## Neutralization Reactions tutorial

A neutralization reaction is simply a double replacement reaction between an acid and a base in which water and a salt is formed.
$\underset{\text { acid }}{\mathrm{HX}(\mathrm{aq})}+\underset{\text { base }}{\mathrm{MOH}(\mathrm{aq})} \rightarrow \underset{\text { water }}{\mathrm{H}_{2} \mathrm{O}}+\underset{\text { salt }}{\mathrm{MX}}$

The neutralization portion occurs when the $\mathrm{H}^{+}$from the acid reacts with the $\mathrm{OH}^{-}$from the base to produce water. The salt formed is a byproduct of the reaction made by combining the cation (positive ion) from the base with the anion (negative ion) from the acid.

Always make sure in the end that the chemical equation obeys the law of conservation of mass and is balanced.

1. Write the balanced chemical equations for the neutralization reactions between:
a) $\mathrm{Ca}(\mathrm{OH})_{2}$ and $\mathrm{H}_{3} \mathrm{PO}_{4}$
b) HI and NaOH
c) $\mathrm{H}_{2} \mathrm{CO}_{3}$ and $\mathrm{Sr}(\mathrm{OH})_{2}$

For each of the following - first write the chemical formula for the acid and base, then complete the neutralization reaction.
d) hydrobromic acid and barium hydroxide
e) zinc hydroxide and nitric acid
f) aluminum hydroxide and hydrochloric acid
2. Complete and balance the following equations representing neutralization reactions:
a) $\mathrm{CsOH}+\quad \mathrm{H}_{2} \mathrm{CO}_{3}$
b) $\mathrm{HF}+\mathrm{Mg}(\mathrm{OH})_{2}$
c) $\mathrm{HNO}_{3}+\mathrm{Al}(\mathrm{OH})_{3} \rightarrow$
$\begin{array}{llllll}\text { d) } & + & \rightarrow & \mathrm{H}_{2} \mathrm{O} & + & \mathrm{KCl} \\ \text { e) } \mathrm{HBrO}_{3} & + & \rightarrow & \mathrm{H}_{2} \mathrm{O} & + & \mathrm{LiBrO}_{3}\end{array}$
3. Give the name and the formula of the ionic compound produced by neutralization reactions between the following acids and bases:

| Acid and Base reactants | Name of ionic compound | Formula |
| :--- | :--- | :--- |
| a)nitric acid <br> and sodium hydroxide |  |  |
| b)hydroiodic acid <br> and calcium hydroxide |  |  |
| c)magnesium hydroxide <br> and hydrosulfuric acid |  |  |
| d)ammonium hydroxide <br> and hydrofluoric acid |  |  |
| e)barium hydroxide <br> and sulfuric acid |  |  |
| f)chloric acid <br> and rubidium hydroxide |  |  |
| g)calcium hydroxide <br> and carbonic acid |  |  |

4. For each of the following ionic compounds, identify the acid and base that reacted to form them.

|  | Salt | Acid | Base |
| :--- | :--- | :--- | :--- |
| a) | NaCl |  |  |
| b) | $\mathrm{Ca}_{3}\left(\mathrm{PO}_{4}\right)_{2}$ |  |  |
| c) | $\mathrm{Zn}\left(\mathrm{NO}_{3}\right)_{2}$ |  |  |
| d) | $\mathrm{Al}(\mathrm{ClO})_{3}$ |  |  |
| e) | $\mathrm{NH}_{4} \mathrm{I}$ |  |  |

## ANSWER KEY

1. Write the balanced chemical equations for the neutralization reactions between:
a) $\mathrm{Ca}(\mathrm{OH})_{2}$ and $\mathrm{H}_{3} \mathrm{PO}_{4}$

$$
3 \mathrm{Ca}(\mathrm{OH})_{2}+2 \mathrm{H}_{3} \mathrm{PO}_{4} \rightarrow 6 \mathrm{H}_{2} \mathrm{O}+\mathrm{Ca}_{3}\left(\mathrm{PO}_{4}\right)_{2}
$$

b) HI and NaOH

$$
\mathrm{HI}+\mathrm{NaOH} \rightarrow \mathrm{H}_{2} \mathrm{O}+\mathrm{NaI}
$$

c) $\mathrm{H}_{2} \mathrm{CO}_{3}$ and $\mathrm{Sr}(\mathrm{OH})_{2}$

$$
\mathrm{H}_{2} \mathrm{CO}_{3}+\mathrm{Sr}(\mathrm{OH})_{2} \rightarrow 2 \mathrm{H}_{2} \mathrm{O}+\mathrm{SrCO}_{3}
$$

d) hydrobromic acid and barium hydroxide

$$
2 \mathrm{HBr}+\mathrm{Ba}(\mathrm{OH})_{2} \rightarrow 2 \mathrm{H}_{2} \mathrm{O}+\mathrm{BaBr}_{2}
$$

e) zinc hydroxide and nitric acid

$$
\mathrm{Zn}(\mathrm{OH})_{2}+2 \mathrm{HNO}_{3} \rightarrow 2 \mathrm{H}_{2} \mathrm{O}+\mathrm{Zn}\left(\mathrm{NO}_{3}\right)_{2}
$$

f) aluminum hydroxide and hydrochloric acid

$$
\mathrm{Al}(\mathrm{OH})_{3}+\mathbf{3} \mathrm{HCl} \rightarrow \mathbf{3} \mathrm{H}_{2} \mathrm{O}+\mathrm{AlCl}_{3}
$$

2. Complete and balance the following equations representing neutralization reactions:

| a) $\mathbf{2 ~ C s O H}$ | + | $\mathrm{H}_{2} \mathrm{CO}_{3}$ | $\rightarrow$ | $\mathbf{2} \mathbf{H}_{\mathbf{2}} \mathbf{O}$ | + | $\mathbf{C s}_{\mathbf{2}} \mathbf{C O}_{\mathbf{3}}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| b) $\mathbf{2} \mathrm{HF}$ | + | $\mathrm{Mg}(\mathrm{OH})_{2}$ | $\rightarrow$ | $\mathbf{2} \mathbf{H}_{\mathbf{2}} \mathbf{O}$ | + | $\mathbf{M g F}_{2}$ |
| c) $\mathbf{3} \mathrm{HNO}_{3}$ | + | $\mathrm{Al}(\mathrm{OH})_{3}$ | $\rightarrow$ | $\mathbf{3} \mathbf{H}_{2} \mathbf{O}$ | + | $\mathrm{Al}\left(\mathrm{NO}_{3}\right)_{3}$ |
| d) $\mathbf{H C l}$ | + | $\mathbf{K O H}$ | $\rightarrow$ | $\mathrm{H}_{2} \mathrm{O}$ | + | KCl |
| e) $\mathbf{H B r O}_{3}$ | + | $\mathbf{L i O H}$ | $\rightarrow$ | $\mathbf{H}_{2} \mathbf{O}$ | + | $\mathrm{LiBrO}_{3}$ |

3. Give the name and the formula of the ionic compound produced by neutralization reactions between the following acids and bases:

| Acid and Base reactants | Name of ionic compound | Formula |
| :--- | :---: | :---: |
| ric acid <br> a sodium hydroxide | sodium nitrate | $\mathbf{N a N O}_{3}$ |
| b) <br> hydroiodic acid <br> and calcium hydroxide | calcium iodide | $\mathbf{C a I}_{\mathbf{2}}$ |
| c)magnesium hydroxide <br> and hydrosulfuric acid | magnesium sulfide | $\mathbf{M g S}$ |
| d)ammonium hydroxide <br> and hydrofluoric acid | ammonium fluoride | $\mathbf{N H}_{4} \mathbf{F}$ |
| e)barium hydroxide <br> and sulfuric acid | barium sulfate | $\mathbf{B a S O}_{\mathbf{4}}$ |
| f)chloric acid <br> and rubidium hydroxide | rubidium chlorate | $\mathbf{R b C l O}_{\mathbf{3}}$ |


| g)calcium hydroxide <br> and carbonic acid | calcium carbonate | $\mathbf{C a C O}_{3}$ |
| :--- | :--- | :--- |

4. For each of the following ionic compounds, identify the acid and base that reacted to form them.

| Salt | Acid | Base |  |
| :--- | :--- | :--- | :--- |
| a) | NaCl | $\mathbf{H C l}$ | $\mathbf{N a O H}$ |
| b) | $\mathrm{Ca}_{3}\left(\mathrm{PO}_{4}\right)_{2}$ | $\mathbf{H}_{3} \mathbf{P O}_{4}$ | $\mathbf{C a}(\mathbf{O H})_{2}$ |
| c) | $\mathrm{Zn}\left(\mathrm{NO}_{3}\right)_{2}$ | $\mathbf{H N O}_{3}$ | $\mathbf{Z n}(\mathbf{O H})_{2}$ |
| d) | $\mathrm{Al}(\mathrm{ClO})_{3}$ | $\mathbf{H C l O}_{3}$ | $\mathbf{A l}(\mathbf{O H})_{3}$ |
| e) | $\mathrm{NH}_{4} \mathrm{I}$ | $\mathbf{H I}$ | $\mathbf{N H}_{4} \mathbf{O H}$ |

