Chemistry 1st. Secondary

Chemistry Lovers

By:Mr.Mohamed Taha

Unit (1): Chemical equation & chemical calculation

1- Calculation of the chemical formulas

Chemistry: It is the branch of science that deals with the composition & structure of matter and the changes that matter undergoes.

Matter could be:

1) Element 2) Compound 3) Mixture

Element: is a pure substance that contains only one type of atoms.
Elements are expressed chemically by simple symbols like:

Element	Symbol	Atomic no.	Electronic configuration	Valence	Kind
Hydrogen	H	1	1	1^+	Non metal
Sodium	Na	11	2,8,1	1^+	Metal
Chlorine	Cl	17	2,8,7	1^-	Non metal
Argon	Ar	18	2,8,8	Zero	Inert gas
Silicon	Si	14	2,8,4	4	Metalloid
Sulfur	S	16	2,8,6	2^-	Non metal
Calcium	Ca	20	2,8,8,2	2^+	Metal

Molecules of elements could be:

Monatomic			Diatomic
All metals like: Fe – Al – Na Ca – Cu - Ag	Solid non metals like: C – S – P	Inert gases like: He – Ne – Ar Kr – Xe – Rn	Liquid and gaseous non metals like: H_2 – N_2 – O_2 – Cl_2 – F_2 – Br_2 – I_2

Compound:
It is formed by the chemical combination of atoms or ions of two or more elements in a certain weight ratio.

Compounds are expressed chemically by formulas like:
1- Molecular formula **2- Empirical formula**

1- **Chemical (molecular) formula:** it is a simple symbolic formula that shows the number and the type of atoms or ions in the molecule of a compound.

Compound	Molecular formula	Compound	Molecular formula
Sodium hydroxide	Na OH	Magnesium oxide	Mg O
Copper carbonate	Cu CO_3	Barium sulphate	Ba SO_4
Sulfuric acid	H_2 SO_4	Ammonium chloride	NH_4 Cl

Important notes:

A) Atomic groups (Radicals) or (Polyatomic ions):

Monovalent	Divalent	Trivalent
Hydroxide $(OH)^{-1}$ Bicarbonate $(HCO_3)^{-1}$ Nitrite $(NO_2)^{-1}$ Nitrate $(NO_3)^{-1}$ Ammonium $(NH_4)^{+1}$	Carbonate $(CO_3)^{-2}$ Sulphate $(SO_4)^{-2}$ Sulphite $(SO_3)^{-2}$ Thiosulphate $(S_2O_3)^{-2}$	Phosphate $(PO_4)^{-3}$

B) **Mole:** it is the atomic mass of an element expressed in grams
Or it is the molecular mass of a compound expressed in grams

Example (1): The molecular formula of lead bromide is $PbBr_2$ therefore:
Each **1 mole of lead bromide** $PbBr_2$ contains **1 mole of lead ion** Pb^{++} and **2 moles of bromide ions** $2Br^-$

Example (2): The molecular formula of water is H_2O therefore:
Each **1 mole of H_2O** contains **2 moles of hydrogen atoms** and **1 mole of Oxygen atoms**

Example (3): How many moles in 53 gm. Sodium carbonate (Na2CO3) ?
(Na = 23 – C = 12 – O = 16)
Solution: 1 mole of (Na_2CO_3) = (23x2) + (12) + (16x3) = 106 gm.
1mole of Na_2CO_3 ⟶ 106 gm
? mole of Na_2CO_3 ⟶ 53 gm
No. of moles = 53x1/106 = 0. 5 moles

Note: **no. of moles = mass/molar mass**

Example (4): calculate the mass of 0.1 mole of water? (H=1 - O=16)
Solution: 1 mole of H_2O =2+16=18 gm
1mole of H_2O ⟶ 18 gm
0.1 mole of H_2O ⟶ ? gm
The mass of 0.1mole of H_2O = 0.1 x 18/1=1.8 gm,

2- **Empirical formula:** it is a simple symbolic formula that shows the simplest ratio (percentage composition) of atoms of a compound.

Examples:

Compound	**Molecular formula**	Empirical formula
Magnesium oxide	Mg O	Mg O
Glucose sugar	$C_6H_{12}O_6$	CH_2O
Sodium Chloride	Na Cl	Na Cl
Ethyl Alcohol	C_2H_5OH (C_2H_6O)	C_2H_6O

Note: The empirical formula is similar to the molecular formula in the ionic compounds.

Problems:

1- A magnesium ribbon is heated until complete combustion and a white ash of magnesium oxide is formed. If the mass of magnesium used = 0.24 gram, and the mass of magnesium oxide produced = 0.40 gm. Calculate the empirical formula of magnesium oxide (Mg = 24, O=16)

Solution: Magnesium + oxygen → magnesium oxide.
The mass of reacting oxygen = 0.40 - 0.24 = 0.16 gram.

	Mg	O
Masses	0.24	0.16
No. of moles	0.24/24 =0.1	0.16/16=0.1
Molar ratio	1	1

The empirical formula is: Mg O

2- Calculate the empirical formula of an unknown hydrocarbon compound If the masses of carbon and hydrogen are 0.12 and 0.02gram, then calculate the molecular formula if you know that the molecular mass of the compound is 56 gm.
(C = 12, H=1).

Solution:

	C	H
Masses	0.12	0.02
No. of moles	0.12/12 = 0.01	0.02/1 = 0.02
Molar ratio	1	2

The empirical formula is CH_2

Mass of the empirical formula = (12 x 1) + (2 x 1) = 14
Number of units of the empirical formula=56/14=4
the formula of the compound = 4 x CH_2 = C_4 H_8

Note: The molecular formula = empirical formula x no. of units of the empirical formula

3- If the molecular mass of a hydrocarbon compound is 70 gm and its empirical formula is CH_2. Find the molecular formula.

Solution:

The mass of the empirical formula = (12x1) + (1x2) =14
the number of units of the empirical formula =70/14=5.
The molecular formula is C_5H_{10}

2- The chemical equation

"It is a simple and concise description of the changes happened I the chemical reaction"

Chemical equation includes:
(Reactants – products – conditions of the reactions – physical state of both reactants and products)

Example: The reaction of hydrogen and nitrogen gases to produce ammonia gas.

Hydrogen + Nitrogen $\xrightarrow{heat-pressure}$ Ammonia,

$3\ H_{2\ (g)} + N_{2\ (g)} \xrightarrow{heat-pressure} 2\ NH_{3\ (g)}$

As shown in the above example the chemical equation must be balanced.

Balanced chemical equation:
"It is the equation at which the number of atoms in the both sides of the equation is equal."

Example: Write the balanced equation representing the reaction between aluminum and oxygen to form aluminum oxide.

Aluminum + oxygen gas → Aluminum oxide

$4Al_{(s)} + 3O_{2\ (g)} \rightarrow 2\ Al_2O_{3(s)}$

Note: the equation $H_{2\ (g)} + O_{2\ (g)} \rightarrow H_2O_{2\ (l)}$ is balanced wrongly because the produced compound is water and its formula is H_2O not H_2O_2.

Balance the following equation: $C_2H_4 + O_2 \rightarrow CO_2 + H_2O$

Solution:

R	:	P
C = **2**		C= 1 → (1 x 2) = **2**
H= **4**		H = 2→ (2 x 2)= **4**
O = 2 →(2x3)=**6**		O = 3→ 5→ **6**

Ionic equation:

"It is the equation that represents the chemical reaction taking place between ions in the aqueous solutions".

Examples of ionic equations:

1-Nuetralizatin reaction **2-precipitation reaction**

1-Nutralization reaction:
"It is the reaction between acid and base to form salt and water."

It is called neutralization reaction **because** the properties of both acid and base disappear after they react together.

Example: on adding aqueous solution of hydrochloric acid to aqueous solution of sodium hydroxide it produces water and sodium chloride. The balanced symbolic equation for this reaction is:

$$HC1_{(aq)} + Na\,OH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}.$$

The equation in the ionic form is:

$$H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)} + Na^+_{(aq)} + Cl^-_{(aq)}$$

The reacted ions are:

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

2-Precipitation reaction:

"It is the reaction of ions in the aqueous solution which gives insoluble substance"

Example: Addition of silver nitrate solution to sodium chloride solution, gives a white insoluble sliver chloride precipitate

$$Ag\,NO_{3\,(aq)} + Na\,Cl_{(aq)} \longrightarrow Ag\,Cl_{(s)} + Na\,NO_{3\,(aq)}.$$

$$Ag^+_{(aq)} + NO_3^-{}_{(aq)} + Na^+_{(aq)} + Cl^-_{(aq)} \longrightarrow Ag\,Cl_{(s)} + Na^+_{(aq)} + NO_3^-{}_{(aq)}$$

This ionic equation is :

$$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow Ag\,Cl_{(s)}$$

The equation is balanced because the atoms and charges are the same on both sides.

Since the sum of the charges on the left side equals to zero (+1 -l = 0) and the same for the charges on the right side where AgC1compound is neutral.

3- Chemical calculation

"It is the study of the quantitative relations in the chemical equation by the calculation of the amounts of both reactants and products"

Give reasons:

1-The balanced chemical equation represents the base of the true chemical calculation.
Because it expresses the true ratio of the atoms, ions or molecules which share in the chemical reaction

2-The mole is considered as the suitable unit which can be used in the chemical calculations.
Because it is difficult to deal with limited atoms, ions or molecules due to their small masses and volumes

Mole: it is the atomic or molecular mass of a substance expressed in grams

Number of moles = 1 mole of substance / molar mass

Avogadro's number:
(It is the number of atoms or ions or molecules which are existed in one mole of a substance
Avogadro's number = 6.02×10^{23})

Examples:

1- One mole of helium (He) = 6.02×10^{23} molecule (or atom) of helium
2- One mole of oxygen (O_2) = 6.02×10^{23} molecule of oxygen Or
$2 \times 6.02 \times 10^{23}$ oxygen atoms
3- One mole of sodium sulphide (Na_2S) = 6.02×10^{23} sodium sulphide molecules
= 6.02×10^{23} sulphide ions
= $2 \times 6.02 \times 10^{23}$ sodium ions

Problems:

1- How many moles are present in 90 gm of water?

Solution: 1 mole of water = (2 x 1) + 16 = 18 gm

No. of moles of water = mass of water / molar mass = 90/18 = 5 moles

2- How many moles of lead are present in 41.4 grams of lead? And how many atoms of lead are in this mass? (Pb = 207)

Solution: The mass of one mole of lead = 207 grams

mole: gm
1 : 207
? : 41.4

No. Of moles=41.4/207= 0.2 mole

Secondly:

mole: atoms
1 : 6.02×10^{23}
0.2 : ?

No.of atoms = $0.2 \times 6.02 \times 10^{23} = 1.204 \times 10^{23}$ atoms.

3- What is the mass of 3.01×10^{22} carbon atoms? (C = 12)

Solution:

mole	:	gm	:	atoms
1	:	12	:	6.02×10^{23}
?	:	?	:	3.01×10^{22}

No. of moles = $3.1 \times 10^{22} / 6.02 \times 10^{23} = 5 \times 10^{-2}$ moles

1 mole of carbon = 12 gm

The mass of 5×10^{-2} moles = $5 \times 10^{-2} \times 12 = 0.6$ gm

4- How many molecules are present in 32 grams of sulpher dioxide? (S =32, 0= 16)

Solution:

1 mole of sulpher dioxide (SO_2) = (32 x 1) + (16 x 2) =64 gm

Mole	:	gm	:	molecules
1	:	64	:	6.02×10^{23}
?	:	32	:	?

No. of moles = 32/64=0.5 mole

No.of molecules =$0.5 \times 6.02 \times 10^{23} = 3.01 \times 10^{23}$ molecules

Or: directly no. Of molecules = $32 \times 6.02 \times 10^{23} / 64 = 3.01 \times 10^{23}$

5- How many moles of H_2O are produced from the reaction of 10 moles of O_2 and excess of H_2, based on the following balanced equation:

$2H_{2\,(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$ Calculate the mass of water produced and the mass of hydrogen needed.

Solution: $2\ H_{2\,(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$

2mole : 1 mole : 2 moles

? : 10 moles : ?

No. of water moles = 2 x 10 /1 = 20 mole

The mass of 1 mole of H_2O = 16 + 2 x1 = 18 gm.

$2\ H_{2\,(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$

2x2gm : 2x16gm : 2 x 18gm

? : 10x32 : ?

The mass of H_2O = 36 x 320/32= 360 gm.

hydrogen moles = 20 mole → mass of H2 = 320 x 4/32=40gm

6- Calculate the mass of calcium oxide produced from the thermal dissociation of 50 grams of calcium carbonate according to the following equation:

$CaCO_{3\,(s)} \rightarrow CaO + CO_{2\,(g)}$ [Ca=40 ,C= 12,O=16]

Solution:

$CaCO_{3\,(s)} \rightarrow CaO_{(s)} + CO_{2\,(g)}$

1mole : 1mole : 1mole

40+12+(3x16)=100gm : 40+16 =56gm : 12+2 x 16

50 gm : ? : ?

Mass of CaO = 50x56/100=28gm