

## Balancing Chemical Equations

### A Chemical Equation:

- is a representation of a chemical reaction in terms of chemical formulas

### Example:

#### 1. Word Description of a Chemical Reaction

When methane gas ( $\text{CH}_4$ ) burns in the presence of oxygen gas, it produces carbon dioxide gas and water vapor.

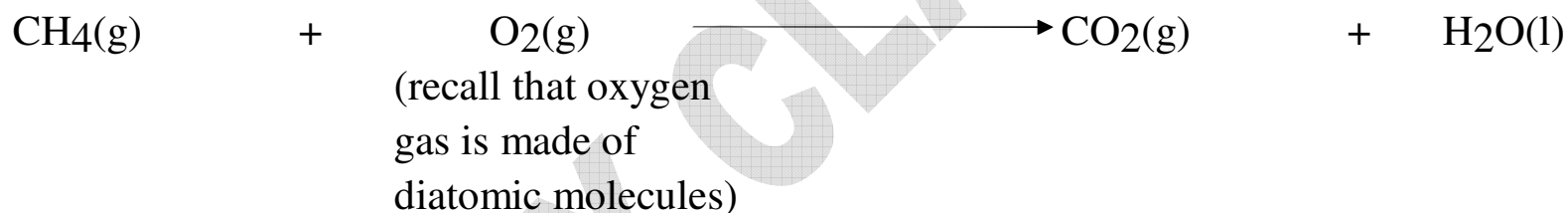
#### 2. Word Equation

- distinguishes between the starting substances (**REACTANTS**) and the substances that result from the chemical reaction (**PRODUCTS**)
- indicates the chemical change with an arrow, referred to as the “**YIELD**” sign ( $\longrightarrow$ )

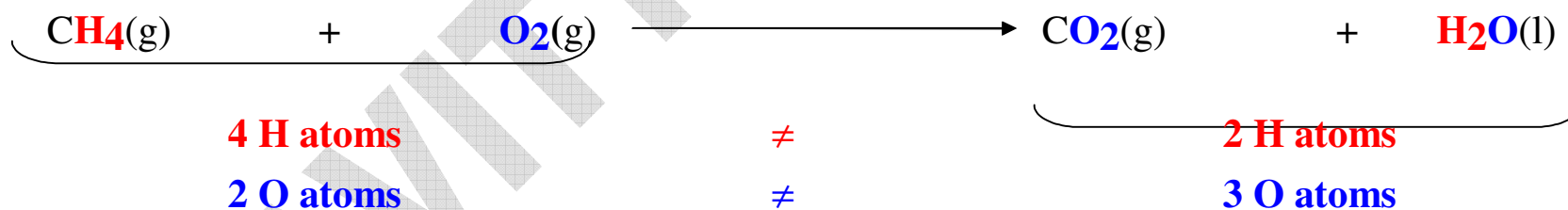


### 3. Unbalanced Chemical Equation

- represents Reactants and Products with correct chemical formulas
- indicates the physical state (phase designation) of all substances involved:
  - “s” for solid
  - ‘l’ for liquid
  - “g” for gas
  - “aq” for “dissolved in water (aqueous solution)”
- does not attempt to account for the number of atoms involved in the reaction. yields



NOTE:



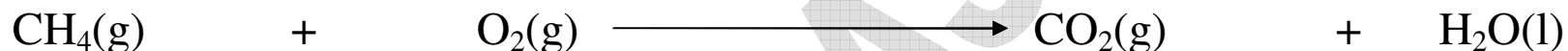
This equation is not in agreement with one of the postulates of Dalton’s Atomic Theory:

A Chemical Reaction consists of the **REARRANGEMENT OF ATOMS** present in the reacting substances.

**ATOMS ARE NEITHER CREATED, NOR DESTROYED IN A CHEMICAL REACTION.**

#### 4. Balanced Chemical Equation

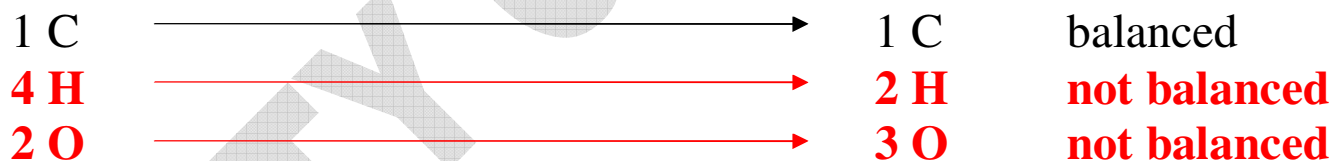
- the number of atoms of each element are equal on both sides of the arrow
- uses “**coefficients**” to ensure that the “equation is balanced”
  - coefficients – are the **smallest set of whole numbers** placed in front of the formulas in order to balance the equation.



To balance:

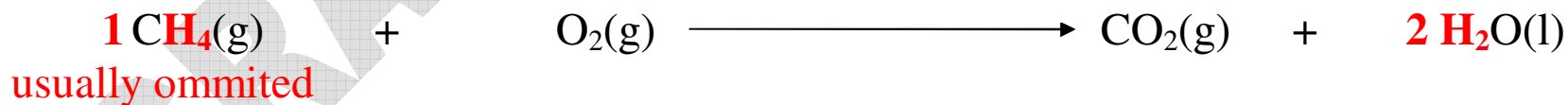
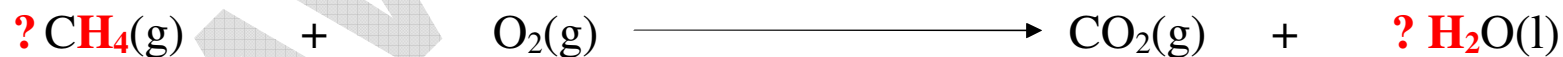
First:

- check number of atoms of each element on both sides of the arrow



Second:

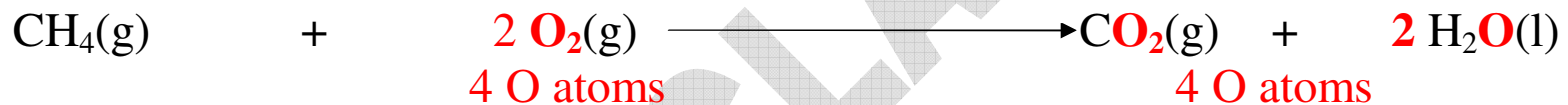
- balance first the atoms for elements that occur in only one substance on each side of equation.



H is now balanced (4 H atoms on both side of the equation)

Third:

Balance all other atoms:



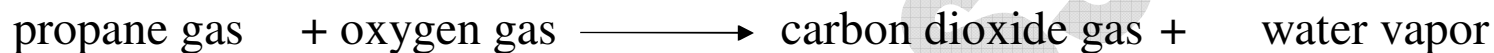
The equation is now balanced:



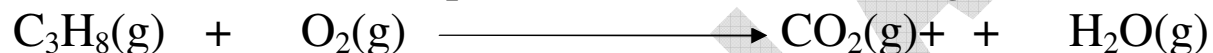
## Examples:

1. Propane gas (C<sub>3</sub>H<sub>8</sub>) burns in the presence of oxygen and produces carbon dioxide gas and water vapor.

(A) WordEquation



(B) UnbalancedChemicalEquation(include State Designations)



(C) BalancedChemicalEquation



3 C

1 C

8 H

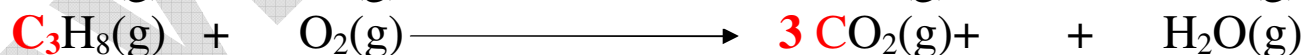
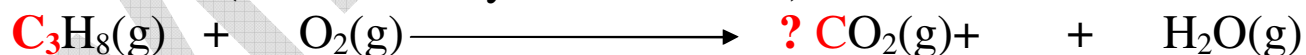
2 H

2 O

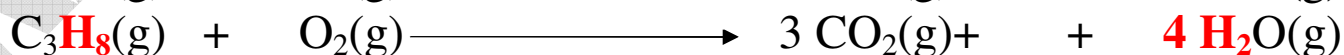
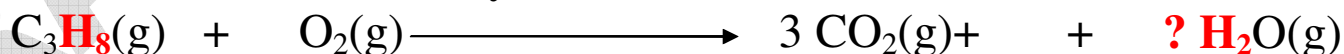
2 O

1 O

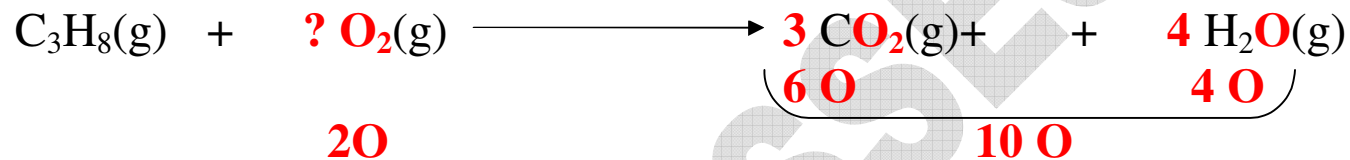
First: Balance C (occurs in only one substance):



Second: Balance H (occurs in only one substance):



Third: Balance O (occurs in more than one substance on right hand side):



The Equation is now balanced:



2. Ethane gas (C<sub>2</sub>H<sub>6</sub>) burns in the presence of oxygen and produces carbon dioxide gas and water vapor.

(A) Word Equation

ethane gas + oxygen gas → carbon dioxide gas + water vapor

(B) Unbalanced Chemical Equation (include State Designations)

C<sub>2</sub>H<sub>6</sub>(g) + O<sub>2</sub>(g) → CO<sub>2</sub>(g) + H<sub>2</sub>O(g)

(C) Balanced Chemical Equation

C<sub>2</sub>H<sub>6</sub>(g) + O<sub>2</sub>(g) → CO<sub>2</sub>(g) + H<sub>2</sub>O(g)

2 C

1 C

6 H

2 H

2 O

2 O

1 O

First: Balance C (occurs in only one substance):

**C**<sub>2</sub>H<sub>6</sub>(g) + O<sub>2</sub>(g) → **?** CO<sub>2</sub>(g) + H<sub>2</sub>O(g)

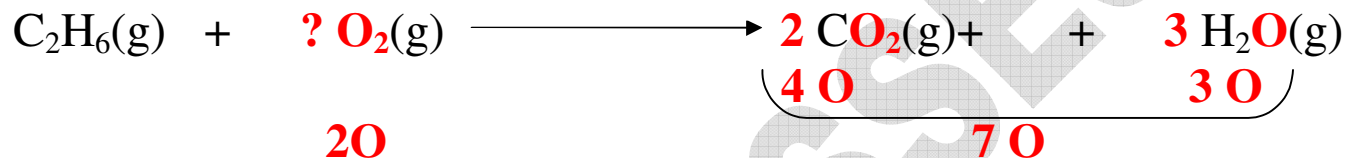
**C**<sub>2</sub>H<sub>6</sub>(g) + O<sub>2</sub>(g) → **2** CO<sub>2</sub>(g) + H<sub>2</sub>O(g)

Second: Balance H (occurs in only one substance):

C<sub>2</sub>**H**<sub>6</sub>(g) + O<sub>2</sub>(g) → 2 CO<sub>2</sub>(g) + **?** H<sub>2</sub>O(g)

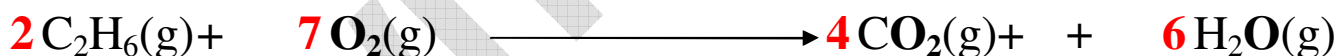
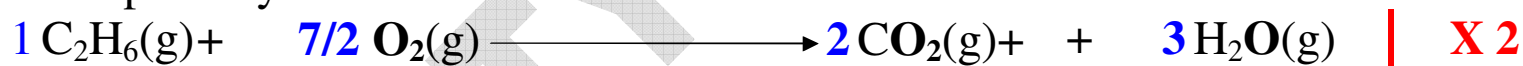
C<sub>2</sub>**H**<sub>6</sub>(g) + O<sub>2</sub>(g) → 2 CO<sub>2</sub>(g) + **3** H<sub>2</sub>O(g)

Third: Balance O (occurs in more than one substance on right hand side):



**NOTE:** The equation is balanced, but it uses a fractional coefficient (3/2)  
 - while this is mathematically correct, the fractional coefficient is not consistent with the chemical reality (half molecules do not exist)

Fourth: To remove the fractional coefficient, the whole equation (all the coefficients) are multiplied by 2:



4 C	=	4C	
12 H	=		12 H
14 O	=	8 O	+ 6 O

Balanced Chemical Equation:



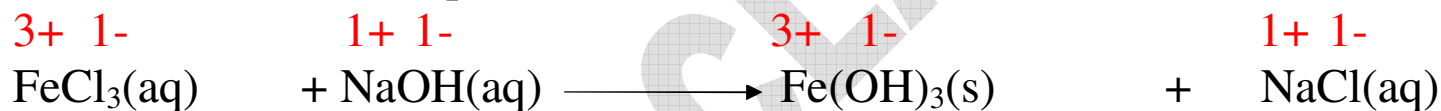
3. An aqueous solution of iron (III) chloride reacts with an aqueous solution of sodium hydroxide and forms solid iron (III) hydroxide and an aqueous solution of sodium chloride.

Write a balanced chemical equation that illustrates this chemical reaction.

(A) WordEquation

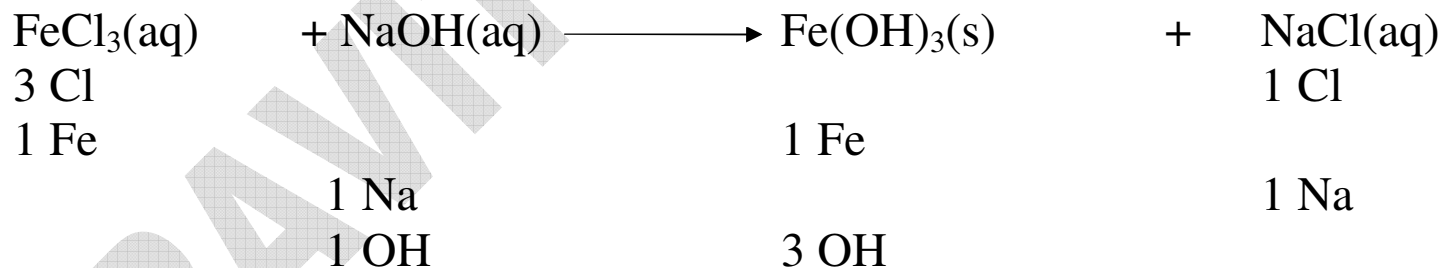
iron(III)chloride (aq) + sodium hydroxide (aq)  $\longrightarrow$  iron(III)hydroxide + sodium chloride(aq)

(B) UnbalancedChemicalEquation



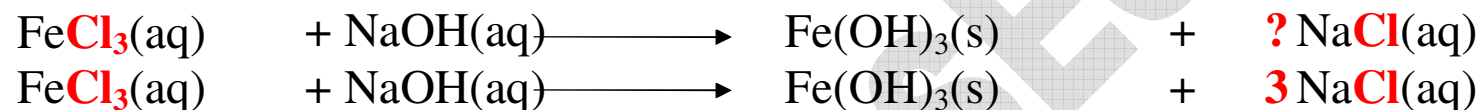
NOTE: Make absolutely sure that all formulas are correctly written before you go to the next step (consider the names given and the charges of ions)

(C) BalancedChemicalEquation

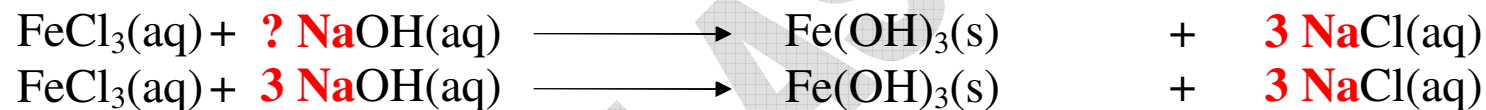


(since the OH<sup>-</sup> ion does not change, it may be balanced as a group)

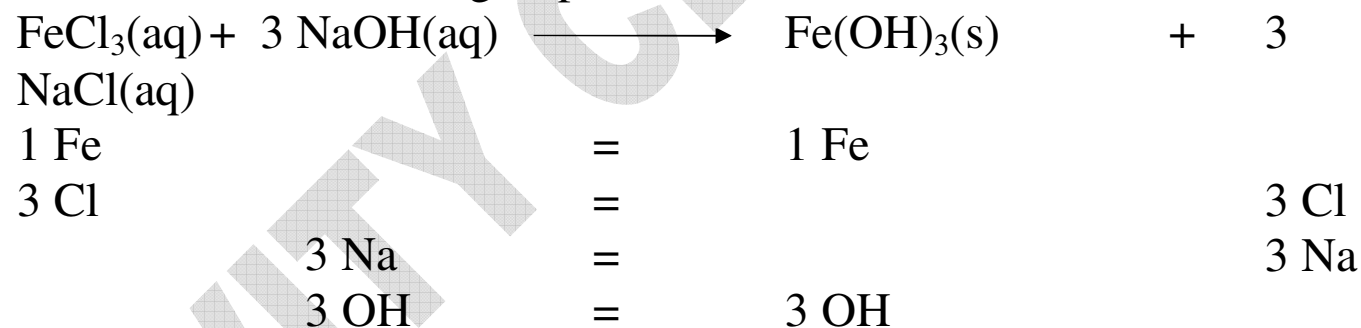
First: Balance Cl:



Second: Balance Na:



Third: Check all other atoms and groups:



The equation is correctly balanced:

