The General Balance

All material and energy (M&E) balance calculations are based on our experience that matter and energy may change its form, but it cannot appear from nor disappear to nothing. This observation is expressed mathematically in equation 1.01, the *General Balance Equation.*

For a defined *system* and a specified *quantity:*

Accumulation in system = Input to system - Output from system + Generation in system - Consumption in system *Equation 1.01*

Where:

Accumulation in system	= [final amount of the quantity – initial amount of the quantity] inside the system boundary.	
Input to system	= amount of the quantity entering the system through the system boundary.	(input)
Output from system	= amount of the quantity leaving the system through the system boundary.	(output)
Generation in system	= amount of the quantity generated (i.e. formed) inside the system boundary.	(source)
Consumption in system	= amount of the quantity consumed (i.e. converted) inside the system boundary.	(sink)

The general balance equation (equation 1.01) is a powerful equation, which can be used in various ways to solve many practical problems. Once you understand equation 1.01 the calculation of M&E balances is simply a matter of bookkeeping.

The general balance equation (equation 1.01) is the primary equation that is repeated throughout these notes. In each chapter where it appears the first number of this equation corresponds to the number of the chapter, so that it enters Chapter 4 as equation 4.01, Chapter 5 as equation 5.01 and Chapter 7 as equation 7.01.

Every time you apply equation 1.01 you must begin by defining the *system* under consideration and the *quantity* of interest in the system. The *system* is a physical space, which is completely enclosed by a hypothetical envelope whose location exactly defines the extent of the system. The *quantity* may be any specified measurable (extensive[1]) property, such as the mass, moles*, volume or energy content of one or more components of the system. When equation 1.01 is applied to energy balances the quantity also includes energy transfer across the system envelope as heat and/or work (see Chapter 5).

When you use the general balance equation it is best to begin with a conceptual diagram of the system, which clearly shows the complete system boundary plus the inputs and outputs of the system. Figure 1.01 is an example of such a diagram. Note that:

- Figure 1.01 is a two-dimensional representation of a real three-dimensional system.
- the system has a closed boundary.
- the system may have singular or multiple inputs and/or outputs.

* A *mole* is the amount of a substance containing the same number of "*elementary particles"* as there are atoms in 0.012 kg of carbon 12 (i.e. Avogadro's number = 6.028E23 of particles.) The number of moles in a given quantity of a molecular species (or element) is its mass divided by its molar mass, i.e. n = m / M. For molecular and ionic compounds in chemical processes (e.g. H_2O, H_2, O_2, CH_4, NaCl) the "*elementary particles"* are molecules. For elements and ions whose atoms are not associated (e.g. C, Na^+, Cl^-) the "elementary particles" are atoms. Refer to a basic chemistry text for more comprehensive information of atoms, ions, molecules and chemical bonding.

[1.] An extensive property is a property whose value is proportional to the amount of material.