# SYMBOLS FOR THERMODYNAMICAL AND PHYSICO-CHEMICAL QUANTITIES AND CONVENTIONS RELATING TO THEIR USE, ADOPTED AS RECOMMENDED PRACTICE BY THE CHEMICAL SOCIETY.

*(Where two or more symbols separated by commas or semicolons are given for a quantity, these symbols are to be regarded as alternatives for which no preference is expressed. On the other hand, where two symbols are separated by a dotted line, the former is the first preference.)*

## 1. To be Printed in Black Italic.

*(Certain important physical constants.)*

***F*** Faraday's constant.
***J*** Mechanical equivalent of heat.
***N*** Avogadro's number.
***R*** {Gas constant per mol. / Rydberg's constant.
***c*** Velocity of light in vacuo.
***e*** Electronic charge (charge equal and opposite in sign to that of an electron).
***g*** Acceleration due to gravity (standard value, if variation from standard is significant).
***h*** Planck's constant.
***k*** Boltzmann's constant.
***m*** Rest mass of an electron.

## 2. To be Printed in Ordinary Italic, when not Greek.

*General Physics and Chemistry.*

| | |
|---|---|
| Length | $l$ |
| mean free path of molecules | $l$ |
| height | $h$ |
| diameter, distance | $d$ |
| diameter of molecules | $\sigma$ |
| radius | $r$ |
| Mass | $m$ |
| molecular weight | $M$ |
| atomic weight | $A$ |
| atomic number | $Z$ |
| gram-equivalent weight | $Z, J$ |
| Time | $t$ |
| time interval, especially half- or mean-life | $\tau$ |
| frequency | $\nu$ |
| Velocity | $v$; $c$, $(u, v, w)$ |
| of ions | $u$ (with subscript) |
| angular | $\omega$ |
| Acceleration | $f \ldots a$ |
| due to gravity (as variable) | $g$ |
| Force | $F$, $(X, Y, Z)$ |
| Moment of inertia | $I$ |
| Pressure | $p, P$ |
| especially osmotic | $\Pi$ |
| Volume | $v, V$ |
| Density | $\rho \ldots d$ |
| Compressibility | $\kappa \ldots K$ |

| | |
|---|---|
| Viscosity | $\eta$ |
| Fluidity | $\phi$ |
| Surface area | $A \ldots s$ |
| Angle of contact | $\theta$ |
| Surface tension | $\gamma \ldots \sigma$ |
| Parachor | $[P]$ |
| Surface concentration excess | $\Gamma$ |
| Number of mols | $n$ |
| Concentration, mol fraction | $N, x$ |
| in other terms | $c, C$ |
| Solubility | $s$ |
| Diffusion coefficient | $D$ |
| Chemical equilibrium constant (products/reactants) | $K$ |
| solubility product | $K_s \ldots L$ |
| Velocity constant of chemical reaction | $k$ |
| Number of molecular collisions per second | $Z$ |
| Partition function | $f$ |
| Efficiency, of any process | $\eta$ |
| Wave function | $\psi$ |

*Heat and Thermodynamics.*

| | |
|---|---|
| Temperature, on absolute scale, (°K) | $T$ |
| on other scales | $\theta \ldots t$ |
| Thermal conductivity | $k$ |
| Energy (general symbol) | $E$ |
| Work done by or on a system | $w \ldots W$ |
| Heat entering a system | $q$ |
| Specific heat | $c_p$ and $c_v$ |
| molecular heat | $C_p$ and $C$ |
| Ratio of specific heats | $\gamma$ |
| Latent heat, per g. | $l$ |
| per mol | $L$ |
| Intrinsic energy | $U \ldots E$ |
| Enthalpy, total heat, or heat content | $H$ |
| Entropy | $S$ |
| Free energy (Helmholtz) | $A \ldots F$ |
| Thermodynamic potential, Gibbs function, free energy (G. N. Lewis) | $G$ |
| Vapour pressure constant | $i$ |
| Chemical potential | $\mu$ |
| Activity | $a$ |
| coefficient (for molar concentration) | $f$ |
| Osmotic coefficient | $g$ |
| Van 't Hoff's factor | $i$ |

*Electricity.*

| | |
|---|---|
| Quantity of electricity | $Q$ |
| especially electrostatic charge | $e$ |
| Potential (difference) | $V$ |
| Volta potential | $V$ |
| electrokinetic potential | $\zeta$ |
| especially electromotive force of voltaic cells | $E$ |
| Potential gradient, in electric field | $X$ |
| Electronic exit work function | $\phi$ |

| | |
|---|---|
| Current | $I$ |
| Resistance | $R$ |
| specific resistance | $\rho \ldots r$ |
| specific conductance | $\kappa \ldots \sigma$ |
| Inductance, self | $L$ |
| mutual | $M$ |
| Electrostatic capacity | $C$ |
| Dielectric constant | $\epsilon$ |
| Dipole moment | $\mu$ |

*Electrochemistry.*

| | |
|---|---|
| Degree of electrolytic dissociation | $\alpha$ |
| Valency of an ion | $z$ |
| Ionic strength | $I$ |
| Equivalent conductance | $\Lambda$ |
| equivalent ionic conductance, "mobility" | $l$ (with subscript) |
| Transport number | $T$ (with subscript) . . . $n$ (with subscript) |
| Single electrode potential | $e$ (with subscript), $E$ (with subscript) |
| Electrolytic polarisation, overvoltage | $\eta \ldots \pi$ |

*Magnetism.*

| | |
|---|---|
| Magnetic field strength | $H$ |
| flux | $\phi$ |
| permeability | $\mu$ |
| susceptibility—volume | $\kappa$ |
| mass | $\chi$ |
| moment | $M$ |
| induction | $B$ |

*Optics.*

| | |
|---|---|
| Wave length | $\lambda$ |
| Wave number | $\nu$ |
| Intensity of light | $I$ |
| Refractive index | $n$ (with subscript) . . . $\mu$ (with subscript) |
| specific refraction | $r$ (with subscript) |
| molecular refraction | $[R]$ (with subscript) |
| Molar extinction coefficient | $\epsilon$ |
| Angle of (optical) rotation | $\alpha$ |
| specific rotation | $[\alpha]$ |
| Specific magnetic rotation | $\omega$ |

### 3. To be Printed in Roman, when not Greek.

(a) *Examples of Mathematical Constants and Operators.*

| | |
|---|---|
| Base of natural logarithms | e |
| Ratio of circumference to diameter | $\pi$ |
| Differential | d |
| partial | $\partial$ |
| Increment | $\Delta$ |
| very small increment | $\delta$ |
| Sum | $\Sigma$ |
| Product | $\Pi$ |
| Function | f, $\phi$ |

(b) *Examples of single-letter abbreviations*

| | |
|---|---|
| *Ampère (in sub-units) | a. |
| Volt | V. |
| Ohm | Ω. |
| Watt | W. |
| Farad | F. |
| Henry | H. |
| Centigrade | C. |
| Fahrenheit | F. |
| Kelvin | K. |
| Ångstrom unit | A. |
| micron | μ. |
| metre | m. |
| gram | g. |
| litre | l. |
| Röntgen unit | r. |
| †Normal (concentration) | N. |
| †Molar (concentration) | M. |

The following prefixes to abbreviations for the names of units should be used to indicate the specified multiples or sub-multiples of these units:

| | | |
|---|---|---|
| M | mega- | $10^{6}\times$ |
| k | kilo- | $10^{3}\times$ |
| d | deci- | $10^{-1}\times$ |
| c | centi- | $10^{-2}\times$ |
| m | milli- | $10^{-3}\times$ |
| μ | micro- | $10^{-6}\times$ |

*e.g.*, MΩ. denotes megohm; kw., kilowatt; and μg., microgram. The use of μμ. instead of mμ. to denote $10^{-7}$ cm., or of $\gamma$ to denote microgram is deprecated.

## 4. Subscripts and other Modifying Signs.

(a) *Subscripts to symbols for quantities.*

| | |
|---|---|
| I, II . . . | *especially with symbols for thermodynamic functions*, referring to different systems or different states of a system. |
| 1, 2 . . . | |
| A B . | referring to molecular species A, B, etc. |
| i | referring to a typical ionic species i. |
| u | referring to an undissociated molecule. |
| +, − | referring to a positive or negative ion, or to a positive or negative electrode. |
| *p*, *v*, *T* | indicating constant pressure, volume, and temperature respectively. |
| *q* | indicating adiabatic conditions. |
| *w* | indicating that no work is performed. |
| *p*, *c*, *a* | *with symbol for an equilibrium constant*, indicating that it is expressed in terms of pressure, concentration, or activity. |
| G, V, L, X | referring to gas, vapour, liquid, and crystalline states, respectively. |
| *f*, *e*, *s*, *t*, *d* | referring to fusion, evaporation (vaporisation of liquid), sublimation, transition, and dissolution or dilution respectively. |
| c | referring to the critical state or indicating a critical value. |
| 0 | referring to a standard state, or indicating limiting value at infinite dilution. |

* *E.g.* " ma." for " milliampère "; but " amp." is preferred for " ampère."

† Separated by a hyphen (and no full stop) from a chemical formula which follows it.

o, d. f *with symbols for optical properties*, referring to a particular wavelength.

Where a subscript has to be added to a symbol which already carries a subscript, the two subscripts may be separated by a comma or the symbol with the first subscript may be enclosed in parentheses with the second subscript outside.

(b) *Other modifying signs.*

° *as right-hand superscript to symbol (particularly to a symbol for a general thermodynamic function—see p. 718)*, referring to a standard state.

[ ] *enclosing formula of chemical substance*, indicating its molar concentration.

{ } *enclosing formula of chemical substance*, indicating its molar activity.

In crystallography it is recommended that :

Millerian indices be enclosed in parentheses, ( ) ;
Laue indices be unenclosed ;
Indices of a plane family be enclosed in braces, { } ;
Indices of a zone axis or line be enclosed in brackets, [ ].

Numerals attached to a symbol for a chemical element in various positions have the following meanings :

| | |
|---|---|
| upper left | mass number of atom. |
| lower left | nuclear charge of atom. |
| lower right | number of atoms in molecule. |

*e.g.*, ${}^{7}_{3}\mathrm{Li}$; ${}^{2}_{1}\mathrm{H}_2$ (= $\mathrm{D}_2$).

## ALPHABETICAL INDEX OF RECOMMENDED SYMBOLS, and single-letter abbreviations.

including all those given in the above lists except prefixes, subscripts and other modifying signs.

*The name of any quantity for which a given symbol is a second preference is printed in parentheses.*

*A* free energy—Helmholtz ; atomic weight; surface area.
A. Ångstrom unit.
*a* activity; (acceleration).
a. ampère, in sub-units—see footnote, p. 720.
*B* magnetic induction.
*C* concentration; electrostatic capacity.
*with subscript :* molecular heat capacity.
c. Centigrade.
**c** velocity of light in vacuo.
*c* velocity; concentration.
*with subscript :* specific heat.
*D* diffusion coefficient.
*d* diameter; distance; (density).
d differential.
∂ partial differential.
*E* energy; (intrinsic energy); potential difference, especially electromotive force of voltaic cells.
*with subscript :* single electrode potential.
**e** electronic charge—charge equal and opposite in sign to that of an electron.
*e* quantity of electricity, especially electrostatic charge.
*with subscript :* single electrode potential.

e base of natural logarithms.
**F** Faraday's constant.
*F* force; (free energy—Helmholtz).
F. farad; Fahrenheit.
*f* acceleration; activity coefficient, for molar concentration; partition function.
f function.
*G* thermodynamic potential, Gibbs function, free energy—G. N. Lewis.
**g** acceleration due to gravity, standard value.
*g* acceleration due to gravity, as a variable; osmotic coefficient.
g. gram.
*H* enthalpy, total heat, heat content; magnetic field strength.
H. henry.
**h** Planck's constant.
*h* height.
*I* moment of inertia; ionic strength; electric current; intensity of light.
*i* vapour pressure constant; van 't Hoff's factor.
**J** mechanical equivalent of heat.
*J* gram-equivalent weight.
*K* chemical equilibrium constant; (compressibility).
$K_s$ solubility product.
K. Kelvin.
**k** Boltzmann's constant.
*k* thermal conductivity; velocity constant of chemical reaction.
*L* latent heat per mol; self inductance; (solubility product).
*l* latent heat per g.; length; mean free path of molecules.
*with subscript:* equivalent ionic conductance, " mobility ".
l. litre.
*M* molecular weight; mutual inductance; magnetic moment.
M. molar concentration.
**m** rest mass of an electron.
*m* mass.
m. metre.
**N** Avogadro's number.
*N* mol fraction.
N. normal concentration.
*n* number of mols.
*with subscript:* (transport number).
*with subscript:* refractive index.
*P* pressure.
[*P*] parachor.
*p* pressure.
*Q* quantity of electricity.
*q* heat entering a system.
**R** gas constant per mol; Rydberg's constant.
*R* electrical resistance.
[*R*] *with subscript:* molecular refraction.
*r* radius; (specific resistance).
*with subscript:* specific refraction.
r. Röntgen unit.
*S* entropy.
*s* solubility; (surface area).
*T* temperature, on absolute Kelvin scale.
*with subscript:* transport number.
*t* time; (temperature—not on absolute scale).
*U* intrinsic energy.
*u* velocity component.
*with subscript:* velocity of ions.
*V* volume; potential, potential difference, including Volta potential.

v. volt.
$v$ volume; velocity; velocity component.
$W$ (work done by or on a system).
w. watt.
$w$ work done by or on a system; velocity component.
$X$ force component; potential gradient in electric field.
$x$ mol fraction.
$Y$ force component.
$Z$ force component; g.-equivalent weight; number of molecular collisions per second; atomic number.
$z$ valency of an ion.

$\alpha$ degree of electrolytic dissociation; angle of optical rotation.
$[\alpha]$ specific optical rotation.
$\Gamma$ surface concentration excess.
$\gamma$ ratio of specific heats; surface tension.
$\Delta$ increment.
$\delta$ very small increment.
$\epsilon$ dielectric constant; molar extinction coefficient.
$\zeta$ electrokinetic potential.
$\eta$ efficiency of any process; viscosity; electrolytic polarisation, overvoltage.
$\theta$ angle of contact; temperature—not on absolute scale.
$\kappa$ compressibility; specific conductance; magnetic susceptibility—volume.
$\Lambda$ equivalent conductance.
$\lambda$ wave length.
$\mu$ chemical potential; dipole moment; magnetic permeability.
*with subscript:* (refractive index).
$\mu$. micron.
$\nu$ frequency; wave number.
$\Pi$ pressure, especially osmotic pressure.
$\Pi$ product.
$\pi$ (electrolytic polarisation, overvoltage).
$\pi$ ratio of circumference to diameter.
$\rho$ density; specific resistance.
$\Sigma$ sum.
$\sigma$ diameter of molecules; (surface tension); (specific conductance).
$\tau$ time interval, especially half or mean life.
$\phi$ fluidity; electronic exit work function; magnetic flux.
$\Phi$ function.
$\chi$ magnetic susceptibility—mass.
$\psi$ wave function.
$\Omega$. ohm.
$\omega$ angular velocity; specific magnetic rotation.