Topic Page: matter

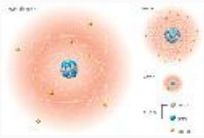

Image from: **The mass of an atom depends on the size of the...** in *Philip's Encyclopedia*

Summary Article: **matter**
From *The Columbia Encyclopedia*

anything that has mass and occupies space. Matter is sometimes called koinomatter (Gr. *koinos*=common) to distinguish it from antimatter, or matter composed of antiparticles.

The Properties of Matter

The general properties of matter result from its relationship with mass and space. Because of its mass, all matter has inertia (the mass being the measure of its inertia) and weight, if it is in a gravitational field (see gravitation). Because it occupies space, all matter has volume and impenetrability, since two objects cannot occupy the same space simultaneously.

The special properties of matter, on the other hand, depend on internal structure and thus differ from one form of matter, i.e., one substance, to another. Such properties include ductility, elasticity, hardness, malleability, porosity (ability to permit another substance to flow through it), and tenacity (resistance to being pulled apart).

The States of Matter

Matter is ordinarily observed in three different states, or phases (see states of matter), although scientists distinguish three additional states. Matter in the solid state has both a definite volume and a definite shape; matter in the liquid state has a definite volume but no definite shape, assuming the shape of whatever container it is placed in; matter in the gaseous state has neither a definite volume nor a definite shape and expands to fill any container. The properties of a plasma, or extremely hot, ionized gas, are sufficiently different from those of a gas at ordinary temperatures for scientists to consider them to be the fourth state of matter. So too are the properties of the Bose-Einstein and fermionic condensates, which exist only at temperatures approximating absolute zero (−273.15 degrees Celsius), and they are considered the fifth and sixth states of matter respectively.

Early Theories of Matter

In ancient times various theories were suggested about the nature of matter. Empedocles held that all matter is made up of four “elements”—earth, air, fire, and water. Leucippus and his pupil Democritus proposed an atomic basis of matter, believing that all matter is built up from tiny particles differing in size and shape. Anaxagoras, however, rejected any theory in which matter is viewed as composed of smaller constituents, whether atoms or elements, and held instead that matter is continuous throughout, being entirely of a single substance.

Modern Theory of Matter

The modern theory of matter dates from the work of John Dalton at the beginning of the 19th cent. The atom is considered the basic unit of any element, and atoms may combine chemically to form molecules, the molecule being the smallest unit of any substance that possesses the properties of that substance. An element in modern theory is any substance all of whose atoms are the same (i.e., have the same atomic number), while a compound is composed of different types of atoms together in molecules.

Physical and Chemical Changes

The difference between a mixture and a compound helps to illustrate the difference between a physical change and a chemical change. Different atoms may also be present together in a mixture, but in a mixture they are not bound together chemically as they are in a compound. In a physical change, such as a change of state (e.g., from solid to liquid), the substance as a whole changes, but its underlying structure remains the same; water is still composed of molecules containing two hydrogen atoms and one oxygen atom whether it is in the form of ice, liquid water, or steam. In a chemical change, however, the substance participates in a chemical reaction, with a consequent reordering of its atoms. As a result, it becomes a different substance with a different set of properties.

Many of the physical properties and much of the behavior of matter can be understood without detailed assumptions about the structure of atoms and molecules. For example, the kinetic-molecular theory of gases provides a good explanation of the nature of temperature and the basis of the various gas laws and also gives insight into the different states of matter. Substances in different states vary in the strength of the forces between their molecules, with intermolecular forces being strongest in solids and weakest in gases. The force holding like molecules together is called cohesion, while that between unlike molecules is called adhesion (see adhesion and cohesion). Among the phenomena resulting from intermolecular forces are surface tension and capillarity. An even larger number of aspects of matter can be understood when the nature and structure of the atom are taken into account. The quantum theory has provided the key to understanding the atom, and most basic problems relating to the atom have been solved.

The Relationship of Matter and Energy

The atomic theory of matter does not answer the question of the basic nature of matter. It is now known that matter and energy are intimately related. According to the law of mass-energy equivalence, developed by Albert Einstein as part of his theory of relativity, a quantity of matter of mass m possesses an intrinsic rest mass energy E given by $E = mc^2$, where c is the speed of light. This equivalence is dramatically demonstrated in the phenomena of nuclear fission and fusion (see nuclear energy; nucleus), in which a small amount of matter is converted to a rather large amount of energy. The converse reaction, the conversion of energy to matter, has been observed frequently in the creation of many new elementary particles. The study of elementary particles has not solved the question of the nature of matter but only shifted it to a smaller scale.

Bibliography

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