The D-Series

Scientific Datasheet Collection

First Edition

Neo Skinner

March 2023

INDEX (A1)

PRESS RELEASE (B1)

Saturday, 25 March 2023

To the wider scientific community,

Today marks the first release of the full set one of the D-series of scientific datasheets – with one major exclusion. These datasheets have been produced due to a considerable time investment for the betterment of the established physical sciences and the broader community.

There are eight datasheets total in set one of which seven will today be published. They cover topics across two of the scientific disciplines, chemistry and physics, and serve as a valuable companion to any physical scientist. Each datasheet is produced to a high quality with data sourced from the most reputable scientific institutions, including the European Organization for Nuclear Research, the American National Institute of Standards and Technology, the International Bureau of Weights and Measures, the International Union of Pure and Applied Chemistry and the American National Nuclear Data Center.

The eight datasheets in set one are as follows:

- D1 – Periodic Table of Elements
- D2 – Properties of Elements
- D3 – Properties of Nuclides (Excluded)
- D4 – Standard Model of Elementary Particles
- D5 – Properties of Elementary Particles
- D6 – SI Unit Definitions
- D7 – SI Defining Physical Constants
- D8 – Radioactive Decay Modes
- (Also Present is a Source Document)

Unfortunately, D3 has been omitted from this release due to its current state of completion. Latest estimates indicate that it is only 13.2% complete (by number of nuclides) and that an additional 144 hours would be required to complete the datasheet. For this reason, it has been excluded and will be released at a later date which is to be confirmed.

This project is the result of work solely by one person, and whilst all of the datasheets have been produced to a high standard and Harvard format sources have been provided, there may be errors within this work that have not yet been caught. If any error are found, they are to be reported to the author for correction in the next edition and the author has an obligation to find and correct all mistakes that may arise within the work.

Yours Sincerely,

Neo Skinner

Author of the D-Series Datasheet Collection

PREFACE (B2)

When this project began, I had no idea of the scale it would become, at that time I had only produced a periodic table and had no plans to continue and make any other datasheets. Look at it now. A complete system of datasheets has since been carefully crafted using data from across the internet, reference libraries and journal articles.

The project is still by no means complete, as new data arises it will be incorporated into the datasheets to form a more accurate and complete view of our world. By definition, this series will always be a working draft, but hopefully a very good one at that. I also have plans to extend the series in the future to include datasheets across all three disciplines instead of the two you see today – but that's still in the oven, what can you experience today?

Today, topics across chemistry and physics – the physical sciences – are explored to provide a mathematical view of our universe. Ever wanted to know the mean life of an electron? Well now you can – it's more than 66 octillion years! Or how about the numerical value of avogadro's constant? That's $6.022\ 140\ 76 \times 10^{23}$ as defined by the BIPM. That's just a small subset of the information held within these pages, treat them well and who knows how much more they'll tell you.

Now go, explore and experience this series in its entirety. I hope it will be able to inform and enable many more scientific adventures in the future. But for now, just relish in pages of numbers, diagrams, facts and figures, for knowledge is power and nobody can take that away from you.

GENERAL NOTES (B3)

Standard Abbreviations and Quantities

Within this work, several abbreviations and standardised quantities are self-evident

Degree of Accuracy and Precision

All of the data provided within this work comes from generally-accepted reliable sources and represents the highest degrees of both accuracy and precision currently achievable within the scientific industry. The largest possible number of digits has been provided for all numerical data with exceptions made clear within the work in the case of diagrammatic datasheets.

If any errors are identified, they will be resolved as soon as possible to prevent the embitterment of this work. If you identify any errors, please contact the publisher and author directly through the following means:

POST:
RE: The D-Series
SkinnerMedia
79 Twyford Way
Poole
Dorset
The United Kingdom of Great Britain and Northern Ireland
BH17 8SR

EMAIL:
RE: The D-Series
skinnermedia@outlook.com

Metrology

This work utilises an extension of the International System of Units, the SI. More information about this system, units, symbols, uncertainty and metrology can be found in the SI Notice (B3).

Citations

Citations for this work can be found in the bibliography (F1) provided at the back of this document series. For section B, this information is printed within document endnotes.

The standard format of citations within this work is that of the Harvard Educational Review.

SI NOTICE (B4)

The International System of Units and its Use Within This Work

"The International System of Units, the SI, has been used around the world as the preferred system of units, the basic language for science, technology, industry and trade since it was established in 1960 by a resolution at the 11th meeting of the Conférence Générale des Poids et Mesures, the CGPM (known in English as the General Conference on Weights and Measures). […]

"The SI has always been a practical and dynamic system that has evolved to exploit the latest scientific and technological developments. In particular, the tremendous advances in atomic physics and quantum metrology made over the last 50 years have enabled the definitions of the second, the metre, and the practical representation of the electrical units to take advantage of atomic and quantum phenomena to achieve levels of accuracy for realizing the respective units limited only by our technical capability and not by the definitions themselves. […]

"The SI is a consistent system of units for use in all aspects of life, including international trade, manufacturing, security, health and safety, protection of the environment, and in the basic science that underpins all of these. The system of quantities underlying the SI and the equations relating them are based on the present description of nature and are familiar to all scientists, technologists and engineers.

"The definition of the SI units is established in terms of a set of seven defining constants. The complete system of units can be derived from the fixed values of these defining constants, expressed in the units of the SI. These seven defining constants are the most fundamental feature of the definition of the entire system of units. These particular constants were chosen after having been identified as being the best choice, taking into account the previous definition of the SI, which was based on seven base units, and progress in science. […]

"To be of any practical use, these units not only have to be defined, but they also have to be realized physically for dissemination. In the case of an artefact, the definition and the realization are equivalent – a path that was pursued by advanced ancient civilizations. Although this is simple and clear, artefacts involve the risk of loss, damage or change. The other types of unit definitions are increasingly abstract or idealized. Here, the realizations are separated conceptually from the definitions so that the units can, as a matter of principle, be realized independently at any place and at any time. In addition, new and superior realizations may be introduced as science and technologies develop, without the need to redefine the unit. These advantages – most obviously seen with the history of the definition of the metre from artefacts through an atomic reference transition to the fixed numerical value of the speed of light – led to the decision to define all units by using defining constants. […]

"The definitions of the SI units, as decided by the CGPM, represent the highest reference level for measurement traceability to the SI.

"Metrology institutes around the world establish the practical realizations of the definitions in order to allow for traceability of measurements to the SI. The Consultative Committees provide the framework for establishing the equivalence of the realizations in order to harmonize traceability world-wide.

"Standardization bodies may specify further details for quantities and units and rules for their application, where these are needed by interested parties. Whenever SI units are involved, these standards must refer to the definitions by the CGPM. Many such specifications are listed for example in the standards developed by the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC 80000 series of international standards).

“Individual countries have established rules concerning the use of units by national legislation, either for general use or for specific areas such as commerce, health, public safety and education. In almost all countries, this legislation is based on the SI. The International Organization of Legal Metrology (OIML) is charged with the international harmonization of the technical specifications of this legislation.”[i]

It is from the above extract that the decision was drawn to use the SI as this works primary unitary system and, as such, all units are traceable back to this basic system. The Bureau International des Poids et Mesures, the BIPM (known in English as the International Bureau of Weights and Measures) is the direct source of all unitary definitions made within this work and should be considered the sole reference for metrology within this work.

“The value of a quantity is generally expressed as the product of a number and a unit. The unit is simply a particular example of the quantity concerned which is used as a reference, and the number is the ratio of the value of the quantity to the unit.

“For a particular quantity different units may be used. For example, the value of the speed v of a particle may be expressed as $v = 25\ \mathrm{m/s}$ or $v = 90\ \mathrm{km/h}$, where metre per second and kilometre per hour are alternative units for the same value of the quantity speed.

“Before stating the result of a measurement, it is essential that the quantity being presented is adequately described. This may be simple, as in the case of the length of a particular steel rod, but can become more complex when higher accuracy is required and where additional parameters, such as temperature, need to be specified.

“When a measurement result of a quantity is reported, the *estimated value* of the measurand (the quantity to be measured), and the *uncertainty* associated with that value, are necessary. Both are expressed in the same unit.”[i]

When units, symbols and uncertainty are used in this work, it is in accordance with the latest guidance from the BIPM, which is published in *The International System of Units (SI) 9th Edition* (2019)[i], *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement (JCGM 100:2008)* (2008)[ii], and *International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM) 3rd Edition (JCGM 200:2012)* (2012)[iii]. Additional guidance for uncertainty can be found in *The NIST Reference on Constants, Units, and Uncertainty*[iv]. The SI is defined within this work by this notice and the *D6 – SI Unit Definitions* and *D7 – SI Defining Physical Constants* datsheets. Additional companion sheets are also provided to aid the use of this unitary system.

The Extension to The International System of Units

This work utilises and recognises many other units that have not been accepted for use with the SI by BIPM and this notice also acts to extend the SI within this work. The unitary extension includes the following units: year (a), electronvolt mass ($\mathrm{eV/c^2}$), unified atomic mass unit (u or Da), and atmospheric pressure (atm). These units are defined by the International Astronomical Union (IAU), the International Science Council’s Committee on Data (CODATA), the International Civil Aviation Organization (ICAO), and the International Organization for Standardization (ISO). The units within the extension are described and defined below:

Unit	Unit Symbol	Definition	Description	Defining Body
Year (Annum)	a	$1\ \mathrm{a} \cong 365.25\ \mathrm{d}$ $1\ \mathrm{a} \cong 31\ 557\ 600\ \mathrm{s}$	Julian Astronomical Year	IAU[v]
Electronvolt (mass)	$\mathrm{eV/c^2}$	$1\ \mathrm{eV/c^2} \cong 1.782\ 661\ 92 \times 10^{-36}\ \mathrm{kg}$	Electronvolt Mass-Equivalence	CODATA[vi]
Unified Atomic Mass Unit (Dalton)	u or Da	$1\ \mathrm{u} \cong 1.660\ 539\ 066\ 60(50) \times 10^{-27}\ \mathrm{kg}$	Mass Relative to an Unbound Neutral Carbon 12 Atom	CODATA[vi]
Atmospheric Pressure (Standard Atmosphere)	atm	$1\ \mathrm{atm} \cong 101\ 325\ \mathrm{Pa}$	Relative Atmosphere of the Earth at Sea Level	ICAO and ISO[vii][viii]

The units above are used within this work as an extension to the SI and have been standardised to match the units, symbols and uncertainty guidance outlined by BIPM. The SI unit prefix system is utilised with this unitary system extension due to the standardisation process. Additional companion sheets are also provided to aid the use of this unitary system extension.

The SI Unit Prefix System

The SI unit prefix system defined by BIPM allows for numerical data length shortening in a similar way to standard form or scientific notation. By adding a prefix to an SI unit, the magnitude of data can altered by powers of 10^3 (one thousand) from 10^{30} (quetta) to 10^{-30} (quecto). Unit prefixes are commonly used within this work and form an essential tool for the unitary system. The full prefix system can be found within the companion sheet selection.

Time Unitary Conventions

Due to the SI extension described above, five units of time are analogous within this work. For this reason a convention has been implemented to enable consistency and transparency. Where a time period shorter than 1 minute (min) acts as numerical data, the second (s) is preferred for all uses with appropriate SI prefixes. For data between 60 seconds and 1 hour (h), the minute should be used exclusive of SI prefixes and, similarly, data between 60 minutes and 1 day (d) will be listed using the hour also excluding SI prefixes. For a period of 24 hours to 1 year (a), the day is preferred and must not be used with SI prefixes and for periods extending beyond 365.25 days, the year will be used alongside appropriate SI prefixes.

The second may be used as the SI base unit or the year as the largest unit of time to standardise numerical data within table columns and rows or graphs to prevent the use of time units within each table cell or graphical point when the unit is explicitly stated with graphical axes titles or table header rows or columns.

A companion sheet has been provided to aid conversions between time units and in cases where maximum accuracy is required, the second must always be used due to its status as the SI base unit for time.

Typesetting

Within this work, formulae, equations, numerical data provided with units, and related constant and quantity symbols are indicated using the Cambria Math typeface (for example, the speed of light, c, is defined as $299\,792\,458\ \mathrm{m/s}$). Numerical values exclusive of units will inherit the document typeface. Symbols for constants and quantities will be placed into an oblique typeset whilst units are the only letters to be placed into a roman typeface. Note that superscript, subscript and greek letters, characters and symbols are always placed into a roman typeface.

When numerical data is presented, groups of three digits are separated by white space delimiters in both the integer and fractional elements of numbers. For example, the number 1875402548.55834 is written as 1 875 402 548.558 34 to allow for subitizing. This is official policy accepted for use by many institutions including BIPM[ix].

Companion Sheets

Companion sheets for either the SI or the SI extension within this work can be found under section C. Some companion sheets have been provided for non-SI units that have not been outlined and defined in this statement to enable the international use of this work.

---

[i] BIPM. (2019). Le Système International d'Unités / The International System of Units (9th ed). Bureau international des poids et mesures. `http://www.bipm.org/en/si/si_brochure`

[ii] BIPM. (2008). JCGM 100:2008 Evaluation of Measurement Data—Guide to the Expression of Uncertainty in Measurement. Bureau International des Poids et Mesures. `https://www.iso.org/sites/JCGM/GUM/JCGM100/C045315e-html/C045315e.html?csnumber=50461`

[iii] BIPM. (2012). JCGM 200:2012 International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM) (3rd ed). Bureau International des Poids et Mesures. `https://www.bipm.org/documents/20126/2071204/JCGM_200_2012.pdf/f0e1ad45-d337-bbeb-53a6-15fe649d0ff1`

[iv] NIST. (2017). Uncertainty of Measurement Results from NIST. `https://physics.nist.gov/cuu/Uncertainty/index.html`

[v] Wilkins, G. A. & International Astronomical Union. (1989). The IAU Style Manual: The Preparation of Astronomical Papers and Reports. `https://www.iau.org/static/publications/stylemanual1989.pdf`

[vi] CODATA & NIST. (2018). 2018 CODATA Recommended Values. The NIST Reference on Constants, Units, and Uncertainty. `https://physics.nist.gov/cuu/Constants`

[vii] ISO. (1975). ISO 2533:1975, Standard Atmosphere. International Organization for Standardization. `https://www.iso.org/obp/ui/#iso:std:iso:2533:ed-1:v1:en`

[viii][PUBLIC] U.S. Standard Atmosphere, 1976 (NOAA-S/T-76-1562). (1976). `https://ntrs.nasa.gov/citations/19770009539`

[ix] Wallard, A. & BIPM. (2004). Resolution 10 of the 22nd CGPM: Symbol for the Decimal Marker. Metrologia, 41(1), 99–108. `https://doi.org/10.1088/0026-1394/41/1/M01`

REPORT (B5)

D1 – Periodic Table of Elements

The full periodic table provided is the result of numerous iterations (all of which can be found in E1) and as such, the one chosen for the final product is representative of the highest degree of accuracy and clearly conveys the largest amount of information of all iterations. The information provided fits into the following categories: elemental numbers, electronic properties, chemical properties, physical properties, and other properties. These categories are explored in more detail below.

Elemental Numbers

The elemental numbers chosen were the atomic number (Z), mass number (A), and neutron number (N). The atomic number of any given element can be obtained experimentally using Moseley's law, which states that the characteristic K_α x-ray lines emitted by elements are related to the atomic number as seen in the following relationship:

$$v = A \cdot (Z - b)^2 \tag{1}$$

Where v is the frequency of the observed K_α x-ray emission line, A and b are constants: $A = \left(\frac{1}{1^2} - \frac{1}{2^2}\right) \cdot Rydberg\ frequency$ and $b = 1$, and Z is the atomic number. This relationship can thus be rearranged to find the atomic number, Z:

$$Z = \sqrt{\frac{v}{A}} + b \tag{2}$$

This relationship was first described by Henry Moseley in 1913 in the paper *The High-Frequency Spectra of the Elements*. The atomic numbers of the elements are now defined by the International Union of Pure and Applied Chemistry (IUPAC) and are equal to the proton number (n_p) of the ordinary nucleus of any given element. In any ordinary uncharged atom, the proton number will also be equal to the number of electrons.

The mass number of an ordinary atom can be obtained by finding the sum of both the atomic (Z) and neutron numbers (N), as described in the following equation:

$$A = Z + N \tag{3}$$

The mass number is always expressed in unified atomic mass units (unit: Da or u) which can be converted to kilograms (unit: kg) by multiplying by the atomic mass constant (m_u). The atomic mass constant was defined by CODATA in 2018 as $1.660\,539\,066\,60(50) \times 10^{-27}\ \mathrm{kg}$ and is equal to one-twelfth of the mass of an unbound neutral atom of carbon-12 in its nuclear and electronic ground state and at rest, as seen in the following equation:

$$m_\mathrm{u} = \frac{m(^{12}\mathrm{C})}{12} = 1\ \mathrm{Da} \tag{4}$$

Atomic mass numbers are defined by the Commission on Isotopic Abundances and Atomic Weights (CIAAW) and are rounded to the nearest whole unified atomic mass unit. In the case of elements where the atomic mass number falls closer to the midpoint of two whole number values (such as chlorine - $Z = 17$), the atomic mass number value has been provided rounded to half of a unified atomic mass unit ($\frac{1}{2}$ Da).

Finally, the neutron number (N) is the number of neutrons in any given nuclide. For an exact atom of an element according to the periodic table, equation 3 can be rearranged to find the neutron number as follows:

$$N = A - Z \tag{5}$$

This can be inferred as the difference between the mass and atomic numbers of an element and, as such, is defined by CIAAW and IUPAC due to their affiliation with both elemental numbers. The neutron number is rarely useful outside of nuclear physics and another common property derived from elemental numbers within this field is the neutron excess (D) which is the difference between the neutron number and the atomic number as seen in the below equation:

$$D = N - Z = A - 2Z \tag{6}$$

A nuclide's neutron excess is a good indicator of its nuclear stability as stable atoms tend to have more neutrons than protons with increasing atomic numbers and thus increasing neutron excesses. This relationship can be found in the below figure:

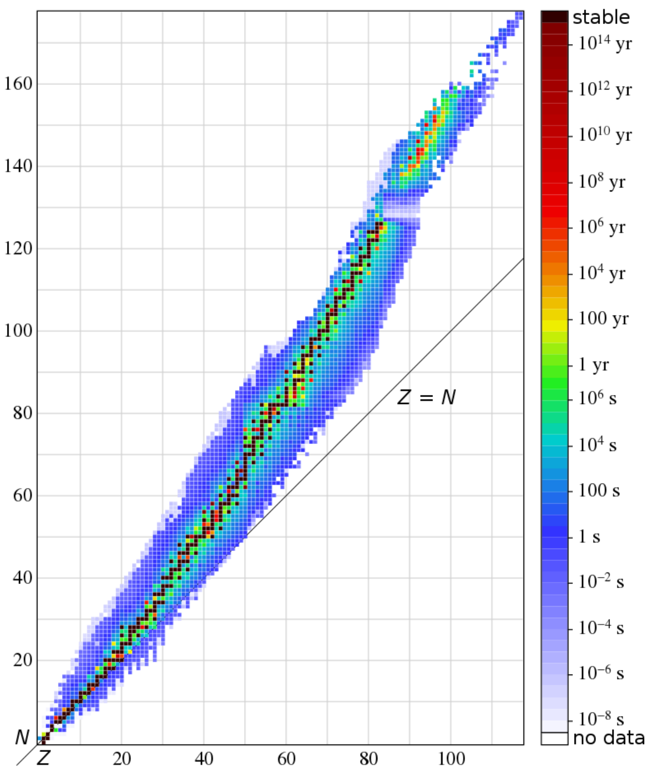


Figure 1: This diagram shows the half-life ($t_{1/2}$) of various nuclides related to their atomic number (Z) and their neutron number (N). $yr = a$The neutron excess can be calculated by finding the gradient of a tangent to a specific nuclide. Source: User: BenRG (wikimedia.org) – Public Domain.

Electronic Properties

The chosen electronic properties were the ionic charge, and electronic configuration (represented by coloured blocks on the table). The ionic charge is the range of net electrical charges that an ion of a given element can hold in normal conditions, excluding radioactive decay and synthetic procedures. This net charge is caused by an excess of protons or electrons within an atom and is the result of chemical activities between atoms and, by extension, the loss or gain of electrons. An ion with a net negative charge (electron excess) is called an anion whilst one with a net positive charge (proton excess) is called a cation. An important distinction must be made between ionic charge and oxidation states as the oxidation state is the hypothetical charge of an atom if all of its chemical bonds were ionic – describing the degree of oxidation of an atom in a chemical compound. Oxidation is the process whereby atoms lose electrons and reduction is the opposing process of electron gain. The periodic table merely lists ionic charge and not oxidation states.

Charged states can be denoted with the addition of superscript characters to chemical symbols. The net charge is written as either positive (+) or negative (-) proceeded by the magnitude if higher than one. For example, the ionic state of iron(II) is represented as Fe^{2+}, whilst fluorine can be represented as F^{-}.

It is ionic charges that account for all chemical processes as opposing electric charges act attractively. Furthermore, the process described above whereby an atom gains a net positive or negative charge is known as ionisation.

Within the table, the electronic configuration of an element can be obtained by first identifying the location of the element and then finding which shells and subshells are filled. The electronic shells are colour-coded, with the s-block coloured lilac, the p-block in rose, the d-block coloured light blue, and the f-block in yellow. Finally, count the element's position within the final electronic subshell and use this as the final value in the electronic configuration. Each subshell configuration can be written as the shell number (principal quantum number, n) followed by the subshell letter and the number of electrons is then placed in superscript. For example, phosphorus is in the 3p-subshell with 15 electrons, giving it an electronic configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$.

The electronic configurations of the elements are often abbreviated to place the previous noble gas in square brackets before the section of the configuration that is added to the noble gas. For example, phosphorus' abbreviated electronic configuration (see above) is [Ne] $3s^2\ 3p^3$ as neon and phosphorus share the $1s^2\ 2s^2\ 2p^6$ configuration section. The electronic subshell filling order according to Madelung's rule can be found diagrammatically below:

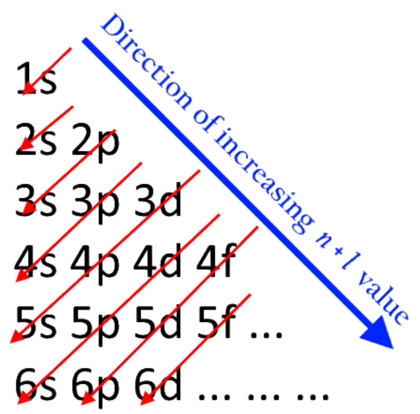


Figure 2: This diagram presents the electronic subshell filling order, first follow the blue arrow downwards, then the red ones. Source: User: Atchemey (wikimedia.org) – CC BY-SA 4.0.

Madelung's rule states that subshells are filled in the order of increasing $n + \ell$ and where two subshells have the same $n + \ell$ value, an order of increasing n is preferred. n is the principle quantum number and is indicative of the electron shell number that a given electron resides within, values currently range from 1 to 7 and, for any element, the highest electron valency has an n value equal to the element's period in the periodic table. ℓ is the azimuthal quantum number and determines the orbital of any given electron, equated to a letter s, p, d or f – where s is assigned a ℓ value of 0 and f is assigned a value of 3.

Each azimuthal quantum number equivalent letter can hold a set number of electrons, calculated by the below formula:

$$number\ of\ electrons\ in\ subshell = 2(2\ell + 1)$$

COMMON UNIT CONVERSIONS (C1)

Unit	Unit Symbol	Quantity	Equation Expressed in Terms of SI Base Units	Equation Expressed in Terms of Other Units
Degree Celsius	$°\mathrm{C}$	Celsius Temperature	$x\ °\mathrm{C} = x\ \mathrm{K}$, where $-273.15\ °\mathrm{C} \equiv 0\ \mathrm{K}$	$x\ °\mathrm{C} \equiv (x - 32) \times \frac{5}{9}\ °\mathrm{F}$
Atomic Mass Unit	u Da	Atomic Mass	$x\ \mathrm{u} \equiv 1.660\ 539\ 066\ 60(50) \times 10^{-27} x\ \mathrm{kg}$	-
Atmospheric Pressure	atm	Atmospheric Pressure of Earth	$x\ \mathrm{atm} \equiv 101\ 325 x\ \mathrm{Pa}$	-
Electronvolt (Mass)	$\mathrm{eV/c^2}$	Mass	$x\ \mathrm{eV/c^2} \equiv 1.782\ 661\ 92 \times 10^{-36} x\ \mathrm{kg}$	$x\ \mathrm{eV/c^2} \equiv 1.073\ 544\ 102\ 33(32) \times 10^{-9} x\ \mathrm{u}$
Electronvolt (Energy)	eV	Energy	$x\ \mathrm{eV} \equiv 1.602\ 176\ 634 \times 10^{-19} x\ \mathrm{J}$	-
Elementary Charge	e	Charge	$x\ e \equiv 1.602\ 176\ 634 \times 10^{-19} x\ \mathrm{C}$	-

Sources:

- Unit [1] [2] [3]
- Unit Symbol [1] [2] [3]
- Quantity [1] [2] [3]
- Equation Expressed in Terms of SI Base Units [1] [2] [3]
- Equation Expressed in Terms of Other Units [1] [3]

COMMON UNIT PREFIXES (C2)

Factor	Name	Symbol	Nominal Name
10^{30}	Quetta	Q	Nonillion
10^{27}	Ronna	R	Octillion
10^{24}	Yotta	Y	Septillion
10^{21}	Zetta	Z	Sextillion
10^{18}	Exa	E	Quintillion
10^{15}	Peta	P	Quadrillion
10^{12}	Tera	T	Trillion
10^{9}	Giga	G	Billion
10^{6}	Mega	M	Million
10^{3}	Kilo	k	Thousand
10^{2}	Hecto	h	Hundred
10^{1}	Deca	da	Ten
10^{0}			Unit
10^{-1}	Deci	d	Tenth
10^{-2}	Centi	c	Hundredth
10^{-3}	Milli	m	Thousandth
10^{-6}	Micro	μ	Millionth
10^{-9}	Nano	n	Billionth
10^{-12}	Pico	p	Trillionth
10^{-15}	Femto	f	Quadrillionth
10^{-18}	Atto	a	Quintillionth
10^{-21}	Zepto	z	Sextillionth
10^{-24}	Yocto	y	Septillionth
10^{-27}	Ronto	r	Octillionth
10^{-30}	Quecto	q	Nonillionth

Notes:

- The kilogram (kg) is anomalous within the SI prefix system as the base unit utilises the -kilo prefix. For unit conversions, consider the kilogram as 10^3 grams (g).

Sources:

- Factor [1] [2]
- Name [1] [2]
- Symbol [1] [2]
- Nominal Name [2]

COMMON TIME CONVERSIONS (C3)

Unit	Symbol	In Seconds	In Minutes	In Hours	In Days	In Years
Second	s	1				
Minute	min	60	1			
Hour	h	3 600	60	1		
Day	d	86 400	1440	24	1	
Year	a	31 557 600	525 960	8766	365.25	1

Notes:

- The month (mo) is a unit not generally accepted for scientific use due the variability in its value between 28 and 31 days (d), if its use is necessary an average value can be derived as 29.53 days.
- Year (a) multiples such as the decade, centuary and millenium should not be used, SI unit prefixes are preferred for this use case.

Sources:

- Unit [1] [2] [3]
- Symbol [1] [2] [3]
- Conversions [1] [2] [3]

COMMON FUNDAMENTAL PHYSICAL CONSTANTS (C4)

Constant	**Constant Symbol**	**Numerical Value**
Unperturbed Ground State Hyperfine Transition Frequency of the Caesium 133 Atom	Δv_{Cs}	$9\ 192\ 631\ 770\ \mathrm{Hz}$
Speed of Light in Vacuum	c	$299\ 792\ 458\ \mathrm{m/s}$
Planck Constant	h	$6.626\ 070\ 15 \times 10^{-34}\ \mathrm{J\ s}$
Elementary Charge	e	$1.602\ 176\ 634 \times 10^{-19}\ \mathrm{C}$
Boltzmann Constant	k	$1.380\ 649 \times 10^{-23}\ \mathrm{J/K}$
Avogadro Constant	N_{A}	$6.022\ 140\ 76 \times 10^{23}\ \mathrm{mol}^{-1}$
Luminous Efficacy of Monochromatic Radiation of Frequency $\mathbf{540 \times 10^{12}\ Hz}$	K_{cd}	$683\ \mathrm{lm/W}$
Standard Acceleration of Gravity	g_n	$9.806\ 65\ m/s^2$
Molar Mass Constant	M_u	$0.999\ 999\ 999\ 65(30) \times 10^{-3}\ \mathrm{kg/mol}$
Pi	π	$3.141\ 592\ 653\ 589\ 793$

Notes:

- Pi (π) is an irrational number with a supposed infinite number of decimal places, the first 12 decimal places provided are reccomended for use by NASA in a large number of applications. If a larger number of decimal places are required, they are readily available from many online locations. For most non-sensitive calculations, the value of pi can be considered as the numerical value 3.

Sources:

- Constant [1] [2] [4]
- Constant Symbol [1] [2] [4]
- Numerical Value [1] [2] [3] [4]

COMMON NON-SI UNIT CONVERSIONS (C5)

Unit	Unit Symbol	Quantity	Equation Expressed in Terms of SI Units	Equation Expressed in Terms of Other Units
Degree Fahrenheit	$°\mathrm{F}$	Fahrenheit Temperature	$x\ °\mathrm{F} \equiv \left(x \times \frac{9}{5} - 459.67\right)\mathrm{K}$	$x\ °\mathrm{F} \equiv \left(x \times \frac{9}{5} + 32\right)°\mathrm{C}$
Foot	ft	Length	$x\ \mathrm{ft} \equiv 0.304\ 8x\ \mathrm{m}$ [U.S. Survey] $x\ \mathrm{ft} \equiv 0.304\ 800\ 6x\ \mathrm{m}$	-
Inch	in	Length	$x\ \mathrm{in} \equiv 25.4x\ \mathrm{mm}$	-
Yard	yd	Length	$x\ \mathrm{yd} \equiv 0.914\ 4x\ \mathrm{m}$	-
Mile	mi	Length	$x\ \mathrm{mi} \equiv 1.609\ 344x\ \mathrm{km}$	$x\ \mathrm{mi} \equiv 5280x\ \mathrm{ft}$
Acre	ac acre	Area	$x\ \mathrm{ac} \equiv 4\ 046.873x\ \mathrm{m}^2$	-
Square Inch	in^2	Area	$x\ \mathrm{in}^2 \equiv 645.16x\ \mathrm{mm}^2$	-
Square Foot	ft^2	Area	$x\ \mathrm{ft}^2 \equiv 0.092\ 903\ 04x\ \mathrm{m}^2$	-
Square Yard	yd^2	Area	$x\ \mathrm{yd}^2 \equiv 0.836\ 127\ 36x\ \mathrm{m}^2$	-
Square Mile	mi^2	Area	$x\ \mathrm{mi}^2 \equiv 2.589\ 988x\ \mathrm{km}^2$	-
Gallon	gal	Volume	$x\ \mathrm{gal} \equiv 3.785\ 412x\ \mathrm{L}$	-
Quart	qt	Volume	$x\ \mathrm{qt} \equiv 0.946\ 352\ 9x\ \mathrm{L}$	-
Pint	pt	Volume	$x\ \mathrm{pt} \equiv 0.473\ 176\ 5x\ \mathrm{L}$	-
Fluid Ounce	$\mathrm{fl\ oz}$	Volume	$x\ \mathrm{fl\ oz} \equiv 29.573\ 53\ \mathrm{mL}$	-

Unit	Unit Symbol	Quantity	Equation Expressed in Terms of SI Units	Equation Expressed in Terms of Other Units
Mile per Hour	mph	Velocity	$x\ \mathrm{mph} \equiv 1.609\ 344x\ \mathrm{km/h}$	-
Ton (Short)	t	Mass	$x\ \mathrm{t} \equiv 907.184\ 74x\ \mathrm{kg}$	-
Pound (Avoirdupois)	lb	Mass	$x\ \mathrm{lb} \equiv 0.453\ 592\ 37x\ \mathrm{kg}$	-
Ounce (Avoirdupois)	oz	Mass	$x\ \mathrm{oz} \equiv 28.349\ 52x\ \mathrm{g}$	-
Bar	bar	Pressure	$x\ \mathrm{bar} \equiv 100x\ \mathrm{kPa}$	-
Pound-Force per Square Inch	psi	Pressure	$x\ \mathrm{psi} \equiv 6.894\ 757x\ \mathrm{kPa}$	-
Kilowatt-Hour	kWh	Energy	$x\ \mathrm{kWh} \equiv 3.6x\ \mathrm{MJ}$	-
Calorie (Nutrition)	cal	Energy	$x\ \mathrm{cal} \equiv 4.184x\ \mathrm{kJ}$	-
Horsepower	hp	Power	$x\ \mathrm{hp} \equiv 746x\ \mathrm{W}$	-
Angstrom	Å	Wavelength	$x\ \text{Å} \equiv 0.1x\ \mathrm{nm}$	-
Curie	Ci	Radioactivity	$x\ \mathrm{Ci} \equiv 37\ 000x\ \mathrm{MBq}$	-
Rad	rad	Absorbed Dose	$x\ \mathrm{rad} \equiv 0.01x\ \mathrm{Gy}$	-
Roentgen Equivalent Man	rem	Dose Equivalent	$x\ \mathrm{rem} \equiv 0.01x\ \mathrm{Sv}$	-
Roentgen	R	Exposure	$x\ \mathrm{R} \equiv 0.000\ 258x\ \mathrm{C/kg}$	-

Notes:

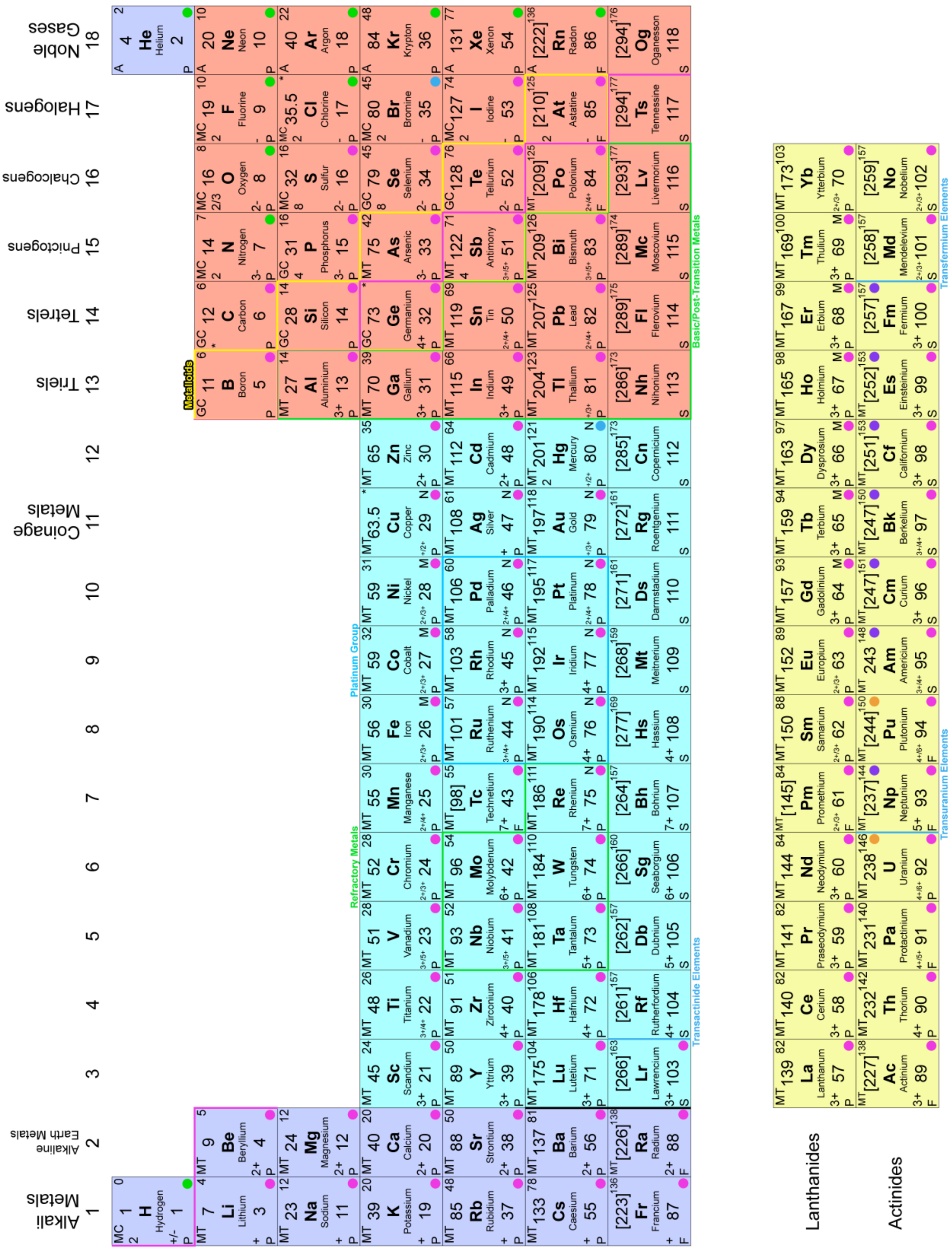
- The rad and radian share a common unit symbol, rad, for this reason the use of the rad is strongly discouraged and the gray (Gy) should instead be used as the unit for absorbed dose.

- Most units listed above are discouraged from use outside of the United States of America (U.S.) and conversion factors are only provided to convert to and from the U.S. customary system when communicating with the general public, all other uses – including U.S. scientific – are discouraged.

Sources:

- Unit [1] [2]
- Unit Symbol [1] [2]
- Quantity [1] [2]
- Equation Expressed in Terms of SI Units [1] [2]
- Equation Expressed in Terms of Other Units [1] [2]

PERIODIC TABLE OF ELEMENTS (D1)



Key:

Element Representation:

1		*N*
2	*A*	3
	Chemical Symbol	
	Element Name	
4	*Z*	6
5		7

1 Simple Substance Bonding (Symbols: **MT**, Metallic; **GC**, Giant Covalent; **MC**, Molecular Covalent; **A**, Single Atom)
2 Atomicity (if no number, only 1 atom is present)
N Neutron Number
3 Actinide Type (Symbols: ●, Major; ●, Minor)
A Mass Number (If bracketed, element is unstable and mass number of the most stable isotope is provided)
Z Atomic/Proton Number
4 Ionic Charge
5 Natural Occurrence (Symbols: **P**, Primordial; **F**, From Decay; **S**, Synthetic)
6 Additional Properties (Symbols: **M**, Ferromagnetic; **N**, Noble Metal)
7 State of Matter at Standard Temperature and Pressure[1] (Symbols: ●, Solid; ●, Liquid; ●, Gas)

Block Representation:

s p d f

Electron Shell Filling Order:

Source: User:Atchemey (wikimedia.org) – CC-BY-SA-4.0

Sources:

- Simple Substance Bonding, 1 [2] [3] [4] [5] [6] [10] [20]
- Atomicity, 2 [24]
- Neutron Number, *N* [12] [14] [15] [16] [26]
- Actinide Type, 3 [7]
- Mass Number, *A* [8] [12] [15] [16] [17] [19] [26]
- Chemical Symbol [8] [12] [15] [16] [17] [19] [26]
- Element Name [8] [12] [15] [17] [19] [26]
- Atomic/Proton Number, *Z* [8] [12] [15] [17] [19] [26]
- Ionic Charge, 4 [1] [11] [23] [26]
- Natural Occurrence, 5 [10] [16] [18] [21] [25] [26]
- Additional Properties, 6 [9] [13] [26]
- State of Matter at Standard Temperature and Pressure, 7 [19]
- Groups [8] [12] [25]
- Electron Configuration Blocks [8] [19 [25]

[1] Standard Temperature and Pressure (also abbreviated as NTP) is here defined as 293.15 K and 1 atm.

PROPERTIES OF ELEMENTS (D2)

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Hydrogen	H	1.007 825 032 230 (90)	1	$1s^1$	Gas	14.01	20.28
Helium	He	4.002 603 254 130 (60)	2	$1s^2$	Gas	0.00 [No solid state]	4.22
Lithium	Li	7.016 003 436 600 (4 500)	3	[He] $2s^1$	Solid	453.69	1 615.00
Beryllium	Be	9.012 183 065 000 (82 000)	4	[He] $2s^2$	Solid	1 560.00	2 743.00
Boron	B	11.009 305 360 000 (450 000)	5	[He] $2s^2$ $2p^1$	Solid	2 348.00	4 273.00
Carbon	C	12.000 000 000 000	6	[He] $2s^2$ $2p^2$	Solid	3 823.00	4 300.00
Nitrogen	N	14.003 074 004 430 (200)	7	[He] $2s^2$ $2p^3$	Gas	63.10	77.36
Oxygen	O	15.994 914 619 570 (170)	8	[He] $2s^2$ $2p^4$	Gas	54.80	90.20
Fluorine	F	18.998 403 162 730 (920)	9	[He] $2s^2$ $2p^5$	Gas	53.50	85.03
Neon	Ne	19.992 440 176 200 (1 700)	10	[He] $2s^2$ $2p^6$	Gas	24.56	27.07
Sodium	Na	22.989 769 282 000 (1 900)	11	[Ne] $3s^1$	Solid	370.87	1 156.00
Magnesium	Mg	23.985 041 697 000 (14 000)	12	[Ne] $3s^2$	Solid	923.00	1 363.00
Aluminium	Al	26.981 538 530 000 (110 000)	13	[Ne] $3s^2$ $3p^1$	Solid	933.47	2 792.00

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Silicon	Si	27.976 926 534 650 (440)	14	[Ne] $3s^2$ $3p^2$	Solid	1 687.00	3 200.00
Phosphorus	P	30.973 761 998 420 (700)	15	[Ne] $3s^2$ $3p^3$	Solid	317.30 [Yellow]	553.60 [Yellow]
Sulfur	S	31.972 071 174 400 (1 400)	16	[Ne] $3s^2$ $3p^4$	Solid	388.36	717.87
Chlorine	Cl	34.968 852 682 000 (37 000)	17	[Ne] $3s^2$ $3p^5$	Gas	171.70	239.11
Argon	Ar	39.962 383 123 700 (2 400)	18	[Ne] $3s^2$ $3p^6$	Gas	83.80	87.40
Potassium	K	38.963 706 486 400 (4 900)	19	[Ar] $4s^1$	Solid	336.53	1 032.00
Calcium	Ca	39.962 590 863 000 (22 000)	20	[Ar] $4s^2$	Solid	1 115.00	1 757.00
Scandium	Sc	44.955 908 280 000 (770 000)	21	[Ar] $3d^1$ $4s^2$	Solid	1 814.00	3 103.00
Titanium	Ti	47.947 941 980 000 (380 000)	22	[Ar] $3d^2$ $4s^2$	Solid	1 941.00	3 560.00
Vanadium	V	50.943 957 040 000 (940 000)	23	[Ar] $3d^3$ $4s^2$	Solid	2 183.00	3 680.00
Chromium	Cr	51.940 506 230 000 (630 000)	24	[Ar] $3d^5$ $4s^1$	Solid	2 180.00	2 944.00
Manganese	Mn	54.938 043 910 000 (480 000)	25	[Ar] $3d^5$ $4s^2$	Solid	1 519.00	2 334.00
Iron	Fe	55.934 936 330 000 (490 000)	26	[Ar] $3d^6$ $4s^2$	Solid	1 811.00	3 134.00
Cobalt	Co	58.933 194 290 000 (560 000)	27	[Ar] $3d^7$ $4s^2$	Solid	1 768.00	3 200.00

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Nickel	Ni	57.935 342 410 000 (520 000)	28	[Ar] $3d^8$ $4s^2$	Solid	1 728.00	3 186.00
Copper	Cu	62.929 597 720 000 (560 000)	29	[Ar] $3d^{10}$ $4s^1$	Solid	1 357.77	2 835.00
Zinc	Zn	63.929 142 010 000 (710 000)	30	[Ar] $3d^{10}$ $4s^2$	Solid	692.68	1 180.00
Gallium	Ga	68.925 573 500 000 (1 300 000)	31	[Ar] $3d^{10}$ $4s^2$ $4p^1$	Solid	302.91	2 477.00
Germanium	Ge	73.921 177 761 000 (13 000)	32	[Ar] $3d^{10}$ $4s^2$ $4p^2$	Solid	1 211.00	3 093.00
Arsenic	As	74.921 594 570 000 (950 000)	33	[Ar] $3d^{10}$ $4s^2$ $4p^3$	Solid	1 090.00	887.00
Selenium	Se	79.916 521 800 000 (1 300 000)	34	[Ar] $3d^{10}$ $4s^2$ $4p^4$	Solid	494.00	958.00
Bromine	Br	78.918 337 600 000 (1 400 000)	35	[Ar] $3d^{10}$ $4s^2$ $4p^5$	Liquid	265.80	332.00
Krypton	Kr	83.911 497 728 200 (4 400)	36	[Ar] $3d^{10}$ $4s^2$ $4p^6$	Gas	115.79	119.93
Rubidium	Rb	84.911 789 737 900 (5 400)	37	[Kr] $5s^1$	Solid	312.46	961.00
Strontium	Sr	87.905 612 500 000 (1 200 000)	38	[Kr] $5s^2$	Solid	1 050.00	1 655.00
Yttrium	Y	88.905 840 300 000 (2 400 000)	39	[Kr] $4d^1$ $5s^2$	Solid	1 799.00	3 618.00
Zirconium	Zr	89.904 697 700 000 (2 000 000)	40	[Kr] $4d^2$ $5s^2$	Solid	2 128.00	4 682.00
Niobium	Nb	92.906 373 000 000 (2 000 000)	41	[Kr] $4d^4$ $5s^1$	Solid	2 750.00	5 017.00

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Molybdenum	Mo	97.905 404 820 000 (490 000)	42	[Kr] $4d^5$ $5s^1$	Solid	2 896.00	4 912.00
Technetium	Tc	[96.906 366 7(40), 98.906 250 8(10)]	43	[Kr] $4d^5$ $5s^2$	Solid	2 430.00	4 538.00
Ruthenium	Ru	101.904 344 100 000 (1 200 000)	44	[Kr] $4d^7$ $5s^1$	Solid	2 607.00	4 423.00
Rhodium	Rh	102.905 498 000 000 (2 600 000)	45	[Kr] $4d^8$ $5s^1$	Solid	2 237.00	3 968.00
Palladium	Pd	105.903 480 400 000 (1 200 000)	46	[Kr] $4d^{10}$	Solid	1 828.00	3 236.00
Silver	Ag	106.905 091 600 000 (2 600 000)	47	[Kr] $4d^{10}$ $5s^1$	Solid	1 234.90	2 435.00
Cadmium	Cd	113.903 365 090 000 (430 000)	48	[Kr] $4d^{10}$ $5s^2$	Solid	594.22	1 040.00
Indium	In	114.903 878 776 000 (12 000)	49	[Kr] $4d^{10}$ $5s^2$ $5p^1$	Solid	429.80	2 345.00
Tin	Sn	119.902 201 630 000 (970 000)	50	[Kr] $4d^{10}$ $5s^2$ $5p^2$	Solid	505.08	2 875.00
Antimony	Sb	120.903 812 000 000 (3 000 000)	51	[Kr] $4d^{10}$ $5s^2$ $5p^3$	Solid	903.78	1 860.00
Tellurium	Te	129.906 222 748 000 (12 000)	52	[Kr] $4d^{10}$ $5s^2$ $5p^4$	Solid	722.66	1 261.00
Iodine	I	126.904 471 900 000 (3 900 000)	53	[Kr] $4d^{10}$ $5s^2$ $5p^5$	Solid	386.90	457.50
Xenon	Xe	131.904 155 085 600 (5 600)	54	[Kr] $4d^{10}$ $5s^2$ $5p^6$	Gas	161.30	165.00
Caesium	Cs	132.905 451 961 000 (8 000)	55	[Xe] $6s^1$	Solid	301.59	944.00

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Barium	Ba	137.905 247 000 000 (310 000)	56	[Xe] $6s^2$	Solid	1 000.00	2 143.00
Lanthanum	La	138.906 356 300 000 (2 400 000)	57	[Xe] $5d^1$ $6s^2$	Solid	1 193.00	3 737.00
Cerium	Ce	139.905 443 100 000 (2 300 000)	58	[Xe] $4f^1$ $5d^1$ $6s^2$	Solid	1 071.00	3 633.00
Praseodymium	Pr	140.907 657 600 000 (2 300 000)	59	[Xe] $4f^3$ $6s^2$	Solid	1 204.00	3 563.00
Neodymium	Nd	141.907 729 000 000 (2 000 000)	60	[Xe] $4f^4$ $6s^2$	Solid	1 294.00	3 400.00
Promethium	Pm	[144.912 755 9(33), 146.915 145 0(19)]	61	[Xe] $4f^5$ $6s^2$	Solid	1 400.00	3 300.00
Samarium	Sm	151.919 739 700 000 (1 800 000)	62	[Xe] $4f^6$ $6s^2$	Solid	1 345.00	2 067.00
Europium	Eu	152.921 238 000 000 (1 800 000)	63	[Xe] $4f^7$ $6s^2$	Solid	1 095.00	1 800.00
Gadolinium	Gd	157.924 112 300 000 (1 700 000)	64	[Xe] $4f^7$ $5d^1$ $6s^2$	Solid	1 586.00	3 523.00
Terbium	Tb	158.925 354 700 000 (1 900 000)	65	[Xe] $4f^9$ $6s^2$	Solid	1 629.00	3 503.00
Dysprosium	Dy	163.929 181 900 000 (2 000 000)	66	[Xe] $4f^{10}$ $6s^2$	Solid	1 685.00	2 840.00
Holmium	Ho	164.930 328 800 000 (2 100 000)	67	[Xe] $4f^{11}$ $6s^2$	Solid	1 747.00	2 973.00
Erbium	Er	165.930 299 500 000 (2 200 000)	68	[Xe] $4f^{12}$ $6s^2$	Solid	1 770.00	3 141.00
Thulium	Tm	168.934 217 900 000 (2 200 000)	69	[Xe] $4f^{13}$ $6s^2$	Solid	1 818.00	2 223.00

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Ytterbium	Yb	173.938 866 400 000 (2 200 000)	70	[Xe] $4f^{14}$ $6s^2$	Solid	1 092.00	1 469.00
Lutetium	Lu	174.940 775 200 000 (2 000 000)	71	[Xe] $4f^{14}$ $5d^1$ $6s^2$	Solid	1 936.00	3 675.00
Hafnium	Hf	179.946 557 000 000 (2 000 000)	72	[Xe] $4f^{14}$ $5d^2$ $6s^2$	Solid	2 506.00	4 876.00
Tantalum	Ta	180.947 995 800 000 (2 000 000)	73	[Xe] $4f^{14}$ $5d^3$ $6s^2$	Solid	3 290.00	5 731.00
Tungsten	W	183.950 930 920 000 (940 000)	74	[Xe] $4f^{14}$ $5d^4$ $6s^2$	Solid	3 695.00	5 828.00
Rhenium	Re	186.955 750 100 000 (1 600 000)	75	[Xe] $4f^{14}$ $5d^5$ $6s^2$	Solid	3 459.00	5 896.00
Osmium	Os	191.961 477 000 000 (2 900 000)	76	[Xe] $4f^{14}$ $5d^6$ $6s^2$	Solid	3 306.00	5 285.00
Iridium	Ir	192.962 921 600 000 (2 100 000)	77	[Xe] $4f^{14}$ $5d^7$ $6s^2$	Solid	2 739.00	4 701.00
Platinum	Pt	194.964 791 700 000 (1 000 000)	78	[Xe] $6s^1$ $4f^{14}$ $5d^9$	Solid	2 041.50	4 098.00
Gold	Au	196.966 568 790 000 (710 000)	79	[Xe] $4f^{14}$ $5d^{10}$ $6s^1$	Solid	1 337.33	3 129.00
Mercury	Hg	201.970 643 400 000 (690 000)	80	[Xe] $4f^{14}$ $5d^{10}$ $6s^2$	Liquid	234.32	629.88
Thallium	Tl	204.974 427 800 000 (1 400 000)	81	[Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^1$	Solid	577.00	1 746.00
Lead	Pb	207.976 652 500 000 (1 300 000)	82	[Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^2$	Solid	600.61	2 022.00
Bismuth	Bi	208.980 399 100 000 (1 600 000)	83	[Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^3$	Solid	544.40	1 837.00

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Polonium	Po	[208.982 430 8(20), 209.982 874 1(13)]	84	[Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^4$	Solid	527.00	1 235.00
Astatine	At	[209.987 147 9(83), 210.987 496 6(30)]	85	[Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^5$	Solid	575.00	-
Radon	Rn	[210.990 601 1(73), 222.017 578 2(25)]	86	[Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^6$	Gas	202.00	211.40
Francium	Fr	223.019 736 000 000 (2 500 000)	87	[Rn] $7s^1$	Solid	-	-
Radium	Ra	[223.018 502 3(27), 228.031 070 7(26)]	88	[Rn] $7s^2$	Solid	970.00	2 010.00
Actinium	Ac	227.027 752 300 000 (2 500 000)	89	[Rn] $6d^1$ $7s^2$	Solid	1 323.00	3 473.00
Thorium	Th	232.038 055 800 000 (2 100 000)	90	[Rn] $6d^2$ $7s^2$	Solid	2 023.00	5 093.00
Protactinium	Pa	231.035 884 200 000 (2 400 000)	91	[Rn] $5f^2$ $6d^1$ $7s^2$	Solid	1 845.00	4 273.00
Uranium	U	238.050 788 400 000 (2 000 000)	92	[Rn] $5f^3$ $6d^1$ $7s^2$	Solid	1 408.00	4 200.00
Neptunium	Np	[236.046 570(54), 237.048 173 6(19)]	93	[Rn] $5f^4$ $6d^1$ $7s^2$	Solid	917.00	4 300.00
Plutonium	Pu	[238.049 560 1(19), 244.064 205 3(56)]	94	[Rn] $5f^6$ $7s^2$	Solid	913.00	3 503.00
Americium	Am	[241.056 829 3(19), 243.061 381 3(24)]	95	[Rn] $5f^7$ $7s^2$	Solid	1 449.00	2 284.00
Curium	Cm	[243.061 389 3(22), 248.072 349 9(56)]	96	[Rn] $5f^7$ $6d^1$ $7s^2$	Solid	1 618.00	3 383.00
Berkelium	Bk	[247.070 307 3(59), 249.074 987 7(27)]	97	[Rn] $5f^9$ $7s^2$	Solid	1 323.00 [alpha]	-

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Californium	Cf	[249.074 853 9(23), 252.081 627 2(56)]	98	[Rn] $5f^{10}$ $7s^2$	Solid	1 173.00	-
Einsteinium	Es	252.082 980 000 000 (54 000 000)	99	[Rn] $5f^{11}$ $7s^2$	Solid	1 133.00	-
Fermium	Fm	257.095 106 100 000 (6 900 000)	100	[Rn] $5f^{12}$ $7s^2$	-	1 800.00	-
Mendelevium	Md	[258.098 431 5(50), 260.103 65(34#)]	101	[Rn] $5f^{13}$ $7s^2$	-	1 100.00	-
Nobelium	No	259.101 030 000 000 (110 000 000#)	102	[Rn] $5f^{14}$ $7s^2$	-	1 100.00	-
Lawrencium	Lr	262.109 610 000 000 (220 000 000#)	103	[Rn] $5f^{14}$ $7s^2$ $7p^1$	-	1 900.00	-
Rutherfordium	Rf	267.121 790 000 000 (620 000 000#)	104	[Rn] $5f^{14}$ $6d^2$ $7s^2$	-	-	-
Dubnium	Db	268.125 670 000 000 (570 000 000#)	105	[Rn] $5f^{14}$ $6d^3$ $7s^2$	-	-	-
Seaborgium	Sg	271.133 930 000 000 (630 000 000#)	106	[Rn] $5f^{14}$ $6d^4$ $7s^2$	-	-	-
Bohrium	Bh	272.138 260 000 000 (580 000 000#)	107	[Rn] $5f^{14}$ $6d^5$ $7s^2$	-	-	-
Hassium	Hs	270.134 290 000 000 (270 000 000#)	108	[Rn] $5f^{14}$ $6d^6$ $7s^2$	-	-	-
Meitnerium	Mt	276.151 590 000 000 (590 000 000#)	109	[Rn] $5f^{14}$ $6d^7$ $7s^2$	-	-	-
Darmstadtium	Ds	281.164 510 000 000 (590 000 000#)	110	[Rn] $5f^{14}$ $6d^9$ $7s^1$	-	-	-
Roentgenium	Rg	280.165 140 000 000 (610 000 000#)	111	[Rn] $5f^{14}$ $6d^{10}$ $7s^1$	-	-	-

Chemical Element Name	Chemical Symbol	Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]	Atomic Number *Z*	Abbreviated Electron Configuration/ Ground Shells	State of Matter at STP	Melting Point/ Liquefaction Point at 1 atm [K]	Boiling Point at 1 atm [K]
Copernicium	Cn	285.177 120 000 000 (600 000 000#)	112	[Rn] $5f^{14}$ $6d^{10}$ $7s^2$	-	-	-
Nihonium	Nh	284.178 730 000 000 (620 000 000#)	113	[Rn] $5f^{14}$ $6d^{10}$ $7s^2$ $7p^1$	-	-	-
Flerovium	Fl	289.190 420 000 000 (600 000 000#)	114	[Rn] $5f^{14}$ $6d^{10}$ $7s^2$ $7p^2$	-	-	-
Moscovium	Mc	288.192 740 000 000 (620 000 000#)	115	[Rn] $5f^{14}$ $6d^{10}$ $7s^2$ $7p^3$	-	-	-
Livermorium	Lv	293.204 490 000 000 (600 000 000#)	116	[Rn] $5f^{14}$ $6d^{10}$ $7s^2$ $7p^4$	-	-	-
Tennessine	Ts	292.207 460 000 000 (750 000 000#)	117	[Rn] $5f^{14}$ $6d^{10}$ $7s^2$ $7p^5$	-	-	-
Oganesson	Og	294.213 920 000 000 (710 000 000#)	118	[Rn] $5f^{14}$ $6d^{10}$ $7s^2$ $7p^6$	-	-	-

Abbreviations and Notes:

- Uncertainty: Provided in Concise Form (1σ)
- [] (Relative Atomic Mass): No Stable Isotope Observed, Range of Isotopic Masses Provided
- # (Relative Atomic Mass): Value Partially Derived from Trends from the Mass Surface (TMS)
- [] (Abbreviated Electron Configuration/Ground Shells): Designations Used,
  - **[He]** $1s^2$
  - **[Ne]** $1s^2\ 2s^2\ 2p^6$
  - **[Ar]** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
  - **[Kr]** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$
  - **[Xe]** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6$
  - **[Rn]** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6\ 4f^{14}\ 5d^{10}\ 6s^2\ 6p^6$
- STP: Standard Temperature and Pressure (also abbreviated as NTP)[2]

Units:

- atm: Atmospheric Pressure
- Pa: Pascal
- K: Kelvin
- u or Da: Unified Atomic Mass Unit

Sources:

- Chemical Element Name [6] [10] [13] [17]

[2] Standard Temperature and Pressure (also abbreviated as NTP) is here defined as 293.15 K and 1 atm.

- Chemical Symbol [6] [10] [13] [17]
- Relative Atomic Mass of Isotope with Highest Isotopic Abundance, A_r [1] [4] [5] [10] [13] [14] [20] [21]
- Atomic Number, *Z* [6] [10] [13] [17]
- Abbreviated Electron Configuration/Ground Shells [2] [3] [7] [8] [9] [11] [12] [15] [16] [18] [19] [20] [21]
- State of Matter/Phase at STP [14] [17] [20] [21]
- Melting Point/Liquefaction Point at STP [14] [17] [20] [21]
- Boiling Point at STP [14] [17] [20] [21]

PROPERTIES OF NUCLIDES (D3)

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
			Hydrogen				
^{1}H Protium	-	1	0	1.007 825 032 23(9)	**Stable**		0.999 885(70)
^{2}H Deuterium	-	1	1	2.014 101 778 12(12)	**Stable**		0.000 115(70)
^{3}H Tritium	**^{3}He**	1	2	3.016 049 277 9(24)	12.32 a	β^-	Trace
^{4}H	^{3}H	1	3	4.026 43(11)	99.1 739 130 434 8 ys	n	-
^{5}H	^{3}H	1	4	5.035 311(96)	80.035 087 719 3 ys	2n	-
^{6}H	^{5}H	1	5	6.044 96(27)	290 ys	n	-
	^{3}H					3n	
	^{2}H					4n	
^{7}H	^{3}H	1	6	7.052 7(11#)	23 ys	4n	-
			Helium				
^{2}He	**2 ^{1}H**	2	0	2.015 894(2)	$\ll 10^{-9}$ s	p (> 99.99%)	-
	^{2}H					β^+ (< 0.01%)	
^{3}He	-	2	1	3.016 029 320 1(25)	**Stable**		0.000 001 34(3)
^{4}He	-	2	2	4.002 603 254 13(6)	**Stable**		0.999 998 66(3)
^{5}He	^{4}He	2	3	5.012 057(21)	760.333 333 333 3 ys	n	-
^{6}He	**^{6}Li**	2	4	6.018 885 891(57)	806.92 ms	β^- (99.99%)	-
	^{4}He					β^-, α (0.000 28%)	
^{7}He	^{6}He	2	5	7.027 990 7(81)	3.041 333 333 333 zs	n	-
^{8}He	^{8}Li	2	6	8.033 934 390(95)	119.5 ms	β^- (83.0%)	-
	^{7}Li					β^-, n (16.1%)	
	^{5}He					β^-, fission (0.9%)	
^{9}He	^{8}He	2	7	9.043 946(50)	2.5 zs	n	-
^{10}He	^{8}He	2	8	10.052 79(11)	1.520 666 666 667 zs	2n	-
			Lithium				
^{3}Li	^{2}He	3	0	3.030 8(21#)	-	p	-
^{4}Li	**^{3}He**	3	1	4.027 19(23)	75.655 058 043 12 ys	p	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{5}Li	^{4}He	3	2	5.012 538(54)	304.133 333 333 3 ys	p	-
^{6}Li	-	3	3	6.015 122 887 4(16)	**Stable**		0.075 9(4)
^{7}Li	-	3	4	7.016 003 436 6(45)	**Stable**		0.924 1(4)
^{8}Li	^{8}Be	3	5	8.022 486 246(50)	838.7 ms	β^-	-
	^{4}He					β^-, α	
^{9}Li	^{8}Be	3	6	9.026 790 19(20)	178.2 ms	β^-, n (50.8%)	-
	^{9}Be					β^- (49.2%)	
^{10}Li	^{9}Li	3	7	10.035 483(14)	2 zs	n	-
^{11}Li	^{10}Be	3	8	11.043 723 58(66)	8.75 ms	β^-, n (86.3%)	-
	^{11}Be					β^- (5.978%)	
	^{9}Be					β^-, 2n (4.1%)	
	^{8}Be					β^-, 3n (1.9%)	
	^{7}He					β^-, α (1.7%)	
	^{6}He					β^-, n, α	
	^{8}Li					β^-, fission (0.009%)	
	^{9}Li					β^-, fission (0.013%)	
^{12}Li	^{11}Li	3	9	12.052 517(16)	10 ns	n	-
^{13}Li	^{11}Li	3	10	13.062 63(38)	3.3 zs	2n	-
Beryllium							
^{5}Be	^{4}Li	4	1	5.039 9(22#)	-	p	-
^{6}Be	**^{4}He**	4	2	6.019 726 4(58)	5 zs	2p	-
^{7}Be	**^{7}Li**	4	3	7.016 928 717(76)	53.217 592 592 59 d	ε	Trace
^{8}Be	**^{4}He**	4	4	8.005 305 102(37)	81.903 052 064 63 as	α	-
^{9}Be	-	4	5	9.012 183 065(82)	**Stable**		1.000 000(00)
^{10}Be	**^{10}B**	4	6	10.013 534 695(86)	1 512.557 077 626 ka	β^-	Trace
^{11}Be	**^{11}B**	4	7	11.021 661 08(26)	13.76 s	β^- (97.1%)	-
	^{7}Li					β^-, α (2.9%)	
^{12}Be	^{12}B	4	8	12.026 922 1(20)	21.46 ms	β^- (99.5%)	-
	^{11}B					β^-, n (0.5%)	
^{13}Be	^{12}Be	4	9	13.036 135(11)	1 zs	n	-
^{14}Be	^{13}B	4	10	14.042 89(14)	4.53 ms	β^-, n (98.0%)	-

Nuclide	**Daughter Nuclide/ Decay Product**	**Atomic Number *Z***	**Neutron Number *N***	**Isotopic Mass (Uncertainty) [u or Da]**	**Half-Life (Uncertainty)**	**Decay Mode (Probability)**	**Natural Abundance (Uncertainty) [mole fraction]**
					Stable Nuclide		
	^{14}B					β^- (1.2%)	
	^{12}B					β^-, 2n (0.8%)	
	^{11}B					β^-, 3n (0.2%)	
	^{11}Be					β^-, fission (0.02%)	
	^{10}Li					β^-, α (0.004%)	
^{15}Be	^{14}Be	4	11	15.053 42(43#)	790 ys	n	-
^{16}Be	^{14}Be	4	12	16.061 67(18)	650 ys	2n	-
Boron							
^{6}B	^{4}Li	5	1	6.050 8(22#)	-	2p	-
^{7}B	^{6}Be	5	2	7.029 712(27)	325.857 142 857 1 ys	p	-
^{8}B	**2 ^{4}He**	5	3	8.024 607 3(11)	770(3) ms	β^+, α	-
^{9}B	**2 ^{4}He**	5	4	9.013 329 65(97)	844.814 814 814 8 zs	p, α	-
	^{8}Be					p	
^{10}B	-	5	5	10.012 936 95(41)	**Stable**		0.199(7)
^{11}B	-	5	6	11.009 305 36(45)	**Stable**		0.801(7)
^{12}B	**^{12}C**	5	7	12.014 352 7(14)	20.20(2) ms	β^- (98.4%)	-
	^{8}Be					β^-, α (1.6%)	
^{13}B	**^{13}C**	5	8	13.017 780 2(12)	17.33(17) ms	β^- (99.72%)	-
	^{12}C					β^-, n (0.28%)	
^{14}B	^{14}C	5	9	14.025 404(23)	12.5(5) ms	β^- (93.96%)	-
	^{13}C					β^-, n (6.04%)	
^{15}B	^{14}C	5	10	15.031 088(23)	9.93(7) ms	β^-, n (93.6%)	-
	^{15}C					β^- (6.0%)	
	^{13}C					β^-, 2n (0.4%)	
^{16}B	^{15}B	5	11	16.039 842(26)	> 4.6 zs	n	-
^{17}B	^{16}C	5	12	17.046 99(18)	5.08(5) ms	β^-, n (63.0%)	-
	^{17}C					β^- (63.0%)	
	^{15}C					β^-, 2n (11.0%)	
	^{14}C					β^-, 3n (3.5%)	
	^{13}C					β^-, 4n (0.4%)	
^{18}B	^{17}B	5	13	18.055 66(18)	< 26 ns	n	-
^{19}B	^{18}C	5	14		2.92(13) ms	β^-, n (71.0%)	-

Nuclide	**Daughter Nuclide/ Decay Product**	**Atomic Number *Z***	**Neutron Number *N***	**Isotopic Mass (Uncertainty) [u or Da]**	**Half-Life (Uncertainty)**	**Decay Mode (Probability)**	**Natural Abundance (Uncertainty) [mole fraction]**
					Stable Nuclide		
	^{17}C			19.063 10(43#)		β^-, 2n (17.0%)	
	^{19}C					β^- (12%)	
^{20}B	^{19}B	5	15	20.072 07(75#)	-	n	-
^{21}B	^{19}B	5	16	21.081 29(97#)	< 260 ns	2n	-
Carbon							
^{8}C	^{6}Be	6	2	8.037 643(20)	3.5(1.4) zs	2p	-
^{9}C	^{9}B	6	3	9.031 037 2(23)	126.5(9) ms	β^+ (60.0%)	-
	^{8}Be					β^+, p (23.0%)	
	^{5}Li					β^+, α (17.0%)	
^{10}C	**^{10}B**	6	4	10.016 853 31(42)	19.300 9(17) s	β^+	-
^{11}C	**^{11}B**	6	5	11.011 433 6(10)	20.364(14) min	β^+ (99.79%)	-
	^{11}B					ε (0.21%)	
^{12}C	-	6	6	12.000 000 000(00)	**Stable**		0.989 3(8)
^{13}C	-	6	7	13.003 354 835 07(23)	**Stable**		0.010 7(8)
^{14}C	**^{14}N**	6	8	14.003 241 988 4(40)	570 7.762 557 078 a	β^-	Trace
^{15}C	**^{15}N**	6	9	15.010 599 26(86)	2.449(5) s	β^-	-
^{16}C	**^{15}N**	6	10	16.014 701 3(38)	747(8) ms	β^-, n (97.9%)	-
	^{16}N					β^- (2.1%)	
^{17}C	^{17}N	6	11	17.022 577(19)	193(5) ms	β^- (71.6%)	-
	^{16}N					β^-, n (28.4%)	
^{18}C	^{18}N	6	12	18.026 751(32)	92(2) ms	β^- (68.5%)	-
	^{17}N					β^-, n (31.5%)	
^{19}C	^{18}N	6	13	19.034 80(11)	46.2(23) ms	β^-, n (47.0%)	-
	^{19}N					β^- (46.0%)	
	^{17}N					β^-, 2n (7.0%)	
^{20}C	^{19}N	6	14	20.040 32(26)	16(3) ms	β^-, n (70.0%)	-
	^{20}N					β^- (30.0%)	
^{21}C	^{20}C	6	15	21.049 00(43#)	29.999 999 999 98 ns	n	-
^{22}C	^{22}N	6	16	22.057 53(26)	6.2(13) ms	β^-	-
	^{21}N					β^-, n	
	^{20}N					β^-, 2n	
^{23}C	-	6	17	23.068 9(11#)	-	-	-
Nitrogen							

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{10}N	^{9}C	7	3	10.041 65(43)	200(140) ys	p	-
^{11}N	^{10}C	7	4	11.026 091(50)	550(20) ys	p	-
^{12}N	**^{12}C**	7	5	12.018 613 2(11)	11.000(16) ms	β^+ (96.5%)	-
	^{8}Be					β^+, α (3.5%)	
^{13}N	**^{13}C**	7	6	13.005 738 61(29)	9.965(4) min	β^+	-
^{14}N	-	7	7	14.003 074 004 43(20)	**Stable**		0.996 36(20)
^{15}N	-	7	8	15.000 108 898 88(64)	**Stable**		0.003 64(20)
^{16}N	**^{16}O**	7	9	16.006 101 9(25)	7.13(2) s	β^- (99.998 55%)	-
	^{12}C					β^-, α (0.001 45%)	
^{17}N	**^{16}O**	7	10	17.008 449(16)	4.173(4) s	β^-, n (95.0%)	-
	^{17}O					β^- (4.997 5%)	
	^{13}C					β^-, α (0.002 5%)	
^{18}N	**^{18}O**	7	11	18.014 078(20)	619.2(19) ms	β^- (80.8%)	-
	^{14}C					β^-, α (12.2%)	
	^{17}O					β^-, n (7.0%)	
^{19}N	^{19}O	7	12	19.017 022(18)	336(3) ms	β^- (7.0%)	-
	^{18}O					β^-, n (41.8%)	
^{20}N	^{20}O	7	13	20.023 366(60)	136(3) ms	β^- (57.1%)	-
	^{19}O					β^-, n (42.9%)	
^{21}N	^{20}O	7	14	21.027 11(10)	84(7) ms	β^-, n (90.5%)	-
	^{21}O					β^- (9.5%)	
^{22}N	^{22}O	7	15	22.034 39(21)	23(3) ms	β^- (54.0%)	-
	^{21}O					β^-, n (34.0%)	
	^{20}O					β^-, 2n (12.0%)	
^{23}N	^{23}O	7	16	23.041 14(32#)	13.9(14) ms	β^- (50.0%)	-
	^{22}O					β^-, n (42.0%)	
	^{21}O					β^-, 2n (8.0%)	
^{24}N	^{23}N	7	17	24.050 39(43#)	52.000 000 000 01 ns	n	-
^{25}N	^{25}O	7	18	25.060 10(54#)	< 260 ns	β^-	-
	^{23}N					2n	
	^{24}N					n	
Oxygen							
^{11}O	^{9}C	8	3	-	-	2p	-
^{12}O	^{10}C	8	4	12.034 262(26)	1.140 5 zs	2p (60.0%)	-
	^{11}N					p (40.0%)	
	^{12}N					β^+	

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty) / Stable Nuclide	Decay Mode (Probability) / Stable Nuclide	Natural Abundance (Uncertainty) [mole fraction]
^{13}O	^{13}N	8	5	13.024 815(10)	8.58(5) ms	β^+ (89.1%)	-
	^{12}C					β^+, p (10.9%)	
^{14}O	**^{14}N**	8	6	14.008 596 36(12)	1.176 766 666 667 min	β^+	-
^{15}O	**^{15}N**	8	7	15.003 065 62(53)	2.037 333 333 333 min	β^+	-
^{16}O	-	8	8	15.994 914 619 57(17)	**Stable**		0.997 57(16)
^{17}O	-	8	9	16.999 131 756 50(69)	**Stable**		0.000 38(1)
^{18}O	-	8	10	17.999 159 612 86(76)	**Stable**		0.002 05(14)
^{19}O	**^{19}F**	8	11	19.003 578 0(28)	26.470(6) s	β^-	-
^{20}O	^{20}F	8	12	20.004 075 35(95)	13.51(5) s	β^-	-
^{21}O	^{21}F	8	13	21.008 655(13)	3.42(10) s	β^-	-
^{22}O	^{22}F	8	14	22.009 966(61)	2.25(9) s	β^- (78.0%)	-
	^{21}F					β^-, n (22.0%)	
^{23}O	^{23}F	8	15	23.015 696(97)	97(8) ms	β^- (93.0%)	-
	^{22}F					β^-, n (7.0%)	
^{24}O	^{24}F	8	16	24.019 86(12)	77.4(45) ms	β^- (57.0%)	-
	^{23}F					β^-, n (43.0%)	
^{25}O	^{24}O	8	17	25.029 36(12)	49.999 999 999 97 ns	n	-
^{26}O	^{24}O	8	18	26.037 29(17)	39.999 999 999 98 ns	2n (70.0%)	-
	^{25}O					n (30.0%)	
	^{26}F					β^-	
^{27}O	^{26}O	8	19	27.047 72(54#)	260 ns	n	-
	^{25}O					2n	
^{28}O	^{28}F	8	20	28.055 91(75#)	100 ns	β^-	-
	^{26}O					2n	
	^{27}O					n	
Fluorine							
^{13}F	^{12}O	9	4	-	-	p	-
^{14}F	^{13}O	9	5	14.034 315(44)	500(60) ys	p	-
^{15}F	^{14}O	9	6	15.018 043(67)	0.456 2 zs	p	-
^{16}F	^{15}O	9	7	16.011 465 7(89)	11.405 zs	p	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{17}F	**^{17}O**	9	8	17.002 095 24(27)	1.074 833 333 333 min	β^+	-
^{18}F	**^{18}O**	9	9	18.000 937 33(50)	1.829 516 666 667 h	β^+ (96.86%)	Trace
	^{18}O					ε (3.14%)	
^{19}F	-	9	10	18.998 403 162 73(92)	**Stable**		1.000 000(00)
^{20}F	**^{20}Ne**	9	11	19.999 981 252(31)	11.163(8) s	β^-	-
^{21}F	**^{21}Ne**	9	12	20.999 948 9(19)	4.158(20) s	β^-	-
^{22}F	**^{22}Ne**	9	13	22.002 999(13)	4.23(4) s	β^- (89.0%)	-
	^{21}Ne					β^-, n (11.0%)	
^{23}F	^{23}Ne	9	14	23.003 557(54)	2.23(14) s	β^- (86.0%)	-
	^{22}Ne					β^-, n (14.0%)	
^{24}F	^{24}Ne	9	15	24.008 115(78)	384(16) ms	β^- (94.1%)	-
	^{23}Ne					β^-, n (5.9%)	
^{25}F	^{25}Ne	9	16	25.012 199(81)	80(9) ms	β^- (76.9%)	-
	^{24}Ne					β^-, n (23.1%)	
^{26}F	^{26}Ne	9	17	26.020 038(83)	8.2(9) ms	β^- (86.5%)	-
	^{25}Ne					β^-, n (13.5%)	
^{27}F	^{26}Ne	9	18	27.026 44(20)	4.9(2) ms	β^-, n (77.0%)	-
	^{27}Ne					β^- (23.0%)	
^{28}F	^{27}F	9	19	28.035 34(21)	39.999 999 999 98 ns	n	-
^{29}F	^{28}Ne	9	20	29.042 54(54#)	2.5(3) ms	β^-, n (60.0%)	-
	^{29}Ne					β^- (40.0%)	
	^{27}Ne					β^-, 2n	
^{30}F	^{29}F	9	21	30.051 65(64#)	260 ns	n	-
^{31}F	^{31}Ne	9	22	31.059 71(56#)	250 ns	β^-	-
	^{30}Ne					β^-, n	
Neon							
^{15}Ne	^{13}O	10	5	15.043 17(7)	0.77(3) zs	2p	-
^{16}Ne	^{14}O	10	6	16.025 750(22)	3.739 344 262 295 zs	2p	-
^{17}Ne	**^{16}O**	10	7	17.017 713 96(38)	109.2(6) ms	β^+, p (96.0%)	-
	^{13}N					β^+, α (2.7%)	
	^{17}F					β^+ (1.3%)	
^{18}Ne	^{18}F	10	8	18.005 708 70(39)	1.664 20(47) s	β^+	-
^{19}Ne	^{19}F	10	9	19.001 880 91(17)	17.274(10) s	β^+	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{20}Ne	-	10	10	19.992 440 176 2(17)	**Stable**		0.904 8(3)
^{21}Ne	-	10	11	20.993 846 685(41)	**Stable**		0.002 7(1)
^{22}Ne	-	10	12	21.991 385 114(18)	**Stable**		0.092 5(3)
^{23}Ne	**^{23}Na**	10	13	22.994 466 91(11)	37.140(28) s	β^-	-
^{24}Ne	^{24}Na	10	14	23.993 610 65(55)	3.383 333 333 333 min	β^-	-
^{25}Ne	^{25}Na	10	15	24.997 789(48)	602(8) ms	β^-	-
^{26}Ne	^{26}Na	10	16	26.000 515(20)	197(2) ms	β^- (99.87%)	-
	^{25}Na					β^-, n (0.13%)	
^{27}Ne	^{27}Na	10	17	27.007 553(70)	31.5(13) ms	β^- (98.0%)	-
	^{26}Na					β^-, n (2.0%)	
^{28}Ne	^{28}Na	10	18	28.012 12(10)	20(1) ms	β^- (84.3%)	-
	^{27}Na					β^-, n (12.0%)	
	^{26}Na					β^-, 2n (3.7%)	
^{29}Ne	^{29}Na	10	19	29.019 75(11)	14.7(4) ms	β^- (68.0%)	-
	^{28}Na					β^-, n (28.0%)	
	^{27}Na					β^-, 2n (4.0%)	
^{30}Ne	^{30}Na	10	20	30.024 73(30)	7.22(18) ms	β^- (78.1%)	-
	^{29}Na					β^-, n (13.0%)	
	^{28}Na					β^-, 2n (8.9%)	
^{31}Ne	^{31}Na	10	21	31.033 1(17)	3.4(8) ms	β^-	-
	^{30}Na					β^-, n	
^{32}Ne	^{32}Na	10	22	32.039 72(54#)	3.5(9) ms	β^-	-
	^{31}Na					β^-, n	
^{33}Ne	^{32}Ne	10	23	33.049 38(64#)	180 ns	n	-
^{34}Ne	^{34}Na	10	24	34.056 73(55#)	60.000 000 000 02 ns	β^-	-
	^{33}Na					β^-, n	
Sodium							
^{18}Na	^{17}Ne	11	7	18.026 88(12)	1.3(4) zs	p (> 99.9%)	-
	^{18}Ne					β^+ (< 0.1%)	
^{19}Na	^{18}Ne	11	8	19.013 880(11)	39.999 999 999 98 ns	p	-
^{20}Na	**^{20}Ne**	11	9	20.007 354 4(12)	447.9(23) ms	β^+ (75.0%)	-
	^{16}O					β^+, α (25.0%)	
^{21}Na	**^{21}Ne**	11	10	20.997 654 69(30)	22.422(10) s	β^+	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{22}Na	**^{22}Ne**	11	11	21.994 437 41(18)	2.601 8(22) a	β^+	Trace
^{23}Na	-	11	12	22.989 769 282 0(19)	**Stable**		1.000 000(00)
^{24}Na	**^{24}Mg**	11	13	23.990 962 950(38)	14.957(4) h	β^-	Trace
^{25}Na	**^{25}Mg**	11	14	24.989 954 0(13)	59.1(6) s	β^-	-
^{26}Na	**^{26}Mg**	11	15	25.992 634 6(38)	1.071 28(25) s	β^-	-
^{27}Na	^{27}Mg	11	16	26.994 076 5(40)	301(6) ms	β^- (99.87%)	-
	^{26}Mg					β^-, n (0.13%)	
^{28}Na	^{28}Mg	11	17	27.998 939(11)	30.5(4) ms	β^- (99.42%)	-
	^{27}Mg					β^-, n (0.58%)	
^{29}Na	^{29}Mg	11	18	29.002 877 1(79)	44.1(9) ms	β^- (25.9%)	-
	^{28}Mg					β^-, n (25.9%)	
^{30}Na	^{30}Mg	11	19	30.009 097 9(51)	48.4(17) ms	β^- (68.85%)	-
	^{29}Mg					β^-, n (30.0%)	
	^{28}Mg					β^-, 2n (1.15%)	
	^{26}Ne					β^-, α (0.000 055%)	
^{31}Na	^{31}Mg	11	20	31.013 163(25)	17.35(40) ms	β^- (61.78%)	-
	^{30}Mg					β^-, n (37.3%)	
	^{29}Mg					β^-, 2n (0.87%)	
	^{28}Mg					β^-, 3n (0.05%)	
^{32}Na	^{32}Mg	11	21	32.020 19(13)	12.9(3) ms	β^- (68.0%)	-
	^{31}Mg					β^-, n (24.0%)	
	^{30}Mg					β^-, 2n (8.0%)	
^{33}Na	^{32}Mg	11	22	33.025 73(64#)	8.2(4) ms	β^-, n (47.0%)	-
	^{33}Mg					β^- (40.0%)	
	^{31}Mg					β^-, 2n (13.0%)	
^{34}Na	^{32}Mg	11	23	34.033 59(54#)	5.5(10) ms	β^-, 2n (50.0%)	-
	^{34}Mg					β^- (35.0%)	
	^{33}Mg					β^-, n (15.0%)	
^{35}Na	^{35}Mg	11	24	35.040 62(63#)	1.5(5) ms	β^-	-
	^{34}Mg					β^-, n	
^{36}Na	^{35}Na	11	25	36.049 29(64#)	180 ns	n	-
^{37}Na	^{37}Mg	11	26	37.057 05(65#)	60.000 000 000 02 ns	β^-	-
	^{36}Mg					β^-, n	
^{39}Na	^{38}Mg	11	28	-	-	β^-, n (#)	-
Magnesium							

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{19}Mg	^{17}Ne	12	7	19.034 169(54)	5(3) ps	2p	-
^{20}Mg	^{20}Na	12	8	20.018 850(29)	93(5) ms	β⁺ (69.7%)	-
	^{19}Ne					β⁺, p (30.3%)	
^{21}Mg	^{21}Na	12	9	21.011 716(18)	118.6(5) ms	β⁺ (66.9%)	-
	^{20}Ne					β⁺, p (32.6%)	
	^{17}F					β⁺, α (0.5%)	
^{22}Mg	^{22}Na	12	10	21.999 570 65(34)	3.875 5(12) s	β⁺	-
^{23}Mg	**^{23}Na**	12	11	22.994 124 21(74)	11.317(11) s	β⁺	-
^{24}Mg	-	12	12	23.985 041 697(14)	**Stable**		0.789 9(4)
^{25}Mg	-	12	13	24.985 836 976(50)	**Stable**		0.100 0(1)
^{26}Mg	-	12	14	25.982 592 968(31)	**Stable**		0.110 1(3)
^{27}Mg	**^{27}Al**	12	15	26.984 340 624(53)	9.458 333 333 333 min	β⁻	-
^{28}Mg	^{28}Al	12	16	27.983 876 7(22)	20.915(9) h	β⁻	-
^{29}Mg	^{29}Al	12	17	28.988 617(12)	1.30(12) s	β⁻	-
^{30}Mg	^{30}Al	12	18	29.990 462 9(37)	313(4) ms	β⁻ (99.94%)	-
	^{29}Al					β⁻, n (0.06%)	
^{31}Mg	^{31}Al	12	19	30.996 648 0(33)	236(20) ms	β⁻ (93.8%)	-
	^{30}Al					β⁻, n (6.2%)	
^{32}Mg	^{32}Al	12	20	31.999 110 2(34)	86(5) ms	β⁻ (94.5%)	-
	^{31}Al					β⁻, n (94.5%)	
^{33}Mg	^{33}Al	12	21	33.005 327 1(31)	90.5(16) ms	β⁻ (86.0%)	-
	^{32}Al					β⁻, n (14.0%)	
^{34}Mg	^{34}Al	12	22	34.008 935(31)	20.197 730 572 45 ms	β⁻ (70.0%)	-
	^{33}Al					β⁻, n (30.0%)	
^{35}Mg	^{34}Al	12	23	35.016 79(19)	70.692 057 003 56 ms	β⁻ (52.0%)	-
	^{35}Al					β⁻, n (48.0%)	
^{36}Mg	^{36}Al	12	24	36.021 88(49)	3.9(13) ms	β⁻	-
^{37}Mg	^{37}Al	12	25	37.030 37(54#)	8(4) ms	β⁻	-
	^{36}Al					β⁻, n	
^{38}Mg	^{38}Al	12	26	38.036 58(54#)	260 ns	β⁻	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty) / Stable Nuclide	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
^{39}Mg	^{38}Mg	12	27	39.045 38(55#)	180 ns	n	-
^{40}Mg	^{39}Al	12	28	40.052 18(64#)	170 ns	β⁻, n	-
	^{40}Al					β⁻	
Aluminium							
^{21}Al	^{20}Mg	13	8	21.028 97(43#)	35.000 000 000 01 ns	p	-
^{22}Al	^{21}Na	13	9	22.019 54(43#)	91.1(5) ms	β⁺, p (55.0%)	-
	^{22}Mg					β⁺ (43.862%)	
	^{20}Ne					β⁺, 2p (1.1%)	
	^{18}Ne					β⁺, α (0.038%)	
^{23}Al	^{23}Mg	13	10	23.007 244 35(37)	470(30) ms	β⁺ (99.54%)	-
	^{22}Na					β⁺, p (0.46%)	
^{24}Al	**^{24}Mg**	13	11	23.999 948 9(12)	2.053(4) s	β⁺ (99.963 4%)	-
	^{20}Ne					β⁺, α (0.035%)	
	^{23}Na					β⁺, p (0.001 6%)	
^{25}Al	**^{25}Mg**	13	12	24.990 428 10(51)	7.183(12) s	β⁺	-
^{26}Al	**^{26}Mg**	13	13	25.986 891 904(69)	716 641.298 833 1 a	β⁺ (85.0%)	Trace
						ε (15.0%)	
^{27}Al	-	13	14	26.981 538 53(11)	**Stable**		1.000 000(00)
^{28}Al	**^{28}Si**	13	15	27.981 910 21(13)	2.241 333 333 333 min	β⁻	-
^{29}Al	**^{29}Si**	13	16	28.980 456 5(10)	6.566 666 666 667 min	β⁻	-
^{30}Al	**^{30}Si**	13	17	29.982 960(15)	3.62(6) s	β⁻	-
^{31}Al	^{31}Si	13	18	30.983 945(22)	644(25) ms	β⁻ (98.4%)	-
	^{30}Si					β⁻, n (1.6%)	
^{32}Al	^{32}Si	13	19	31.988 085(13)	33.0(2) ms	β⁻ (99.3%)	-
	^{31}Si					β⁻, n (0.7%)	
^{33}Al	^{33}Si	13	20	32.990 909(81)	41.7(2) ms	β⁻ (91.5%)	-
	^{32}Si					β⁻, n (8.5%)	
^{34}Al	^{34}Si	13	21	33.996 705(74)	56.3(5) ms	β⁻ (74.0%)	-
	^{33}Si					β⁻, n (26.0%)	
^{35}Al	^{35}Si	13	22	34.999 764(75)	37.2(8) ms	β⁻ (62.0%)	-
	^{34}Si					β⁻, n (38.0%)	
^{36}Al	^{36}Si	13	23	36.006 39(11)	90(40) ms	β⁻ (70.0%)	-
	^{35}Si					β⁻, n (30.0%)	
^{37}Al	^{37}Si	13	24	37.010 53(13)	11.5(4) ms	β⁻ (71.0%)	-
	^{36}Si					β⁻, n (29.0%)	

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{38}Al	^{38}Si	13	25	38.017 40(27)	9.0(7) ms	β^-	-
^{39}Al	^{38}Si	13	26	39.022 54(54#)	7.6(16) ms	β^-, n (90.0%)	-
	^{39}Si					β^- (10.0%)	
^{40}Al	^{40}Si	13	27	40.030 03(54#)	260 ns	β^-	-
	^{39}Si					β^-, n	
^{41}Al	^{41}Si	13	28	41.036 38(64#)	260 ns	β^-	-
^{42}Al	^{42}Si	13	29	42.043 84(64#)	170 ns	β^-	-
	^{41}Si					β^-, n	
^{43}Al	^{43}Si	13	30	43.051 47(75#)	1(#) ms	β^-	-
Silicon							
^{22}Si	^{22}Mg	14	8	22.035 79(54#)	29(2) ms	β^+, p (88.0%)	-
	^{23}Al					β^+ (8.4%)	
	^{21}Na					β^+, 2p (3.6%)	
^{23}Si	^{22}Mg	14	9	23.025 44(54#)	42.3(4) ms	β^+, p (88.0%)	-
	^{23}Al					β^+ (8.4%)	
	^{21}Na					β^+, 2p (3.6%)	
^{24}Si	^{24}Al	14	10	24.011 535(21)	140(8) ms	β^+, p (62.4%)	-
	^{23}Mg					β^+ (37.6%)	
^{25}Si	^{25}Al	14	11	25.004 109(11)	220(3) ms	β^+ (64.8%)	-
	^{24}Mg					β^+, p (35.2%)	
^{26}Si	^{26}Al	14	12	25.992 333 84(11)	2.245 3(7) s	β^+	-
^{27}Si	^{27}Al	14	13	26.986 704 81(15)	4.15(4) s	β^+	-
^{28}Si	-	14	14	27.976 926 534 65(44)	**Stable**		0.922 23(19)
^{29}Si	-	14	15	28.976 494 664 90(52)	**Stable**		0.046 85(8)
^{30}Si	-	14	16	29.973 770 136(23)	**Stable**		0.030 92(11)
^{31}Si	**^{31}P**	14	17	30.975 363 194(46)	2.621 666 666 667 h	β^-	-
^{32}Si	^{32}P	14	18	31.974 151 54(32)	153(19) a	β^-	Trace
^{33}Si	^{33}P	14	19	32.977 976 96(75)	6.18(18) s	β^-	-
^{34}Si	^{34}P	14	20	33.978 576(15)	2.77(20) s	β^-	-
^{35}Si	^{35}P	14	21	34.984 583(41)	780(120) ms	β^- (94.74%)	-
	^{34}P					β^-, n (5.26%)	
^{36}Si	^{36}P	14	22		450(60) ms	β^- (87.5%)	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
	^{35}P			35.986 695(77)		β⁻, n (12.5%)	
^{37}Si	^{37}P	14	23	36.992 921(89)	90(60) ms	β⁻ (83.0%)	-
	^{36}P					β⁻, n (17.0%)	
^{38}Si	^{37}P	14	24	37.995 523(75)	90(#) ms	β⁻, n	-
	^{38}P					β⁻	
^{39}Si	^{39}P	14	25	39.002 491(97)	47.5(20) ms	β⁻	-
^{40}Si	^{40}P	14	26	40.005 83(25)	33.0(10) ms	β⁻	-
	^{39}P					β⁻, n	
^{41}Si	^{41}P	14	27	41.013 01(40)	20.0(25) ms	β⁻	-
^{42}Si	^{42}P	14	28	42.017 78(54#)	12.5(35) ms	β⁻	-
	^{41}P					β⁻, n	
^{43}Si	^{43}P	14	29	43.024 80(64#)	60.000 000 000 02 ns	β⁻	-
	^{42}P					β⁻, n	
^{44}Si	^{44}P	14	30	44.030 61(64#)	360.673 760 222 2 ns	β⁻	-
	^{43}P					β⁻, n	
^{45}Si	-	14	31	45.039 95(75#)	-	-	-
Phosphorus							
^{24}P	^{23}Si	15	9	24.035 77(54#)	-	p	-
	^{24}Si					β⁺	
^{25}P	^{24}Si	15	10	25.021 19(43#)	29.999 999 999 98 ns	p	-
^{26}P	^{26}Si	15	11	26.011 78(21#)	43.7(6) ms	β⁺ (98.0%)	-
	^{24}Mg					β⁺, 2p (1.0%)	
	^{25}Al					β⁺, p (0.9%)	
^{27}P	^{27}Si	15	12	26.999 224(28)	260(80) ms	β⁺ (99.93%)	-
	^{26}Al					β⁺, p (0.07%)	
^{28}P	**^{28}Si**	15	13	27.992 326 6(12)	270.3(5) ms	β⁺ (99.99%)	-
	^{27}Al					β⁺, p (0.001 3%)	
	^{24}Mg					β⁺, α (0.000 86%)	
^{29}P	**^{29}Si**	15	14	28.981 800 79(60)	4.142(15) s	β⁺	-
^{30}P	**^{30}Si**	15	15	29.978 313 75(34)	2.498 333 333 333 min	β⁺	-
^{31}P	-	15	16	30.973 761 998 42(70)	**Stable**		1.000 000(00)
^{32}P	**^{32}S**	15	17	31.973 907 643(42)	14.268(5) d	β⁻	Trace
^{33}P	**^{33}S**	15	18	32.971 725 7(12)	25.335 648 148 15 d	β⁻	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{34}P	**^{34}S**	15	19	33.973 645 89(87)	12.43(10) s	β^-	-
^{35}P	^{35}S	15	20	34.973 314 1(20)	47.3(8) s	β^-	-
^{36}P	**^{36}S**	15	21	35.978 260(14)	5.6(3) s	β^-	-
^{37}P	^{37}S	15	22	36.979 607(41)	2.31(13) s	β^-	-
^{38}P	^{38}S	15	23	37.984 252(93)	640(14) ms	β^- (87.5%)	-
	^{37}S					β^-, n (12.5%)	
^{39}P	^{39}S	15	24	38.986 227(98)	282(24) ms	β^- (73.2%)	-
	^{38}S					β−, n (26.8%)	
^{40}P	^{40}S	15	25	39.991 33(12)	150(8) ms	β^- (84.2%)	-
	^{39}S					β^-, n (15.8%)	
^{41}P	^{41}S	15	26	40.994 654(86)	101(5) ms	β^- (70.0%)	-
	^{40}S					β^-, n (30.0%)	
^{42}P	^{42}S	15	27	42.001 08(23)	48.5(15) ms	β^- (50.0%)	-
	^{41}S					β^-, n (50.0%)	
^{43}P	^{42}S	15	28	43.005 02(40)	35.8(13) ms	β^-, n	-
	^{43}S					β^-	
^{44}P	^{44}S	15	29	44.011 21(54#)	18.5(25) ms	β^-	-
^{45}P	^{45}S	15	30	45.016 45(64#)	200 ns	β^-	-
^{46}P	^{46}S	15	31	46.024 46(75#)	200 ns	β^-	-
^{47}P	^{47}S	15	32	47.031 39(86#)	2(#) ms	β^-	-
Sulfur							
^{26}S	^{24}Si	16	10	26.029 07(64#)	10 ms	2p	-
^{27}S	^{27}P	16	11	27.018 28(43#)	15.5(15) ms	β^+ (96.6%)	-
	^{26}Si					β^+, p (2.3%)	
	^{25}Al					β^+, 2p (1.1%)	
^{28}S	^{28}P	16	12	28.004 37(17)	125(10) ms	β^+ (79.3%)	-
	^{27}Si					β^+, p (20.7%)	
^{29}S	^{29}P	16	13	28.996 611(54)	188(4) ms	β^+ (53.6%)	-
	^{28}Si					β^+, p (46.4%)	
^{30}S	^{30}P	16	14	29.984 907 03(40)	1.175 9(17) s	β^+	-
^{31}S	**^{31}P**	16	15	30.979 557 01(25)	2.553 4(18) s	β^+	-
^{32}S	-	16	16	31.972 071 174 4(14)	**Stable**		0.949 9(26)

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{33}S	-	16	17	32.971 458 909 8(15)	**Stable**		0.007 5(2)
^{34}S	-	16	18	33.967 867 004(47)	**Stable**		0.042 5(24)
^{35}S	^{35}Cl	16	19	34.969 032 310(43)	87.511 574 074 07 d	β^-	Trace
^{36}S	-	16	20	35.967 080 71(20)	**Stable**		0.000 1(1)
^{37}S	^{37}Cl	16	21	36.971 125 51(21)	5.05(2) min	β^-	-
^{38}S	^{38}Cl	16	22	37.971 163 3(77)	2.838 888 888 889 h	β^-	-
^{39}S	^{39}Cl	16	23	38.975 134(54)	11.5(5) s	β^-	-
^{40}S	^{40}Cl	16	24	39.975 482 6(43)	8.8(22) s	β^-	-
^{41}S	^{41}Cl	16	25	40.979 593 5(44)	1.99(5) s	β^- (> 99.9%)	-
	^{40}Cl					β^-, n (< 0.1%)	
^{42}S	^{42}Cl	16	26	41.981 065 1(30)	1.016(15) s	β^- (> 96.0%)	-
	^{41}Cl					β^-, n (< 4.0%)	
^{43}S	^{43}Cl	16	27	42.986 907 6(53)	265(13) ms	β^- (60.0%)	-
	^{42}Cl					β^-, n (40.0%)	
^{44}S	^{44}Cl	16	28	43.990 118 8(56)	100(1) ms	β^- (81.7%)	-
	^{43}Cl					β^-, n (18.2%)	
^{45}S	^{44}Cl	16	29	44.995 72(74)	68(2) ms	β^-, n (54.0%)	-
	^{45}Cl					β^- (46.0%)	
^{46}S	^{46}Cl	16	30	46.000 04(54#)	50(8) ms	β^-	-
^{47}S	^{47}Cl	16	31	47.007 95(54#)	20.197 730 572 45 ms	β^-	-
^{48}S	^{48}Cl	16	32	48.013 70(64#)	200 ns	β^-	-
^{49}S	^{49}Cl	16	33	49.022 76(72#)	200 ns	β^-	-
	^{48}S					n	
Chlorine							
^{28}Cl	^{27}S	17	11	28.029 54(64#)	-	p	-
^{29}Cl	^{28}S	17	12	29.014 78(43#)	< 10 ps	p	-
^{30}Cl	^{29}S	17	13	30.004 77(21#)	29.999 999 999 98 ns	p	-
^{31}Cl	^{31}S	17	14	30.992 414(54)	190(1) ms	β^+ (97.6%)	-
	^{30}P					β^+, p (2.4%)	

Nuclide	**Daughter Nuclide/ Decay Product**	**Atomic Number *Z***	**Neutron Number *N***	**Isotopic Mass (Uncertainty) [u or Da]**	**Half-Life (Uncertainty)**	**Decay Mode (Probability)**	**Natural Abundance (Uncertainty) [mole fraction]**
					Stable Nuclide		
^{32}Cl	**^{32}S**	17	15	31.985 684 64(60)	298(1) ms	β^+ (99.92%)	-
	^{28}Si					β^+, α (0.054%)	
	^{31}P					β^+, p (0.026%)	
^{33}Cl	**^{33}S**	17	16	32.977 451 99(42)	2.503 8(22) s	β^+	-
^{34}Cl	**^{34}S**	17	17	33.973 762 485(52)	1.526 6(4) s	β^+	-
^{35}Cl	**-**	17	18	34.968 852 682(37)	**Stable**		0.757 6(10)
^{36}Cl	**^{36}Ar**	17	19	35.968 306 809(38)	301 243.023 845 8 a	β^- (98.1%)	Trace
	^{36}S					β^+ (1.9%)	
^{37}Cl	**-**	17	20	36.965 902 602(55)	**Stable**		0.242 4(10)
^{38}Cl	**^{38}Ar**	17	21	37.968 010 44(11)	37.233 333 333 33 min	β^-	-
^{39}Cl	^{39}Ar	17	22	38.968 008 2(19)	56.2(6) min	β^-	-
^{40}Cl	**^{40}Ar**	17	23	39.970 415(34)	1.35(2) min	β^-	-
^{41}Cl	^{41}Ar	17	24	40.970 685(74)	38.4(8) s	β^-	-
^{42}Cl	^{42}Ar	17	25	41.973 25(15)	6.8(3) s	β^-	-
^{43}Cl	^{43}Ar	17	26	42.973 89(10)	3.13(9) s	β^- (> 99.9%)	-
	^{42}Ar					β–, n (< 0.1%)	
^{44}Cl	^{44}Ar	17	27	43.977 87(20)	560(11) ms	β^- (92.0%)	-
	^{43}Ar					β^-, n (8.0%)	
^{45}Cl	^{45}Ar	17	28	44.980 29(11)	413(25) ms	β^- (76.0 %)	-
	^{44}Ar					β^-, n (24.0%)	
^{46}Cl	^{46}Ar	17	29	45.985 17(17)	232(2) ms	β^-, n (60.0%)	-
	^{45}Ar					β^- (40.0%)	
^{47}Cl	^{47}Ar	17	30	46.989 16(43#)	101(6) ms	β^- (97.0%)	-
	^{46}Ar					β^-, n (3.0%)	
^{48}Cl	^{48}Ar	17	31	47.995 64(54#)	200 ns	β^-	-
^{49}Cl	^{49}Ar	17	32	49.001 23(64#)	170 ns	β^-	-
^{50}Cl	^{50}Ar	17	33	50.009 05(64#)	20.197 730 572 45 ms	β^-	-
^{51}Cl	^{51}Ar	17	34	51.015 54(75#)	200 ns	β^-	-
^{52}Cl	^{52}Ar	17	35	-	-	β^-	-
Argon							

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{29}Ar	^{27}S	18	11	-	40 zs	2p	-
^{30}Ar	^{28}S	18	12	30.023 07(54#)	< 10 ps	2p	-
^{31}Ar	^{30}S	18	13	31.012 12(22#)	15.1(3) ms	β⁺, p (63.0%)	-
	^{31}Cl					β⁺ (28.0%)	
	^{29}P					β⁺, 2p (7.2%)	
	^{28}Si					β⁺, 3p (1.4%)	
	^{26}Si					β⁺, p, α (0.38%)	
	^{27}P					β⁺, α (0.03%)	
^{32}Ar	^{32}Cl	18	14	31.997 637 8(19)	98.103 262 780 45 ms	β⁺ (64.42%)	-
	^{31}S					β⁺, p (35.58%)	
^{33}Ar	^{33}Cl	18	15	32.989 925 55(43)	173.0(20) ms	β⁺ (61.3%)	-
	^{32}S					β⁺, p (38.7%)	
^{34}Ar	^{34}Cl	18	16	33.980 270 090(83)	843.8(4) ms	β⁺	-
^{35}Ar	**^{35}Cl**	18	17	34.975 257 59(80)	1.7756(10) s	β⁺	-
^{36}Ar	**^{36}S**	18	18	35.967 545 105(28)	**Observationally Stable**	εε	0.003 336(21)
^{37}Ar	**^{37}Cl**	18	19	36.966 776 33(22)	35.011(19) d	ε	-
^{38}Ar	**-**	18	20	37.962 732 11(21)	**Stable**		0.000 629(7)
^{39}Ar	**^{39}K**	18	21	38.964 313 0(54)	269.216 133 942 2 a	β⁻	Trace
^{40}Ar	**-**	18	22	39.962 383 123 7(24)	**Stable**		0.996 035(25)
^{41}Ar	**^{41}K**	18	23	40.964 500 57(37)	1.826 833 333 333 h	β⁻	-
^{42}Ar	^{42}K	18	24	41.963 045 7(62)	32.978 183 663 12 a	β⁻	Trace
^{43}Ar	^{43}K	18	25	42.965 636 1(57)	5.366 666 666 667 min	β⁻	-
^{44}Ar	^{44}K	18	26	43.964 923 8(17)	11.87(5) min	β⁻	-
^{45}Ar	^{45}K	18	27	44.968 039 73(55)	21.48(15) s	β⁻	-
^{46}Ar	^{46}K	18	28	45.968 083(44)	8.4(6) s	β⁻	-
^{47}Ar	^{47}K	18	29	46.972 935(96)	1.23(3) s	β⁻ (99.8%)	-
	^{46}K					β⁻, n (0.2%)	
^{48}Ar	^{48}K	18	30	47.975 91(32#)	415(15) ms	β⁻	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{49}Ar	^{48}K ^{49}K	18	31	48.981 90(43#)	236(8) ms	β⁻, n (65.0%) β⁻ (35.0%)	-
^{50}Ar	^{50}K ^{49}K	18	32	49.986 13(54#)	106(6) ms	β⁻ (65.0%) β⁻, n (35.0%)	-
^{51}Ar	^{51}K	18	33	50.993 70(64#)	200 ns	β⁻	-
^{52}Ar	^{52}K	18	34	51.998 96(64#)	10 ms	β⁻	-
^{53}Ar	^{53}K ^{52}K	18	35	53.007 29(75#)	3 ms	β⁻ β⁻, n	-
^{54}Ar	^{54}K	18	36	-	-	β⁻	-
Potassium							
^{31}K	^{28}S	19	12		< 10 ps	3p	-
^{32}K	^{31}Ar	19	13	32.022 65(54#)	-	p	-
^{33}K	^{32}Ar	19	14	33.007 56(21#)	25 ns	p	-
^{34}K	^{33}Ar	19	15	33.998 69(32#)	25 ns	p	-
^{35}K	^{35}Ar ^{34}Cl	19	16	34.988 005 41(55)	178(8) ms	β⁺ (99.63%) β⁺, p (0.37%)	-
^{36}K	**^{36}Ar** **^{35}Cl** **^{32}S**	19	17	35.981 302 01(37)	341(3) ms	β⁺ (99.95%) β⁺, p (0.048%) β⁺, α (0.003 4%)	-
^{37}K	^{37}Ar	19	18	36.973 375 89(10)	1.236 5(9) s	β⁺	-
^{38}K	**^{38}Ar**	19	19	37.969 081 12(21)	7.636 666 666 667 min	β⁺	-
^{39}K	-	19	20	38.963 706 486 4(49)	**Stable**		0.932 581(44)
^{40}K	**^{40}Ca** **^{40}Ar**	19	21	39.963 998 166(60)	1.248(3) Ga	β⁻ (89.28%) ε (10.72%) β⁺ (0.001%)	0.000 117(1)
^{41}K	**-**	19	22	40.961 825 257 9(41)	**Stable**		0.067 302(44)
^{42}K	**^{42}Ca**	19	23	41.962 402 31(11)	12.355(7) h	β⁻	-
^{43}K	**^{43}Ca**	19	24	42.960 734 70(44)	22.305 555 555 56 h	β⁻	-
^{44}K	**^{44}Ca**	19	25	43.961 586 99(45)	22.133 333 333 33 min	β⁻	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{45}K	^{45}Ca	19	26	44.960 691 49(56)	17.8(6) min	β⁻	-
^{46}K	**^{46}Ca**	19	27	45.961 981 59(78)	105(10) s	β⁻	-
^{47}K	^{47}Ca	19	28	46.961 661 6(15)	17.50(24) s	β⁻	-
^{48}K	^{48}Ca	19	29	47.965 341 19(83)	6.8(2) s	β⁻ (98.86%)	-
	^{47}Ca					β⁻, n (1.14%)	
^{49}K	^{48}Ca	19	30	48.968 210 75(86)	1.26(5) s	β⁻, n (86.0%)	-
	^{49}Ca					β⁻ (14.0%)	
^{50}K	^{50}Ca	19	31	49.972 380 0(83)	472(4) ms	β⁻ (71.0%)	-
	^{49}Ca					β⁻, n (29.0%)	
^{51}K	^{50}Ca	19	32	50.975 828(14)	365(5) ms	β⁻, n (65.0%)	-
	^{51}Ca					β⁻ (35.0%)	
^{52}K	^{51}Ca	19	33	51.982 24(43#)	110(4) ms	β⁻, n (74.0%)	-
	^{52}Ca					β⁻ (23.7%)	
	^{50}Ca					β⁻, 2n (2.3%)	
^{53}K	^{52}Ca	19	34	52.987 46(54#)	30(5) ms	β⁻, n (64.0%)	-
	^{53}Ca					β⁻ (26.0%)	
	^{51}Ca					β⁻, 2n (10.0%)	
^{54}K	^{54}Ca	19	35	53.994 63(64#)	10(5) ms	β⁻ (> 99.9%)	-
	^{53}Ca					β⁻, n (< 0.1%)	
^{55}K	^{55}Ca	19	36	55.000 76(75#)	3(#) ms	β⁻	-
	^{54}Ca					β⁻, n	
^{56}K	^{56}Ca	19	37	56.008 51(86#)	1(#) ms	β⁻	-
	^{55}Ca					β⁻, n	
^{57}K	^{57}Ca	19	38	-	-	β⁻	-
^{58}K *[Unconfirmed]*	^{59}Ca	19	40	-	-	β⁻	-
Calcium							
^{34}Ca	^{32}Ar	20	14	34.014 87(32#)	35.000 000 000 01 ns	2p	-
^{35}Ca	^{34}Ar	20	15	35.005 14(21#)	25.7(2) ms	β⁺, p (95.9%)	-
	^{33}Cl					β⁺, 2p (4.1%)	
^{36}Ca	^{35}Ar	20	16	35.993 074(43)	101.2(15) ms	β⁺, p (51.2%)	-
	^{36}K					β⁺ (48.8%)	
^{37}Ca	**^{36}Ar**	20	17	36.985 897 85(68)	181.1(10) ms	β⁺, p (82.1%)	-
	^{37}K					β⁺ (17.9%)	
^{38}Ca	^{38}K	20	18	37.976 319 22(21)	443.70(25) ms	β⁺	-
^{39}Ca	**^{39}K**	20	19	38.970 710 81(64)	860.3(8) ms	β⁺	-

Nuclide	**Daughter Nuclide/ Decay Product**	**Atomic Number *Z***	**Neutron Number *N***	**Isotopic Mass (Uncertainty) [u or Da]**	**Half-Life (Uncertainty)**	**Decay Mode (Probability)**	**Natural Abundance (Uncertainty) [mole fraction]**
					Stable Nuclide		
^{40}Ca	^{40}Ar	20	20	39.962 590 863(22)	**< 5 900 Ea** (Observationally Stable)	εε [Unconfirmed]	0.969 41(156)
^{41}Ca	**^{41}K**	20	21	40.962 277 92(15)	102.105 530 187 7 ka	ε	Trace
^{42}Ca	-	20	22	41.958 617 83(16)	**Stable**		0.006 47(23)
^{43}Ca	-	20	23	42.958 766 44(24)	**Stable**		0.001 35(10)
^{44}Ca	-	20	24	43.955 481 56(35)	**Stable**		0.020 86(110)
^{45}Ca	**^{45}Sc**	20	25	44.956 186 35(39)	162.61(9) d	β^-	-
^{46}Ca	**^{46}Ti**	20	26	45.953 689 0(24)	**2.8 Pa** (Observationally Stable)	$\beta^-\beta^-$ [Unconfirmed]	0.000 04(3)
^{47}Ca	^{47}Sc	20	27	46.954 542 4(24)	4.535 879 629 63 d	β^-	-
^{48}Ca	**^{48}Ti** **^{48}Sc**	20	28	47.952 522 76(13)	**19 Ea** (Observationally Stable)	$\beta^-\beta^-$ β^- [Unconfirmed]	0.001 87(21)
^{49}Ca	^{49}Sc	20	29	48.955 662 74(23)	8.718 333 333 333 min	β^-	-
^{50}Ca	^{50}Sc	20	30	49.957 499 2(17)	13.9(6) s	β^-	-
^{51}Ca	^{51}Sc ^{50}Sc	20	31	50.960 989(24)	10.0(8) s	β^- β^-, n	-
^{52}Ca	^{52}Sc ^{51}Sc	20	32	51.963 217(64)	4.6(3) s	β^- (98.0%) β^-, n (2.0%)	-
^{53}Ca	^{53}Sc ^{52}Sc	20	33	52.969 45(43#)	461(90) ms	β^- (60.0%) β^-, n (40.0%)	-
^{54}Ca	^{54}Sc ^{53}Sc	20	34	53.973 40(54#)	90(6) ms	β^- (93.0%) β^-, n (7.0%)	-
^{55}Ca	^{55}Sc	20	35	54.980 30(54#)	22(2) ms	β^-	-
^{56}Ca	^{56}Sc	20	36	55.985 08(64#)	11(2) ms	β^-	-
^{57}Ca	^{57}Sc ^{56}Sc	20	37	56.992 62(64#)	5(#) ms	β^- β^-, n	-
^{58}Ca	^{58}Sc ^{57}Sc	20	38	57.997 94(75#)	3(#) ms	β^- β^-, n	-
^{59}Ca	^{59}Sc	20	39	-	-	β^-	-
^{60}Ca	^{60}Sc	20	40	-	-	β^-	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
Scandium							
^{36}Sc	^{35}Ca	21	15	36.016 48(32#)	-	p	-
^{37}Sc	^{36}Ca	21	16	37.003 74(32#)	-	p	-
^{38}Sc	^{37}Ca	21	17	37.995 12(21#)	300 ns	p	-
^{39}Sc	^{38}Ca	21	18	38.984 785(26)	300 ns	p	-
^{40}Sc	**^{40}Ca**	21	19	39.977 967 3(30)	182.3(7) ms	β^+ (99.54%)	-
	^{39}K					β^+, p (0.44%)	
	^{36}Ar					β^+, α (0.017%)	
^{41}Sc	^{41}Ca	21	20	40.969 251 105(88)	596.3(17) ms	β^+	-
^{42}Sc	**^{42}Ca**	21	21	41.965 516 53(18)	681.3(7) ms	β^+	-
^{43}Sc	**^{43}Ca**	21	22	42.961 150 5(20)	3.891 666 666 667 h	β^+	-
^{44}Sc	**^{44}Ca**	21	23	43.959 402 9(19)	3.972 222 222 222 h	β^+	-
^{45}Sc	-	21	24	44.955 908 28(77)	**Stable**		1.000 000(00)
^{46}Sc	**^{46}Ti**	21	25	45.955 168 26(78)	83.784 722 222 22 d	β^-	-
^{47}Sc	**^{47}Ti**	21	26	46.952 403 7(21)	3.349 189 814 815 d	β^-	-
^{48}Sc	**^{48}Ti**	21	27	47.952 223 6(53)	1.819 444 444 444 d	β^-	-
^{49}Sc	**^{49}Ti**	21	28	48.950 014 6(29)	57.166 666 666 67 min	β^-	-
^{50}Sc	**^{50}Ti**	21	29	49.952 176(16)	1.708 333 333 333 min	β^-	-
^{51}Sc	^{51}Ti	21	30	50.953 592(21)	12.4(1) s	β^-	-
^{52}Sc	^{52}Ti	21	31	51.956 88(15)	8.2(2) s	β^-	-
^{53}Sc	^{53}Ti	21	32	52.959 09(29)	2.4(0.6) s	β^- (>99.9%)	-
	^{52}Ti					β^-, n (<0.1%)	
^{54}Sc	^{54}Ti	21	33	53.963 93(39)	260(30) ms	β^- (>99.9%)	-
	^{53}Ti					β^-, n (<0.1%)	
^{55}Sc	^{55}Ti	21	34	54.967 82(50)	0.115(15) s	β^- (>99.9%)	-
	^{54}Ti					β^-, n (<0.1%)	
^{56}Sc	^{56}Ti	21	35	55.973 45(43#)	35(5) ms	β^-	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{57}Sc	^{57}Ti	21	36	56.977 77(54#)	13(4) ms	β^- (67.0%)	-
	^{56}Ti					β^-, n (33.0%)	
^{58}Sc	^{58}Ti	21	37	57.984 03(64#)	12(5) ms	β^-	-
^{59}Sc	^{58}Ti	21	38	58.988 94(64#)	10# ms	β^-, n	-
	^{59}Ti					β^-	
^{60}Sc	^{60}Ti	21	39	59.995 65(75#)	3# ms (>620 ns)	β^-	-
	^{59}Ti					β^-, n	
	^{58}Ti					β^-, 2n	
^{61}Sc	^{61}Ti	21	40	61.001 00(86#)	2# ms (>620 ns)	β^-	-
	^{60}Ti					β^-, n	
	^{59}Ti					β^-, 2n	
Titanium							
^{38}Ti	^{36}Ca	22	16	38.011 45(32#)	<120 ns	2p	-
^{39}Ti	^{38}Ca	22	17	39.002 36(22#)	$31(^{+6}_{-4})$ ms	β^+, p (85.0%)	-
	^{39}Sc					β^+ (15.0%)	
	^{37}K					β^+, 2p (<0.1%)	
^{40}Ti	^{40}Sc	22	18	39.990 50(17)	53.3(15) ms	β^+ (56.99%)	-
	^{39}Ca					β^+, p (43.01%)	
^{41}Ti	**^{40}Ca**	22	19	40.983 148(30)	80.4(9) ms	β^+, p (>99.9%)	-
	^{41}Sc					β^+ (<0.1%)	
^{42}Ti	^{42}Sc	22	20	41.973 049 03(30)	199(6) ms	β^+	-
^{43}Ti	^{43}Sc	22	21	42.968 5225(78)	509(5) ms	β^+	-
^{44}Ti	^{44}Sc	22	22	43.959 689 95(75)	60.248 604 769 15 a	ε	-
^{45}Ti	**^{45}Sc**	22	23	44.958 121 98(95)	3.080 555 555 556 h	β^+	-
^{46}Ti	-	22	24	45.952 627 72(35)	**Stable**		0.082 5(3)
^{47}Ti	-	22	25	46.951 758 79(38)	**Stable**		0.074 4(2)
^{48}Ti	-	22	26	47.947 941 98(38)	**Stable**		0.737 2(3)
^{49}Ti	-	22	27	48.947 865 68(39)	**Stable**		0.054 1(2)
^{50}Ti	-	22	28	49.944 786 89(39)	**Stable**		0.051 8(2)
^{51}Ti	**^{51}V**	22	29	50.946 610 65(65)	5.766 666 666 667 min	β^-	-
^{52}Ti	^{52}V	22	30	51.946 893 0(76)	1.7(1) min	β^-	-

Nuclide	Daughter Nuclide/ Decay Product	Atomic Number *Z*	Neutron Number *N*	Isotopic Mass (Uncertainty) [u or Da]	Half-Life (Uncertainty)	Decay Mode (Probability)	Natural Abundance (Uncertainty) [mole fraction]
					Stable Nuclide		
^{53}Ti	^{53}V	22	31	52.949 73(11)	32.7(9) s	β^-	-
^{54}Ti	^{54}V	22	32	53.951 05(13)	1.5(4) s	β^-	-
^{55}Ti	^{55}V	22	33	54.955 27(17)	490(90) ms	β^-	-
^{56}Ti	^{56}V ^{55}V	22	34	55.957 91(15)	164(24) ms	β^- (>99.9%) β^-, n (<0.1%)	-
^{57}Ti	^{57}V ^{56}V	22	35	56.963 64(27)	60(16) ms	β^- (>99.9%) β^-, n (<0.1%)	-
^{58}Ti	^{58}V	22	36	57.966 60(43#)	54(7) ms	β^-	-
^{59}Ti	^{59}V	22	37	58.972 47(43#)	30(3) ms	β^-	-
^{60}Ti	^{60}V	22	38	59.976 03(54#)	22(2) ms	β^-	-
^{61}Ti	^{61}V ^{60}V	22	39	60.982 45(64#)	10# ms (>300 ns)	β^- β^-, n	-
^{62}Ti	^{62}V	22	40	61.986 51(75#)	10# ms	β^-	-
^{63}Ti	^{63}V ^{62}V	22	41	62.993 75(75#)	3# ms	β^- β^-, n	-
Vanadium							
^{40}V	^{39}Ti	23	17	40.012 76(43#)	-	p	-
^{41}V	^{40}Ti	23	18	41.000 21(32#)	-	p	-
^{42}V	^{41}Ti	23	19	41.991 82(32#)	<55 ns	p	-
^{43}V	^{43}Ti	23	20	42.980 766(46)	80# ms	β^+	-
^{44}V	^{44}Ti **^{40}Ca**	23	21	43.974 11(20)	111(7) ms	β^+ (>99.9%) β^+, α (<0.1%)	-
^{45}V	^{45}Ti	23	22	44.965 774 8(86)	547(6) ms	β^+	-
^{46}V	**^{46}Ti**	23	23	45.960 198 78(36)	422.50(11) ms	β^+	-
^{47}V	**^{47}Ti**	23	24	46.954 904 91(36)	32.666 666 666 67 min	β^+	-
^{48}V	**^{48}Ti**	23	25	47.952 252 2(11)	15.973 495 370 37 d	β^+	-
^{49}V	**^{49}Ti**	23	26	48.948 511 80(96)	329.861 111 111 1 d	ε	-
^{50}V	**^{50}Ti**	23	27		**0.14 Ea**	ε (83.0%)	0.002 50(4)

Nuclide	**Daughter Nuclide/ Decay Product**	**Atomic Number *Z***	**Neutron Number *N***	**Isotopic Mass (Uncertainty) [u or Da]**	**Half-Life (Uncertainty)**	**Decay Mode (Probability)**	**Natural Abundance (Uncertainty) [mole fraction]**
					Stable Nuclide		
	^{50}Cr			49.947 156 01(95)	(Observationally Stable)	β$^-$ (17.0%)	
^{51}V	-	23	28	50.943 957 04(94)	**Stable**		0.997 50(4)
^{52}V	**^{52}Cr**	23	29	51.944 773 01(95)	3.743 333 333 333 min	β$^-$	-
^{53}V	**^{53}Cr**	23	30	52.944 336 7(34)	1.60(4) min	β$^-$	-
^{54}V	**^{54}Cr**	23	31	53.946 439(16)	49.8(5) s	β$^-$	-
^{55}V	^{55}Cr	23	32	54.947 24(10)	6.54(15) s	β$^-$	-
^{56}V	^{56}Cr	23	33	55.950 48(19)	216(4) ms	β- (>99.9%)	-
	^{55}Cr					β-, n	
^{57}V	^{57}Cr	23	34	56.952 52(24)	0.35(1) s	β$^-$ (>99.9%)	-
	^{56}Cr					β$^-$, n (<0.1%)	
^{58}V	^{58}Cr	23	35	57.956 72(14)	191(8) ms	β$^-$ (>99.9%)	-
	^{57}Cr					β$^-$, n (<0.1%)	
^{59}V	^{59}Cr	23	36	58.959 39(17)	75(7) ms	β$^-$ (>99.9%)	-
	^{58}Cr					β$^-$, n (<0.1%)	
^{60}V	^{60}Cr	23	37	59.964 31(24)	122(18) ms	β$^-$ (>99.9%)	-
	^{59}Cr					β$^-$, n (<0.1%)	
^{61}V	^{61}Cr	23	38	60.967 25(96)	47.0(12) ms	β$^-$ (94.0%)	-
	^{60}Cr					β$^-$, n (6.0%)	
^{62}V	^{62}Cr	23	39	61.972 65(32#)	33.5(20) ms	β$^-$	-
^{63}V	^{63}Cr	23	40	62.976 39(43#)	17(3) ms	β$^-$ (65.0%)	-
	^{62}Cr					β$^-$, n (35.0%)	
^{64}V	^{64}Cr	23	41	63.982 64(43#)	10# ms (>300 ns)	β$^-$	-
^{65}V	^{65}Cr	23	42	64.987 50(54#)	10# ms	β$^-$	-
	^{64}Cr					β$^-$, n	
^{66}V	-	23	43	65.993 98(64#)	-	-	-
Chromium							

Abbreviations and Notes:

- **^{A}X** (Daughter Nuclide/Decay Product): Daughter Nuclide/Decay Product is Stable
- Uncertainty: Provided in Concise Form (1σ)
- # (Isotopic Mass): Value Partially Derived from Trends from the Mass Surface (TMS)
- # (Half-Life): Value Partially Derived from Trends of Neighbouring Nuclides (TNN)
- Stable Nuclide: No Radioactive Decay Observed
- Decay Modes: See D8

Units:

- u or Da: Unified Atomic Mass Unit
- a: Year
- d: Day
- min: Minute
- s: Second

Sources:

- Nuclide [2] [4] [5] [6]
- Daughter Nuclide/Decay Product [2] [3] [5] [6]
- Atomic Number, *Z* [2] [4] [5] [6]
- Neutron Number, *N* [2] [3] [4] [5] [6]
- Isotopic Mass [1] [3] [4] [5]
- Half-Life [2] [3] [5] [6]
- Decay Mode [2] [3] [5] [6]
- Natural Abundance [4] [5]

STANDARD MODEL OF ELEMENTARY PARTICLES (D4)

Elementary Fermions / Elementary Antifermions

Quarks

I	II	III	I	II	III
2.16 MeV ⅔ ½ **u** Up	1.27 GeV ⅔ ½ **c** Charm	172.69 GeV ⅔ ½ **t** Top	2.16 MeV −⅔ ½ $\bar{u}$ Antiup	1.27 GeV −⅔ ½ $\bar{c}$ Anticharm	172.69 GeV −⅔ ½ $\bar{t}$ Antitop
4.67 MeV −⅓ ½ **d** Down	93.4 MeV −⅓ ½ **s** Strange	4.18 GeV −⅓ ½ **b** Bottom	4.67 MeV ⅓ ½ $\bar{d}$ Antidown	93.4 MeV ⅓ ½ $\bar{s}$ Antistrange	4.18 GeV ⅓ ½ $\bar{b}$ Antibottom

Leptons

I	II	III	I	II	III
0.51 MeV −1 ½ e^- Electron	105.66 MeV −1 ½ μ^- Muon	1.78 GeV −1 ½ τ^- Tau	0.51 MeV 1 ½ e^+ Positron	105.66 MeV 1 ½ μ^+ Antimuon	1.78 GeV 1 ½ τ^+ Antitau
< 1.10 eV > 0 ½ ν_e Electron Neutrino	< 0.19 MeV > 0 ½ ν_μ Muon Neutrino	< 18.20 MeV > 0 ½ ν_τ Tau Neutrino	< 1.10 eV > 0 ½ $\bar{\nu}_e$ Electron Antineutrino	< 0.19 MeV > 0 ½ $\bar{\nu}_\mu$ Muon Antineutrino	< 18.20 MeV > 0 ½ $\bar{\nu}_\tau$ Tau Antineutrino

Elementary Bosons

Gauge Bosons	Scalar Bosons
0.00 eV 0 1 **g** Gluon	125.25 GeV 0 0 **H** Higgs
> 0.00 eV > 0 1 γ Photon	
91.19 GeV 0 1 **Z** Z^0 Boson	
80.38 GeV 1 1 W^+ W^+ Boson	
80.38 GeV −1 1 W^- W^- Boson	

Key:

Elementary Particle Representation:

1
2
3

Particle Symbol

Particle Name

1 Invariant Mass, m_0, in GeV/c^2, MeV/c^2 and eV/c^2 (Units Simplified on Diagram)
2 Electric Charge, Q, in e
3 Spin, S

Units:

- eV: Electronvolt
- e: Elementary Charge

Sources:

- Invariant Mass, 1 [1]
- Electric Charge, 2 [1]
- Spin, 3 [1]
- Particle Symbol [1]
- Particle Name [1]

PROPERTIES OF ELEMENTARY PARTICLES (D5)

Particle Name	**Symbol**	**Antiparticle**	**Invariant Mass m_0 [MeV/c²] (Uncertainty)**	**Electric Charge Q [e]**	**Type and Sub-type / Generation**	**Spin S**	**Mean Life τ [per eV] (Uncertainty)**
Up Quark	u	Antiup ($\bar{u}$)	2.160 000 000 000 $^{+0.49}_{-0.26}$	$+\frac{2}{3}$	Quark: Up-type, Gen. I	$\frac{1}{2}$	-
Down Quark	d	Antidown ($\bar{d}$)	4.670 000 000 000 $^{+0.48}_{-0.17}$	$-\frac{1}{3}$	Quark: Down-type, Gen. I	$\frac{1}{2}$	-
Charm Quark	c	Anticharm ($\bar{c}$)	1 270.000 000 000 000 ± 20	$+\frac{2}{3}$	Quark: Up-type, Gen. II	$\frac{1}{2}$	-
Strange Quark	s	Antistrange ($\bar{s}$)	93.400 000 000 000 $^{+8.6}_{-3.4}$	$-\frac{1}{3}$	Quark: Down-type, Gen. II	$\frac{1}{2}$	-
Top Quark	t	Antitop ($\bar{t}$)	172 690.000 000 000 000 ± 300	$+\frac{2}{3}$	Quark: Up-type, Gen. III	$\frac{1}{2}$	-
Bottom Quark	b	Antibottom ($\bar{b}$)	4 180.000 000 000 000 $^{+30}_{-20}$	$-\frac{1}{3}$	Quark: Down-type, Gen. III	$\frac{1}{2}$	-
Electron	e	Positron (e^{+})	0.510 998 950 000 ± 0.000 000 000 15	-1	Lepton: Charged, Gen. I	$\frac{1}{2}$	> 6.6×10^{28} a
Electron Neutrino	ν_e	Electron Antineutrino ($\bar{\nu}_e$)	< 0.000 001 100 000	< 4×10^{-35}	Lepton: Neutral, Gen. I	$\frac{1}{2}$	> 300 s
Muon	μ	Antimuon (μ^{+})	105.658 375 500 000 ± 0.000 002 3	-1	Lepton: Charged, Gen. II	$\frac{1}{2}$	(2.196 981 1 ± 0.000 002 2) × 10^{-6} s
Muon Neutrino	ν_μ	Muon Antineutrino ($\bar{\nu}_\mu$)	< 0.190 000 000 000	< 4×10^{-35}	Lepton: Neutral, Gen. II	$\frac{1}{2}$	> 300 s
Tau (Tauon)	τ	Antitau (τ^{+})	1 776.860 000 000 000 ± 0.12	-1	Lepton: Charged, Gen. III	$\frac{1}{2}$	(290.3 ± 0.5) × 10^{-15} s
Tau Neutrino	ν_τ	Tau Antineutrino ($\bar{\nu}_\tau$)	< 18.200 000 000 000	< 4×10^{-35}	Lepton: Neutral, Gen. III	$\frac{1}{2}$	> 300 s
Photon	γ	-	< 1×10^{-24}	< 1×10^{-46}	Boson: Gauge	1	-
Gluon	g	-	0 (Theoretical)	0	Boson: Gauge	1	-

Particle Name	Symbol	Antiparticle	Invariant Mass m_0 [MeV/c^2] (Uncertainty)	Electric Charge Q [e]	Type and Sub-type / Generation	Spin S	Mean Life τ [per eV] (Uncertainty)
W⁺	W^+	-	80 377.000 000 000 000 ± 12	1	Boson: Gauge	1	-
W⁻	W^-	-	80 377. 000 000 000 000 ± 12	-1	Boson: Gauge	1	-
Z	Z	-	91 187.600 000 000 000 ± 2.1	0	Boson: Gauge	1	-
Higgs	H^0	-	125 250.000 000 000 000 ± 170	0	Boson: Scalar	0	1.6×10^{-22} s

Notes:
- Uncertainty: Provided in Standard Uncertainty Form ($1 \pm \sigma$) and Combined Standard Uncertainty Form ($1^{+\sigma}_{-\sigma}$)

Units:
- MeV/c^2: Megaelectronvolts/Speed of Light^2 (Mass)
- e: Elementary Charge
- a: Year
- s: Second

Sources:
- Particle Name [1]
- Symbol [1]
- Invariant Mass, m_0 [1]
- Electric Charge, Q [1]
- Type and Sub-type/Generation [1]
- Spin, S [1]
- Mean Life, τ [1] [2]

SI UNIT DEFINITIONS (D6)

Base Units

Base Unit	**Base Symbol**	**Base Quantity**	**Typical Symbol**	**Formal Definition**	**Equation**
Second	s	Time	t	The second, symbol s, is the SI unit of time. It is defined by taking the fixed numerical value of the caesium frequency, $\Delta\nu_{\mathrm{Cs}}$, the unperturbed ground-state hyperfine transition frequency of the caesium 133 atom, to be 9 192 631 770 when expressed in the unit Hz, which is equal to s^{-1}.	$1\ \mathrm{s} = \dfrac{9\,192\,631\,770}{\Delta\nu_{\mathrm{Cs}}}$
Metre	m	Length	$l, x, r,$ etc.	The metre, symbol m, is the SI unit of length. It is defined by taking the fixed numerical value of the speed of light in vacuum, c, to be 299 792 458 when expressed in the unit $\mathrm{m\ s^{-1}}$, where the second is defined in terms of the caesium frequency $\Delta\nu_{\mathrm{Cs}}$.	$1\ \mathrm{m} = \left(\dfrac{c}{299\,792\,458}\right)\mathrm{s}$
Kilogram	kg	Mass	m	The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant, h, to be $6.626\,070\,15 \times 10^{-34}$ when expressed in the unit $\mathrm{J\ s}$, which is equal to $\mathrm{kg\ m^2\ s^{-1}}$, where the metre and the second are defined in terms of c and $\Delta\nu_{\mathrm{Cs}}$.	$1\ \mathrm{kg} = \left(\dfrac{h}{6.626\,070\,15 \times 10^{-34}}\right)\mathrm{m^{-2}s}$
Ampere	A	Electric Current	I, i	The ampere, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the elementary charge, e, to be $1.602\,176\,634 \times 10^{-19}$ when expressed in the unit C, which is equal to $\mathrm{A\ s}$, where the second is defined in terms of $\Delta\nu_{\mathrm{Cs}}$.	$1\ \mathrm{A} = \left(\dfrac{e}{1.602\,176\,634 \times 10^{-19}}\right)\mathrm{s^{-1}}$
Kelvin	K	Thermodynamic Temperature	T	The kelvin, symbol K, is the SI unit of thermodynamic temperature. It is defined by taking the fixed numerical value of the Boltzmann constant, k, to be $1.380\,649 \times 10^{-23}$ when expressed in the unit $\mathrm{J\ K^{-1}}$, which is equal to $\mathrm{kg\ m^2\ s^{-2}}$	$1\ \mathrm{K} = \left(\dfrac{1.380\,649 \times 10^{-23}}{k}\right)\mathrm{kg\ m^2\ s^{-2}}$

Base Unit	Base Symbol	Base Quantity	Typical Symbol	Formal Definition	Equation
				K^{-1}, where the kilogram, metre and second are defined in terms of h, c and $\Delta\nu_{\mathrm{Cs}}$.	
Mole	mol	Amount of Substance	n	The mole, symbol mol, is the SI unit of amount of substance. One mole contains exactly $6.022\ 140\ 76 \times 10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant, N_{A}, when expressed in the unit mol^{-1} and is called the Avogadro number. The amount of substance, symbol n, of a system is a measure of the number of specified elementary entities. An elementary entity may be an atom, a molecule, an ion, an electron, any other particle or specified group of particles.	$1\ \mathrm{mol} = \left(\frac{6.022\ 140\ 76 \times 10^{23}}{N_{\mathrm{A}}}\right)$
Candela	cd	Luminous Intensity	I_{V}	The candela, symbol cd, is the SI unit of luminous intensity in a given direction. It is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency $540 \times 10^{12}\ \mathrm{Hz}$, K_{cd}, to be 683 when expressed in the unit $\mathrm{lm\ W^{-1}}$, which is equal to $\mathrm{cd\ sr\ W^{-1}}$, or $\mathrm{cd\ sr\ kg^{-1}}$ $\mathrm{m^{-2}\ s^{3}}$, where the kilogram, metre and second are defined in terms of h, c and $\Delta\nu_{Cs}$.	$1\ \mathrm{cd} = \left(\frac{K_{\mathrm{cd}}}{683}\right) \mathrm{kg\ m^{2}\ s^{-3}\ sr^{-1}}$

Sources:

- Base Unit [1] [2]
- Base Symbol [1] [2]
- Base Quantity [1] [2]
- Typical Symbol [1] [2]
- Formal Definition [1] [2]
- Equation [1] [2]

Derived Units

Derived Unit	**Unit Symbol**	**Derived Quantity**	**Equation Expressed in Terms of SI Base Units**	**Equation Expressed in Terms of Other SI Units**
Radian	rad	Plane Angle	$\mathrm{rad} = \mathrm{m/m}$	-
Steradian	sr	Solid Angle	$\mathrm{sr} = \mathrm{m^2/m^2}$	-
Hertz	Hz	Frequency	$\mathrm{Hz} = \mathrm{s^{-1}}$	-
Newton	N	Force	$\mathrm{N} = \mathrm{kg\ m\ s^{-2}}$	-
Pascal	Pa	Pressure, Stress	$\mathrm{Pa} = \mathrm{kg\ m^{-1}\ s^{-2}}$	-
Joule	J	Energy, Work, Amount of Heat	$\mathrm{J} = \mathrm{kg\ m^2\ s^{-2}}$	$\mathrm{J} = \mathrm{N\ m}$
Watt	W	Power, Radiant Flux	$\mathrm{W} = \mathrm{kg\ m^2\ s^{-3}}$	$\mathrm{W} = \mathrm{J/s}$
Coulomb	C	Electric Charge	$\mathrm{C} = \mathrm{A\ s}$	-
Volt	V	Electric Potential Difference	$\mathrm{V} = \mathrm{kg\ m^2\ s^{-3}\ A^{-1}}$	$\mathrm{V} = \mathrm{W/A}$
Farad	F	Capacitance	$\mathrm{F} = \mathrm{kg^{-1}\ m^{-2}\ s^4\ A^2}$	$\mathrm{F} = \mathrm{C/V}$
Ohm	Ω	Electric Resistance	$\Omega = \mathrm{kg\ m^2\ s^{-3}\ A^{-2}}$	$\Omega = \mathrm{V/A}$
Siemens	S	Electric Conductance	$\mathrm{S} = \mathrm{kg^{-1}\ m^{-2}\ s^3\ A^2}$	$\mathrm{S} = \mathrm{A/V}$
Weber	Wb	Magnetic Flux	$\mathrm{Wb} = \mathrm{kg\ m^2\ s^{-2}\ A^{-1}}$	$\mathrm{Wb} = \mathrm{V\ s}$
Tesla	T	Magnetic Flux Density	$\mathrm{T} = \mathrm{kg\ s^{-2}\ A^{-1}}$	$\mathrm{T} = \mathrm{Wb/m^2}$
Henry	H	Inductance	$\mathrm{H} = \mathrm{kg\ m^2\ s^{-2}\ A^{-2}}$	$\mathrm{H} = \mathrm{Wb/A}$

Derived Unit	**Unit Symbol**	**Derived Quantity**	**Equation Expressed in Terms of SI Base Units**	**Equation Expressed in Terms of Other SI Units**
Degree Celsius	$^\circ\mathrm{C}$	Celsius Temperature	$^\circ\mathrm{C} = \mathrm{K}$, where $-273.15\ ^\circ\mathrm{C} \equiv 0\ \mathrm{K}$	-
Lumen	lm	Luminous Flux	$\mathrm{lm} = \mathrm{cd\ sr}$	$\mathrm{lm} = \mathrm{cd\ sr}$
Lux	lx	Illuminance	$\mathrm{lx} = \mathrm{cd\ sr\ m^{-2}}$	$\mathrm{lx} = \mathrm{lm/m^2}$
Becquerel	Bq	Activity Referred to a Radionuclide	$\mathrm{Bq} = \mathrm{s^{-1}}$	-
Gray	Gy	Absorbed Dose, Kerma	$\mathrm{Gy} = \mathrm{m^2\ s^{-2}}$	$\mathrm{Gy} = \mathrm{J/kg}$
Sievert	Sv	Dose Equivalent	$\mathrm{Sv} = \mathrm{m^2\ s^{-2}}$	$\mathrm{Sv} = \mathrm{J/kg}$
Katal	kat	Catalytic Activity	$\mathrm{kat} = \mathrm{mol\ s^{-1}}$	-

Sources:

- Derived Unit [1] [2]
- Unit Symbol [1] [2]
- Derived Quantity [1] [2]
- Equation Expressed in Terms of SI Base Units [1] [2]
- Equation Expressed in Terms of Other SI Units [1] [2]

SI DEFINING PHYSICAL CONSTANTS (D7)

Defining Constant	Symbol	Numerical Value	Unit
Unperturbed Ground State Hyperfine Transition Frequency of the Caesium 133 Atom	$\Delta\nu_{\mathrm{Cs}}$	$9\ 192\ 631\ 770$	Hz
Speed of Light in Vacuum	c	$299\ 792\ 458$	$\mathrm{m\ s^{-1}}$
Planck Constant	h	$6.626\ 070\ 15 \times 10^{-34}$	$\mathrm{J\ s}$
Elementary Charge	e	$1.602\ 176\ 634 \times 10^{-19}$	C
Boltzmann Constant	k	$1.380\ 649 \times 10^{-23}$	$\mathrm{J\ K^{-1}}$
Avogadro Constant	N_{A}	$6.022\ 140\ 76 \times 10^{23}$	$\mathrm{mol^{-1}}$
Luminous Efficacy of Monochromatic Radiation of Frequency $\mathbf{540 \times 10^{12}\ Hz}$	K_{cd}	683	$\mathrm{lm\ W^{-1}}$

Sources:

- Defining Constant [1] [2]
- Symbol [1] [2]
- Numerical Value [1] [2]
- Unit [1] [2]

RADIOACTIVE DECAY MODES (D8)

Decay Mode	**Symbol**	**Equation**	**Nucleus Changes**
Alpha Emission	α	${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}X + {}^{4}_{2}\alpha$	$(A-4, Z-2)$
Proton Emission ***2-Proton Emission***	p $2p$	${}^{A}_{Z}X \rightarrow {}^{A-1}_{Z-1}X + {}^{1}_{1}p$ ${}^{A}_{Z}X \rightarrow {}^{A-2}_{Z-2}X + 2{}^{1}_{1}p$	$(A-1, Z-1)$ $(A-2, Z-2)$
Neutron Emission ***2-Neutron Emission***	n $2n$	${}^{A}_{Z}X \rightarrow {}^{A-1}_{Z}X + {}^{1}_{0}n$ ${}^{A}_{Z}X \rightarrow {}^{A-2}_{Z}X + 2{}^{1}_{0}n$	$(A-1, Z)$ $(A-2, Z)$
Electron Capture	ε	${}^{A}_{Z}X + {}^{0}_{-1}e \rightarrow {}_{Z-1}^{A}X + {}^{0}_{0}\nu_e$	$(A, Z-1)$
Positron Emission	e^+	${}^{A}_{Z}X \rightarrow {}_{Z-1}^{A}X + {}^{0}_{+1}e + {}^{0}_{0}\nu_e$	$(A, Z-1)$
Beta-Plus Decay	β^+	$\beta^+ = \varepsilon + e^+$ (Combined rate of ε and e^+)	Variable
Beta-Minus Decay	β^-	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}^{0}_{-1}e + {}^{0}_{0}\overline{\nu}_e$	$(A, Z+1)$
Double Beta-Minus Decay	$2\beta^-$	${}^{A}_{Z}X \rightarrow {}_{Z+2}^{A}X + 2{}^{0}_{-1}e + 2{}^{0}_{0}\overline{\nu}_e$	$(A, Z+2)$
Double Beta-Plus Decay	$2\beta^+$	${}^{A}_{Z}X \rightarrow {}_{Z-2}^{A}X + 2{}^{0}_{+1}e + 2{}^{0}_{0}\nu_e$	$(A, Z-2)$
Beta-Minus-Delayed Neutron Emission	β^-n	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}^{0}_{-1}e + {}^{0}_{0}\overline{\nu}_e$ ${}_{Z+1}^{A}X \rightarrow {}^{A-1}_{Z+1}X + {}^{1}_{0}n$	$(A-1, Z+1)$
Beta-Minus-Delayed 2-Neutron Emission	β^-2n	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}^{0}_{-1}e + {}^{0}_{0}\overline{\nu}_e$ ${}_{Z+1}^{A}X \rightarrow {}^{A-1}_{Z+1}X + 2{}^{1}_{0}n$	$(A-2, Z+1)$
Beta-Minus-Delayed 3-Neutron Emission	β^-3n	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}^{0}_{-1}e + {}^{0}_{0}\overline{\nu}_e$ ${}_{Z+1}^{A}X \rightarrow {}^{A-1}_{Z+1}X + 3{}^{1}_{0}n$	$(A-3, Z+1)$
Beta-Plus-Delayed Proton Emission	β^+p	${}^{A}_{Z}X \rightarrow {}_{Z-1}^{A}X + {}^{0}_{+1}e + {}^{0}_{0}\nu_e$ ${}_{Z-1}^{A}X \rightarrow {}^{A-1}_{Z-2}X + {}^{1}_{1}p$	$(A-1, Z-2)$
Beta-Plus-Delayed 2-Proton Emission	β^+2p	${}^{A}_{Z}X \rightarrow {}_{Z-1}^{A}X + {}^{0}_{+1}e + {}^{0}_{0}\nu_e$ ${}_{Z-1}^{A}X \rightarrow {}^{A-2}_{Z-3}X + 2{}^{1}_{1}p$	$(A-2, Z-3)$
Beta-Plus-Delayed 3-Proton Emission	β^+3p	${}^{A}_{Z}X \rightarrow {}_{Z-1}^{A}X + {}^{0}_{+1}e + {}^{0}_{0}\nu_e$ ${}_{Z-1}^{A}X \rightarrow {}^{A-3}_{Z-4}X + 3{}^{1}_{1}p$	$(A-3, Z-4)$

Decay Mode	Symbol	Equation	Nucleus Changes
Beta-Minus-Delayed Alpha Emission	$\beta^-\alpha$	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}_{-1}^{0}e + {}_{0}^{0}\overline{\nu}_e$ ${}_{Z+1}^{A}X \rightarrow {}_{Z-1}^{A-4}X + {}_{2}^{4}\alpha$	$(A-4, Z-1)$
Beta-Plus-Delayed Alpha Emission	$\beta^+\alpha$	${}^{A}_{Z}X \rightarrow {}_{Z-1}^{A}X + {}_{+1}^{0}e + {}_{0}^{0}\nu_e$ ${}_{Z-1}^{A}X \rightarrow {}_{Z-3}^{A-4}X + {}_{2}^{4}\alpha$	$(A-4, Z-3)$
Beta-Minus-Delayed Deuteron Emission	β^-d	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}_{-1}^{0}e + {}_{0}^{0}\overline{\nu}_e$ ${}_{Z+1}^{A}X \rightarrow {}^{A-2}_{Z}X + {}_{1}^{2}d$	$(A-2, Z)$
Beta-Minus-Delayed Triton Emission	β^-t	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}_{-1}^{0}e + {}_{0}^{0}\overline{\nu}_e$ ${}_{Z+1}^{A}X \rightarrow {}^{A-3}_{Z}X + {}_{1}^{3}t$	$(A-3, Z)$
Internal (Isomeric) Transition	IT	${}^{Am}_{Z}X \rightarrow {}^{A}_{Z}X + {}_{0}^{0}\gamma$	(A, Z)
Spontaneous Fission	SF	Variable	Variable
Beta-Plus-Delayed Fission	β^+SF	${}^{A}_{Z}X \rightarrow {}_{Z-1}^{A}X + {}_{+1}^{0}e + {}_{0}^{0}\nu_e$ Variable	Variable
Beta-Minus-Delayed Fission	$\beta^-\,SF$	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}_{-1}^{0}e + {}_{0}^{0}\overline{\nu}_e$ Variable	Variable
Heavy Cluster Emission **Cluster Decay**	${}^{A}X$ CD	Variable	Variable

Sources:

- Decay Mode [2]
- Symbol [1] [2]
- Equation [1] [3]
- Nucleus Changes [1] [3

PERIODIC TABLE VARIANTS (E1)

1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	63.5 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	[98] **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	175 **Lu** Lutetium 71	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	[209] **Po** Polonium 84	[210] **At** Astatine 85	[222] **Rn** Radon 86
[223] **Fr** Francium 87	[226] **Ra** Radium 88	[266] **Lr** Lawrencium 103	[261] **Rf** Rutherfordium 104	[262] **Db** Dubnium 105	[266] **Sg** Seaborgium 106	[264] **Bh** Bohrium 107	[277] **Hs** Hassium 108	[268] **Mt** Meitnerium 109	[271] **Ds** Darmstadium 110	[272] **Rg** Roentgenium 111	[285] **Cn** Copernicium 112	[286] **Nh** Nihonium 113	[289] **Fl** Flerovium 114	[289] **Mc** Moscovium 115	[293] **Lv** Livermorium 116	[294] **Ts** Tennessine 117	[294] **Og** Oganesson 118

139 **La** Lanthanum 57	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	[145] **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70
[227] **Ac** Actinium 89	232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	[237] **Np** Neptunium 93	[244 **Pu** Plutonium 94	243 **Am** Americium 95	[247] **Cm** Curium 96	[247] **Bk** Berkelium 97	[251] **Cf** Californium 98	[252] **Es** Einsteinium 99	[257] **Fm** Fermium 100	[258] **Md** Mendelevium 101	[259] **No** Nobelium 102

1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	63.5 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	[98] **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	175 **Lu** Lutetium 71	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	[209] **Po** Polonium 84	[210] **At** Astatine 85	[222] **Rn** Radon 86
[223] **Fr** Francium 87	[226] **Ra** Radium 88	[266] **Lr** Lawrencium 103	[261] **Rf** Rutherfordium 104	[262] **Db** Dubnium 105	[266] **Sg** Seaborgium 106	[264] **Bh** Bohrium 107	[277] **Hs** Hassium 108	[268] **Mt** Meitnerium 109	[271] **Ds** Darmstadium 110	[272] **Rg** Roentgenium 111	[285] **Cn** Copernicium 112	[286] **Nh** Nihonium 113	[289] **Fl** Flerovium 114	[289] **Mc** Moscovium 115	[293] **Lv** Livermorium 116	[294] **Ts** Tennessine 117	[294] **Og** Oganesson 118

139 **La** Lanthanum 57	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	[145] **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70
[227] **Ac** Actinium 89	232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	[237] **Np** Neptunium 93	[244 **Pu** Plutonium 94	243 **Am** Americium 95	[247] **Cm** Curium 96	[247] **Bk** Berkelium 97	[251] **Cf** Californium 98	[252] **Es** Einsteinium 99	[257] **Fm** Fermium 100	[258] **Md** Mendelevium 101	[259] **No** Nobelium 102

1	2											3	4	5	6	7	0/8
1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	63.5 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	[98] **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	175 **Lu** Lutetium 71	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	[209] **Po** Polonium 84	[210] **At** Astatine 85	[222] **Rn** Radon 86
[223] **Fr** Francium 87	[226] **Ra** Radium 88	[266] **Lr** Lawrencium 103	[261] **Rf** Rutherfordium 104	[262] **Db** Dubnium 105	[266] **Sg** Seaborgium 106	[264] **Bh** Bohrium 107	[277] **Hs** Hassium 108	[268] **Mt** Meitnerium 109	[271] **Ds** Darmstadium 110	[272] **Rg** Roentgenium 111	[285] **Cn** Copernicium 112	[286] **Nh** Nihonium 113	[289] **Fl** Flerovium 114	[289] **Mc** Moscovium 115	[293] **Lv** Livermorium 116	[294] **Ts** Tennessine 117	[294] **Og** Oganesson 118

139 **La** Lanthanum 57	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	[145] **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70
[227] **Ac** Actinium 89	232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	[237] **Np** Neptunium 93	[244 **Pu** Plutonium 94	243 **Am** Americium 95	[247] **Cm** Curium 96	[247] **Bk** Berkelium 97	[251] **Cf** Californium 98	[252] **Es** Einsteinium 99	[257] **Fm** Fermium 100	[258] **Md** Mendelevium 101	[259] **No** Nobelium 102

Alkali Metals 1	2											3	4	5	6	Halogens 7	Noble Gases 0/8
1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	63.5 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	[98] **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	175 **Lu** Lutetium 71	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	[209] **Po** Polonium 84	[210] **At** Astatine 85	[222] **Rn** Radon 86
[223] **Fr** Francium 87	[226] **Ra** Radium 88	[266] **Lr** Lawrencium 103	[261] **Rf** Rutherfordium 104	[262] **Db** Dubnium 105	[266] **Sg** Seaborgium 106	[264] **Bh** Bohrium 107	[277] **Hs** Hassium 108	[268] **Mt** Meitnerium 109	[271] **Ds** Darmstadium 110	[272] **Rg** Roentgenium 111	[285] **Cn** Copernicium 112	[286] **Nh** Nihonium 113	[289] **Fl** Flerovium 114	[289] **Mc** Moscovium 115	[293] **Lv** Livermorium 116	[294] **Ts** Tennessine 117	[294] **Og** Oganesson 118

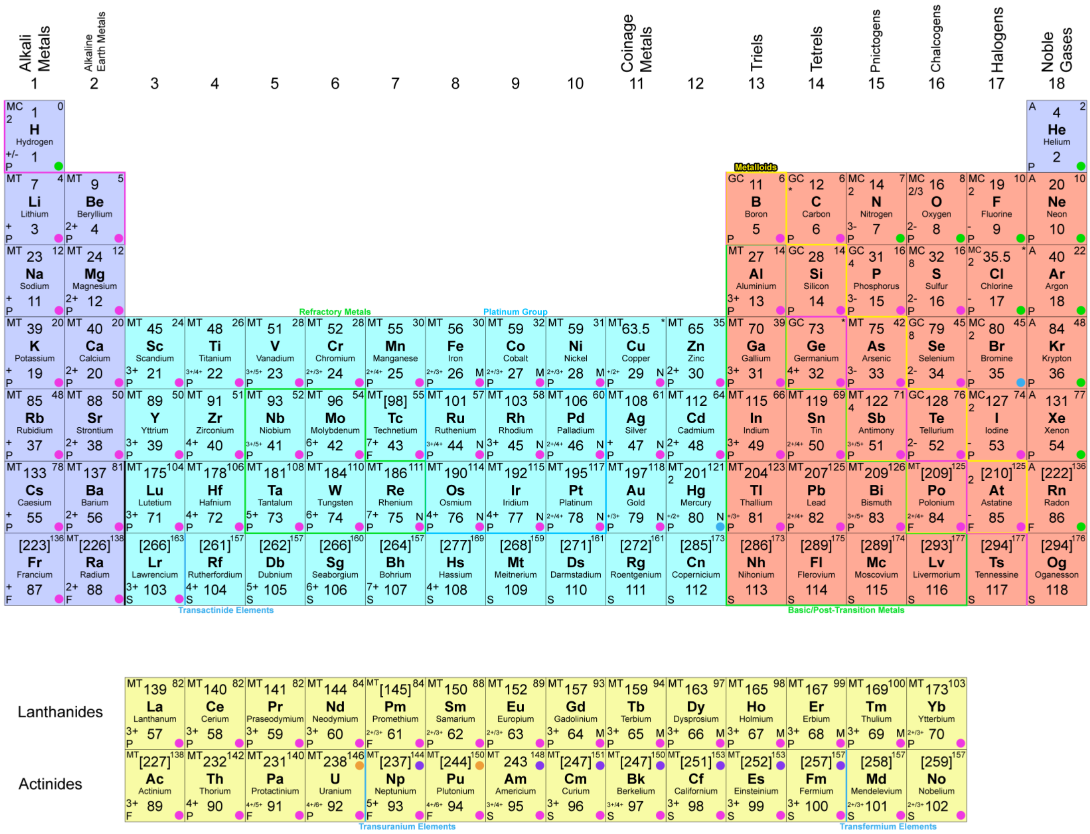
Lanthanides	139 **La** Lanthanum 57	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	[145] **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70
Actinides	[227] **Ac** Actinium 89	232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	[237] **Np** Neptunium 93	[244 **Pu** Plutonium 94	243 **Am** Americium 95	[247] **Cm** Curium 96	[247] **Bk** Berkelium 97	[251] **Cf** Californium 98	[252] **Es** Einsteinium 99	[257] **Fm** Fermium 100	[258] **Md** Mendelevium 101	[259] **No** Nobelium 102

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	63.5 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	[98] **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	175 **Lu** Lutetium 71	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	[209] **Po** Polonium 84	[210] **At** Astatine 85	[222] **Rn** Radon 86
[223] **Fr** Francium 87	[226] **Ra** Radium 88	[266] **Lr** Lawrencium 103	[261] **Rf** Rutherfordium 104	[262] **Db** Dubnium 105	[266] **Sg** Seaborgium 106	[264] **Bh** Bohrium 107	[277] **Hs** Hassium 108	[268] **Mt** Meitnerium 109	[271] **Ds** Darmstadium 110	[272] **Rg** Roentgenium 111	[285] **Cn** Copernicium 112	[286] **Nh** Nihonium 113	[289] **Fl** Flerovium 114	[289] **Mc** Moscovium 115	[293] **Lv** Livermorium 116	[294] **Ts** Tennessine 117	[294] **Og** Oganesson 118

139 **La** Lanthanum 57	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	[145] **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70
[227] **Ac** Actinium 89	232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	[237] **Np** Neptunium 93	[244 **Pu** Plutonium 94	243 **Am** Americium 95	[247] **Cm** Curium 96	[247] **Bk** Berkelium 97	[251] **Cf** Californium 98	[252] **Es** Einsteinium 99	[257] **Fm** Fermium 100	[258] **Md** Mendelevium 101	[259] **No** Nobelium 102

Alkali Metals 1	Alkaline Earth Metals 2	3	4	5	6	7	8	9	10	Coinage Metals 11	12	Triels 13	Tetrels 14	Pnictogens 15	Chalcogens 16	Halogens 17	Noble Gases 18
1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	63.5 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	[98] **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	175 **Lu** Lutetium 71	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	[209] **Po** Polonium 84	[210] **At** Astatine 85	[222] **Rn** Radon 86
[223] **Fr** Francium 87	[226] **Ra** Radium 88	[266] **Lr** Lawrencium 103	[261] **Rf** Rutherfordium 104	[262] **Db** Dubnium 105	[266] **Sg** Seaborgium 106	[264] **Bh** Bohrium 107	[277] **Hs** Hassium 108	[268] **Mt** Meitnerium 109	[271] **Ds** Darmstadium 110	[272] **Rg** Roentgenium 111	[285] **Cn** Copernicium 112	[286] **Nh** Nihonium 113	[289] **Fl** Flerovium 114	[289] **Mc** Moscovium 115	[293] **Lv** Livermorium 116	[294] **Ts** Tennessine 117	[294] **Og** Oganesson 118

Lanthanides	139 **La** Lanthanum 57	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	[145] **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70
Actinides	[227] **Ac** Actinium 89	232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	[237] **Np** Neptunium 93	[244 **Pu** Plutonium 94	243 **Am** Americium 95	[247] **Cm** Curium 96	[247] **Bk** Berkelium 97	[251] **Cf** Californium 98	[252] **Es** Einsteinium 99	[257] **Fm** Fermium 100	[258] **Md** Mendelevium 101	[259] **No** Nobelium 102


Alkali Metals
Alkaline Earth Metals
Coinage Metals
Triels
Tetrels
Pnictogens
Chalcogens
Halogens
Noble Gases
Metalloids
Refractory Metals
Platinum Group
Transactinide Elements
Basic/Post-Transition Metals
Lanthanides
Actinides
Transuranium Elements
Transfermium Elements

STANDARD MODEL VARIANTS (E2)

Elementary Fermions / Elementary Antifermions

Quarks

I	II	III	I	II	III
2.16 MeV ⅔ ½ **u** Up	1.27 GeV ⅔ ½ **c** Charm	172.69 GeV ⅔ ½ **t** Top	2.16 MeV −⅔ ½ $\bar{u}$ Antiup	1.27 GeV −⅔ ½ $\bar{c}$ Anticharm	172.69 GeV −⅔ ½ $\bar{t}$ Antitop
4.67 MeV −⅓ ½ **d** Down	93.4 MeV −⅓ ½ **s** Strange	4.18 GeV −⅓ ½ **b** Bottom	4.67 MeV ⅓ ½ $\bar{d}$ Antidown	93.4 MeV ⅓ ½ $\bar{s}$ Antistrange	4.18 GeV ⅓ ½ $\bar{b}$ Antibottom

Leptons

I	II	III	I	II	III
0.51 MeV −1 ½ e^- Electron	105.66 MeV −1 ½ μ^- Muon	1.78 GeV −1 ½ τ^- Tau	0.51 MeV 1 ½ e^+ Positron	105.66 MeV 1 ½ μ^+ Antimuon	1.78 GeV 1 ½ τ^+ Antitau
< 1.10 eV > 0 ½ ν_e Electron Neutrino	< 0.19 MeV > 0 ½ ν_μ Muon Neutrino	< 18.20 MeV > 0 ½ ν_τ Tau Neutrino	< 1.10 eV > 0 ½ $\bar{\nu}_e$ Electron Antineutrino	< 0.19 MeV > 0 ½ $\bar{\nu}_\mu$ Muon Antineutrino	< 18.20 MeV > 0 ½ $\bar{\nu}_\tau$ Tau Antineutrino

Elementary Bosons

Gauge Bosons	Scalar Bosons
0.00 eV 0 1 **g** Gluon	125.25 GeV 0 0 **H** Higgs
> 0.00 eV > 0 1 γ Photon	
91.19 GeV 0 1 **Z** Z^0 Boson	
80.38 GeV 1 1 W^+ W^+ Boson	
80.38 GeV −1 1 W^- W^- Boson	

u Up	**c** Charm	**t** Top	$\bar{u}$ Antiup	$\bar{c}$ Anticharm	$\bar{t}$ Antitop
d Down	**s** Strange	**b** Bottom	$\bar{d}$ Antidown	$\bar{s}$ Antistrange	$\bar{b}$ Antibottom

e^- Electron	μ^- Muon	τ^- Tau	e^+ Positron	μ^+ Antimuon	τ^+ Antitau
ν_e Electron Neutrino	ν_μ Muon Neutrino	ν_τ Tau Neutrino	$\bar{\nu}_e$ Electron Antineutrino	$\bar{\nu}_\mu$ Muon Antineutrino	$\bar{\nu}_\tau$ Tau Antineutrino

g Gluon	**H** Higgs
γ Photon	
Z Z^0 Boson	
W^+ W^+ Boson	
W^- W^- Boson	

+⅔ ⅓ **u** Up	−⅓ ⅓ **d** Down

+⅔ ⅓ **u** Up	+⅔ ⅓ **c** Charm	+⅔ ⅓ **t** Top
−⅓ ⅓ **d** Down	−⅓ ⅓ **s** Strange	−⅓ ⅓ **b** Bottom

⅓ ⅔ **u** Up	⅓ ⅔ **c** Charm	⅓ ⅔ **t** Top	⅓ −⅔ $\bar{\mathbf{u}}$ Antiup	⅓ −⅔ $\bar{\mathbf{c}}$ Anticharm	⅓ −⅔ $\bar{\mathbf{t}}$ Antitop
⅓ −⅓ **d** Down	⅓ −⅓ **s** Strange	⅓ −⅓ **b** Bottom	⅓ ⅓ $\bar{\mathbf{d}}$ Antidown	⅓ ⅓ $\bar{\mathbf{s}}$ Antistrange	⅓ ⅓ $\bar{\mathbf{b}}$ Antibottom

BIBLIOGRAPHY (F1)

C1 – COMMON UNIT CONVERSIONS

[1] CODATA & NIST. (2018). *2018 CODATA Recommended Values*. The NIST Reference on Constants, Units, and Uncertainty. `https://physics.nist.gov/cuu/Constants`

[2] Skinner, N. (2023). *D6 – SI Unit Definitions*. `https://skinnerscience.neoski.tk/datasheets/D6`

[3] *U.S. Standard Atmosphere, 1976* (NOAA-S/T-76-1562). (1976). `https://ntrs.nasa.gov/citations/19770009539`

C2 – COMMON UNIT PREFIXES

[1] BIPM. (2019). *A Concise Summary of the International System of Units, SI*. BIPM.

[2] NIST Metric Program. (2022). *Metric (SI) Prefixes | NIST*. NIST. `https://www.nist.gov/pml/owm/metric-si-prefixes`

C3 – COMMON TIME CONVERSIONS

[1] BIPM. (2019). *Le Système International d'Unités / The International System of Units* (9th ed). Bureau International des Poids et Mesures. `http://www.bipm.org/en/si/si_brochure`

[2] Newell, D. B., & Tiesinga, E. (2019). *The International System of Units (SI)* (NIST SP 330-2019; p. NIST SP 330-2019). National Institute of Standards and Technology. `https://doi.org/10.6028/NIST.SP.330-2019`

[3] Wilkins, G. A. & International Astronomical Union. (1989). *The IAU Style Manual: The Preparation of Astronomical Papers and Reports*. `https://www.iau.org/static/publications/stylemanual1989.pdf`

C4 – COMMON FUNDAMENTAL PHYSICAL CONSTANTS

[1] BIPM. (2019). *Le Système International d'Unités / The International System of Units* (9th ed). Bureau International des Poids et Mesures. `http://www.bipm.org/en/si/si_brochure`

[2] CODATA & NIST. (2018). *2018 CODATA Recommended Values*. The NIST Reference on Constants, Units, and Uncertainty. `https://physics.nist.gov/cuu/Constants`

[3] *How Many Decimals of Pi Do We Really Need? - Edu News*. (n.d.). NASA/JPL Edu. Retrieved March 12, 2023, from `https://www.jpl.nasa.gov/edu/news/2016/3/16/how-many-decimals-of-pi-do-we-really-need`

[4] Newell, D. B., & Tiesinga, E. (2019). *The International System of Units (SI)* (NIST SP 330-2019; p. NIST SP 330-2019). National Institute of Standards and Technology. `https://doi.org/10.6028/NIST.SP.330-2019`

C5 – COMMON NON-SI UNIT CONVERSIONS

[1] Butcher, K. S., Crown, L. D., & Gentry, E. J. (2006). *The International System of Units (SI) — Conversion Factors for General Use* (NIST SP 1038; 0 ed., p. NIST SP 1038). National Institute of Standards and Technology. `https://doi.org/10.6028/NIST.SP.1038`

[2] NIST. (2010). Unit Conversion. *NIST*. `https://www.nist.gov/pml/owm/metric-si/unit-conversion`

D1 – PERIODIC TABLE OF ELEMENTS

[3] Brunning, A. (2019, December 10). #ChemistryAdvent #IYPT2019 Day 10: A Periodic Table of Common Ions [Blog]. *Compound Interest*. `https://www.compoundchem.com/2019advent/day10`

[4] Clark, J. (2012). *Metal Structures*. ChemGuide. `https://chemguide.co.uk/atoms/structures/metals.html`

[5] Clark, J. (2019). *Metallic Bonding*. ChemGuide. `https://chemguide.co.uk/atoms/bonding/metallic.html`

[6] Clark, J. (2021). *Atomic and Physical Properties of Period 3 Elements*. ChemGuide. `https://chemguide.co.uk/inorganic/period3/elementsphys.html`

[7] Clark, J. (2022). *Intermolecular Bonding—Van der Waals Forces*. ChemGuide. `https://chemguide.co.uk/atoms/bonding/vdw.html`

[8] Clark, J. (2022). *The Trend from Non-Metal to Metal in Group 4*. ChemGuide. `https://chemguide.co.uk/inorganic/group4/properties.html`

[9] CNRS. (2023). Minor Actinides. Radioactivity.Eu.Com. `https://laradioactivitefr.gatsbyjs.io/nuclearenergy/minor_actinides`

[10] Connelly, N., Damhus, T., Hartshorn, R., & Hutton (Eds.). (2005). Nomenclature of Inorganic Chemistry – IUPAC Recommendations 2005. *Chemistry International -- Newsmagazine for IUPAC*, *27*(6). `https://doi.org/10.1515/ci.2005.27.6.25`

[11] Cullity, B. D., & Graham, C. D. (2009). *Introduction to Magnetic Materials* (2nd ed). IEEE/Wiley.

[12] Gonick, L., & Criddle, C. (2005). *The Cartoon Guide to Chemistry*. New York : HarperResource. `http://archive.org/details/cartoonguidetoch00gonirich`

[13] Greenwood, N. N., & Earnshaw, A. (1997). *Chemistry of the Elements* (2nd ed). Butterworth-Heinemann.

[14] IUPAC. (2022). *Periodic Table of Elements—IUPAC | International Union of Pure and Applied Chemistry*. International Union of Pure and Applied Chemistry. `https://iupac.org/what-we-do/periodic-table-of-elements`

[15] Jackson, M. (2000). Wherefore Gadolinium? Magnetism of the Rare Earths. *The IRM Quarterly*, *10*(3). `https://conservancy.umn.edu/bitstream/handle/11299/171280/irmq10-3.pdf`

[16] Kondev, F. G., Wang, M., Huang, W. J., Naimi, S., & Audi, G. (2021). The NUBASE2020 Evaluation of Nuclear Physics Properties. *Chinese Physics C*, *45*(3), 030001.

https://doi.org/10.1088/1674-1137/abddae

[17] Meija, J., Coplen, T. B., Berglund, M., Brand, W. A., De Bièvre, P., Gröning, M., Holden, N. E., Irrgeher, J., Loss, R. D., Walczyk, T., & Prohaska, T. (2016). Atomic Weights of the Elements 2013 (IUPAC Technical Report). *Pure and Applied Chemistry*, *88*(3), 265–291. https://doi.org/10.1515/pac-2015-0305

[18] Meija, J., Coplen, T. B., Berglund, M., Brand, W. A., De Bièvre, P., Gröning, M., Holden, N. E., Irrgeher, J., Loss, R. D., Walczyk, T., & Prohaska, T. (2016). Isotopic Compositions of the Elements 2013 (IUPAC Technical Report). *Pure and Applied Chemistry*, *88*(3), 293–306. https://doi.org/10.1515/pac-2015-0503

[19] Prohaska, T., Irrgeher, J., Benefield, J., Böhlke, J. K., Chesson, L. A., Coplen, T. B., Ding, T., Dunn, P. J. H., Gröning, M., Holden, N. E., Meijer, H. A. J., Moossen, H., Possolo, A., Takahashi, Y., Vogl, J., Walczyk, T., Wang, J., Wieser, M. E., Yoneda, S., … Meija, J. (2022). Standard Atomic Weights of the Elements 2021 (IUPAC Technical Report). *Pure and Applied Chemistry*, *94*(5), 573–600. https://doi.org/10.1515/pac-2019-0603

[20] Science Struck. (2009, June 15). A Complete List of Man-Made Synthetic Elements [Blog]. *Science Struck*. https://sciencestruck.com/synthetic-elements

[21] Skinner, N. (2023). *D2—Properties of Elements*. https://skinnerscience.neoski.tk/datasheets/D2

[22] Smith, J. D., & Smith, J. D. (1975). *The Chemistry of Arsenic, Antimony and Bismuth*. Pergamon Press.

[23] Synthetic Elements. (2023). In P. Lagassé & Columbia University (Eds.), *The Colombia Encyclopedia* (6th ed). Columbia University Press ; Sold and Distributed by Gale Group.

[24] The Royal Society of Chemistry. (2023). *Periodic Table – Royal Society of Chemistry*. https://www.rsc.org/periodic-table

[25] Weiner, J. (2020). *Periodic Table of Ions*. ScienceGeek.Net. https://sciencegeek.net/tables/PT_ions.pdf

[26] Wikimedia Foundation. (2023). Atomicity (Chemistry). In Wikipedia. https://en.wikipedia.org/w/index.php?title=Atomicity_(chemistry)&oldid=1136378998

[27] Winter, M. (2023). *The Periodic Table of the Elements by WebElements*. WebElements. https://www.webelements.com

[28] Wolfram Research, Inc. (2023). *Wolfram|Alpha: Making the World's Knowledge Computable*. Wolfram|Alpha. https://www.wolframalpha.com

D2 – PROPERTIES OF ELEMENTS

[1] Coursey, J. S., Schwab, D. J., Tsai, J. J., & Dragoset, R. A. (2009, August 23). *Atomic Weights and Isotopic Compositions with Relative Atomic Masses* [National Institute of Standards and Technology]. NIST. https://www.nist.gov/pml/atomic-weights-and-isotopic-compositions-relative-atomic-masses

[2] Glotzel, D. (1978). Ground-State Properties of f-Band Metals: Lanthanum, Cerium and Thorium. *Journal of Physics F: Metal Physics*, *8*(7), L163. https://doi.org/10.1088/0305-4608/8/7/004

[3] Hill, J. W., & Petrucci, R. H. (2002). *General Chemistry: An Integrated Approach* (3rd ed). Upper Saddle River, N.J. : Prentice Hall. `http://archive.org/details/generalchemistry00hill`

[4] Huang, W. J., Wang, M., Kondev, F. G., Audi, G., & Naimi, S. (2021). The AME 2020 Atomic Mass Evaluation (I). Evaluation of Input Data, and Adjustment Procedures. *Chinese Physics C*, *45*(3), 030002. `https://doi.org/10.1088/1674-1137/abddb0`

[5] Huang, W. J., Wang, M., Kondev, F. G., Audi, G., & Naimi, S. (2021). The AME 2020 Atomic Mass Evaluation (II). Tables, Graphs and References. *Chinese Physics C*, *45*(3), 030003. `https://doi.org/10.1088/1674-1137/abddaf`

[6] IUPAC. (2022). *Periodic Table of Elements—IUPAC | International Union of Pure and Applied Chemistry*. International Union of Pure and Applied Chemistry. `https://iupac.org/what-we-do/periodic-table-of-elements`

[7] Kramida, A., Ralchenko, Yu., Reader, J., & NIST ASD Team. (2009). NIST Atomic Spectra Database. *NIST*. `https://doi.org/10.18434/T4W30F`

[8] Lange, N. A. (1999). *Lange's Handbook of Chemistry* (J. A. Dean, Ed.; 15th ed). McGraw-Hill.

[9] Meek, T. L., & Allen, L. C. (2002). Configuration Irregularities: Deviations from the Madelung Rule and Inversion of Orbital Energy Levels. *Chemical Physics Letters*, *362*(5), 362–364. `https://doi.org/10.1016/S0009-2614(02)00919-3`

[10] Meija, J., Coplen, T. B., Berglund, M., Brand, W. A., De Bièvre, P., Gröning, M., Holden, N. E., Irrgeher, J., Loss, R. D., Walczyk, T., & Prohaska, T. (2016). Isotopic Compositions of the Elements 2013 (IUPAC Technical Report). *Pure and Applied Chemistry*, *88*(3), 293–306. `https://doi.org/10.1515/pac-2015-0503`

[11] Melrose, M. P., & Scerri, E. R. (1996). Why the 4s Orbital is Occupied Before the 3d. *Journal of Chemical Education*, *73*(6), 498. `https://doi.org/10.1021/ed073p498`

[12] Morss, L. R., Edelstein, N. M., Fuger, J., & Katz, J. J. (Eds.). (2006). *The Chemistry of the Actinide and Transactinide Elements* (3rd ed). Springer.

[13] Prohaska, T., Irrgeher, J., Benefield, J., Böhlke, J. K., Chesson, L. A., Coplen, T. B., Ding, T., Dunn, P. J. H., Gröning, M., Holden, N. E., Meijer, H. A. J., Moossen, H., Possolo, A., Takahashi, Y., Vogl, J., Walczyk, T., Wang, J., Wieser, M. E., Yoneda, S., … Meija, J. (2022). Standard Atomic Weights of the Elements 2021 (IUPAC Technical Report). *Pure and Applied Chemistry*, *94*(5), 573–600. `https://doi.org/10.1515/pac-2019-0603`

[14] Rumble, J. R., Bruno, T. J., & Doa, M. J. (2022). *The CRC Handbook of Chemistry and Physics: A Ready Reference Book of Chemical and Physical Data* (103rd ed). CRC Press.

[15] Scerri, E.R. (2013, November 7). *The Trouble with the Aufbau Principle*. RSC Education. `https://edu.rsc.org/feature/the-trouble-with-the-aufbau-principle/2000133.article`

[16] Scerri, E. R. (2019). Five Ideas in Chemical Education that Must Die. *Foundations of Chemistry*, *21*(1), 61–69. `https://doi.org/10.1007/s10698-018-09327-y`

[17] The Royal Society of Chemistry. (2023). *Periodic Table – Royal Society of Chemistry*. `https://www.rsc.org/periodic-table`

[18] Umemoto, K., & Saito, S. (1996). Electronic Configurations of Superheavy Elements. *Journal of the Physical Society of Japan*, *65*(10), 3175–3179. `https://doi.org/10.1143/JPSJ.65.3175`

[19] Weisstein, E. W. (2007). *Electron Orbital—From Eric Weisstein's World of Physics* [Text]. Eric Weisstein's World of Physics; Wolfram Research, Inc. `https://scienceworld.wolfram.com/physics/ElectronOrbital.html`

[20] Winter, M. (2023). *The Periodic Table of the Elements by WebElements*. WebElements. `https://www.webelements.com`

[21] Wolfram Research, Inc. (2023). *Wolfram|Alpha: Making the World's Knowledge Computable*. Wolfram|Alpha. `https://www.wolframalpha.com`

D3 – PROPERTIES OF NUCLIDES

[1] Coursey, J. S., Schwab, D. J., Tsai, J. J., & Dragoset, R. A. (2009, August 23). *Atomic Weights and Isotopic Compositions with Relative Atomic Masses* [National Institute of Standards and Technology]. NIST. `https://www.nist.gov/pml/atomic-weights-and-isotopic-compositions-relative-atomic-masses`

[2] Gray, T., Mann, N., & Whitby, M. (2017, October 28). *The Photographic Periodic Table of the Elements*. PeriodicTable.Com. `https://periodictable.com`

[3] Kondev, F. G., Wang, M., Huang, W. J., Naimi, S., & Audi, G. (2021). The NUBASE2020 Evaluation of Nuclear Physics Properties. *Chinese Physics C*, *45*(3), 030001. `https://doi.org/10.1088/1674-1137/abddae`

[4] Meija, J., Coplen, T. B., Berglund, M., Brand, W. A., De Bièvre, P., Gröning, M., Holden, N. E., Irrgeher, J., Loss, R. D., Walczyk, T., & Prohaska, T. (2016). Isotopic Compositions of the Elements 2013 (IUPAC Technical Report). *Pure and Applied Chemistry*, *88*(3), 293–306. `https://doi.org/10.1515/pac-2015-0503`

[5] National Nuclear Data Center. (2023). *NuDat 3*. NuDat 3. `https://www.nndc.bnl.gov/nudat3`

[6] Wolfram Research, Inc. (2023). *Wolfram|Alpha: Making the World's Knowledge Computable*. Wolfram|Alpha. `https://www.wolframalpha.com`

D4 – STANDARD MODEL OF ELEMENTARY PARTICLES

[1] Skinner, N. (2023). *D5—Properties of Elementary Particles*. `https://skinnerscience.neoski.tk/datasheets/D5`

D5 – PROPERTIES OF ELEMENTARY PARTICLES

[1] CMS Collaboration. (2021). *Life of the Higgs Boson | CMS Experiment*. The CMS Experiment at CERN. `https://cms.cern/news/life-higgs-boson`

[2] Particle Data Group, Workman, R. L., Burkert, V. D., Crede, V., Klempt, E., Thoma, U., Tiator, L., Agashe, K., Aielli, G., Allanach, B. C., Amsler, C., Antonelli, M., Aschenauer, E. C., Asner, D. M., Baer, H., Banerjee, S., Barnett, R. M., Baudis, L., Bauer, C. W., … Zyla, P. A. (2022). Review of Particle Physics. *Progress of Theoretical and Experimental Physics*, *2022*(8), 083C01. `https://doi.org/10.1093/ptep/ptac097`

D6 – SI UNIT DEFINITIONS

[1] BIPM. (2019). *Le Système International d'Unités / The International System of Units* (9th ed). Bureau International des Poids et Mesures. `http://www.bipm.org/en/si/si_brochure`

[2] Newell, D. B., & Tiesinga, E. (2019). *The International System of Units (SI)* (NIST SP 330-2019; p. NIST SP 330-2019). National Institute of Standards and Technology. `https://doi.org/10.6028/NIST.SP.330-2019`

D7 – SI DEFINING PHYSICAL CONSTANTS

[1] BIPM. (2019). *Le Système International d'Unités / The International System of Units* (9th ed). Bureau International des Poids et Mesures. `http://www.bipm.org/en/si/si_brochure`

[2] Newell, D. B., & Tiesinga, E. (2019). *The International System of Units (SI)* (NIST SP 330-2019; p. NIST SP 330-2019). National Institute of Standards and Technology. `https://doi.org/10.6028/NIST.SP.330-2019`

D8 – RADIOACTIVE DECAY MODES

[1] Abdulla, S. (2017, March 16). Radioactive Decay. *Radiology Cafe*. `https://www.radiologycafe.com/frcr-physics-notes/basic-science/radioactive-decay`

[2] Kondev, F. G., Wang, M., Huang, W. J., Naimi, S., & Audi, G. (2021). The NUBASE2020 Evaluation of Nuclear Physics Properties. *Chinese Physics C*, *45*(3), 030001. `https://doi.org/10.1088/1674-1137/abddae`

[3] Rice University & Western Oregon University. (2016). CH103 – CHAPTER 3: Radioactivity and Nuclear Chemistry – Chemistry. *Allied Heath Chemistry*. `https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch103-allied-health-chemistry/ch103-chapter-3-radioactivity`

GUIDE TO REFERENCING (F2)

When referencing this work, the following guidelines must be upheld.

Referencing Singular Datasheets

When only a single datasheet has been used as a data source within a work, it is permissible to reference the individual datasheet. The information for this use case is as follows:

Reference Component	Value
Author	Skinner, N.
Year	2023
Datasheet Title	D# – Full Datasheet Title
Work Title	The D-Series Scientific Datasheet Collection
Edition	First (1st)
Identifier	TBC

When a companion sheet is the reference source, the entire collection must always be cited.

Referencing the Collection

When more than one datasheet is used, the entire collection must be cited. The information for this use case is as follows:

Reference Component	Value
Author	Skinner, N.
Year	2023
Work Title	The D-Series Scientific Datasheet Collection
Edition	First (1st)
Identifier	TBC

Examples

The Periodic Table of Elements (D1) datasheet can be cited as follows:

> Skinner, N. (2023). D1 – Periodic Table of Elements. *The D-Series Scientific Datasheet Collection* (1st ed). `https://skinnerscience.neoski.tk/datasheets/D1`

The entire collection can be cited as follows:

> Skinner, N. (2023). *The D-Series Scientific Datasheet Collection* (1st ed). `https://skinnerscience.neoski.tk/datasheets/D1`

ACKNOWLEDGEMENTS (F3)

Many people have been instrumental in this work and have influenced the final presentation you see today. I strongly believe that everyone involved in this project, whether their influence is large or small, should be duly thanked and appreciated within these pages. Below is a complete list of those noble few who have given their time to help support me and this project.

Firstly, I would like to thank my science technician, Artie Herbert, for their continued faith in me and genuine conviction for the project – your thoughts have been paramount in the communication of scientific ideas and clarity of practices outlined in this project, an important element in any work.

Next comes my closest friend and advisor to all my scientific endeavours, Tyler Rocha. Your continued signs of genius and madness have ensured that I have been entertained every step of the way and your glimpses into the work have afforded me an overview of the general response to the project – both very important factors, especially the former.

Then there's my link to exam boards and qualifications, Mrs Bleeze has been important to ensure that the project has been produced in a timely and organised manner as well as aiding me in submitting it for an AQA Higher Project Qualification – thanks a bunch!

Ephram Matocha has given their support for the project with their continued interest and zeal for the results – they have been interested every step of the way and taken time to attend my initial presentation on the subject, something that I know most people would not sit through!

Finally, and in no particular order, I would like to thank Mr Barrett for their funny and entertaining questions along the way, Mr Daniel Willmott has graciously been my STEM Ambassador and answered all of my questions regarding the datasheets contents, Mrs Biddle is my HPQ centre coordinator and has given their time to ensure that I am equipped with an arsenal of qualifications that will see me well in my future careers – whatever they may be! An enormous thank you goes out to all of those mentioned.

LICENSING (F4)

Public Use

This work is licensed for public use under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International Public License (CC BY-NC-ND 4.0).

The full license terms are printed below and are available on the Creative Commons website at the following web address: `creativecommons.org/licenses/by-nc-nd/4.0/legalcode`

By exercising the Licensed Rights (defined below), You accept and agree to be bound by the terms and conditions of this Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International Public License ("Public License"). To the extent this Public License may be interpreted as a contract, You are granted the Licensed Rights in consideration of Your acceptance of these terms and conditions, and the Licensor grants You such rights in consideration of benefits the Licensor receives from making the Licensed Material available under these terms and conditions.

Section 1 – Definitions.

a. **Adapted Material** means material subject to Copyright and Similar Rights that is derived from or based upon the Licensed Material and in which the Licensed Material is translated, altered, arranged, transformed, or otherwise modified in a manner requiring permission under the Copyright and Similar Rights held by the Licensor. For purposes of this Public License, where the Licensed Material is a musical work, performance, or sound recording, Adapted Material is always produced where the Licensed Material is synched in timed relation with a moving image.

b. **Copyright and Similar Rights** means copyright and/or similar rights closely related to copyright including, without limitation, performance, broadcast, sound recording, and Sui Generis Database Rights, without regard to how the rights are labeled or categorized. For purposes of this Public License, the rights specified in Section `2(b)(1)-(2)` are not Copyright and Similar Rights.

c. **Effective Technological Measures** means those measures that, in the absence of proper authority, may not be circumvented under laws fulfilling obligations under Article 11 of the WIPO Copyright Treaty adopted on December 20, 1996, and/or similar international agreements.

d. **Exceptions and Limitations** means fair use, fair dealing, and/or any other exception or limitation to Copyright and Similar Rights that applies to Your use of the Licensed Material.

e. **Licensed Material** means the artistic or literary work, database, or other material to which the Licensor applied this Public License.

f. **Licensed Rights** means the rights granted to You subject to the terms and conditions of this Public License, which are limited to all Copyright and Similar Rights that apply to Your use of the Licensed Material and that the Licensor has authority to license.

g. **Licensor** means the individual(s) or entity(ies) granting rights under this Public License.

h. **NonCommercial** means not primarily intended for or directed towards commercial advantage or monetary compensation. For purposes of this Public License, the exchange of the Licensed Material for other material subject to Copyright and Similar Rights by digital file-sharing or similar means is NonCommercial provided there is no payment of monetary compensation in connection with the exchange.

i. **Share** means to provide material to the public by any means or process that requires permission under the Licensed Rights, such as reproduction, public display, public performance, distribution, dissemination, communication, or importation, and to make material available to the public including in ways that members of the public may access the material from a place and at a time individually chosen by them.

j. **Sui Generis Database Rights** means rights other than copyright resulting from Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the legal protection of databases, as amended and/or succeeded, as well as other essentially equivalent rights anywhere in the world.

k. **You** means the individual or entity exercising the Licensed Rights under this Public License. **Your** has a corresponding meaning.

Section 2 – Scope.

a. **License grant**.

1. Subject to the terms and conditions of this Public License, the Licensor hereby grants You a worldwide, royalty-free, non-sublicensable, non-exclusive, irrevocable license to exercise the Licensed Rights in the Licensed Material to:

    A. reproduce and Share the Licensed Material, in whole or in part, for NonCommercial purposes only; and

    B. produce and reproduce, but not Share, Adapted Material for NonCommercial purposes only.

2. Exceptions and Limitations. For the avoidance of doubt, where Exceptions and Limitations apply to Your use, this Public License does not apply, and You do not need to comply with its terms and conditions.

3. Term. The term of this Public License is specified in Section `6(a)`.

4. Media and formats; technical modifications allowed. The Licensor authorizes You to exercise the Licensed Rights in all media and formats whether now known or hereafter

created, and to make technical modifications necessary to do so. The Licensor waives and/or agrees not to assert any right or authority to forbid You from making technical modifications necessary to exercise the Licensed Rights, including technical modifications necessary to circumvent Effective Technological Measures. For purposes of this Public License, simply making modifications authorized by this Section `2(a)(4)` never produces Adapted Material.

5. Downstream recipients.

    A. Offer from the Licensor – Licensed Material. Every recipient of the Licensed Material automatically receives an offer from the Licensor to exercise the Licensed Rights under the terms and conditions of this Public License.

    B. No downstream restrictions. You may not offer or impose any additional or different terms or conditions on, or apply any Effective Technological Measures to, the Licensed Material if doing so restricts exercise of the Licensed Rights by any recipient of the Licensed Material.

6. No endorsement. Nothing in this Public License constitutes or may be construed as permission to assert or imply that You are, or that Your use of the Licensed Material is, connected with, or sponsored, endorsed, or granted official status by, the Licensor or others designated to receive attribution as provided in Section `3(a)(1)(A)(i)`.

b. **Other rights**.

1. Moral rights, such as the right of integrity, are not licensed under this Public License, nor are publicity, privacy, and/or other similar personality rights; however, to the extent possible, the Licensor waives and/or agrees not to assert any such rights held by the Licensor to the limited extent necessary to allow You to exercise the Licensed Rights, but not otherwise.

2. Patent and trademark rights are not licensed under this Public License.

3. To the extent possible, the Licensor waives any right to collect royalties from You for the exercise of the Licensed Rights, whether directly or through a collecting society under any voluntary or waivable statutory or compulsory licensing scheme. In all other cases the Licensor expressly reserves any right to collect such royalties, including when the Licensed Material is used other than for NonCommercial purposes.

Section 3 – License Conditions.

Your exercise of the Licensed Rights is expressly made subject to the following conditions.

a. **Attribution**.

1. If You Share the Licensed Material, You must:

    A. retain the following if it is supplied by the Licensor with the Licensed Material:

        i. identification of the creator(s) of the Licensed Material and any others designated to receive attribution, in any reasonable manner requested by the Licensor (including by pseudonym if designated);

        ii. a copyright notice;

iii. a notice that refers to this Public License;

iv. a notice that refers to the disclaimer of warranties;

v. a URI or hyperlink to the Licensed Material to the extent reasonably practicable;

B. indicate if You modified the Licensed Material and retain an indication of any previous modifications; and

C. indicate the Licensed Material is licensed under this Public License, and include the text of, or the URI or hyperlink to, this Public License.

For the avoidance of doubt, You do not have permission under this Public License to Share Adapted Material.

2. You may satisfy the conditions in Section `3(a)(1)` in any reasonable manner based on the medium, means, and context in which You Share the Licensed Material. For example, it may be reasonable to satisfy the conditions by providing a URI or hyperlink to a resource that includes the required information.

3. If requested by the Licensor, You must remove any of the information required by Section `3(a)(1)(A)` to the extent reasonably practicable.

Section 4 – Sui Generis Database Rights.

Where the Licensed Rights include Sui Generis Database Rights that apply to Your use of the Licensed Material:

a. for the avoidance of doubt, Section `2(a)(1)` grants You the right to extract, reuse, reproduce, and Share all or a substantial portion of the contents of the database for NonCommercial purposes only and provided You do not Share Adapted Material;

b. if You include all or a substantial portion of the database contents in a database in which You have Sui Generis Database Rights, then the database in which You have Sui Generis Database Rights (but not its individual contents) is Adapted Material; and

c. You must comply with the conditions in Section `3(a)` if You Share all or a substantial portion of the contents of the database.

For the avoidance of doubt, this Section `4` supplements and does not replace Your obligations under this Public License where the Licensed Rights include other Copyright and Similar Rights.

Section 5 – Disclaimer of Warranties and Limitation of Liability.

a. Unless otherwise separately undertaken by the Licensor, to the extent possible, the Licensor offers the Licensed Material as-is and as-available, and makes no representations or warranties of any kind concerning the Licensed Material, whether express, implied, statutory, or other. This includes, without limitation, warranties of title, merchantability, fitness for a particular purpose, non-infringement, absence of latent or other defects, accuracy, or the presence or absence of errors, whether or not known or discoverable. Where disclaimers of warranties are not allowed in full or in part, this disclaimer may not apply to You.

b. **To the extent possible, in no event will the Licensor be liable to You on any legal theory (including, without limitation, negligence) or otherwise for any direct, special, indirect, incidental, consequential, punitive, exemplary, or other losses, costs, expenses, or damages arising out of this Public License or use of the Licensed Material, even if the Licensor has been advised of the possibility of such losses, costs, expenses, or damages. Where a limitation of liability is not allowed in full or in part, this limitation may not apply to You.**

c. The disclaimer of warranties and limitation of liability provided above shall be interpreted in a manner that, to the extent possible, most closely approximates an absolute disclaimer and waiver of all liability.

Section 6 – Term and Termination.

a. This Public License applies for the term of the Copyright and Similar Rights licensed here. However, if You fail to comply with this Public License, then Your rights under this Public License terminate automatically.

b. Where Your right to use the Licensed Material has terminated under Section `6(a)`, it reinstates:

   1. automatically as of the date the violation is cured, provided it is cured within 30 days of Your discovery of the violation; or

   2. upon express reinstatement by the Licensor.

For the avoidance of doubt, this Section `6(b)` does not affect any right the Licensor may have to seek remedies for Your violations of this Public License.

c. For the avoidance of doubt, the Licensor may also offer the Licensed Material under separate terms or conditions or stop distributing the Licensed Material at any time; however, doing so will not terminate this Public License.

d. Sections `1`, `5`, `6`, `7`, and `8` survive termination of this Public License.

Section 7 – Other Terms and Conditions.

a. The Licensor shall not be bound by any additional or different terms or conditions communicated by You unless expressly agreed.

b. Any arrangements, understandings, or agreements regarding the Licensed Material not stated herein are separate from and independent of the terms and conditions of this Public License.

Section 8 – Interpretation.

a. For the avoidance of doubt, this Public License does not, and shall not be interpreted to, reduce, limit, restrict, or impose conditions on any use of the Licensed Material that could lawfully be made without permission under this Public License.

b. To the extent possible, if any provision of this Public License is deemed unenforceable, it shall be automatically reformed to the minimum extent necessary to make it enforceable. If the provision cannot be reformed, it shall be severed from this Public License without affecting the enforceability of the remaining terms and conditions.

c. No term or condition of this Public License will be waived and no failure to comply consented to unless expressly agreed to by the Licensor.

d. Nothing in this Public License constitutes or may be interpreted as a limitation upon, or waiver of, any privileges and immunities that apply to the Licensor or You, including from the legal processes of any jurisdiction or authority.

Commercial Use

A commercial useage license must be obtained from the author of this work in order for the work to be used or modified for commerical purposes.

The commercial useage license available with consent from the author is the Creative Commons Attribution-ShareAlike 4.0 International License (CC BY-SA 4.0).

The author can be contacted directly for licensing purposes through the following means:

POST:
RE: The D-Series
SkinnerMedia
79 Twyford Way
Poole
Dorset
The United Kingdom of Great Britain and Northern Ireland
BH17 8SR

EMAIL:
RE: The D-Series
skinnermedia@outlook.com