General Reactions

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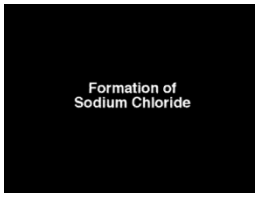
General Chemical Reactions

- *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 of Sodium & Chlorine



The reaction is written as a chemical equation with chemical formulas:

$2\ Na + Cl_2 \longrightarrow 2\ NaCl$

Reactants *Product*

Chemical Equations

Chemical equations describe the change(s) in Reactant(s) to Product(s) including physical state(s).

- *Notations: (g), (l), (s), (aq)*
- ***2 Na*** $_{(s)}$ ***+ Cl***$_{2(g)}$ $\longrightarrow$ ***2 NaCl*** $_{(s)}$
- *Others:*

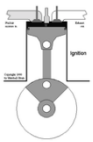
arrows for gas (↑) and solid (↓)

Δ for heat, $\rightleftharpoons$ *for reversibility (equilibrium)*

Types of Chemical Reactions

- *Combination (Synthesis)*
- *Decomposition*
- *Single Displacement*
- *Double Displacement*
- *Combustion: Oxidation-Reduction*
- *Biological Reactions: Enzyme Catalysts*

Example: Fermentation
http://www.piney.com/BabNinkasi.html)



General Chemical Reactions

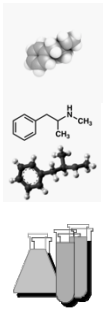
http://chemconnections.org/general/movies/rxn-types.mov

Chemical Reactions

- Combination (Synthesis)
- A + B ⟶ C
- Example:
  - $H_{2\,(g)} + O_{2\,(g)} \longrightarrow H_2O_{\,(g)}$

Balancing (Conservation of Atoms):

$\underline{2}\ H_{2\,(g)} + O_{2\,(g)} \longrightarrow \underline{2}\ H_2O_{\,(g)}$



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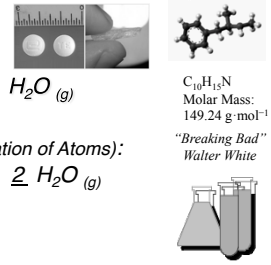


$C_{10}H_{15}N$
Molar Mass:
149.24 g·mol^{-1}

"Breaking Bad"
Walter White

Synthesis of Water

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

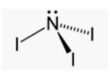
Three Balloons:
https://www.youtube.com/watch
?v=a6qGIMqDKwA&index=4&list=PLA3383CE72437FC43

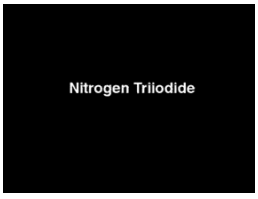
An Unwanted Synthesis of Water

Combustion & the Hindenburg 1937

Chemical Reactions

- Decomposition
- A ⟶ B + C
- $2\ NI_{3\,(s)} \longrightarrow N_{2\,(g)} + 3\ I_{2\,(s)}$





QUESTION

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**

Chemical Reactions

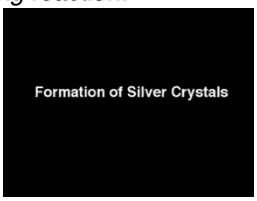
- Single Displacement
- $AB + C \longrightarrow CB + A$
- Example:
  - $HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$
  - Balanced Equation: ?

$2\,HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$

Name $HCl_{(aq)}$? Hydrochloric acid

Single Displacement

- Write a balanced equation for the following reaction:



$Cu_{(s)} + 2\,AgNO_{3(aq)} \longrightarrow 2\,Ag_{(s)} + Cu(NO_3)_{2\,(aq)}$

Chemical Reactions

- Double Displacement
- $AB + CD \longrightarrow AD + CB$
- 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: ?

$Na_3PO_{4\,(aq)} + 3\,AgNO_{3\,(aq)} \longrightarrow Ag_3PO_{4\,(s)} + 3\,NaNO_{3\,(aq)}$

Chemical Reactions

Predict the products:

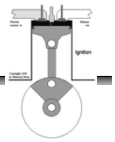
$H_2SO_4(aq) + NaOH(aq) \rightarrow$

$H_2SO_4(aq) + NaOH(aq) \rightarrow H_2O(l) + Na_2SO_4(aq)$

Balance the equation:

$H_2SO_4(aq) + 2\,NaOH(aq) \rightarrow 2\,H_2O(l) + Na_2SO_4(aq)$

Chemical Equations



- Combustion:

$C_8H_{18(l)} + O_{2(g)} \longrightarrow CO_{2(g)} + H_2O_{(l)}$

- Oxygen reacts with octane to produce carbon dioxide and water.
- Reminder: the equation must balance:

- **2** $C_8H_{18(l)}$ + **25** $O_{2(g)} \longrightarrow$ **16** $CO_{2(g)}$ + **18** $H_2O_{(l)}$

Carbon is oxidized: looses 4 electrons
Oxygen is reduced: gains 2 electrons

QUESTION

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

$C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$

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

Combustion: Oxidation-Reduction Reactions "Redox"

$$1\ CH_{4\ (g)} + 2\ O_{2(g)} \rightarrow 1\ CO_{2(g)} + 2\ H_2O_{(l)}$$

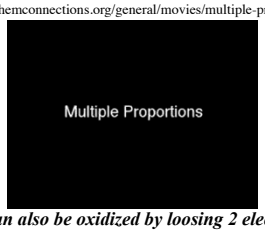
$$2\ C_4H_{10\ (g)} + 13\ O_{2(g)} \rightarrow 8\ CO_{2(g)} + 10\ H_2O_{(l)}$$

$$2\ C_8H_{18\ (l)} + 25\ O_{2(g)} \rightarrow 16\ CO_{2(g)} + 18\ H_2O_{(l)}$$

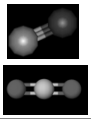
Carbon is oxidized: loosing 4 electrons
Oxygen is reduced: gaining 2 electrons

Combustion Products
Formulas & Multiple Proportions

http://chemconnections.org/general/movies/multiple-proportions.MOV



Carbon can also be oxidized by loosing 2 electrons
Oxygen remains reduced by gaining 2 electrons

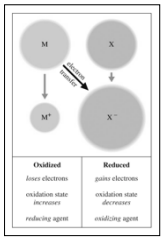


$$2\ CH_{4\ (g)} + 3\ O_{2(g)} \rightarrow 2\ CO_{g)} + 4\ H_2O_{(l)}$$

$$1\ CH_{4\ (g)} + 2\ O_{2(g)} \rightarrow 1\ CO_{2(g)} + 2\ H_2O_{(l)}$$

Oxidation-Reduction Reactions
"Redox": Changes in Oxidation State

- ***Oxidation*** *is the loss of electrons.*
- ***Reduction*** *is the gain of electrons.*
- *The reactions occur together. One does not occur without the other.*
- *The terms are used relative to the change in the* ***oxidation state*** *or* ***oxidation number*** *of the reactant(s).*



Oxidation Number (State)

http://chemconnections.org/general/movies/Oxid%20States.MOV

Rules for Assigning an Oxidation Number (O.N.)

General rules

1. For an atom in its elemental form (Na, O_2, Cl_2, etc.): O.N. = 0
2. For a monatomic ion: O.N. = ion charge
3. The sum of O.N. values for the atoms in a compound equals zero. The sum of O.N. values for the atoms in a polyatomic ion equals the ion charge.

Rules for specific atoms or periodic table groups

1. For Group 1A(1): O.N. = +1 in all compounds
2. For Group 2A(2): O.N. = +2 in all compounds
3. For hydrogen: O.N. = +1 in combination with nonmetals
   O.N. = −1 in combination with metals and boron
4. For fluorine: O.N. = −1 in all compounds
5. For oxygen: O.N. = −1 in peroxides
   O.N. = −2 in all other compounds (except with F)
6. For Group 7A(17): O.N. = −1 in combination with metals, nonmetals, (except O), and other halogens lower in the group

Tutorial

https://www.youtube.com/watch?v=w0RfMRDy34w

Assign oxidation numbers for all of the elements in the following compounds:

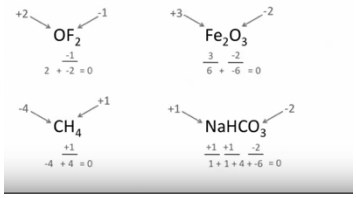
OF_2 Fe_2O_3

CH_4 $NaHCO_3$

Tutorial

https://www.youtube.com/watch?v=w0RfMRDy34w

Assign oxidation numbers for all of the elements in the following compounds:



QUESTION

In which of the following does nitrogen have an oxidation state of +4?

A. HNO_3
B. NO_2
C. NH_4Cl
D. $NaNO_2$

QUESTION

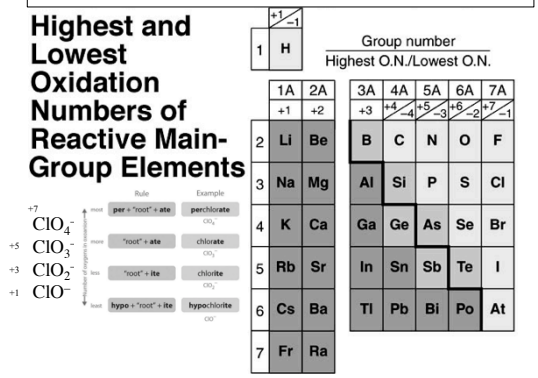
(More Challenging)

What is the oxidation number of chromium in ammonium dichromate?

A) +3 **B) +4** **C) +5** **D) +6**

Formula: ? $(NH_4)_2Cr_2O_7$

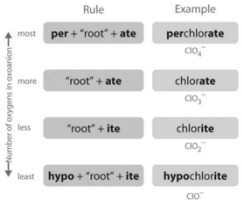
Highest and Lowest Oxidation Numbers of Reactive Main-Group Elements



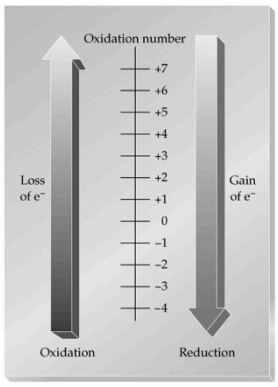
QUESTION

Hypochlorous acid is related to the anion found in common household bleach. Identify the formula of the polyatomic anion.

A. ClO_4^-
B. ClO_3^-
C. ClO_2^-
D. ClO^-



https://chem.libretexts.org/

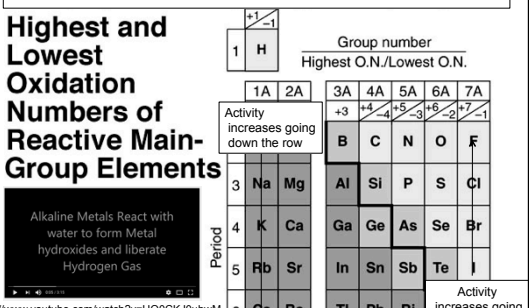


QUESTION

In a redox reaction, oxidation and reduction must both occur. Which statement is an accurate statement?

A. The substance (atom) that is oxidized has a lower oxidation number in the product.
B. The substance that is oxidized gains electrons.
C. The substance that is oxidized must have a higher oxidation number afterwards.
D. The substance that is oxidized must combine with oxygen.

Highest and Lowest Oxidation Numbers of Reactive Main-Group Elements



https://www.youtube.com/watch?v=UO0CKJ0ubwM

Cesium:
https://www.youtube.com/watch?v=D4pQz3TC0Jo

Rubidium:
https://www.youtube.com/watch?v=iP6CRZdDu6o

Which would be most reactive?
A) $Li + I_2$ B) $Na + Cl_2$ C) $Cs + F_2$

Write a balanced equation for the rubidium reacting.

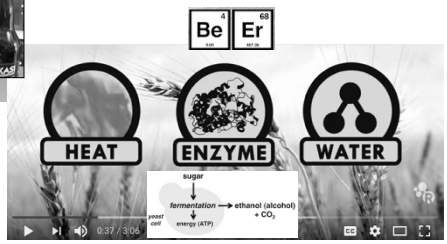
QUESTION

How many of the following are oxidation-reduction reactions?

$NaOH + HCl \rightarrow NaCl + H_2O$
$Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$
$Mg(OH)_2 \rightarrow MgO + H_2O$
$N_2 + 3H_2 \rightarrow 2NH_3$

A) 0
B) 1
C) 2
D) 3
E) 4

Biological Reactions eg. Fermentation

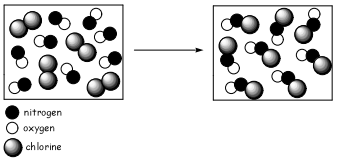


https://www.youtube.com/watch?v=vW99JEaDApY

http://www.piney.com/BabNinkasi.html

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) $NO + Cl \rightarrow ClNO$