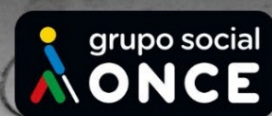


Documentos técnicos de la Comisión Braille Española

B 6-1

Signografía braille para química lineal



Technical document B 6-1: Braille signography for linear chemistry

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Technical documents B 3: Standards for transcription

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Technical document B 7: Braille signography for phonetics

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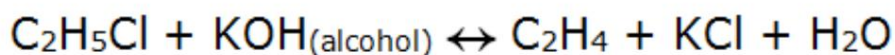
1. Introduction

The Science Group of the Spanish Braille Commission aims, with the development of this signography for *Linear Chemistry*, to obtain a Braille equivalence for the different structures and concepts of Chemistry that appear in those texts that must be transcribed, while promoting their use. by students and teachers to create their own notes and examples.

From a strictly graphic point of view, we can consider that the representation of chemical structures and concepts has three levels of complexity that imply a different treatment of the braille signography that must be used.

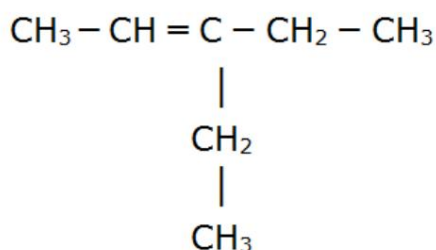
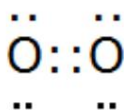
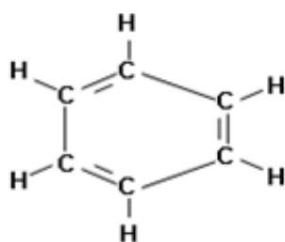
Thus, there is a representation that fundamentally includes all those aspects related to chemical reactions and the electronic configuration of the different elements. We will allow ourselves the license to call it **linear**.

Example:



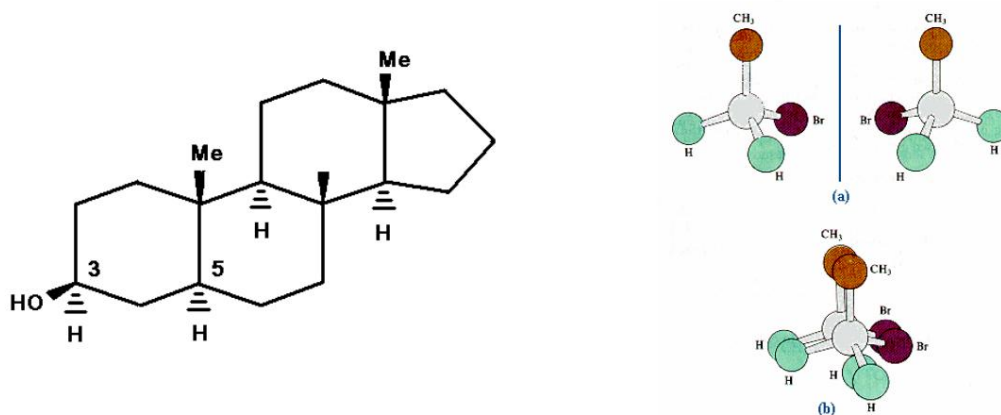
A second group is made up of those representations in the plane (cyclic, branched, Lewis notation, etc.) that are used to visualize the structures of different compounds. We will call this representation **two-dimensional**.

Examples:



Finally, we can consider a third group with those cases in which it is necessary to represent the three-dimensional structure of chemical compounds, for which lines of different thickness are used in order to represent whether a bond is above or below the plane of the structure. We will classify this type of representation as **three-dimensional**.

Examples:



In this technical document, a proposal is made for the first of these representations, the "linear" one, so that it can serve as a basis for the elaboration of the "two-dimensional" and "three-dimensional" representations, always trying to seek agreement between the three types of representation.

In some of the examples, a sign is used, which we have called "chemical hyphen", to indicate that the structure represented is continued in the next line. To do this, the braille sign formed by the six dots will be used.

"Chemical dash" sign:

⠏

2. Elements and molecules

2.1. Atomic symbols

The symbols for chemical elements can consist of one or two letters, the first of which is always capitalized. As in visual characters, in Braille they are written following the sequence: capital letter (46 points) – letter/s of the element.

Thus, the chemical element oxygen has as its symbol: O. In Braille it is written:

The {the

Sodium has a symbol made up of two letters: **Na**. In braille it is written:

Na {na

2.2. Molecular formulas of simple elements

In visual characters, the molecules of chemical elements are represented with the corresponding symbol and then, written in subscript, the number of atoms that form it (*simple numerical subscript*).

Example:

O₂

Sometimes the subscript is a more complex expression than an integer (*alphanumeric subscript*).

Examples:

C_n

C_{n-1}

In braille, each of these types of subscript has a different treatment.

a) Simple numeric subscript

The number that forms the subscript will be written, after the element, in a lower position (5th series of the braille system;¹ v. *Appendix 4*), regardless of the number of digits that compose it.

¹ The different series of the braille system can be found in *Technical Document B 2*, chapter 2, «Braille System Series».

Cl₂ {cl;

O₃ {of:

C₆ {c+

C₂₄ {c;*

b) Alphanumeric subscript

Following the element symbol, the subscript sign (points 34) and the characters that form it will be written.

Example:

C_n _

When the subscript contains more than one symbol in visual characters, it is necessary to use the resource of auxiliary parentheses, whose opening sign is formed by points 26, and the closing sign by points 35 (see *Appendix 2*).

Examples:

Sn-1 {yes?n-#a}

C_{2n} {address?#bn}

C₁₄₋₁ {cí?#ad-#a}

This structure does not follow this structure in the braille transcription that information that qualifies the element or the molecule, normally related to the physical states of matter, and which is always textual (v. 5. *Physical states and other specifications*).

23. Formulas of molecules of chemical compounds

They are made up of two or more written elements without separation between them. Thus H₂ and O form the molecule H₂O.

In braille, in general, the same resources will be used as for the representation of the molecules of chemical elements.

Examples:

Norm 1.^a

To write some of the numbers in low position, combinations of points that coincide with the signs of the *arithmetic operators* and the *equality sign* are used (see *Appendix 1*). To avoid any confusion, when any of the latter is included between molecules, it must be preceded and followed by a blank space.

Norm 2.^a

After any chemical expression that is followed by a sign that matches a low-position number character, there must be a blank space between it and the chemical expression. This case occurs especially with punctuation marks and closing italics.

Example:

Ozone, that is, O₃, is found in large quantities....

In braille, the sequence "O₃, is found" will be written:

{or: , is found

Rule 3

In the texts, the sequence formed by "molecule-space-punctuation mark" must always be on the same line.

Example:

Butane, whose formula is C₄H₁₀, is a combustible hydrocarbon.

On a line of 40 spaces, write:

{butane, whose formula is {c*{h,>,

It is a combustible hydrocarbon.

On a line of 36 spaces, write:

{butane, whose formula is

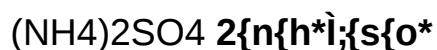
{c*{h,> , is a combustible hydrocarbon

tible

2.4. Atomic groups with subscript

Atomic groups, when affected by a subscript, are enclosed in unifying signs (parentheses, brackets, etc.). In braille, the corresponding unifying signs will be used (see *Appendix 5*).

Examples:



2.5. Molecular coefficients

Molecular coefficient is understood as any letter or numerical expression that immediately precedes the molecular formula.

Example:



In braille, the same sequence will be followed as in texts in visual characters.

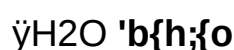
The previous example will be:



When the coefficient is a fraction whose two terms are numerical, it will be written in Braille following the abbreviated method of representing fractions (number sign ÿ numerator in normal position ÿ denominator in lower position) (see *Technical document B 2: Basic signography*).

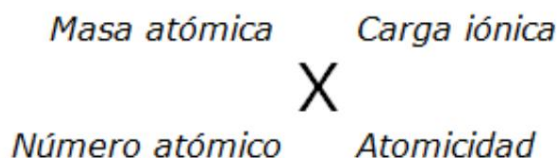
When the coefficient is a Greek letter, the prefix corresponding to this alphabet will be used, whether uppercase or lowercase (see *Appendix 3*).

Examples:



3. Other indices affecting atomic symbols

They normally refer to the atomic number, atomic mass, ionic charge and atomicity.



Although this is usually the usual arrangement of the superscripts and subscripts that affect the atomic symbol, this is not always the case in the originals in visual characters.

The most common variants are explained in the following sections.

3.1. Representation of only the atomic number and atomic mass in numerical form

Its most common representation has both indices to the left of the atomic symbol.



It can sometimes be represented with both indices to the right of the atomic symbol.



Regardless of whether the indices are on the left or right, in Braille *the chemical element will always be written first*, following the sequence:

- Element symbol.
- The numerical subscript, in a low position and without a number sign, is to the right or left of the element.
- The superscript figure, in normal position and without a number sign, is to the right or left of the chemical element.

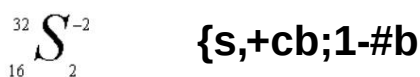
{cl,= what

3.2. Representation of the four indices in numerical form

The sequence will be:

- Element symbol.
- The figure of the left subscript, in a low position and without a sign of number.
- The figure of the left superscript, in normal position and without sign of number.
- The figure of the right subscript, in a low position and without a sign of number.
- Superscript braille sign.
- Full text of the ionic charge (can be an Arabic number, Roman, positive or negative signs, etc., as can be seen in chapter 4. *Ions and oxidation numbers*).

Example:



3.3. Representation of the ionic charge and the number of atoms in numerical form

In visual characters, the number of atoms is always represented at the bottom right (see *Appendix 4*) and the charges either in superscript on the right, or in superscript (see chapter 4. *Ions and oxidation numbers*).

In braille the sequence follows:

- Element symbol.
- The number of atoms, in a low position and without a number sign (v. *Appendix 4*).
- Superscript sign.
- Ionic charge (see chapter 4. *Ions and oxidation numbers*).

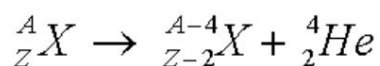
Example:



3.4. Simple and compound alphanumeric indexes

In the event that any of the indices on the right or left cannot be clearly represented by the rules of this code, the general form of mathematical transcription will be used, using the corresponding index signs and, if necessary, auxiliary parentheses. (see *Appendix 2*).

Example:



{x_í{z'1{a :r
:r {x_í?{z-#b}'1?{a-#d} +
+ {he;d

4. Ions and oxidation numbers

4.1. Ions

From the point of view of graphic representation, the positive or negative ions of an atom or molecule are represented with the positive or negative signs that correspond either in superscript to the right or in superscript.

X⁺

O⁻⁻

The ionization number in superscript on the right, plus the positive or negative sign.

Al³⁺

The following sections detail how to carry out the Braille transcription of each of the variants.

4.1.1. Positive and negative signs in superscript on the right or in superscript

Regardless of whether the charges are in superscript on the right or in superscript, in braille this sequence will always be followed:

- Atomic symbol or molecular formula.
- Superscript sign .
- *Positive* or negative signs , as appropriate.

Superscript examples:

K⁺ {d1+

NH₄⁺ {n{h*1+

Fe⁺⁺ {fe1++

SO₄⁻⁻ {s{o*1--

HPO₄⁻⁻ {h{p{o*1--

Examples of representation on an atomic symbol:²

$\overset{-}{\text{F}}$ {f1-

$\overset{--}{\text{O}}$ {o1--

4.1.2. Representation on a molecule

In graphic characters, they are written on the molecular formula, usually in the center of it. In braille, it will always be transcribed after the last element of the molecule, or its subscript if it has one.

Braille writing sequence:

- Molecular formula.
- Superscript sign .
- *Positive or negative sign/s* as appropriate.

Example:

+

NH₄ {n{h*1+

4.1.3. Including the number of ionization or charges

Sequence:

- Atomic symbol or molecular formula.
- Superscript sign .
- Characters of the signs that form the superscript (in the case of that it is a transcription of an original, the same order as the visual characters will be followed).

Examples:

Al³⁺ {al1#c+

Al⁺³ {al1+#c

² Special care must be taken not to confuse with the signs sometimes used in the *Notation of Lewis* to represent the electrons found at the top of the chemical element symbol. *Lewis Notation* is part of the two-dimensional chemical representation.



4.2. Oxidation number

They are always written with Roman numerals. Regardless of whether or not they are capitalized in visual characters, in braille they will be written without a capital letter.

Braille writing sequence:

- Atomic symbol or molecular formula.
- Superscript sign .
- Roman characters without capital letters.

Examples:



5. Physical states and other specifications

5.1. Type states of substances

In visual characters, they are represented after the molecule using its corresponding abbreviation, in subscript and in parentheses.

States:

- Aqueous or in aqueous solution. Abbreviations: "ac" and "aq".

Examples: $\text{H}_2\text{SO}_4(\text{ac})$ $\text{Al}(\text{OH})_3(\text{aq})$

- Gaseous. Abbreviation: "g".

Example: $\text{O}_2(\text{g})$

- Liquid. Abbreviation: "l".

Example: $\text{H}_2\text{O}(\text{l})$

- Solid. Abbreviation: "s".

Example: $\text{CaCO}_3(\text{s})$

5.1.1. braille representation

They will be transcribed omitting the parentheses and putting point 6 before the textual content.

Examples:

$\text{H}_2\text{SO}_4(\text{ac})$ {h;{s{o*_ac

$\text{CaCO}_3(\text{s})$ {ca{c{o:_s

$\text{Al}(\text{OH})_3(\text{aq})$ {al2{o{hì:_aq

$\text{O}_2(\text{g})$ {o;_g

$\text{H}_2\text{O}(\text{l})$ {h;{o_l

$\text{Fe}(\text{s})$ {fe_s

$\text{CaCO}_3(\text{s})$ {ca{c{o:_s

5.1.2. Physical state of matter abbreviated and with abbreviation dot

Sometimes states of matter are represented with an abbreviation dot. In braille the original representation can be respected but it will not be necessary to transcribe the abbreviation point.

Examples:

$\text{CaCO}_3(\text{s.})$ {ca{c{o:_s.

Preferably it will be transcribed like this:

$\text{CaCO}_3(\text{s})$ {ca{c{o:_s

As a good practice, it is recommended that, when the physical state of the matter is written in full in the original and there is certainty about the concept, it is written in abbreviated form, using the following signs:

Braille sign	Braille dots	Abbreviation	Meaning
.and	6-1-14	and	Aqueous
_g	6-1245	g	Gaseous
_l	6-123	,	Liquid
_s	6-234	s	Solid

Norm 4

When the physical state of matter is written in the original in an abbreviated form and separated by a space from the chemical element, in Braille that space will not be left blank.

In this way, $\text{O}_2(\text{g})$ and $\text{O}_2(\text{g})$ will be transcribed into braille:

{o;_g

5.2. Other specifications

Sometimes, information related to them is included after the molecular formula or reaction. It is usually written in parentheses, either at the same height as the molecular formula or in a subscript.

Examples:

C (graphite)

H₂SO₄ (diluted)

In braille the sequence used in normal writing will be followed. That is to say:

- Element.
- Blank space.
- In parentheses, physical state or specification of the matter.

Examples:

C (graphite) **{c 2grafito}**

H₂SO₄ (diluted) **{h;{s{o* 2diluido}**

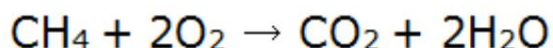
6. Arrows and reactions³

Chemical reactions and equations are made up of two members, both made up of chemical expressions. Between each of the members there is an arrow or an equal sign.

first member second member

Each member is composed of one or more terms that can be linked by operators.

Example:



Rule 5

In braille, *arithmetic operators* are represented as shown in *Appendix 1* and there must always be a blank space separating them from each term. This same rule will apply to reaction arrows (rule 6).

6.1. Right reaction arrow

Regardless of its visual representation, braille will transcribe:

:r

6.2. Left reaction arrow

Regardless of its visual representation, braille will transcribe:

ln:

6.3. Arrow in both directions (chemical equilibrium)

Regardless of its visual representation, braille will transcribe:

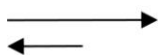
w:r

³ It is advisable to also consult Chapter 12, where rules are given that affect the partitioning of lines in which reaction arrows are found.

6.4. Double arrow of chemical equilibrium indicating displacement in one of the directions

In graphic characters, it is composed of two horizontal arrows in parallel and indicating opposite directions, one being longer.

Thus, the double arrow is represented in this way when the longest one points to the right:



In braille, this case is transcribed:

***:r**

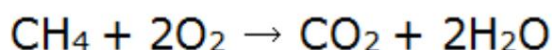
When the longest one goes to the left, it is transcribed:

in:+

Rule 6

Reaction arrows must have a blank space in front and a blank space behind.

Example:

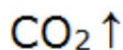


**{c{h* + #b{o; :r {c{o; +
+ #b{h;{o**

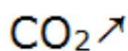
6.5. Up arrow (gas evolution)

In visual characters it always appears written after the molecular formula and can present three variants:

- As a vertical arrow up:



- As an oblique arrow up and to the right:



- As an oblique arrow up and to the right in the same vertical as the subscript of the last atomic symbol.

In braille it will always be transcribed:

%a

The graphical representations of the previous example will be transcribed:

{c{o;%a

Norm 7.^a

When the up arrow accompanies a molecular formula, it will be transcribed at the end of the formula, even after any attributes it may have.

Example:

CO_{2(g)} ↑ **{c{o;_g%a**

6.6. Down arrow (precipitation)

In visual characters it always appears written after the molecular formula and can present three variants:

- As a vertical downward arrow:

CaCO₃ ↓

- As an oblique arrow downwards and to the right:

CaCO₃ ↘

- As an oblique arrow up and to the right in the same vertical as the subscript of the last atomic symbol.

In braille it will always be transcribed:

%.

The graphical representations of the previous example will be transcribed:

{as{c{o:%.

Norm 8.^a

Like the up arrow (gas evolution), the down arrow (precipitation) is the last sign to be transcribed from the molecule.

Example:

AgCl_(g) ↓ **cl_g%.**

7. Arrows with specifications⁴

7.1. Arrow with a single qualifier

Regardless of whether the qualifying sign of an arrow is above or below it, in braille it will be written inside the arrow, preceded by the braille character 25 and followed by the characters 5 and 25.

Examples:



:^d{h@:r

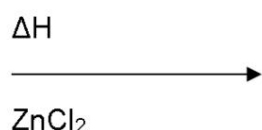
Note: In this example the sign for "enthalpy" has been used, which is made up of a Greek letter "capital delta" and an "H". The Greek alphabet is found in Appendix 3. The prefixes to be used with each alphabet are found in Appendix 2.



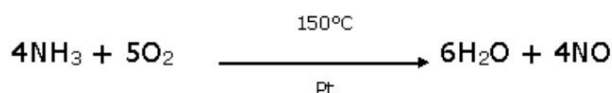
7.2. Simple arrow with two qualifiers

In Braille, the sign above the arrow will be written first and then, separated by character 25, the one below it.

Examples:



:^d{h@:{zn{cl;@:r



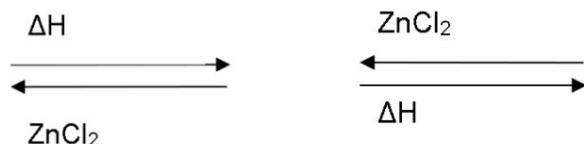
#d{n{h: + #e{o; :#aej>{c@:{pt@:r
:r #f{h;o + #d{n{o

⁴ It is also advisable to consult Chapter 12, where rules are given that affect the splitting of lines that include a reaction arrow with qualifiers.

7.3. Double arrow with two qualifiers

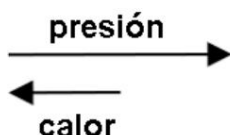
In Braille, the determining factor is to first transcribe the element that qualifies the arrow pointing to the left, regardless of whether it is above or below the double arrow.

These two examples are transcribed the same in Braille:



w:{zn{cl;@:^d{h@:r

Example:

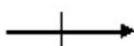


***:heat@:pressure@:r**

7.4. Other modifications

7.4.1. Energy ray or chemical bond break sign

Graphically it is a line that cuts any horizontal arrow. The line cut by the arrow can sometimes be broken, similar to a lightning bolt.



In braille it will be represented as follows:

:8:r

Example:



{h; + #,b{o; :8:r {h;{o

7.4.2. Crossed out arrow (not chemical reaction)

It is represented by an arrow with a cross on its stroke.



In braille it will be transcribed as follows:

:^:r:

8. Horizontal links

8.1. *Enlaces convalescent*

8.1.1. Simple and dipolar

In visual texts, the single bond is represented as a long dash between two molecules.

In braille it is transcribed:

@,

Example:

CH₃ŸCH₃ {c{h:@,{c{h:

Sometimes the polar or dative covalent bond is also used. Its representation in braille will be:

Braille sign	Braille dots	Ink sign	Meaning
—;	6-23	Ÿ	Leftward polar or dative covalent bond.
".	56-3	ÿ	Polar or right-dative covalent bond.

Example:

[H₃NŸH]⁺ on{h:{n".{hú1+

8.1.2. Double

In visual characters it is represented with two long parallel dashes between molecules. In braille it is transcribed:

;;

Example:

CH₂=CH₂ {c{h;"}{c{h;

8.1.3. Triple

The triple bond is represented in visual characters with three parallel long dashes between two molecules. In braille it is transcribed:

%l

Example:

CH₂CH₂ :{c{h%l{c{h

8.1.4. Quadruple

In texts in visual characters it appears as four long parallel dashes between molecules. In braille it is transcribed:

#in

Example:

C₂C {c#v{c

8.2. Other links

8.2.1. hydrogen bond

In visual characters it is represented with a dot between two molecules or at the end of one of them. In the first case it is surrounded by the hydrogen sign and, in the second, it is the last character of the molecule, having the hydrogen symbol as prior.

In braille it is transcribed:

@@

Example:

FH.HF {f{h@@{h{f

8.2.2. Hydration and addition

In visual characters it is represented with a dot between two molecules. In braille it is represented with the dot 3.

▪

Examples:

Na₂SO₄·5H₂O {na;{s{o*.{#e{h;{o

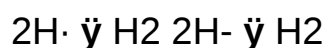
K₃PO₄·6H₂O {k;{p{o*.{#f{h;{o

Ugly ugly {fe{o.{fe{o

CaCl·NH {ca{cl.{n{h

8.2.3. Radical libre

In visual characters, it is usually represented close to the molecule, either at the beginning or at the end of it. When it is simple, it is usually represented with a thick dot or a horizontal stripe.



In Braille it is represented by the dots 5 and 2. It is distinguished from the simple link because after the sign there is no chemical symbol, but a blank space.

The previous example will be written as follows:

#b{h@, :r {h;

Sometimes the free radical is written to the left of the element or functional group.

Example:

·OH @,{o{h

8.2.4. high energy link

In visual characters it is represented by a wavy line between the two molecules it links, like an accent.

9

In braille it is represented with the following sign:

@?.

9. Schematic formulas of linear chains

It is a representation of molecular formulas of chains of atoms, in which only the bonds (single, double or triple) are indicated consecutively.

It is preferably used in Organic Chemistry, since the symbols for Carbon (C) and Hydrogen (H) are not written. The vertices correspond to carbon atoms, and the bonds and symbols corresponding to hydrogen atoms are omitted.

To distinguish graphically the links are represented in zigzag, following two oblique directions.

In braille they are represented as follows:

Braille sign	Braille dots	Visual sign	Meaning
—,	6-2	/	Simple link from bottom left to top right
@.	5-3	\	Simple link from top left to bottom right
"b	56-12	//	Double link from bottom left to top right
^;	45-23	\	Double link from top left to bottom right
"	56-123	///	Triple link from bottom left to top right
^	45-123	\	Triple link from top left to bottom right

Thus the representation of *trans*-2-hexene would be:

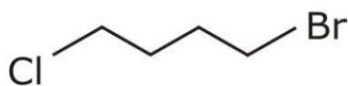


When symbols of chemical elements, other than Carbon or Hydrogen, appear, they will be written in the corresponding vertex between the bond signs. See the following example of *diethyl ether*.



@._,{O@._,

Example of 1-bromo-4-chlorobutane:



{cl_,@._,@._,{br

If links appear in a horizontal direction, the corresponding signs will be used (see following example of *hexene*).



@,@._,@."b

10. Electronic configuration

The electronic configuration is the expression of the way in which the electrons would be distributed in an atom.

The graphic representation is carried out with three degrees of complexity, which are detailed in the following sections.

10.1. Simple electronic configuration (first degree of complexity)

It is formed by:

- Level, first quantum number.
- Sublevel, second quantum number.
- Number of electrons in the sublevel.

In general, your transcription must adhere to the original in visual characters, but the following particularities must be considered:

- 1) The number of electrons that affects the sublevel will be written in the lower position without the number sign (see *Appendix 4*):

Example:

Electronic configuration of Helium (He)

1s2 #as;

- 2) When in an edition in visual characters the levels and sublevels appear followed by a separating character (comma, blank space, etc.), in braille a blank space will always be left between them.

Tanto 1s2 , 2s2 , 2p5 as 1s2 2s2 2p5 will be transcribed:

#as; #bs; #bp?

If there are no characters, no space will be left, being faithful to the original:

1s22s22p5 #as;#bs;#bp?

10.2. Second degree of complexity

At this level of complexity the following are represented:

- Level, first quantum number.
- Sublevel, second quantum number.
- Orbital, third quantum number (values "x, y, z...").
- Number of electrons.

10.2.1. Orbital represented by letters and algebraic expressions

The cases that may occur are the following:

- Sublevel p: px, py, pz,
- Subnível d: dxy, dxz, dyz, dx²-y², dz²
- Subnível f: fz³, fxz², fyz², fxyz, fz(x²-y²), fx(x²-3y²), fy(3x²-y²)

In graphic characters, they can appear in various ways, the most common being in a subscript, either below the number of electrons in the sublevel or in the following character:

2¹¹²² p_{xy} p p p s

Whatever its form of representation, Braille will be transcribed following this order:

- Level or first quantum number.
- Sublevel or second quantum number.
- Orbital or third quantum number.
- Number of electrons, written in braille *in a low position* (see Appendix 4).

2¹¹²² p_{xy} p p p s

#bs; #bpx; #bpy, #bpz,

Sometimes the author does not specify the number of electrons in the sublevel when the value is 1. In braille it will be written as it appears in the original.

Example:

2s2 2p2x 2py 2pz **#bs; #bpx; #bpy #bpz**

The different cases of each sublevel are transcribed as follows:

- *Sublevel p*

p_x $2p_x$ **#bpx;**

p_y $2p_y$ **#bpy**

p_z $2p_z$ **#bpz**

- *Sublevel d*

d_{xy} **4dxy #d@dx1#b-y1#b**

d_{xz}

d_{yz} **4dyz #d@dyz**

$d_{x^2-y^2}$ **4dx² and 2 #d@dx1#b-y1#b**

d_{z^2} **2 #d@dz1#b 4dz**

- *Sublevel f*

f_z **3 #d@fz1#c 4fz**

f_{xz} **2 #d@fxz1#b 4fxz**

f_{yz} **2 #d@fyz1#b 4fyz 4fz(x² 4fx(x² -3y²)**

f_{xyz} **2 and #d@fz2x1#b-y1#bi**

$f_x(x^2 -3y^2)$ **#d@fx2x1#b-#cy1#bi**

$f_y(3x^2 -y^2)$ **4fy(3x² -y²) #d@fy2#cx1#b-y1#bi**

10.2.2. Orbital represented by integers

In braille, in these cases, the corresponding subscript signs will be used, adhering to their representation in visual characters.

Example:

$2s_0$, $2p_{+1}$, $2p_0$, $2p_{-1}$

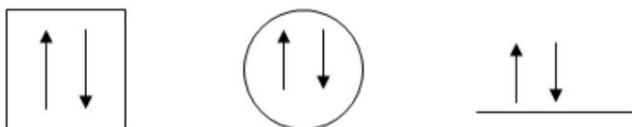
#bsí#j #bpí+#a #bpí#j #bpí-#a

10.3. Third degree of complexity with electron spin for orbital

In this level of complexity, the spin of the electrons is represented by arrows.

To do this, arrows are used within circles or squares, or on a horizontal line, as shown in these examples:

- With double arrow:



In braille it will be transcribed:

%k

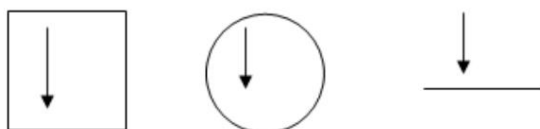
- With up arrow:



In braille it will be transcribed:

%a

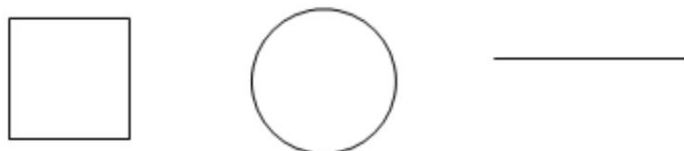
- With down arrow:



In braille it will be transcribed:

%.

- Empty:



In braille it will be transcribed:

%

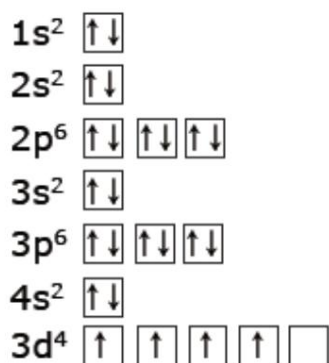
All spin symbols will be transcribed below the sublevel.

Example:



#c@d*%a%a%a%a%

The orbitals of the element 24Cr – 1s² , 2s² , 2p⁶ , 3s² , 3p⁶ , 4s² , 3d⁴ see represent as follows:



In braille they are represented as follows:

#as;%k

#bs;%k

#bp+%k%k%k

#cs;%k

#cp+%k%k%k

#ds;%k

#c@d*%a%a%a%a%

Example:



#bs; #bp?%k%k%k%a

11. Molecular geometry

11.1. Types of molecular orbitals

They are represented with a Greek letter (sigma, pi...). They can be of two types.

- *Linkers*: They are represented with the corresponding Greek letter alone or affected by the letter b in superscript (σ^b).

Examples:

σ 's σ 'p

σ^b 's1b σ^b 'p1b

- *Antibonding*: They are represented with the corresponding Greek letter affected by a superscript asterisk (σ^*).

Examples:

σ^* 's1* σ^* 'p1*

11.2. Bonded atomic orbitals

Both bonding and antibonding can sometimes be affected by a subscript that refers to the atomic orbitals involved. In this case, the following structure will be followed, regardless of whether they are displaced or not:

1. Base letter.
2. Subscript sign.
3. Content of the subscript, in auxiliary parentheses if it consists of more than one character.
4. Superscript sign.
5. Superscript content.

Examples:

σ_x 'píx1b 'pí?

π_{xy}^* xy}1* 'pí?xz,yz}1*

$\pi_{xz,yz}^*$

σ_{2x-y}^* 2 'yes?x1#b-y1#b}1* σ_{2s}^* 's1*#bs

12. Expressions that exceed the length of the line braille

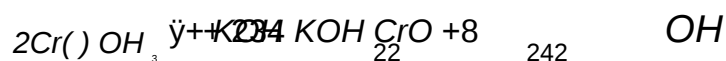
12.1. Chemical reactions

12.1.1. Chemical reactions with arrow without qualifiers

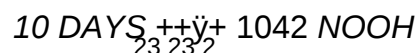
In the event that a chemical reaction cannot be written completely on a Braille line, it will be transcribed as follows:

- 1) First member without indentation, ending the line with the arrow corresponding reaction and starting the next one by indenting two spaces, then repeating the reaction arrow. If it is necessary to make a line cut before writing the arrow, it will be done using one of the arithmetic operators, writing the lines that belong to the first member at the same height as the first line.

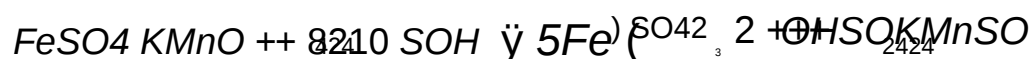
Examples:



#b{cr2{o{h}: + #d{k{o{h + #c{h;o; :r
:r #b{k;{cr{o* + #h{h;o



#aj{h{n{o: + {i; :r
:r #b{h{i{o: + #d{h;o +
+ #also{n{o;



#aj{fe{s{o* + #b{k{mn{o* +
+ #h{h;s{o* :r
:r #e{fe;2{s{o*i: +
+ #b{mn{s{o* + {k;s{o** +
+ {h;o

- 2) The second member of the reaction will begin to be transcribed in new line indented two spaces, repeating the arrow as long as the second member does not enter the line completely. If it is necessary to make a line cut in the second member, it will be done by one of the arithmetic operators, writing all the lines occupied by the second member with an indentation of two spaces.

Examples:



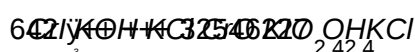
```
{k;{cr;{o= + #f{h{i + #d{h;{s{o* :r
:r {k;{s{o* + {cr;2{s{o*! : +
+ #c{i; + #g{h;{o
```



```
#c{cu + #h{h{n{o :r
:r #c{cu2{n{o!; + #b{n{o +
+ #d{h;{o
```



```
{with{s + #d{h{n{o :r
:r {s{o; + {cu2{n{o!; + #b{n{o +
+ {h;{o
```



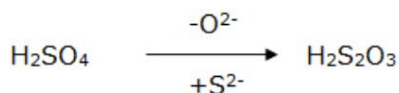
```
#b{cr{i: + #fd{k{o{h + #bg{cl; :r
:r #b{k;{cr{o* + #f{k{i{o* +
+ #ed{k{cl + #cb{h;{o
```

12.1.2. Chemical reactions with arrow with qualifiers

When a chemical reaction whose members are linked by an arrow with qualifiers cannot be written in its entirety on a braille line, it will be broken as follows:

- 1) If the total content of the arrow can be written on the same line as the end of the first member of the reaction, on the next line, after an indentation of two spaces, the arrow sign will be written

corresponding without qualifiers and then the second member of the reaction.

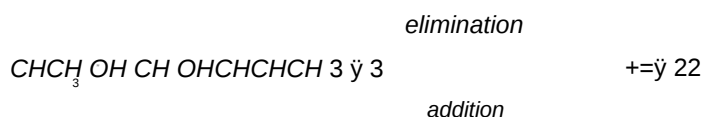


Example:

**{h;{s{o* :{-o1#b-@: +{s1#b-@:r
:r {h;{s;{o:**

- 2) If the entire content of the arrow cannot be written in it line than the first member, at the end of the line the arrow without qualifiers will be written and, on the next line, the arrow with qualifiers preceded by an indentation of two spaces, to then continue with the second member. If it is necessary to cut the latter, it will be done by any of the arithmetic operators.

Example:



**{c{h:@,{c{h{o{h@,{c{h: w:r
w:deletion@:addition@:r
w:r {c{h:@,{c{h";{c{h; +
+ {h;{o**

In this example the signs for single bond and double bond appear (v. 8. *horizontal links*).

12.2. "Chemical script" resource

The braille character formed by points 123456 will be used when it is necessary to divide a chemical expression that occupies more than one braille line and to which the partition rules included in the previous section are not applicable.

It will always be repeated at the beginning of the next line.

As a good practice, these principles will be followed in your transcription:

1. In molecular formulas, do not separate subscripts and superscripts from the atomic symbol or functional group they affect.

Example (Vesuvianite formula):

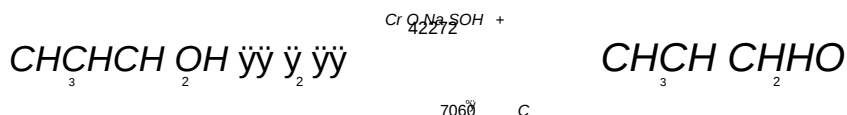


$\{\text{ca},\}\{\text{fe}_2\{\text{mg},\{\text{al}\}\{\text{al}^2\{\text{si}\{\text{o}^{\text{i}},>\}$

$\backslash 2\{\text{si};\{\text{o}=\text{i}^2\{\text{o}\{\text{h}^{\text{i}},>$

2. In arrows with a double qualifier, they will be split by the sign of arrow continuity (points 5-25), which must also be written in the next line after the chemical script, to continue with the content of the second qualifier.

Example:



$\{\text{c}\{\text{h}:@,\{\text{c}\{\text{h};@,\{\text{c}\{\text{h};\{\text{o}\{\text{h} :r$

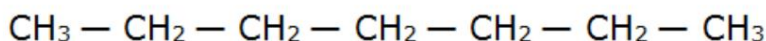
$:\{\text{cr};\{\text{o}=\{\text{na}; + \{\text{h};\{\text{s}\{\text{o}^* @:\backslash$

$\backslash : \# \text{fj} - \# \text{gj} > \{\text{c} @ : r$

$:r \{\text{c}\{\text{h}:@,\{\text{c}\{\text{h};@,\{\text{c}\{\text{h}\{\text{h}\{\text{o}$

3. In expressions in which chemical bonds appear, a link will be followed by a link and, in the next line, after the chemical hyphen sign, the link will be repeated.

Example:



$\{\text{c}\{\text{h}:@,\{\text{c}\{\text{h};@,\{\text{c}\{\text{h};@,\{\text{c}\{\text{h};@,\backslash$

$\backslash @,\{\text{c}\{\text{h};@,\{\text{c}\{\text{h};@,\{\text{c}\{\text{h};@,\{\text{c}\{\text{h};@,\backslash$

4. In electronic configurations, the starting point will be any white space separating levels and/or sublevels.

Example (electron configuration of rubidium):



$\# \text{as}; \# \text{bs}; \# \text{bp} + \# \text{cs}; \# \text{cp} + \# \text{ds}; \# \text{c} @ \text{d}, > \backslash$

$\backslash \# \text{dp} + \# \text{es},$

5.º In the molecular orbitals, the braille signs that make up each of the orbitals must be kept grouped.

Example:

$$(\psi^*_{xz,yz})^4 (\psi^*_z)^2 (2\psi^*_{xy})^2$$

2'pí?xz,yz}1*ì1#d2'sí?z1#b}1*ì1#b

\21pí?xy}1*ì1#b

13. Alphanumeric characters, marks, colors and typographic variants

13.1. Numbering of atoms, bonds and/or vertices in a chain

13.1.1. Case 1. A single type of numbering or alphanumeric series in the string

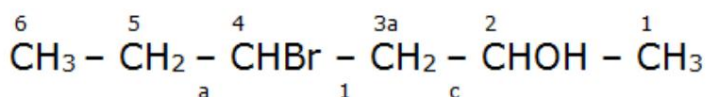
What Rule 14 QB of "Two-Dimensional Chemistry" says will apply. (Technical document B 6-2). Said text is included below.

Norma 14 QB

The braille representation of numbers and letters characterizing graphic elements (atomic symbols or links) will conform to the following:

1. Numbers or letters that characterize graphic elements will be written before of the atomic symbol or bond they affect.
2. The letters will be transcribed first and then the numbers, provided that the letter is not associated with the number.
3. The numbering will be written with a number sign and corresponding figure in low position.
4. If the numbers are affected by punctuation marks, these will be written in the order they appear in the graphic representation.
5. The letters of the first braille series (aj) that affect numbers must be preceded by point 5.
6. In the case of schematic representations - and only in this case - and if no atomic symbol appears in the place of the vertex, point 6 must be prefixed to the first of the letters or numbers that affect a link.
7. If it is necessary to split the formula using chemical hyphens, the numbering and letters and/or marks associated with it are inseparable from the graphic element they affect.

Example of 4-bromyl-2-hydroxyhexane



```
#+{c{h:@,#?{c{h;_a@,#*{c{h{br#,@,\
\#,@,#:@a{c{h;c@,#; {c{h{o{h@,\
\@,#,{c{h:
```

13.1.2. Case 2. More than one alphanumeric numbering or series In the chain

What Rule 15 QB of "Two-Dimensional Chemistry" says will apply.
(*Technical Document B 6-2*), included below.

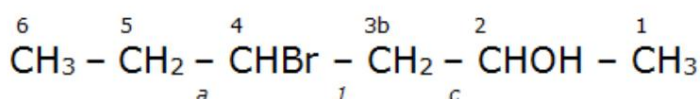
Norma 15 QB

If there is more than one number, the following will be done:

1. A main numbering will be chosen and will be written as when it is unique. HE recommends that it be the most abundant.
2. The rest of the numbers will be transcribed in the same way by adding high position the order number that has been assigned so that the first number of the second numbering would be written with 1 in low position and then 2 in high position, the first number of the third numbering would be 1 in low position and then 3 in high position, etc.
3. When an element is affected by two or more different numbers, they will be written in the order assigned to them.
4. If both numberings, or one of them, are affected by a letter, point 5 must be used to separate the number from the letter if it is one of the first series.
5. The Braille representation of the formula will always begin with a transcription note describing the difference in typography, position, color, or brand, that the numbers present in the original.

	1st numbering	2nd numbering	3rd numbering	
1 #,		#,b	#,c	...
2 #;		#;b	#;c	...
3 #:		#:b	#:c	...
... ..		...	...	...

Example of 4-bromyl-2-hydroxyhexane in which the second numbering appears in italics:



```

#+{c{h:@,#?{c{h;_a@,#*{c{h{br#b@,\
\#,b@,#:@b{c{h;c@,#; {c{h{o{h@,\
\@,#,{c{h:

```

13.2. Marks on atoms, bonds and/or vertices in a chain

To indicate their position, the following signs written after the element they affect will be used:

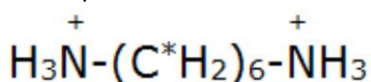
Position	Signo braille	Braille dots
In superscript on the right	1	16
in superwritten	1	16
In superscript on the left '1		4-16

The most common brands that usually affect elements in a formula son:

Braille sign	Braille dots	Sign	Meaning
*	256	*	asterisk
+	235	+	positive charge
++	235-235	++	two positive charges
-	36	-	negative charge
--	36-36	--	of negative charges

To write any other mark, the signs established for this purpose in Mathematical Signography (*Technical Document B 5*) will be used.

Example:



{h:{n1+@,2{c1*{h;ì+@,{n1+{h:

13.3. Use of colors and other typographic resources for differentiation of elements in a molecular formula

Sometimes, some elements of the molecular formulas are represented with typographic resources, such as colors, curves that delimit them, different backgrounds, etc.

To indicate these typographic changes in Braille, the provisions of Standard 16 QB of "Two-Dimensional Chemistry" (Technical Document B 6-2) *will be followed*, the text of which is included below.

Norma 16 QB

The use of different colors or typographical resources in a chemical formula - for differentiation of backgrounds or for delimitation by lines - will be considered equivalent for the purposes of its braille representation, and will comply with the provisions of this Standard.

1. The braille transcription of a formula in which different colors or typographical resources, backgrounds or separation lines, must be preceded by a "Braille transcription note" specifying the correspondence between the braille signs used in that formula and the graphic value that each one of them represents.
2. If one or two elements in a row are written with the same font or color, different from those of the base, in Braille the following will be placed before each of them:
 - the % sign (points 456) when only graphic differentiation is required in that formula;
 - the sign %(points 456) followed by an order number if in the formula
It is necessary to make more than one graphic differentiation: thus, the sign will be followed by the numbers 2, 3, etc., in a low position for the 2nd, 3rd, etc. differentiations.

Signo braille	Braille dots	Definition
%	456	To indicate the first typographical change
%;	456-23 (#2 in low position)	To indicate the second typographical change
%:	456-25 (#3 in low position)	To indicate the third typographical change
% ...	456 and subsequent numbers in low position	...

- For these purposes, the subscript of an atomic symbol is considered part hers. If they had to be differentiated from each other, the subscript would be written in a non-abbreviated form (using the í sign (dots 34) for the subscript, the # sign (dots 3456) for the number and the number in high position).
 - If it is necessary to use the chemical script, the signs indicating change typographic are inseparable from the elements to which it refers, so the color indication must be repeated, where appropriate, with the element to be differentiated.
3. If there are more than two consecutive elements with the same differentiation graph different from the base, the "period of graphic differentiation" sign will be used:

- if only a graphic differentiation is required in this formula, the period opens with the sign 6 (points 2346), to be written before the first affected element;
- If in the formula it is necessary to make more than one graphic differentiation, the sign 6 (points 2346) will be used followed by the numbers 2, 3, etc., in low position for the 2nd, 3rd, etc. differentiations.
- Likewise, it will be closed with the sign 5 (points 156), after the last graphic element affected by differentiation. When there is more than one differentiation, this sign will be followed by the corresponding order number in low position.

Signo braille	Braille dots	Definition
It is	2346	To indicate the first typographical change
It is;	2346-23 (#2 in low position)	To indicate the second typographical change
It is:	2346-25 (#3 in low position)	To indicate the third typographical change

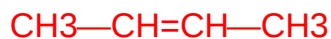
4. If a segment or period of graphic differentiation is interrupted by one or two consecutive elements in base graphic representation (or other differentiation), the sign % (points 456) will be prefixed to each of them, followed - if applicable - of the corresponding number in low position. If there are more than two consecutive elements, said graphic differentiation period must be closed and reopened where appropriate, or a new differentiation period must be opened for those elements.
5. If it is necessary to use the chemical script within a period of graphical differentiation, the differentiation period start indicator will be written again immediately before the repetition of the chemical script on the next line.
6. In the formulas developed, the typographic variants will be applied line by line.
7. In the linearizations of branched and cyclic formulas, the typographic variants will be indicated in the description of each branch or cycle.⁵

In the examples that follow, a Braille Transcription Note should be entered informing that the typographic differentiation is in red, different from the base color.



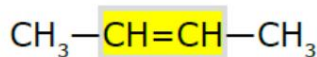
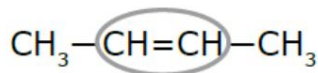
{c%{h:@,{c%{h;@,{c%{h:

⁵ These last two points refer to "Two-dimensional Chemistry" (Technical Document B 6-2), where the Braille representation of expanded, branched and cyclic formulas is discussed.



{c{h:@,é{c{h";{c{h5@,{c{h:

In the same way, typographic resources that encompass certain segments of the formula or that are on colored backgrounds are represented in braille.



In the example that follows, a Braille Transcription Note would have to be entered informing that with the first typographical change the color red is indicated and with the second the color blue.



**{c{h:@,é{c{h;@,{o@,5é;{c{h;@,5\
 \@,5{c{h;é;@,{c{h;u5é@,{o@,\
 \@,{c{h;5@,{c{h:**

Appendix 1. Most used arithmetic operators

Braille sign	Braille dots	Sign	Meaning
+	235	+	addition
-	36	-	subtraction
<	236	· x	multiplication
*	256	:	division
=	2356	=	equal
'=	4-2356	̃	approximately equal to
^=	45-2356	̂	distinct from
0	135	>	greater than
9	246	<	smaller than
and	135-135	>>	much older than
99	246-246	<<	much smaller than

Appendix 2. Specific signs of braille

Signo braille	Braille dots	Meaning
?	26	open auxiliary parenthesis
}	35	close auxiliary parenthesis
in	34	subscript
1	16	superscript
_in	6-34	left subscript
'1	4-16	superscript on the left
@	5	lowercase latin letter indicator
{	46	capital latin letter indicator
'	4	lowercase greek letter indicator
^	45	uppercase greek letter indicator

Appendix 3. Greek alphabet

Capital letter	Signo braille	Braille dots	Lowercase letter	Signo braille	Braille dots
A	^a	45-1	a	'a	4-1
B	^b	45-12	b	'b	4-12
C	^g	45-1245	c	'g	4-1245
D	^d	45-145	d	'd	4-145
E	^e	45-15	e	't is	4-15
G	^z	45-1356	g	'of	4-1356
THE	^5	45-156	the	'5	4-156
Th	^4	45-1456	i	'4	4-1456
I	^i	45-24	i	'i	4-24
K	^k	45-13	K	'k	4-13
L	^l	45-123	l	'l	4-123
M	^m	45-134	m	'm	4-134
N	^n	45-1345	n	'n	4-1345
X	^x	45-1346	x	'x	4-1346
THE	^o	45-135	The	'O	4-135
Pi	^p	45-1234	Pi	'p	4-1234
R	^r	45-1235	r	'r	4-1235
S	^s	45-234	s, s	's	4-234
T	^t	45-2345	t	't	4-2345
Y	^u	45-136	u	'in	4-136
Phi	^f	45-124	Phi	'f	4-124
X	^&	45-12346	h	'&	4-12346
Ps	^y	45-13456	p	'and	4-13456
Oh	^w	45-2456	oh	'at	4-2456

Appendix 4. Numbers in low position

They are formed with the elements of the 5th series of braille, which correspond to the same combinations of dots that make up the first ten letters but using only rows 2 and 3 (instead of rows 1 and 2) of the box. In this way, points 1 and 4 start to occupy the central row of the braille box, formed by points 2 and 5, and those that occupy these last two positions start to occupy those corresponding to the last row.

In this document, whenever numbers are used in low position, the number sign is not used, except in the case that they are "fractional coefficients" that precede a molecule.

Therefore, as it is the most common representation in this document, the numbers are presented in lower position without the number prefix.

These are:

Number	Braille sign	Braille dots
1	,	2
2	;	23
3	:	25
4	*	256
5	?	26
6	+	235
7	=	2356
8	<	236
9	}	35
0	>	356

Appendix 5. Other signs

Braille sign	Braille dots	Sign	Meaning
2	126	(	open parentheses
̀	345	)	close parentheses
on	12356	[	open brackets
u	23456	]	close square brackets
@l	5-123	{	open key
%,	456-2	}	close key
%>	456-356	% So much	percent
%>>	456-356-356	% so much	per thousand
—,	6-2	/	forward slash
%ö	456-0d		barra vertical

Documentos técnicos de la Comisión Braille Española

