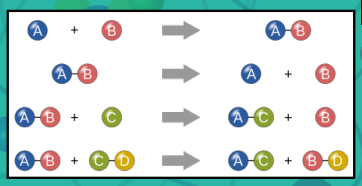
CHEMICAL REACTIONS



Chemical Reactions

CHEMICAL REACTION

5 signs of a chemical reaction

1. a gas is produced
2. light is produced
3. formation of a precipitate (a solid formed from 2 solutions)
4. temperature change [temp goes up (exothermic) or down (endothermic)]
5. permanent color change

Additional Questions

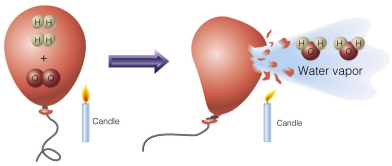
CHEMICAL REACTION

A **chemical reaction** is the rearrangement of atoms to form new substance(s).

Reactant(s) appear on the left, and **product(s)** appear on the right.

Example: $2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$

Reactants **Product**



Additional Questions

BALANCING EQUATIONS

- The big numbers that are used to balance the equation are called **coefficients**.

$2\ Fe_{(s)} + 3\ Cl_{2\,(g)} \rightarrow 2\ FeCl_{3\,(s)}$

- **Subscripts** are the small numbers written in formulas; they stand for the number of atoms or polyatomic ions immediately to their left.

Examples: $FeCl_3$ 3 is a subscript, meaning there are 3 Cl atoms

$Mg(NO_3)_2$ 3 is a subscript, meaning there are 3 O atoms;
2 is a subscript, meaning there are 2 NO_3
(2 N atoms and 6 O atoms all together)

Additional Questions

WRITING CHEMICAL FORMULA EQUATIONS FROM WORDS

Symbols Used in Chemical Reactions

(s) solid
(l) liquid
(g) gas
(aq) aqueous solution (the substance is dissolved in water; example: $NaCl_{(aq)}$ is salt water)

What are some indications in vocabulary that you have an aqueous solution?
a solution of sodium chloride
1.0 M NaCl *M means mole/L
sodium chloride is dissolved in water
aqueous sodium chloride

Additional Questions

WRITING CHEMICAL FORMULA EQUATIONS FROM WORDS

Symbols Used in Chemical Reactions

+ separates 2 reactants or products, reads as "reacts with" on reactant side, reads as "and" on product side

→ separates reactants from products; read as "yields" or "produces"

Δ → heat added to reactants (triangle appears above arrow)

Catalysts are not used up in the reaction so they appear above the arrow

$2\ KClO_3(s) \xrightarrow{MnO_2} 2KCl(s) + 3\ O_2(g)$

Catalysts are substances that increase the rate of the reaction but are not used up themselves. The formula for the catalyst is written above the arrow: (example MnO_2)

↔ reaction is at equilibrium (later concept)...means the forward and the reverse reaction occurs

Additional Questions

CHEMICAL EQUATIONS

According to the Law of Conservation of Mass, matter is not created or destroyed in a chemical reaction. So **the mass of all reactants must equal the mass of all products**. (this is a review)

Example 1: What is the **total** mass of **reactants** in the reaction below?

$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$
? 72 g

Answer: _____g

Example 2: What is the mass of **zinc** produced in the reaction below?

$Ca\ (s) + ZnCO_3(aq) \rightarrow CaCO_3(s) + Zn(s)$
40 g 125 g 100 g ?

Answer: _____g

Additional Questions

LAW OF CONSERVATION OF MASS

Because the Law of Conservation of Mass always holds in chemical reactions, we must always be sure we are working with a **balanced** equation. A balanced equation is one in which *the number of atoms of each element is the same on both sides of the arrow.*

Example of an equation that **IS NOT** balanced:

$Na(s) + FeCl_3(aq) \rightarrow NaCl(aq) + Fe(s)$

Atom inventory:

-Na-
-Fe-
-Cl-

Additional Questions

BALANCING EQUATIONS

When balancing equations, **ONLY add coefficients to balance**. **NEVER** alter a chemical formula in the equation in order to balance **(do not change SUBSCRIPTS!!)**.

Example

_____ CaO + _____ $C \rightarrow$ _____ CaC_2 + _____ CO

Additional Questions

BALANCING EQUATIONS

When balancing equations, **ONLY add coefficients to balance**. **NEVER** alter a chemical formula in the equation in order to balance **(do not change SUBSCRIPTS!!)**.

Example

___ $H_2O_{2(aq)} \rightarrow$ ___ $H_2O_{(l)}$ + ___ $O_{2(g)}$

Additional Questions

BALANCING EQUATIONS

When balancing equations, **ONLY add coefficients to balance**. **NEVER** alter a chemical formula in the equation in order to balance **(do not change SUBSCRIPTS!!)**.

Example

$NH_4OH + FeCl_3 \rightarrow Fe(OH)_3 + NH_4Cl$

Additional Questions

BALANCING EQUATIONS

When balancing equations, **ONLY add coefficients to balance**. **NEVER** alter a chemical formula in the equation in order to balance **(do not change SUBSCRIPTS!!)**.

****Trick for balancing tough combustion reactions:****

Balance the H first by placing a coefficient in front of the water. If that coefficient is **ODD**, **double it** and proceed with balancing C, then O. **Always balance oxygen last!!!**

Example: _____ C_7H_{14} + _____ $O_2 \rightarrow$ _____ CO_2 + _____ H_2O

Additional Questions

This concludes video 1 on reactions.

You should have taken high quality and in-depth notes.

Rewatch the video as needed.

Ask questions!

Dec 13-7:58 AM

Types of Reactions

We start with learning 5 basic reaction types.

More types exist, and we will learn more of them later in the unit.

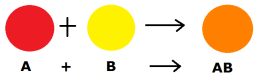
1. Synthesis
2. Decomposition
3. Single Replacement or Single Displacement
4. Double Replacement or Double Displacement
5. Combustion

Additional Questions

Types of Reactions

1. Synthesis (or combination)

- The combination of 2 of more substances to form a compound
- *only one product*



Example: $2Cu(s) + O_2(g) \rightarrow 2CuO(s)$

Additional Questions

Types of Reactions

2. Decomposition

- a compound breaks down into 2 of more simpler substances
- *only one reactant*

$AB \rightarrow A + B$

Example: $2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2(g)}$

Additional Questions

Types of Reactions

3. Single Replacement

- occurs when a single element reacts with an ionic compound and switches places with one of the elements in the compound.
- *element and compound gives you an element and compound*

$A + BC \rightarrow B + AC$

Single Displacement Reaction

Additional Questions

Types of Reactions

3. Single Replacement

General Form: $C + AB \rightarrow AC + B$

$A + BC \rightarrow B + AC$

Cation Displacement

$Al_{(s)} + CuCl_{2\,(aq)} \rightarrow Cu_{(s)} + AlCl_{3(aq)}$

Anion Displacement

$Cl_{2(g)} + KBr_{(aq)} \rightarrow KCl_{(aq)} + Br_{2(g)}$

review balancing

Additional Questions

Types of Reactions

4. Double Replacement

- ions in two compounds "change partners"
- Cation of one compound combines with the anion of another.
- compound & a compound gives you a compound & a compound

$AB + CD \rightarrow AD + CB$

A and C are Cations (Positive Ions)
B and D are Anions (Negative Ions)

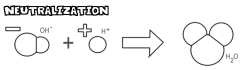
Double Displacement Reaction

Additional Questions

Types of Reactions

4. Double Replacement

*Note: An **acid-base (neutralization)** reaction is a special type of double replacement reaction. It occurs when an acid and a base react to form an ionic compound (a salt) and water.*



Examples: $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

$H_2SO_{4(aq)} + 2KOH_{(aq)} \rightarrow 2H_2O_{(l)} + K_2SO_{4(aq)}$

Additional Questions

Types of Reactions

5. Combustion Reactions

- rapidly occurring reactions with oxygen involving light and heat
- commonly occurs when oxygen reacts with a hydrocarbon to produce water and carbon dioxide. (A hydrocarbon is a compound containing only carbon, hydrogen, and sometimes oxygen)

Example:

$C_{10}H_{8(s)} + 12O_{2(g)} \rightarrow 10CO_{2(g)} + 4H_2O_{(g)}$

Additional Questions

Types of Reactions

5. Combustion Reactions

- rapidly occurring reactions with oxygen involving light and heat
- However, it does not just happen with hydrocarbons.

For example, when we heat metal magnesium in the presence of oxygen...it combusts.

$Mg(s) + O_2(g) \xrightarrow{\Delta} MgO$

Careful, just because you see O_2 does NOT make it a combustion reaction.

For us, we will classify combustion as reacting with a hydrocarbon with the products of carbon dioxide and water.

Additional Questions

Types of Reactions

Identify the types of reactions

$H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$

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

$Pb(NO_3)_{2(aq)} + K_2CrO_{4(aq)} \rightarrow PbCrO_{4(s)} + 2KNO_{3(aq)}$

$2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$

$C_3H_7OH_{(l)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$

review balancing

Additional Questions

WRITING CHEMICAL FORMULA EQUATIONS FROM WORDS

You will write reactions from word equations.

You will need to recall:

- How to write formulas
- What the physical states of elements are at STP (as well as some compounds)...most metal are solids (except Hg), Noble gases are gases, most of the diatomic elements are gases (except bromine and iodine). Sulfur and phosphorous are solids.
- How to indicate the physical states
- How to balance
- The diatomic elements

I_2, Br_2, Cl_2, F_2, O_2, N_2, H_2 NOT ~~I, Br, Cl, F, O, N, H~~ !!!!!

Additional Questions

WRITING CHEMICAL FORMULA EQUATIONS FROM WORDS

A few things we will assume ***unless indicated otherwise***:

1. Reactions are at STP
2. Water is a liquid (except in combustion).
3. Acids are in aqueous solution

Additional Questions

WRITING CHEMICAL FORMULA EQUATIONS FROM WORDS

Example

Solid sodium metal reacts with water to produce aqueous sodium hydroxide and hydrogen gas.

Additional Questions

WRITING CHEMICAL FORMULA EQUATIONS FROM WORDS

Example

1.0 M lithium hydroxide with 2.0 M phosphoric acid reacts to produce a solution of lithium phosphate and water.

Additional Questions

This concludes video 2 on reactions.

You should have taken high quality and in-depth notes.

Rewatch the video as needed.

Ask questions!

Dec 13-11:54 AM

PREDICTING PRODUCTS

You will predict products of reactions.

1. **Write the reactants including physical states**
2. **predict the products including physical states**
3. **balance the equation using the lowest possible integers**

Types of Reactions

PREDICTING PRODUCTS

Decomposition AB → A + B

1) All binary compounds will break down into their elements.
2) All metal carbonates break down to the metal oxide and carbon dioxide.
3) Chlorates will break down to the binary salt and oxygen.
4) metallic hydroxides (base) break down into metal oxides and water.

Types of Reactions

PREDICTING PRODUCTS

Decomposition AB → A + B

1) All binary compounds will break down into their elements.

Example 1: solid silver oxide decomposes

Example 2: crystals of mercury (II) oxide decompose

Types of Reactions

PREDICTING PRODUCTS

Decomposition AB → A + B

*All metal carbonates break down to the metal oxide and carbon dioxide.

Example 3: solid magnesium carbonate is heated

Types of Reactions

PREDICTING PRODUCTS

Decomposition AB → A + B

* Chlorates will break down to the binary salt and oxygen.

Example 4: solid lithium chlorate decomposes

Types of Reactions

PREDICTING PRODUCTS

Decomposition AB → A + B

*metallic hydroxides (base) break down into metal oxides and water.

Example 5: calcium hydroxide flakes decompose

Types of Reactions

PREDICTING PRODUCTS

Synthesis A + B → AB

1) Direct union of two elements will produce a binary compound.
2) Metallic oxides and carbon dioxide react to produce metal carbonates.
3) Binary salts and oxygen react to produce a chlorate.
4) metallic oxide plus water will produce a hydroxide (base)

Types of Reactions

PREDICTING PRODUCTS

Synthesis A + B → AB

*Direct union of two elements will produce a binary compound.

Example 1: solid sodium reacts with bromine

Example 2: $Al_{(s)} + Cl_{2(g)} \rightarrow$

Types of Reactions

PREDICTING PRODUCTS

Synthesis A + B → AB

*Metallic oxides and carbon dioxide react to produce metal carbonates.

Example 3: crystals of potassium oxide and carbon dioxide

Types of Reactions

PREDICTING PRODUCTS

Synthesis A + B → AB

*Binary salts and oxygen react to produce a chlorate.

Example 4: crystals of calcium chloride and oxygen

Types of Reactions

PREDICTING PRODUCTS

Synthesis A + B → AB

*Metallic oxide plus water will produce a hydroxide (base)

Example 5: flakes of sodium oxide and water

Types of Reactions

PREDICTING PRODUCTS

Combustion

C and H (& sometimes O) compound + O_2 → CO_2 + H_2O

Example 1: gaseous propane (C_3H_8) combusts

Types of Reactions

This concludes video 3 on reactions.

You should have taken high quality and in-depth notes.

Rewatch the video as needed.

Ask questions!

Dec 13-11:54 AM

PREDICTING PRODUCTS

Single Replacement

A + BC → B + AC cation replacement

D + BC → C + BD anion replacement

How do we know if the reaction will take place?

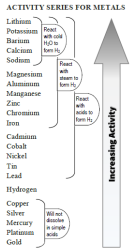
check activity series!

Types of Reactions

PREDICTING PRODUCTS

Single Replacement (check activity series!)

A + BC → B + AC (cation replacement)



Can Al replace Li? __

Can Cu replace Au? __

Can Zn replace H? __

Can Fe replace Ca? __

Types of Reactions

PREDICTING PRODUCTS

Single Replacement (check activity series!)

D + BC → C + BD (anion replacement)

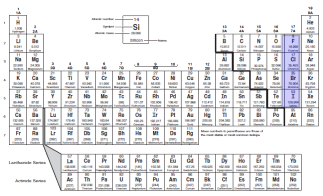
Halogen Activity Series (same order as on periodic table)

F most active

Cl

Br

I least active

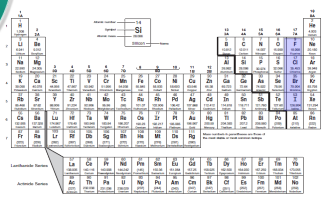


Types of Reactions

PREDICTING PRODUCTS

Single Replacement (check activity series!)

D + BC → C + BD (halogen replacement)



Can F_2 replace Br? __

Can I_2 replace Cl? __

Can Cl_2 replace F? __

Can Br_2 replace I? __

Types of Reactions

PREDICTING PRODUCTS

Single Replacement (check activity series!)

Pull

Pull PT

Example 1: $Cl_{2(g)} + KF_{(aq)} \rightarrow$

Example 2: $Ca_{(s)} + AlCl_{3(aq)} \rightarrow$

Types of Reactions

PREDICTING PRODUCTS

Single Replacement (check activity series!)

Pull

Pull PT

Example 3: pellets of lead are put in 1.5 M zinc nitrate

Example 4: fluorine is bubbled into a solution of sodium bromide

Types of Reactions

PREDICTING PRODUCTS

Double Replacement

AB + CD → CB + AD

Some products are precipitates ... we use solubility rules to determine if a precipitate forms. If a precipitate forms, we consider the reaction a precipitate reaction.

Types of Reactions

PREDICTING PRODUCTS

Double Replacement
AB + CD → CB + AD

Recap: There are now two kinds of reactions that stem from a double replacement reaction.

Neutralization Reaction
Acid + Base--> a salt (an ionic compound) and water

Precipitation Reaction
solution + solution --> solid compound + compound in any state

Types of Reactions

PREDICTING PRODUCTS

How do we know if a precipitate forms?

SOLUBILITY RULES FOR SALTS

These rules are written by priority, top to bottom. Rules higher in the list override rules lower in the list. Each statement implies that the listed ion behaves as the title states.
**Examining several sources will yield several slightly different sets of solubility rules. For our work and assessments, these are the only rules to consider.*

Always Soluble
1. alkali metal cations (Li^+, Na^+, K^+, Rb^+, Cs^+) and NH_4^+
2. NO_3^-, $C_2H_3O_2^-$, NO_2^-, ClO_3^-, ClO_4^-, CN^-, HCO_3^-

Generally Soluble
3. Cl^-, Br^-, I^- except when bound to Hg_2^{2+}, Ag^+, Pb^{2+}
4. SO_4^{2-} except Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+}, Ag^+, Pb^{2+}

Generally Insoluble
5. F^-, CO_3^{2-}, PO_4^{3-}, S^{2-}, SO_3^{2-}, $C_2O_4^{2-}$, CrO_4^{2-}, $Cr_2O_7^{2-}$ except Rule 1.
6. O^{2-}, OH^- except Rule 1. Oxides and hydroxides of Ca^{2+}, Sr^{2+}, Ba^{2+} are slightly soluble (this is still considered insoluble!)

Types of Reactions

PREDICTING PRODUCTS

How do we know if a precipitate forms?

SOLUBILITY RULES FOR SALTS

These rules are written by priority, top to bottom. Rules higher in the list override rules lower in the list. Each statement implies that the listed ion behaves as the title states.
**Examining several sources will yield several slightly different sets of solubi rules. For our work and assessments, these are the only rules to consider.*

Always Soluble
1. alkali metal cations (Li^+, Na^+, K^+, Rb^+, Cs^+) and NH_4^+
2. NO_3^-, $C_2H_3O_2^-$, NO_2^-, ClO_3^-, ClO_4^-, CN^-, HCO_3^-

Generally Soluble
3. Cl^-, Br^-, I^- except when bound to Hg_2^{2+}, Ag^+, Pb^{2+}
4. SO_4^{2-} except Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+}, Ag^+, Pb^{2+}

Generally Insoluble
5. F^-, CO_3^{2-}, PO_4^{3-}, S^{2-}, SO_3^{2-}, $C_2O_4^{2-}$, CrO_4^{2-}, $Cr_2O_7^{2-}$ except Rule 1.
6. O^{2-}, OH^- except Rule 1. Oxides and hydroxides of Ca^{2+}, Sr^{2+}, Ba^{2+} are slightly soluble (this is still considered insoluble!)

Add the physical state:

$LiNO_3$	$Pb(ClO_3)_2$
$CaCO_3$	Na_2CO_3
$MgCl_2$	$PbCl_2$
$BaSO_4$	$FeSO_4$
$Sr_3(PO_4)_2$	Na_3PO_4
$Ca(OH)_2$	LiOH

Types of Reactions

PREDICTING PRODUCTS

Double Replacement
AB + CD → CB + AD

Example 1:

hydrochloric acid with a solution of sodium hydroxide

Example 2:

aqueous barium chloride with aqueous potassium sulfate

Types of Reactions

PREDICTING PRODUCTS

Double Replacement
AB + CD → CB + AD

Example 3:

phosphoric acid with a solution of calcium fluoride

Example 4:

aqueous sodium acetate with aqueous lithium sulfide

Types of Reactions

This concludes video 4 on reactions.

You should have taken high quality and in-depth notes.

Rewatch the video as needed.

Ask questions!

Dec 13-11:54 AM

REDOX REACTIONS

In **oxidation-reduction (redox) reactions** the oxidation number for an element **changes** in a chemical reaction.

Oxidation Number: A number assigned to an element, based on the distribution of electrons. The same element can have very different properties in different oxidation states.

Redox

RULES FOR ASSIGNING OXIDATION #S

	Rules for Assigning Oxidation #s	Examples	Oxidation #
1	The oxidation number of any uncombined **ELEMENT** is **0**	Na, O_2	Na = , O_2 =
2	The ox. # of an **ION** equals the **charge** of the ion	Cl^-	Cl^- =
3	The ox. # of elements in **COMPOUNDS** *typically*, but not always (unless noted otherwise), follow a trend on the periodic table: **Group 1 = +1** ┐ **ALWAYS** **Group 2 = +2** ┘ **Group 13 = +3** **Group 15 = -3** **Group 16 = -2 (O usually -2)** **Group 17 = -1 (F ALWAYS -1)** **Transition metals AND Group 14 = variable charges** **Note: H has exceptions but we will use +1 in this course**	LiF $CaCO_3$ HF H_2O	Li = Ca = F = H =
4	The **sum** of ox.#s of all atoms in a **NEUTRAL COMPOUND** is **0**	LiF $CaCO_3$	Li = + F = 0 Ca = C = O -2 (x3) = 0
	The **sum** of ox. #s of all atoms in a **POLYATOMIC ION** equals the **charge** of the ion	SO_4^{2-}	S = +O -2 (x4) = -2

Note: Additional rules/exceptions to these rules do exist, but are beyond the scope of this course.

Redox

REDOX REACTIONS

Determine the oxidation number for each atom in the following:

a. FeO

b. Fe_2O_3

c. CO_3^{2-}

d. Li_2SO_4

e. Li

Redox

REDOX REACTIONS

Oxidation is a reaction in which there is the **loss** of electrons.

Ex: $\overset{0}{Na} \rightarrow \overset{+1}{Na^+} + e^-$ (When there is a loss of electrons, there is an increase in charge (more positive))

"LEO the lion says **GER"**

Losing of Electrons is Oxidation

Gaining of Electrons is Reduction

OR

Reduction is a reaction in which there is the **gain** of electrons.

Ex: $\overset{0}{Cl_2} + 2e^- \rightarrow 2\overset{-1}{Cl^-}$ (When there is a gain of electrons, there is a decrease in charge (more negative))

"OIL RIG"

Oxidation Is Loss (of electrons)

Reduction Is Gain (of electrons)

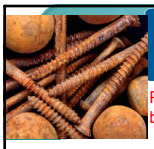
Redox

REDOX REACTIONS

Since oxidation is the **loss** of electrons and reduction is the **gain** of electrons, they must occur *simultaneously*.

****Any chemical process in which elements undergo changes in oxidation number is an oxidation-reduction reaction, or redox reaction for short.****

Redox



REDOX REACTIONS

Practice determining whether the following elements have been oxidized or reduced and label the reaction type.

Example 1: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ **TYPE of Reaction: S/D/SR/DR**

Element	Ox.# Reactants side	Ox.# Products side	Lose/Gain e⁻	Oxidized/Reduced

Redox

REDOX REACTIONS

Practice determining whether the following elements have been oxidized or reduced and label the reaction type.

Example 2: $Mg + 2HCl \rightarrow MgCl_2 + H_2$ **TYPE of Reaction: S/D/SR/DR**

Element	Ox.# Reactants side	Ox.# Products side	Lose/Gain e^-	Oxidized/Reduced

Redox

REDOX REACTIONS

Practice determining whether the following elements have been oxidized or reduced and label the reaction type.

Example 3: $HCl + NaOH \rightarrow NaCl + H_2O$ **TYPE of Reaction: S/D/SR/DR**

Element	Ox.# Reactants side	Ox.# Products side	Lose/Gain e^-	Oxidized/Reduced

Redox

This concludes video 5 on reactions.

You should have taken high quality and in-depth notes.

Rewatch the video as needed.

Ask questions!

Dec 13-11:54 AM

The End