Chemical Reactions and Equations - Balancing of Chemical Equations

Contents

1. Law of Conservation of Mass

(a) Total mass of the elements present in the products of a chemical reaction must be equal to the total mass of the elements present in the reactants

i.e.

The number of atoms of each element remains the same, before and after a chemical reaction

2. Identifying the Number of Atoms of Each Element

(a) Subscript: Indicates the number of atoms of the element immediately before it

(b) Coefficient: Indicates the number of molecules of the substance immediately following it

Na	1 Sodium atom
H_2	2 Hydrogen atoms
$2H_2$	4 Hydrogen atoms
H_2O	2 Hydrogen atoms and 1 Oxygen atom
$2H_2O$	4 Hydrogen atoms and 2 Oxygen atom
$Pb(NO_3)_2$	1 Lead atom, 2 Nitrogen atoms and 6 Oxygen atoms
$2Pb(NO_3)_2$	2 Lead atom, 4 Nitrogen atoms and 12 Oxygen atoms

3. Methods of Balancing of Chemical Equations

Points to Remember

(i) Do NOT change subscripts while balancing an equation

Equation 1:

Skeletal equation: $H_2 + O_2 \rightarrow H_2O$

Step 1: Write down each element and check the number of atoms on reactant and product sides.

Element	Reactant side	Product side
H	2	2
O	2	1

Step 2: Balance O atom on product side by changing the coefficient of H_2O to 2.

$$H_2 + O_2 \rightarrow 2H_2O$$

Element	Reactant side	Product side
H	2	2 x2
O	2	1 x 2

Due to change in the coefficient of H_2O to 2, the number of Hydrogen atoms has changed to 2 on the product side.

Step 3: To balance Hydrogen atom on reactant side, change coefficient of H_2 to 2.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Element	Reactant side	Product side
H	2 x 2	2 x 2
O	2	1 x 2

The equation is thus balanced and represented as follows:

Balanced equation: $2H_2 + O_2 \rightarrow 2H_2O$

Points to Remember

ii) Start with the most complex substance

(iii) First balance elements which appear only once on either side of the equation

(iv) Balance H and O at the end.

Equation 2:

Skeletal equation: $Na_2CO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

Step 1: Write down each element and check the number of atoms on reactant and product sides.

Element	Reactant side	Product side
Na	2	1
C	1	1
O	3	3
H	1	2
Cl	1	1

Step 2: Na_2CO_3 is the most complex compound in the equation. Start by balancing Na atom on the product side (since it only appears once on both sides of the equation) by changing the coefficient of NaCl to 2.

$$Na_2CO_3 + HCl \rightarrow 2NaCl + H_2O + CO_2$$

Element	Reactant side	Product side
Na	2	1 x 2
C	1	1
O	3	3
H	1	2
Cl	1	1 x 2

Due to change in the coefficient of NaCl to 2, the number of Chlorine atoms has changed to 2 on the product side.

Step 3: Balance Cl atom on product side by changing the coefficient of HCl to 2.

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Element	Reactant side	Product side
Na	2	1 x 2
C	1	1
O	3	3
H	1 x 2	2
Cl	1 x 2	1 x 2

Due to change in the coefficient of HCl to 2, the number of Hydrogen atoms has changed to 2 on the reactant side.

Step 4: Hydrogen and Oxygen are already balanced.

Balanced equation: $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Points to Remember

(v) While balancing H and O, first balance in places where they are in combined form

Equation 3:

Skeletal equation: $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O +$ energy

Step 1: Write down each element and check the number of atoms on reactant and product sides.

Element	Reactant side	Product side
C	6	1
H	12	2
O	8	3

Step 2: Start by balancing C atom on product side by changing the coefficient of CO_2 to 6.

$$C_6H_{12}O_6 + O_2 \rightarrow 6CO_2 + H_2O$$

Element	Reactant side	Product side
C	6	1 x 6
H	12	2
O	8	13

Due to change in the coefficient CO_2 to 6, the number of Oxygen atoms has changed to 13 on the reactant side.

Step 3: Since Hydrogen atoms are in combined form throughout the equation, let's first balance Hydrogen by changing the coefficient of H_2O to 6 on product side.

$$C_6H_{12}O_6 + O_2 \rightarrow 6CO_2 + 6H_2O$$

Element	Reactant side	Product side
C	6	1 x 6
H	12	2 x 6
O	8	18

Due to change in the coefficient H_2O to 6, the number of Oxygen atoms has changed to 18 on the reactant side.

Step 4: Balance oxygen atoms by changing the coefficient of O_2 to 6 on reactant side.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

Element	Reactant side	Product side
C	6	1 x 6
H	12	2 x 6
O	18	18

Balanced equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Points to Remember

(vi) Balance least complex substance at the end, using fractional coefficients if necessary

Equation 4:

Skeletal equation: $Al + O_2 \rightarrow Al_2O_3$

Step 1: Write down each element and check the number of atoms on reactant and product sides.

Element	Reactant side	Product side
Al	1	2
O	2	3

Step 2: Start by balancing Aluminum atoms by changing the coefficient of Al to 2 on reactant side.

$$2Al + O_2 \rightarrow Al_2O_3$$

Element	Reactant side	Product side
Al	1 x 2	2
O	2	3

Step 3: To balance Oxygen, multiply O_2 on reactant side by fractional coefficient 3/2 (where 3 is the desirable number which brings about balance and 2 correspond to the subscript of the molecule/atom we're balancing)

$$2Al + 3/2\ O_2 \rightarrow Al_2O_3$$

Element	Reactant side	Product side
Al	1 x 2	2
O	2	3

Step 4: Since fractional form of coefficient is not allowed, multiply the whole equation with the denominator to bring it to whole number format.

$$(2Al + 3/2\ O_2 \rightarrow Al_2O_3) \times 2 = 4Al + 3\ O_2 \rightarrow 2Al_2O_3$$

Element	Reactant side	Product side
Al	4	4
O	6	6

Balanced equation: $4Al + 3\ O_2 \rightarrow 2Al_2O3$

Equation 5:

Skeletal equation: $C_2H_6 + O_2 \rightarrow H_2O + CO_2$

Step 1: Write down each element and check the number of atoms on reactant and product sides.

Element	Reactant side	Product side
C	2	1
H	6	2
O	2	3

Step 2: Start with the compound C_2H_6. Balance C atoms first by changing the coefficient of CO_2 to 2 on the product side.

$$C_2H_6 + O_2 \rightarrow H_2O + 2CO_2$$

Element	Reactant side	Product side
C	2	1 x 2
H	6	2
O	2	5

Due to change in the coefficient CO_2 to 2, the number of Oxygen atoms has changed to 5 on the reactant side.

Step 3: Now balance H atoms as it is in combined form. This can be done by changing the coefficient of H_2O to 3 on the product side.

$$C_2H_6 + O_2 \rightarrow 3H_2O + 2CO_2$$

Element	Reactant side	Product side
C	2	1 x 2
H	6	2 x 3
O	2	7

Due to change in the coefficient H_2O to 3, the number of Oxygen atoms has changed to 7 on the reactant side.

Step 4: Now balance Oxygen atoms using fractional coefficient method (by changing the coefficient of O2 to 7/2 on reactant side).

$$C_2H_6 + 7/2\ O_2 \rightarrow 3H_2O + 2CO_2$$

Step 5: Now to remove the fractional form of coefficient, multiply the complete equation by 2.

$$(C_2H_6 + 7/2\ O_2 \rightarrow 3H_2O + 2CO_2) \times 2$$

$$=$$

$$2C_2H_6 + 7\ O_2 \rightarrow 6H_2O + 4CO_2$$

Element	Reactant side	Product side
C	4	4
H	12	12
O	14	14

Balanced equation: $2C_2H_6 + 7\ O_2 \rightarrow 6H_2O + 4CO_2$

Equation 6:

Skeletal equation: $KClO_3 \rightarrow KCl + O_2$

Step 1: Write down each element and check the number of atoms on reactant and product sides.

Element	Reactant side	Product side
K	1	1
Cl	1	1
O	3	2

Step 2: Since the atoms of Potassium and Chlorine are already balanced, start with balancing Oxygen atoms. Using fractional coefficient method (by changing the coefficient of O_2 to 3/2 on the products)

$$KClO_3 \rightarrow KCl + 3/2\ O_2$$

Step 3: Now to remove the fractional form of coefficient, multiply the complete equation by 2.

$$(KClO_3 \rightarrow KCl + 3/2\ O_2) \times 2 = 2KClO_3 \rightarrow 2KCl + 3\ O_2$$

Element	Reactant side	Product side
K	2	2
Cl	2	2
O	6	6

Balanced equation: $2KClO_3 \rightarrow 2KCl + 3\ O_2$

Points to Remember

(vii) Polyatomic ions can be considered as one unit

Equation 7:

Skeletal equation: $BaCl_2 + Al_2(SO_4)_3 \rightarrow BaSO_4 + AlCl_3$

Step 1: Write down each element and check the number of atoms on reactant and product sides.

Element	Reactant side	Product side
Ba	1	1
Cl	2	3
Al	2	1
SO_4	3	1

Step 2: Start with the most complex compund $Al_2(SO_4)_3$. Balance the Aluminum atom by changing the coefficient of $AlCl_3$ to 2.

$$BaCl_2 + Al_2(SO_4)_3 \rightarrow BaSO_4 + 2AlCl_3$$

Element	Reactant side	Product side
Ba	1	1
Cl	2	6
Al	2	1 x 2
SO_4	3	1

Due to change in the coefficient $AlCl_3$ to 2, the number of Chlorine atoms has changed to 6 on the reactant side.

Step 3: Balance SO_4 as a single unit. This is done by changing the coefficient of $BaSO_4$ to 3.

$$BaCl_2 + Al_2(SO_4)_3 \rightarrow 3BaSO_4 + 2AlCl_3$$

Element	Reactant side	Product side
Ba	1	3

Cl	2	6
Al	2	1 x 2
SO_4	3	1 x 3

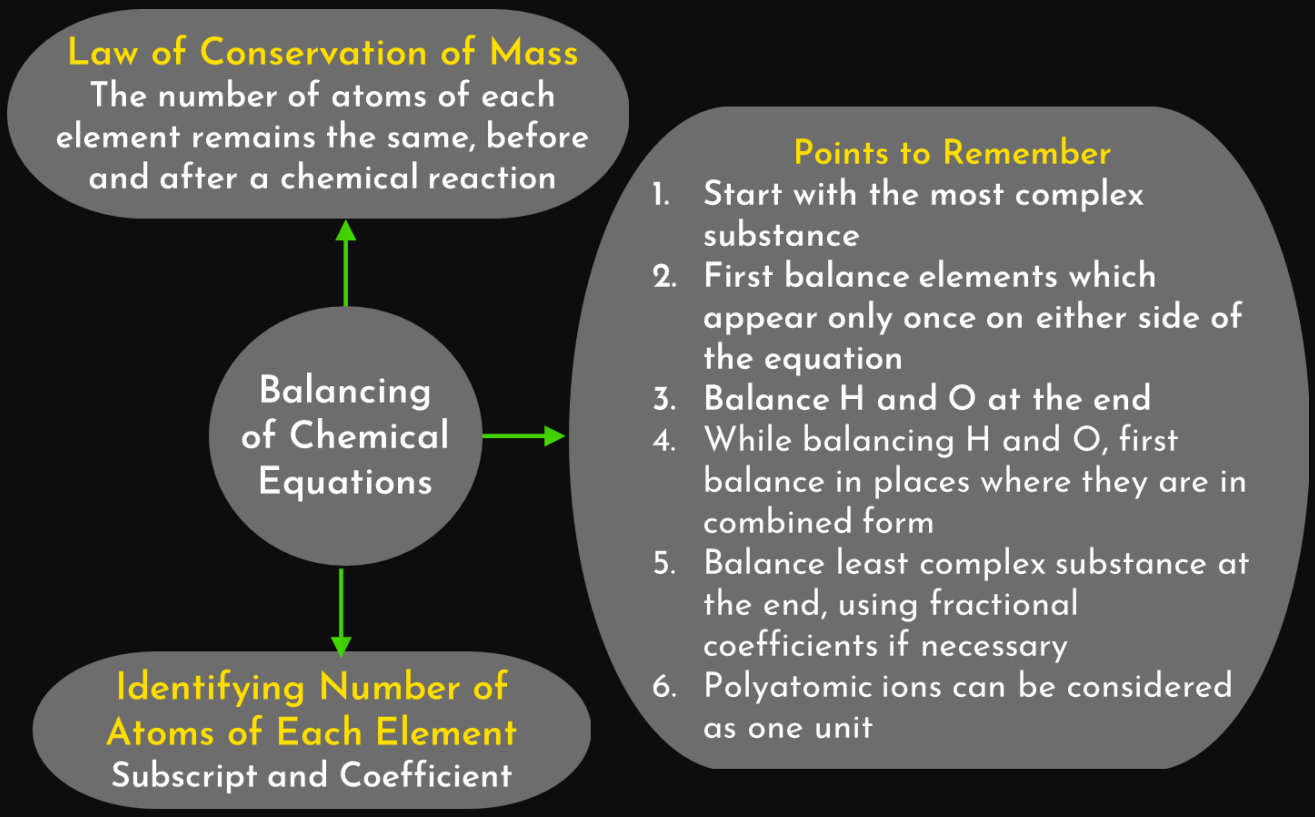
Due to change in the coefficient of $BaSO_4$ to 3, the number of Barium atoms has changed to 3 on the product side.

Step 4: Balance Barium by changing the coefficient of $BaCl_2$ to 3.

$$3BaCl_2 + Al_2(SO_4)_3 \rightarrow 3BaSO_4 + 2AlCl_3$$

Element	Reactant side	Product side
Ba	1 x 3	3
Cl	6	6
Al	2	1 x 2
SO_4	3	1 x 3

Balanced Equation: $3BaCl_2 + Al_2(SO_4)_3 \rightarrow 3BaSO_4 + 2AlCl_3$


Law of Conservation of Mass
The number of atoms of each element remains the same, before and after a chemical reaction
Balancing of Chemical Equations
Identifying Number of Atoms of Each Element
Subscript and Coefficient
Points to Remember
1. Start with the most complex substance
2. First balance elements which appear only once on either side of the equation
3. Balance H and O at the end
4. While balancing H and O, first balance in places where they are in combined form
5. Balance least complex substance at the end, using fractional coefficients if necessary
6. Polyatomic ions can be considered as one unit