Science 10

unit 1: chemistry

book 4: chemical equations & balancing

name: Key block: ______

Part A: Intro to Chemical Reactions

Chemistry is the science concerned with the properties, composition, and behaviour of matter. matter is anything that has mass and occupies space

mass is the amount of matter contained in a thing. Usually the mass of common things is measured in grams(g) or kilograms(kg)

Properties are the qualities of a thing, especially those qualities common to a group of things. The relationship between matter and its properties is a very important aspect of chemistry.

A physical property of a substance is a property that can be found without creating a new substance.

For example: Lustre, state of matter (s, l, g), conductivity, hardness, ductile, colour, malleable, shape, density.

A chemical property is the ability of a substance to undergo *chemical change/* reaction and change into a NEW substance.

For example: flammability, corrosion, toxicity, combustion, oxidation, radioactivity, etc.

Physical Properties versus Chemical Properties

The properties of matter are also classified as being either physical properties or chemical properties. Recall, **Physical properties** describe physical changes which are changes of state or form. Physical properties also describe the physical characteristics of a material.

Figure 2.1.2 *The wood that is burning to heat the pot is undergoing chemical changes. The boiling soup in the pot is undergoing a physical change.*

Chemical properties describe chemical changes. Chemical changes are those in which a new substance(s) or species is formed (Figure 2.1.2). Chemical properties also describe the tendency of a chemical to react. *generally irreversible change.

Chemical properties describe relationships or interactions between different forms of matter.

They include a chemical's
- stability
- reactivity
- toxicity
- flammability

Signs of Chem. Δ
- gas formed (bubbles)
- odor produced.
- light/sound energy prod.
- change in heat ↑↓
- precipitate formed (solid from liquids)
- colour change

Most physical properties describe relationships or interactions between matter and energy.

- -Hardness (Moh's hardness scale) quality of resisting abrasion
- -Malleability the ability to be bent + shaped under pressure
- -Ductility the ability to be stretched into a fine wire
- -Lustre how something reflects light (shiney or dull)
- -Viscosity thickness or stickiness of liquid
- -Diffusion movement from an area of ↑ concentration to an area of ↓ concentration (liquids + gas)

For example,
A material can be classified as opaque, transparent or translucent by how it interacts with light. Other physical properties you may have learned about include mallibility density, ductile., and surface tension. I

Physical properties describe **physical changes**.

Chemical properties describe interactions between different forms of matter...or **chemical change.**

Assignment #1: Physical & Chemical Properties Part A & B pg 3-4
Complete this assignment ***in the space provided on the following pages***

Name KEY

PHYSICAL AND CHEMICAL PROPERTIES AND CHANGES

Part A: Physical or Chemical?

Identify the following as a chemical (C) or physical property (P):

P 1. blue color
P 2. density
C 3. flammability (burns)
P 4. solubility (dissolves)
C 5. reacts with acid
C 6. supports combustion
P 7. sour taste
P 8. melting point
C 9. reacts with water
P 10. hardness
P 11. boiling point
P 12. ~~luster~~ shine
P 13. odor
C 14. reacts with air

Identify the following as chemical (C) or physical (P) changes.

P 1. NaCl (Table Salt) dissolves in water.
C 2. Ag (Silver) tarnishes.
P 3. An apple is cut.
P 4. Heat changes H_2O to steam.
C 5. Baking soda reacts to vineger.
C 6. Fe (Iron) rusts.
P 7. Alcohol evaporates .
P 8. Ice melts.
C 9. Milk sours.
P 10. Sugar dissolves in water.
C 11. Wood rots.
C 12. Pancakes cook.
C 13. Grass grows.
P 14. A tire is inflated.
C 15. Food is digested.
P 16. Paper towel absorbs water.
P 17. An ice cube is placed in the sun.
C 18. Two chemicals are mixed together and a gas is produced.
C 19. A bicycle changes colour as it rusts.
P 20. A solid is crushed into a powder.
C 21. Two substances are mixed and light is produced.
C 22. A piece of ice melts and reacts with sodium.
P 23. Mixing salt and pepper.
P 24. Chocolate syrup is dissolved in milk.
C 25. A marshmallow is toasted over a campfire.
P 26. A marshmallow is cut in half

Part B

Read each scenario. Decide whether a physical or chemical change has occurred and give evidence for your decision. The first one has been done for you to use as an example.

	Scenario	Physical or Chemical Change?	Evidence…
1.	Umm! A student removes a loaf of bread hot from the oven. The student cuts a slice off the loaf and spreads butter on it.	Physical	No change in substances. No unexpected color change, temperature change or gas given off.
2.	Your friend decides to toast a piece of bread, but leaves it in the toaster too long. The bread is black and the kitchen if full of smoke.	Chemical	New substance produced ↳colour change, smell
3.	You forgot to dry the bread knife when you washed it and reddish brown spots appeared on it.	Chemical	New substance produced (rust)
4.	You blow dry your wet hair.	Physical	No new substance produced
5.	In baking biscuits and other quick breads, the baking powder reacts to release carbon dioxide bubbles. The carbon dioxide bubbles cause the dough to rise.	Chemical	Reaction takes place
6.	You take out your best silver spoons and notice that they are very dull and have some black spots.	Chemical	New substance produced
7.	A straight piece of wire is coiled to form a spring.	Physical	Just changed the shape.
8.	Food color is dropped into water to give it color.	Physical	Chemical make-up of H_2O and food colouring not changed.
9.	Chewing food to break it down into smaller particles represents a __①__ change, but the changing of starch into sugars by enzymes in the digestive system represents a __②__ change.	① Physical ② chemical	Just breaking food down Chemical reaction
10.	In a fireworks show, the fireworks explode giving off heat and light.	Chemical	Reaction takes place

Part C: True (T) or False (F)?

1.	F	Changing the size and shapes of pieces of wood would be a chemical change.
2.	F	In a physical change, the makeup of matter is changed.
3.	T	Evaporation occurs when liquid water changes into a gas.
4.	T	Evaporation is a physical change.
5.	F	Burning wood is a physical change.
6.	F	Combining hydrogen and oxygen to make water is a physical change.
7.	T	Breaking up concrete is a physical change.
8.	F	Sand being washed out to sea from the beach is a chemical change.
9.	F	When ice cream melts, a chemical change occurs.
10.	F	Acid rain damaging a marble statue is a physical change.

chemical properties = chemical change

What is a chemical reaction?

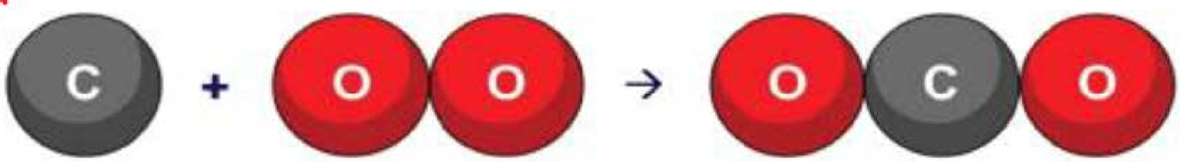
A chemical reaction is a change that takes place when one or more substances (called Reactants) form one or more NEW substances (called Products).

reactant ① + reactant ② | reactants "yeilds" → products + product ② + ……

"produces"

For example:

state of matter



word equation: solid carbon + oxygen gas → carbon dioxide gas

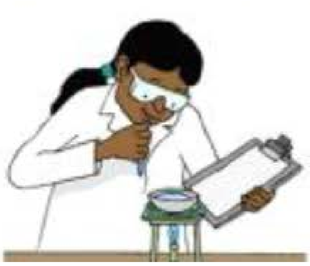
symbol equation: $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

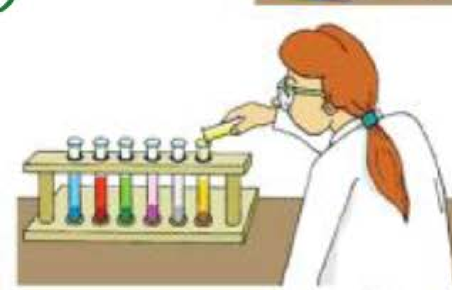
How can you spot a chemical reaction?

Chemical reactions can appear very different.

As you observe a chemical reaction, you may detect:

- a colour change
- precipitate (solid) forming ← when a solid form from 2 Liquids
- Energy being produced (heat, light)
- Gas produced (fizzing, bubbles)
- an odor being produced. (smell)





What is a word equation?

and usually states of matter

A word equation uses the names of the reactants and products to show what happens in a ***chemical reaction.***

For example, when a piece of sulfur is burned in oxygen gas it produces a white solid called sulfur dioxide.

"yeilds"/"produces"

The word equation for this reaction is:

solid sulfur + oxygen gas → solid sulfer dioxide

reactants — product

What is a symbol equation?

A ***symbol equation*** uses the formula of the reactants and products to show what happens in a chemical reaction. ***(also called a skeleton equation-because it's NOT balanced...yet!))***

A symbol equation ***MUST*** be balanced to give the ***correct ratio*** of reactants and products.

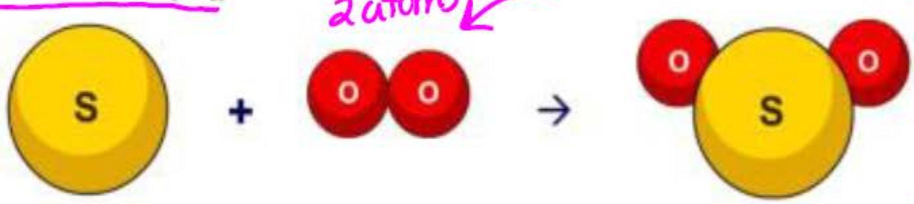
"HOFBrINCl" diatomic elements

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

S=1 O=2 | S=1 O=2 ✓yes, balanced

This equation shows that 1 atom of sulfur (S) reacts with 1 molecule of oxygen (O_2) to make one molecule of sulfur dioxide (SO_2).

2 atoms



1 molecule = 3 atoms (2=O 1=S)

What do state symbols show?

State symbols are added to a symbol equation to show whether the reactants and products are:

- Solid – symbol is (s)
- Liquid – symbol is (l)
- Gas – symbol is (g)
- dissolved in water – symbol is (aq). = "aqueous" (eg. HCl solution = $HCl_{(aq)}$)

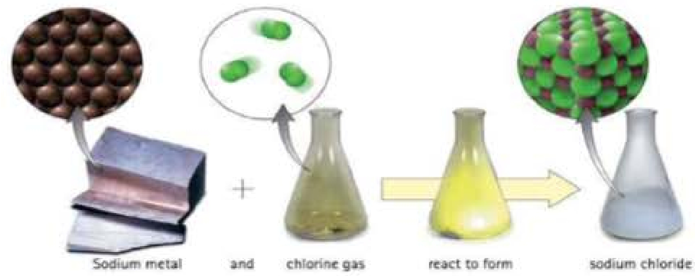
$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(s)}$$

With state symbols in place, this symbol equation now shows that the sulfur is a SOLID, the oxygen is a GAS and the sulfur dioxide is also a SOLID.

Chemical Reaction Equations

Chemical word equations are descriptive but ***chemical reaction equations*** are much more efficient.

*Using chemical symbols and numbers creates a **"chemical shorthand"** for all chemists to understand... much like txt language saves our thumbs and shortens convs.*



The **general form** of a chemical equation is: **Reactants** **Product**

"Sodium metal reacts with chlorine gas to produce sodium chloride crystals." ← solid

Chemical Word Equation: sodium + chlorine → sodium chloride

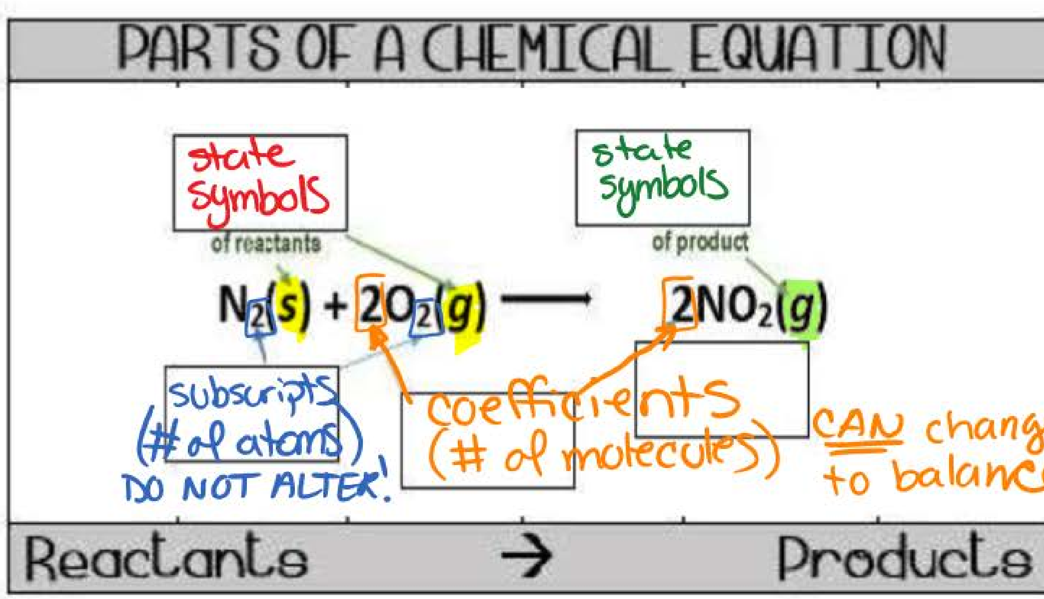
unbalanced — **Skeleton chemical reaction equation:** $Na + Cl_2 \rightarrow NaCl$

Balanced chemical reaction equation: $2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$

2x (NaCl) (NaCl)

Quick Check

1. Convert the following from a *word equation* to a **formula equation**:
   Calcium oxide powder is combined with water to form calcium hydroxide solid.
   $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$
2. Convert the following from a *formula equation* to a **word equation:**
   $H_2CO_3(aq) \rightarrow CO_2(g) + H_2O(l)$
   hydrogen carbonate → carbon dioxide + water



Homework

Assignment # 2: Writing Word Equations pg 8-9
*Complete this assignment **in the space provided on the following pages***

Writing Word Equations - Answers

Task 1

Reactants - magnesium, hydrochloric acid

Products - magnesium chloride, hydrogen

Task 2

Aluminium	+	Sulfuric Acid	→	Aluminium Sulfate	+	Hydrogen

Task 3

a.	Iron	+	Nitric Acid	→	Iron Nitrate	+	Hydrogen		
b.	Zinc	+	Iron Chloride	→	Zinc Chloride	+	Iron		
c.	Potassium	+	Water	→	Potassium Hydroxide	+	Hydrogen		
d.	Copper Carbonate	+	Sodium	→	Sodium Carbonate	+	Copper		
e.	Calcium Carbonate	+	Sulfuric Acid	→	Calcium Sulfate	+	Carbon Dioxide	+	Water

Word equations

Write the skeleton equation for each of the following reactions. Then balance each of the following chemical equations.

1. hydrogen + oxygen → water

   $2H_2 + O_2 \rightarrow 2H_2O$

2. iron(III) oxide + hydrogen → water + iron

   $Fe_2O_3 + H_2 \rightarrow H_2O + 2Fe$

3. sodium + water → sodium hydroxide + hydrogen

   $2Na + 2H_2O \rightarrow 2NaOH + H_2$

4. calcium carbide + oxygen → calcium + carbon dioxide

   $CaC_2 + 2O_2 \rightarrow Ca + 2CO_2$

5. potassium iodide + chlorine → potassium chloride + iodine

   $2KI + Cl_2 \rightarrow 2KCl + I_2$

6. chromium + tin(IV) chloride → chromium(III) chloride + tin

   $4Cr + 3SnCl_4 \rightarrow 4CrCl_3 + 3Sn$

7. magnesium + copper(II) sulphate → magnesium sulphate + copper

   $Mg + CuSO_4 \rightarrow MgSO_4 + Cu$

8. zinc sulphate + strontium chloride → zinc chloride + strontium sulphate

   $ZnSO_4 + SrCl_2 \rightarrow ZnCl_2 + SrSO_4$

9. ammonium chloride + lead(III) nitrate → ammonium nitrate + lead(III) chloride

   $3NH_4Cl + Pb(NO_3)_3 \rightarrow 3NH_4NO_3 + PbCl_3$

10. iron(III) nitrate + magnesium sulphide → iron(III) sulphide + magnesium nitrate

    $2Fe(NO_3)_3 + 3MgS \rightarrow Fe_2S_3 + 3Mg(NO_3)_2$

11. aluminum chloride + sodium carbonate → aluminum carbonate + sodium chloride

    $2AlCl_3 + 3Na_2CO_3 \rightarrow Al_2(CO_3)_3 + 6NaCl$

12. sodium phosphate + calcium hydroxide → sodium hydroxide + calcium phosphate

    $Na_3PO_4 + Ca(OH)_2 \rightarrow NaOH + Ca_3(PO_4)_2$

Balancing Chemical Equations: An Inquiry Lesson

Part 1: The Law of Conservation of Mass

To Know & Think About

TO READ:

The Law of Conservation of Mass: Matter is neither created or destroyed in an ordinary chemical reaction or physical change.

The Law of Conservation of Mass (in other words): The mass of the reactants must equal the mass of the products.

Think About It & Answer: (Record your answer on your Student Answer Sheet.)

1. How do the above statements relate to a balanced chemical equation?

To Do!

Law of Conservation of Mass: Prove It!

Materials:

125 mL Erlenmyer Flask + Cork Stopper
water
electronic balance
small piece of Alka-Seltzer (about ¼ of a tablet)

Procedure:

1. Collect all needed materials, including goggles.
2. Fill the flask about ¾ full with water. Put the cork on the Flask. Find the mass of both the bottle and the cap, and record the mass in the data table.
3. Using weighing paper, find the mass of a small piece of Alka-Seltzer. (Either tare the balance or subtract out the mass of the paper.) Record mass in data table.
4. Add both masses to come up with the total mass of the system before reaction.
5. Remove the cap from the bottle and drop in the Alka-Seltzer. Replace cap quickly. After the reaction stops, find the mass of the total system and record in the data table.
6. Slowly remove the cap, and leave open for 20 seconds. Replace the cap and find the final mass and record in data table.

Data: Record data on the data table included on your Student Answer Sheet.
Analysis/Questions: See your Student Answer Sheet.
Conclusion: See your Student Answer Sheet.

Part 2: The Balanced Chemical Equation

Materials:

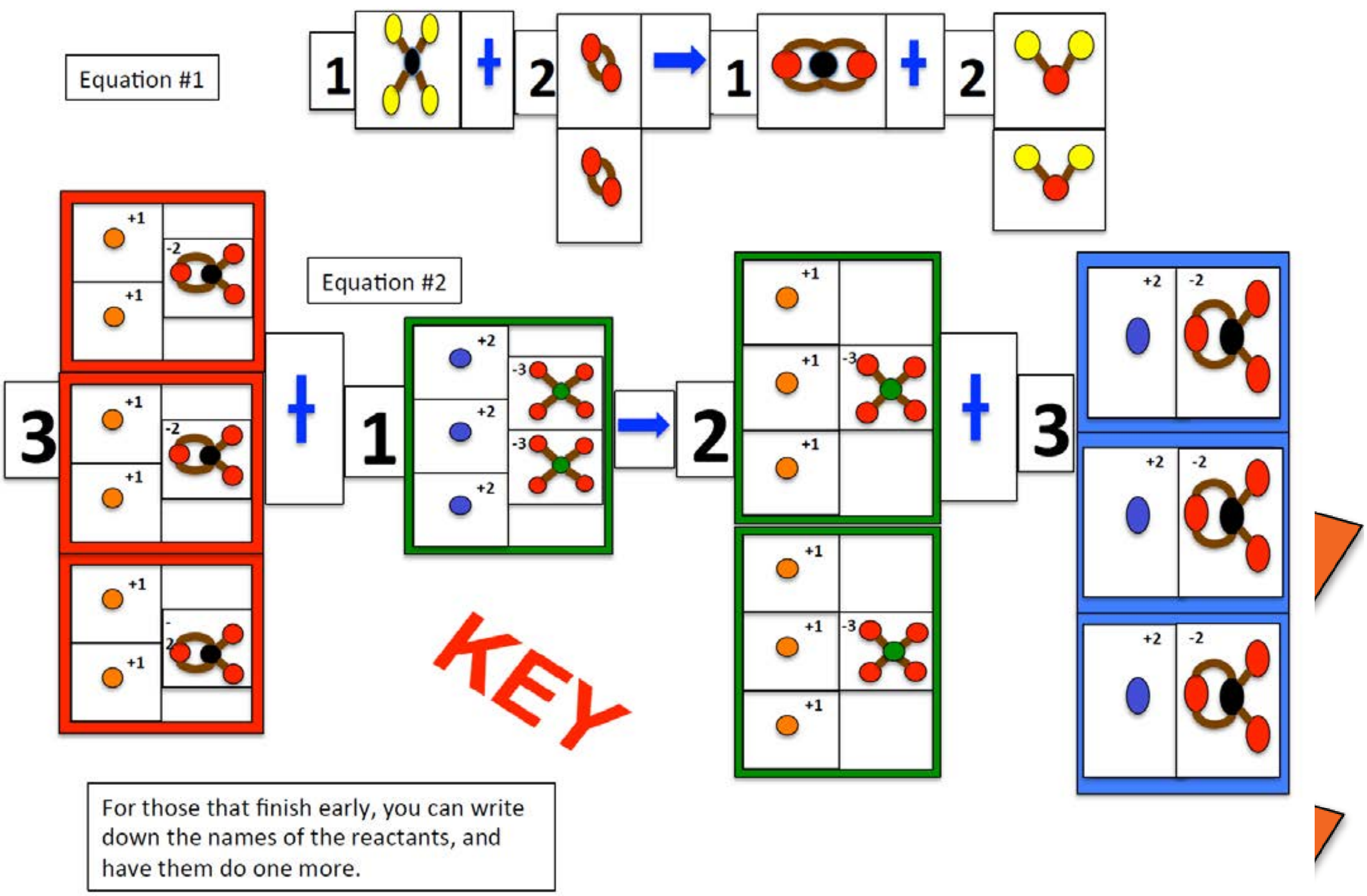
Set of Balancing Chemical Equations cards
White board & markers (or other directions from your teacher)

Directions:
Follow the directions, and when you see a question box, 

return to your Student Answer Sheet to answer that question.

1. Lay out your cards, and find the card that you think represents methane (CH_4). 

2. The reactants for the first reaction are CH_4 and O_2. Find a diatomic molecule that represents oxygen and a plus sign. Lay out the reactants.
3. Place a yield sign after the oxygen. The products for this reaction are water and carbon dioxide. Find the models that represent these two molecules and place them on the product side with another plus sign.
4. Count the number of each type of atom. If there are not the same number of atoms on each side of the equation, add molecules until you get the equation balanced.
5. Once you have the equation balanced (with the same number of atoms for each element on both sides of the equation), choose coefficients (the numbers) that go in front of each compound and represent the number of molecules needed.



Notice!

- ✓ In order to balance a chemical equation, you can only change coefficients (the number of compounds you need), NOT subscripts. Changing subscripts would change the compound.
- ✓ Polyatomic ions can be balanced together as one unit IF they stay together on both sides of the equation!

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Name: ________________________________ Date: _____________ Period: ______

KEY

Part 1: The Law of Conservation of Mass

Think About It Question: ____

A balanced equation must have the same number of atoms for each element on each side of the equation. If the same number of atoms are on both sides, then the mass will be the same.

Data:	**Law of Conservation of Mass Data**
	Mass (g)
Bottle, cap, H_2O	fill about ¾ full (water bottle)
Alka-Seltzer	¼ of a tablet (≈ 0.75 g)
Mass of total system before reaction	total mass of the two above
Mass of total system after reaction	should be the same as above
Final Mass (after 20 seconds)	should be a little less

Analysis/Questions:

1. What evidence did you observe that indicates that a chemical reaction took place?

   frizzing, bubbles, indicates the production of a gas

2. Compare the mass of the closed system before the reaction and the mass of the closed system after the reaction. Describe your results. They should be the same or just a little bit less.

   If your data shows a difference between the initial mass and the mass of the total system after the reaction, (before the cap is opened) how do you explain this discrepancy?

   Maybe didn't get the cap on quick enough before some of the gas escaped.

3. How do you account for the difference in mass after the top was opened for 20 seconds?

   The mass is less due to "escaping" gas after the top was opened.

4. This experiment was conducted in a "closed" system. If it had been conducted in an "open" system, how would your data have been different? ______________________

   The mass of the total system after reaction would have been much less than the initial mass due to "escaping" gas.

Analysis/Questions:

The chemical equation for this reaction is as follows:

$$3\ NaHCO_3 + C_6H_8O_7 \rightarrow Na_3C_6H_5O_7 + 3\ H_2O + 3\ CO_2$$

sodium bicarbonate + citric acid → sodium citrate + water + carbon dioxide

KEY

5. Identify the reactants of this reaction: __sodium bicarbonate & citric acid__
6. Identify the products of this reaction: __sodium citrate & water & carbon dioxide__
7. What product "escaped" when the bottle cap was opened? __carbon dioxide__

Conclusion:

Does this experiment support the Law of Conservation of Mass? Explain.

__Yes, the mass of the reactants is equal to the mass of the products.__

Does this experiment support the second statement in the beginning box? (The mass of the reactants must equal the mass of the products.) __Yes, the mass of the reactants is equal to the mass of the products.__

Part 2: The Balanced Chemical Equation

Questions:

1. There are two types of cards that have an element in the middle surrounded by 4 hydrogen atoms. Explain your choice of cards. __CH_4 is a neutral compound. The other card type is an anion with a -3 charge.__
2. Using the coefficients and compound models, write the balanced chemical equation for this reaction. __$CH_4 + 2\ O_2 \rightarrow 2\ H_2O + CO_2$__
3. Name the two compounds that make up the reactants of this reaction.

   __sodium carbonate & calcium phosphate__
4. Write the formulas and give the names of what you predict will be the products of this reaction. __Na_3PO_4 sodium phosphate & $CaCO_3$ calcium carbonate__
5. Write your completed balanced equation here.

   __$3\ Na_2CO_3 + Ca_3(PO_4)_2 \rightarrow 2\ Na_3PO_4 + 3\ CaCO_3$__
6. Describe how this balanced equation supports the Law of Conservation of Mass.

   __There are the same number of atoms of each element on either side of the equation. Therefore there is the same mass on both sides. Mass of the reactants = mass of the products.__

Part B: Balancing Chemical Equations

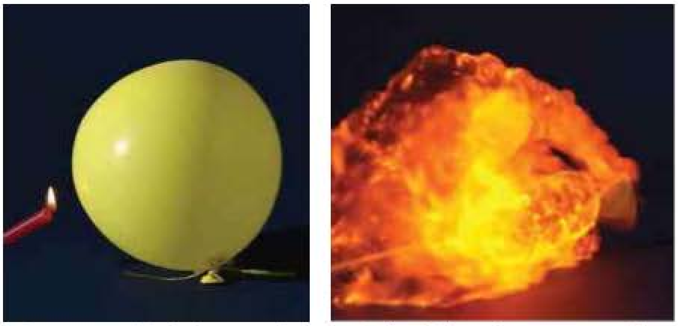


Figure 4.30 The hydrogen and oxygen in the balloon do not react until the balloon is touched by a flame (A). Then, an explosive chemical reaction occurs (B).

Law of Conservation of Mass

What happens to atoms of hydrogen and atoms of oxygen when the two gases are brought together and ignited ?

Hydrogen + oxygen burn + water vapor produced

Are new atoms created in the flash?

new product... but NO new atoms

Are some destroyed?

no ... matter is rearranged, but not created or destroyed.

$2H_2(g)$ + $O_2(g)$ → $2H_2O(g)$

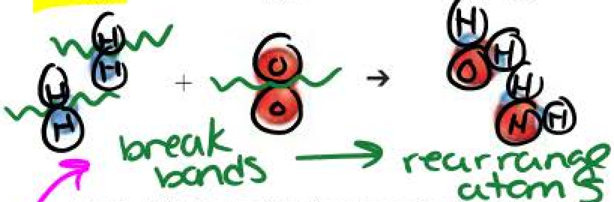


Figure 4.32 The reaction of oxygen molecules with hydrogen molecules involves rearranging atoms in new ways.

When a chemical reaction occurs, new compounds are created, BUT…

No new matter is created or destroyed; atoms are just rearranged as the atoms change partners to form ***new compounds***.

If there are 2 atoms of oxygen in the **reactants**, THERE MUST BE 2 atoms of oxygen in the **products.**

Number of each atom in reactants = number of each atom in products. This is called **THE LAW OF CONSERVATION OF ATOMS**. And also explains why we must balance chemical equations.

THE LAW OF CONSERVATION OF MASS

mass is conserved in a chemical reaction.

mass of reactants (total) = mass of products (total)

"no matter is created or destroyed"

If you could collect and measure all of the exhaust from this car, you would find that mass of reactants (gas + O_2) = mass of products (exhaust).

The law of conservation of mass states that ***mass is conserved in a chemical reaction.***

The total mass of the products is always equal to the total mass of the reactants in a chemical reaction.

The idea that atoms are conserved *(neither made nor destroyed)* is believed to be true for all chemical reactions .

Balancing Chemical Equations

A brief examination of the equation for the decomposition of mercury(II) oxide, $HgO_{(s)} \rightarrow Hg_{(l)} + O_{2(g)}$, shows that it **does not obey** the law of conservation of mass. The reactant, HgO contains 1 less oxygen atom than the products, Hg and O_2.

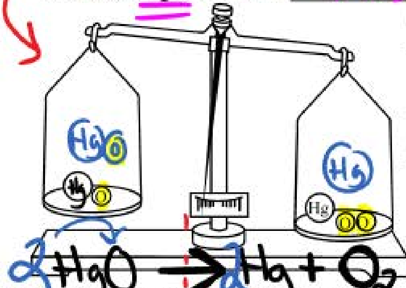


Figure 4.1.2 The reactant in this reaction weighs less than the products.

To show that the mass before and after a chemical reaction occurs remains constant, the formula equation has to be Balanced.

Balancing a chemical equation requires the placement of **coefficients** in front of reactant and/or product species.

coefficients are numbers that **multiply** the entire chemical species that follows them.

These numbers ensure that the number of atoms of each kind on the reactant side is **equal** to those on the product side of the equation.

> It is critical to remember balancing must always involve the placement of coefficients and **NEVER the changing of subscripts.**
> Altering the subscripts will give an ***incorrect formula*** for a substance.

Example Balance $\_(NH_4)_3PO_4 + \_NaOH \longrightarrow \_Na_3PO_4 + \_NH_3 + \_H_2O$

The Method

Note: ☝ ***Until you are finished balancing, missing coefficients are treated as zeros!*****

☝ ***Do not start with atoms that are easy or difficult to balance; it's best to balance them last.***
Elemental species are easy; *elements that occur in more than one species on each side (usually O and H) are tough.*

☝ ***Balance preserved groups (those that don't come apart) whenever possible.***

Find an element that only occurs in one species on each side; **these are usually metal ions.**
Put a coefficient in front of the two species so as to balance the element of interest.
(** Very Important: The 1st step is the only step where you place coefficients on both sides.**)

$$\_(NH_4)_3PO_4 + \_NaOH \longrightarrow \_Na_3PO_4 + \_NH_3 + \_H_2O$$

You have successfully balanced one element. Booyah! The problem has now becomes easier to solve.
The coefficients will also have fixed another element (or group) on one side.

Now place a coefficient to balance the atom (or group) on the opposite side.

$$\_(NH_4)_3PO_4 + \_NaOH \longrightarrow \_Na_3PO_4 + \_NH_3 + \_H_2O$$

Repeat the process until all of the elements are balanced.

$$\_(NH_4)_3PO_4 + \_NaOH \longrightarrow \_Na_3PO_4 + \_NH_3 + \_H_2O$$

$$\_(NH_4)_3PO_4 + \_NaOH \longrightarrow \_Na_3PO_4 + \_NH_3 + \_H_2O$$

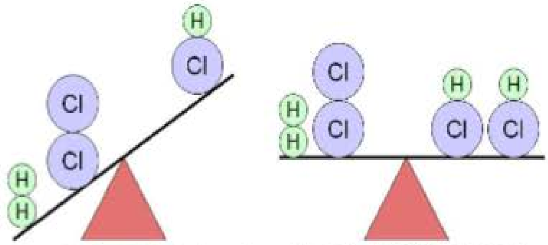
Omit coefficients of 1 in your final answer. *****Always do a check to make sure that all atoms are balanced.*****

$$\_(NH_4)_3PO_4 + \_NaOH \longrightarrow \_Na_3PO_4 + \_NH_3 + \_H_2O$$

Rules for Writing Balanced Equations

1. Write a **word equation** for the chemical reaction
   - ✓ Water → hydrogen + oxygen
2. Write a **chemical formula** for each of the reactants and products
   - ✓ $H_2O \rightarrow H_2 + O_2$
3. Use **numbers in front** of the formulae **to balance** the numbers of atoms on each side of the equation
   - ✓ $2H_2O \rightarrow 2H_2 + O_2$
4. **Check** each type of atom to make sure that the equation is balanced
   - ✓ 4 x H + 2 x O → 4 x H + 2 x O
5. Include the **symbols** for the **states of matter** for the substances involved
   - ✓ $2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2(g)}$

Unbalanced and Balanced Equations



$H_2 + Cl_2 \rightarrow HCl$ (unbalanced)

	reactants	products
H	2	1
Cl	2	1

$H_2 + Cl_2 \rightarrow 2\,HCl$ (balanced)

	reactants	products
H	2	2
Cl	2	2

The Algebra method:

Example 1 Balance A K + B H_2O → C KOH + D H_2 ⇒ ($\underline{1}$ K + $\underline{1}$ H_2O → $\underline{1}$ KOH + $\frac{1}{2}$ H_2) ×2

① K: a = c
H: 2b = c + 2d
O: b = c

② Let a = 1 (choose the variable that will be the most helpful)

③ substitute a = 1
a = c
(1) = c = 1
b = c (substitute)
(1)
b = 1

2b = c + 2d
2(1) = (1) + 2d
2 = 1 + 2d
2 − 1 = 2d
$\frac{1}{2} = \frac{2d}{2}$
$\frac{1}{2} = d$

$2K + 2H_2O \rightarrow 2KOH + H_2$

Example 2 Balance 4 $MoCl_3$ + 1 O_2 + 4 AgCl → 4 $MoCl_4$ + 2 Ag_2O

Mo: a = d (let a = 1) → (1) = d ✓
Cl: 3a + c = 4d → 3(1) + c = 4(1)
3 + c = 4 − 3
c = 1 ✓
O: 2b = e
Ag: c = 2e

c = 2e
(1) = 2e
$\frac{1}{2} = e$

2b = e
2b = ½
$\left(\frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}\right)$ → b = $\frac{1}{4}$

a = 1 → 4
b = ¼ → 1
c = 1 → 4
d = 1 → 4
e = ½ → 2
(×4)

$\frac{1}{2} \cdot \frac{4}{1} = \frac{4}{2} = 2$

These are your coefficients.

Assignment #3: Balancing Equations Review pg 17-20
Complete this assignment ***in the space provided on the following pages***

Balancing Equations

Writing balanced symbol equations

There are four stages to writing a full equation for a reaction:

1. Write out the word equation
2. Work out the formulae for all elements and compounds present
3. Balance the equation
4. Add information about the state of each chemical (solid, liquid, gas or aqueous solution).

This worksheet is concerned with the third task – balancing symbol equations.

Example 1 – The reaction between magnesium and oxygen

Magnesium + Oxygen → Magnesium Oxide

We can work out (using valency or otherwise) that the formula for magnesium oxide is MgO.
We need to remember that oxygen is a diatomic molecule and hence has the formula O_2.

We can now begin our symbol equation:

Magnesium	+	Oxygen	→	Magnesium Oxide
Mg	+	O_2	→	MgO

The next stage is to look at the number of atoms of each type of element on either side of the equation. If we start with one magnesium atom, we must finish the reaction with one. If we start with two oxygen atoms, we must also end up with two.

$$Mg + O_2 \rightarrow MgO$$

We can see from the diagram that there are the same number of magnesium atoms on either side of the arrow, but the oxygen atoms are not balanced. We cannot introduce a single oxygen atom to the right hand side. We can only introduce a whole magnesium oxide group. We do this by placing a 2 **before** the MgO formula.

$$Mg + O_2 \rightarrow 2MgO$$

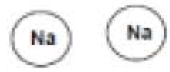
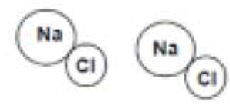
We now have two oxygen atoms on each side of the equation, but the magnesium atoms no longer match. We have to introduce one more magnesium atom to the left hand side. We do this by placing a 2 **in front** of the magnesium symbol.

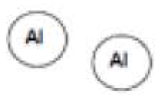
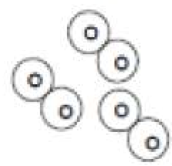
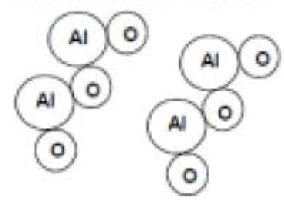
Magnesium	+	Oxygen	→	Magnesium Oxide
2Mg	+	O_2	→	2MgO

Our symbol equation is now balanced.

Balancing Equations - Answers

Task 1

a.	**Sodium**	**+**	**Chlorine**	**→**	**Magnesium Oxide**
		+		→	
Balance this →	**$2Na$**	**+**	**Cl_2**	**→**	**$2NaCl$**

b.	**Aluminium**	**+**	**Oxygen**	**→**	**Aluminium Oxide**
		+		→	
Balance this →	**$2Al$**	**+**	**$3O_2$**	**→**	**$2Al_2O_3$**

Task 2

a.	$2Ca$	+	O_2	→	$2Ca0$		
b.	$2Li$	+	F_2	→	$2LiF$		
c.	Mg	+	Br_2	→	$MgBr_2$		
d.	$4K$	+	O_2	→	$2K_20$		
e.	$2Al$	+	$3Cl_2$	→	$2AlCl_3$		
f.	$4Fe$	+	$3O_2$	→	$2Fe_20_3$		
g.	$2H_2$	+	O_2	→	$2H_2O$		
h.	H_2	+	Cl_2	→	$2HCl$		
i.	S	+	O_2	→	SO_2		
j.	C	+	$2H_2$	→	CH_4		
k.	$4Ag$	+	O_2	→	$2Ag_2O$		
l.	Ca	+	$2HCl$	→	$CaCl_2$	+	H_2
m.	Mg	+	$2HCl$	→	$MgCl_2$	+	H_2
n.	$2Na$	+	$2HCl$	→	$2NaCl$	+	H_2
o.	$2Al$	+	$6HCl$	→	$2AlCl_3$	+	$3H_2$

Writing and balancing equations

Skills: Interpreting, Numeracy, Knowledge

1 Define the Law of Conservation of Mass.

The law of conservation of mass states that mass in an isolated system is neither created nor destroyed by chemical reactions or physical transformations. According to the law of conservation of mass, the mass of the products in a chemical reaction must equal the mass of the reactants

2 Apply the Law of Conservation of Mass by balancing the following equations.

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

b $2KI_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow PbI_{2(s)} + 2KNO_{3(aq)}$

c $H_3PO_{4(aq)} + 3KOH_{(aq)} \rightarrow 3H_2O_{(l)} + K_3PO_{4(aq)}$

d $2Al_{(s)} + 3Cl_{2(g)} \rightarrow 2AlCl_{3(s)}$

e $(2NH_{3(g)} + \frac{5}{2}O_{2(g)} \rightarrow 2NO_{(g)} + 3H_2O_{(g)})^{\times 2}$ × multiply by the bottom number in the fraction

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

You must apply the following steps to write balanced chemical equations.

- Write the word equation for the reaction.
- Directly underneath the word equation, write the unbalanced formula equation.
- Add subscripts—(s), (l), (g) or (aq).
- Balance the equation.

Note: *Dilute* means a solution with water and therefore the appropriate subscript is (aq).

The table below lists various compounds and the chemical formula of each compound.

Compound name	Compound formula
Hydrochloric acid	HCl
Nitric acid	HNO_3
Sulfuric acid	H_2SO_4
Magnesium chloride	$MgCl_2$
Barium sulfate	$BaSO_4$
Sodium sulfate	Na_2SO_4
Water	H_2O

Compound name	Compound formula
Carbon dioxide	CO_2
Calcium carbonate	$CaCO_3$
Calcium nitrate	$Ca(NO_3)_2$
Magnesium hydroxide	$Mg(OH)_2$
Barium nitrate	$Ba(NO_3)_2$
Sodium hydroxide	$NaOH$
Sodium carbonate	Na_2CO_3

Writing and balancing equations

Skills: Interpreting, Numeracy, Knowledge

acids are always = (aq) "solutions"

3 **Use** the information in the table on page 1 of this worksheet to **construct** balanced chemical equations, including subscripts, for each of the following reactions.

a Dilute hydrochloric acid is added to solid magnesium hydroxide, producing water and the soluble salt magnesium chloride.

$2HCl_{(aq)} + Mg(OH)_{2(s)} \rightarrow 2H_2O_{(l)} + MgCl_{2(aq)}$

(means it has dissolved in H_2O)

b Dilute nitric acid is added to solid calcium carbonate, producing bubbles of carbon dioxide, water, and the soluble salt calcium nitrate.

$2HNO_{3(aq)} + CaCO_{3(s)} \rightarrow CO_{2(g)} + H_2O_{(l)} + Ca(NO_3)_{2(aq)}$

c When dilute sodium sulfate solution (aq) is added to dilute barium nitrate solution, barium sulfate precipitates (solid (s)), leaving sodium nitrate in solution.

$Na_2SO_{4(aq)} + Ba(NO_3)_{2(aq)} \rightarrow BaSO_{4(s)} + 2NaNO_{3(aq)}$

d Dilute sodium hydroxide is added to dilute sulfuric acid, producing water and the soluble salt sodium sulfate.

$2NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow 2H_2O_{(l)} + Na_2SO_{4(aq)}$

e Dilute sulfuric acid is poured over solid sodium carbonate, producing carbon dioxide, water and the soluble salt sodium sulfate.

$H_2SO_{4(aq)} + Na_2CO_{3(s)} \rightarrow CO_{2(g)} + H_2O_{(l)} + Na_2SO_{4(aq)}$

4 **Construct** balanced equations, including subscripts, for the following reactions. You may need to use the cross method from Worksheet 1.1 to **construct** the chemical formulas first on a separate sheet of paper.

a Iron metal reacts with chlorine gas (diatomic molecule.) to produce iron chloride.

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

b Sodium chloride solution is mixed with silver nitrate solution, producing a precipitate of solid silver chloride.

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

c Lead nitrate solution is added to sodium sulfate solution, producing lead sulfate precipitate.

$Pb(NO_3)_2 + Na_2SO_{4(aq)} \rightarrow PbSO_{4(s)} + NaNO_{3(aq)}$

d Sulfur dioxide gas reacts with oxygen to produce sulfur trioxide gas.

$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$

O_2: diatomic molecule