

CHEM 106

Chemical Reactions & Chemical Equations

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The Reaction of Sodium & Chlorine

Formation of
Sodium Chloride

<http://chemconnections.org/general/movies/NaCl-form.MOV>

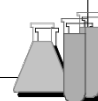
General Chemical Reactions

- Any chemical reaction can be described as a molecular or atomic change. It produces one or more observable changes.
- e.g. color change, gas bubbles, heat, etc.
- Reactions are generally described as
Reactant(s) → Product(s)
- The reaction is written as a chemical equation with chemical formulas:
$$2 \text{Na} + \text{Cl}_2 \rightarrow 2 \text{NaCl}$$



Chemical Equations

- Chemical equations describe the change(s) in Reactant(s) to Product(s) including physical state(s).
- Notations: (g), (l), (s), (aq)
- $2 \text{Na}_{(s)} + \text{Cl}_{2(g)} \rightarrow 2 \text{NaCl}_{(s)}$
- Others:
arrows for gas (↑) and solid (↓)
Δ for heat, ⇌ for reversibility (equilibrium)



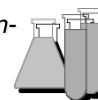
Types of Chemical Reactions

- Combination (Synthesis)
- Decomposition
- Single Displacement
- Double Displacement
- Combustion
- Others: Precipitation, Oxidation-Reduction, Neutralization



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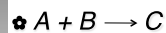
General Chemical Reactions



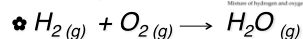
<http://chemconnections.org/general/movies/rxn-types.mov>

Chemical Reactions

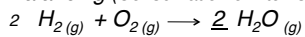
✧ Combination (Synthesis)



✧ Example:



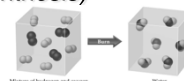
Balancing (Conservation of Atoms):



Stoichiometry:

[https://www.youtube.com/watch](https://www.youtube.com/watch?v=hSBT6oe6dSA&index=5&list=PLA3383CE72437FC43)

[?v=hSBT6oe6dSA&index=5&list=PLA3383CE72437FC43](https://www.youtube.com/watch?v=hSBT6oe6dSA&index=5&list=PLA3383CE72437FC43)



Synthesis of Water

<http://chemconnections.org/general/movies/H2O-form.MOV>

Formation of Water

Three Balloons:

[https://www.youtube.com/watch](https://www.youtube.com/watch?v=a6qGIMqDKwA&index=4&list=PLA3383CE72437FC43)

[?v=a6qGIMqDKwA&index=4&list=PLA3383CE72437FC43](https://www.youtube.com/watch?v=a6qGIMqDKwA&index=4&list=PLA3383CE72437FC43)

An Unwanted Synthesis of Water

Combustion & the Hindenburg 1937



<http://chemconnections.org/general/movies/qthiburg.mov>

QUESTION

The electrolysis of water is the reverse of the synthesis of water. Which equation best represents the change that takes place when water is electrolyzed?

- A) $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$
- B) $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$
- C) $2 \text{H}_2\text{O}(\text{l}) \rightarrow 2 \text{H}_2(\text{g}) + \text{O}_2(\text{g})$
- D) $2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{l})$

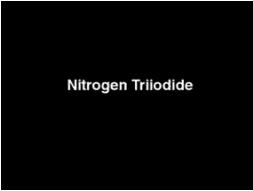
Answer

The electrolysis of water is the reverse of the synthesis of water. Which equation best represents the change that takes place when water is electrolyzed?

- A) $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$
- B) $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$
- C) $2 \text{H}_2\text{O}(\text{l}) \rightarrow 2 \text{H}_2(\text{g}) + \text{O}_2(\text{g})$
- D) $2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{l})$

Chemical Reactions
https://phet.colorado.edu/sims/html/balancing-chemical-equations/latest/balancing-chemical-equations_en.html

✧ **Decomposition**
 ✧ $A \rightarrow B + C$
 ✧ $2 \text{NI}_3(s) \rightarrow \text{N}_2(g) + 3 \text{I}_2(s)$



Nitrogen Triiodide

<http://chemconnections.org/general/movies/NI3-decomp.MOV>

QUESTION

Ammonium nitrate, when heated, decomposes into nitrogen gas, oxygen gas, and water vapor. It may be explosive. What is the sum of the coefficients in the balanced equation using smallest integer coefficients?

A) 3 B) 5 C) 7 D) 9

<https://www.youtube.com/watch?v=c5orJHRHbX0> (2013)

$__ \text{NH}_4\text{NO}_3(s) \rightarrow __ \text{N}_2(g) + __ \text{O}_2(g) + __ \text{H}_2\text{O}(g)$

<https://www.youtube.com/watch?v=TworclNhDhQ>
 See 2:30 (1947)

ANSWER

Ammonium nitrate, when heated, decomposes into nitrogen gas, oxygen gas, and water vapor. What is the sum of the coefficients in the balanced equation using smallest integer coefficients?

A) 3 B) 5 C) 7 D) 9

$2 \text{NH}_4\text{NO}_3(s) \rightarrow 2 \text{N}_2(g) + 1 \text{O}_2(g) + 4 \text{H}_2\text{O}(g)$

Chemical Reactions
Balancing Chemical Equations

✧ **Single Displacement**
 ✧ $AB + C \rightarrow CB + A$
 ✧ **Example:**

- $\text{HCl}_{(aq)} + \text{Mg}_{(s)} \rightarrow \text{MgCl}_{2(aq)} + \text{H}_{2(g)}$
- **Balanced Equation: ?**

$2 \text{HCl}_{(aq)} + \text{Mg}_{(s)} \rightarrow \text{MgCl}_{2(aq)} + \text{H}_{2(g)}$

Avogadro's Law allows calculation of the Molar Mass of the gas from its experimental volume and calculated # of moles produced.

Chemical Reactions
Balancing Chemical Equations

✧ **Double Displacement**
 ✧ $AB + CD \rightarrow AD + CB$
 ✧ **Example:**

- A solution of sodium phosphate reacts with a solution of silver nitrate to produce aqueous sodium nitrate and a precipitate of silver phosphate.
- **Balanced equation: ?**

$\text{Na}_3\text{PO}_4(aq) + 3 \text{AgNO}_3(aq) \rightarrow \text{Ag}_3\text{PO}_4(s) + 3 \text{NaNO}_3(aq)$

Chemical Reactions
Balancing Chemical Equations

• **Combustion:**

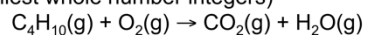
$\text{C}_8\text{H}_{18(l)} + \text{O}_{2(g)} \rightarrow \text{CO}_{2(g)} + \text{H}_2\text{O}_{(l)}$

- Oxygen reacts with octane to produce carbon dioxide and water.
- The balanced equation:
- ✧ $2 \text{C}_8\text{H}_{18(l)} + 25 \text{O}_{2(g)} \rightarrow 16 \text{CO}_{2(g)} + 18 \text{H}_2\text{O}_{(l)}$

https://phet.colorado.edu/sims/html/balancing-chemical-equations/latest/balancing-chemical-equations_en.html

QUESTION

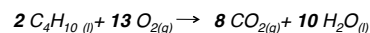
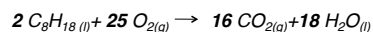
Determine the coefficient for O_2 when the following equation is balanced in standard form (smallest whole number integers)



- A) 4
- B) 8
- C) 10
- D) 13
- E) 20

ANSWER

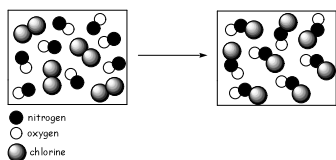
D) 13



O_2 should be balanced last since it contains only one type of element and balancing it will not cause an imbalance in another element.

QUESTION

Consider the molecular view of reactants converted to a product in the boxes shown below:

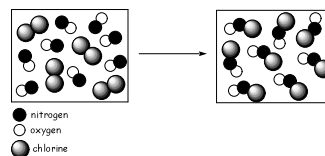


Which balanced equation best represents this reaction?

- | | |
|--|-------------------------------------|
| A) $NO + Cl_2 \rightarrow Cl_2NO$ | B) $2 NO + Cl_2 \rightarrow 2 ClNO$ |
| C) $N_2 + O_2 + Cl_2 \rightarrow 2 ClNO$ | D) $NO + Cl \rightarrow ClNO$ |

ANSWER

Consider the molecular view of reactants converted to a product in the boxes shown below:



Which balanced equation best represents this reaction?

- | | |
|--|-------------------------------------|
| A) $NO + Cl_2 \rightarrow Cl_2NO$ | B) $2 NO + Cl_2 \rightarrow 2 ClNO$ |
| C) $N_2 + O_2 + Cl_2 \rightarrow 2 ClNO$ | D) $NO + Cl \rightarrow ClNO$ |