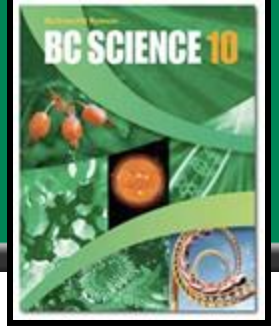
4.3 Balancing Chemical Equations



- **Chemical reactions result in chemical changes.**
  - **Bonds are broken and new substances are created.**
  - **The original substance(s), are called reactants,**
  - **The new substance(s) are called *PRODUCTS*.**
- **Chemical reactions $2NO + O_2 \longrightarrow 2NO_2$**

Coefficients

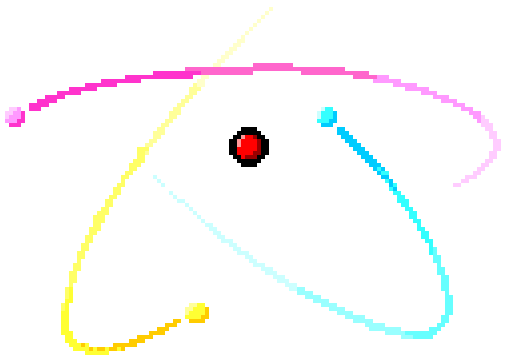
- Indicate the ratio of compounds in the reaction.

- Here, there is twice as much NO and NO_2 than as is O_2.

ℓ

See pages 202 - 203

Reviewing Counting Atoms and Balancing Chemical Equations



Subscripts

- $C_{12}H_{22}O_{11}$
  - There are 12 atoms of Carbon
  - There are 22 atoms of Hydrogen
  - There are 11 atoms of Oxygen
- If there is not a subscript listed, it is understood to be 1.
- Example: NaCl
  - There is one atom of Sodium
  - There is one atom of Chlorine

You Practice!

$NaHCO_3$

Sodium – 1

Hydrogen – 1

Carbon – 1

Oxygen -3

HCl

Hydrogen – 1

Chlorine - 1

There are times you will see a compound with parenthesis.

$Pb(NO_3)_2$

The 2 after the parenthesis indicates there are two sets of the parenthesis.

$Pb(NO_3)\ (NO_3)$

So, in counting the atoms, you would have the following:

Lead – 1

Nitrogen -2

Oxygen - 6

You Practice!!

$(NH_4)_3PO_4$

Nitrogen – 3

Hydrogen – 12

Phosphorus – 1

Oxygen – 4

$Mg(OH)_2$

Magnesium – 1

Oxygen – 2

Hydrogen – 2

Coefficient

$2H_2SO_4$

This means there are 2 compounds of Sulfuric Acid. Think:

H_2SO_4 H_2SO_4

Counting the atoms:

- Hydrogen – 4
- Sulfur – 2
- Oxygen - 8

You Practice!!

$3H_3PO_4$

Hydrogen – 9

Phosphorus – 3

Oxygen - 12

$2H_2O$

Hydrogen – 4

Oxygen - 2

Got It????

Movin' On!!

Chemical Equations

Chemical equations express what is happening in a chemical reaction using symbols.

$2K + Cl_2$ $\longrightarrow$ $2KCl$

yields

Reactant Product

Law of Conservation of Mass

In a chemical reaction, matter cannot be created or destroyed. It can only be ***CHANGED***.

Therefore the ATOMS you start with (***Reactants***) must equal the ATOMS you finish with (***Products***)

Is it balanced?

$H_2 + O_2 \longrightarrow H_2O$

Reactants	Products
H = 2	H = 2
O = 2	O = 1

This cannot happen. An oxygen atom cannot be destroyed.

So what do we do?

$2H_2 + O_2 \longrightarrow 2H_2O$

Reactants:

H = 4

O = 2

Products:

H = 4

O = 2

*** REMEMBER YOU CAN ONLY CHANGE THE SUBSCRIPTS (big numbers)– NOT THE COEFFICIENTS (little numbers)

You Practice!!!
Is it balanced?

NOPE

$HgO \longrightarrow Hg + O_2$

Hg = Hg =

O = O =

$N_2 + 3H_2 \longrightarrow 2NH_3$ YUP

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$ YUP

More Practice

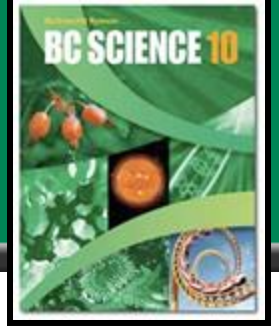
$K + Br_2 \longrightarrow 2KBr$ **NOPE**

$2Fe + O_2 \longrightarrow 6Fe_2O_3$ **NOPE**

$2Na + 2H_2O \longrightarrow 2NaOH + H_2$ YUP

Got It???

Strategies for Balancing Equations – remember

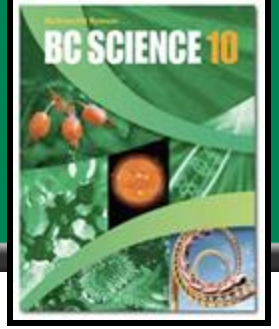


- Balance one compound at a time.
- Only change the coefficients (BIG NUMBERS in front); NEVER change subscripts (little numbers within the formula).
- If H and O appear in more than one place, attempt to balance them LAST.
- Polyatomic ions (such as SO_4^{2-}) can often be balanced as a whole group.
- Always double-check after you think you are finished.

See pages 209 - 211

Take the Section 4.3 Quiz

Chemical reactions



Chemical reactions

Chemical equations

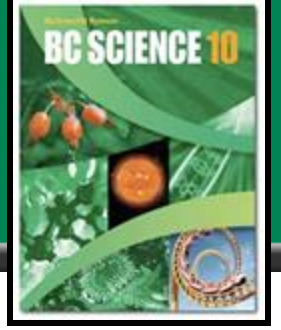
- Balancing equations
- Predicting products from reactants

Chemical equations

- Synthesis
- Decomposition
- Single replacement
- Double replacement
- Combustion

Packard, Jacobs, Marshall, Chemistry Pearson AGS Globe, page 175

Review: What is a Physical Change?

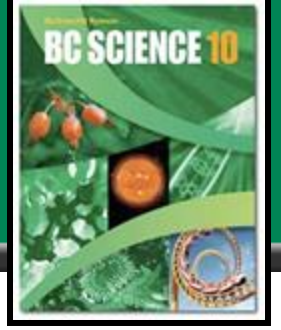


- **A physical change alters the form of a substance, but does <u>NOT</u> change it to <u>ANOTHER SUBSTANCE.</u>**
- **No chemical bonds break**

Example:

Making Orange Juice

What is a Chemical Change?



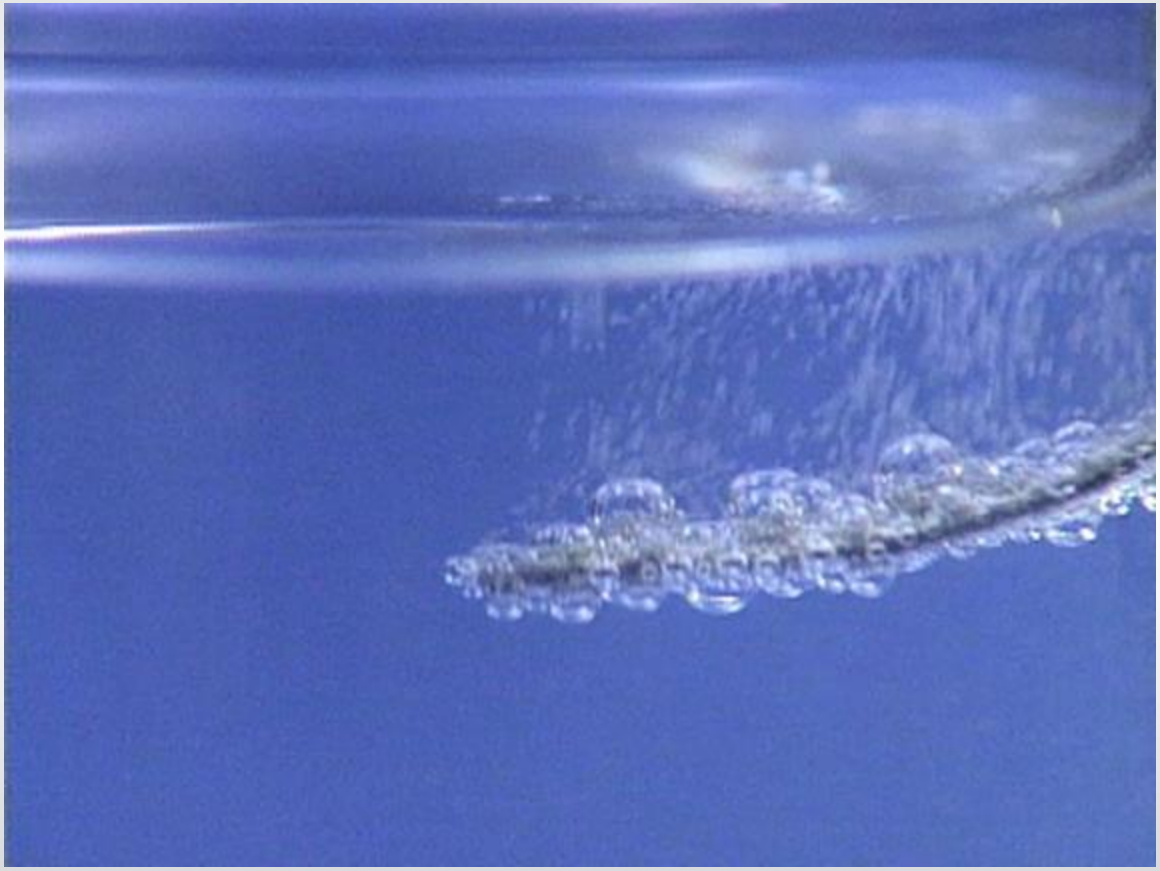
- **When old chemical bonds ***BREAK*** and new chemical bonds form a different substance with different properties.**

Example:

Baking a Cake

Produces light, sound or temperature change

Makes new gases



Precipitation

It looks like a cloudy solid in an otherwise clear solution.

Colour Change

Chemical or Physical Change?

- **Cutting paper?**
- **Physical**

Chemical or Physical Change?

- **Ice melting?**
- **Physical**

Chemical or Physical Change?

- **Toast burning?**
- **Chemical**

Chemical or Physical Change?

- **Rocket fuel burning?**
- **Chemical**

Chemical or Physical Change?

- **Metal rusting?**
- **Chemical**

Chemical or Physical Change?

- Disappearing puddle?
- Physical

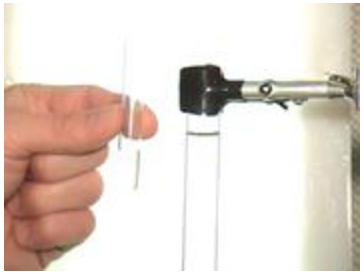
Chemical or Physical Change?

- Dry ice?
- Physical

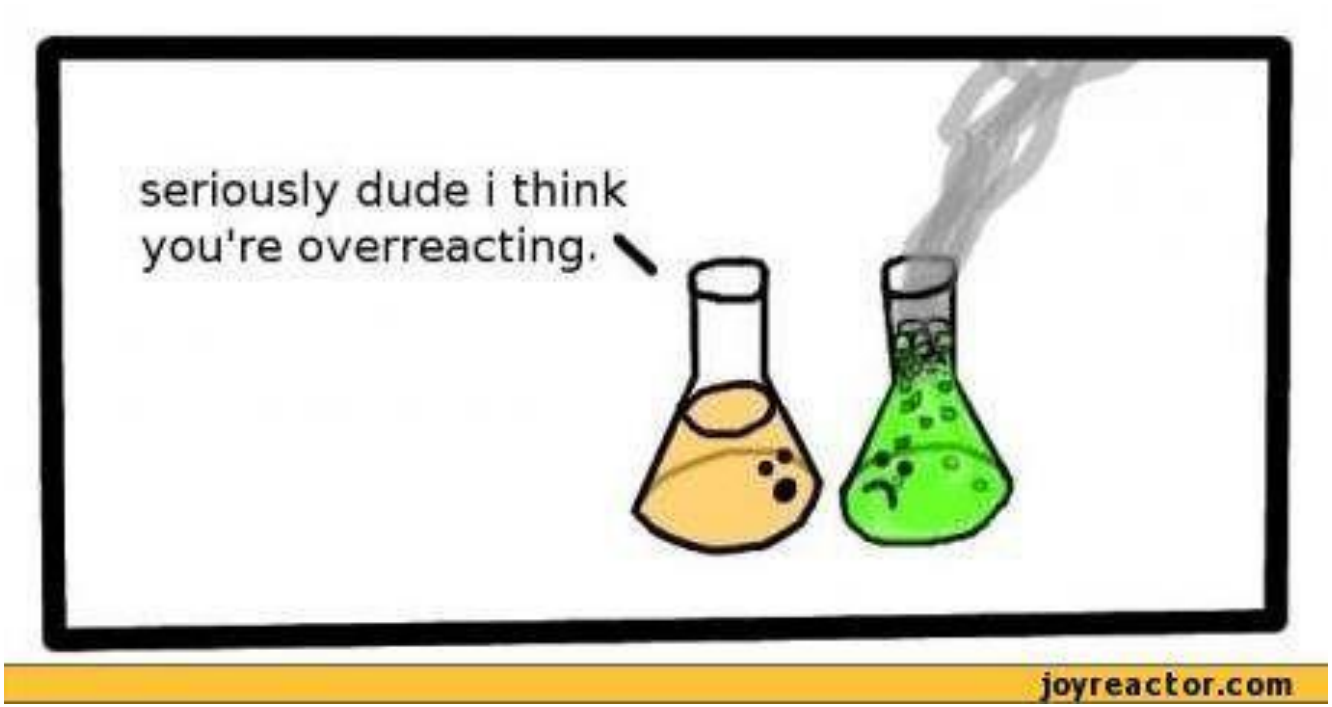
Review: a Chemical Reaction

Indications of a Chemical Reaction

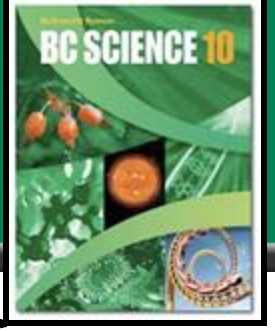
- Evolution of heat, light, and/or sound
- Production of a *GAS*
- Formation of a *PRECIPITATE*
- Color change



6-1 Chemical reaction types



6.1 Types of Chemical Reactions: Synthesis

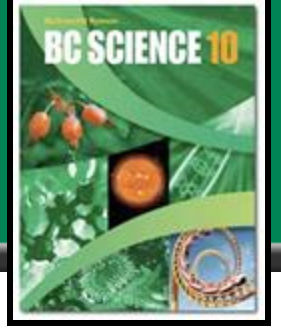


- **Synthesis reactions are also known as formation reactions.**
  - **Two or more reactants *JOIN* to form a compound.**
  - **A + B → AB**
  - $2Na + Cl_2 \rightarrow 2NaCl$
  - $2Mg + O_2 \rightarrow 2MgO$
  - $2N_2 + O_2 \rightarrow 2N_2O$

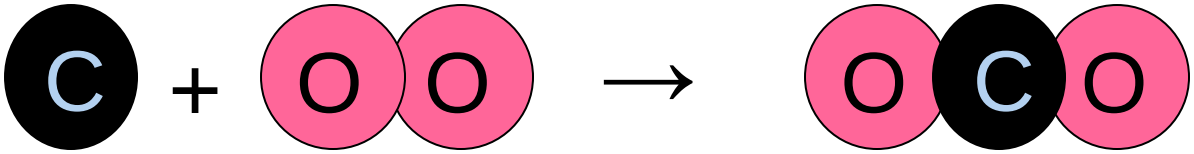
Sodium added to chlorine gas

See pages 258 - 259

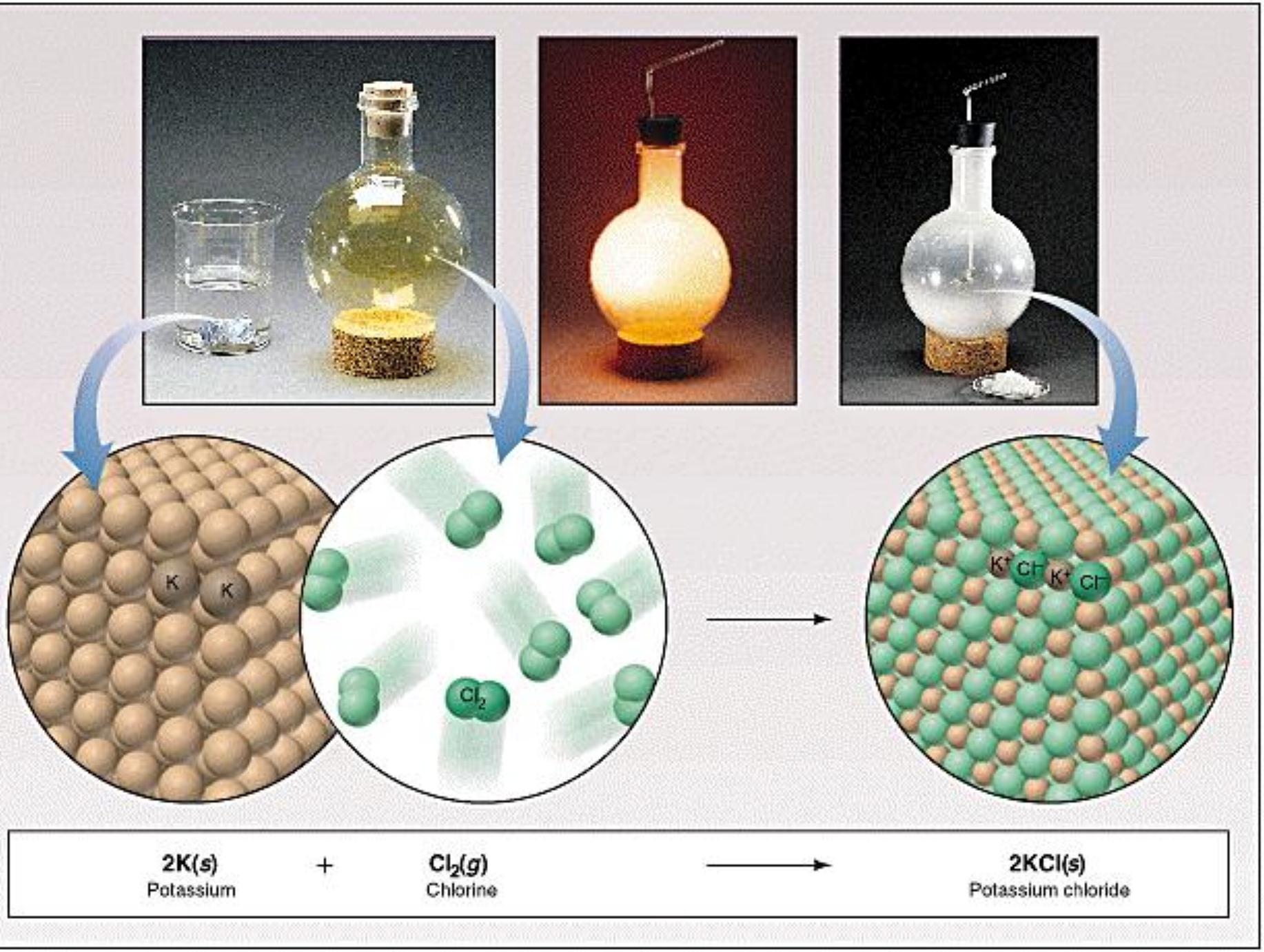
Synthesis



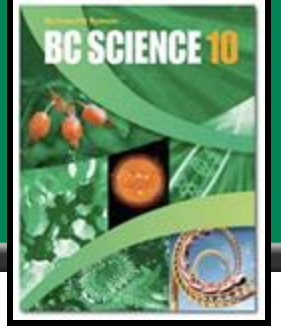
Example $C + O_2$



General: $A + B \rightarrow AB$


K
K
Cl2
K+
Cl−
K+
Cl−
2K(s)
Potassium
+
Cl2(g)
Chlorine
2KCl(s)
Potassium chloride

Which ones are Synthesis?



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

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

(c) $2KClO_3 \rightarrow 2KCl + 3O_2$

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

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

Synthesis worksheet answers

a) $4Li + 2O_2 \rightarrow 2Li_2O$

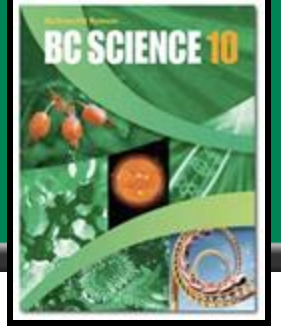
b) $P4 + 3O^2 \rightarrow 2P_2O_3$

c) $3Mg + N_2 \rightarrow Mg_3N_2$

d) $K2O + H_2O \rightarrow 2KOH$

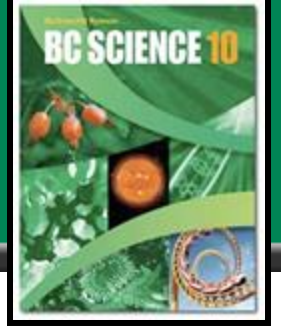
e) $SO2 + H_2O \rightarrow H_2SO_3$

2. Decomposition

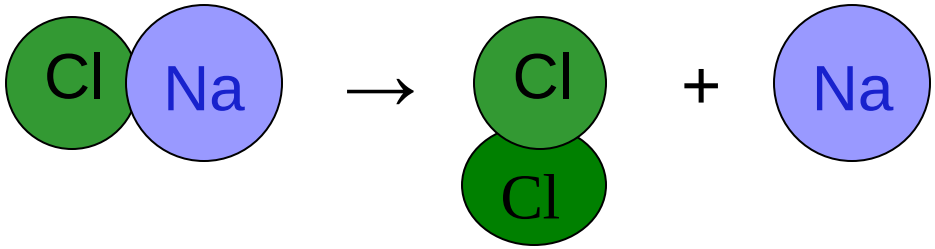


- **Decomposition -- the opposite of synthesis reactions.**
  - **One compounds breaks down into two or more products**
  - **AB → A + B**

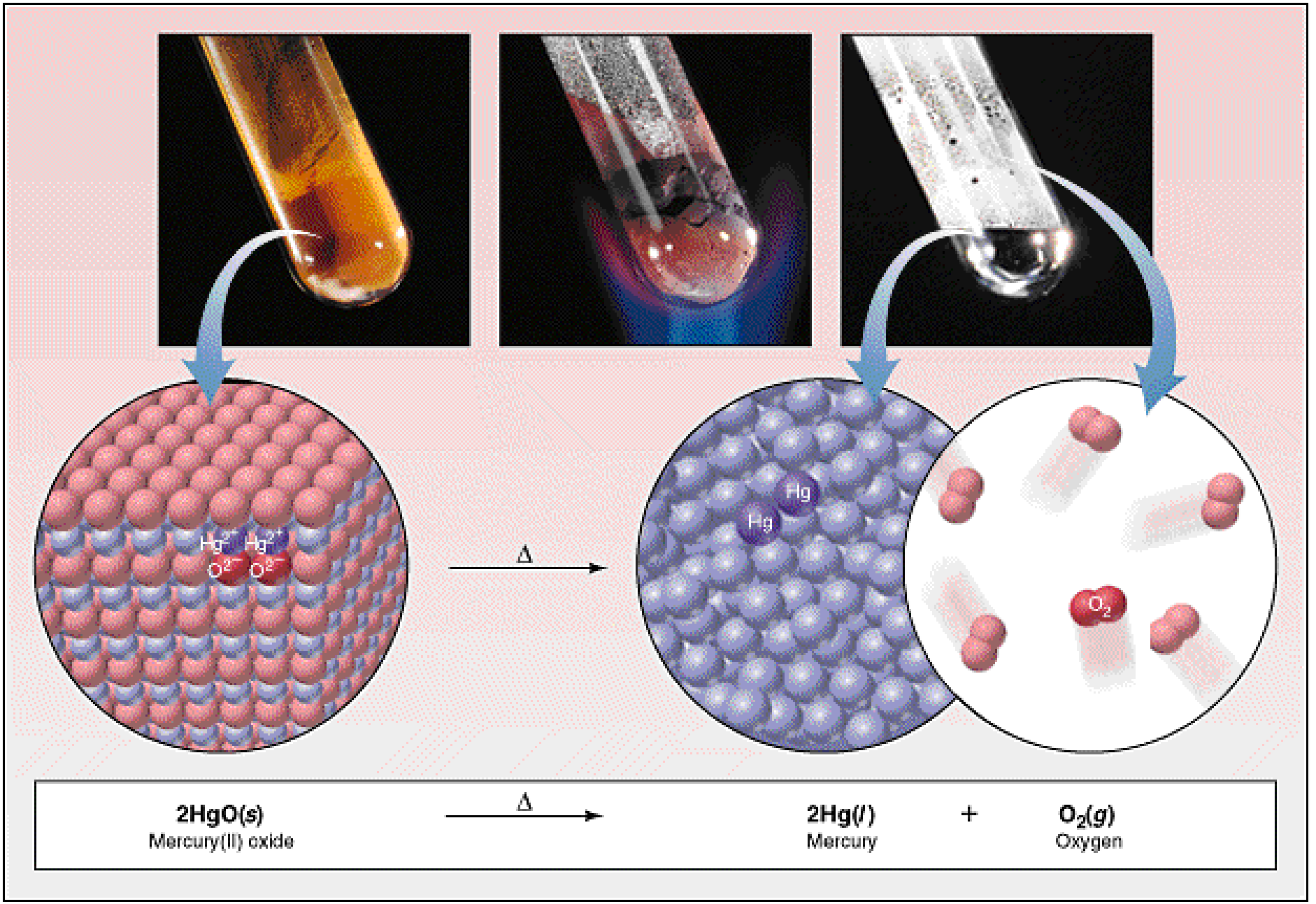
Decomposition



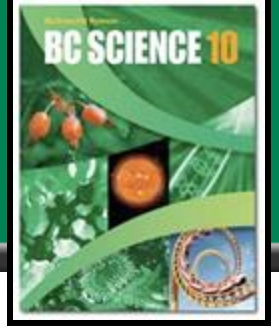
Example: NaCl



General: AB → A + B


Hg2+ Hg2+
O2− O2−
Δ
Hg
Hg
O2
2HgO(s)
Mercury(II) oxide
Δ
2Hg(l)
Mercury
+
O2(g)
Oxygen

Hydrolysis of Water Decomposition



- **Electricity through water breaks down ⊠ hydrogen and oxygen**

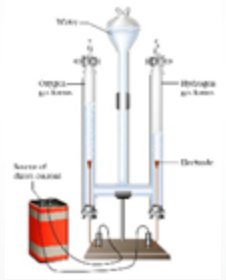
$2H_2O \rightarrow 2H_2 + O_2$

Practice Decomposition Reactions

Hydrogen Peroxide

$$2\,H_2O_2 \longrightarrow 2\,H_2O + O_2$$

Electrolysis of water



$$2\,H_2O \xrightarrow{electricity} 2\,H_2 + O_2$$

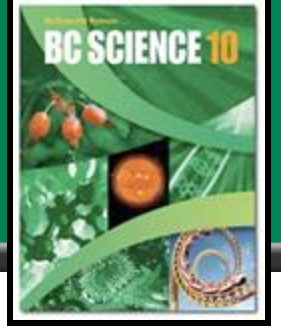
Nitrogen triiodide

$$2\,NI_3 \longrightarrow N_2 + 3\,I_2$$

General Form

$$AB \longrightarrow A + B$$

Synthesis Or Decomposition?



- (a) $CO_2 \rightarrow C + O_2$
- (b) $2Cr + 3F_2 \rightarrow 2CrF_3$
- (c) $2NaClO_3 \rightarrow 2NaCl + 3O_2$

Decomposition worksheet answers

a) $2Ag_2O$ □ $4\ Ag + O_2$

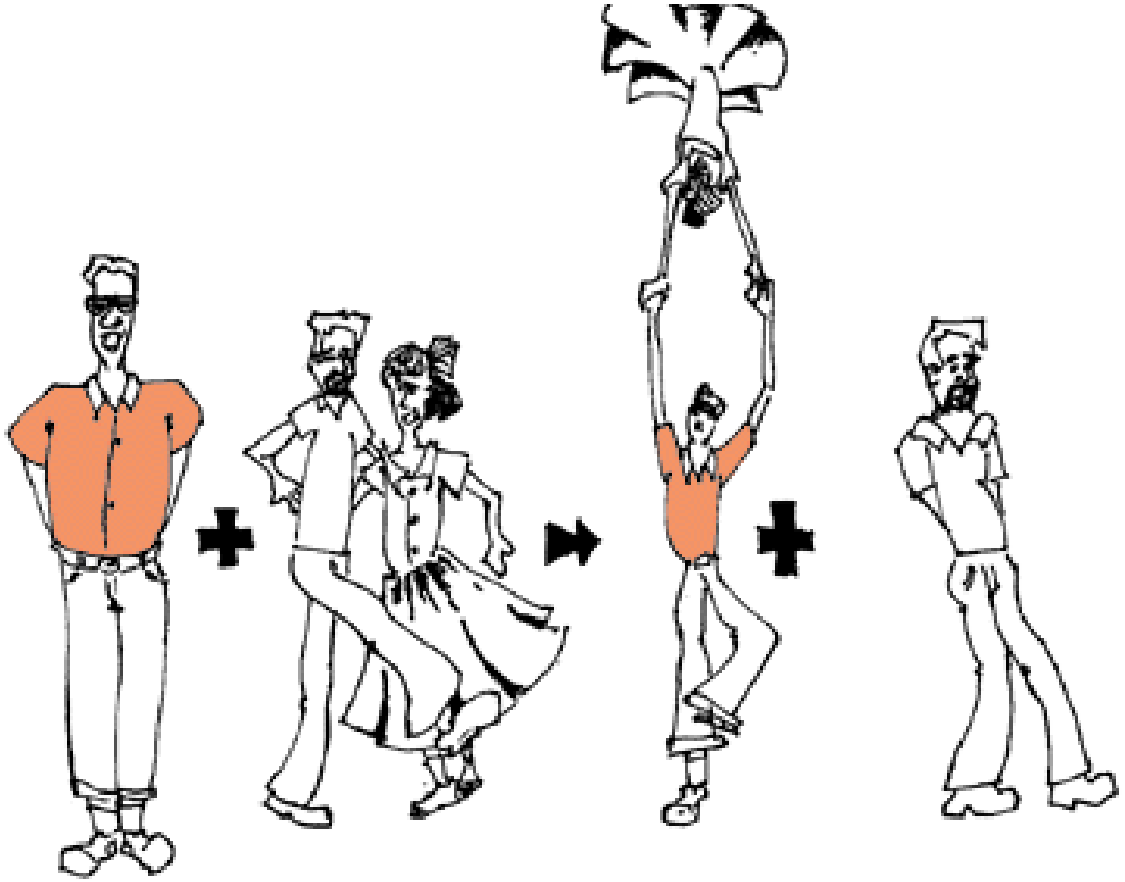
b) $CuCO3$ □ $CuO + CO_2$

c) $2Ag2O$ □ $4Ag + O_2$

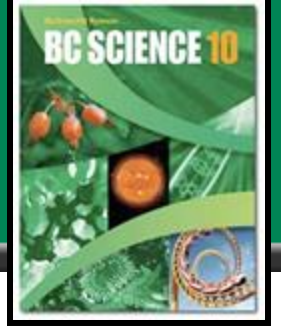
d) $2Sb2O5$ □ $4Sb + 5O_2$

e) $2\ PBr_5$ □ $2P + 5Br_2$

3. Single Replacement



3. Single Replacement

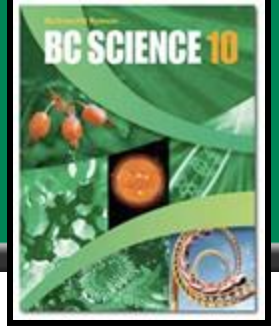


- **When single *ELEMENT* takes the place of an element in the compound**
  - **Metal (positive ions) replaces metal**
  - **The metals (front position) swap places**
  - $2Al + 3CuCl_2 \rightarrow 3Cu + 2AlCl_3$

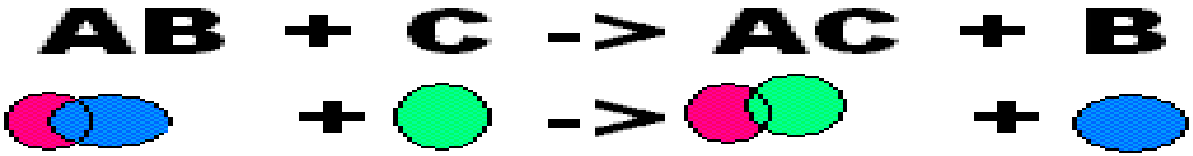
Single Displacement Reaction

See page 261

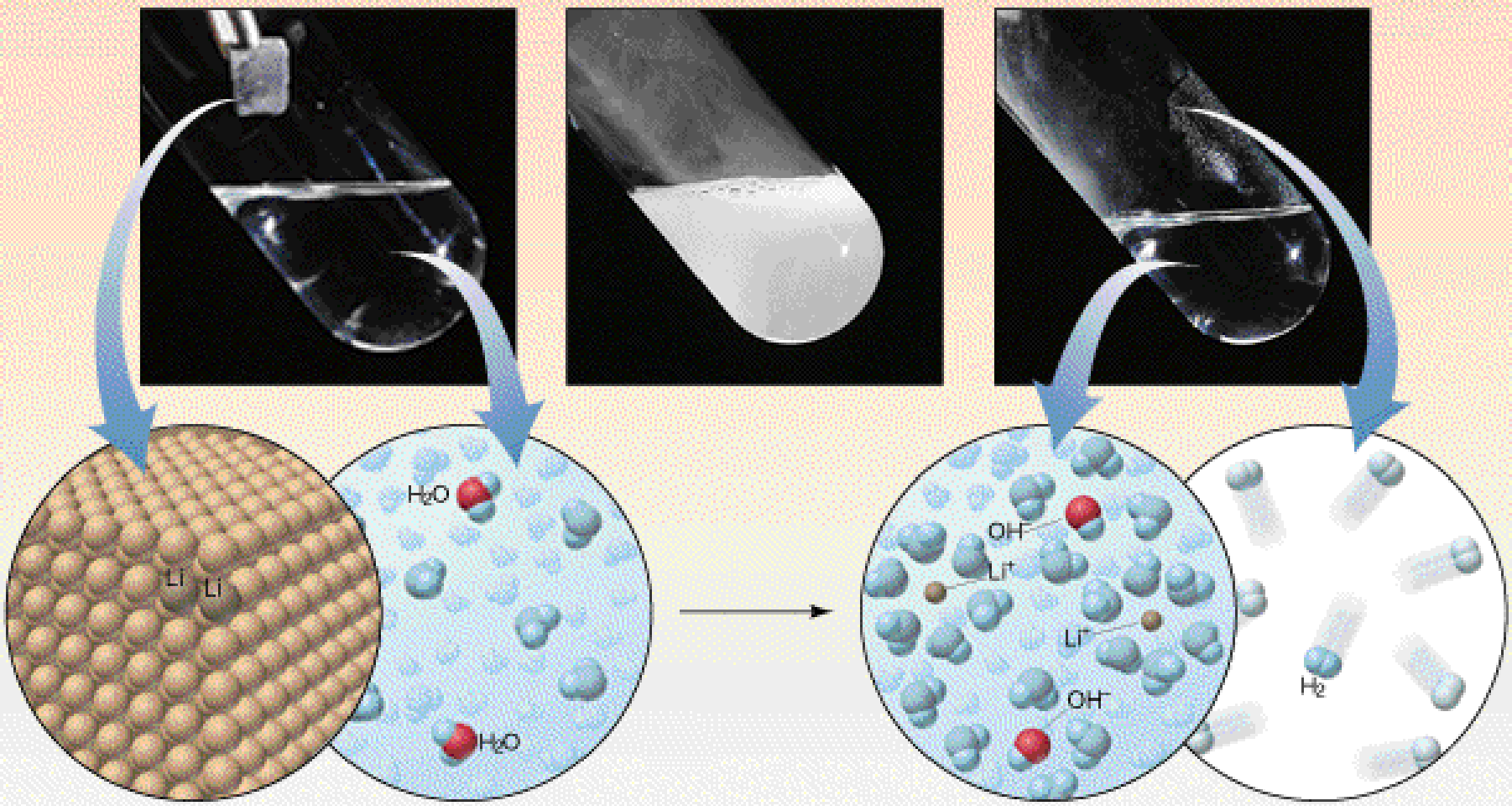
Non metal replaces a non metal



- When single element is a non-metal
- The non-metals (negative ions) swap places



- $F_2 + 2NaI \rightarrow I_2 + 2NaF$

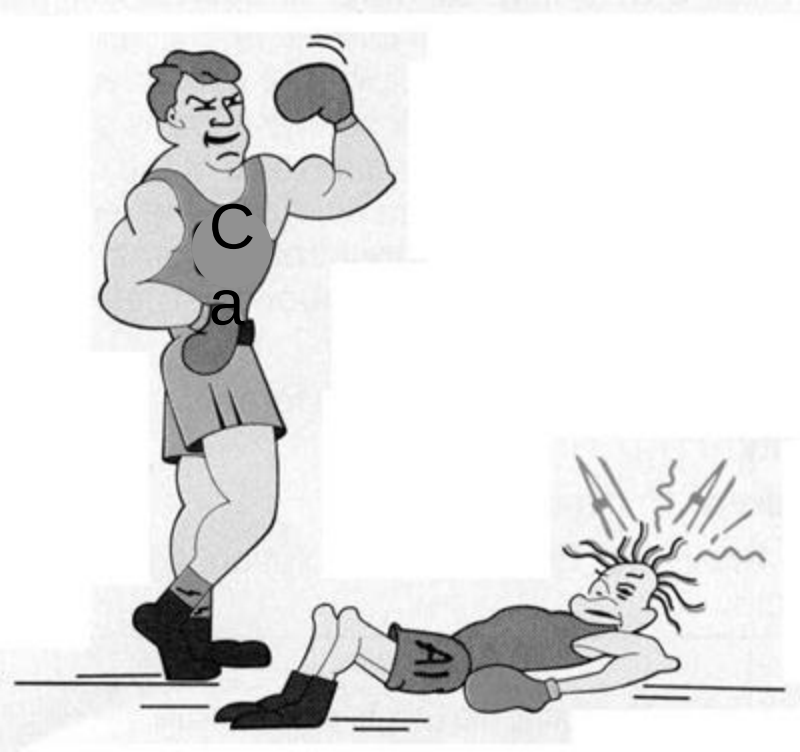


$$2Li(s) + 2H_2O(l) \longrightarrow 2LiOH(aq) + H_2(g)$$

Lithium + Water → Lithium hydroxide + Hydrogen

Activity Series - you only get to replace if you are the stronger chemical

Foiled again –
Aluminum loses to Calcium



Element Reactivity

Li
Rb
K
Ba
Ca
Na
Mg
Al
Mn
Zn
Cr
Fe
Ni
Sn
Pb
H_2
Cu
Hg
Ag
Pt
Au

Halogen Reactivity

F_2
Cl_2
Br_2
I_2

Single-Replacement Reactions

$$Fe + CuCl_2 \longrightarrow FeCl_2 + Cu$$

Can Fe *replace* Cu? Yes

$$Zn + 2HNO_3 \longrightarrow Zn(NO_3)_2 + H_2$$

Can Zn *replace* H? Yes

NO REACTION

$$MgCl_2 + Br_2 \not\longrightarrow MgBr_2 + Cl_2$$

Can Br *replace* Cl? No

General Form

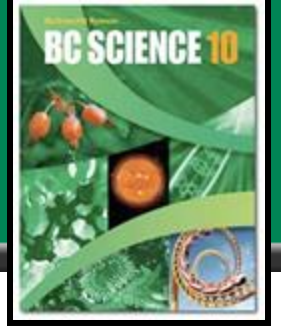
$$A + BC \longrightarrow AC + B$$

Activity Series

Li
Rb
K
Ba
Ca
Na
Mg
Al
Mn
Zn
Cr
Fe
Ni
Sn
Pb
H_2
Cu
Hg
Ag
Pt
Au

F_2
Cl_2
Br_2
I_2

4. Double Replacement

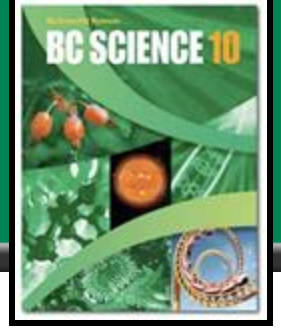


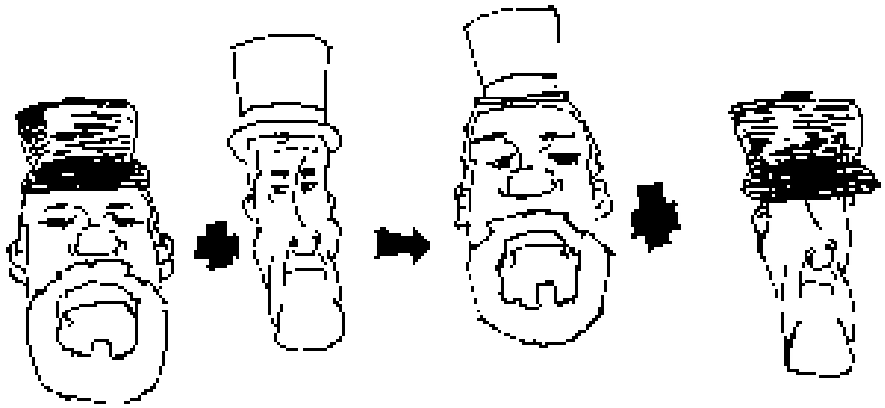
- **Two compounds react⊠ *SWAP* equivalent parts (e.g. metal swap with metal)**
- **AB + CD → AD + CB**
- **Double replacements – always will make a *PRECIPITATE* (solid) within the new solution**

  - **When potassium chromate and silver nitrate react, they form a red precipitate, silver chromate, in a solution of potassium nitrate.**
  - $K_2CrO_{4(aq)} + 2AgNO_{3(aq)} \rightarrow Ag_2CrO_{4(s)}$ (red) + $2KNO_{3(aq)}$

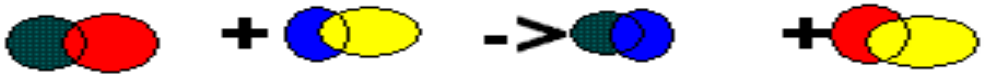
See page 262

4. Double Replacement





AB + CD -> AC + BD



Review: Single vs Double Replacement Reactions

Single-replacement reaction

$Mg + CuSO_4 \rightarrow MgSO_4 + Cu$

General form:

$A + BC \rightarrow AC + B$

Double-replacement reaction

$CaCO_3 + 2\,HCl \rightarrow CaCl_2 + H_2CO_3$

General form:

$AB + CD \rightarrow AD + CB$

Formation of a solid: AgCl

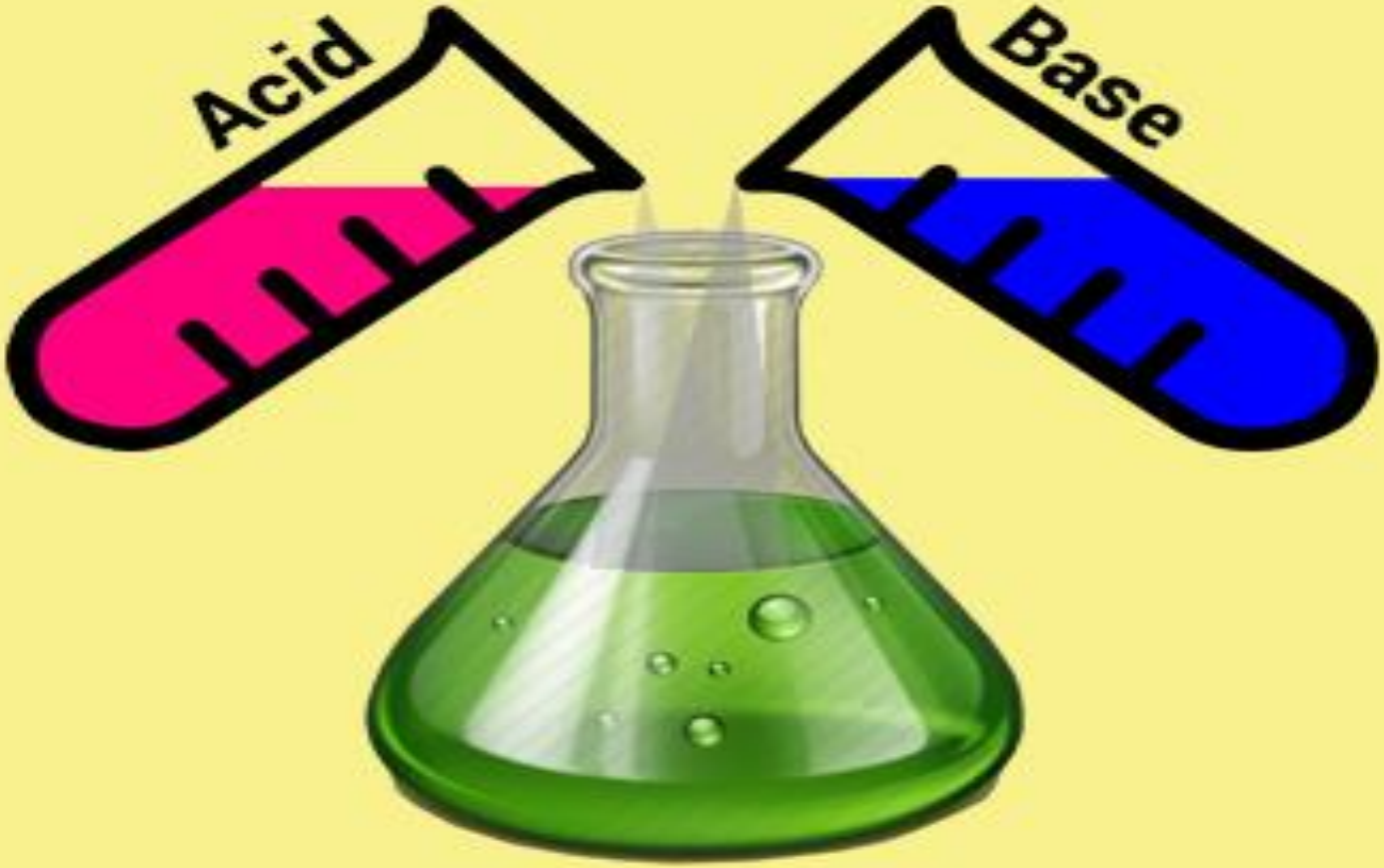
$AgNO_3(aq) + KCl(aq) \rightarrow KNO_3(aq) + AgCl(s)$

lead (II) chloride + potassium iodide ⟶ potassium chloride + lead (II) iodide

Pb^{2+} Cl^{1-} K^{1+} I^{1-} Pb^{2+} Cl^{1-} K^{1+} I^{1-}

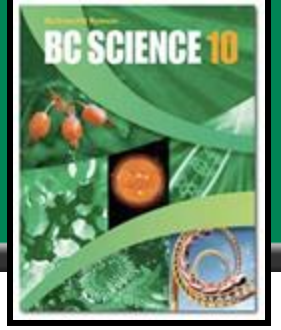
$$PbCl_2 + KI \longrightarrow KCl_{(aq)} + PbI_{2\,(ppt)}$$

NEUTRALISATION



Salt + Water

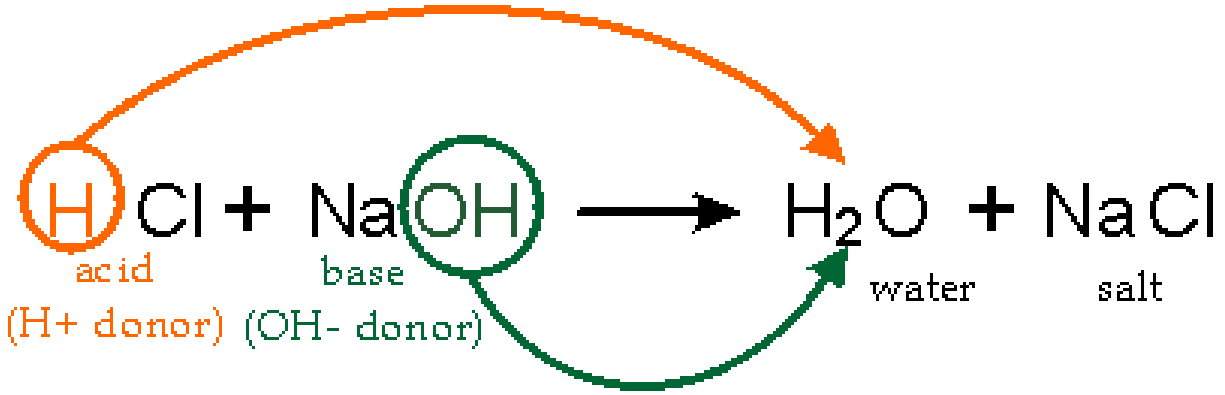
Neutralization (Acid–Base Reactions)



- **Acid + base → salt + water**
- **H...(acid) + ...(base)OH → Salt + H_2O**

- $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$
- Acid + base - □ salt + water

Neutralization

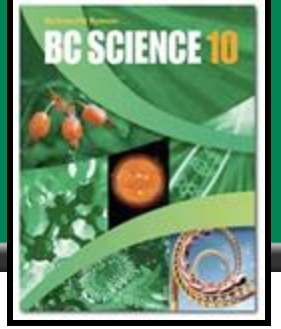


Acid + Base salt and water

A ***SALT*** is a metal and a non-metal.

Table salt NaCl is one example of a salt.

Combustion

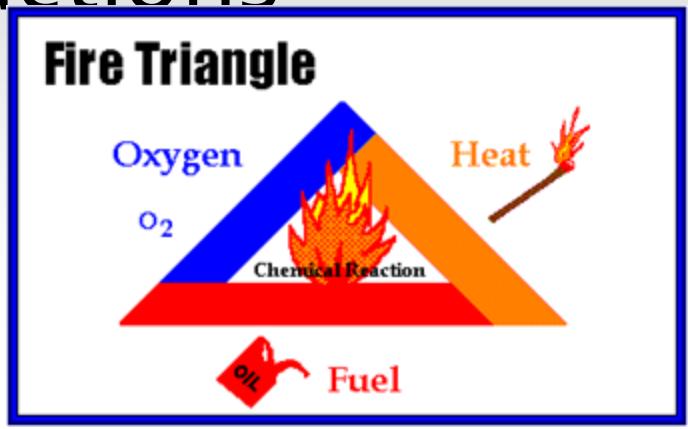


- **Combustion = when something <u>REACTS WITH OXYGEN -</u> energy and an oxide.**
  - **Natural gas (methane) is burned in furnaces to heat homes.**
  - $CH_4 + O_2 \rightarrow CO_2 + 2H_2O$
  - **Carbohydrates like glucose combine with oxygen in our body to release energy.**
  - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Acetylene torch

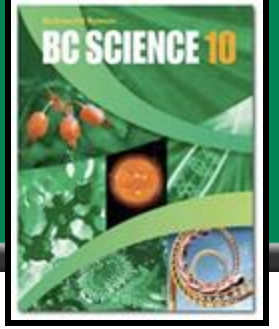
See page 264

Combustion Reactions



- Also called burning!!!
- In order to burn something you need the 3 things in the "fire triangle":
  1) ***A FUEL*** (hydrocarbon)
  2) ***OXYGEN*** to burn it with
  3) Something to
- the reaction (spark)

Combustion of Methane



CH_4 + $2\ O_2$ ---> CO_2 + $2\ H_2O$

Methane Oxygen Carbon Dioxide Water

Combustion Reaction

6–1 Types of Chemical Reactions: Summary of Types

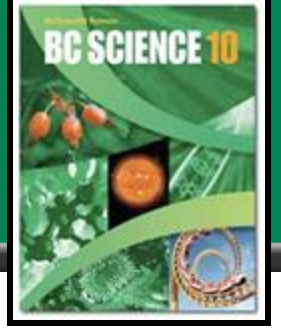


Table 6.1 Summary of Chemical Reactions

Reaction Type	Reactants and Products	Notes on the Reactants
Synthesis (combination)	$A + B \rightarrow AB$	• Two elements combine (Figure 6.9).
Decomposition	$AB \rightarrow A + B$	• One reactant only (Figure 6.9)
Single replacement		
If A is a metal	$A + BC \rightarrow B + AC$	• One element and one compound
If A is a non-metal	$A + BC \rightarrow C + BA$	
Double replacement	$AB + CD \rightarrow AD + CB$	• Two compounds react.
Neutralization (acid-base)	$HX + MOH \rightarrow MX + H_2O$	• Acid plus base
Combustion	$C_XH_Y + O_2 \rightarrow CO_2 + H_2O$	• Organic compound with oxygen

See page 265

Take the Section 6.1 Quiz

Your Turn!!

$2\ Ca + O_2 \rightarrow 2\ CaO$ **Synthesis**

$Br_2 + 2\ LiI \rightarrow 2\ LiBr + I_2$ **Single Replacement**

$2\ Al + 3\ Fe(NO_3)_2 \rightarrow 2\ Al(NO_3)_3 + 3\ Fe$ **Single Replacement**

$MgO + HCl \rightarrow MgCl_2 + H_2O$ **Double Replacement**

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

Your Turn!!

$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$ **Decomposition**

$2\ (NH_4)_3(PO_4) + 3\ Sr(OH)_2 \rightarrow Sr_3(PO_4)_2 + 6\ (NH_4)(OH)$

Double Replacement

$H_2(SO_4) + 2\ Na(OH) \rightarrow Na_2(SO_4) + 2\ H_2O$

Double Replacement

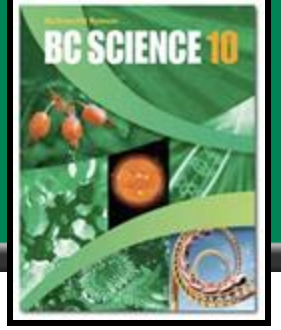
$Zn + 2\ Ag(NO_3) \rightarrow Zn(NO_3)_2 + 2\ Ag$

Single Replacement

$Cu(NO_3) + KCl \rightarrow K(NO_3) + CuCl$

Double Replacement

Review: Identify the type of reaction



1. $2\ Sb + 3\ Cl_2 \rightarrow 2\ SbCl_3$

2. $2\ Mg + O_2 \rightarrow 2\ MgO$

3. $CaCl_2 \rightarrow Ca + Cl_2$

4. $2\ NaClO_3 \rightarrow 2\ NaCl + 3\ O_2$

5. $Fe + 2\ HCl \rightarrow FeCl_2 + H_2$

6. $CuO + H_2 \rightarrow Cu + H_2O$

7. $2\ Al + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\ H_2$