Chemistry 1010

Physical, Chemical, and Nuclear Changes (continued)

Review

What type of change is occurring in the following situations?

whittling a stick of wood

physical change

carbon-14 in a wooden artifact decaying to nitrogen-14

nuclear reaction

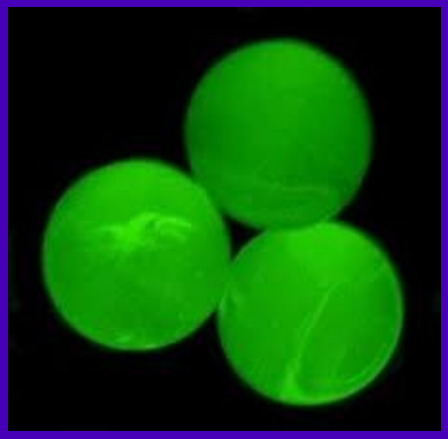
burning wood in a campfire

chemical reaction

What kind of change is taking place in each of the following equations? What does each represent?

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

chemical reaction
propane burning



$^{238}U \longrightarrow {}^{234}Th + {}^{4}He$

nuclear reaction
uranium decaying in uranium marbles

$C_9H_8O_{(l)} \longrightarrow C_9H_8O_{(g)}$

physical change
cinnamaldehyde evaporating

Types of Physical and Nuclear Reactions

There are two main types of physical changes that are commonly described by an equation in chemistry. What are they?

1) changes of state

$$H_2O_{(s)} \longrightarrow H_2O_{(l)}$$

2) dissolving

$$C_{11}H_{22}O_{11} + H_2O \rightarrow C_{11}H_{22}O_{11(aq)}$$

There are three common types of nuclear reactions. Where do each of these occur?

1) fusion – atoms are joined together to make larger ones

in stars

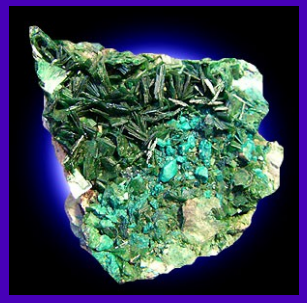
in particle accelerators

2) fission – large, unstable atoms are split apart

in nuclear weapons

in nuclear power plants

3) radioactive decay – a small piece of the nucleus of an atom is ejected



naturally occurring radioisotopes

inside nuclear reactors

nuclear waste

Label the following reactions as fusion, fission, or radioactive decay.

$^{236}U \longrightarrow {}^{90}Sr + {}^{143}Xe + 3\ n^{o}$ fission

$^{255}Fm \longrightarrow {}^{251}Cf + {}^{4}He$ radioactive decay

$^{209}Bi + {}^{64}Ni \longrightarrow {}^{273}Rg$ fusion

Clues that a chemical reaction is happening

How can you recognize a chemical reaction if you have an equation?

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

new compounds are formed
chemical bonds are broken and formed

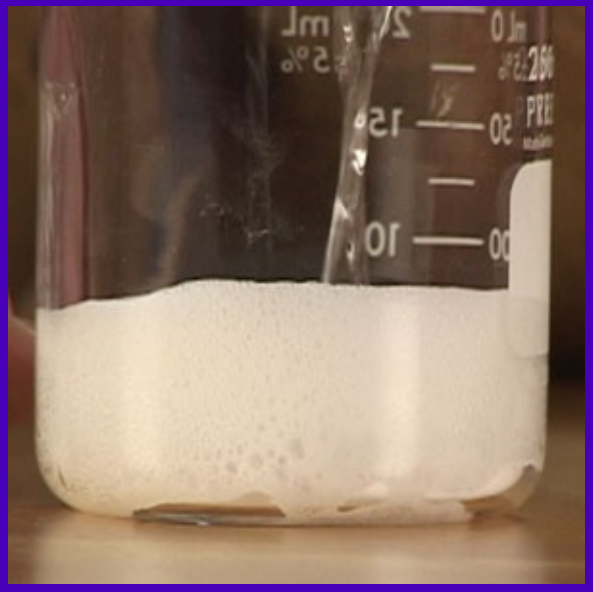
If you don't know what the equation is, how can you tell?

look for clues that new compounds are formed, or that chemical bonds are being broken and formed

What kind of clues?

Clue #1 – new compound forming that is a gas

antacid tablet + stomach acid



gas formed

What gas is being formed?

$$\underbrace{CaCO_3}_{\text{antacid}} + \underbrace{2\,HCl}_{\text{stomach acid}} \rightarrow CaCl_2 + H_2O + \underbrace{CO_{2(g)}}_{\text{gas}}$$

Can you think of anything else that bubbles?

Clue #2 – new compound forming that is a solid

solution 1 + solution 2 ⟶

precipitate forms

What new compound is being formed?

$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + AgCl_{(s)}$

- $NaCl_{(aq)}$: table salt in water
- $AgNO_{3(aq)}$: silver nitrate in water
- $NaNO_{3(aq)}$: sodium nitrate in water
- $AgCl_{(s)}$: silver chloride precipitate

Can you think of anything else that forms a solid?

Clue #3 – new compound formed that is a different color

solution 3 + solution 4 →

bright yellow solid

What is the yellow solid?

$KI + Pb(NO_3)_2 \rightarrow KNO_3 + PbI_2$

potassium iodide

lead nitrate

potassium nitrate

lead iodide yellow solid

Can you think of anything else that changes color?

Clue #4 – heat or light is released

strong acid + strong base →  + heat

What reaction is happening?

HCl + NaOH → $NaCl + H_2O$ + heat

HCl: strong acid

NaOH: strong base

Can you think of anything else that releases light or heat?

Now that you know the clues, you are ready to make some educated guesses about everyday processes. Which are chemical reactions, and which are not, and why?

Rolls brown in the oven. chemical – color change

A red shirt fades in the sun. chemical – color change

Detergent washes grease off of pans. physical – grease dissolves

Copper roof tiles turn greenish over time. chemical – color change

Cement dries and hardens. chemical – heat released

Silver candlesticks tarnish. chemical – color change

Silver polish removes the tarnish. physical – dissolving

One drop of food coloring turns the whole bowl of frosting red. physical – mixing

An acidic cleaner removes hard water deposits. chemical – gas is released

Food is digested. chemical – color change

Bleach removes a grass stain. chemical – color change

Hydrogen peroxide bubbles when poured on a cut. chemical – gas is released

A microwave heats a hot dog. physical (unless it turns black)

Candle wax melts. physical – change of state

A candle burns wax. chemical – heat released

Meat turns brown when you cook it. chemical – color change

Plants make sugar and oxygen from carbon dioxide and water. chemical – new compounds

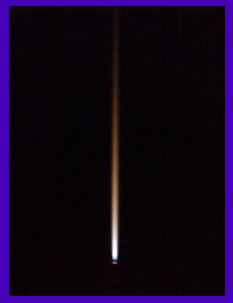
"Hot hands" get warm when bent. chemical – heat released

Old wine turns into vinegar. chemical – new smell

Paint remover loosens paint so it can be removed. physical – paint dissolves

Balancing chemical reactions

When we write a chemical reaction, it is important to know how many units of each compound are needed.



hydrogen burning

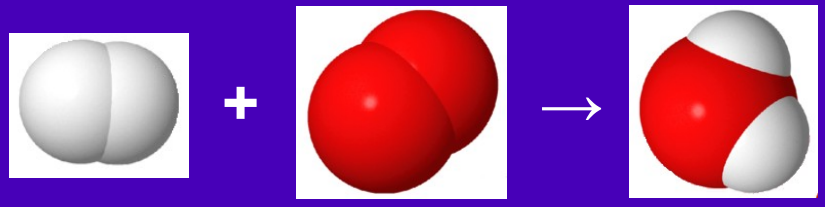
What are the reactants and products?

hydrogen + oxygen → water

What are the formulas for these molecules?

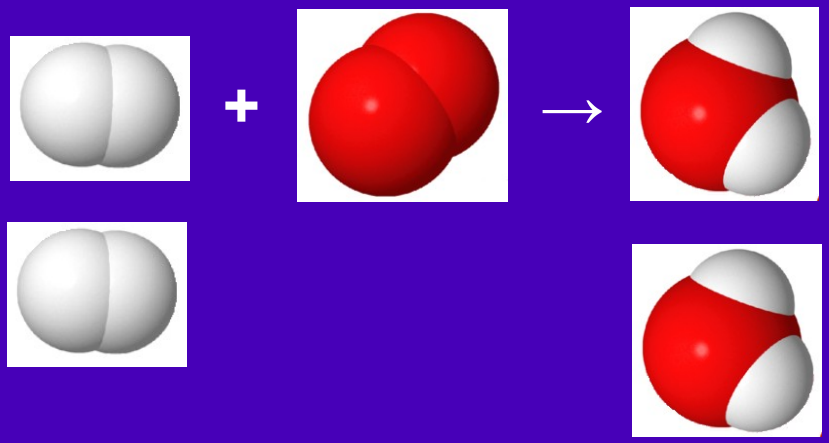
$H_2 + O_2 \rightarrow H_2O$

What's wrong with this?



Where did the other oxygen go?

How do we fix it?



use two hydrogen molecules
and make two water molecules

What does the new equation look like?

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

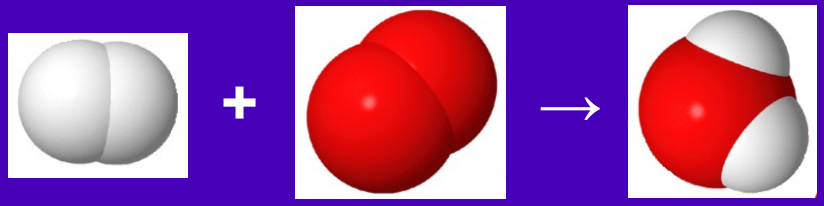
Why can't we just alter the formula?

$$H_2 + O \rightarrow H_2O$$ NOPE!

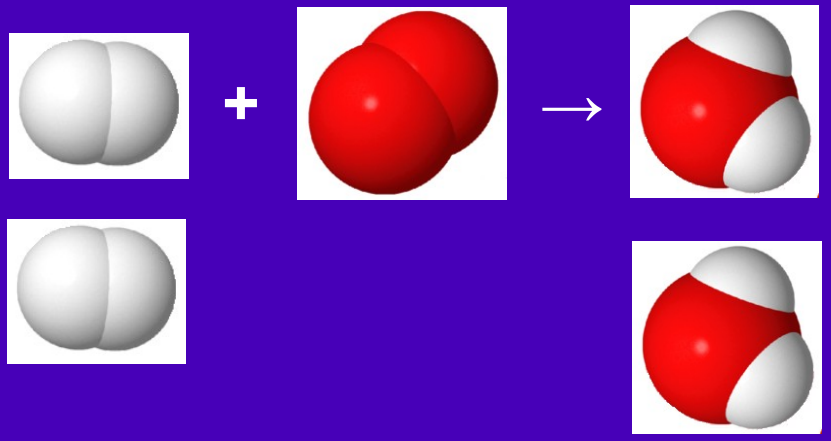
oxygen doesn't exist that way

In order to make sure that the equation works, make sure there are the same number of atoms of each element at the beginning and at the end of the reaction.

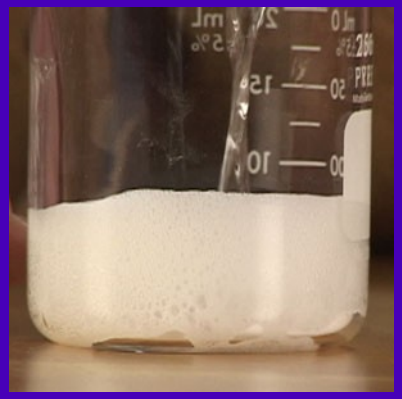
	reactants		products		
	H	O	H	O	
original equation:					
$H_2 + O_2 \rightarrow H_2O$	2	2	2	1	:(



new equation:					
$2\,H_2 + O_2 \rightarrow 2\,H_2O$	4	2	4	2	:)



Let's try another example.



antacid + stomach acid

$$CaCO_3 + 2\ HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

reactants					products				
Ca	C	O	H	Cl	Ca	C	O	H	Cl
1	1	3	~~1~~ 2	~~1~~ 2	1	1	3	2	2

Try another:

propane burning

	reactants			products		
	C	H	O	C	H	O
$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$	3	8	2	~~1~~	2	~~3~~
$C_3H_8 + O_2 \rightarrow 3\,CO_2 + H_2O$	3	8	2	3	~~2~~	~~7~~
$C_3H_8 + O_2 \rightarrow 3\,CO_2 + 4\,H_2O$	3	8	~~2~~	3	8	10
$C_3H_8 + 5\,O_2 \rightarrow 3\,CO_2 + 4\,H_2O$	3	8	10	3	8	10

One more:

iron rusting

$4\ Fe + 3\ O_2 \longrightarrow 2\ Fe_2O_3$

reactants		products	
Fe	O	Fe	O
1	2	2	3
2	2	2	3
2	2	4	6
2	6	4	6
4	6	4	6