

G10 ADV – Chemical reactions

Lesson 1: Reactions and Equations

1. What Is a Chemical Reaction?



- **Chemical reactions** occur when atoms in one or more substances are rearranged to form new substances.
- This process is also called a **chemical change**. تعغير كيميائي
- Chemical reactions happen constantly:
 - ✓ Cooking food
 - ✓ Inside living organisms (digestion, respiration)
 - Vehicle engines
 - Factories
 - The atmosphere

Importance of Chemical Reactions

- They:
 - 1- Break down food to release energy
 - 2- Power vehicles (cars, buses)
 - 3- Produce natural fibers (cotton, wool)
 - 4- Produce synthetic materials (e.g. nylon)

Example: Nylon is produced when adipoyl chloride reacts with hexanediamine.

- Nylon is used in carpets, clothing, sports equipment, and tires.



2. Evidence of a Chemical Reaction

Some chemical reactions are easy to observe because they show **physical evidence**:

Common Signs of a Chemical Reaction

1- Temperature change (heat released or absorbed)

2- Light production (e.g. burning wood)
heat

3- Color change (e.g. iron rusting)

4- Odor change

5- Gas formation (bubbles)

6- Formation of a solid (precipitate)

Example:

- Iron nails turning orange-brown when exposed to air shows a reaction between **iron** and **oxygen**.



$O_2 + \text{iron}$



gas formation

3. Representing Chemical Reactions

Chemists use **chemical equations** to represent reactions.

Key Terms

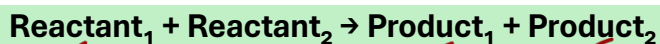
- **Reactants**: Starting substances (written on the left)
- **Products**: Substances formed (written on the right)

Equation Structure

- An arrow ($\rightarrow$) shows the direction of the reaction
- The arrow is read as "react to produce" or "yield"
- A **plus sign** (+) separates multiple reactants or products



General form:

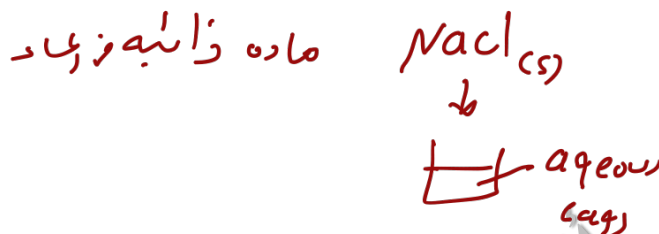


Chemical equations are not mathematical equalities because reactants are used up as products form.

4. Symbols Used in Chemical Equations

Physical State Symbols

- (s) = solid ✓
- (l) = liquid ✓
- (g) = gas ✓
- (aq) = aqueous (dissolved in water)



Other Symbols

- $\rightarrow$: reaction proceeds in one direction
- $\rightleftharpoons$: reversible reaction (can proceed in both directions)

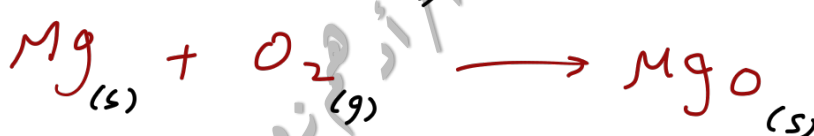
Showing physical states is important because they give clues about how a reaction occurs.

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TABLE 1 SYMBOLS USED IN EQUATIONS

Symbol	Purpose
+	separates two or more reactants or products
→	separates reactants from products
⇌	separates reactants from products and indicates a reversible reaction
(s)	identifies a solid state
(l)	identifies a liquid state
(g)	identifies a gaseous state
(aq)	identifies a water solution

Solid (s)	Liquid (l)	Gas (g)	Aqueous (aq)
1. All Metals except mercury ex. $\text{Na}_{(s)}$ $\text{Mg}_{(s)}$ 2. All metal oxides ex. $\text{Na}_2\text{O}_{(s)}$ $\text{MgO}_{(s)}$ 3. All insoluble Salts جدول $\text{PbSO}_4_{(s)}$ 4. All non metals except ~~$\text{Br}_{2(l)}$ $\text{Cl}_{2(l)}$ $\text{I}_{2(l)}$ $\text{O}_{2(g)}$ $\text{H}_{2(g)}$~~ $\text{C}_{(s)}$ $\text{S}_{(s)}$	Mercury $\text{Hg}_{(l)}$ ✓ Water $\text{H}_2\text{O}_{(l)}$ ✓ Bromine $\text{Br}_{2(l)}$	$\text{CO}_2_{(g)}$ $\text{O}_2_{(g)}$ ✓ $\text{Cl}_2_{(g)}$ ✓ $\text{SO}_3_{(g)}$ $\text{PH}_3_{(g)}$ Phosphine Most of Non-metal oxides $\text{NH}_3_{(g)}$	All ions $\text{Na}^+_{(aq)}$ $\text{Cl}^-_{(aq)}$ All Soluble salts $\text{NaCl}_{(aq)}$ $\text{Na}_2\text{CO}_3_{(aq)}$ All Acids ✓ $\text{HCl}_{(aq)}$, $\text{H}_2\text{SO}_4_{(aq)}$ All Alkali $\text{NaOH}_{(aq)}$

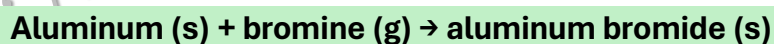


5. Word Equations

- Word equations describe reactions using names of substances.

Example: Aluminum and Bromine Reaction

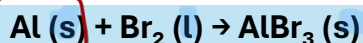
Word equation:



6. Skeleton Equations

- A **skeleton equation** uses chemical formulas instead of words.
- It shows:
 - Reactants ✓
 - Products ✓
 - Physical states ✓
- It does **not** show quantities (not balanced). ✗

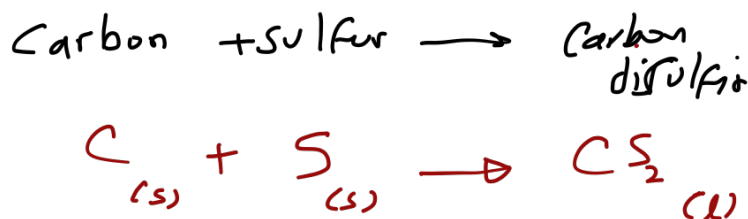
Example 1: Aluminum and Bromine



Example 2: Carbon and Sulfur Reaction

Step 1: Identify reactants and states

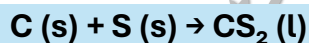
- Carbon: solid $\rightarrow \text{C (s)}$
- Sulfur: solid $\rightarrow \text{S (s)}$



Step 2: Write product and state

- Carbon disulfide: liquid $\rightarrow \text{CS}_2 \text{ (l)}$

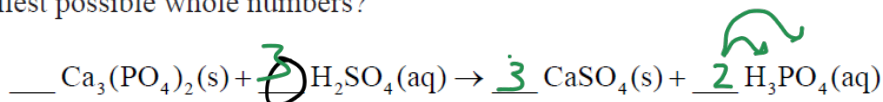
Skeleton equation:



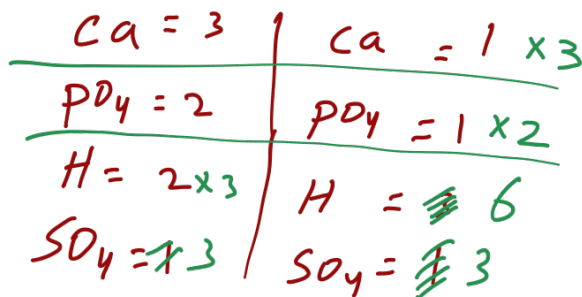
Important Note

- Skeleton equations **do not indicate amounts** of substances involved.
- Balancing equations is required to show correct quantities (covered in later lessons).

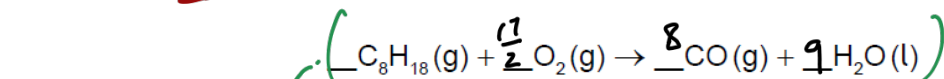
What are the coefficients of $\text{H}_2\text{SO}_4(\text{aq})$ and $\text{H}_3\text{PO}_4(\text{aq})$ when the following equation is balanced using the smallest possible whole numbers?



	Coefficient of $\text{H}_2\text{SO}_4(\text{aq})$	Coefficient of $\text{H}_3\text{PO}_4(\text{aq})$
A.	1	2
B.	2	3
C.	3	1
<u>D.</u>	3	2



What is the sum of the coefficients when the equation is balanced with whole numbers?

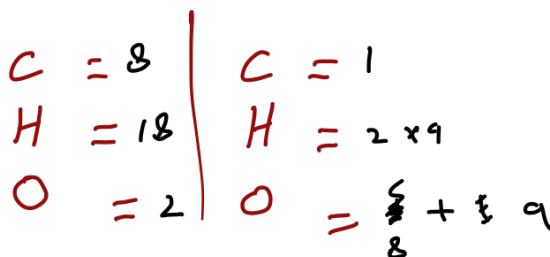


A. 26.5

B. 30

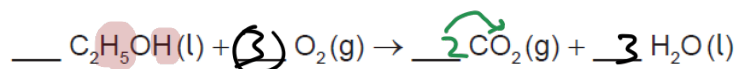
C. 53

D. 61



$$2 + 17 + 16 + 18 =$$

Combustion of ethanol takes place according to the following unbalanced equation.



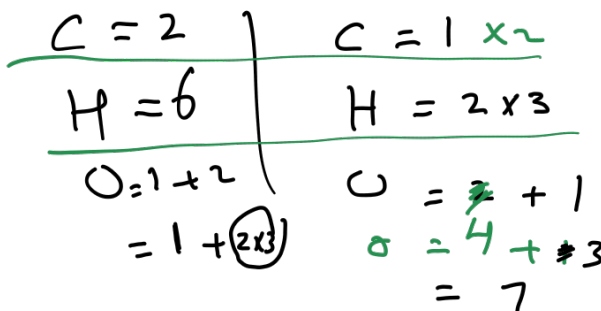
What is the mole ratio of ethanol to oxygen in the balanced equation?

A. 1:1

B. 2:1

C. 1:3

D. 2:7



Aluminium carbide reacts with water according to the equation below. What is the sum of all the coefficients when the equation is balanced?

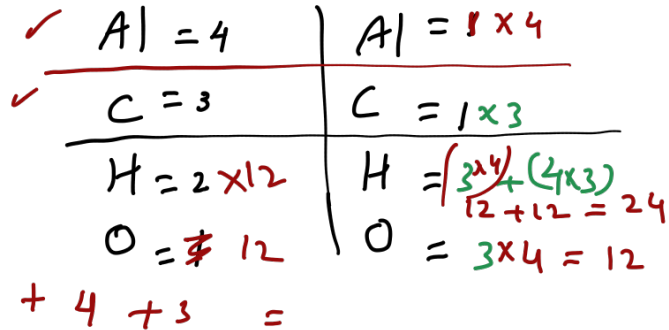


A. 13

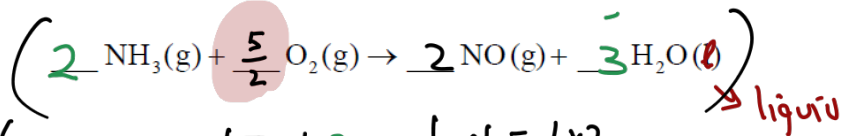
B. 14

C. 19

D. 20



What is the whole number ratio of the coefficients of ammonia to oxygen when the following equation is balanced correctly?

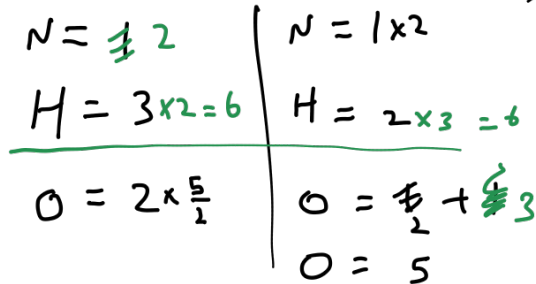


A. 1 : 2

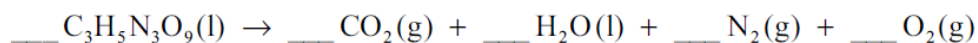
B. 2 : 1

C. 4 : 5

D. 5 : 4



Nitroglycerine, $\text{C}_3\text{H}_5\text{N}_3\text{O}_9$, can be used in the manufacture of explosives. What is the coefficient of $\text{C}_3\text{H}_5\text{N}_3\text{O}_9(\text{l})$ when the equation for its decomposition reaction is balanced using the lowest whole numbers?



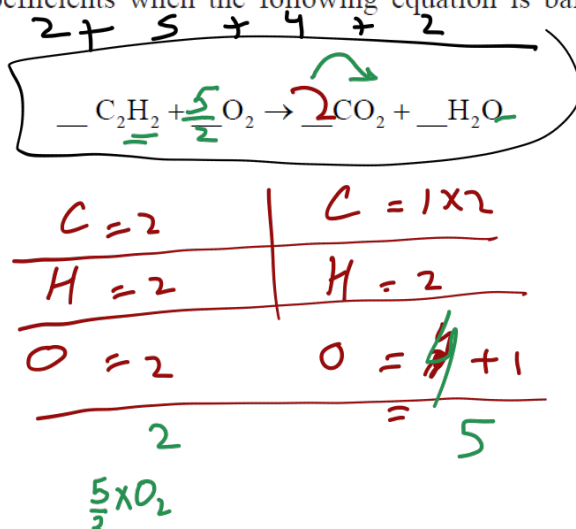
A. 2

B. 4

C. 20

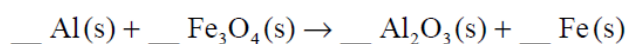
D. 33

What is the sum of all coefficients when the following equation is balanced using the smallest possible whole numbers?



- A. 5
B. 7
C. 11
D. 13

What is the coefficient of Fe_3O_4 when the following equation is balanced using the lowest whole numbers?

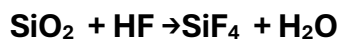


- A. 2
B. 3
C. 4
D. 5

A balanced chemical equation is a direct presentation of the _____.

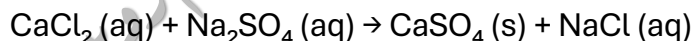
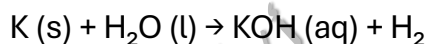
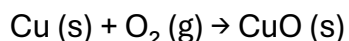
- A. law of conservation of momentum
B. law of multiple proportions
C. ideal gas law
D. law of conservation of mass

Balance the following equation. What is the **coefficient** for hydrogen fluoride?



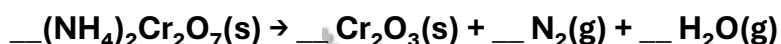
- A. 1
- B. 2
- C. 3
- D. 4

Write **word equations** for the following skeleton equations.

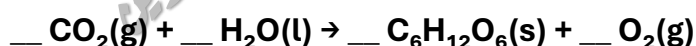


Balance the following equations. Enter 1 as a coefficient for reactants and products which have no coefficient.

Decomposition of ammonium dichromate



Photosynthesis reaction



✓ Aqueous phosphoric acid reacts with aqueous calcium hydroxide to form **solid calcium phosphate** and **water**.

Which of the following is the **correctly balanced chemical equation** for this reaction?

- A) $\text{H}_3\text{PO}_4(\text{aq}) + \text{Ca}(\text{OH})_2(\text{aq}) \rightarrow \text{Ca}_3(\text{PO}_4)_2(\text{s}) + \text{H}_2\text{O}(\text{aq})$
- B) $2\text{H}_3\text{PO}_4(\text{aq}) + 3\text{Ca}(\text{OH})_2(\text{aq}) \rightarrow \text{Ca}_3(\text{PO}_4)_2(\text{s}) + 6\text{H}_2\text{O}(\text{aq})$
- C) $3\text{H}_3\text{PO}_4(\text{aq}) + 2\text{Ca}(\text{OH})_2(\text{aq}) \rightarrow \text{Ca}_3(\text{PO}_4)_2(\text{s}) + 3\text{H}_2\text{O}(\text{aq})$
- D) $\text{H}_3\text{PO}_4(\text{aq}) + 3\text{Ca}(\text{OH})_2(\text{aq}) \rightarrow \text{Ca}_3(\text{PO}_4)_2(\text{s}) + 6\text{H}_2\text{O}(\text{aq})$

Aqueous sulfuric acid reacts with aqueous sodium hydroxide to form aqueous sodium sulfate and water.

✓ Which of the following is the **correctly balanced chemical equation**?

- A) $\text{H}_2\text{SO}_4(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- B) $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- C) $2\text{H}_2\text{SO}_4(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- D) $\text{H}_2\text{SO}_4(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow 2\text{Na}_2\text{SO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l})$

✓ Aqueous nitric acid reacts with aqueous magnesium hydroxide to form aqueous magnesium nitrate and water.

Which equation is **balanced correctly**?

- A) $\text{HNO}_3(\text{aq}) + \text{Mg}(\text{OH})_2(\text{aq}) \rightarrow \text{Mg}(\text{NO}_3)_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- B) $2\text{HNO}_3(\text{aq}) + \text{Mg}(\text{OH})_2(\text{aq}) \rightarrow \text{Mg}(\text{NO}_3)_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- C) $\text{HNO}_3(\text{aq}) + 2\text{Mg}(\text{OH})_2(\text{aq}) \rightarrow \text{Mg}(\text{NO}_3)_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- D) $2\text{HNO}_3(\text{aq}) + 2\text{Mg}(\text{OH})_2(\text{aq}) \rightarrow \text{Mg}(\text{NO}_3)_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$

✓ Aqueous hydrochloric acid reacts with aqueous aluminum hydroxide to form aqueous aluminum chloride and water.

Which of the following equations is **balanced**?

