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## Observing Chemical Reactions

Changes in physical properties are indicative of a chemical reaction.

Physical Properties:   Color  
                                   Solubility  
                                   Density  
                                   Hardness  
                                   Mp/bp  
                                   Odor  
                                   Energy Changes

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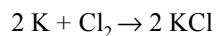
## Reading Chemical Equations

Reactant(s) → Product(s)

Name compounds by the rules we learned in chapter 3

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## Chemical Equations: *Coefficients*

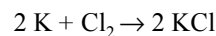


2 K denotes how many react.

The 2 relates to everything which follows in the compound.

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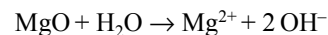
## Chemical Equations: Subscripts and Superscripts



Cl<sub>2</sub> denotes 2 atoms of chlorine in a chlorine molecule

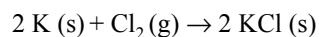
Subscripts refer only to the element immediately preceding

Superscripts will denote the charge on an ion



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## Chemical Equations: State



(s)(l)(g)(aq) denote the *state* of the molecules

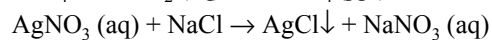
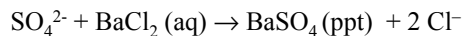
aq = aqueous = dissolved in *water*

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## Chemical Equations

Equations to chemists are like sentences to readers; they specify exactly what happens in a reaction.

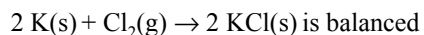
You should be able for the exam to “read” a chemical equation.



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## Chemical Equations Must Be Balanced

There must be an equal number of atoms of each element on both sides of the equation.



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## Balancing Equations by Inspection

Don't change formulas of molecules or subscripts.

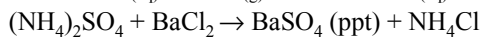
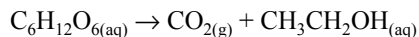
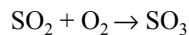
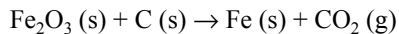
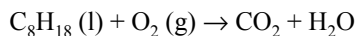
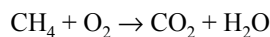
Don't forget that if you use a coefficient, all of the atoms in the molecule are increased.

Consider the substance with the most atoms first

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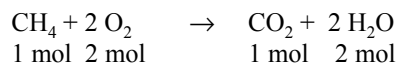
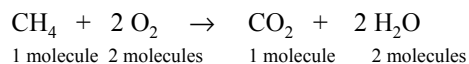
## Sample Test Question

Balance the following reactions, or indicate that they are balanced as written.



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## The Mole



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## Avagadro and the Moles

Avagadro's number-  $6.02 \times 10^{23}$

1 mole (mol) is  $6.02 \times 10^{23}$  atoms or  $6.02 \times 10^{23}$  molecules (or ...)

$6.02 \times 10^{23}$  *particles* = 1 mol

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## Molar Mass

Use *formula weight* to determine *molar mass*



$$1 \text{ C} = 12.011 \text{ amu} = 12.011 \text{ amu}$$

$$1 \text{ H} = 1.0079 \text{ amu} = \underline{4.032 \text{ amu}}$$

$$\text{formula weight} = 16.043 \text{ amu}$$

$$\text{molar mass} = 16.043 \text{ g/mol}$$

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## Mole Calculations

Watch subscripts, especially around parentheses

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## Sample Test Questions

Sucrose has the formula  $C_{12}H_{22}O_{11}$ . What is the formula weight of sucrose?

Calculate the molar mass of  $Fe_2(NO_3)_3$ .

What is the formula weight and the molar mass of copper (II) sulfate heptahydrate?

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## Conversions

- Show your work on the exam
- Set up unit cancellation
- Show units you end up with

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## Sample Test Question

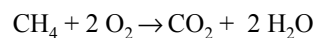
What mass of sucrose,  $C_{12}H_{22}O_{11}$ , should be weighed out if I want 1.54 mol sucrose?

Next semester: 30 g sucrose, how many moles?

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## Stoichiometry

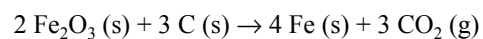
Stoichiometry- ratio of products to reactants  
AKA mole ratio



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## Sample Test Question

Using the following balanced equation, how many moles of  $CO_2$  will I end up with, beginning with 1.5 mol of C?



Using the previous balanced equation, how many moles of Fe will I end up with, beginning with 1.17 mol of  $Fe_2O_3$ ?

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## Theoretical Yield Calculations

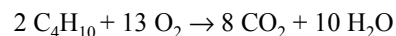
1. Convert mass into moles
2. Do stoichiometry
3. Convert moles back to mass

Stoichiometry is an exact number

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## Sample Test Questions

Using the following balanced chemical reaction, calculate the theoretical yield of carbon dioxide if you burn 1.25g C<sub>4</sub>H<sub>10</sub> in excess oxygen.



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## Limiting Reagent

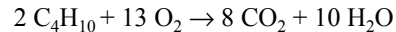
One thing always runs out first- this is known as the limiting reagent.

In order to determine the limiting reagent, calculate the theoretical yield for both (all) reactants.

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## Sample Test Question

Using the following equation, identify the limiting reagent if you burn 1.25g C<sub>4</sub>H<sub>10</sub> in 16.9g of O<sub>2</sub>.



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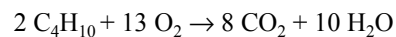
## Percent Yield

$$\text{Percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

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## Sample Test Question

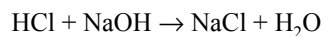
Calculate the percent yield if you begin with 1.25g C<sub>4</sub>H<sub>10</sub> in 16.9g of O<sub>2</sub>, and end up with 3.32g of CO<sub>2</sub>.



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### Sample Test Question

Determine the limiting reagent of the following reaction if you begin with 12.63g HCl and 11.59g of NaOH.



Determine the percent yield in question 10 if you obtain 16.59g NaCl.

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### Chemical Reactions and Energy Changes

All chemical reactions involve a change in energy: heat, light, electricity



**Endothermic reaction**- take up heat from surroundings (cold to the touch).

Reactants are lower energy state than products.

**Exothermic reaction**- produce heat (hot to the touch).  
Products are lower energy state than reactants.

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### Sample Test Questions

50.0 mL of 2 N HCl at 23.0°C is added to a *calorimeter* containing 50.0 mL 2 N NaOH at 23.0°C. The temperature is observed to increase to 37.0°C. Is the neutralization of acid an exothermic or endothermic reaction?

What is the *heat of reaction* in the above experiment?