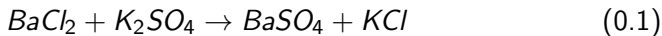


5.10.4

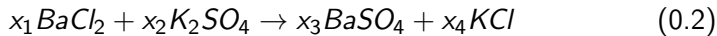
AI25BTECH11001 - ABHISEK MOHAPATRA

September 29, 2025

Question: Write the balanced chemical equations for the following reaction.



Solution: Let the balanced version of given equation be



which results in the following equations:

$$(x_1 - x_3) Ba = 0 \quad (0.3)$$

$$(2x_1 - x_4) Cl = 0 \quad (0.4)$$

$$(2x_2 - x_4) K = 0 \quad (0.5)$$

$$(x_2 - x_3) S = 0 \quad (0.6)$$

$$(4x_2 - 4x_3) O = 0 \quad (0.7)$$

which can be expressed as

$$x_1 + 0x_2 + (-1)x_3 + x_4 = 0 \quad (0.8)$$

$$2x_1 + 0x_2 + 0x_3 + (-1)x_4 = 0 \quad (0.9)$$

$$0x_1 + 2x_2 + 0x_3 + (-1)x_4 = 0 \quad (0.10)$$

$$0x_1 + x_2 + (-1)x_3 + 0x_4 = 0 \quad (0.11)$$

resulting in the matrix equation

$$\begin{pmatrix} 1 & 0 & -1 & 0 \\ 2 & 0 & 0 & -1 \\ 0 & 2 & 0 & -1 \\ 0 & 1 & -1 & 0 \end{pmatrix} \mathbf{x} = 0 \quad (0.12)$$

which can be reduced as follows

$$\begin{pmatrix} 1 & 0 & -1 & 0 \\ 2 & 0 & 0 & -1 \\ 0 & 2 & 0 & -1 \\ 0 & 1 & -1 & 0 \end{pmatrix} \xleftrightarrow{R_2 \leftarrow R_2 - R_1} \begin{pmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 2 & -1 \\ 0 & 2 & 0 & -1 \\ 0 & 1 & -1 & 0 \end{pmatrix} \quad (0.13)$$

$$\xleftrightarrow{R_3 \leftrightarrow R_2} \begin{pmatrix} 1 & 0 & -1 & 0 \\ 0 & 2 & 0 & -1 \\ 0 & 0 & 2 & -1 \\ 0 & 1 & -1 & 0 \end{pmatrix} \xleftrightarrow{R_4 \leftarrow R_4 + \frac{1}{2}R_2 - \frac{1}{2}R_1} \begin{pmatrix} 1 & 0 & -1 & 0 \\ 0 & 2 & 0 & -1 \\ 0 & 0 & 2 & -1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \quad (0.14)$$

$$\xleftrightarrow{R_1 \leftrightarrow R_1 + \frac{1}{2}R_3} \begin{pmatrix} 1 & 0 & 0 & -\frac{1}{2} \\ 0 & 2 & 0 & -1 \\ 0 & 0 & 2 & -1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \xleftrightarrow[R_3 \leftrightarrow \frac{1}{2}R_3]{R_2 \leftrightarrow \frac{1}{2}R_2} \begin{pmatrix} 1 & 0 & 0 & -\frac{1}{2} \\ 0 & 1 & 0 & -\frac{1}{2} \\ 0 & 0 & 1 & -\frac{1}{2} \\ 0 & 0 & 0 & 0 \end{pmatrix} \quad (0.15)$$

Thus,

$$x_1 = \frac{1}{2}x_4, x_2 = \frac{1}{2}x_4, x_3 = \frac{1}{2}x_4 \quad (0.16)$$

$$\Rightarrow \mathbf{X} = x_4 \begin{pmatrix} 1 \\ \frac{1}{2} \\ \frac{1}{2} \\ \frac{1}{2} \\ 1 \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \\ 2 \end{pmatrix} \quad (0.17)$$

by substituting $x_4 = 2$. Hence, The equation finally becomes

