Assignment 2

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***Abstract*—This document balances the Chemical Equation.**

Download all python codes from

https://github.com/priya6971/matrix_theory_EE5609/tree/master/Assignment2/code

and latex-tikz codes from

https://github.com/priya6971/matrix_theory_EE5609/tree/master/Assignment2

1 Problem

Write the balanced chemical equations for the below reaction.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O \tag{1.0.1}$$

2 Explanation

Let the balanced version of (1.0.1) be:-

$$x_1Ca(OH)_2 + x_2CO_2 \rightarrow x_3CaCO_3 + x_4H_2O \tag{2.0.1}$$

which results in the following equations:

$$\begin{aligned} (x_1 - x_3)Ca &= 0 \\ (2x_1 + 2x_2 - 3x_3 - x_4)O &= 0 \\ (2x_1 - 2x_4)H &= 0 \\ (x_2 - x_3)C &= 0 \end{aligned} \tag{2.0.2}$$

which can be expressed as:-

$$\begin{aligned} 1.x_1 + 0.x_2 - 1.x_3 + 0.x_4 &= 0 \\ 2.x_1 + 2.x_2 - 3.x_3 - 1.x_4 &= 0 \\ 2.x_1 + 0.x_2 + 0.x_3 - 2.x4 &= 0 \\ 0.x_1 + 1.x_2 - 1.x_3 + 0.x_4 &= 0 \end{aligned} \tag{2.0.3}$$

resulting in the matrix equation:-

$$\begin{pmatrix} 1 & 0 & -1 & 0 \\ 2 & 2 & -3 & -1 \\ 2 & 0 & 0 & -2 \\ 0 & 1 & -1 & 0 \end{pmatrix} \mathbf{x} = \mathbf{0} \tag{2.0.4}$$

where

$$\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} \tag{2.0.5}$$

3 Solution

Now by applying the Row Reduction Method in the equation (2.0.4) we can easily determine the value of the coefficients of the Chemical Equation:

Equation (2.0.4) can be reduced as follows:

$$\begin{pmatrix} 1 & 0 & -1 & 0 \\ 2 & 2 & -3 & -1 \\ 2 & 0 & 0 & -2 \\ 0 & 1 & -1 & 0 \end{pmatrix} \xleftrightarrow{R2 \leftarrow R2 - 2R1} \begin{pmatrix} 1 & 0 & -1 & 0 \\ 0 & 2 & -1 & -1 \\ 2 & 0 & 0 & -2 \\ 0 & 1 & -1 & 0 \end{pmatrix} \tag{3.0.1}$$

$$\begin{pmatrix} 1 & 0 & -1 & 0 \\ 0 & 2 & -1 & -1 \\ 2 & 0 & 0 & -2 \\ 0 & 1 & -1 & 0 \end{pmatrix} \xleftrightarrow{R3 \leftarrow R3 - 2R1} \begin{pmatrix} 1 & 0 & -1 & 0 \\ 0 & 2 & -1 & -1 \\ 0 & 0 & 2 & -2 \\ 0 & 1 & -1 & 0 \end{pmatrix} \tag{3.0.2}$$

Thus,

$$x_1 = x_3, x_2 = x_3, x_3 = x_4 \tag{3.0.3}$$

$$\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \\ 1 \end{pmatrix} \tag{3.0.4}$$

Then (2.0.1) remains same because the value of $x_1 = 1$,$x_2 = 1$,$x_3 = 1$,$x_4 = 1$ as shown in equation (3.0.4),

$$\boxed{Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O} \tag{3.0.5}$$

(3.0.5) is our required balance equation.