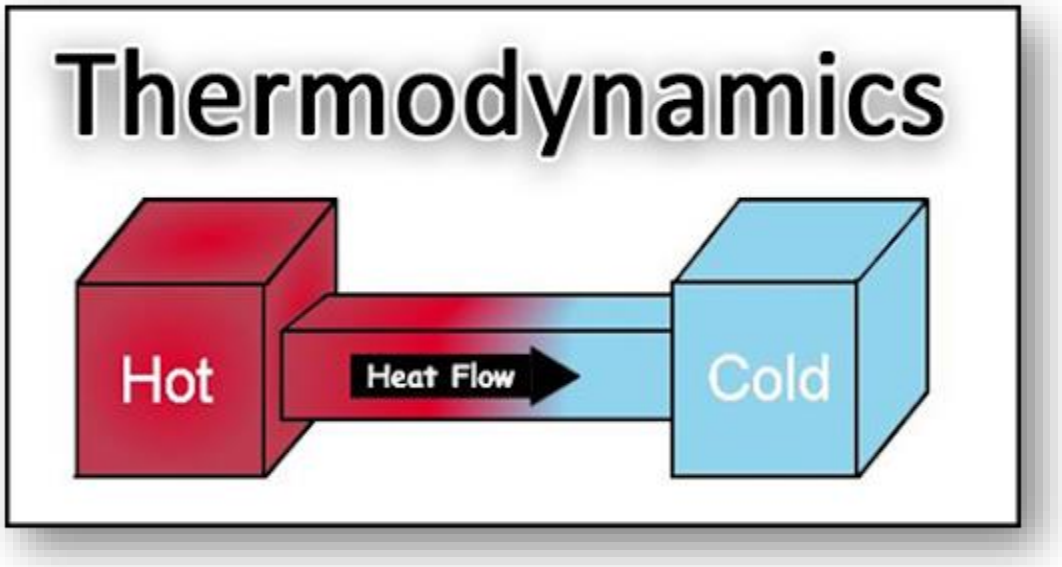
University of Mosul

College of Science

Department of New and Renewable Energies



Thermodynamics

Stage 2, Semester 1

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Syllabus:

-Introduction to physical chemistry

- Gases, their types and laws

- Behavior of real gases and its applications

- Using gas laws in storing biofuels and green hydrogen

- Principles of Thermodynamics

- Basic concepts of the first law of thermodynamics: work, heat, internal energy, and solving mathematical problems.

-First Law of Thermodynamics

- Application of the First Law to Renewable Energy Systems

- Second Law of Thermodynamics

- Carnot cycle, the relationship between entropy and the second law of thermodynamics.

- Apply the Carnot cycle to solar thermal power plants.

- The third law of thermodynamics

- Applications of the Third Law of Thermodynamics in Renewable Energy

- Gibbs' free energy as a measure of the spontaneity of chemical reactions.

- Relating Gibbs's free energy to fuel cells.

References

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Chapter 1

Introduction of Physical Chemistry

1.1 Definition of Physical Chemistry

Physical chemistry is an important branch of chemistry that studies the physical properties, composition of matter, and laws governing chemical reactions.

The aim of physical chemistry is to gather the experimental information we need to determine the properties of gases, liquids, and solids. It also provides us with theoretical foundations in the form of mathematical laws.

Physical chemistry can also be defined as the science of the relationships between molecules, or between molecules and energy.

1.2 Unit systems used in physical chemistry

Physical quantities are measured in different units and include two systems:

The first: the metric system (centimeter-gram-second) Centimeter-Gram-Second (CGS). This system originated in France and is used throughout the world except in the United States. This system is characterized by its simplicity, unlike natural units such as feet and

pounds, and has been preferred over the previous system of units, which was Meter-Kilogram-Second (MKS).
Second: The International System of Units (SI), which was agreed upon by the International Conference on Weights and Measures (the global reference for units) in 1960.

1.3 The Importance of Physical Chemistry in Renewable Energy

The importance of physical chemistry in the field of renewable energy lies in the fact that it provides us with the necessary tools to understand more and more details at the molecular and atomic levels. Here are some options you need for this importance:

Solar Cell Development: Physical chemistry helps us understand how solar cells absorb light and convert it into electricity. By studying the electronic and electrical control within biomaterials (such as silicon), we can inform the design of new products that are more efficient at converting solar energy to electricity.

Improving Fuel Cells: Fuel cells rely on electrochemical reactions to convert energy directly into electricity. Physical chemistry has helped us understand these reactions, allowing us to develop better catalysts and efficient membranes, which increases their energy efficiency and lifespan.

Energy Systems: For storing energy from renewable sources (such as solar and wind power), batteries. Physical chemistry provides us with the foundations needed to understand the electrochemical reactions that occur within batteries, which helps in the development of larger batteries, faster charging, and shorter lifespans.

Hydrogen Chemical Production: Hydrogen is produced by the electrolysis of water. Physical chemistry helps study the reactions that occur at electrodes during this analysis, leading to the design of versatile electrocatalysts for production.

In general, physical chemistry is the foundation of renewable energy technologies and helps transform robots into magic solutions**.**

1.4 The concept of physical quantities

In physical chemistry, there are many quantities that must be addressed and understood.

1.4.1 Force (F)

It is the force that, if applied to a mass of 1 g, would accelerate it at a rate of 1 cm/s².

Force is measured in the **CGS system** in **dynes**, which are usually abbreviated as dyn.

Where. $1\,\mathrm{dyn} = 1\,\mathrm{g\,cm\,s^{-2}}$

In the **SI system**, force is measured in **newtons**(N), which is defined as the force that, when acting on a mass of 1 kg, would accelerate it at a rate of 1 m/s². (1 m/s²).

Where. $1\,\mathrm{N} = 1\,\mathrm{Kg\,m\,s^{-2}}$

$1\,\mathrm{Kg} = 1000\,\mathrm{g}$
$1\,\mathrm{m} = 100\,\mathrm{cm}$
$1\,\mathrm{N} = 10^{5}\,\mathrm{dyn}$

1.4.2 Pressure (P)

Pressure is defined as the specific force acting perpendicularly on a surface area. Mathematically, it is defined as follows:

$$\text{Pressure}(P) = \frac{\text{Force}(F)}{\text{Area}(A)}$$

Pressure is measured in the following units:

.($N m^{-2}$)= (Pascal (Pa)) -1

.($dyn\ cm^{-2}$) -2

$Pa = 10\ dyn\ cm^{-2}$

Atmospheric pressure (barometric pressure) is defined as the force exerted by the column of the atmosphere per unit area; that is, it is the mass of air above a given area. Atmospheric pressure is measured in the following units:

1- atm ($1atm = 10^5\ N m^{-2}$)
2- bar
3- cm/Hg (1atm = 76 cm/Hg)
4- mm/Hg (Torr (1atm = 760 mm/Hg)

1.4.3 Volume (V)

It is a physical measure of the space occupied by a real or imaginary object in a given place. Volume is measured in several units, including:

1- (Lit)

2- (ml)

3- (μl)

4- (M^3)

5- (cm^3)

6- (dm^3)

$$1\,M^3=1000\,Lit$$
$$1\,\mu l=10^{-6}Lit$$
$$1\,cm^3=1ml$$
$$1\,Lit=1000\,ml=1000\,cm^3=1dm^3$$

1.4.4 Temperature (T)

It is a physical measure known as an indicator of the amount of thermal energy stored by the body or the amount of energy stored within the molecules of matter. It is kinetic energy formed as a result of the movement and vibration of molecules, the movement of attraction and repulsion, the rotational movement around the axis,

and the transitional movement. Temperature is measured in the following units:

1- (C^o)

2-(K^o)

3- (F^o)

$$K^o = C^o + 273$$

1.4.5 Energy (E)

It is the ability or capacity to perform work. Energy is defined as:

Energy = Force × Distance. Energy is measured in the following units:

1- Joule (1 joule = 1 newton × meter)

2- Erg (1 erg = 1 dyne × centimeter)

Conversion factor: 1 joule = 1×10^7 erg

1.4.6 Mass (M)

It is a physical quantity defined as the amount of matter contained in an object. It differs from weight. Mass is measured in several units, including:

1- (Kg)

2- (gm)

3- (mg)

4- (μg)

$$1\,Kg=1000\,gm=10^{6}mg$$
$$1\,gm=1000\,mg=10^{6}\mu g$$

1.4.7 Length (L)

It is one of the basic physical quantities and expresses the amount of straight distance between two specific points. Length is measured in the following units:

1-(Km)	2-(m)	3-(dm)
4-(cm)	5-(mm)	6-(μm)
7-(nm)	8-(A°)	

$$1\,\mathrm{Km}=10^{3}\,\mathrm{m}$$
$$1\,\mathrm{m}=100\,\mathrm{cm}=10^{3}\mathrm{mm}=10\,\mathrm{dm}=10^{6}\mu\mathrm{m}=10^{9}\mathrm{nm}=10^{10}\mathrm{A}^{\circ}$$

1.4.8 Mole

The mole is a fundamental unit in the International System of Units, widely used in chemistry to express the unit of measurement of the mass of a substance containing a certain number of atoms, electrons, or molecules. The Avogadro number, symbolized by N, is equal to. $\mathrm{N}=6.022\times10^{23}$

When we divide the Avogadro number by the mole, we obtain the Avogadro constant.