Revision of the International System of Units (Background paper)

$$\frac{h}{m_{\mathrm{u}}} = \frac{N_{\mathrm{A}}h}{M_{\mathrm{u}}} = \frac{c\ \ {}^{2}}{2R_{\infty}} A_{\mathrm{r}}(\mathrm{e}) \qquad (1)$$

where, N_A is the Avogadro constant, h is the Planck constant, m_u is the atomic mass constant, M_u is the molar mass constant, c is the speed of light in vacuum, is the fine structure constant, R_{∞} is the Rydberg constant and $A_r(e)$ is the relative atomic mass of the electron. The components of eqn (1) have either exact values or have uncertainties significantly smaller than the uncertainties in h and N_A prior to SI revision.

Considering that h is related to macroscopic mass *via* the Kibble balance experiment, and N_A is related to macroscopic mass *via* the Avogadro experiment‡ (Bartl, *et al.*, 2017) it is clearly possible to define mass in terms of either of these constants. The corollary to this was that a new definition of the mole, based on a fixed numerical value of N_A, was also likely.

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At the point of redefinition of any unit it is essential that the size of the unit does not change, and furthermore that the new definition is an improvement on the old defi

- The mole is no longer dependent on a material property and is more universal in its applicability;
- It reflects the way most chemists already consider the mole;
- The new definition may prove easier to teach;
- It is a better fit with 21st century technologies and keeps chemical metrology aligned with the rest of the SI.

Relative atomic masses and relative molecular masses are ratios, not dependent on the current definition of the kilogram, and will be unaffected by the proposed new definitions of the kilogram and the mole.

The relative uncertainties associated with the quantities involved in the mole redefinition are still several orders of magnitude smaller than those associated with the practical realisation of chemical quantities, which mostly occurs by weighing materials of known purity. As a result no practical implications of the change are envisaged for analytical chemistry in the short term and improvements may take some time to realise. However, the change is overall of benefit for chemistry in the longer term, paving the way for more accurate chemical measurement in future, particularly at ultra-low amounts of substance.

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Aside from removing the last unique physical artefact from the SI, the new definitions in terms of fixed numerical values of defining constants are more universal in their applicability and more consistent with twenty first century technologies. The way to realise a unit is no longer implicitly or explicitly suggested by its definition. This separation future-proofs the unit definitions, ensuring that unit realisations will be able to benefit from all relevant future advances in technology and lays the foundations for more accurate measurements for all stakeholders for decades to come.

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I. A. Robinson and S. Schlamminger, The watt or Kibble balance: a technique for implementing the new SI definition of the unit of mass, *Metrologia*, 2016, 53, A46–A74.

I. M. Mills, P. J. Mohr, T. J. Quinn, B. N. Taylor and E. R. Williams, Redefinition of the kilogram, ampere, kelvin