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−
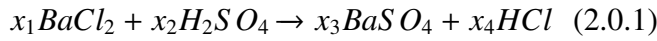EE5609−/tree/master/Assignment_3

1 PROBLEM

Balance the following chemical equation:-

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + HCl \quad (1.0.1)$$

2 EXPLANATION

Let the balanced version of (1.0.1) be:-

$$x_1 BaCl_2 + x_2 H_2SO_4 \rightarrow x_3 BaSO_4 + x_4 HCl \quad (2.0.1)$$

which results in the following equations:-

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

which can be expressed as:-

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

resulting in the matrix equation:-

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

where

$$
\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} \quad (2.0.5)
$$

equation (2.0.4) can be row reduced as follows

$$
\begin{pmatrix}
1 & 0 & -1 & 0 \\
0 & 1 & -1 & 0 \\
0 & 2 & 0 & -1 \\
2 & 0 & 0 & -1
\end{pmatrix}
\xrightarrow{R4\leftarrow R4-2R1}
\begin{pmatrix}
1 & 0 & -1 & 0 \\
0 & 1 & -1 & 0 \\
0 & 2 & 0 & -1 \\
0 & 0 & 2 & -1
\end{pmatrix} \quad (2.0.6)
$$

$$
\xrightarrow{R3\leftarrow R3-2R2}
\begin{pmatrix}
1 & 0 & -1 & 0 \\
0 & 1 & -1 & 0 \\
0 & 0 & 2 & -1 \\
0 & 0 & 2 & -1
\end{pmatrix} \quad (2.0.7)
$$

$$
\xrightarrow{R4\leftarrow R4-R3}
\begin{pmatrix}
1 & 0 & -1 & 0 \\
0 & 1 & -1 & 0 \\
0 & 0 & 2 & -1 \\
0 & 0 & 0 & 0
\end{pmatrix} \quad (2.0.8)
$$

Thus,

$$x_1 = x_3, x_2 = x_3, 2x_3 = x_4 \quad (2.0.9)$$

$$
\mathbf{x} = x_3 \begin{pmatrix} 1 \\ 1 \\ 1 \\ 2 \end{pmatrix} \quad (2.0.10)
$$

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

$$\boxed{BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl} \quad (2.0.11)$$

(2.0.11) is our required balance equation.