Balancing Chemical Equations

SNC2D_06 - 07

Text Book Reference: Chapter 6, Section 6.5 pages 218 – 221, 226 — 229

Chemical equations of a reaction illustrate what is made (**product**) when certain ingredients (**reactants**) are combined.

Reactants $\longrightarrow$ **Products**

Reactants are the starting materials in a chemical reaction.

Products are the substances formed in a chemical reaction.

Like a cooking recipe, where a certain amount of ingredients are required to produce a set amount of food, chemical reactions require a certain amount of reactants to get desired quantity of product.

Useful symbols used in writing equations:

+	Used to separate reactants from products
$\longrightarrow$	yields or "to produce"
$\rightleftharpoons$	A reversible reaction
(s), (l), (g)	Indicates state of matter or phases
(aq)	Indicates solution in water, the solvent is water
(g)	Indicates a gas is released in a reaction
Δ	Indicates heat supplied or released, exothermic, or an endothermic reaction
$\xrightarrow{Pt,\ MnO_2}$	Material over an arrow means a catalyst
↓	Indicates a precipitate is formed

A **word equation** is one way of representing a chemical reaction. It tells one what reacts and what is produced.

A word equation:

- is an efficient way to describe chemical changes
- helps chemists to recognize patterns
- helps predict products of a chemical reaction.

Complete the following word equations:

1. Hydrogen$_{(g)}$ + oxygen$_{(g)}$ $\longrightarrow$
2. Aluminium $_{(s)}$ + $\longrightarrow$ aluminium oxide$_{(s)}$
3. Silver nitrate$_{(aq)}$ + copper$_{(s)}$ $\longrightarrow$
4. Zinc sulphate$_{(aq)}$ + Iron$_{(s)}$ $\longrightarrow$
5. methane$_{(g)}$ + Oxygen$_{(g)}$ $\longrightarrow$

Equations must obey the following Laws:

Law of Conservation of Matter:

Law of Conservation of energy:

The relationship of reactants to product is shown through a chemical equation.

To be useful, the chemical equations must account for each atom used to make a product.
Therefore a balanced chemical equation has an equal number of specific atoms on both sides of the equation:

	Hydrogen gas	+	Oxygen gas	⟶	Water
E.g.	H_2	+	O_2	⟶	H_2O
	2 (H)		2 (O)		[2 H+ 1(O)]

In this reaction, for the formation of water from its elements to be balanced, the number of hydrogen and oxygen atoms on the reactants side must equal the number of hydrogen and oxygen atoms on the product side. $H_2 + O_2 \longrightarrow H_2O$

In the equation, there is one more 1 more O- atom on the reactants side than the products side.

To make the number of atoms equal, a ½ is put in front of the O_2 to get the balanced equation.

$$H_2 + ½\ O_2 \longrightarrow H_2O$$

The ½ in front of O_2 is a coefficient which shows how many units of O_2 are required in the reaction.

Note: It is also possible to put 2 in front of H_2 and H_2O instead of a ½ in front of O_2 to achieve the balanced equation.

$$2H_2 + O_2 \longrightarrow 2\ H_2O$$

Rules for Balancing Equations

Balancing equations is a bit of an art but there are a few guidelines that can help.

1. Write the equation with the reactant units on the left and the product units on the right.

   E.g. $Zn_{(s)} + HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$

2. Balance the atoms that only occur in one molecule on each side by choosing your appropriate coefficient.

3. Balance atoms, one kind at a time, don't jump all over the place.

4. Balance atoms which are in their elemental form last (O_2, H_2, Cu, P_4, etc.)

   E.g. $Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$

5. **Never** change the formula of the reactants and the products just to balance an equation.

NO! $Zn_{(s)} + HCl_{(aq)} \longrightarrow \mathbf{ZnCl}_{(aq)} + H_{2(g)}$ **NO!**

6. Always check to make sure that the number of every kind of atom is the same on both sides of the equation.

Remember:

★ You **cannot change** the **formula** of any substance in the equation.
★ The only way to balance an equation is to place numbers, called **coefficients in front** of the **whole formula**.
★ The coefficients for elements and compounds must be **whole numbers**.
★ If a radical, i.e. a polyatomic ion appears on both sides of the equation then treat the entire radical as one complete unit, i.e. a package.

Example: Now you try to balance the following equation:

$Fe_{(s)} + H_2O_{(l)} \longrightarrow Fe_2O_{3(s)} + H_{2(g)}$

Check atom	Left side	Right side
Fe		
H		
O		

Thus, a balanced chemical equation must represent the facts.

Factors that must be considered in writing a balanced chemical equation:

1. The equation must represent the facts, i.e. the reactants and the products.
2. The equation must include the symbols and formulas of all the elements and compounds that are used as reactants and formed as products.
3. Law of Conservation of Mass and Energy must be satisfied.

Some Chemistry Vocabulary

oxidizes:	reacts with oxygen
combusts:	reacts with oxygen
burns:	reacts with oxygen
rusts:	iron reacts with oxygen to form iron (III) oxide, Fe_2O_3

Recall some important formulas learnt previously:

Diatomic gases are: I_2 H_2 N_2 Br_2 O_2 Cl_2 F_2

glucose:	$C_6H_{12}O_6$
ammonia:	$NH_{3(g)}$
ammonium:	NH_4^{+1} (a cation, compare to a metal cation, .: written first in the formula)
methane:	CH_4
propane:	C_3H_8
butane:	C_4H_{10}
octane:	C_8H_{18}

Practice Exercises: Balance the following equations :

Remember the following rules:

★ balance the metals first

★ balance the polyatomic ions second

★ next balance the nonmetals except oxygen and hydrogen

★ balance the oxygen and hydrogen last!

1. ___$H_{2(g)}$ + ____$Br_{2(g)}$ ⟶ ___ $HBr_{(g)}$
2. ___$Na_{(s)}$ + ____$Cl_{2(g)}$ ⟶ ___ $NaCl_{(s)}$
3. ___$Na_{(s)}$ + ____$O_{2(g)}$ ⟶ ____$Na_2O_{(s)}$
4. ___$Fe_{(s)}$ + ____$O_{2(g)}$ ⟶ ____Fe_2O_3
5. ___Al + ____Cl_2 ⟶ ___$AlCl_3$
6. ___ $KClO_3$ ⟶ ___KCl + ___O_2

7. ___CH_4 + ___ O_2 ⟶ ___CO_2 + ___H_2O

8. ____NH_3 + ___Cl_2 ⟶ ____NH_4Cl + ___N_2

9. ____C_6H_6 + ___ O_2 ⟶ ___CO_2 + ___ H_2O

10. ___Mg + ___HCl ⟶ ____$MgCl_2$ + ___H_2

11. ___Al + ___O_2 ⟶ ____Al_2O_3

12. ___Zn + ___O_2 ⟶ ____ZnO

13. ___Fe + ___Cl_2 ⟶ ____$FeCl_3$

14. ___Al + ___$CuCl_2$ ⟶ ____$AlCl_3$ + ____Cu

15. ___N_2 + ___H_2 ⟶ ____NH_3

16. ___H_2 + ___F_2 ⟶ ____HF

17. ___Al + ___Br_2 ⟶ ____$AlBr_3$

18. ___Mg + ___N_2 ⟶ ____Mg_3N_2

For each of the following, write the correct formulae for the word equations given below, and then balance them:

1. Magnesium + oxygen gas ⟶ magnesium oxide

2. Iron + oxygen gas ⟶ iron (III) oxide

3. Nitrogen gas + hydrogen gas ⟶ ammonia

4. Methane + oxygen ⟶ carbon dioxide + water

5. Copper (II) oxide + hydrogen gas ⟶ copper + water

6. Hydrogen sulphide ⟶ hydrogen gas + sulphur

7. Lead (II) sulphide + oxygen gas ⟶ lead + sulphur dioxide

8. Sodium + water ⟶ sodium hydroxide + hydrogen gas

9. Aluminium + iodine gas ⟶ aluminium iodide

10. Carbon monoxide + oxygen gas ⟶ carbon dioxide

11. Magnesium + nitrogen gas ⟶ magnesium nitride

12. Aluminium oxide ⟶ aluminium + oxygen gas

13. Lithium + sulphur ⟶ lithium sulphide

14. Glucose + oxygen gas ⟶ carbon dioxide + water

15. Octane + oxygen gas ⟶ carbon dioxide + water

Writing and Balancing Chemical Equations

In each case, write the chemical equation and balance it.

1. Potassium reacts with water to form hydrogen gas and potassium hydroxide.
2. Copper(II) oxide reacts with ammonia to form water, nitrogen gas, and copper metal.
3. Aluminium reacts with hydrochloric acid to form aluminium chloride and hydrogen gas.
4. Zinc sulphide reacts with oxygen gas to form zinc oxide and sulphur dioxide.
5. Barium chloride reacts with magnesium sulphate to produce barium sulphate and magnesium chloride.
6. Potassium iodide reacts with lead (II) nitrate to form lead (II) iodide and potassium nitrate.
7. Sodium carbonate reacts with calcium nitrate to form sodium nitrate and calcium carbonate.
8. Sulphuric acid reacts with barium chloride to form barium sulphate and hydrochloric acid.
9. Iron (II) nitrate reacts with sodium hydroxide to form iron (III) hydroxide and sodium nitrate.
10. Sodium bicarbonate reacts with hydrochloric acid to form sodium chloride, water and carbon dioxide gas.