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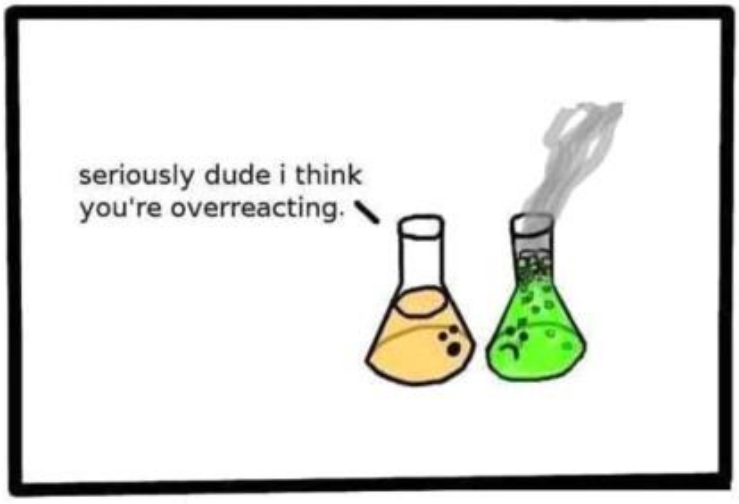
SCIENCE 10

UNIT 2: CHEMISTRY (PART 2)



BOOK 2: TYPES OF CHEMICAL REACTIONS

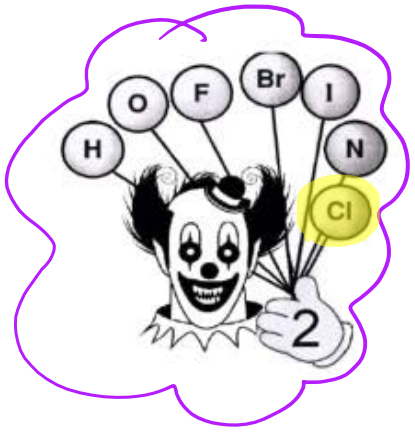
NAME: Key BLOCK: _____

1

PART A: CLASSIFYING CHEMICAL REACTIONS

neutralization

- There are many types/classes of chemical reactions
- Classifying **helps find out how chemical reactions work** and allows us to predict the products
- By understanding how one chemical reaction works, **scientists can understand more about how other reactions** between similar reactants **will behave**
- Reactions with common reactants would be in the same "class" of reaction
- One way to ***predict the outcome*** of a specific reaction is by recognizing that chemical reactions follow predictable patterns.
- Every kind of chemical reaction involves a unique combination of substances. **Reactant bonds** break (endothermic), atoms rearrange, and NEW products are formed. (bond forming (exothermic))
- There are many patterns in the way substances react which allow Chemists to classify chemical reactions in order to predict the products.



REMEMBER: that some atoms, like chlorine are written as a **diatomic molecules**, such as Cl_2.

Chlorine occurs as a diatomic molecule when it is a *pure element*. You need to remember your "HOFBrINCl" elements:

H_2, N_2, O_2, F_2, Cl_2, Br_2, and I_2. When diatomic elements are not combined into a compound, they exist as molecules containing two atoms.

Evidence of a Chemical Reaction?

Think of the comments in the video…

What **evidence** was there a chemical reaction took place?

- light CHANGE (light produced)
- ENERGY CHANGE (heat produced…temperatures exceeding 400°C)
- SOLID PRODUCT (MgO powder remains) (precipitate) ← double replacement reaction
- GAS FORMATION (some Mg_3N_2 is produced which reacts to produce ammonium gas) (bubbles)

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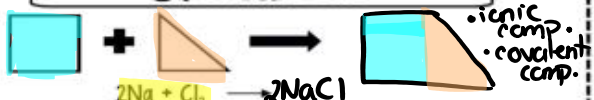
6 TYPES OF CHEMICAL REACTIONS

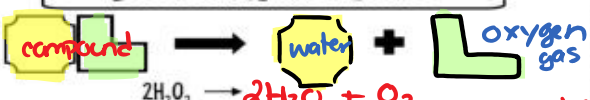
Name _____

Synthesis



A synthesis reaction occurs when simple compounds combine to make a more complex compound.

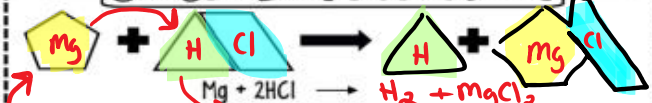
Decomposition



A decomposition reaction occurs when a compound or molecule breaks down into simpler ones.

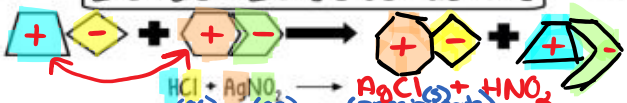
Single Displacement

"replacement"



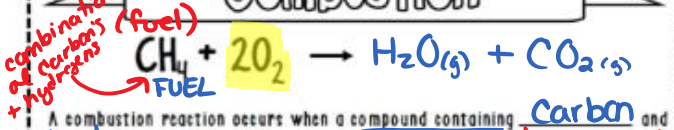
A single displacement or "replacement" reaction occurs when a pure element switches places with an element in a compound.

Double Displacement



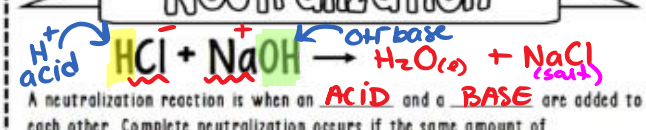
A double displacement or "replacement" reaction occurs when the ⊕ cations of two compounds switch places.

Combustion



A combustion reaction occurs when a compound containing carbon and hydrogen reacts with oxygen to create water (vapor) carbon dioxide and Heat (energy)

Neutralization



A neutralization reaction is when an ACID and a BASE are added to each other. Complete neutralization occurs if the same amount of OH⁻ and H⁺ ions are present and a SALT and water are formed.

↑ ionic compound

1. SYNTHESIS REACTIONS (ALSO CALLED COMBINATION REACTIONS)

In a synthesis reaction, two or more reactants (A and B) combine to produce a single product (AB).

- two or more elements form compound.
- or simple compounds combine to form one product

Examples:

metal + non-metal → ionic compound.

$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

M + NM → $2NaCl(s)$

$2Na(s) + Cl_2(g) \longrightarrow$

A + B → AB

$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(aq)$] be able to recognize

Two or more reactants	combine to yield	a single product
A + B	→	A B

Where do we see **synthesis reactions**…?

- ☐ Industry (large chemical plants)
  - Create hydrochloric acid for laboratories
- ☐ Environment
  - Metals exposed to air react with oxygen (rust)
- ☐ Burning (combustion)
  - Coal reacts with oxygen when burning
- ☐ Living Things
  - Plants and animals take simple substances (water, nitrogen, CO_2, and oxygen) to produce larger complex molecules (sugar, carbohydrates, proteins)

Synthesis Reaction: *EXAMPLES*

Example 1: To make table salt in a synthesis reaction, two atoms of sodium metal (Na) and one !molecule of chlorine gas (Cl_2) react to form! sodium chloride, NaCl

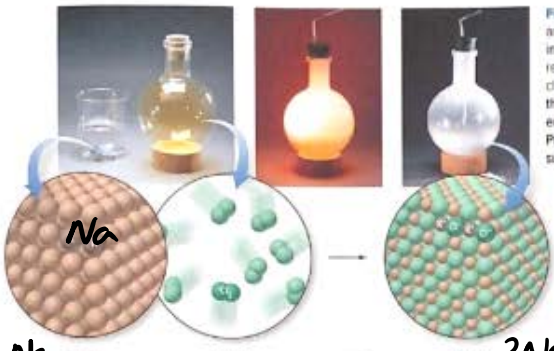
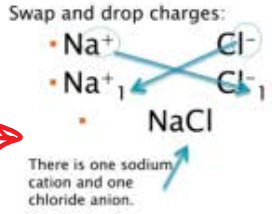


Figure 2.25 Potassium and chlorine combine in a dramatic synthesis reaction to form potassium chloride. **Analyzing:** Is this an exothermic or endothermic reaction? Provide evidence to support your answer.

Predicting Products:

Synthesis of a metal + non-metal produces an ionic compound. Reactants are ions, so "swap and drop" to find the chemical formula of the product:

balance charges →



Balanced chemical equation:

$2\,Na(s) + Cl_2(g) \longrightarrow 2\,NaCl(s)$

Synthesis of 2 NON-metals **produces a** *covalent compound.*

A + B → AB

$2N_2 + O_2 \rightarrow 2N_2O$

The formulas are much more difficult to predict at our level, so you will always be given more info....like a WORD EQUATION!

Practice Problems

1. Complete and balance the following synthesis (combination) reactions. Remember to consider the chemical formulas of the products carefully before you begin to balance.

(a) $3Mg + N_2 \rightarrow Mg_3N_2$

(b) $2Al + 3F_2 \rightarrow 2AlF_3$

(c) $2K + O_2 \rightarrow 2K_2O$

(d) $Cd^{2+} + I_2^- \rightarrow CdI_2$

(e) $12Cs + P_4 \rightarrow 4Cs_3P$

metal + non-metal → IC. Cs^+ P^{3-} 3:1

2. Identify whether or not each of the following chemical equations is a synthesis (combination) reaction.

(a) $2H_2 + O_2 \rightarrow 2H_2O$ synthesis

(b) $2Al + 3CuCl_2 \rightarrow 2AlCl_3 + 3Cu$ X 2 products.

→ (c) $2KClO_3 \rightarrow 2KCl + 3O_2$ X 2 prod. (decomposition)

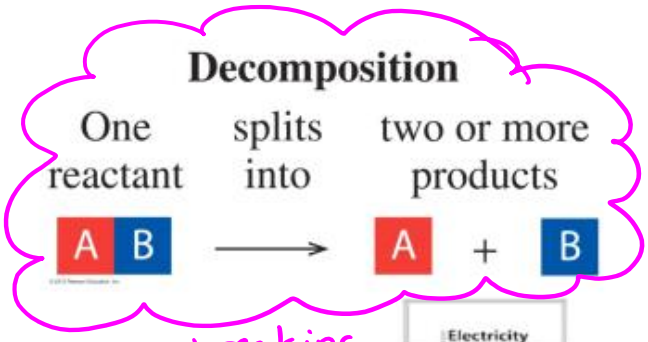
(d) $S_8 + 12O_2 \rightarrow 8SO_3$ synthesis

(e) $2Ti + 3Cl_2 \rightarrow 2TiCl_3$ synthesis.

2. DECOMPOSITION REACTION

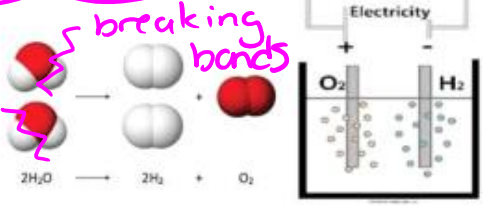
In a **decomposition reaction**, is the breaking down of a compound into smaller compounds or separate elements.

A decomposition reaction is the *reverse of a synthesis reaction.*



Decomposition of a Covalent Compound

- In all decomposition reactions there is 1 reactant and ***several*** product substances.
- *FOR EXAMPLE When an electric current is passed through water, it decomposes into hydrogen and oxygen gas.*



Thermal Decomposition (require heat energy)

Some substances will **only decompose** when heated to **high temperatures**… "thermal decomposition"

- Metal carbonates & hydrogen carbonates *(most ionic compounds)* $MgCO_3$ H_2CO_3

Write the formula for the decomposition of Sodium azide (NaN_3) found in airbags:

$2\,NaN_{3(s)} + heat \rightarrow 3\,N_{2(g)} + 2\,Na_{(s)}$

Decomposition of an Ionic Compound

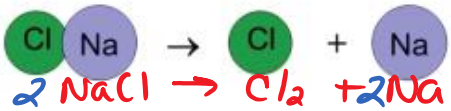
Table salt (NaCl) can be ***decomposed into sodium metal and chlorine gas*** by melting it at 800°C and passing an electric current through the liquid salt.

This is one way to produce chlorine gas (Cl_2)

During decomposition of an ionic compound, electrons transfer back to the atoms of the metal and each element becomes electrically neutral

Because of this, **neither of the products** is an ion.

2NaCl(s) + _____ → _____ + _____



$2\,NaCl \rightarrow Cl_2 + 2\,Na$

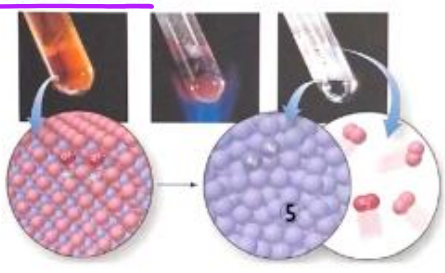
Cl^- Na^+ not ions

Most decomposition reactions are Endothermic reactions (All)

Reactants must absorb enough energy for one or more of its bonds to break.

2HgO(s) + HEAT (energy) → 2Hg + O_2 (g)

diatomic molecule



PRACTICE

Practice Problems

Diatomic molecules: "HOFBrINCl" eg. Cl_2, O_2....

1. Complete and balance the following decomposition reactions. Remember to check for diatomic elements as you write the formulas of the products.

(a) $2AuCl_3 \rightarrow 2Au + 3Cl_2$

(b) $2K_2O \rightarrow 4K + O_2$

(c) $MgF_2 \rightarrow Mg + F_2$

(d) $Ca_3N_2 \rightarrow 3Ca + N_2$

(e) $2CsI \rightarrow 2Cs + I_2$

2. Identify each reaction as synthesis, decomposition, or neither.

(a) $CO_2 \rightarrow C + O_2$ decomposition

(b) $2AgCl + Cu \rightarrow CuCl_2 + 2Ag$ (neither)

(c) $2Cr + 3F_2 \rightarrow 2CrF_3$ synthesis

(d) $CaI_2 + Na_2CO_3 \rightarrow 2NaCl + CaCO_3$ neither

(e) $2NaClO_3 \rightarrow 2NaCl + 3O_2$ decomposition

Motorcycle Air Bags

Many motorcycles have air bags that inflate within thousandths of a second in a crash. A motorcycle changes speed very quickly during a crash. This triggers a sensor in the air bag to create an electric impulse. The impulse sparks sodium azide in the air bag. Sodium azide immediately breaks down into solid sodium and nitrogen gas. The nitrogen gas fills the bag to cushion the driver on impact. The decomposition reaction is

$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$

Limestone and Cement

Limestone is a raw material in a host of products used in construction, agriculture, and the pulp and paper industry. The traditional territory of the Lheidli T'Enneh First Nation includes significant limestone deposits that may be quarried. Limestone is calcium carbonate, which yields calcium oxide (quick lime) and carbon dioxide when heated, as shown in the chemical equation below. The calcium oxide produced in this decomposition reaction is the main component of cement. Cement is added to water, sand, and gravel to make concrete. The calcium oxide acts as a binding agent. It holds the mixture together as the concrete dries and cures over time.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Explosion for Demolition Involving TNT

Many explosives produce tremendous force to break apart materials. They can occur as a result of the decomposition of a compound and the rapid heating and expansion of the gases that are produced. For example, trinitrotoluene (TNT) is a commonly used explosive that decomposes into elements and compounds.

$2C_7H_5N_3O_6(s) \rightarrow 3N_2(g) + 5H_2O(g) + 7CO(g) + 7C(s)$

6

HW

Homework **Assignment #1: Synthesis & Decomposition Reaction Mixed Review**

Part 1 – Classify each of the following reactions as a synthesis (S) or decomposition (D) reaction and then *balance each equation.*

	Reaction	Reaction type
1.	2 NH_3 → ___ N_2 + 3 H_2	D
2.	2 K + ___ Br_2 → 2 KBr	S
3.	2 H_2O → 2 H_2 + ___ O_2	D
4.	2 Al + 3 Cl_2 → 2 $AlCl_3$	S
5.	___ O_2 + 2 Be → 2 BeO	S
6.	___ P_4 + 6 F_2 → 4 PF_3	S
7.	2 H_2 + ___ O_2 → 2 H_2O	S
8.	2 $KClO_3$ → 2 KCl + 3 O_2	D
9.	___ S_8 + 12 O_2 → 8 SO_3	S
10.	2 Ti + 3 Cl_2 → 2 $TiCl_3$	S
11.	___ CO_2 → ___ C + ___ O_2	D
12.	2 $NaClO_3$ → 2 NaCl + 3 O_2	D

Part 2 – Complete the following *synthesis and decomposition reactions. Add phases and balance!*

13.	3 Mg + ___ N_2 → Mg_3N_2	A + B → AB synthesis; ionic compound; Mg^{2+} N^{3-} → Mg_3N_2
14.	___ MgF_2 → Mg + F_2	AB → A + B; diatomic molecule (HOFBrINCl)
15.	___ Ca_3N_2 → 3Ca + N_2	
16.	2 Al + 3 F_2 → 2 AlF_3	M + NM; ionic comp.; Al^{3+} F^{-1} → AlF_3
17.	2 K + 2 O_2 → $2K_2O$	K^{+} O^{2-} 2:1
18.	___ Cd + ___ I_2 → CdI_2	Cd^{2+} I^{-} 1:2
19.	2 K_2O → 2K + O_2	
20.	2 $AuCl_3$ → 2Au + $3Cl_2$	

PART B: REPLACEMENT REACTIONS

3. SINGLE REPLACEMENT REACTIONS

Single replacement

One element replaces another element

In a **single replacement** reaction, a reactive element (*a metal or a non-metal*) and a compound **react** to produce *another element* and *another compound.*

In other words, one of the elements in the compound is replaced by another element.

The element that is replaced could be a ***metal or a non-metal.*** (Hydrogen H^+ will react like a metal)

FOR EXAMPLE:

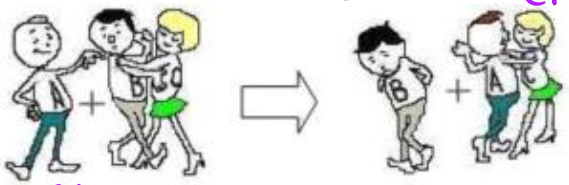
$Zn(s) + 2HCl(aq) \longrightarrow H_2 + ZnCl_2$ (ionic compound; Zn^{2+} Cl^- 1:2; H_2 a diatomic molecule)

$Fe(s) + CuSO_4(aq) \longrightarrow Cu + FeSO_4$ (ionic comp.; Fe^{2+} SO_4^{2-} 2:2 1:1)

Will a single replacement reaction will proceed or not?

Must compare the chemical reactivity of the element, to the reactivity of the element **it will replace** in the compound Table 4.2.2.

Chemical reactivity is the tendency of a substance to undergo chemical change.



A MORE reactive element will "kick off" a LESS reactive one.

Table 4.2.2 *Series of Chemical Reactivity*

Two Activity Series	
Metals	Decreasing Activity
lithium	
potassium	
calcium	
sodium	
magnesium	
aluminum	
zinc	
chromium	
iron	
nickel	
tin	
lead	
HYDROGEN*	
copper	
mercury	
silver	
platinum	
gold	

Non-metals. Halogens: flourine, chlorine, bromine, iodine. most reactive. Least Reactive. H_2O

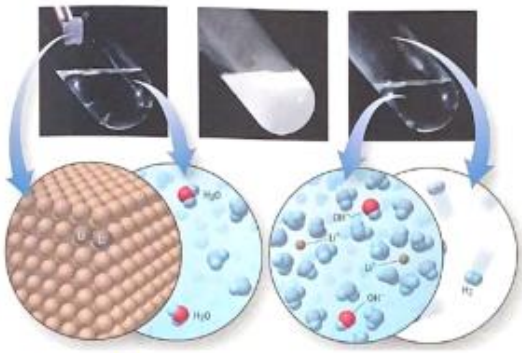
* Hydrogen may be displaced from most acids by all metals above it in the series. However, it may only be displaced from water (at room temperature) by those above magnesium.

PRACTICE **Will the following reactions proceed?**

Predict the products for those that **do proceed** *(if a reaction does not proceed, we write "no reaction")* and balance the equations.

metals rep. metals

1. $3Na_{(s)} + AlCl_{3(aq)} \rightarrow Al + 3NaCl$ ✓ Na is reactive (Na^+ Cl^- 1:1)
2. $Cu_{(s)} + KBr_{(aq)} \rightarrow$ no reaction (K is more reactive) ✗
3. n.m. $F_{2(g)} + 2LiI_{(aq)} \rightarrow I_2 + 2LiF$ ✓ (Li^+ F^- 1:1)
4. $Ca_{(s)} + HOH_{(l)} \rightarrow H_2 + Ca(OH)_2$ ✓ Ca is reactive (H_2O) (Ca^{2+} OH^- 1:2; $Ca_1(OH)_2$)



In some single replacement reactions, hydrogen in water can behave as a metal.

This is because hydrogen can form a positive cation.

Li^+ OH^- 1:1

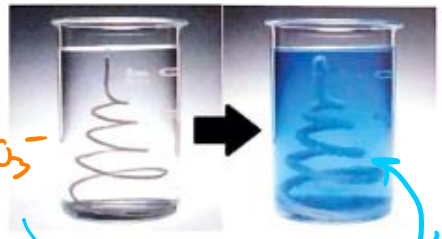
1. $2\,Li(s) + 2HOH(l) \rightarrow H_2 + 2LiOH$ (OH^-)
2. $Zn(s) + H_2O(l) \rightarrow$ no reaction (hydrogen in H_2O is more reactive) → X

IMPORTANT TO REMEMBER:

- a metal element always bonds with a non-metal element
- **metals replace metals**, while *non-metals replace non-metals*
- *cations replace cations*, and **anions replace anions**
  - metal replacement: $2\,K(s) + Cu(NO_3)_2(aq) \rightarrow 2\,KNO_3(aq) + Cu(s)$
  - hydrogen replacement: $2\,Na(s) + 2\,HOH(l) \rightarrow 2\,NaOH(aq) + H_2(g)$
  - non-metal replacement: $Br_2(l) + 2\,NaI(aq) \rightarrow 2\,NaBr(aq) + I_2(s)$

Single Replacement Reaction: *Examples*

"Metals replace Metals"



Another example of a single replacement reaction involving copper occurs when copper is placed into a solution of silver nitrate.

Cu^{2+} NO_3^- 1:2

$Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$

- Copper is MORE reactive than Silver.
- Therefore, the Ag^{3+} ion is 'cation ⊕', and the Cu^{2+} ion takes it's place to ionically bond with anion (NO_3^-) ⊖

$Cu(NO_3)_2$

"NON-Metals replace NON-Metals"

An example of the second type of single replacement reaction is the reaction of chlorine gas with a solution of sodium bromide.

diatomic molecules.

$2NaBr(aq) + Cl_2(g) \rightarrow 2NaCl(aq) + Br_2(\ell)$

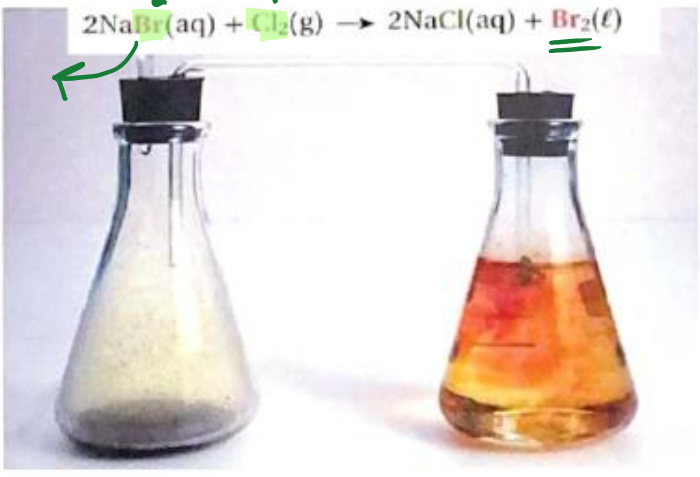


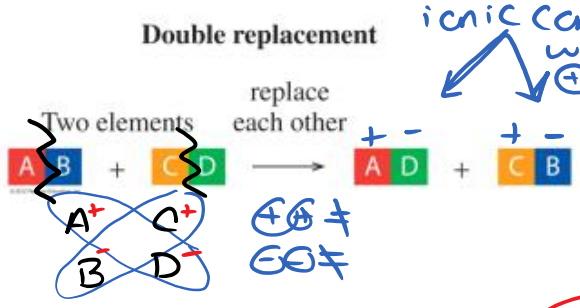
Figure 2.30 Chlorine gas (on the left) is bubbled through an aqueous solution of sodium bromide (on the right). The brown colour is the bromine produced.
Applying: Is this an open or closed system? Why do you think this system was used?

4. DOUBLE REPLACEMENT REACTIONS

must form ionic comp. with ⊕⊖

In a **double replacement**, two elements in the reactants exchange places.

The ⊕ ions of two ionic compounds change places to form **two new ionic compounds** as products.



FOR EXAMPLE:

$AgNO_3(aq) + NaCl(aq) \longrightarrow NaNO_3 + AgCl$

$ZnS(s) + 2HCl(aq) \longrightarrow H_2S + ZnCl_2$

Zn^{2+} Cl^{-1} → 1 : 2

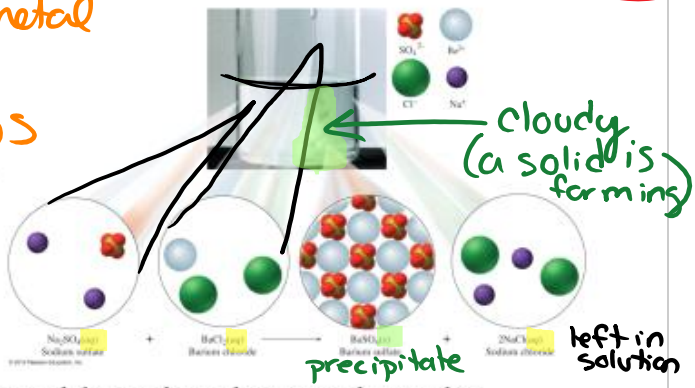
H^+ S^{2-} → 2 : 1 → H_2S

⊕ react like a metal

Double Replacement Reaction: $BaSO_4$

Usually occur between ionic compounds in aqueous solution, meaning they are solid *(salts)* that have been *dissolved in water.*

In many cases, when 2 aqueous solutions are mixed, a precipitate is one of the products. ← a solid forms



Example: *When Sodium sulfate and barium chloride are mixed these 2 clear solutions produce a white powdery looking precipitate suspended in a sodium chloride solution.*

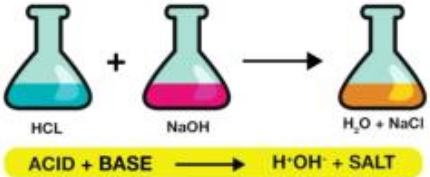
$$BaCl_{2(aq)} + Na_2SO_{4(aq)} \longrightarrow BaSO_{4(s)} + 2NaCl_{(aq)}$$

Two Types of Double Replacement Reactions:

1. **Precipitation Reactions-** where a solid is produced from 2+ aqueous solutions

(coming soon...)

2. **Neutralization Reactions-** when an acid and a base react to produce water and an ionic salt.



solid formation

1. PRECIPITATION REACTIONS

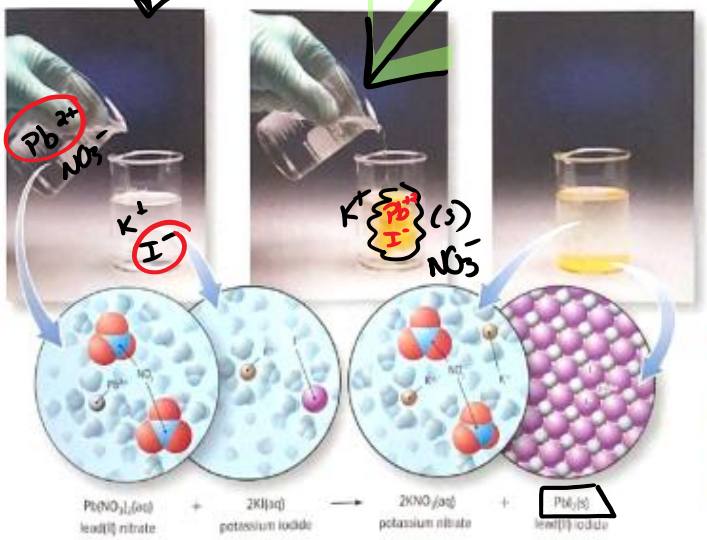
- Reactions in which a solid forms from two aqueous solutions *(appear as liquids)* are called precipitation reactions.
- When a solid **doesn't dissolve** it is called insoluble.

soluble = does dissolve.

EXAMPLE:

When potassium iodide and lead (II)nitrate solutions are mixed, the K^+ and Pb^{2+} ions switch places and the $PbI_{2(s)}$ bright yellow precipitate is formed.

$$2KI_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow PbI_2 + KNO_3$$



Uses of precipitation reactions

✓ Most precipitation reactions are very fast reactions that occur between ions.

This makes them very useful for identifying specific ions based on the type of precipitate formed.

Precipitation reactions have a number of other uses:

- production of coloured pigments for paints + dyes
- removal of toxic chemicals from water
- separation of reaction products.

A lead iodide precipitate.

PRACTICE

1. Complete and balance the following double replacement reactions. You do not need to decide which product(s) form a precipitate or to show states in the balanced equation.

(a) $CaS + NaOH \rightarrow$ $Ca(OH)_2 + Na_2S$

(b) $K_3PO_4 + MgI_2 \rightarrow$ $KI + MgPO_4$

(c) $SrCl_2 + Pb(NO_3)_2 \rightarrow$ $Sr(NO_3)_2 + PbCl_2$ (Pb^{2+})

(d) $AlCl_3 + CuNO_3 \rightarrow$ $AlNO_3 + CuCl$ (copper(I) ion)

(e) $AgNO_3 + Na_2CrO_4 \rightarrow$ $Ag_2CrO_4 + NaNO_3$

2. Classify each reaction as synthesis, decomposition, single replacement, or double replacement.

(a) $2FeBr_3 + 3Zn \rightarrow 3ZnBr_2 + 2Fe$ single replacement

(b) $FeBr_2 + ZnSO_4 \rightarrow ZnBr_2 + FeSO_4$ double replacement

(c) $2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$ single replacement

(d) $2Fe + O_2 \rightarrow 2FeO$ synthesis

(e) $2FeBr_3 \rightarrow 2Fe + 3Br_2$ decomposition

Homework **Assignment #2: Review of Single & Double Replacement Reactions Worksheets pg 12-13**

Single Replacement Reactions Practice

Fill in the blanks below with the correct information.

1. A chemical reaction occurs when bonds are broken + atoms rearrange to form new substances.
2. You can identify single replacement reactions because the reactants are an ionic compound and a single element
3. You can identify double replacement reactions because the reactants are a compound and another compound (both ionic)

Predict the products for the following **single replacement reactions**. ① First write the formulas for the ions found in each reaction in the designated spot then ② write down the products. Finally ③ balance the equations.

1. ____ NaCl + ____ H_2 → no reaction (hydrogen is less reactive than sodium)

Ion Formulas:	Na^+ Cl^- H^+

2. ____ $Cu(NO_3)_2$ + 2 K → $Cu + 2KNO_3$

Ion Formulas:	Cu^{2+} NO_3^- K^+

3. 4 Al + 3 MnO_2 → $2Al_2O_3 + 3Mn$

Ion Formulas:	Al^{3+} Mn^{4+} O^{2-}

4. 3 Br_2 + 2 K_3N → $N_2 + 6KBr$

Ion Formulas:	Br^- K^+ N^{3-}

5. 12 S + 2 Fe_2O_3 → $3O_2 + 4Fe_2S_3$

Ion Formulas:	S^{2-} Fe^{3+} O^{2-}

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Each of the following reactions can occur. Given the reactants, write the type of reaction, write the products, and balance the equation.

Predict the Products: Double Replacement Reactions I

Type of Reaction: Neutralization Reaction

1. $\_2\_ KOH_{(aq)} + \_1\_ H_2SO_{4\,(aq)} \rightarrow \_1\_ K_2SO_{4\,(aq)} + \_2\_ H_2O_{(\ell)}$

Type of Reaction: Precipitation Reaction

2. $\_1\_ K_2CO_{3\,(aq)} + \_1\_ BaCl_{2(aq)} \rightarrow \_2\_ KCl_{(aq)} + \_1\_ BaCO_{3\,(s)}$

Type of Reaction: Gas Production / neutralization *extension*

3. $\_1\_ NH_4Cl_{(aq)} + \_1\_ NaOH_{(aq)} \rightarrow \_1\_ NaCl_{(aq)} + \_1\_ NH_{3\,(g)} + \_1\_ H_2O_{(\ell)}$

Type of Reaction: Gas Production / neutralization

salt + carbon dioxide + water

4. $\_1\_ Na_2CO_{3\,(aq)} + \_1\_ H_2SO_{4\,(aq)} \rightarrow \_1\_ Na_2SO_{4\,(aq)} + \_1\_ CO_{2\,(g)} + \_1\_ H_2O_{(\ell)}$

5. $\_2\_ (NH_4)_3PO_{4\,(aq)} + \_3\_ ZnCl_{2\,(aq)} \rightarrow \_1\_ Zn_3(PO_4)_{2\,(s)} + \_6\_ NH_4Cl_{(aq)}$

6. $\_2\_ LiOH_{(aq)} + \_\_\_ Na_2CrO_{4\,(aq)} \rightarrow Li_2CrO_{4\,(s)} + 2NaOH(aq)$

7. $\_1\_ K_2CrO_{7\,(aq)} + \_1\_ MgBr_{2\,(aq)} \rightarrow \_1\_ MgCrO_{7\,(s)} + \_2\_ KBr_{(aq)}$

8. $\_\_\_ ZnBr_{2\,(aq)} + \_\_\_ Mg(NO_3)_{2\,(aq)} \rightarrow Zn(NO_3)_{2\,(aq)} + MgBr_{2(aq)}$

9. When there is no precipitate forms, what happens in the mixture of the two original solutions? What happens to the ions? there is no reaction

In the mixture of the two solutions, all of the ions are coverd in hydration shells and they remain in solution.

extension.

PART C) COMBUSTION REACTIONS

- combustion is the scientific word for "burning" and is a type of chemical reaction.
- Combustion is the reaction when a compound or element burns and reacts with oxygen to produce heat and light energy.
- Burning has been an important source of energy since primitive man and is still a hugely important process today.
- Burning fuel, like coal, petroleum and natural gas provides > 90% of the energy needed for transport, factories and in the home.

Equations for combustion

When a compound or element burns and reacts with oxygen the ***new substances formed*** are called "oxides".

The oxides contain oxygen and the elements that make up the **reactant compound.**

What are the word equations for these combustion reactions?

1. **Coal** (made from carbon) burns and forms $CO_2(g)$

carbon + oxygen → carbon dioxide

2. **Hydrogen** burns and forms dihydrogen oxide (i.e water!):

hydrogen + oxygen → water

3. **Methane** burns and forms carbon dioxide and water:

CH_4 + oxygen → CO_2 + water

Combustion of methane

The natural gas, methane, is often burnt for cooking.

Methane is made up of carbon and hydrogen.

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

Methane Oxygen Carboen Dioxide Water

1 4

Combustion Reaction

Combustion of Sulfur

The combustion of Sulfur *(or sulfur containing compounds)* will react with oxygen to product sulfur dioxide, $SO_{2(g)}$

SO_2 } react with H_2O in atmosphere (H^+ ions)

NO_2 }

H_2SO_4 + HNO_3

$$S_{8(s)} + 8O_{2(g)} \rightarrow 8SO_{2(g)}$$

- Sulfur containing compounds are said to be *"dirty"* because their combustion releases $SO_{2(g)}$ which is one of the major chemical species that **produces air pollution** contributing to acid rain (reacts in the atmosphere to produce H_2SO_4 and HNO_3)
- This is, of course, harmful to the environment and damages manmade structures, too.

Not all Combustion is bad...

Many combustion reactions produce heat and light

The burning of fuels such as natural gas and gasoline invoves the combustion of compounds called hydrocarbons

Hydrocarbons are compounds made up of just 2 elements: hydrogen *and* carbon

The general equation is:

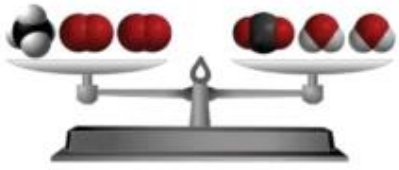
$$C_x H_y + O_2 \rightarrow CO_2 + H_2O$$

(where x and y are any number of carbons and hydrogen atoms)

For Example, the burning of Methane gas:

CH_4 + $2O_2$ → CO_2 + $2H_2O$

methane + oxygen → carbon dioxide + water



Incomplete Combustion

The burning of methane is what supplies school bunsen burners

Air hole open= complete combustion

Air hole closed = incomplete combustion

- When the supply of oxygen is *too low*, incomplete **combustion** occurs.
- Carbon dioxide and water are still products, but there are additional products such as *carbon (soot)* and carbon monoxide gas ($CO_{(g)}$)

Caution

Carbon monoxide is a poisonous gas. This is one of the reasons why BBQs are not used indoors, cars should not be run inside a garage and gas fireplaces are properly vented

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EXAMPLES OF COMBUSTION REACTIONS

Methane Combustion

Methane, $CH_4(g)$, is a hydrocarbon that is the main component in natural gas. The flame and heat produced when using a gas stove is due to the combustion of methane. The balanced chemical equation for the complete combustion of methane is

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

Gasoline Combustion

Gasoline is a mixture of different hydrocarbons. Fuels are graded based on their octane rating. The greater the amount of octane present, the higher the quality of fuel. The combustion of octane is represented by the equation

$2C_8H_{18}(\ell) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$

Propane Combustion

Propane, $C_3H_8(g)$, is a common fuel with several applications. Small propane torches like this one are often used by professionals, such as plumbers, and many people have them in their homes. Propane is also used as a heating fuel, with both indoor and outdoor heaters available. You are probably most familiar with its use as fuel for barbecues. Regardless of what the combustion of propane is used for, its combustion is represented by the equation

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

PRACTICE

1. Complete and balance the following combustion reactions.

(a) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

(b) $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

(c) $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

(d) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

(e) $C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$

2. Classify each reaction as synthesis, decomposition, single replacement, double replacement, neutralization, or combustion.

(a) $3Ca(NO_3)_2 + 2Na_3PO_4 \rightarrow 6NaNO_3 + Ca_3(PO_4)_2$ double replacement

(b) $Ca(OH)_2 + H_2SO_4 \rightarrow 2H_2O + CaSO_4$ neutralization

(c) $2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O$ combustion

(d) $6Mg + P_4 \rightarrow 2Mg_3P_2$ synthesis

(e) $C_2H_6O + 3O_2 \rightarrow 2CO_2 + 3H_2O$ combustion.

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Homework **Assignment #3: Combustion Reaction Practice 1.0 pg 17**

Combustion Reactions Practice 1.0

Objective: - Classify chemical reactions and predict the products
- Apply the Law of Conservation of Matter to balance chemical equations

Directions: For each reaction below:
A. ***Write the chemical equation***, predicting the products as needed.
B. *Balance* the chemical equation.

1. methane (CH_4) + oxygen → carbon dioxide + water

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

2. ethane (C_2H_6) + oxygen → carbon dioxide + water

$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

3. propane (C_3H_8) + oxygen → carbon dioxide + water

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

4. butane (C_4H_{10}) + oxygen → carbon dioxide + water

$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

5. Butene (C_4H_8) burns in air

$C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

still a hydrocarbon so CO_2 + H_2O are products.

6. Methanol (CH_3OH) combusts in the presence of oxygen

$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$

7. Acetylene gas (C_2H_2) is burned

$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

8. Heptyl alcohol ($C_7H_{16}O$) is oxidized by oxygen

$2C_7H_{16}O + 21O_2 \rightarrow 14CO_2 + 16H_2O$

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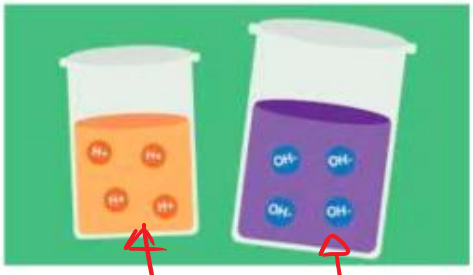
PART D) ACIDS & BASES

Many substances you encounter everyday are acids or bases.

For example, the sour taste of citrus fruits like grapefruit and lemon are due to acetic acid while the biter taste of coffee and the slippery feel of soap are due to the presence of bases.

We classify compounds as acids or bases depending on how they interact with water.

ACIDS

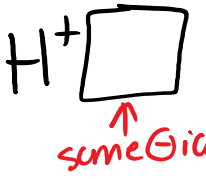


- releases hydrogen ions (H^+(aq)) in solution
- when hydrogen chloride gas is mixed with water, $H^+_{(aq)}$ and $Cl^-_{(aq)}$ form. So $HCl_{(aq)}$ is an *aqueous solution* because it is dissolved in water.

$$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$$

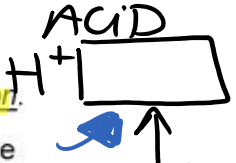
Naming Acids: *Acids come in two categories*

1. Binary acids composed of hydrogen and a non-metal.
   - The names of acids are based on the name of the anion ⊖ formed.
   - The rules for naming acids depend on whether the **anion** contains oxygen. If the anion *doesn't contain oxygen*, the prefix Hydro- goes at the start the name of the anion and the suffix "-ic" replaces the –ide in the anion's name. *+ always add the word "acid"*



Hydrogen fluoride (HF) is Hydrofluoric acid
Hydrogen chloride (HCl) is Hydrochloric acid
Hydrogen cyanide (HCN) Hydrocyanic acid

2. *Oxyacids* made of hydrogen, oxygen, and another element. In many cases, these are an H^+ ion paired with a polyatomic ion. (see data booklet)
   - for example: carbonic acid, $H^+ + CO_3^{2-} \rightarrow H_2CO_3$
   - There is NO prefix! Only use the name of the *polyatomic ion*.
   - The suffix "-ic" replaces "ate" in the anion's name
   - The suffix "-ous" replaces "ite" in the anion's name.
   - ***+ always add the word "acid"***



polyatomic ion that contains oxygen

~~Hydrogen~~ sulph~~ate~~ic (H_2SO_4) *is* sulphuric acid
~~Hydrogen~~ sulphite (ous) (H_2SO_3) *is* sulphurous acid.

NOTE: it's really about the number of oxygen atoms, just like naming polyatomic ions.

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Mnemonic .... that [maybe] helps ... or is just weird.

If an acid contains a polyatomic ion that ends in "-ate", the acid name will end in "-ic".

"I ATE an acid and it was ICky!"

H_2SO_4 = sulfATE ion = sulfurIC acid

If an acid contains a polyatomic ion that ends in "-ite", the acid name will end in "-ous".

"I only bITE into things that are deliciOUS."

H_2SO_3 = sulfITE ion = sulfurOUS acid

maybe this chart is more helpful ...

Acids

(begin with H)

Two Elements

Hydro + stem + ic

Hydrochloric acid

Three Elements

Have Oxygen (O)

Polyatomic Ions List

- ate → Stem + ic → HNO_3 = Nitric acid
- ite → Stem + ous → HNO_2 = Nitrous acid

PRACTICE — Determining the Names and Formulas of Acids

1. Write the formula of each of the following acids:

(a) hydrofluoric acid HF

(b) hypochlorous acid HClO

hypochlorite = ClO^-

(c) phosphoric acid H_3PO_4

(d) hydrosulphuric acid H_2S

2. Name each of the following (as) acids:

(a) HCH_3COO acetic acid

(b) H_2SO_3 sulphurous acid.

(c) H_2CO_3 carbonic acid

(d) HI hydroiodic acid.

H non-metal ⊖

Naming Acids

Many covalent compounds may also be classified as acids. So, what is an acid? An **acid** is a substance that produces H^+ when dissolved in water. We group and name acids by the anion of the compound. These two groups of acids include binary and oxyacids.

2+ non-metal atoms

H, H^+

bi = 2

Binary Acids

Composed of H+ and another non-metal element

Oxyacids

Composed of H+, oxygen, and another element

Examples

HF
HCl
H_2S
} 1 single non-metal element

Polyatomic Ions

HClO
H_2SO_4
H_3PO_3

Naming Rules

1. Write the prefix hydro-.
2. Add the root name of the nonmetal to the prefix.
3. Add the ending "-ic" to the root.
4. Skip a space and write the word acid to complete the name.
5. For example, HF would be named

H^+ F^- ic
Hydrofluoric acid

1. Write the name of the anion leaving off the -ate or the -ite.
2. If the anion name ended in *ate*, replace the ending with -ic.
3. If the anion name ended in *ite*, replace the ending with -ous.
4. Skip a space and write the word acid to complete the name.
5. For example, HClO would be named

H^+ ClO^- = hypochlorite
-ous
hypochlorous acid

Practice

Chemical Formula	Binary or Oxyacid	Acid Name
H_2S	binary	hydrosulfuric acid
H_2SO_4	oxyacid	sulfuric acid
HBr	binary	hydrobromic acid
HCN CN^-	binary	hydrocyanic acid
H_3PO_4	oxyacid	phosphoric acid

S^{2-} = sulphide = sulphuric

P^{3-} = phosphide = phosphoric

Homework

Assignment #4a: Acid Naming Questions # 1-7

1. What type of compound are acids?

   Acids are covalent compounds (all non metal atoms).

2. What happens to acids when added to water?

   Acids release an H+ ion when they dissolve into water.

3. What are the two basic types of acids?

   Binary Acids + Oxyacids

4. What is the distinguishing characteristic of binary acids?

   Binary Acids DO NOT contain any oxygen atoms.
   Usually the negative anion involved in the acid is a single elements *(however it could also be a polyatomic ion such as CN- that does not contain any oxygen atoms)*

5. How do you name binary acids?

   Binary acids are named by adding the prefix "Hydro" -"....then the name of the anion *(but change the "-ide" ending to "-ic")*...and add the word "acid" at the end.

Eg.	HF = Hydrofluoric acid

6. What is the distinguishing characteristic of oxyacids?

   Oxyacids DO CONTAIN oxygen atoms. The negative anion will be made of a polyatomic ion which contains oxygen.

7. How do you name oxyacids?

   Oxyacids are named for their polyatomic ions.

   If the name of the polyatomic ion ends in "-ate", the acid ending is changed to "-ic"
   If the name of the polyatomic ion ends in "-ite", the acid ending is changed to "-ous"
   + always add the word "acid" at the end.

   NOTE: when naming sulphide/sulphate/sulphite ions you need to ADD the "ur" back into sulpher. For example H_2SO_4 = sulph**ur**ic acid. The same applied to phosphide/phosphate/phosphite, ADD the "OR" back into phosph**OR**us. For example H_3PO_3 = phosph**or**ous acid

Homework — Assignment #4: Acid Naming Practice Questions #1+2 + Maze pg 20

1. Categorize each of the following acids as BINARY or OXOACIDS, then name each acid.

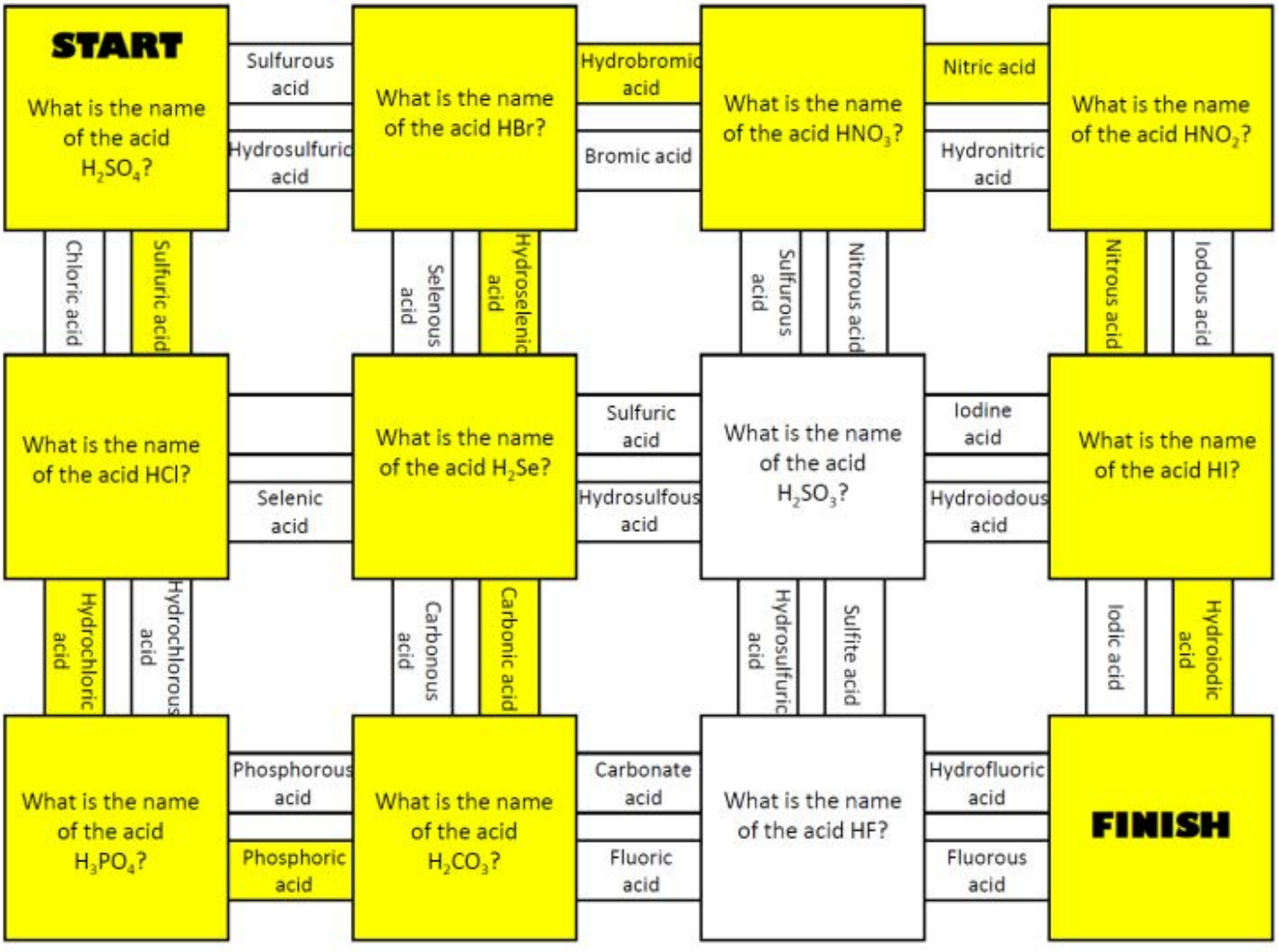
	Binary or Oxoacid	*Acid Name*
g) HF	Binary	hydrofluoric acid
h) H_2SO_4	Oxoacid	sulfuric acid
i) HNO_3	Oxoacid	nitric acid
j) HCl	Binary	hydrochloric acid
k) HBr	Binary	hydrobromic acid
l) H_2CO_3	Oxoacid	carbonic acid

2. Determine the formula for the following acids. (Hint: work backwards from the rules above. E.g. determine if the acid is a binary or oxoacid by looking for the presence (binary) or absence (oxoacid) of the prefix "hydro"; if the acid is an oxoacid the *'ic'* ending means the polyatomic ends in *'ate'*, whereas a *'ous'* ending means the polyatomic ended in *'ite'*).

	Formula		*Formula*
g) hydrochloric acid	HCl	h) phosphoric acid	H_3PO_4
i) nitrous acid	HNO_2	j) sulfuric acid	H_2SO_4
k) hydrofluoric acid	HF	l) phosphorous acid	H_3PO_3

Naming Acids Maze

Directions: *Read the question in the START block. Choose the path to the next question by choosing the correct answer. Color the questions and answers of your path as you move from START to FINISH.*



BASES

- releases hydroxide ions ($OH^-_{(aq)}$) in solution
- when sodium hydroxide crystals dissolve in water, $Na^+_{(aq)}$ and $OH^-_{(aq)}$ form.

$NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

- So $NaOH_{(aq)}$ is a *basic solution.*
- Many bases are ionic compounds composed of metal ions + hydroxide (OH^-)

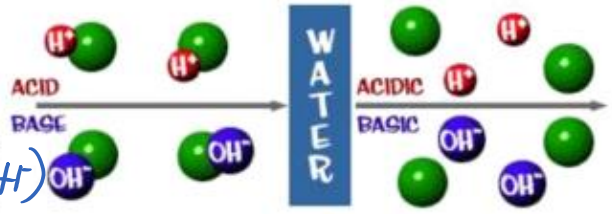


Table 2.2 **Common Bases and Their Uses**

Chemical Formula	Common Name	IUPAC Name	Uses
NaOH(aq)	lye, caustic soda	sodium hydroxide	in drain cleaners, used in making soaps and paper
$Mg(OH)_2$(aq)	Milk of Magnesia®	magnesium hydroxide	antacids and laxatives
$Ca(OH)_2$(aq)	lime water	calcium hydroxide	soil and water treatment

IDENTIFYING ACIDS + BASES

- Most acids and bases form colourless solutions in water.
- Acid-Base indicators are chemicals that change color in response to whether it is exposed to an acid or a base.
- A common indicator is Litmus paper.
- *Litmus is red in an acid and blue in an base.*

THE PH SCALE

- Some acids are more strongly acidic than others, and some bases are more strongly basic than others.
- The pH scale of 0 *(strongly acidic)* → 14 *(strongly basic)* indicates how strongly or weakly acidic or basic a substance is.
- Pure water is neither acidic nor basic = neutral= pH 7
- If there are a lot of H^+ ions, the pH is very acidic = low pH < 7
- If there are a lot of OH^- ions, that means the number of H^+ ions is very low, so the pH is very high > 7

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PART E) NEUTRALIZATION REACTIONS

- A neutralization reaction is a chemical reactions between an ___acid___ and a ___base___ that produces ___water___ and a ___salt___
- A **salt** is a type of ___ionic___ *compound*, it refers to the fact that a metal has bonded with a non-metal in a ***crystalline lattice structure.***

cations switch places (double rep.)

$$HA + BOH \rightarrow HOH + BA$$

Acid + Base → H_2O + Salt

- The reaction is actually a type of ___double___ replacement reaction.
- the ions of the ___reactants___ switch places to form two ___new___ products.
- ___water___ forms as the H^+ ions of the acid and the OH^- ions of the base combine
- The remaining ions for the ___ionic salt___ product. (ionic compound)
- because the hydrogen and hydroxide ions are removed from solution to form water, the pH of the solution will "___neutralized___" and approach pH = ___7___ = neutral.

EXAMPLE: Neutralization Reaction

- Phosphoric acid (H_3PO_4) is a main ingredient in **rust remover solutions.**
- Rust is a mixture of **iron compounds**, one of which is **iron(II) hydroxide ($Fe(OH)_2$).**
- Iron(II) hydroxide **dissolves when it reacts with phosphoric acid.**

Predict the products of the following neutralization reaction:

$2H_3PO_4 + 3Fe(OH)_2 \rightarrow$ water + salt

$H_2O_{(\ell)} + Fe_3(PO_4)_2$

salt

Fe^{2+} PO_4^{3-} 3:2 => $Fe_3(PO_4)_2$

you will always need to balance the charges to form the ionic compound (salt)

PRACTICE

Complete and balance the following equations representing neutralization reactions:

a) $2\,CsOH + H_2CO_3 \rightarrow 2H_2O + Cs_2CO_3$ (ionic compound)

b) $2\,HF + Mg(OH)_2 \rightarrow 2H_2O + MgF_2$

c) $3\,HNO_3 + Al(OH)_3 \rightarrow 3H_2O + Al(NO_3)_3$

d) $HCl + KOH \rightarrow H_2O + KCl$

e) $HBrO_3 + LiOH \rightarrow H_2O + LiBrO_3$ (2 2)

Homework **Assignment #5: Neutralization Reaction Practice pg 23**

1. Write the balanced chemical equations for the neutralization reactions between the listed acid and base.
(Remember, acids and bases react to form water and a type of salt):

a) HI and NaOH

$HI + NaOH \rightarrow H_2O + NaI$

b) H_2CO_3 and $Sr(OH)_2$

$H_2CO_3 + Sr(OH)_2 \rightarrow 2H_2O + SrCO_3$

c) $Ca(OH)_2$ and H_3PO_4

$3Ca(OH)_2 + 2H_3PO_4 \rightarrow 6H_2O + Ca_3(PO_4)_2$

d) HBr and $Ba(OH)_2$

$2HBr + Ba(OH)_2 \rightarrow 2H_2O + BaBr_2$

e) $Zn(OH)_2$ and HNO_3

$Zn(OH)_2 + 2HNO_3 \rightarrow 2H_2O + Zn(NO_3)_2$

f) $Al(OH)_3$ and HCl

$Al(OH)_3 + 3HCl \rightarrow 3H_2O + AlCl_3$

...SPECIAL TYPES OF ACID REACTIONS

Acids react with **metals** and **carbonates**.

(single replacement reactions... but with an acid)

so it's always the H^+ ion being replaced.

Metal + Acid ⟶ salt + Hydrogen

Zinc + hydrochloric acid → Zinc chloride + **hydrogen**

$Zn_{(s)} + HCl_{(aq)} \longrightarrow ZnCl_{(aq)} + H_{2(g)}$

Figure 6.7B Zinc metal reacts with hydrochloric acid to produce zinc chloride and hydrogen. The bubbles shown here are hydrogen bubbles.

Acid + **Carbonate** ⟶ Salt + Water + Carbon dioxide

sulphuric acid + copper carbonate ⟶ **copper sulphate + water + carbon dioxide**

The two reactants have rearranged into a larger number of smaller products, this rxn can be described as a decomposition reaction as well

$H_2SO_{4(aq)} + CuCO_{3(s)} \longrightarrow CuSO_{4(s)} + CO_{2(g)} + H_2O$ (2 3)

Homework

Assignment #6: Metal and Acid Reactions pg 24

Metal and Acid Reactions

General Rules

Metal + Acid → Salt + Hydrogen

1. If hydrochlori
2. If sulfuric aci
3. If nitric acid i

e.g. 1. Zinc

e.g. 2. Zinc

e.g. 3. Zinc

**you only need to do e*

Task 1

In your exercise book, w
reactants. If you have bee
equation. *Remember that*
arrow, and the products to

	Reactants
a.	Sodium and hydroc
b.	Calcium sulfuric aci
c.	Lithium and nitric a
d.	Magnesium and hy
e.	Aluminium and sulf
f.	Potassium and nitri
g.	Berylium and sulfu
h.	Iron and hydrochlo
i.	Lead and nitric acic
j.	Copper and sulfuric
k.	Silver and hydrochl
l.	Aluminium and nitr
m.	Iron and sulfuric ac
n.	Lead and hydrochlo
o.	Copper and nitric a

a.	Sodium	+	Hydrochloric acid	→	Sodium Chloride	+	Hydrogen
	$2Na_{(s)}$	+	$2HCl_{(l)}$	→	$2NaCl_{(aq)}$	+	$H_{2(g)}$
b.	Calcium	+	Sulfuric acid	→	Calcium Sulfate	+	Hydrogen
	$Ca_{(s)}$	+	$H_2SO_{4(l)}$	→	$CaSO_{4(aq)}$	+	$H_{2(g)}$
c.	Lithium	+	Nitric acid	→	Lithium Nitrate	+	Hydrogen
	$2Li_{(s)}$	+	$2HNO_{3(l)}$	→	$2LiNO_{3(aq)}$	+	$H_{2(g)}$
d.	Magnesium	+	Hydrochloric acid	→	Magnesium Chloride	+	Hydrogen
	$Mg_{(s)}$	+	$2HCl_{(l)}$	→	$MgCl_{2(aq)}$	+	$H_{2(g)}$
e.	Aluminium	+	Sulfuric acid	→	Aluminium Sulfate	+	Hydrogen
	$2Al_{(s)}$	+	$3H_2SO_{4(l)}$	→	$Al_2(SO_4)_{3(aq)}$	+	$3H_{2(g)}$
f.	Potassium	+	Nitric acid	→	Potassium Nitrate	+	Hydrogen
	$2K_{(s)}$	+	$2HNO_{3(l)}$	→	$2KNO_{3(aq)}$	+	$H_{2(g)}$
g.	Berylium	+	Sulfuric acid	→	Berylium Sulfate	+	Hydrogen
	$Be_{(s)}$	+	$H_2SO_{4(l)}$	→	$Be\ SO_{4(aq)}$	+	$H_{2(g)}$
h.	Iron	+	Hydrochloric acid	→	Iron (III) Chloride	+	Hydrogen
	$2Fe_{(s)}$	+	$6HCl_{(l)}$	→	$2FeCl_{3(aq)}$	+	$3H_{2(g)}$
I.	Lead	+	Nitric acid	→	Lead (II) Nitrate	+	Hydrogen
	$Pb_{(s)}$	+	$2HNO_{3(l)}$	→	$Pb(NO_3)_{2(aq)}$	+	$H_{2(g)}$
j.	Copper	+	Sulfuric acid	→	Copper (II) Sulfate	+	Hydrogen
	$Cu_{(s)}$	+	$H_2SO_{4(l)}$	→	$CuSO_{4(aq)}$	+	$H_{2(g)}$
k.	Silver	+	Hydrochloric acid	→	Silver Chloride	+	Hydrogen
	$2Ag_{(s)}$	+	$2HCl_{(l)}$	→	$2AgCl_{(aq)}$	+	$H_{2(g)}$
l.	Aluminium	+	Nitric acid	→	Aluminium Nitrate	+	Hydrogen
	$2Al_{(s)}$	+	$6HNO_{3(l)}$	→	$2Al(NO_3)_{3(aq)}$	+	$3H_{2(g)}$
m.	Iron	+	Sulfuric acid	→	Iron (III) Sulfate	+	Hydrogen
	$2Fe_{(s)}$	+	$3H_2SO_{4(l)}$	→	$Fe_2(SO_4)_{3(aq)}$	+	$3H_{2(g)}$
n.	Lead	+	Hydrochloric acid	→	Lead (II) Chloride	+	Hydrogen
	$Pb_{(s)}$	+	$2HCl_{(l)}$	→	$PbCl_{2(aq)}$	+	$H_{2(g)}$
o.	Copper	+	Nitric acid	→	Copper (I) Nitrate	+	Hydrogen
	$2Cu_{(s)}$	+	$2HNO_{3(l)}$	→	$2CuNO_{3(aq)}$	+	$H_{2(g)}$

SUMMARY OF REACTION TYPES & WORKED EXAMPLES

Sample Problem 1:

Predicting the Products of a Synthesis Reaction

Identify the type of reaction. Then predict the products and give the balanced chemical equation.

$$Al + F_2 \longrightarrow$$

Solution

1. This reaction has two reactants and both are elements. Therefore, this is a synthesis reaction.
2. Since one reactant is a metal and the other reactant is a non-metal, the product will be a binary ionic compound composed of ions of both elements. Aluminum forms a Al^{3+} ion and fluorine forms a F^- ion. Therefore, they will produce the compound, AlF_3
3. Write the skeleton equation with the reactants and predicted product.

   $Al + F_2 \longrightarrow AlF_3$
4. Write the balanced chemical equation.

   $2Al + 3F_2 \longrightarrow 2AlF_3$

Sample Problem 2:

Predicting the Products of a Decomposition Reaction

Identify the type of reaction. Then predict the products and give the balanced chemical equation.

$$Mg_3N_2 \longrightarrow$$

Solution

1. This reaction has only one reactant. Therefore, this is a decomposition reaction.
2. The products will be the separate elements, Mg and N_2.
3. Write the skeleton equation with the reactant and predicted products.

   $Mg_3N_2 \longrightarrow Mg + N_2$
4. Write the balanced chemical equation.

   $Mg_3N_2 \longrightarrow 3Mg + N_2$

Sample Problem 3:

Predicting the Products of a Replacement Reaction

Identify the type of reaction. Then predict the products and give the balanced chemical equation.

$$Al + Pb(NO_3)_2 \longrightarrow$$

Solution

1. This reaction has two reactants; one is an element and the other is a compound. Therefore, this is a single replacement reaction.
2. Aluminum is a metal and it will replace lead(II) ions in the compound to form the compound $Al(NO_3)_3$. The element lead will be the other product.
3. Write the skeleton equation with the reactants and predicted products.

   $Al + Pb(NO_3)_2 \longrightarrow Pb + Al(NO_3)_3$
4. Write the balanced chemical equation.

   $2Al + 3Pb(NO_3)_2 \longrightarrow 3Pb + 2Al(NO_3)_3$

Sample Problem 4:

Predicting the Products of a Hydrocarbon Combustion Reaction

Identify the type of reaction. Then predict the products and give the balanced chemical equation.

$$C_3H_8 + O_2 \longrightarrow$$

1. This reaction has two reactants; one is oxygen and the other is a hydrocarbon, which is called propane. Therefore, this represents the combustion of a hydrocarbon.
2. The products of the combustion of a hydrocarbon are carbon dioxide and water.
3. Write the skeleton equation with the reactants and predicted products.

   $C_3H_8 + O_2 \longrightarrow CO_2 + H_2O$
4. Write the balanced chemical equation. A common strategy for balancing these types of equations involves balancing the carbons first, then the hydrogens, and then the oxygens.

   $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

Practice Problems

Identify the type of reaction. Then predict the products and give the balanced chemical equation.

1. $2Al + 3CuCl_2 \longrightarrow 3Cu_{(s)} + 2AlCl_3$ (single replacement)
2. $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$ (double replacement)
3. $2C_6H_{14} + 19O_2 \longrightarrow 12CO_2 + 14H_2O$ (combustion)
4. $Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$ (neutralization)
5. $2KI \longrightarrow 2K + I_2$ (decomposition)
6. $3Zn + N_2 \longrightarrow Zn_3N_2$ (synthesis)
7. $3Cd + 2Au(NO_3)_3 \longrightarrow 3Cd(NO_3)_2 + 2Au$ (singe replacement)
8. $2Fe_2O_3 \longrightarrow 4Fe + 3O_2$ (decomposition)
9. $2K + Cl_2 \longrightarrow 2KCl$ (synthesis)
10. $Cl_2 + 2CsBr \longrightarrow 2CsCl + Br_2$ (single replacement)

Zn^{2+} N^{3-} 3:2 ratio to balance ⊕⊖

(non-metals replace non-metals)

Homework

Assignment #7: Types of Reactions Mixed Review. Practice Q's pg 26, Types of Rxn Worksheets pg 27-28

Types of Reactions Worksheet

Given the reactions below, identify each as synthesis (S), decomposition (D), single replacement (SR), double replacement (DR), or combustion (C). **Afterwards, balance the reaction.**

1) 2 K + ___ Cl_2 → 2 KCl — Type of Reaction: S

2) 2 NH_3 → ___ N_2 + 3 H_2 — Type of Reaction: D

3) 2 NaF + ___ Br_2 → 2 NaBr + ___ F_2 — Type of Reaction: SR

4) ___ SO_2 + 2 Li_2Se → ___ SSe_2 + 2 Li_2O — Type of Reaction: DR

5) 2 $PbSO_4$ → 2 $PbSO_3$ + ___ O_2 — Type of Reaction: D

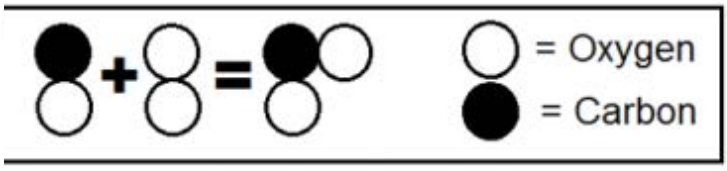
6) 2 Al + ___ Fe_2O_3 → 2 Fe + ___ Al_2O_3 — Type of Reaction: SR

7) ___ SF_6 → ___ S + 3 F_2 — Type of Reaction: D

8) ___ C_2H_4 + 2 O_2 → 2 CO_2 + 2 H_2O — Type of Reaction: C

9) 2 $KClO_3$ → 2 KCl + 3 O_2 — Type of Reaction: D

10) ___ $Pb(NO_3)_2$ + ___ NaCl → ___ $NaNO_3$ + ___ $PbCl_2$ — Type of Reaction: DR



11) What type of reaction is shown to the left?

Synthesis

12) Using the key provided, write the complete chemical formula shown in the box above:

2 CO + O_2 → 2 CO_2

13) **Now balance the equation above so that both sides of the reaction are equal.**

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Name: Answer Key Class: Date:

Each of the following reactions can occur. Write the correct products and balance each equation.

Predict the Products: Mixed Type Practice

Type of Reaction: decomposition with carbonate

1. 1 $CaCO_{3\,(s)}$ → 1 $CaO_{(s)}$ + 1 $CO_{2\,(g)}$

Type of Reaction: Reaction with Water

2. 1 $Li_2O_{(s)}$ + 1 $H_2O_{(l)}$ → 2 $LiOH_{(aq)}$

Type of Reaction: double replacement: precipitation

3. 1 $SrBr_{2\,(aq)}$ + 1 $(NH_4)_2CO_{3\,(aq)}$ → 1 $SrCO_{3\,(s)}$ + 2 $NH_4Br_{(aq)}$

Type of Reaction: metal reaction with water

4. 2 $Li_{(s)}$ + 2 $H_2O_{(l)}$ → 2 $LiOH_{(aq)}$ + 1 $H_{2\,(g)}$

Type of Reaction: metal reaction with acid

5. 1 $Cd_{(s)}$ + 1 $H_2SO_{4\,(aq)}$ → 1 $CdSO_{4\,(aq)}$ + 1 $H_{2\,(g)}$

Type of Reaction: Single Metal Replacement Reaction

6. 2 $Al_{(s)}$ + 1 $Mn_2O_{3\,(s)}$ → 1 $Al_2O_{3\,(s)}$ + 2 $Mn_{(s)}$

Type of Reaction: double replacement: neutralization

7. 1 $Ca(OH)_{2\,(aq)}$ + 2 $HCl_{(aq)}$ → 1 $CaCl_{2\,(aq)}$ + 2 $H_2O_{(l)}$

Type of Reaction: Binary Compound Decomposition Reaction

8. 1 $Mg_3N_{2\,(s)}$ → 3 $Mg_{(s)}$ + 1 $N_{2\,(g)}$