

Lesson (1) Chemistry and measurement

1. **Science:** The systematic building which organizes knowledge in the form of facts, principles, concepts, scientific theories and an organized way of search.
2. **Chemistry:** The science that studies the structure and properties of matter, changes that occur to it, reaction of substances with each other and the suitable conditions for it.
 - Chemistry is one of the oldest physical sciences ancient civilizations had used in all fields of life (Medicine, pharmacy, glass industry, clothes dyeing...etc). Ancient Egyptians used it in Mummification process.

Fields of study in Chemistry

- 1- The study of the atomic and molecular structures of substances and how they bond.
- 2- The description of the chemical properties of substances.
- 3- The discovery of how substances perform their roles.
- 4- Chemical reactions by which reactants change into products.
- 5- The discovery of methods to control the conditions of the reaction; in order to create new products that serve medicine, pharmacy, industry and agriculture.
- 6- Solving some environmental problems (water pollution, soil pollution, air pollution, lack of water and energy resources...etc)

Chemistry is the central science

- ➔ Chemistry plays an important role in other sciences

Chemistry and Biology:-

Biology: The science that studies living organisms

- ➔ Chemistry helps in understanding the chemical reactions occurring within living organisms

Biochemistry: The science that studies the chemical structure of cells and the major substances forming living organisms

Chemistry and Physics

Physics: The science that studies nature, matter, energy and forces.

Chemistry helps in creating new accurate measurement methods.

- **Physical Chemistry:** The science that studies the structure of substances, their properties and the particles forming them.

Chemistry, Medicine and Pharmacy

Chemistry helps in the industry of medicines and understanding how hormones and enzymes work inside human body. Medicines are used to

treat any disorders in them. Chemists prepare these medicines using natural substances.

Chemistry and Agriculture

Chemistry helps in:-

Choosing suitable soil for planting certain crops by means of "chemical analysis" which determines the ratios of soil components to know if they can satisfy the plant's needs

Determination of suitable fertilizers for soil to increase its production.

The industry of insecticides and pesticides.

Chemistry and the future

Chemistry help us discover and create new useful extraordinary substances (**by means of nanotechnology**) in all fields of life (Medicine, Communications, Engineering...etc)

Branches of chemistry

- | | | |
|----------------------------|-------------------------|----------------------|
| 1- Physical chemistry | 2- Biochemistry | 3- Organic chemistry |
| 4- Thermodynamic chemistry | 5- Nuclear chemistry | 6- Electrochemistry |
| 7- Environmental chemistry | 8- Analytical chemistry | |

Measurement in chemistry

The nature of measurement

- The scientific and industrial development these days are due to the right and accurate use of measurement principles

Measurement: Comparing an unknown quantity to another one of the same kind to know the times of the second in the first

- Measurement process should have 3 main points:-

1- Numerical value: By which we describe the measured quantity

2- Suitable measuring unit: A magnitude of a certain physical quantity approved by a law and used as a standard to measure the actual magnitude of this physical quantity.

3- Certain error ratio: due to an error in the used device, its use conditions, or an error caused by the user.

The importance of measurement

1- Used to know the kind and concentration of the substances we use.

2- It is essential for protection and control.

3- The evaluation of situations and proposing solutions for expected errors.

Measurement system and its units

- Old measurement systems: the French system, then the English system, and finally the international system of measuring units (IS)(used till now)

Some measuring units:-

Some units were derived from these mentioned units such as:-

Symbol	Unit	Measured quantity
m	Meter	Length or distance
kg	Kilogram	Mass
s	Second	Time
K	Kelvin	Temperature
A	Ampere	Intensity of electric current
Mol.	Mole	Quantity of matter
Cd	Candela	Luminosity
Coul.	Coulomb	Quantity of electricity

Joule (J), $\text{kg.m}^2\text{S}^{-2}$: used for measuring the amount of heat, work and energy

Degree Celsius (°C) : used for measuring temperature (0 C = 273 Kelvin)

Measurement tools in chemical labs**Requirements of a chemical laboratory**

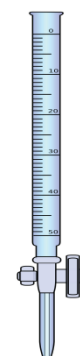
1. Suitable security precautions
2. Water and heat sources
3. Places for keeping chemical substances, tools and devices

Examples of some chemical tools**The sensitive balance:-**

- **Importance:** Measurement of the masses of substances
- **Most common types:** Digital balances
- **Most used types:** Top loading balances

**Burette**

- **Description:** A long glass ended by a valve to control the amount of solution taken from it. Burette is fixed perpendicular.
 1. Zero point of graduation is on the top of it
- **Importance:** used in experiments that require high accuracy, such as "**titration process**"

**Beakers**

- **Description:** Glass containers made of "**Pyrex Glass**" that exist with different volume capacities, some of them may be graduated.
- **Importance:** Holding and transporting liquids, preserving solutions during reactions and measuring their volumes.



Graduated cylinder

- **Description:** cylinder made of either glass or plastic, it exists with different volume capacities.
- **Importance:** Holding liquids, transporting solutions and measuring the volumes of solids and solutions



Flasks

- **Description:** One of the glass tools in chemical labs
- **Importance:** Preparing substances, preserving solutions and measuring their volumes (if the flask has graduation marks)

Types:-

- **Conical Flasks:** made of "**Pyrex glass**" and used in "**titration process**"
- **Round- bottom flasks:** usually made of "**Pyrex glass**" and used in "**distillation and preparation processes**"
- **Volumetric flask:** made of "**Pyrex glass**", on its top there's a mark determining its volume capacity, It is used in the preparation of solutions with certain concentrations accurately.



Pipette:-

- **Description:** A long glass tube with both ends open and a mark on its top determining its capacity.
- Measurement error ratio is written on its top, liquid sucks into it
- **Importance:** Transport of solutions and measurement of their volumes.
- **Power of Hydrogen (pH) measurement**
- **Definition:** pH is the measurement of the concentration of positive Hydrogen ions (H^+) in the solution to know if it's an acid, a base, or neutral.
- **Importance:** It plays an important role in chemical and biochemical reactions.



pH tools:

- We immerse a litmus paper in the solution we want to calculate its pH, so the colour of the paper changes. Then, we compare that colour to a calibrator (ranging from 0 to 14) in order to calculate its pH.
- **Digital device (pH meter):-**

- We immerse pH meter pole in the solution. Then the pH appears on the digital screen of the meter (pH ranges from 0 to 14)
- After calculating the pH of the solution by using either litmus papers or pH meters, we compare it to the numbers of the following table.

Lesson (2)

Nanotechnology and Chemistry

Nanotechnology is one of the greatest breakthroughs in life, it opened the door for more discoveries in all life and science fields (medicine, physics, agriculture, industry...etc) .

- Chemistry (the central science) is regarded as the mother of nanotechnology because it founded its principles.

The concept "Nanotechnology" consists of two words:-

- ✓ **Nano** : which is derived from the Greek words "Nanos" which means dwarf
- ✓ **Technology**: The practical usage of knowledge in a certain field.
- ✓ **Nanotechnology**: The technology of tiny objects, concerned with the manipulation of matter on a nanoscale to create new, special and useful products.
- ✓ Nanometer is a special measuring unit which equals one billionth meter 0.000000001 or 10^{-9} meter
 - m Millimeter equals 0.001 or 10^{-3}
 - Micro meter equal 0.000001 or 10^{-6} m
 - The diameter of a sand granule equals 10^6 nm
 - The diameter of water molecule equals 0.3 nm
 - The diameter of an atom ranges from 0.1 to 0.3 nm
- Scientists discovered that some properties of substances (colour, solidity, flexibility, melting point, speed of chemical reaction...etc) changes on **Nanoscale**. Such properties are known as "**Size-dependent properties**" because they change by the change of size.
- **Size-dependent properties**: properties that change by the change of matter size.

Nanoscale: The scale on which the nano properties of matter appears. It ranges from 1 to 100 nm.

The size-dependant properties of nanoparticles

Nano gold:-

- ✓ Gold is known for its shiny yellow color, but when its size shrinks, its colour changes. Scientists discovered that nanogold has many colours (such as green,



orange and red) which differ according to the nanosize of gold particles.

Nanogold particles are used in the treatment of cancer

Nano copper:-

- The solidity of copper molecules increases when they begin shrinking from **macro scale** to **nanoscale**.
- Nanoparticles have extraordinary size-dependant properties due to the increase of the ratio between their surface areas and volumes and the no. of atoms.
- **When the size of a substance shrinks, the ration between surface area and volume increases (S.A increases, while volume decreases)**

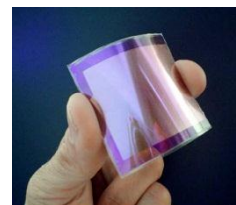
Nanochemistry

- Nanochemistry is one of nano sciences which deals with the chemical applications of nanomaterials. It's concerned with the description, study and creation of substances on nanoscale. It's also concerned with the unique properties of collecting atoms and molecules on nanoscale, too.
- Nanosubstances have a lots of different shapes (thin films, tubes, granules...etc), all of them range from 1 nm to 100nm, they're classified into:-

One-dimensional nanomaterials such as:-

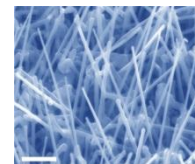
Thin films:

- 1- used for painting roofs to protect them from corrosion and rusting
- 2- used for packaging food products to protect them from pollution and damage



Nanowires:

- 1- used in the manufacture of electric circuits
- 2- used in the manufacture of nano fibers (which are used in water filters manufacture)

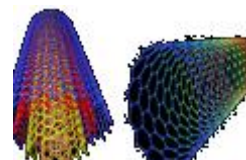


Two-dimensional nanomaterials

- **Carbon nanotubes:** single-walled or multi-walled tubes made of carbon molecules

Properties of carbon nanotubes:-

- 1- **They are good conductors of heat and electricity:** They conduct electricity better than copper and conduct heat better than diamond.
- 2- **They are stronger than steel due to the strong bonds between their molecules:** A nanotube of the size of a hair follicle can carry a whole train!!!



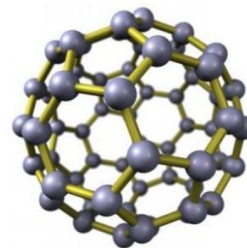
Which made the scientists think of using it in the manufacture of ropes in space-elevators

3- They can bond easily with proteins: because of this property, they can be used as biological sensors.

☞ **Three-dimensional Nanomaterials:-**

Nanoshells: used in the treatment of cancer

Buckyball: A ball made of 60 carbon atoms with the formula C₆₀, it has a lot of properties which depend on its structure



☞ **Importance:** Scientists are working on using it to carry medicines inside human body, as its hollow structure suits molecules of certain medicines, which prevent the occurrence of reactions with the medicines molecules and increases their efficiency .

Nanotechnology Applications

In Agriculture

- 1- Finding bacteria in food products.
- 2- Food preservation
- 3- Improving nutrients, insecticides and medicines for plants and animals with certain specifications

In medicine

- 1- Early diagnosis of diseases
- 2- Photographing organs and tissues
- 3- Transport of medicine right to the infected parts of the body; which improves its efficiency and decreases its side effects.
- 4- Creation of very tiny devices for dialysis (which are being transplanted inside the patient's body)
- 5- Creation of tiny robots which remove blood clots from the walls of arteries in human body

✓ **In the field of energy**

1. Production of solar batteries using nano silicon (**they are preferred to be used because they don't leak thermal energy and have higher ability to transform energy**)
2. Production of cheap hydrogen fuel cells with higher efficiency

1. In industry

- 1- Production of unseen nanoparticles which give glass and ceramic auto-cleaning property.
- 2- Production of nanomaterials which purify ultraviolet rays to improve anti-sun creams and cosmetics

3- Improving packaging technology using nanomaterials in the form of sprays and paintings, which form protective layers on electronic devices to protect them from scratches.

4- Production of stain-repellent clothes with auto-cleaning property

Communication:-

1- The manufacture of nano wireless devices, satellites and mobile phones.

2- Shrinking the size of transistors

3- The manufacture of electronic chips with high capacities.

Environment:-

- The manufacture of nano filters which work on:-

1- Purifying water and air

2- Water desalination

3- Solving the problem of nuclear wastes

4- Removing dangerous elements from industrial wastes

Adverse effects of nanotechnology

Health Effects:-

- Nanoparticles can penetrate the cells of lungs and skin in human, and the cells of plants and animals; which may cause health problems to them.

Environmental effects:-

- The dangerous tiny wastes resulted from nanotechnology can attach to air (due to their tiny sizes), which make them able to penetrate both plant and animal cells. They also affect climate, water, soil and air.

Social effects:-

- It may worsen the problems of social and economic inequality, and the unfair distribution of technology and wealth.

Nanopollution: The pollution resulted from the substances and wastes produced by nanotechnology

Word	Definition
Science	A systematic building that organizes knowledge in the form of facts, principles, concepts, scientific theories and an organized way of search
Chemistry	The science that studies the structure of matter, its properties, the changes that occur to it, the reaction of substances with each other and the suitable conditions for it
Biology	The science that studies living organisms
Biochemistry	The science that studies the chemical structure different living organisms.
Physics	The science that studies nature, matter, energy and forces
Physical chemistry	The science that studies the structure of substances, their properties and the particles forming them
Measurement	Comparing an unknown quantity to another one of the same kind to know its size, degree or amount
Measuring unit	magnitude of a physical quantity approved by a law and used as a standard to measure the actual magnitude of this physical quantity
Burette	A long glass tube with 2 openings used to add liquids in very accurate experiments (especially in titration process)
Beaker	A glass container made of Pyrex glass used to hold and transport liquids, and measuring their volumes
Glass cylinder	A cylinder made of either plastic or glass used to hold and transport solutions, and measuring the volumes of solutions and irregular solids.
Conical flask	A glass tool made of Pyrex glass used in titration process
Round-bottom flask	A glass tool made usually of Pyrex glass and used in distillation and preparation processes
Volumetric flask	A glass tool made of Pyrex glass and used to prepare solutions of certain concentrations accurately
Pipette	A long glass tool with both ends open used to transport liquids (especially dangerous ones) and measure their volumes
Power of	The measurement of the concentration of positive hydrogen

hydrogen (pH)	atoms in solutions to know if it's alkaline, acidic or neutral
pH meter	A digital device used for calculating the pH of solutions

Give reasons for

1- The importance of chemistry

- ✓ Because it studies the structure and properties of matter, changes that occur to it, reaction of substances with each other and the suitable conditions for it

2- Chemistry plays an important role in the physics

- ✓ Because it helps physicists discover new accurate measurement methods. Moreover, physical chemistry (one of chemistry branches) studies the properties and structures of substances, and the particles forming them.

3- Chemistry plays an important role in biology

- ✓ Because chemistry describes the chemical reactions occurring inside living organisms. Moreover, biochemistry (one of chemistry branches) studies the structure of different living organisms.

4- Chemistry plays an important role in the medicine and pharmacy

- ✓ Because chemistry finds out how enzymes and hormones work inside human body, it also helps us in the manufacture of medicines.

5- Chemistry plays an important role in agriculture

- ✓ Because it helps us choose suitable soil for certain crops, determine suitable fertilizers for them and helps us in the industry of pesticides

6- The rise of the idea of forming new measurement systems

- ✓ Due to the industrial development after the industrial revolution in Europe, which made the old traditional measuring units insufficient for measurement

7- The occurrence of errors during measuring process (measuring process is not 100% accurate)

- ✓ Due to errors in the used device, it use conditions, or error in human reading

8- The importance of measurement in chemistry

- ✓ Because it's essential for protection, it helps us know the kind and concentration of the substances we need, and it also helps us evaluate situations and finding solutions for expected errors

9- The development of science and industry these days

- ✓ Due to the right and accurate use of measurement principles

10- The importance of burettes in chemical laboratories

- ✓ Because they are used in experiments that require high accuracy (used for adding small amounts of solutions during titration process)

11- The importance of beakers in chemical laboratories

- ✓ Because they are used for holding and heating liquids, measuring their volumes and preparing chemical substances

12- The importance of glass cylinders

- ✓ Because they are used for holding liquids, transporting them and measuring the volumes of solids and liquids.

13- The importance of conical flasks

- ✓ Because they are used in titration process

14- The importance of round-bottom flasks

- ✓ Because they are used in distillation and preparation processes

15- The importance of volumetric flasks

- ✓ Because they are used for preparing solutions with certain concentrations accurately

16- The importance of pipettes

- ✓ Because they are used for transporting certain volumes of solutions and measuring their volumes

17- The importance of pH (Power of hydrogen) measurement (or meter) in chemical and biochemical reactions.

- ✓ Because it determines the concentration of positive hydrogen ions (H^+) in solutions, which helps us know if they are alkaline, acidic or neutral.

18- The importance of nanochemistry

- ✓ Because it deals with the chemical applications of nanotechnology and the unique properties of nanosubstances

19- The extraordinary properties of nanomaterials

- ✓ Due to the increase of the ratio between the surface area and volume and the no. of atoms on the surface.

20- size-dependant properties are called by this name

- ✓ Because such properties change by the change of the size of substance

21- The importance of thin films.

- ✓ Because they are used for plating roofs to protect them from corrosion and rusting, and packaging food industries to protect them from damage and pollution

22- The importance of nanowires

- ✓ Because they are used in the manufacture of electric circuits and nano fibers (which are used in water filters industry)

23- The importance of carbon nanotubes

- ✓ Because they are good conductors of heat and electricity, they can be used as biological sensors (due to their sensitivity to certain substances), and they also can be used in the manufacture of ropes in space-elevators (due to their solidity)

24- The importance of buckyballs

- ✓ Because they can be used for carrying medicine inside human body (which decreases side effects)

25- Nanotechnology plays an important role in medicine

- ✓ Because it helps us diagnose diseases early, photograph organs and tissues, transport medicine right to the infected parts of the body,

create tiny robots that remove blood clots from the arteries walls and transplant tiny devices to perform dialysis inside patients.

26- Nanotechnology plays an important role in agriculture

- ✓ Because it helps us find bacteria in food and improve insecticides and medicines for animals and plants, it also plays an important role in food preservation.

27- Nanotechnology improves energy resources

- ✓ Because we can use it in the manufacture of sun batteries using nano silicon (which are better at energy transformation and don't leak thermal energy), and hydrogen fuel cells with cheaper price and higher efficiency

28- Nanotechnology plays an important role in industry field

- ✓ Because it can be used in the creation of nanoparticles which give glass auto-cleaning ability, and the manufacture of nanomaterials which purify ultraviolet rays (which are used in anti – sun creams and cosmetics) and stain-repellant clothes that can auto-clean themselves. It's also used for forming protective layers on electronic devices

29- Nanotechnology plays an important role in communication field

- ✓ Because it is used for shrinking transistors sizes, used in the manufacture of nano wireless devices, satellites, mobile phones and electronic chips with high capacities.

30- Some nanotechnology applications serve the environment

- ✓ Because it can be used in the manufacture of nano filters which work on solving nuclear wastes problem, purifying air and water, and removing the dangerous elements from industrial wastes

31- Nanosubstances have adverse health effects

- ✓ Because their tiny sizes make them able to attach to air, so they can penetrate the cells of human, animals and plants.

32- Nanotechnology has adverse environmental effects

- ✓ Because the tiny wastes resulted from nanotechnology can attach to air and penetrate both animal and plant cells. It also affects climate, water, air and soil

33- Nanotechnology has negative social effects

- ✓ Because it may worsen the problems of unfair distribution of wealth and technology, social and economic inequality.