2 \rightarrow 2Sn + 4H_2O$$