Assignment 3

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***Abstract*—This document balances the given chemical equation.**

Download all latex codes from

https://github.com/Matish007/Matrix−Theory−EE5609−/tree/master/Assignment_3

and all python codes from

https://github.com/Matish007/Matrix−Theory−EE5609−/tree/master/Assignment_3/Codes

1 Problem

Balance the following chemical equation:-

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + HCl \tag{1.0.1}$$

2 Explanation

Let the balanced version of (1.0.1) be:-

$$x_1BaCl_2 + x_2H_2SO_4 \rightarrow x_3BaSO_4 + x_4HCl \tag{2.0.1}$$

which results in the following equations:-

$$\begin{aligned}(x_1 - x_3)Ba &= 0\\ (x_2 - x_4)SO_4 &= 0\\ (2x_2 - x4)H &= 0\\ (2x_1 - x_4)Cl &= 0\end{aligned} \tag{2.0.2}$$

which can be expressed as:-

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

resulting in the matrix equation:-

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

where

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

equation (2.0.4) can be row reduced as follows

$$\begin{pmatrix}1 & 0 & -1 & 0\\ 0 & 1 & -1 & 0\\ 0 & 2 & 0 & -1\\ 2 & 0 & 0 & -1\end{pmatrix} \xleftrightarrow{R4\leftarrow R4-2R1} \begin{pmatrix}1 & 0 & -1 & 0\\ 0 & 1 & -1 & 0\\ 0 & 2 & 0 & -1\\ 0 & 0 & 2 & -1\end{pmatrix} \tag{2.0.6}$$

$$\begin{pmatrix}1 & 0 & -1 & 0\\ 0 & 1 & -1 & 0\\ 0 & 2 & 0 & -1\\ 0 & 0 & 2 & -1\end{pmatrix} \xleftrightarrow{R3\leftarrow R3-2R2} \begin{pmatrix}1 & 0 & -1 & 0\\ 0 & 1 & -1 & 0\\ 0 & 0 & 2 & -1\\ 0 & 0 & 2 & -1\end{pmatrix} \tag{2.0.7}$$

$$\begin{pmatrix}1 & 0 & -1 & 0\\ 0 & 1 & -1 & 0\\ 0 & 0 & 2 & -1\\ 0 & 0 & 2 & -1\end{pmatrix} \xleftrightarrow{R4\leftarrow R4-R3} \begin{pmatrix}1 & 0 & -1 & 0\\ 0 & 1 & -1 & 0\\ 0 & 0 & 2 & -1\\ 0 & 0 & 0 & 0\end{pmatrix} \tag{2.0.8}$$

Thus,

$$x_1 = x_3, x_2 = x_3, 2x_3 = x_4 \tag{2.0.9}$$

$$\mathbf{x} = x_3\begin{pmatrix}1\\ 1\\ 1\\ 2\end{pmatrix} \tag{2.0.10}$$

Upon substituting $x_3 = 1$ in(2.0.10),then (2.0.1) becomes,

$$\boxed{BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl} \tag{2.0.11}$$

(2.0.11) is our required balance equation.