Law of Conservation of Mass

The Universe is made up of matter and energy. Stone, table and hydrogen gas are some examples of matter. Matter occupies as pacific space and has specific mass. Energy is the ability of an object to do work.

It is measured in Joules. It is an established fact that matter and energy are inter changeable and both are conserved during a process. A process may be classified as a physical process or a chemical process.

In a physical process there is no change in composition of matter and the state of matter alone changes. Falling of water downhill, melting of ice and boiling of water are some examples of physical change. In a chemical process there is a change in the composition of matter. Burning of coal, digestion of food and ripening of fruit are some examples of chemical process. Most of the chemical processes are irreversible in nature. Law of conservation of energy, Law of conservation of mass and equivalence of mass and energy are dealing with such physical and chemical process.

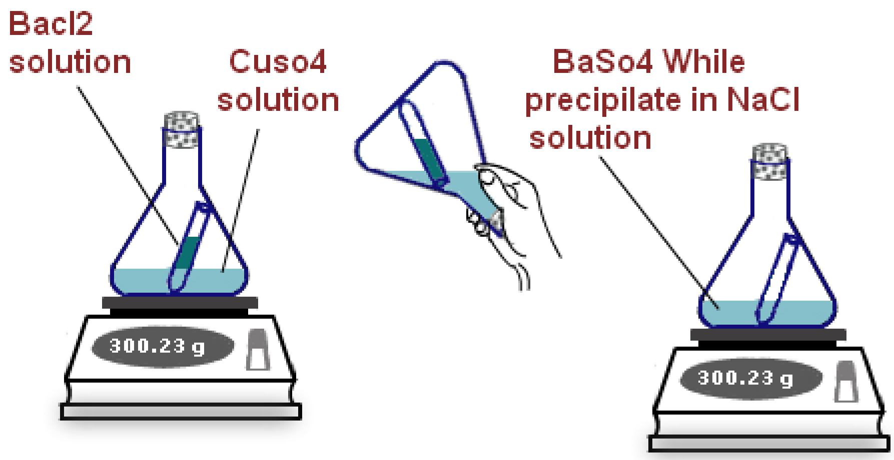
Law of Conservation of Mass and Energy

Law of conservation of energy was stated by Antoine Lavoisier in 17th century. Lavoisier did his experiments on combustion and oxygen. He found that oxygen is the most essential element for a combustion reaction. He also found that during combustion reaction the mass is conserved. In other words the mass of reactants and products are equal and mass is neither generated nor destroyed during a chemical reaction.

Hence the Law of conservation of mass states that during a chemical reaction mass is neither created nor destroyed.

Experimental Verification of Law of Conservation of Mass:

The law can be verified by the below mentioned experimental setup. Take a conical flask and a test tube. Take 10ml barium chloride solution in the conical flask and 10ml copper sulphate solution in the test tube. Measure the initial mass of reactants and note it.
Now mix the solutions together. Copper sulphate reacts with barium chloride to give a white precipitate of barium sulphate. Now we have to take the weight of the products formed. We can observe that the mass of reactants before the reaction and the products formed after the reaction will be equal.



Although law of conservation of mass is applicable in all chemical reactions it is not applicable in the case of nuclear reaction where a fraction of the mass is converted to energy.

Law of Conservation of Energy:

Law of conservation of energy is otherwise known as the First Law of thermodynamics. According to this law **"The total energy of an isolated system is conserved"**. In other words **"energy can neither be created nor be destroyed, one form of energy is changed to another form of energy in a process".**

The above statement shows that in all processes, physical or chemical, there is a change in the form of energy and there is no energy created or spent in a process.

Energy is in different forms like potential energy, kinetic energy, electrical energy, chemical energy, nuclear energy etc. In a process, energy is converted from one form to another.

Conservation of Energy Example:

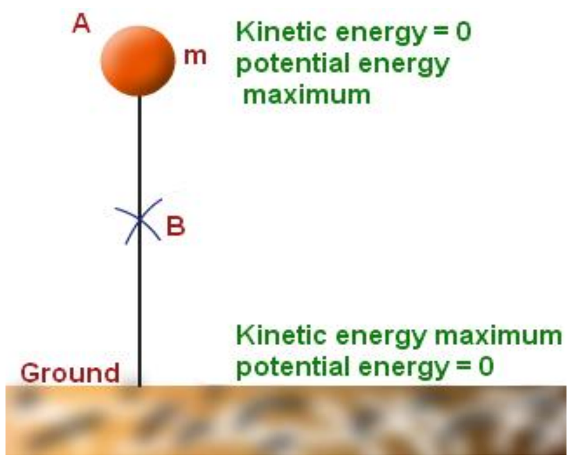
Let us consider two examples to illustrate the law of conservation of energy.

Example-1

Free Falling Object from a Height

Let us consider an object placed above a certain height from the ground level. As it is raised to a certain height, it has certain potential energy due to its position and as it is in rest it has no kinetic energy.

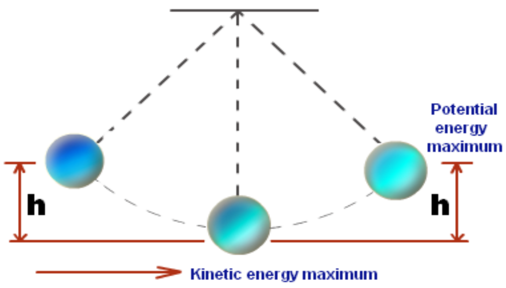
When the object starts falling, the potential energy stored is converted to kinetic energy and when the object reaches the ground the entire potential energy is converted to kinetic energy. Hence at ground level the kinetic energy of the object is maximum and potential energy is zero.



Example-2

Oscillating Pendulum

In the case of a pendulum the potential energy is maximum at the extreme position. When it is moving towards the mean position the potential energy is converted to kinetic energy. Hence the kinetic energy is maximum at the mean position while the potential energy is minimum at mean position.



Equivalence of Mass and Energy

The relationship between matter and energy was discovered by Einstein. Before

that, matter and energy were treated as two distinct parameters. But Einstein

proved that matter can be converted to energy and it is related by his equation

$E = mc^2$

This is also known as equivalence of mass and energy. Here E is energy released in Joules. M is mass of the object in kg and c is velocity of light m. (velocity of light is taken as 3×10^8 m approximately)

Energy Released due to Mass Defect:

Let us look at a sample problem to understand the equivalence of mass and energy.

Solved Example

Question: Calculate the energy released by the complete disintegration of 238g of Uranium-238.

Solution: The energy released = mc^2

$0.238 \times (3 \times 10^8)^2$

2.142×10^{16} Joules or 21420000000000 Kilo Joules

The above problem illustrates the associated with nuclear reaction is much more greater than a chemical reaction.

Efficiency and Conservation of Energy:

- Although energy is conserved and cannot be created or destroyed, there is a severe energy crisis in our daily life.
- This is because of the efficiency of the process. When energy is converted to work, part of the energy is wasted as heat energy to the universe.
- The rate at which energy is converted to work is called the efficiency of the system.
- Efficiency is the important tool to use the energy resources properly and to cultivate maximum from them.

Conservation of Mass Examples:

The following problems will show the conservation of mass in chemical reactions.

Solved Examples

Question 1: In a chemical reaction 100g Baking soda mixture containing sodium bicarbonate and vinegar on heating gives 43g of carbon dioxide gas. What mass of solid residue will left in food?

Solution:

In according to law of conservation of mass, total mass of reactants is equal to total mass of products. Here baking soda mixture on heating gives solid residue and carbon dioxide.

$$M_{\text{Baking soda}} = M_{\text{solid residue}} + M_{CO2}$$

Hence the mass of solid residue is 100g - 43g= 57g

Question 2: How much oxygen will add with 12g carbon to give 44g carbon dioxide assuming complete combustion of carbon?

Solution:

In according to law of conservation of mass

Mass of carbon + mass of oxygen = Mass of carbon dioxide

12g + x = 44g

so mass of oxygen = 32g

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