### P R E M I U M  C O N T E N T

#### FREQUENTLY USED FUNDAMENTAL PHYSICAL CONSTANTS

1 second = 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of $^1$H.

#### Speed of light in vacuum

$c = 299 792 458 \text{ m s}^{-1}$ (exact)

#### Planck constant

$h = 6.626 070 15 \times 10^{-34} \text{ J s}$ (exact)

#### Elementary charge

$e = 1.602 176 634 \times 10^{-19} \text{ C}$ (exact)

#### Avogadro constant

$N_A = 6.022 140 76 \times 10^{23} \text{ mol}^{-1}$ (exact)

#### Boltzmann constant

$k = 1.380 649 \times 10^{-23} \text{ J K}^{-1}$ (exact)

#### Electron voltage

$eV = 1.602 176 634 \times 10^{-19} \text{ J}$ (exact)

#### Electron mass

$m_e = 9.109 383 70 \times 10^{-31} \text{ kg}$ (exact)

#### Energy equivalent

$E_{\text{eq}} = 0.510 998 950 \text{ MeV}$ (for the most accurate values see ciaaw.org and pml.nist.gov/data)

#### Rydberg constant

$R_c = 13.605 693 1230 \text{ eV}$ (exact)

#### Natural constant of gravitation

$G = 6.674 010 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{s}^{-2}$ (exact)

$\bullet$ For the most accurate values of these and other constants, visit pml.nist.gov constants.

#### Terminology

- **Solid**: Materials that maintain a fixed shape and volume. Examples include metals, rocks, and minerals.
- **Liquid**: Materials that are able to flow, maintaining a definite volume but not a definite shape. Examples include water and oils.
- **Gas**: Materials that have neither a definite shape nor a definite volume. They expand to fill any container they are placed in. Examples include air and helium.
- **Artificially Prepared**: Elements that are not naturally occurring, such as plutonium (Pu) and technetium (Tc).

#### Periodic Table

The periodic table is a tabular arrangement of the chemical elements, organized on the basis of their atomic number, electron configurations, and recurring chemical properties. Each element is represented by its atomic number, symbol, and atomic weight. The table is divided into groups (columns) and periods (rows), with elements generally arranged in order of increasing atomic number.

#### Atomic Properties of the Elements

- **Atomic Number**: The number of protons in the nucleus of an atom, which defines the element.
- **Atomic Symbol**: A single letter or two letters representing an element, such as H for hydrogen.
- **Atomic Weight**: The average mass of the naturally occurring isotopes of an element, measured in atomic mass units (amu). It includes the contributions of all isotopes, weighted by their natural abundance.
- **Ground-state Configuration**: The electronic configuration of the element in its lowest energy state. This configuration is determined by the rules of quantum mechanics and is characteristic of each element.

For further information and detailed properties, visit: [CIAA.W](http://ciaaw.org) and [NIST](http://www.nist.gov/pml/data).
Cesium: The frequency of microwave radiation from this atom in atomic clocks such as the NIST-F2 (2014), is used to define the second.

Potassium and Rubidium: JILA researchers married these elements into an ultracold gas of molecules and demonstrated striking predictions of quantum physics by hitting the atoms with “rulers of light” known as frequency combs (Nobel Prize 2005) and trapping them in webs of light known as optical lattices.

Sodium: NIST scientists used lasers to cool a gas of these atoms to more than theoretically expected to temperatures even closer to absolute zero. (Nobel Prize 1997)

Rubidium: These atoms were used by researchers at JILA (NIST-CU Boulder) to create the first Bose-Einstein condensate (Nobel Prize 2001).

Krypton: Wavelengths of light from this atom, measured by NIST researchers, defined the official meter until 1983.

Deuterium: This rare heavy isotope of hydrogen was concentrated at NIST and then identified by Columbia University's Harold Urey (Nobel Prize 1934). On the left is a deuterium lamp; the light on the right comes from the NIST SURF III Synchrotron Ultraviolet Radiation Facility.

Beryllium and Aluminum: Individual ions of these atoms were probed in a NIST trap to create “quantum logic” clocks that measured the second more precisely than before and tested Einstein’s general theory of relativity. Such quantum manipulations were recognized in the 2012 Nobel Prize.

1960
1967
1988
1995
2008
2010/2011