Al-Mustaqbal University College

Department of Medical Device Technologies

Medical Chemistry

First Stage

Lecture 2

Subject :

- Introduction to Analytical Chemistry

-Qualitative analysis Chemistry

-Quantitative analysis Chemistry

Analytical Chemistry

Introduction

Chemistry: The science deals with the study of matter, including its composition, structure, physical properties, and reactivity. It is divided into five fields:

1-Organic chemistry.

2-Inorganic chemistry.

3-Physical chemistry.

4-Biochemical chemistry.

5-Analytical chemistry.

Analytical chemistry

Is a measurement science consisting of a set of powerful ideas and methods that are useful in all fields of science, engineering, and medicine.

* Analytical chemistry concerned with determines the composition of substances. It comprises of two branches:

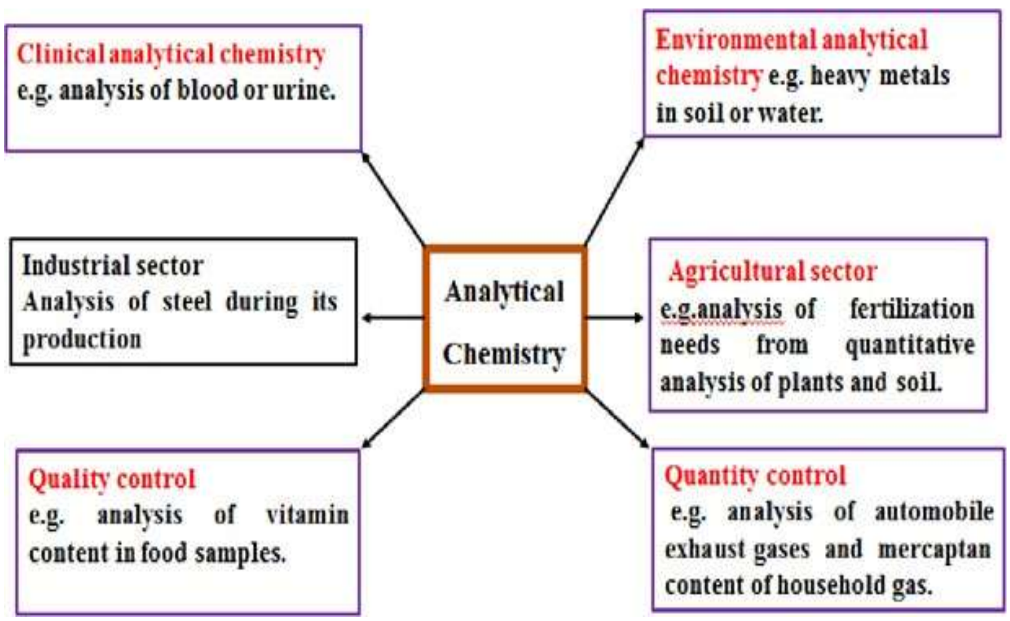
1- Qualitative analysis reveals the identity of the elements and compounds in a sample

2- Quantitative analysis indicates the amount of each substance in a sample.

Chemical Analytical Methods

- Gravimetric methods: Determine the mass of the analyte or some compound chemically related to it.
- Volumetric methods: Measure the volume of a solution containing sufficient reagent to react completely with the analyte.
- Electroanalytical methods: Measure electrical properties such as potential, current, resistance, and quantity of electrical charge.
- Spectroscopic methods: Explore the interaction between electromagnetic radiation and analyte atoms or molecules or the emission of radiation by analytes.

<u>What is role of analytical chemistry?</u>



Fundamental Concepts

1- Atomic weight of element:

The mass of a single atom in grams is much too small a number for convenience, and chemists therefore use a unit called an *atomic mass unit (amu)* also known as a*dalton (Da)*. One *amu* is defined as exactly 1/12 the mass of carbon isotope ^{12}C and equal to 1 .66054 $x10^{-24}$ g.

Example: prove that carbon weighing 1.0 $x10^{-3}$ g contains $5.01x10^{19}$ carbon atom?

Solution:

$$1\times10^{-3}\ g\times\frac{1\ amu}{1.66054\times10^{-24}g}\times\frac{1\ C\ atom}{12.011\ amu}=5.01\times10^{19}\ C\ atom$$

2- Molecular weight.

The sum of the atomic weights of all the atoms in amolecule.

Molecular weight = Summation of atomic weight

Example: Calculate the molecular weight of water.

Solution:

A water molecule, H_2O, has,

2 Hydrogen	2×1.0080 amu
1 Oxygen	1×15.9994 amu
Total molecular weight	$= 18.0154$ amu ≈ 18.02

Example: Calculate the molecular weight of methyl alcohol.

Solution:

The molecular formula is CH_3OH or CH_4O. Then:

1 carbon	1×12.011 amu = 12.011 amu
4 hydrogen	4×1.008 amu = 4.032 amu
1 oxygen	1×15.999 amu = 15.999 amu
Total molecular weight	= 32.04 amu

Home work.

Calculate the molecular weight of C_8H_{18}, $C_7H_{14}O_2$, $C_2H_5N_2SO_4$.

amu = 14.0067 for N_2
= 32.065 for S

3- Chemical equation.

- Representation of chemical reaction in terms of symbols and formula of reactants and products .

- Reactants written in left hand side.

- Products written in right hand side.

- numbers of atoms of different elements are the same on both sides of arrow is called equation. balanced chemical

$$A + B \xrightarrow{Direction\ of\ reaction} C + D$$

Classification of chemical reactions.

1) Combination reaction:

$$2Mg(S) + O_2(g) \rightarrow 2MgO(s)$$

2) Decomposition reaction:

$$2Pb(NO_3)_2\ (s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

3) Displacement reactions:

$$Zn(S) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

$$Cu\ (s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag\ (s)$$

4) Double Displacement reactions:

- **Precipitation reaction:**

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3$$

- **Neutralization reaction:**

$$NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl(aq) + H_2O$$

5) Redox reaction:

$ZnO + C \rightarrow Zn + CO$	ZnO reduce to Zn ------- Reduction O oxidize to CO -------- Oxidation

6) Exothermic reaction and Endothermic reaction:

- **Endothermic reaction**

$$CaCO_3 + Energy \rightarrow CaO + CO_2$$

- **Exothermic reaction:**

$$C + O_2 \rightarrow CO_2(g) + Energy$$

4-Mole (mol).

*** Is the number of Avogadro's number of atom, molecule, electron and proton (6.022×10^{23}).**

The numbers of moles of substance is calculated from.

$$no.\ of\ moles = \frac{mass\ of\ substance\ (g)}{molecular\ weight\ (\frac{g}{mol})}$$

$$Millimole\ (mmol) = 10^{-3}\ mol\ \ and\ 10^{3} mmol = 1\ mol$$

Example: Calculate the molar mass formaldehyde CH_2O.

Solution:

$$\mathcal{M}_{CH_2O} = \frac{1\ \text{mol C}}{\text{mol } CH_2O} \times \frac{12.0\ \text{g}}{\text{mol C}} + \frac{2\ \text{mol H}}{\text{mol } CH_2O} \times \frac{1.0\ \text{g}}{\text{mol H}} + \frac{1\ \text{mol O}}{\text{mol } CH_2O} \times \frac{16.0\ \text{g}}{\text{mol O}} = 30.0\ \text{g/mol } CH_2O$$

Example: Find the number of moles and millimoles of benzoic acid (**M** = 122.1 g/mol) that are contained in 2.00 g of the pure acid.

Solution:

If we use HB_z to represent benzoic acid, we can write that 1 mole of HB_z has a mass of 122.1 g. Therefore,

$$\text{amount HBz} = 2.00\ \text{g HBz} \times \frac{1\ \text{mol HBz}}{122.1\ \text{g HBz}} = 0.0164\ \text{mol HBz}$$

To obtain the number of millimoles, we divide by the millimolar mass (0.1221 g/mmol), that is,

$$\text{amount HBz} = 2.00\ \text{g HBz} \times \frac{1\ \text{mmol HBz}}{0.1221\ \text{g HBz}} = 16.4\ \text{mmol HBz}$$

$$\text{Or, no. of moles} = \frac{\text{mass of substance (g)}}{\text{molar mass }(\frac{g}{mol})}$$

$$\text{no. of moles} = \frac{2\ \text{g}}{122.1(\frac{g}{mol})} = 0.0164\ \text{mol}$$

$$= 0.0164\ \text{mol} \times \frac{10^3\ \text{mmol}}{1\ \text{mol}} = 16.4\ \text{mmol HBz}$$

6-Equivalent weight.

Is the molecular weight divided by the number of reacting units (no.of equivalent = valency).

$$\text{Equivalent Weight} = \frac{\text{molecular weight}}{\text{no. of equivalent}}$$

- **For acid: the number of reacting units is the no. ofhydrogen ions that will furnish.**

For example:

$HCl \leftrightarrow H^+ + Cl^-$ $\quad$ $eq.wt.HCl = \frac{M.wt.}{1}$

$H_2SO_4 \leftrightarrow 2H^+ + SO_4^{-2}$ $\quad$ $eq.wt.H_2SO_4 = \frac{M.wt.}{2}$

$CH_3COOH \leftrightarrow H^+ + CH_3COO^-$ $\quad$ $eq.wt.CH_3COOH = \frac{M.wt.}{1}$

For Phosphoric Acid (H_3PO_4) the equivalent weight depends on the reaction as shown below.

$H_3PO_4 \overset{M.O}{\Longleftrightarrow} H^+ + H_2PO_4^-$ $\quad$ $eq.wt. = \frac{M.wt.}{1}$

$H_3PO_4 \overset{Ph.ph}{\Longleftrightarrow} 2H^+ + HPO_4^{2-}$ $\quad$ $eq.wt. = \frac{M.wt.}{2}$

$H_3PO_4 \overset{CaCl_2}{\Longleftrightarrow} 3H^+ + PO_4^{3-}$ $\quad$ $eq.wt. = \frac{M.wt.}{3}$

- **For bases:** the number of reacting units is the no. of hydrogen ions that will react with it.

For example:

$KOH + H^+ \rightarrow K^+ + H_2O$ $\qquad eq.wt. = M.wt.$

$Ba(OH)_2 + 2H^+ \rightarrow Ba^{2+} + 2H_2O$ $\qquad eq.wt. = \frac{M.wt.}{2}$

$Fe_3O_3 + 6H^+ \rightarrow 2Fe^{3+} + 3H_3O$ $\qquad eq.wt. = \frac{M.wt.}{6}$

- **For salts:**

$$eq.wt. = \frac{M.wt.of\ salt}{no.of\ positive\ ion\ or\ no.of\ negative\ ion}$$

For example:

$Ag^+NO_3^- + H^+Cl^- \rightarrow Ag^+Cl^- + H^+NO_3^-$

$eq.wt.of\ Ag^+NO_3^- = \frac{M.wt.of\ Ag^+NO_3^-}{1}$

$eq.wt.of\ Ag_2{}^+NO_3^{-2} = \frac{M.wt.}{2}$

$eq.wt.of\ Al^{+3}PO_4^{-3} = \frac{M.wt.}{3}$

$eq.wt.of\ Ca_3^{+2}(PO_4)_2^{-3} = \frac{M.wt.}{6}$

- **For oxidation / reduction reactions:**

$$eq.wt.\,of\ reducing\ agent = \frac{M.wt.}{no.\,of\ electrons\ loosed\ for\ one\ molcule}$$

$$eq.wt.\,of\ oxidizing\ agent = \frac{M.wt.}{no.\,of\ electrons\ accepted\ for\ one\ molcule}$$

For example:

$Mn^{+7}O_4^- + H^+ + 5e \rightarrow Mn^{+2} + H_2O$ ………… *In acidic medium*

$$eq.wt.\,of\ Mn^{+7}O_4^- = \frac{M.wt.}{5}$$

$Mn^{+7}O_4^- + H_2O \rightarrow Mn^{+4}O_2^- + OH^-$ …………… *In basic medium*

$$eq.wt.\,of\ Mn^{+7}O_4^- = \frac{M.wt.}{3}$$

Home work:

Calculate the equivalent weights of the following substances as acids or bases: (a) HCl, (b) $Ba(OH)_2$, (c) $KH(IO_3)_2$, (d) H_2SO_3, (e) CH_3COOH.