How many atoms to the kilo?

The standard for measuring weight may soon be developed in terms of the weight of a given number of atoms, says S.Ananthanarayanan.	

The progress of science has been marked with improvements in the standards of measurement. The standards for time and length have been defined in terms of the frequency of light waves and the speed of light. But the standard for weight is still linked to a sample weight of platinum stored outside Paris.

The standard metre

A standard of length was developed soon after the French revolution, as one ten millionth of the distance from the equator to the North Pole, along the longitude that passed through Paris. The actual length measured, by celebrated scientists, was the distance from Dunkirk to Barcelona, which is a tenth of the full distance. The standard that came about was marked on a platinum bar stored in a laboratory outside Paris and this was the standard for over a century.

When more a more exact standard was found necessary, chiefly for science, the standard metre was redefined, first in terms of the wavelength of the orange-red light emitted by the krypton atom. This was later refined as the distance that light travels in a tiny instant measured to the accuracy of one part in a hundred billion, with the cesium clock. The standard of time itself is also well defined with reference to the rhythms of atomic nuclei.

The standard of weight

Like for length, the need for standards of weight was first commercial. After the French revolution, the need to do away with the multitude of standards was felt and the French instituted the standard kilogram, a slab of platinum stored outside Paris. There are certified facsimiles at nominated places and the standard, both for trade and for science, is maintained by periodical verifications with the base at Paris.

A refinement of this standard would be possible if we could arrive at a count of atoms of a material, which had the weight of this standard at Paris. The base could then be stated by this number and the basic kilogram could be verified at any place and without need to refer to Paris ‘kilogram block’.

Avogadro's number

Avogadro discovered the principle that the weights of different elements that typically reacted with each other must contain the same number of atoms. The weight of an element that reacts with nearly 2 grams of hydrogen, or the equivalent, which is 32 grams of oxygen, etc, is of interest. This number of atoms, specifically, in 12 grams of carbon^{12} is called Avogadro's number The number has been estimated to be 6.02×10^{23} with is about two thirds of a million billion billion.

An accurate way to estimate the number would be to take the weight of a single crystal of a material and then to estimate the number of atoms by measuring the inter-atomic distance. This is like estimating the density of people by making measurements of an army that has formed in ranks and files, for the parade, rather than a crowd racing across a football field.

Scientists at Braunschweig, Germany, have made measurements on single crystals of silicon, using light at X Ray frequencies to reflect and interfere, and thereby yield estimates of the distance between atoms and also the whole distance. When the estimates are shown to have a reliability of one part in a 100 million, it may be time to revise the present standard for weight too!