

Definition of 'element'

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In a recent paper I showed how basic chemical concepts can be defined at a macroscopic level (Nelson, 2003). However, a personal correspondent, Dr. Daniel K.C. Tan, has pointed out that my definition of 'element' does not take proper account of the phenomenon of allotropy. I have accordingly revised the section of my paper on elements and compounds as set out below.

Elements and compounds

Substances can be divided into *elementary substances* and *compounds* on the basis of the chemical changes they are involved in. Compounds decompose into other substances, elementary substances do not (not in a chemical change). Likewise, compounds can be made by combination of other substances, elementary substances cannot. Compounds ultimately decompose into, and can be made from, elementary substances.

These considerations are helped by weighing the substances involved. When a compound decomposes, the masses of the products sum to the mass of the compound (an instance of the law of conservation of mass). Masses likewise balance when a compound is made by the combination of other substances. The conclusion from such studies is that the mass of a compound is equal to the sum of the masses of the elementary substances of which it is composed.

Some elementary substances in the same solid, liquid, or gaseous state can be interconverted without change in mass, and combine with other substances to give the same compounds. For example, graphite and diamond can be interconverted at high temperatures and pressures, and both burn in oxygen to give carbon dioxide. Elementary substances of this kind are reckoned to be variants of the same *element* (e.g. 'carbon'). The variants are called *allotropes*, and their occurrence *allotropy* (Greek *allos*, another, *tropos*, manner). Different crystalline forms of an elementary substance (e.g. α - and β -sulfur) are also called allotropes.

Summary of definitions

Elementary substance: a substance that does not undergo chemical decomposition into, and cannot be made by chemical combination of, other substances.

Element: basic type of matter existing as elementary substances that can be interconverted without change in mass.

Allotropy: existence of an element as more than one solid, liquid, or gaseous substance, or in more than one crystalline form.

This definition of 'element' is for use in courses in which chemistry is introduced progressively, starting at the macroscopic level (Nelson, 2002). At an atomic and subatomic

level, an element corresponds to an assembly of atoms with the same nuclear charge, without regard to how they are bound.

References

- Nelson P.G., (2002), Teaching chemistry progressively: from substances, to atoms and molecules, to electrons and nuclei, *Chemistry Education Research and Practice*, **3**, 215–228.
- Nelson P.G., (2003), Basic chemical concepts, *Chemistry Education Research and Practice*, **4**, 19–24.