Step 1 At the heart of chemistry

Here is a review of the main concepts of this step!

1 Breaking down chemistry

Chemistry studies the composition and properties of matter, and the changes it undergoes. It evolved from alchemy, an ancient pseudoscientific discipline that combined elements of chemistry, philosophy, astrology, astronomy, mysticism, and medicine.

Chemistry is divided into organic chemistry, which focuses on carbon compounds, and inorganic chemistry, which studies non-carbon compounds. Chemistry is often called "the central science" because it links other natural sciences such as physics, biology, astronomy, and geology. Understanding plants, rocks, the atmosphere, medicines, and the environment requires knowledge of chemistry.

2 Exploring matter

Matter and energy are fundamental to all objective phenomena. Energy is the ability to do work. Matter is defined as anything with mass and occupying space and forms the substance of all known objects. Air, water, animals, plants, and humans are all made of matter.

Modern science reveals that matter consists of elementary particles like quarks and leptons, with quarks forming protons and neutrons that, along with electrons, create atoms. Atoms combine into molecules, such as H_2O, and large groups of atoms or molecules form the matter in everyday life.

3 Quantities and measurements

To measure something means determining how many times a basic unit fits into a physical quantity. Measurements are crucial in everyday life and science. A unified measurement system is essential for effective scientific communication globally.

The International System of Units (SI), derived from the metric system, is a global measurement system. It is a decimal system consisting of seven base units representing different physical quantities. Examples of base units are the meter, the second and the ampere. Derived units are expressed using these base units.

Examples of derived units are the pascal for pressure, the coulomb for electric charge, the square meter for surface area, and the cubic meter for volume.

In addition to SI units, non-SI units like minutes (time) and liters (volume) are also used, especially by chemists.

Prefixes are used to denote multiples or fractions of units, with each prefix representing an integer power of ten. For example, kilo- indicates a multiple of a thousand, and milli- indicates a thousandth. Hence, a kilogram is 1,000 grams, a kilometer is 1,000 meters, and a milligram is 0.001 grams (or 1,000 milligrams in a gram).

4 Mass and weight

While both mass and weight use units like grams and kilograms, they are different concepts. Mass is the quantity of matter in an object. According to Newton's first law of motion, an object in motion stays in motion, and an object at rest stays at rest unless acted upon by an outside force. More mass means more inertia, making it harder to start or stop the object's motion. The SI unit of mass is the kilogram (kg), though chemists often use grams (g).

Weight depends on the gravitational force between an object and the place where it is measured. According to Newton's second law of motion, weight is the product of mass and gravitational acceleration. Consequently, weight varies with gravity and would differ on the Moon compared to Earth, while mass remains constant throughout the universe. Scientists prefer to refer to mass because it is invariant.

5 Volume

Volume is the amount of space that a substance or object occupies, often referred to as capacity when considering containers. The volume of solid objects is determined by the three-dimensional space they occupy: length, width, and height. The SI unit for volume is the cubic meter (m^3), with the cubic centimetre (cm^3) being a commonly used submultiple.

6 Temperature

Temperature measures the average kinetic energy of particles in a substance. It is a measurable physical property, like mass and density, and it does not depend on the size or type of an object, unlike heat.

For example, a small cup and a large tub of water can have the same temperature but different amounts of heat, with the tub having more total thermal energy.

Temperature is measured using thermometers, which utilize materials that change in some way when heated or cooled. Traditional mercury thermometers show temperature through the length of a liquid column, while modern thermometers often use electronic displays. The SI unit for temperature is Kelvin (K), though Celsius (°C) and Fahrenheit (°F) are also used.

7 Density

Two objects can have the same volume but different masses, and this exemplified by a polystyrene ball and a lead ball. Density, the mass-to-volume ratio, indicates how much mass occupies a given volume. In the SI system, density is in kg/m^3, but in chemistry, g/mL is common.

In everyday life, density is evident in objects floating or sinking in water; the density of water at 20°C is 1 g/mL. Objects denser than water sink, like lead, while less dense ones, like wood, float. Chemists specify density measurements at standard atmospheric pressure and 20°C, a convenient temperature.