

## Balancing Chemical Equations

### key concepts:

- In balancing a **chemical equation**, start with the **compound** with the greatest diversity of **atoms**, and balance pure **elements** last; when there is not an obvious starting point, begin with the first compound.
- In a balanced chemical equation, all coefficients must be whole numbers and the number of atoms of each type of element must be the same on both sides of the equation.

$\_ \text{KO}_2(\text{s}) + \_ \text{CO}_2(\text{g}) + \_ \text{H}_2\text{O}(\text{g}) \rightarrow \_ \text{KHCO}_3(\text{s}) + \_ \text{O}_2(\text{g})$	<p>Rules to balance a chemical equation:</p> <ol style="list-style-type: none"> <li>1. Start with the compound with the greatest diversity of atoms.</li> <li>2. Leave pure elements for last.</li> <li>3. If rule 1 does not indicate where to start, begin with the first compound.</li> </ol> <p>Apply rule 1 and start with the first compound on the right side, potassium bicarbonate (<math>\text{KHCO}_3</math>). Place a "1" before it because there is a single potassium atom in the first compound on the left and a single carbon atom in the second compound of the left.</p> <p>Do not try to balance <math>\text{O}_2</math> yet, since it is a pure element (rule 2). Rule 3 need not be applied here.</p>
$1\text{KO}_2(\text{s}) + \_ \text{CO}_2(\text{g}) + \_ \text{H}_2\text{O}(\text{g}) \rightarrow 1\text{KHCO}_3(\text{s}) + \_ \text{O}_2(\text{g})$	<p>Balance the potassium by placing a "1" in front of the potassium dioxide (<math>\text{KO}_2</math>). Balance the carbon by doing the same for carbon dioxide (<math>\text{CO}_2</math>).</p>
$1\text{KO}_2(\text{s}) + 1\text{CO}_2(\text{g}) + \frac{1}{2}\text{H}_2\text{O}(\text{g}) \rightarrow 1\text{KHCO}_3(\text{s}) + \_ \text{O}_2(\text{g})$ <p>H atoms: <math>\frac{1}{2} \cdot 2 = 1</math>    <math>1 \cdot 1 = 1</math></p>	<p>Next, balance the hydrogen atoms by temporarily putting a "<math>\frac{1}{2}</math>" in front of the water molecule. Note that rule 2 is still being followed.</p>
$1\text{KO}_2(\text{s}) + 1\text{CO}_2(\text{g}) + \frac{1}{2}\text{H}_2\text{O}(\text{g}) \rightarrow 1\text{KHCO}_3(\text{s}) + x\text{O}_2(\text{g})$ $2 + 2 + \frac{1}{2} = 3 + 2x$ $4\frac{1}{2} = 3 + 2x$ $\frac{3}{4} = x$	<p>Balance the number of oxygen atoms on both sides. To do this, set the coefficient of <math>\text{O}_2</math> to <math>x</math> and solve for it algebraically.</p> <p>The final rules are:</p> <ol style="list-style-type: none"> <li>4. All coefficients must be whole numbers, which may require multiplying through by the least common multiple to remove fractions.</li> <li>5. The number of atoms of each element must be balanced on both sides.</li> </ol>

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Following rule 4, multiply the entire equation by the lowest common multiple, in this case the "4" in the denominator of the coefficient for  $\text{O}_2$ .

As a final step, verify that the number of atoms of each element balance (rule 5).