

# BRAILLE CODE FOR CHEMICAL NOTATION 1997

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## PREFACE

This code is based on the *Nemeth Braille Code for Mathematics and Science Notation, 1972 Revision*. Since the Nemeth Code does not include symbols and rules for chemistry notation, transcriptions of chemical material have varied greatly depending on the ideas of the individual transcriber. The Mathematics Technical Committee of the Braille Authority of North America (BANA) felt there was a great need for uniformity and the BANA Board agreed.

The BANA Mathematics Technical Committee examined chemistry textbooks and examples submitted by transcribers to this committee and to the National Braille Association Mathematics Committee for many years to decide the content of a code. Symbols for bonds, electron dots, and other symbols not included in the Nemeth Code were carefully selected and rules for their use were formulated.

Transcribers and readers have been involved in this endeavor. They have reviewed the code, evaluated it, and offered comments and suggestions to improve it. Those who have used it have found it effective.

The BANA Mathematics Technical Committee thanks all who have been involved in this work. Special thanks are extended to Priscilla Harris and Robin Banker, who have assisted in the production of this document.

### BANA MATHEMATICS TECHNICAL COMMITTEE

Von Eulert, Chair  
Christopher Gray  
Helen McMillan  
Joyce Van Tuyl  
Jane Corcoran, Consultant





## INTRODUCTION

Any symbols and rules in this Code which differ from those of the *Nemeth Code for Mathematics and Science Notation* are to be used in chemistry notation exclusively and are not to be used in Nemeth Code transcriptions.

Some specific instances of differing rules are the following:

*Runover sites.* Regardless of print format, runover sites of links in chemical equations are indented two cells to the right of the signs of comparison. (Section 2)

*Cancellation.* Linear transcriptions of uncomplicated fractions containing cancellation with no replacement symbols are forbidden in the Nemeth Code but are permitted in this code.

*Capitalization and punctuation.* All letters in acronyms and abbreviations must be capitalized individually and must be punctuated in the mathematical mode. Spacing may also differ from the Nemeth Code. (Section 9)

*Transcriber's Notes page.* If a Nemeth Code transcription contains some chemistry notation, cite the use of this Chemistry Code, along with its date of adoption, on the Transcriber's Notes page.

*Special Symbols page.* A list of any chemistry symbols used that are not included in the Nemeth Code must be listed on the Special Symbols page. These symbols are shown in Section 1 (Braille Indicators) and Section 3 (Chemical Signs and Symbols).

When this Chemistry Code does not address a particular transcribing problem, the rules of the Nemeth Code should be used. See Example 4.2.6-1 as an instance of such a situation.







## 2 GENERAL FORMAT

- 2.1 **Runover Sites.** Runover sites must be selected carefully to minimize the number of runovers and to keep related material intact. Do not divide any mathematical expression if it can be contained on one line. Avoid running over within material between bonds, ring structures, superscripts or subscripts, and modifications.
- 2.2 **Preference List for Runovers.** When a chemical expression cannot be kept on one braille line and must be divided between lines, the division must be made giving priority to the following items in descending order:
- (1) Before a symbol of comparison
  - (2) Before a symbol of operation
  - (3) Before an opening fraction indicator
  - (4) Before a chemical bond
  - (5) Before a fraction line
  - (6) Before the base-line indicator\*
  - (7) Before a change-of-level indicator or within a superscript or subscript before one of the symbols listed above
  - (8) After a comma which occurs between items in an enclosed list
  - (9) Between factors which are enclosed within grouping symbols
  - (10) After a termination indicator.

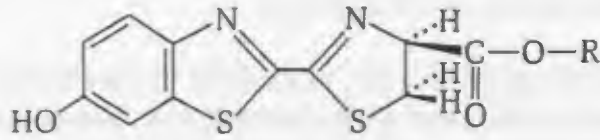
Fractions, parenthetical expressions, and chemical formulas should be completed on one braille line if possible. If the numerator or denominator of a fraction must be run over, a division must occur also at the fraction line. If a chemical compound in a mathematical link must be run over, a division must be made also at a sign of operation. (See Example 2.5-2.)

\*The baseline indicator assumes the priority position of the symbol which follows it. (See Examples 6-8 and 7.1-2.)

- 2.3 **Linked Expressions.** If a displayed expression is too long to fit on one line and contains "links" (as defined in §189 of the Nemeth Code), the special margin requirements for linked expressions of the Nemeth Code (§190c, §191a(iv) and b(v)) apply regardless of the print format. Thus:
- (1) Indent two cells from the anchor margin when the runover begins with a comparison symbol.
  - (2) When the runover begins with some symbol other than a comparison symbol, indent four cells to the right of the anchor margin. (See Example 2.5-2 below.)



Example 2.5-4: (spatial structure requiring a runover locator)



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
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23  
24

The Braille representation of the chemical structure is a large, complex pattern of dots arranged in a grid that roughly corresponds to the shape of the molecule. It uses various Braille characters to represent the different atoms and bonds in the structure, including the benzene ring, sulfur atoms, nitrogen atoms, and the carbonyl group. The Braille is positioned to the right of the line numbers 1 through 24.

- 2.6 **Spatial Material.** Structures occupying more than one print line and having a vertical relationship are spatial arrangements. In braille, spatial material must be preceded and followed by a blank line.

*Embedded.* When spatial expressions are embedded in narrative text, the portions of narrative text which occur on the same braille line as the spatial structure must be aligned with the main line of the structure.

*Displayed.* In displayed spatial expressions, the leftmost symbol must begin two cells to the right of the current margin. EXCEPTION: It is permissible to start a structure that occupies much space both horizontally and vertically (e.g., a ring structure or a spatial structure of a very large molecule), in cell 1 in order to avoid a runover. (See Example 4.4.3-21.) This exception should be used sparingly.

*Identified.* When a spatial structure or expression is identified by a number or letter (as in an example or set of exercises), the identifier must be placed at the top line of the structure in braille. One column of blank cells must be left between the identifier and the left-most symbol of the structure. If by placing the identifier on a separate line it is possible to get the complete structure across the page, this may be done. In this case, a blank line must be left between the identifier and the spatial structure.

*Chemical Equations.* When a chemical equation consists of a spatial element and a linear element separated by a sign of operation (usually a plus sign), the linear element, along with the sign of operation, must be placed so that it is not in direct contact with any branch of the spatial structure either vertically or diagonally. A clear blank cell must be left between the beginning (or end) of the linear element and a vertical or diagonal branch of the spatial structure to prevent direct contact. (See Example 4.2.3-4.) Moreover, a diagonal portion of the spatial structure may not "overlap" the linear element either above or below even if this could be done without making direct contact. However, no clear blank cell is necessary if the placement of the linear portion does not make direct vertical or diagonal contact with a branch of the spatial structure. (See Examples 4.2.5-2, 4.8-2.)

A linear element may be placed adjacent to a ring structure or to a horizontal portion of a spatial structure if that is the print format and if the linear portion can be brailled so that no part of it is in direct contact with a vertical or diagonal branch of the spatial structure. (See Example 4.2.6-3.)

If it is necessary to place a linear portion of an equation so far distant from the main line of a spatial structure that it is difficult to locate, the enlarged transcriber's grouping symbols may be used and the linear material top-adjusted to the grouping symbols. (See Example 2.6-4.)



*Example 2.6-1: (embedded spatial expression)*

not contribute equally. The hybrid is estimated to be 10 percent

$\cdot\text{C}:\ddot{\text{O}}:\cdot$ , 20 percent each  $\text{:C}::\text{O}:$  and  $\text{:C}::\ddot{\text{O}}:$ , and 50 percent

$\cdot\text{C}:::\text{O}:\cdot$ . The electronegativity difference is discussed in the

*Example 2.6-2: (displayed spatial expression)*

That for an atom of chlorine is



When these atoms react, sodium atoms become sodium ions.

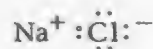
The electron-dot symbol for a sodium ion is



The chlorine atoms become chloride ions, which have the electron-dot symbol



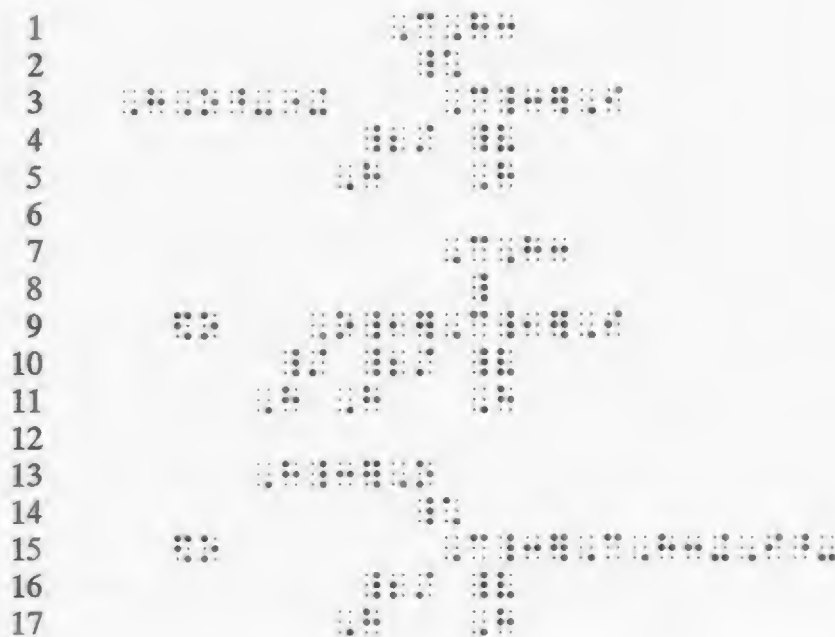
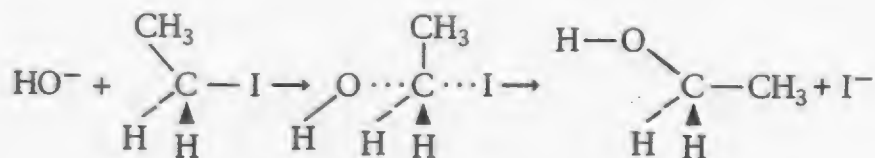
These ions form the compound sodium chloride. The electron-dot formula for sodium chloride may be written as



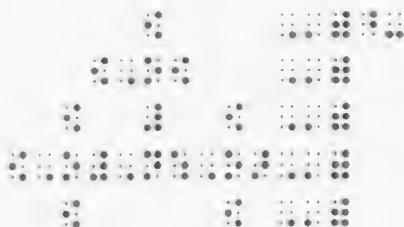
or as a simpler ionic formula,  $\text{Na}^+\text{Cl}^-$ .



Example 2.6-3: (linear adjacent to spatial)



Example 2.6-4: (requires transcriber's grouping symbols; what appears as a bold dot is a normal electron dot in this text)



- 2.7 **Cancellation.** Material containing cancellation with no replacement symbols may be transcribed linearly. (Nemeth Code Rule XI requiring spatial arrangement does not apply in this situation.) (See Example 9.5-6.)

## 3 CHEMICAL SIGNS AND SYMBOLS

3.1 Chemical Arrows. The braille representation of arrows listed below must be used in place of the ones listed in the Nemeth Code. All other arrows must be transcribed as required by the Nemeth Code.

Up-pointing				
Regular	↑		⠠⠠⠠⠠	
Boldface	↑		⠠⠠⠠⠠⠠⠠	
Down-pointing				
Regular	↓		⠠⠠⠠⠠	
Boldface	↓		⠠⠠⠠⠠⠠⠠	
Bold up-pointing followed by regular down-pointing	↑↓		⠠⠠⠠⠠⠠⠠⠠⠠	
Regular up-pointing followed by bold down-pointing	↑↓		⠠⠠⠠⠠⠠⠠⠠⠠	
Regular up-pointing followed by regular down-pointing	↑↓		⠠⠠⠠⠠⠠⠠	
Vertical or oblique dipole				
Up-pointing	↑	or	↑	⠠⠠⠠⠠
Down-pointing	↓	or	↓	⠠⠠⠠⠠
Half-barb up-pointing followed by half-barb down-pointing	↑↓		⠠⠠⠠⠠⠠⠠⠠⠠	

## Horizontal

Dipole, right-pointing	$+ \rightarrow$	or	$\rightarrow +$	
Dipole, left-pointing	$\leftarrow +$	or	$\leftarrow +$	
Crossed arrow	$\leftrightarrow$			

## 3.2 Bonds

## 3.2.1 Electron Dots

Single regular	$\cdot$		
Single bold or hollow	$\bullet$ $\circ$		
Small x	$\times$		
Pair, regular	$\cdot$ $\cdot$		
Pair, hollow or bold	$\bullet$ $\bullet$ $\circ$ $\circ$		
Pair, x's	$\times$ $\times$ $\times$ $\times$		
Pair, right or upper bold or hollow, left or lower regular	$\bullet$ $\circ$ $\cdot$ $\cdot$		
Pair, right or upper x, left or lower regular	$\times$ $\times$ $\cdot$ $\cdot$		
Pair, right or upper regular, left or lower bold or hollow	$\cdot$ $\cdot$ $\bullet$ $\bullet$ $\circ$ $\circ$		

Pair, right or upper regular,  
left or lower x

x ·     · x     ⋮

Pair, right or upper bold or  
hollow, left or lower x

x •     • x  
x ◦     ◦ x     ⋮

Pair, right or upper x, left or  
lower bold or hollow

• x     x •  
◦ x     x ◦     ⋮

Triplet (three pairs of regular  
electron dots)

⋮     or     ⋮     ⋮

Other triplets

Insert dots 46 before a pair shown  
horizontally in the list above to  
indicate that the arrangement is  
a triplet. For example:

•x     ⋮  
•x     ⋮  
•x     ⋮

## Bonds, cont.

## 3.2.2 Horizontal (including indicators)

Single	—	⠠⠠⠠⠠
Double	==	⠠⠠⠠⠠⠠⠠
Triple	≡	⠠⠠⠠⠠⠠⠠⠠⠠
Arrow, right-pointing	→	⠠⠠⠠⠠⠠⠠⠠⠠
Arrow, left-pointing	←	⠠⠠⠠⠠⠠⠠⠠⠠
Barred		⠠⠠⠠⠠
Bold	—	⠠⠠⠠⠠
Broken	- - -	⠠⠠⠠⠠
Dotted	.....	⠠⠠⠠⠠
Jagged, single	⚡	⠠⠠⠠⠠
Jagged, double	⚡⚡	⠠⠠⠠⠠⠠⠠
Wavy, single	〰	⠠⠠⠠⠠
Wavy, double	〰〰	⠠⠠⠠⠠⠠⠠



**Bonds, cont.**

**3.2.3 Oblique**

Lower left to upper right	/	⠠⠨⠠⠇
Lower left to upper right, double	//	⠠⠨⠠⠇⠠⠨⠠⠇
Upper left to lower right	\	⠠⠇⠠⠨
Upper left to lower right, double	\\	⠠⠇⠠⠨⠠⠇⠠⠨
Arrow, lower left to upper right	↗	⠠⠨⠠⠇
Arrow, lower right to upper left	↖	⠠⠇⠠⠨
Arrow, upper left to lower right	↘	⠠⠇⠠⠨
Arrow, upper right to lower left	↙	⠠⠇⠠⠨
Broken, lower left to upper right	- - -	⠠⠨⠠⠇
Broken, upper left to lower right	- - -	⠠⠇⠠⠨
Dotted, lower left to upper right	⋯	⠠⠨⠠⠇
Dotted, upper left to lower right	⋯	⠠⠇⠠⠨
Barred, lower left to upper right		⠠⠨⠠⠇
Barred, upper left to lower right		⠠⠇⠠⠨

## Bonds, cont.

## 3.2.4 Vertical

Single		⠠⠨
Double		⠠⠨⠨
Triple		⠠⠨⠨⠨
Arrow, up-pointing	↑	⠠⠨⠨⠨
Arrow, down-pointing	↓	⠠⠨⠨⠨
Barred	≡	⠠⠨⠨
Bold	⠠⠨	⠠⠨⠨
Broken	- - -	⠠⠨⠨
Dotted	⋮	⠠⠨⠨
Jagged, single	⚡	⠠⠨⠨
Jagged, double	⚡⚡	⠠⠨⠨⠨
Wavy, single	⏏	⠠⠨⠨
Wavy, double	⏏⏏	⠠⠨⠨⠨

**Bonds, cont.**

**3.2.5 Wedges, Vertical or Oblique**

Down-pointing, normal outline



Up-pointing, normal outline



Down-pointing, filled in



Up-pointing, filled in



Down-pointing, dotted outline



Up-pointing, dotted outline



Down-pointing, dashed outline



Up-pointing, dashed outline



Down-pointing, barred























Up-pointing, barred



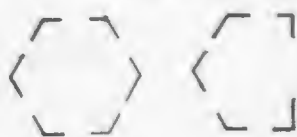
## Bonds, cont.

## 3.2.6 Wedges, Horizontal (including indicators)

Right-pointing, normal outline		
Left-pointing, normal outline		
Right-pointing, filled in		
Left-pointing, filled in		
Right-pointing, dotted outline		
Left-pointing, dotted outline		
Right-pointing, dashed outline		
Left-pointing, dashed outline		
Right-pointing, barred		
Left-pointing, barred		

## 3.3 Ring Structures

Vertices (this two-celled symbol represents any unlabeled vertex)



Circle (broken outline)



Hexagon (broken outline)



### 3.4 Miscellaneous Symbols and Indicators

#### 3.4.1 Chemical Period

3.4.2 Modifiers. These symbols are to be used as spatial modifiers only. In linear expressions, the full construct of the Nemeth Code must be used. (See Examples 5.3.1-9 and 7.2-3.)

Crossed O	$\ominus$	⠠⠠⠠⠠⠠⠠
Plus sign within a circle	$\oplus$	⠠⠠⠠⠠⠠⠠
Minus sign within a circle	$\ominus$	⠠⠠⠠⠠⠠⠠

#### 3.4.3 Lines (partitions, not bonds)

Broken vertical	⋮	⠠⠠⠠⠠
Dotted vertical	⋮	⠠⠠⠠⠠
Dotted, double vertical	⋮⋮	⠠⠠⠠⠠⠠⠠
Jagged, vertical	⌚	⠠⠠⠠⠠
Jagged, horizontal	⌚	⠠⠠⠠⠠⠠⠠

#### 3.4.4 Modified-Letter Indicators

Small capital*	⠠⠠⠠⠠
Barred capital	⠠⠠⠠⠠

Example 3.4.4-1: (small capital D) D

⠠⠠⠠⠠

Example 3.4.4-2: (barred capital R) R

⠠⠠⠠⠠

\*Assuming the small capital letter is on the same level as normal letters.



- 4 **CHEMICAL FORMULAS AND EQUATIONS.** Chemical formulas and equations may contain electron dots, bonds, mathematical operation and comparison signs, chemical arrows, and other notation.

#### 4.1 Chemical Formulas

4.1.1 **General Formula.** An expression of the composition of a compound (or radical, etc.) by a combination of SYMBOLS and numerals to show the constituents, usually in exact proportion. The following are definitions of the different types of formulas.

4.1.2 **Empirical Formula.** A chemical formula which gives the composition of a compound but does not specify the structural arrangement or proportion.

*Example 4.1.2-1:* (empirical formula for benzene)

CH



4.1.3 **Molecular Formula.** A formula which gives the kinds of atoms or radicals and the number of each kind in a molecular compound.

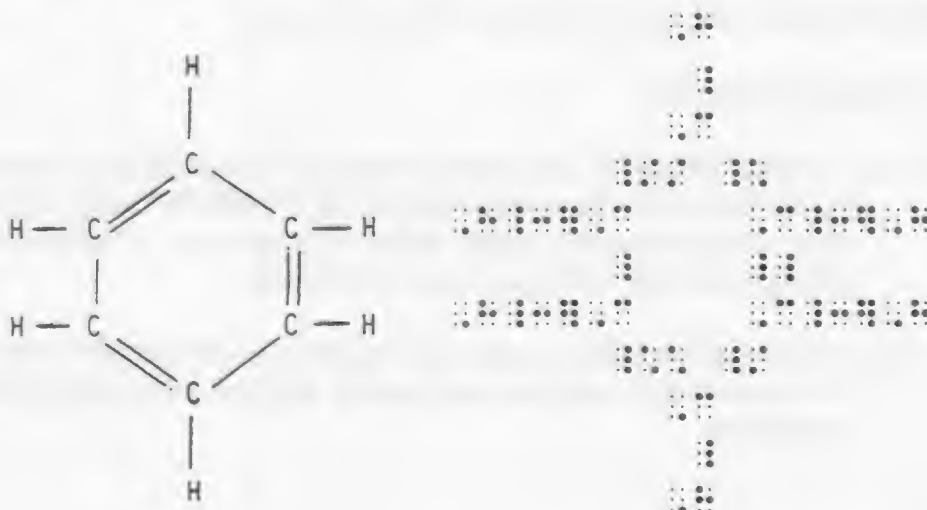
*Example 4.1.3-1:* (molecular formula for benzene)

C<sub>6</sub>H<sub>6</sub>



4.1.4 **Structural Formula.** A formula which illustrates the arrangement of the atoms and bonds in a molecule. Structural formulas are spatial arrangements and may contain "closed figures," called "cyclical" or "ring" structures.

Example 4.1.4-1: (benzene ring)

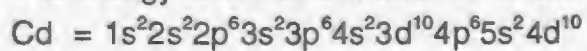


#### 4.1.5 Electron Dot Formula (also known as Lewis Electron Dot Diagram).

This is a formula which employs the SYMBOL of an element to represent the nucleus of an atom and all electrons except those in the outer level. Dots represent the outer level of electrons, drawn on the appropriate sides (top, bottom, left, right) or on the diagonal (upper left, upper right, lower left, lower right) of the SYMBOL.

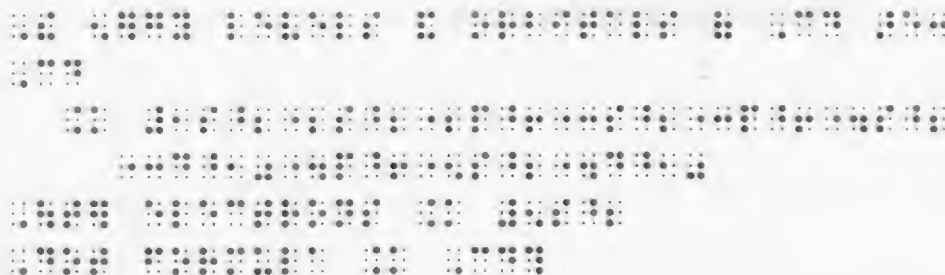
Example 4.1.5-1:

The energy levels and orbital of Cd are:



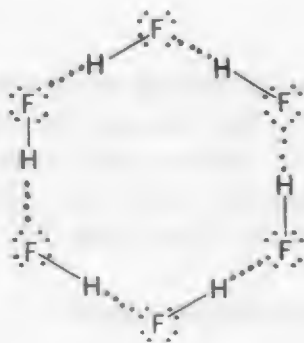
Outer electrons =  $5s^2$

Dot formula = Cd :





*Example 4.1.5-2:* (structural diagram consisting of a combination of molecular bonds and electron dots)



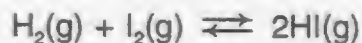
4.2 Arrows. The chemical arrows listed in Section 3.1 are for use in transcribing chemical formulas only. Various forms of arrows are often included in these formulas. It is imperative that the print form of the arrows be represented in braille. If double arrow combinations show one arrow heavier or longer than the other, the difference is significant and thus must be duplicated in braille.

4.2.1 Horizontal Arrows. The symbols for horizontal arrows are those listed in the Nemeth Code. Added to this list are the horizontal dipoles ( $\rightarrow$  and  $\leftarrow$ ). Except for dipoles and arrow bonds, horizontal arrows are signs of comparison and are spaced and punctuated in compliance with the Nemeth Code, Rule XX.

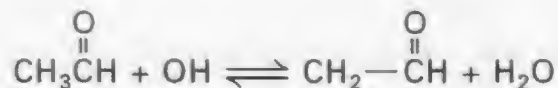
*Example 4.2.1-1:* (single, right-pointing arrow, normal barb)



*Example 4.2.1-2:* (double arrows, equal lengths, normal barbs)

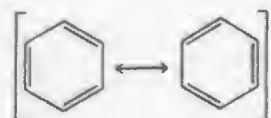


*Example 4.2.1-3:* (double arrows, equal lengths, half-barbs)

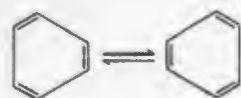


*Example 4.2.1-4: (resonance and equilibrating arrows)*

In resonance language, we may depict benzene by two equivalent resonance structures.



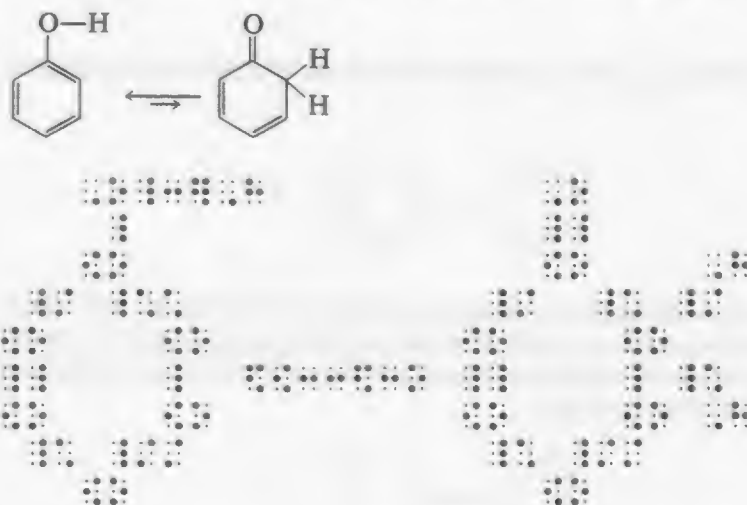
Note the important difference in meaning between this formulation and that of equilibrating cyclohexatrienes. Cyclohexatriene would have alternating single and double bonds, and the chemical equilibrium between the two alternative structures requires the movement of nuclei.



In the resonance structures, the C—C distances remain the same. The resulting resonance hybrid may be written with dotted lines to indicate the partial double bond character of the benzene bonds.



Example 4.2.1-5: (double arrows, different lengths, normal barbs)



Example 4.2.1-6: (double arrows, upper bold, normal barbs)



#### 4.2.2 Vertical Arrows. See the Symbols List, Section 3 of this Code.

Vertical and oblique arrows are often used to facilitate the presentation of a 3-dimensional figure on a 2-dimensional page. The fact that these are not horizontal often has no chemical significance. It is preferable to use right- and left-pointing arrows if this will make the presentation easier to follow in braille. Normally, chemical equations are arranged in print from left to right and from top to bottom. The direction of the reaction from one component to another must be preserved. The arrow does not mean that the reaction proceeds from the particular element which precedes the arrow but from the entire construct. (See Example 4.2.2-5.)

Although up-pointing and down-pointing arrows are normally comparison signs, in a spatial arrangement they occupy a line by themselves and no blank lines are left above or below unless required by other considerations. *Note:* Up-pointing arrows representing vaporization and down-pointing arrows representing precipitation are not comparison signs. Such arrows must be transcribed unspaced from the SYMBOLS to which they apply and the print direction must be duplicated. These arrows and the SYMBOLS or compounds to which they apply must be placed on the same braille line. If an arrow is interior to the expression, a space must follow the arrow. (See Example 4.6-1.)

Example 4.2.2-1: (up-pointing, vaporization)



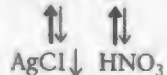
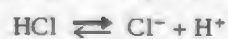
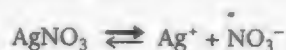
Example 4.2.2-2: (down-pointing, precipitation)



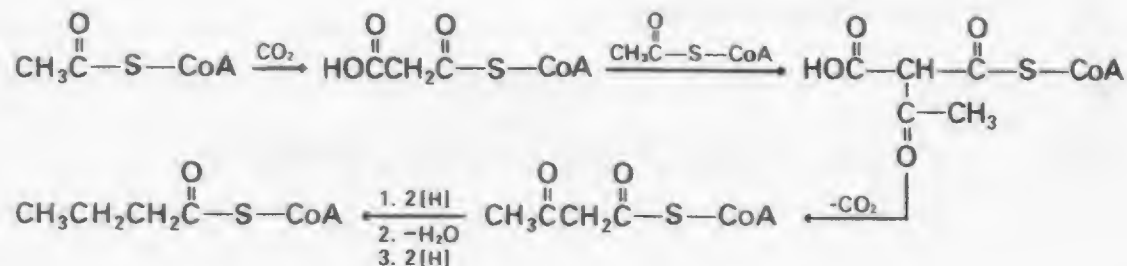
Example 4.2.2-3: (interior down-pointing, precipitation)



Example 4.2.2-4: (as comparison signs in spatial arrangement)



Example 4.2.2-5: (as comparison signs, print arranged for the convenience of the printer, normal direction in braille)



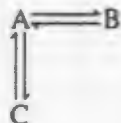
(In this example, the print shows the arrows wrapping in a loop, left to right, down, and then from right to left. In braille, the arrows are arranged to be read from left to right as is the normal reading direction.)

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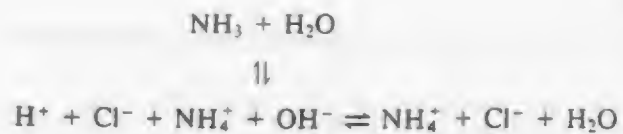
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Example 4.2.2-6: (double vertical arrows with half-barbs)

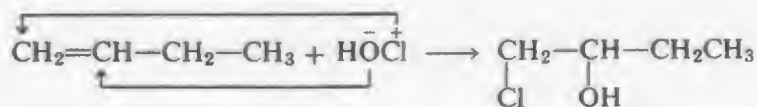


Example 4.2.2-7: (vertical arrows pointing to a portion of a reaction)

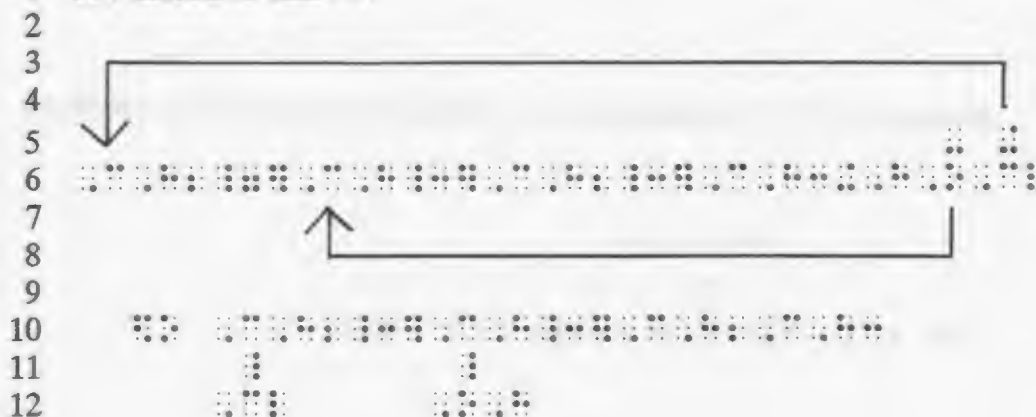


4.2.3 Lead Lines and Lead Arrows. These must be present as directed in *Guidelines for Mathematical Diagrams*. The brailled arrows must not be used.

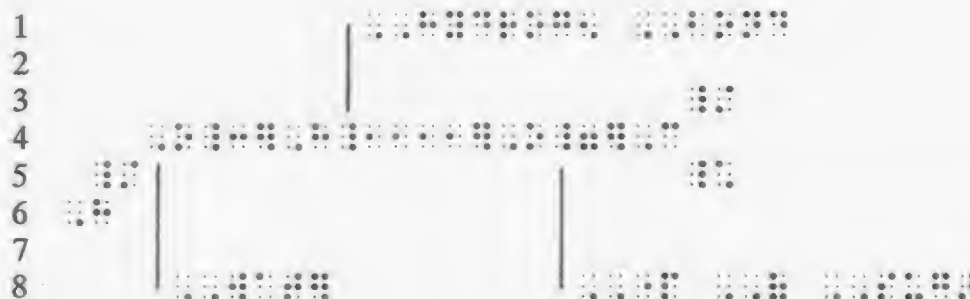
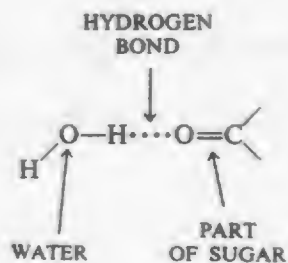
Example 4.2.3-1: (lead arrows, direction required)



1 . . . narrative text . . .



Example 4.2.3-2: (lead arrows, direction not significant)

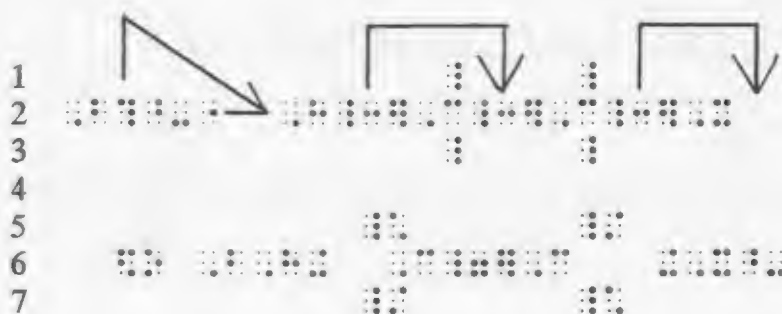
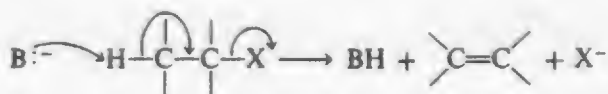








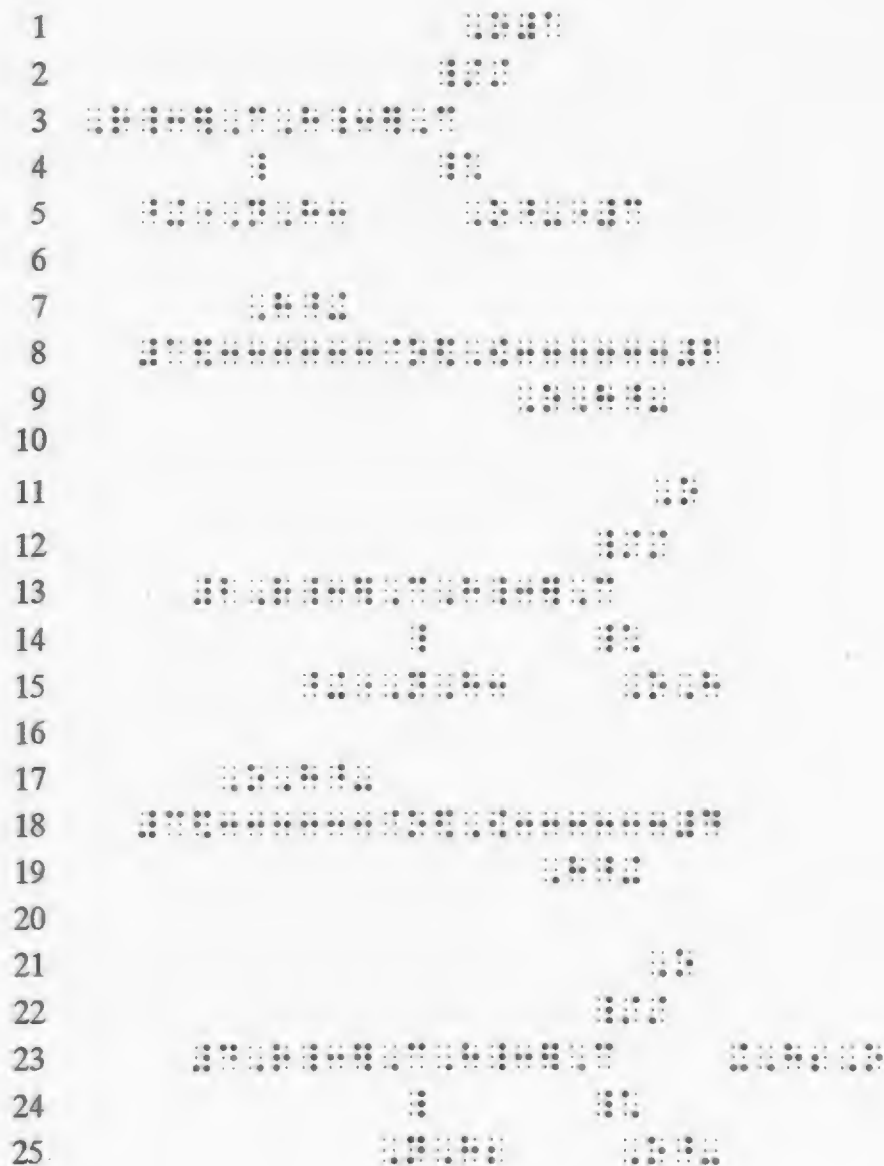
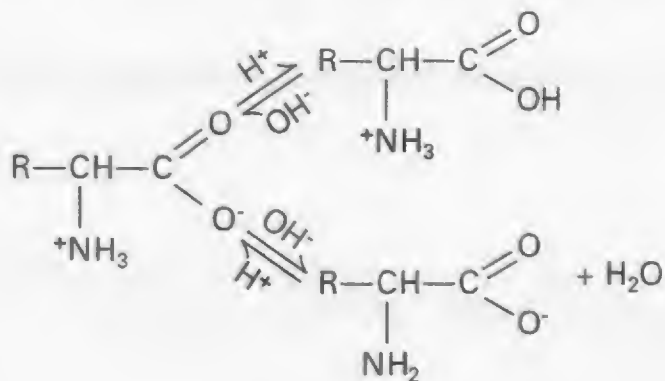
Example 4.2.3-4: (arrows showing displacement or substitution reactions)







Example 4.2.5-2: (double arrows, same length, each modified)



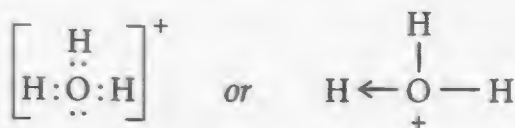


4.2.6 Arrow Bonds. Occasionally arrows are used as bonds. Care must be taken to distinguish between arrow bonds and arrows used as comparison signs. If arrows occur between chemical compounds, they are comparison signs. If they occur within a compound or structure, they are bonds. Context of surrounding material will help identify the purpose of the arrow.

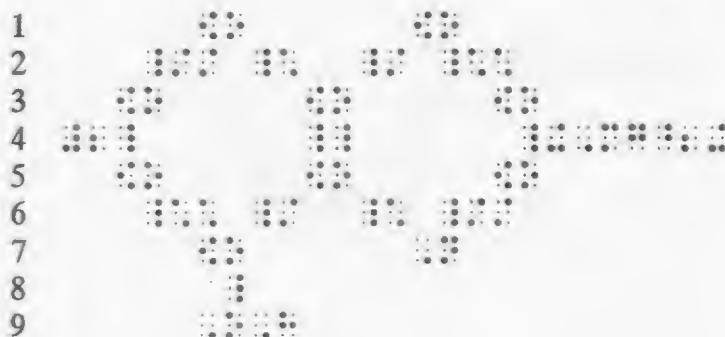
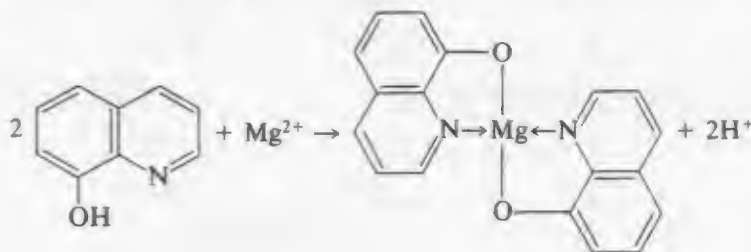
Example 4.2.6-1: (two covalent and one coordinate covalent bond)



Example 4.2.6-2: (coordinate covalent bond)



Example 4.2.6-3: (arrow bonds within spatial structure)



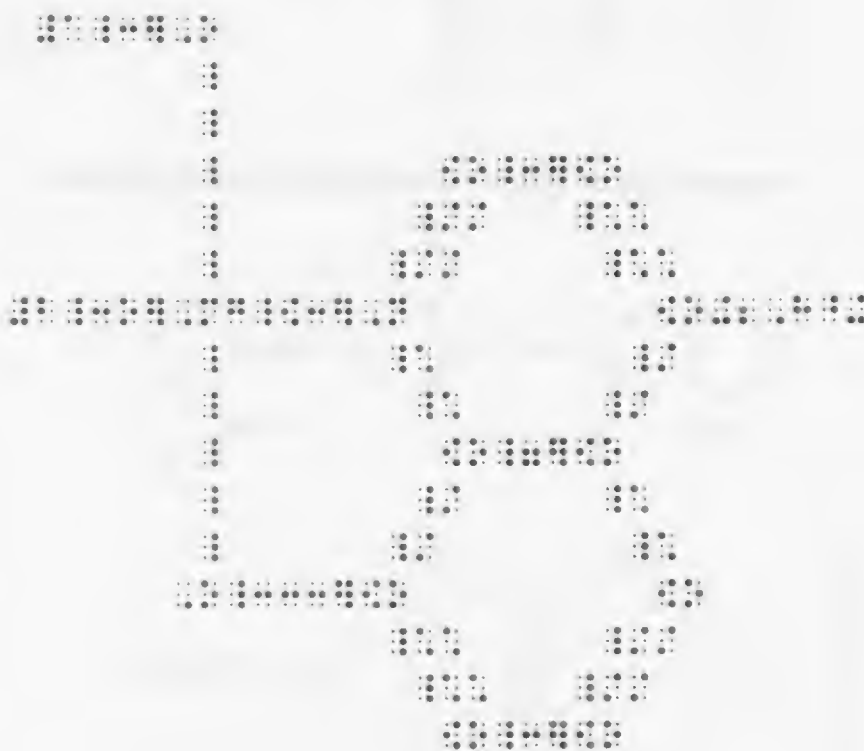
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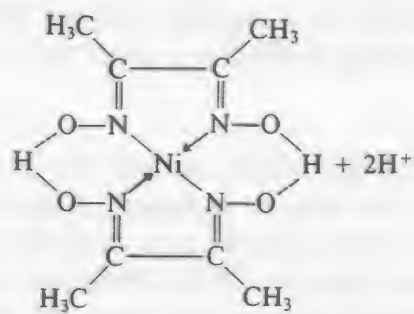
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Example 4.2.6-4: (oblique arrow bonds within spatial structure)



- 4.3 **Electron Dot Bonds.** Although all electron dots have the same chemical meaning, writers of textbooks use different types of dot notation to illustrate a point, trace transferred or shared electrons, denote free electrons, etc. In braille, these differences must be maintained. If what appears to be a bold dot is used and a smaller dot is not used elsewhere in the text, the bold dot must be transcribed as a regular electron dot (dots 16). Other types are transcribed according to the list in Section 3.2 of this Code.

When colored dots are used in print for distinction, choose one of the dot configurations not used elsewhere in the text to represent these colored dots. If this occurs in only one place, a transcriber's note must be used to show the meaning of the configuration chosen. If the technique is used throughout the text, this use, including the color of the print dot, must be noted on the Special Symbols page.

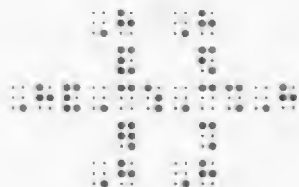
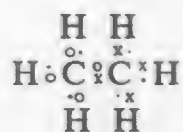
- 4.3.1 **Placement of Electron Dots.** Electron dots must be placed above, below, to the right, to the left or on the diagonal as they appear in print. At times a single dot which appears above, below, to the right or left of the element may not be centered in print, but in braille this displacement is to be ignored unless it is on the diagonal. (See Examples 4.3.1-3, 4.3.1-4, and 4.3.1-5.)

When dots appear on the diagonal to the element in print, the symbol must be located to the right or left of the SYMBOL in braille on the line immediately above/below in the first cell preceding or following the SYMBOL to which it applies. When a pair of electron dots appears on the diagonal to the element, the left-most dot of the pair is considered the "left" dot in selecting the correct symbol to use (from the list in Section 3.2.1). If there are two sets of dots on the diagonal in print, they should be placed one directly under the other, on the diagonal to the SYMBOL. However, they may be placed diagonally to each other when it is necessary to avoid confusion with other notation in the structure. (See Example 4.3.1-11.)

*Example 4.3.1-1:* (all dots, single or double, identical in size and shape)



Example 4.3.1-2: (different types of dots)



Example 4.3.1-3: (single dots, centered in print)



Example 4.3.1-4: (single dots not centered on the SYMBOL in print)



Example 4.3.1-5: (single dot appears to be in subscript position in print)



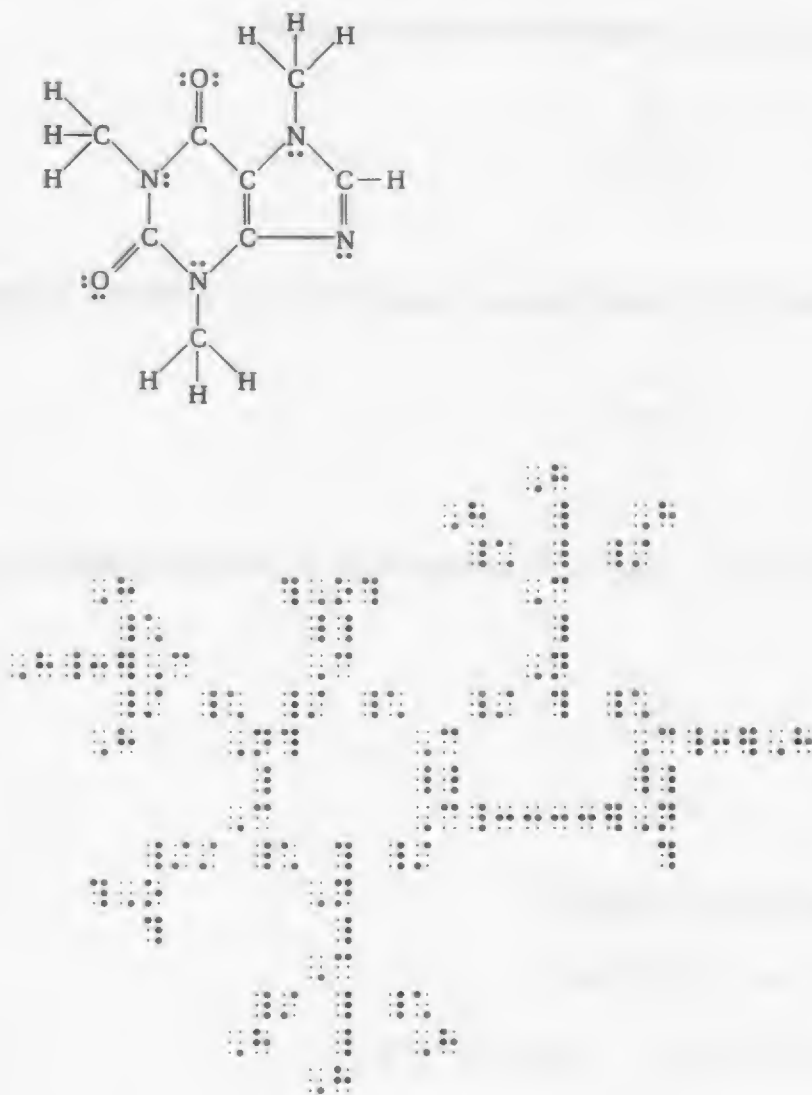
Example 4.3.1-6: (triplets)



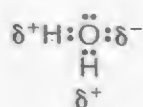
Example 4.3.1-7: (structure enclosed in grouping signs with superscript)



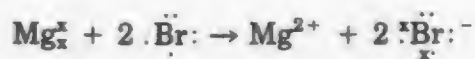
Example 4.3.1-8: (dots in ring structure)



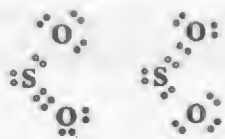
*Example 4.3.1-9:* (dots combined with other notation [delta - partial charge])



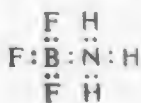
*Example 4.3.1-10:* (dots combined with superscript)



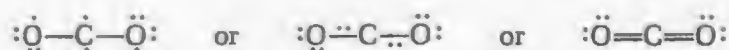
*Example 4.3.1-11:* (diagonal dots)



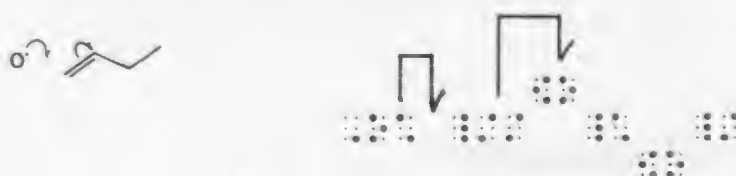
*Example 4.3.1-12:* (dots and letters in colored print)



Example 4.3.1-13: (dots combined with bonds)



Example 4.3.1-14: (ion transfer)



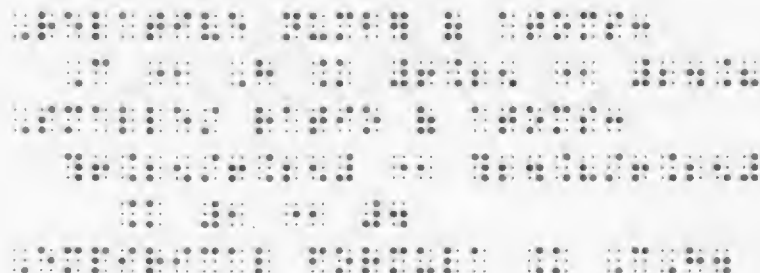
4.3.2 Proportion. Sometimes print dots appear to be pairs of electron dots but are denoting proportion. Context will determine the meaning of these dots.

Example 4.3.2-1: (dots mean ratio, not electron dots)

Relative number of atoms: C:H = 6.25:24.8

Smallest ratio of atoms:  $\frac{6.25}{6.25} : \frac{24.8}{6.25} = 1:4$

Empirical formula = CH<sub>4</sub>



*Example 4.3.2-2:* (dots mean ratio, not electron dots)

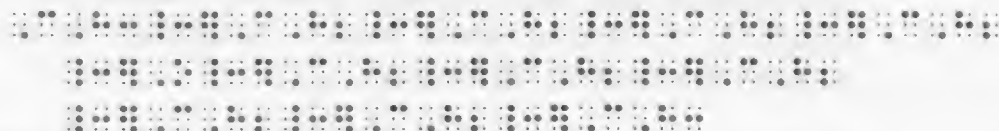
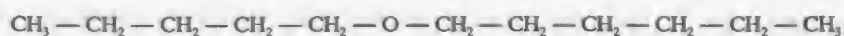
Hg : Na : Al  
 0.0300:0.0600:0.0200  
 3 : 6 : 2



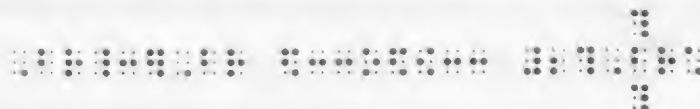
**4.4 Other Bonds.** All of the following bonds may be extended to accommodate surrounding material. (See Examples 4.4.3-1, 4.4.3-6, and 4.4.3-19.)

**4.4.1 Horizontal Bonds.** Horizontal bonds are employed in both spatial and non-spatial structures and they are subject to Nemeth Code Rule XIX (Operation Signs). See Section 1.1 of this Code for construction of horizontal bonds. If numbers or other notation appear above and/or below some of the SYMBOLS or symbols, the arrangement is spatial. See Section 5.3 for placement of numbers and other notation.

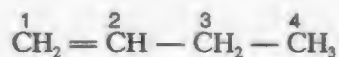
*Example 4.4.1-1:* (horizontal bonds; no comparison sign; runovers required; displayed but not spatial)



*Example 4.4.1-2:* (horizontal bond; displayed; spatial because of electron dots over/under SYMBOL)



*Example 4.4.1-3:* (horizontal bonds; displayed; spatial because carbon atoms are numbered)



**4.4.2 Vertical Bonds.** Structures containing vertical or oblique bonds are always considered to be spatial arrangements and, in braille, require a blank line preceding and following the structure, whether embedded or displayed. As with horizontal bonds, the print type of bond must be duplicated in braille.

**4.4.3 Format.** A single vertical bond must be aligned with the first letter of the SYMBOL to which it applies. When bonds consisting of two or more cells apply to a single-letter SYMBOL, the first cell of the bond should be aligned with the capitalization indicator. If the SYMBOL consists of two or more letters, the first cell of a two-cell bond must be aligned with the first letter of the SYMBOL.

Oblique bonds are brailled to the right or left of the SYMBOL to which they apply, on a separate line below/above the SYMBOL as indicated by the print. Oblique bonds can be transcribed as oblique, vertical or horizontal if the print uses oblique bonds simply to accommodate the other notation present. **Exception:** In ring structures, the oblique bonds must be transcribed as in print to preserve the shape of the structure.

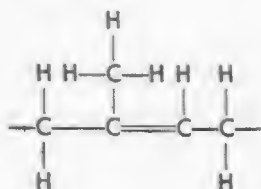
In cyclical or ring structures, some leeway is allowed in order to duplicate the print shape. However, the bonds must be arranged in such a way that the reader has no doubt as to which SYMBOL the bond applies.

When vertical bonds appear above or below unlabeled vertices, the bond should normally be aligned with the "outer" cell of the two-cell symbol. However, it may be aligned with the "inner" cell of the two-cell symbol in order to avoid confusion with other notation. (See Example 4.2.1-5.)

Displayed expressions should be indented two cells to the right of the margin but may start at the margin if by so doing the structure or an integral portion of the structure can be kept intact. It is crucial to avoid runovers within a ring.

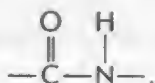


*Example 4.4.3-1:* (horizontal bonds extended to accommodate other notation)



*Example 4.4.3-2:* (incomplete spatial arrangement displayed to narrative text; punctuation following bond)

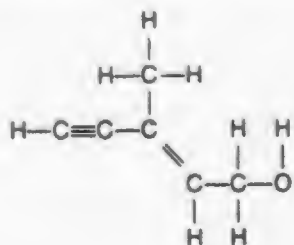
In Section 29.17 we found that carboxylic acids reacted with amines to form amides.



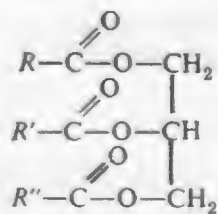
Amino acids are linked through the same condensation process. However, biochemists call the amide link a **peptide bond**. The new molecule



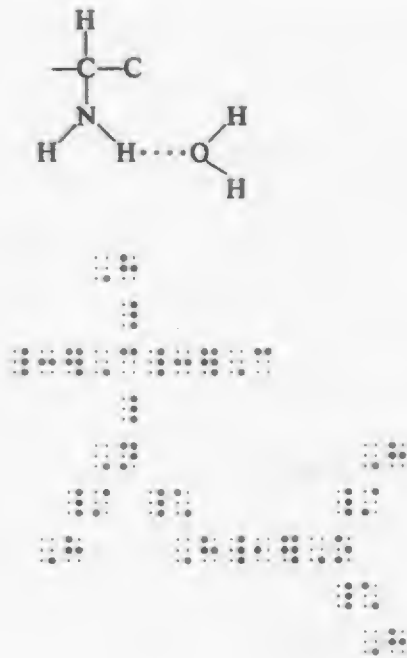
Example 4.4.3-3: (horizontal, vertical, and oblique bonds)



Example 4.4.3-4: (horizontal, vertical, and oblique bonds; vertical bonds extended to accommodate the oblique bonds;  $R$  represents a chemical group [Section 9.4])

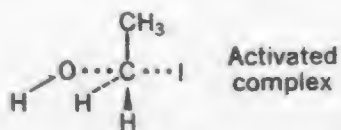


Example 4.4.3-5: (structure with dotted hydrogen bond)



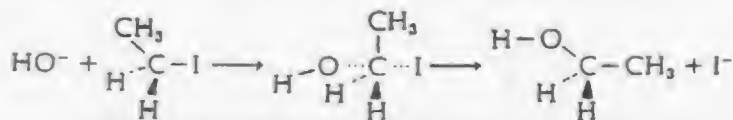


Example 4.4.3-7: (dotted bonds)



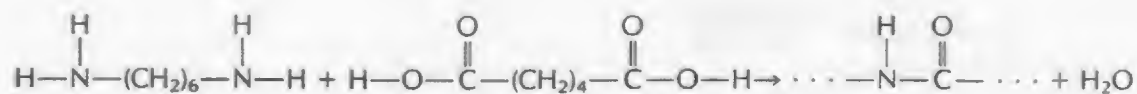
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Example 4.4.3-8: (variety of bonds)

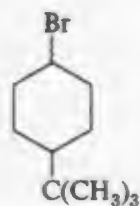


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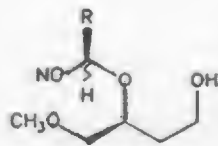
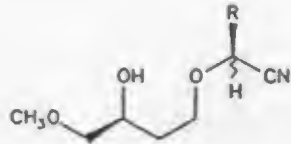
Example 4.4.3-9: (dots representing omissions, not bonds)



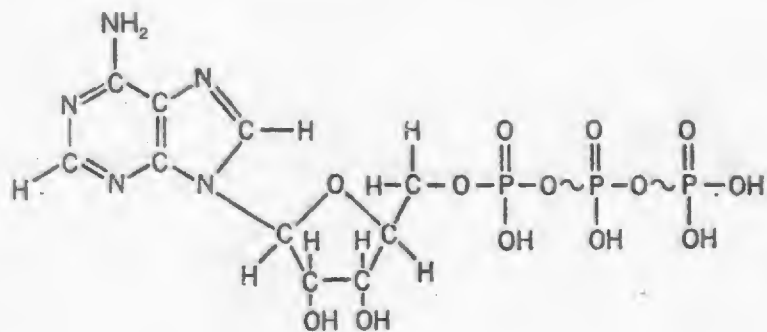
Example 4.4.3-10: (structure containing vertical wavy bond)



## Example 4.4.3-11: (vertical jagged bonds)



Example 4.4.3-12: (wavy horizontal bond)



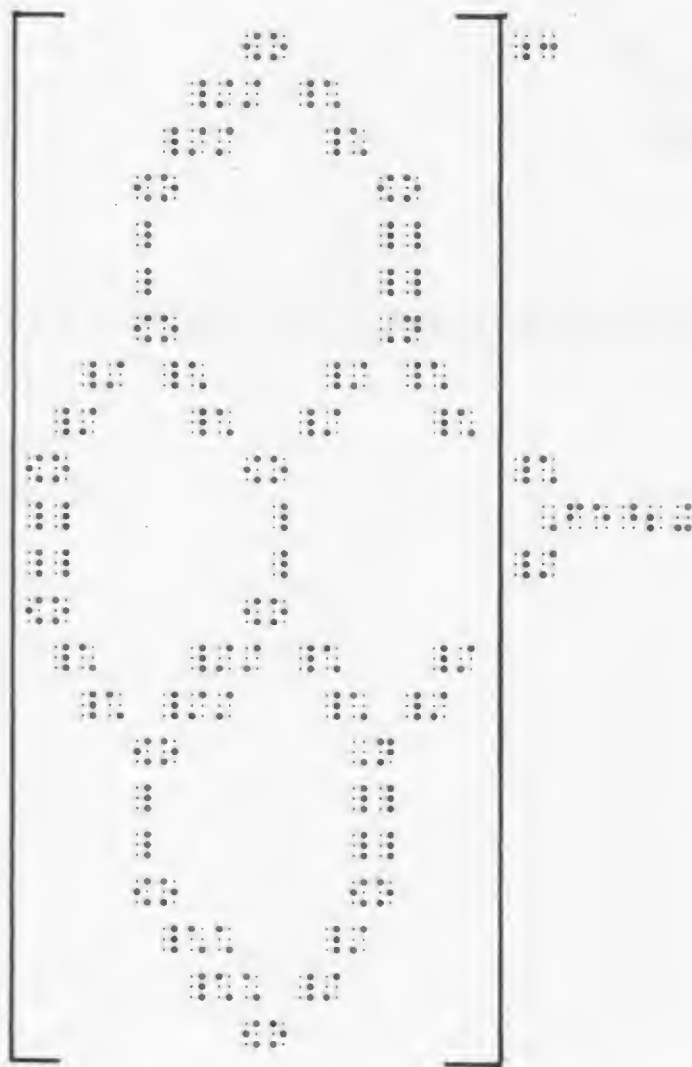
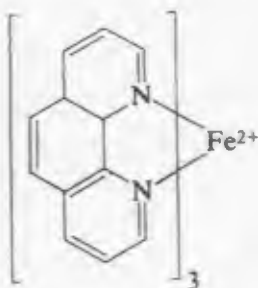
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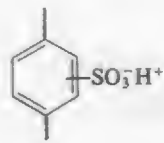




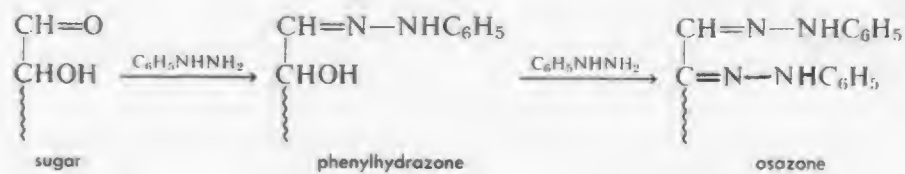
*Example 4.4.3-14:* (The bracket extending through bonds must be drawn for readability. According to the Nemeth Code, the subscript 3 which applies to the material enclosed in brackets must be top justified and the subscript indicator used. The superscript 2+ applies to the Fe.)



Example 4.4.3-15: (horizontal bond through vertical double bond)



*Example 4.4.3-16:* (extended tilde representing omission of part of a compound; not a wavy vertical bond)



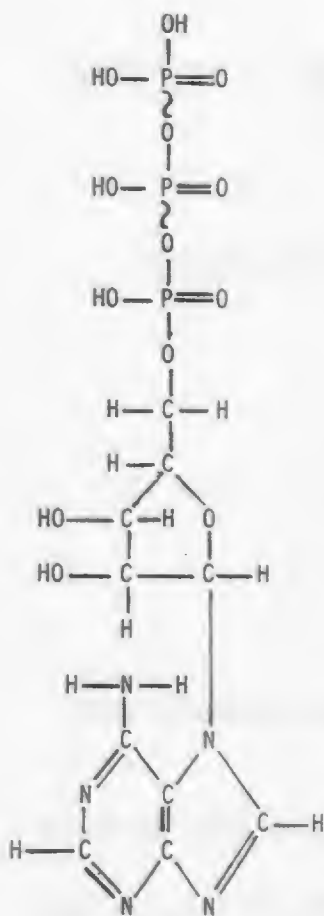
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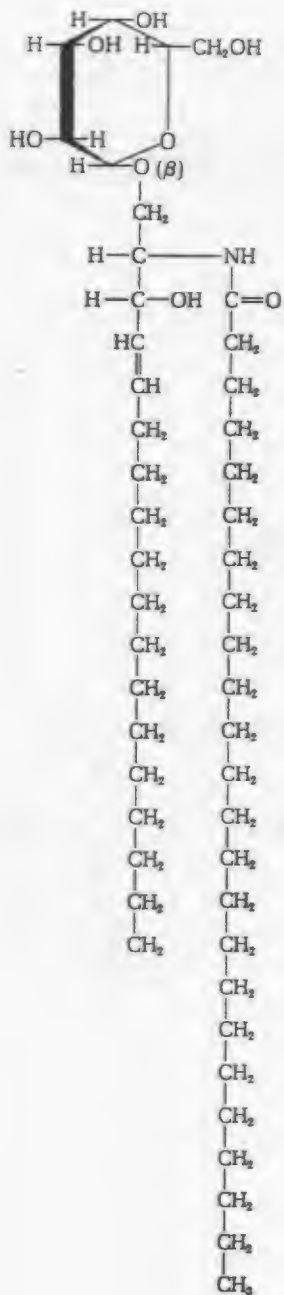
*Example 4.4.3-19:* (spatial structure requiring runover to another page;  
contains vertical wavy bond)

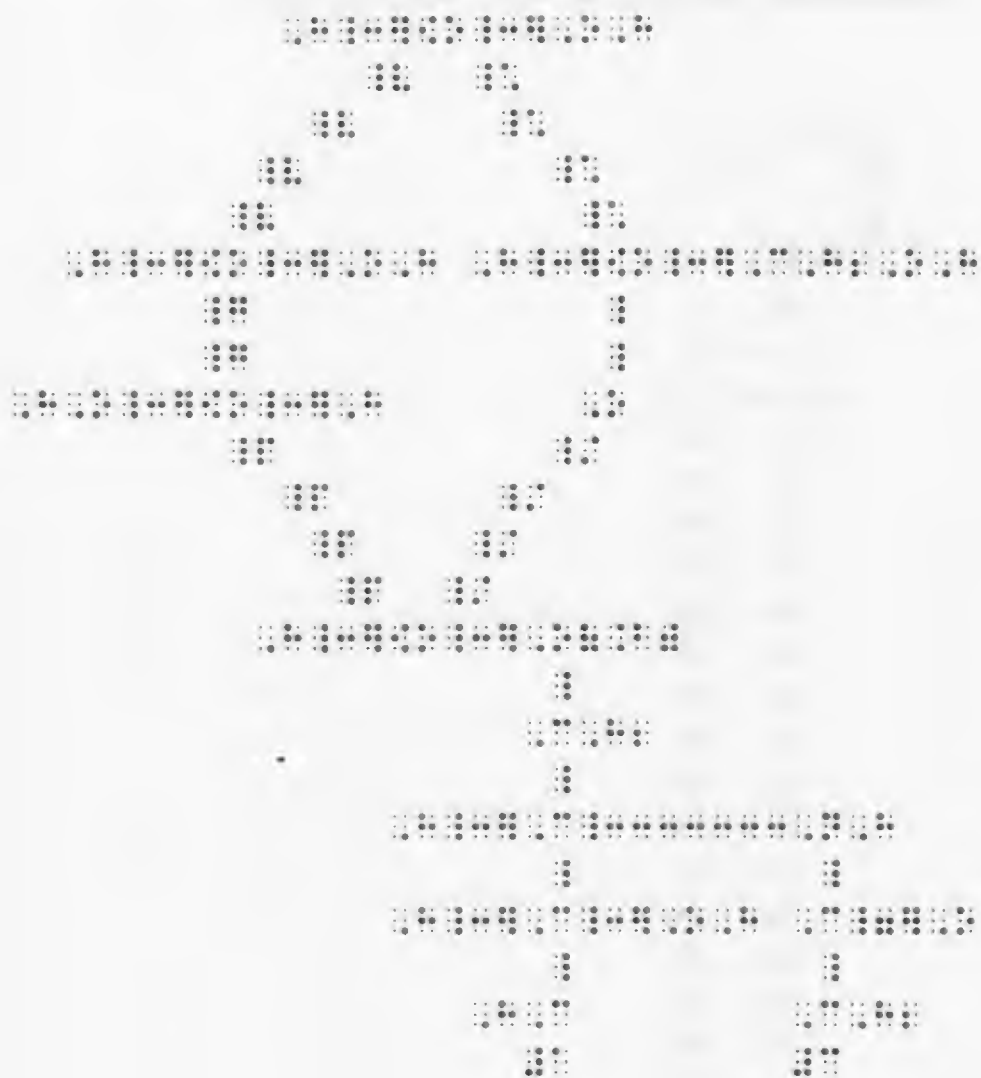


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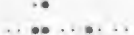
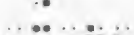







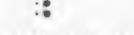


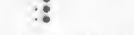
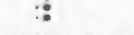







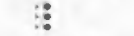


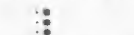
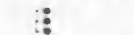


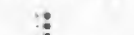
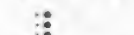



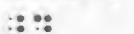




Example 4.4.3-20: (long structure requiring three pages; runovers start in identical cell number as material being continued)







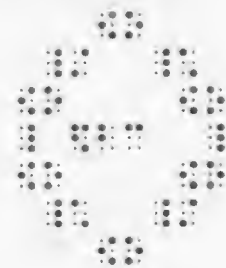
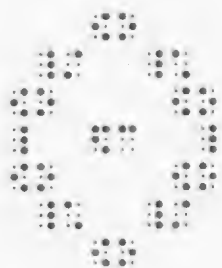
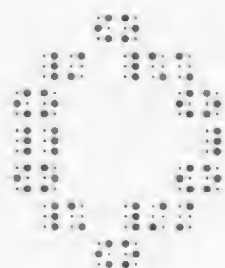
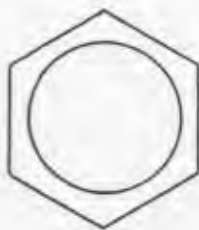
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	
	



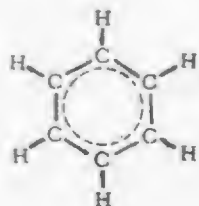




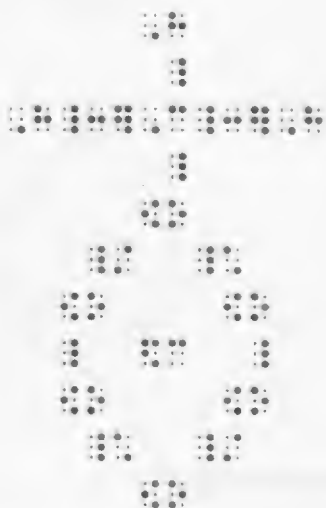
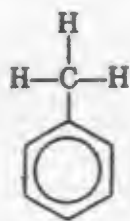
*Example 4.4.3-22:* (three common print structural representations of benzene rings)



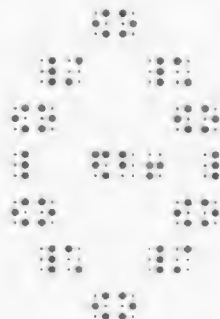
*Example 4.4.3-23:* (completely structured benzene ring)



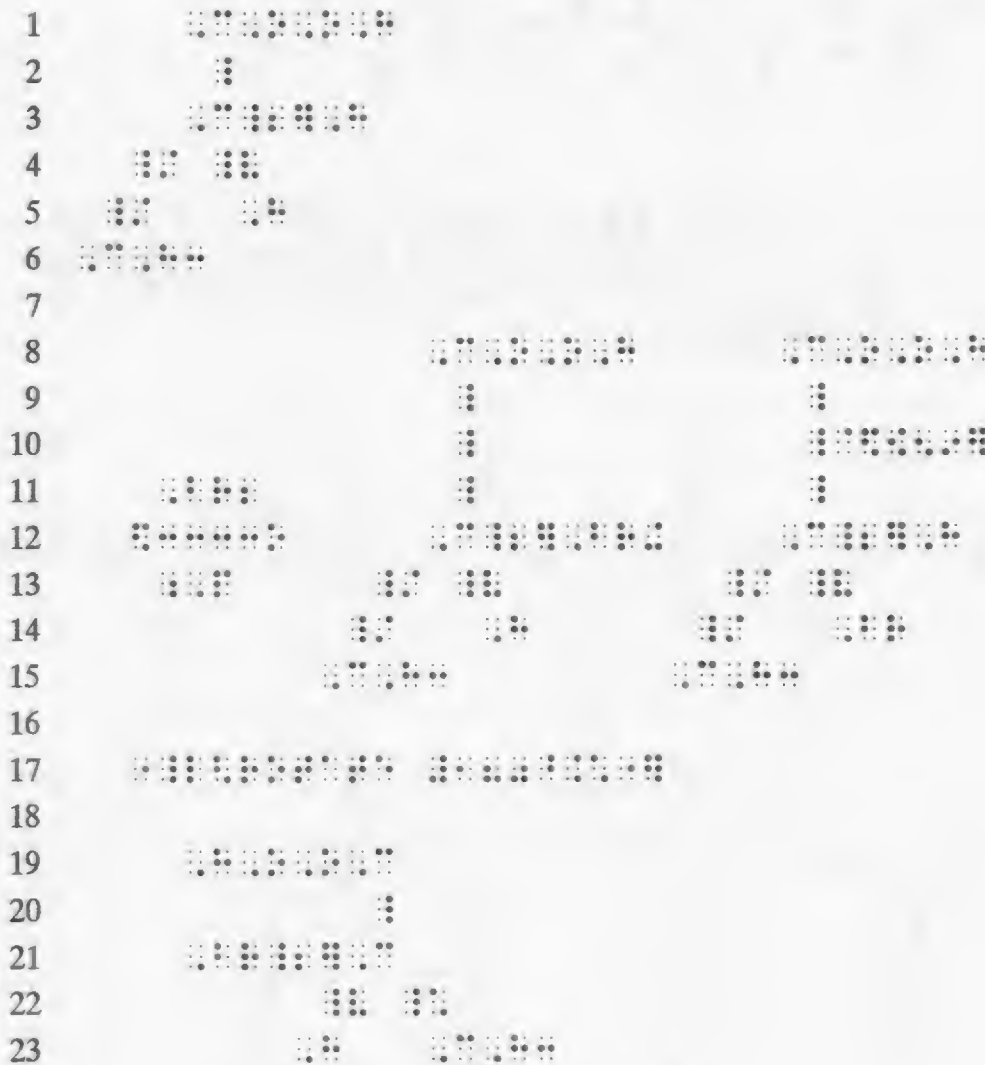
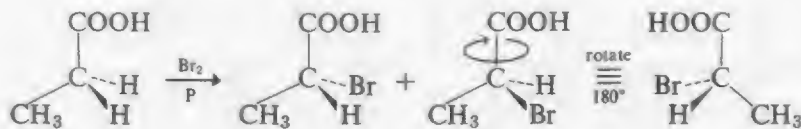
*Example 4.4.3-24:* (benzene ring used in molecule of toluene)



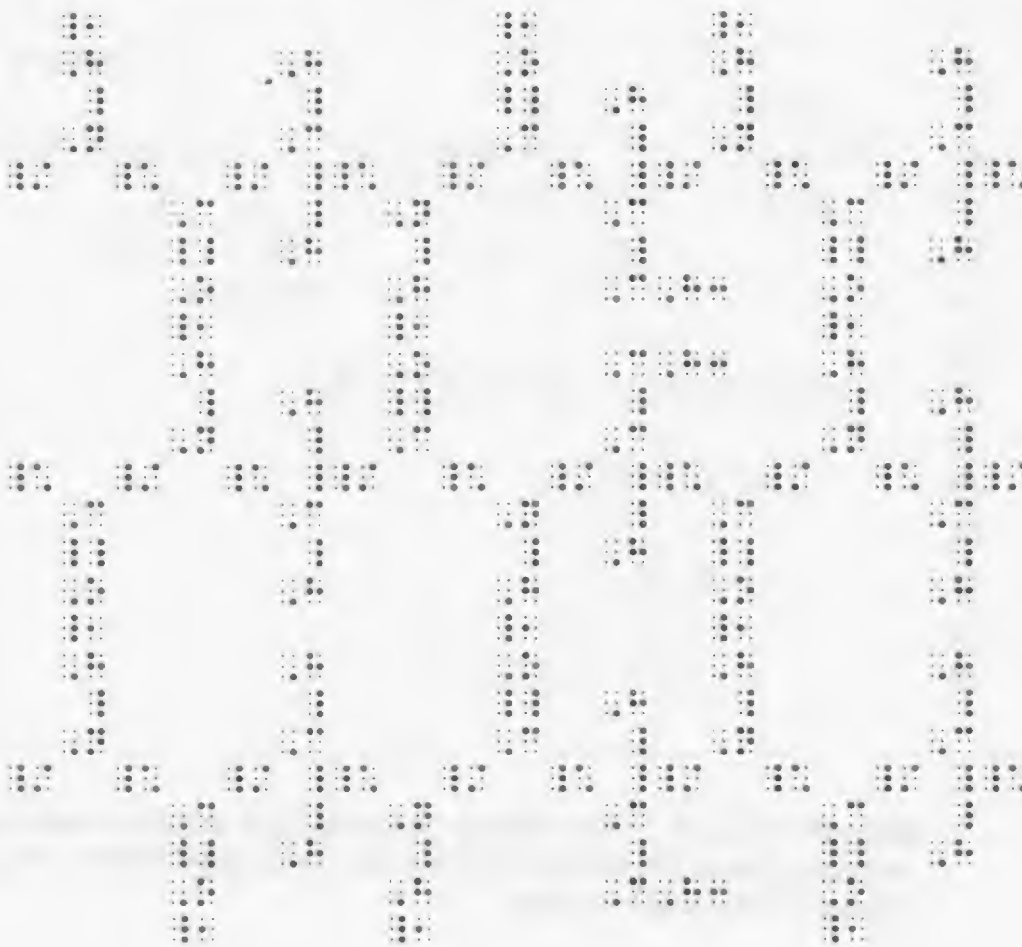
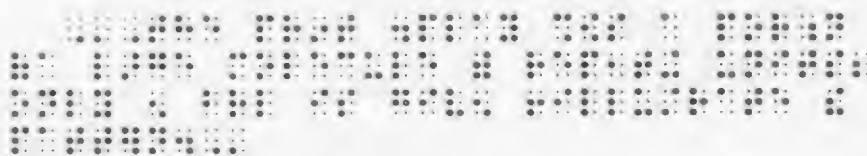
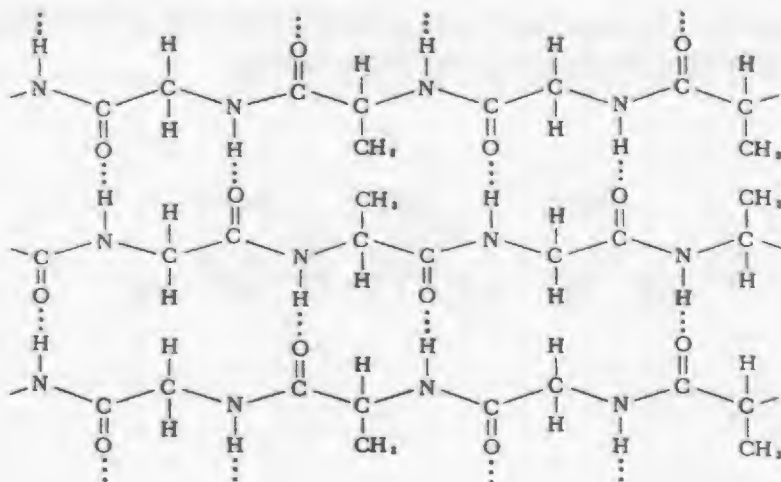
*Example 4.4.3-25:* (resonance hybrid benzene ring)



Example 4.4.3-26: (3 horizontal bars meaning congruent, not triple bond; vertical bond with superimposed clockwise arrow)



Example 4.4.3-27: (large display of incomplete molecule with repeating pattern of rings; transcribe enough braille to clearly illustrate the pattern; requires a transcriber's note)





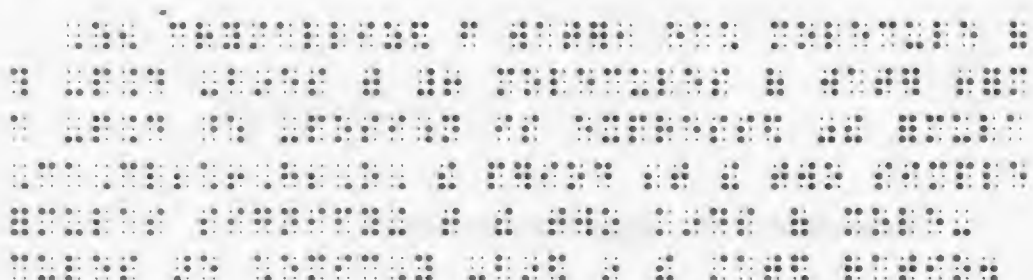
## 4.5 Miscellaneous Symbols

**4.5.1 Chemical Period.** The chemical period is not a mark of punctuation but is a notational device much like a bond. It separates two components of a compound. It is often used between the water of hydration and other components of a compound. It is also used for other purposes. The nature of the dot will be clear from context, so it will not be confused with an electron dot.

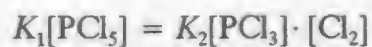
Dots 16 represent this dot in braille just as these same dots represent a print dot which is neither punctuation nor the decimal point in the Nemeth Code. No space must be left before or after the chemical period. The Nemeth Code rules for operation signs apply to the chemical period.

*Example 4.5.1-1:* (crystallization from water)

When crystallized from water, each molecule of this compound combines with 6 molecules of water to form a compound whose composition is expressed by the formula  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ , the period between the two simple formulas signifying that the two kinds of molecules are chemically combined in the stated ratio.



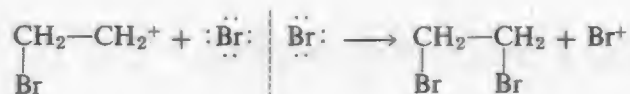
*Example 4.5.1-2:* (equilibrium computation)



**4.5.2 Separators or Partitions.** Separators or partitions are used for various purposes and must not be confused with bonds. A blank cell must precede and follow this notation.



Example 4.5.2-3: (broken vertical line)

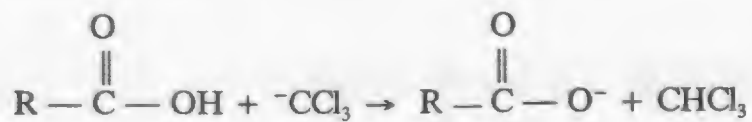


4.6 Nemeth Notation in Chemical Equations. Chemical equations often contain mathematical operation and comparison signs. In such cases, Rules XIX and XX of the Nemeth Code must be observed.

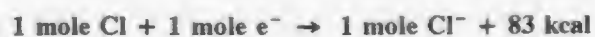
Example 4.6-1: (down-pointing arrow indicates precipitation)



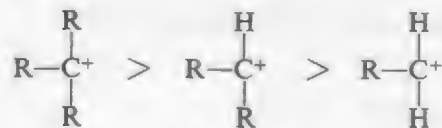
Example 4.6-2:



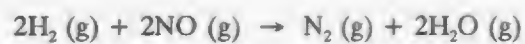
Example 4.6-3:



Example 4.6-4:



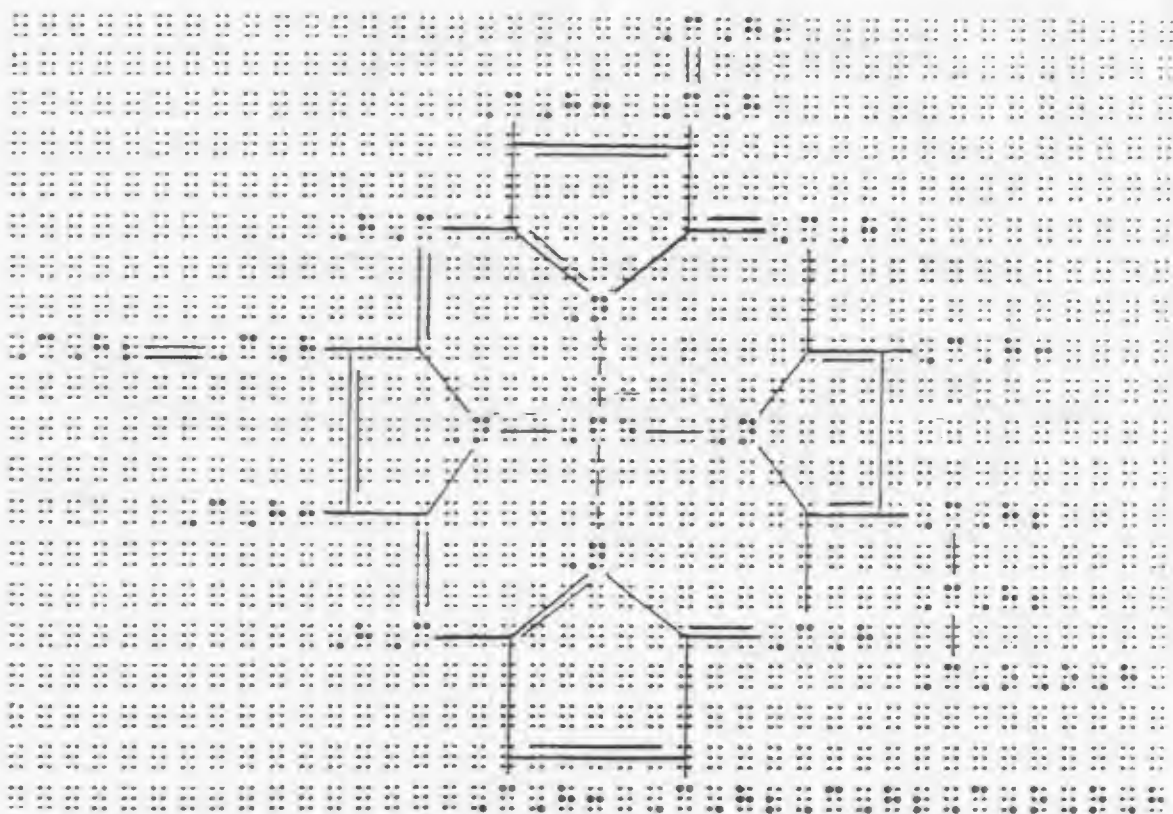
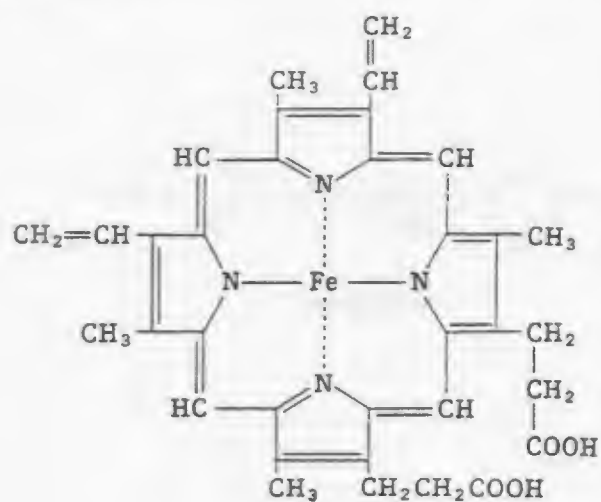
Example 4.6-5:



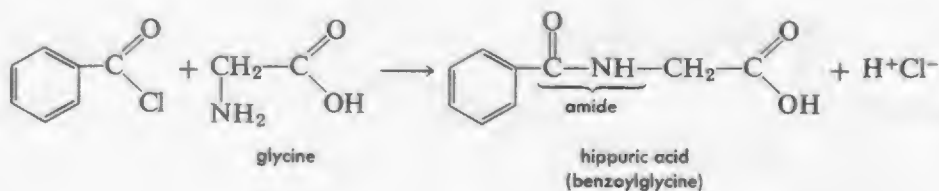




Example 4.8-1: (spurred bonds used to avoid runovers within a ring structure)



*Example 4.8-2:* (spurred horizontal brace to indicate portion of molecule being labeled; displayed, but starts in cell 1; runover at comparison sign not indented to avoid poor runover site)



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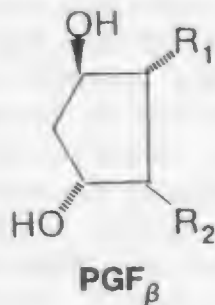




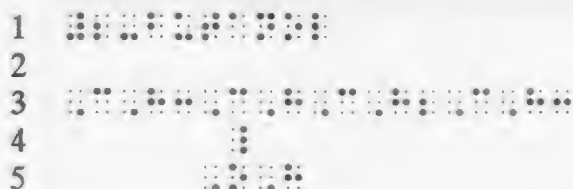
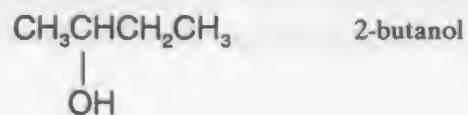




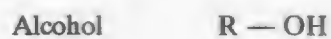
Example 5.1-2: (print label below spatial structure)



Example 5.1-3: (print label to the right of spatial structure)

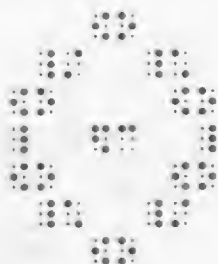


Example 5.1-4: (print label in left margin)

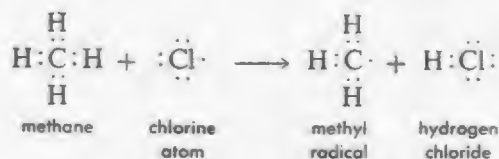


*Example 5.1-5:* (print label above spatial structure)

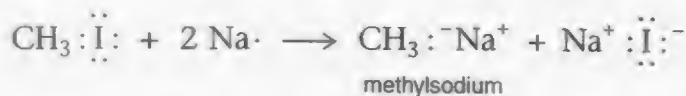
Modern symbolism for benzene



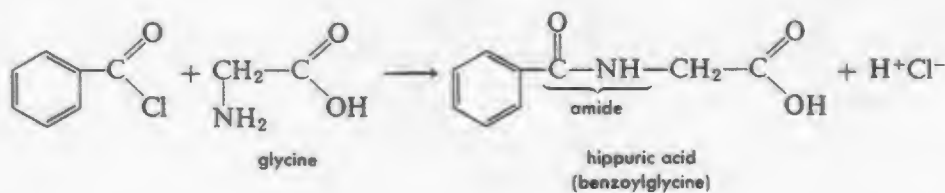
*Example 5.1-6:* (in print, each molecule or atom labeled below; labels in equation form in braille; must be explained in a transcriber's note.) [See Example 4.4.3-16 for an example of an appropriate note.]



*Example 5.1-7:* (only one of the molecules labeled in print; label aligned above the labeled molecule in braille; spurred line added for orientation)



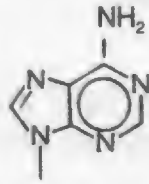
*Example 5.1-8:* (label on portion of a molecule requires a spurred brace; to avoid going to another braille page, displayed structure starts in cell 1 with runover at comparison sign also starting in cell 1.)



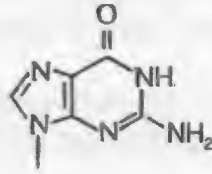
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Example 5.1-9: (primary label as well as individual labels)



Adenine (A)



Guanine (G)

Purines

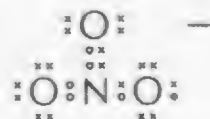


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5.2 **Remarks or Conditions.** Remarks or conditions should be treated in the same manner as remarks or conditions to mathematical expressions, blocked 6 cells to the right of the start of the expression.

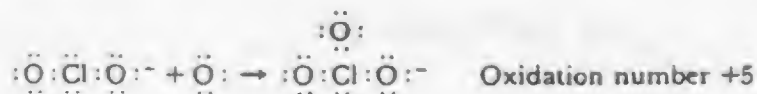
*Example 5.2-1:* (structure with marginal remarks; transcriber's grouping symbols used; what appears as a bold dot is a normal electron dot in this text)



In  $\text{NO}_3^-$ , all bond lengths are equal.



*Example 5.2-2:* (print shows remarks following on same line as spatial structure)





**5.3 Labeled SYMBOLS and Bonds.** These labels are often called markers or numbered atoms. They may consist of numbers, letters, Greek letters, asterisks or other symbols and may appear in conjunction with SYMBOLS for atoms, vertices on ring structures or bonds. The printer frequently places the labels in the most convenient positions. In linear structures, they usually occur directly over or under the SYMBOL or bond to which they apply. In spatial structures, they may appear as if they were superscripts or subscripts. The transcriber can determine from context the meaning of the material. Normally the following are superscripts or subscripts:

Electron charge or, occasionally, isomer number as in  $U^{238}$ ; right superscript.

Number of atoms or, if with R or Greek letter, an identifier; right subscript.

Mass number; left superscript.

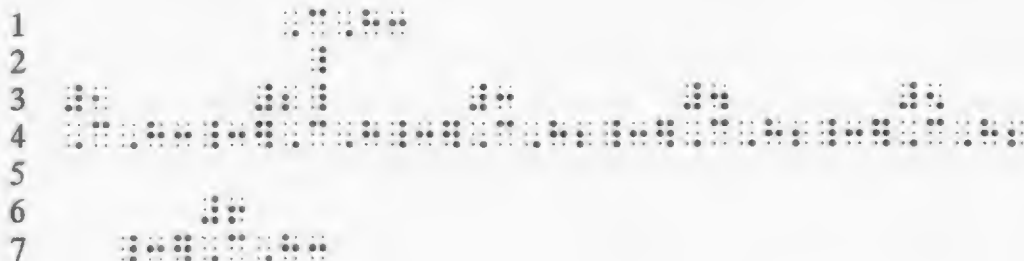
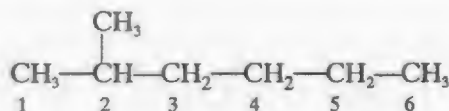
Atomic number; left subscript.

Primes with R (unspecified chain or ring) or Greek letter; identifiers.

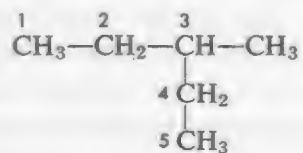
**5.3.1 Chains.** In braille transcriptions, consistent placement of label or marker is important although not always possible. When possible, the label should be placed immediately above the applicable SYMBOL or bond. When vertical bonds are present and SYMBOLS are labeled, the labels should be placed to the left of the bond. When oblique bonds are present, place the label on the same side of the bond as the SYMBOL to which it applies.

NOTE: Examples 5.3.1-1 and 5.3.1-2 are from the same text and show print placement of numbers varied to accommodate difference in structure.

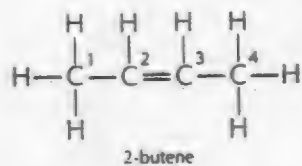
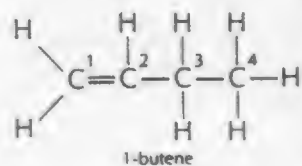
*Example 5.3.1-1:* (numbers below SYMBOLS in print)



Example 5.3.1-2: (numbers above SYMBOLS)

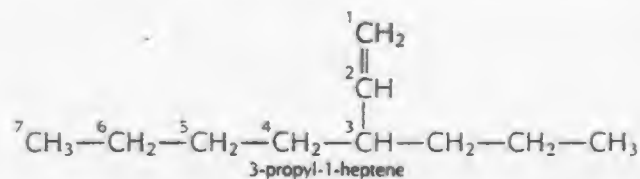


Example 5.3.1-3: (portion of a text page illustrating inconsistent placement of numbers; some appear as right superscripts and others as left superscripts)



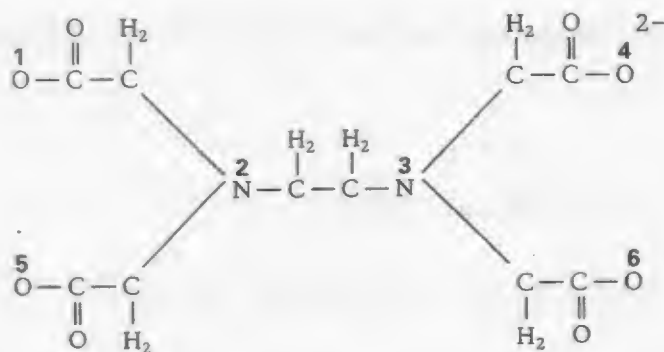
comes from the carbon on which the double bond begins, and is always placed before the name of the parent compound.

Alkenes are numbered so that the lowest position number is assigned to the first carbon atom to which the double bond is attached. The parent compound is named from the longest continuous chain containing a double bond. Thus, the name of the following alkene is 3-propyl-1-heptene.



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*Example 5.3.1-4:* (numbers adjacent to oblique bonds in print; a superscript applies to the entire structure)



EDTA ion



Example 5.3.1-5: (oxidation numbers above SYMBOLS)

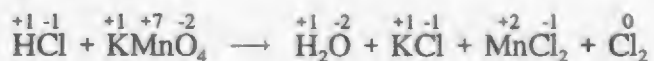
The oxidation number of elementary chlorine is

zero:  $\overset{0}{\text{Cl}}$  (Rule 1). The oxidation number of chloride ion is minus

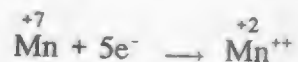
one:  $\overset{-1}{\text{Cl}^-}$  (Rule 2).



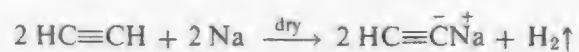
Example 5.3.1-6: (oxidation numbers above SYMBOLS requiring spacing adjustments)



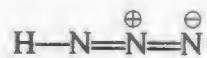
Example 5.3.1-7: (oxidation numbers combined with electron charge symbols)



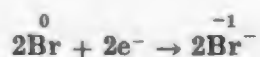
*Example 5.3.1-8:* (positive and negative signs above SYMBOLS)



*Example 5.3.1-9:* (positive and negative signs within circles above SYMBOLS)

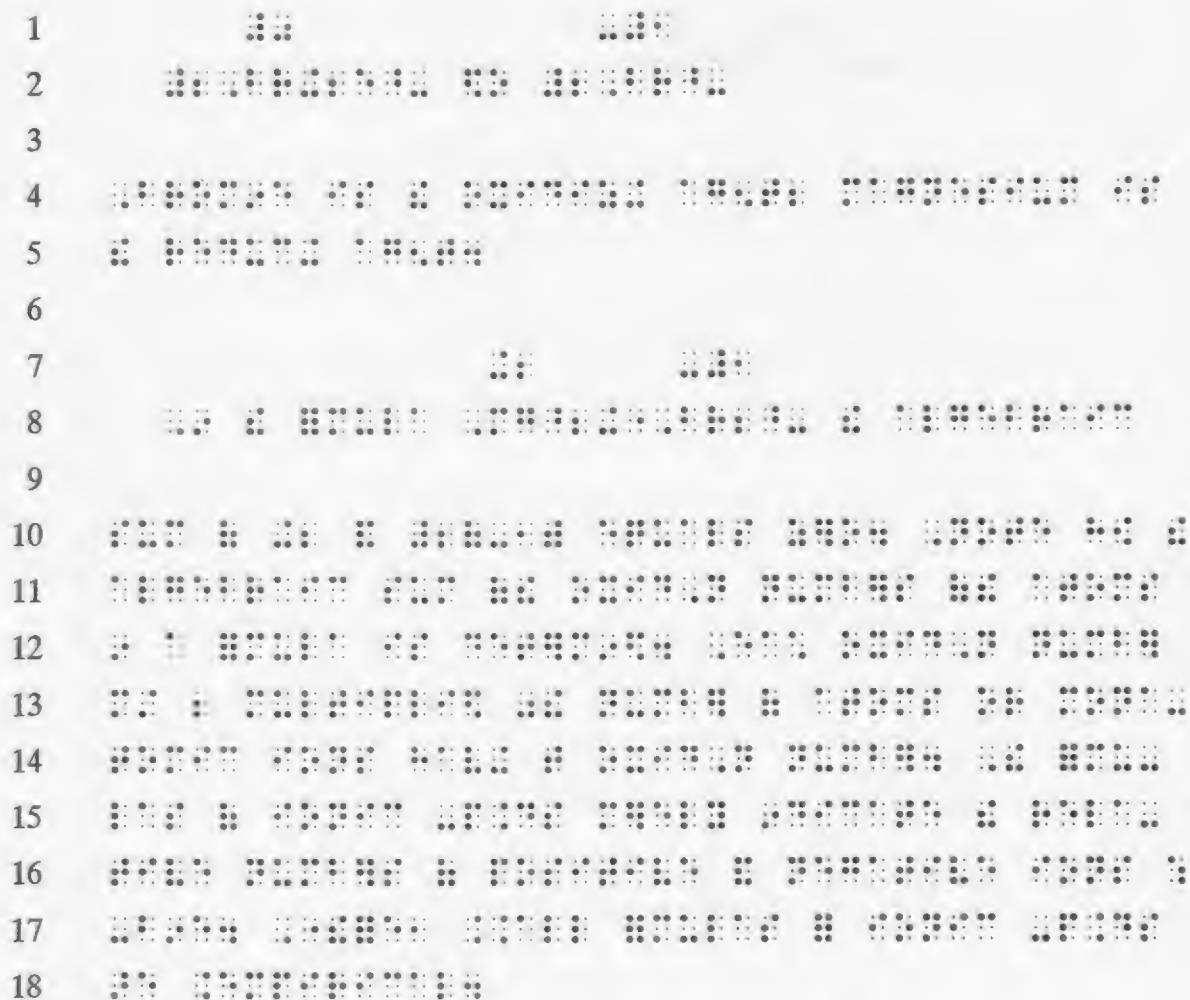


*Example 5.3.1-10: (number with negative sign above SYMBOLS)*



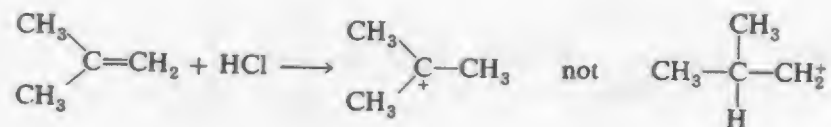
Bromine is the oxidizing agent; magnesium is the reducing agent.

In the formula  $\text{Mg}^{+2}\text{Br}_2^{-1}$  the algebraic sum of +2 and 2 (-1) equals zero. Note how the algebraic sum of the oxidation numbers of the atoms in a formula is determined. Each oxidation number must be multiplied by the number of atoms or monatomic ions having that oxidation number. The formulas of ionic compounds merely indicate the relative numbers of positive and negative ions which combine. Therefore, *all formulas for ionic compounds are empirical.*

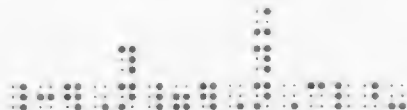
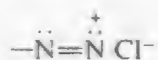




Example 5.3.1-11: (positive sign below SYMBOL in print)

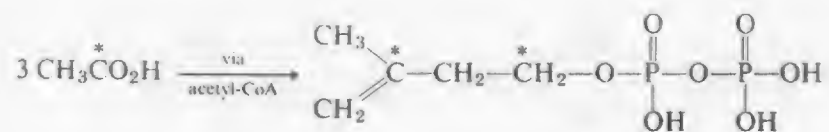


Example 5.3.1-12: (oxidation sign combined with electron dots)

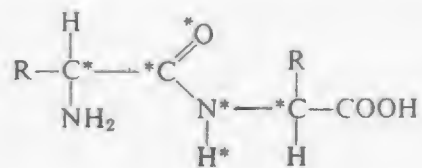


## BRaille CODE FOR CHEMICAL NOTATION

Example 5.3.1-13: (asterisks labeling atoms being discussed in text)



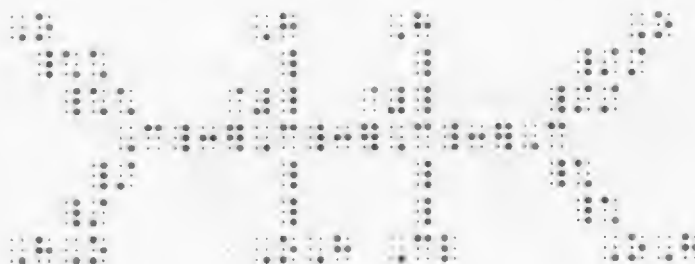
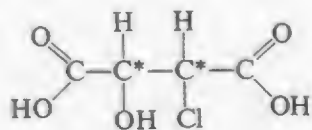
Example 5.3.1-14: (asterisks used as markers)



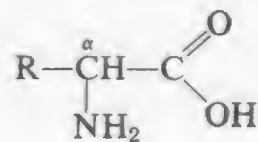
The atoms marked with an asterisk tend to lie in a single plane.



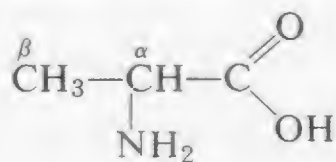
Example 5.3.1-15: (asterisks used to mark asymmetric carbon atoms)



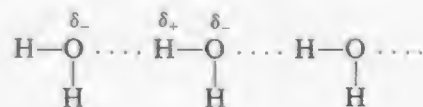
Example 5.3.1-16: (alpha amino acid carbon labeled)



Example 5.3.1-17: (amino acid with both alpha and beta carbons labeled)

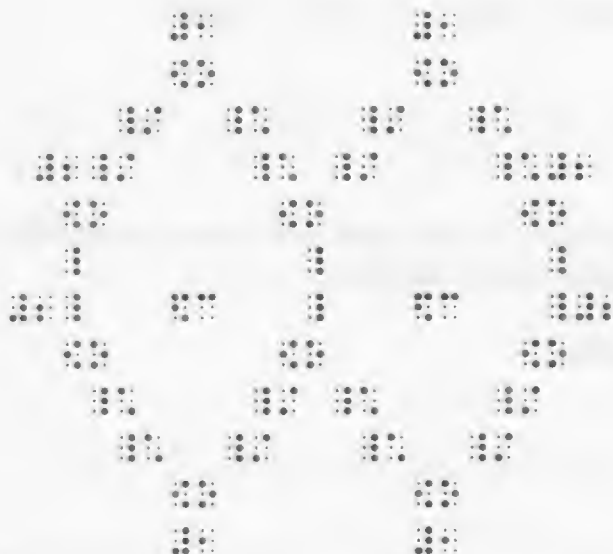
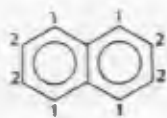


Example 5.3.1-18: (atoms marked with deltas carrying subscripts)

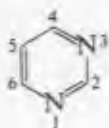




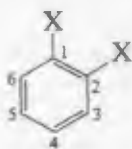
*Example 5.3.2-1: (joined rings; outer vertices numbered)*



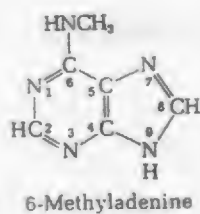
*Example 5.3.2-2: (simple ring with some atoms included; each vertex and SYMBOL labeled)*



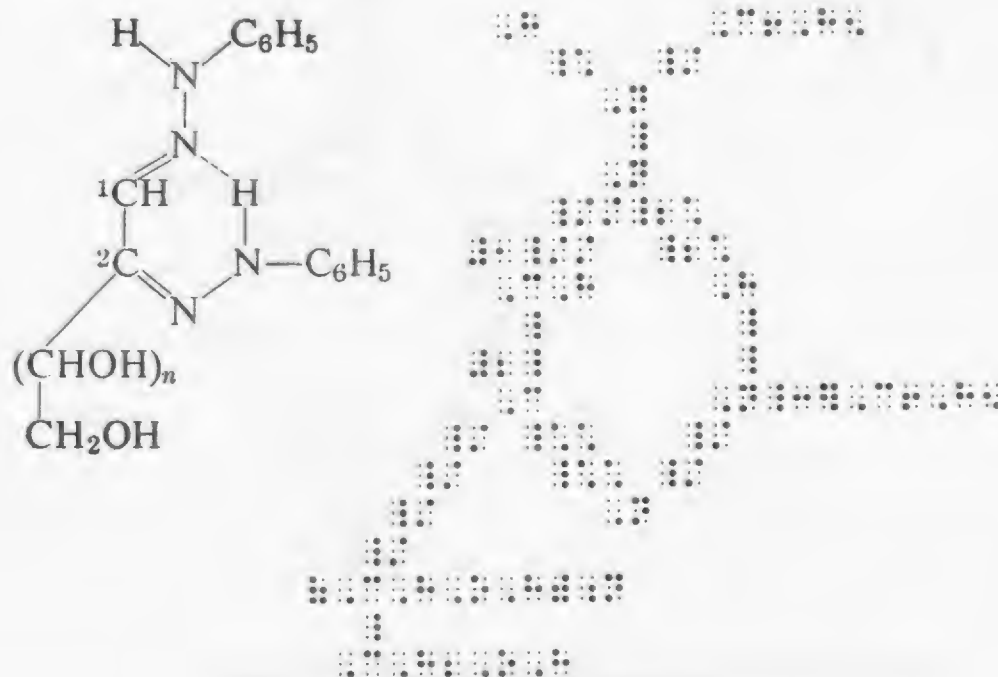
Example 5.3.2-3: (simple ring with branches; each vertex numbered)



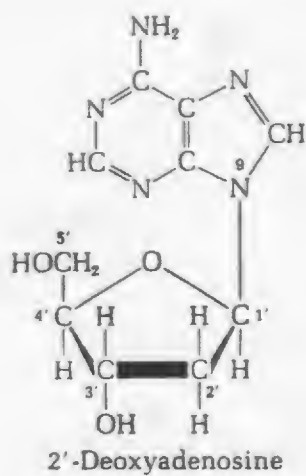
Example 5.3.2-4: (rings with numbers inside the rings)



*Example 5.3.2-5:* (ring with atoms included; some numbered; broken oblique bond)



*Example 5.3.2-6:* (rings with atoms included; numbered randomly)



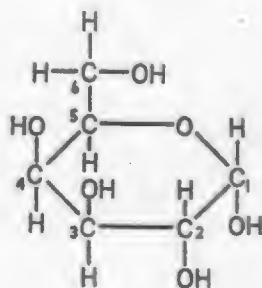




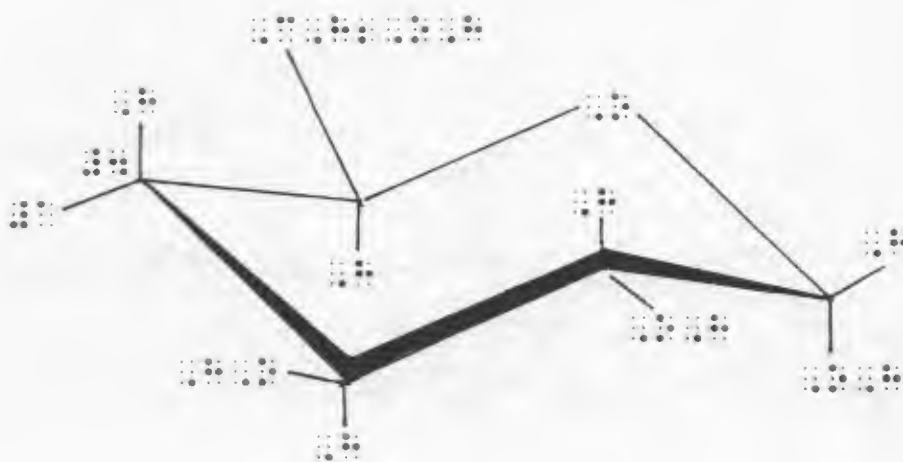
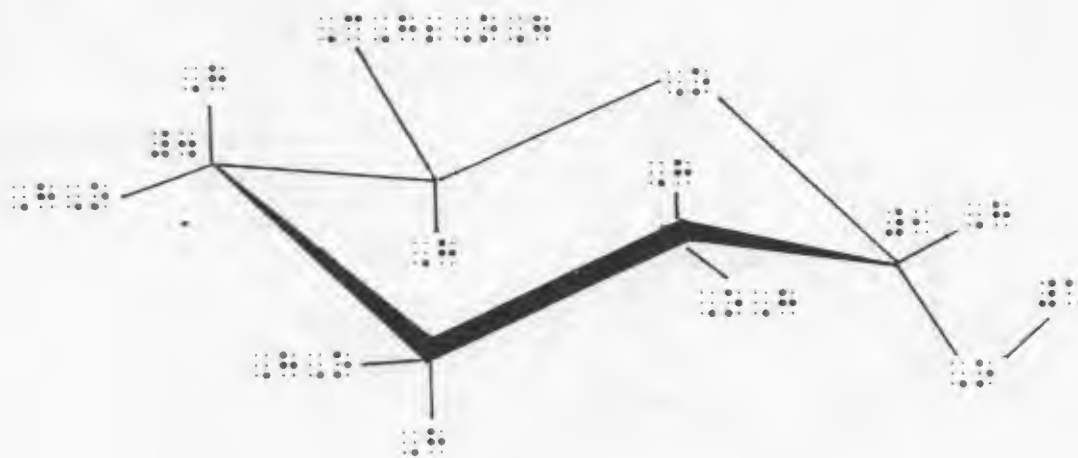
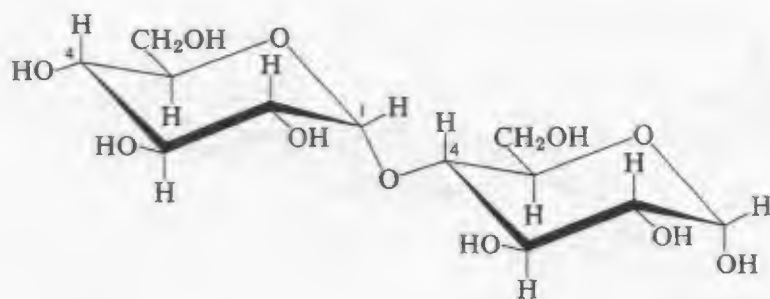
///// NEW PAGE /////



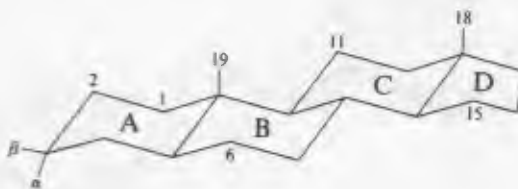
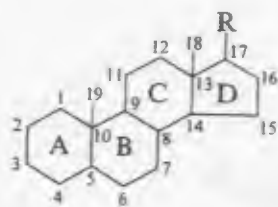
Example 5.3.2-7: (ring with branches; numbers appear to be subscripts and superscripts)



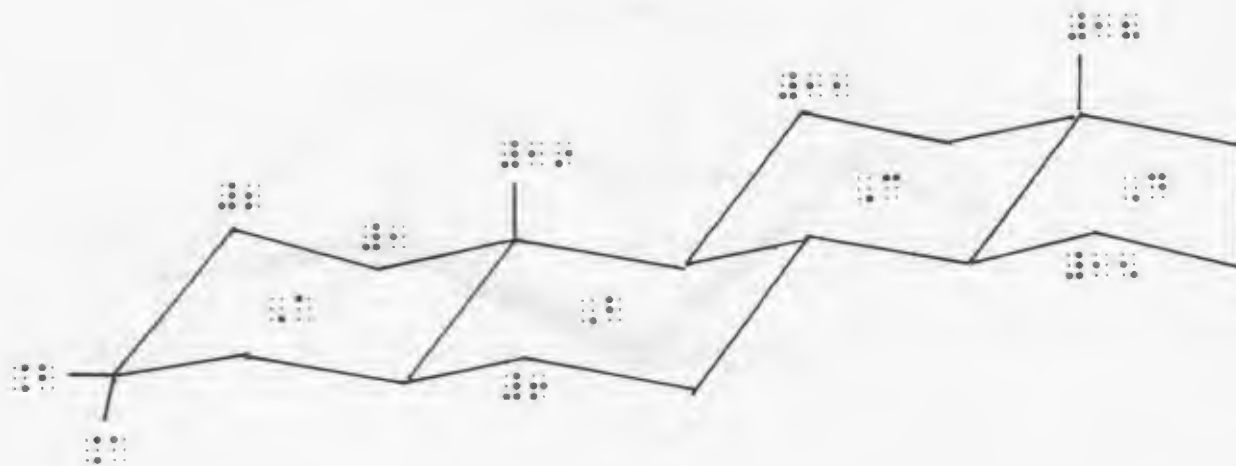
Example 5.3.2-8: (oddly shaped ring structure must be spurred in)



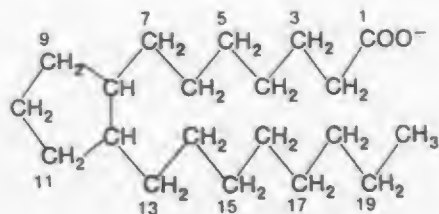
*Example 5.3.2-9:* (two representations of the same steroid ring; the second must be drawn)



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*Example 5.3.2-10:* (ring structure with long chains attached; runovers require runover locators.)



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## 6 TYPE FORMS IN MATHEMATICAL EXPRESSIONS

Mathematical expressions and equations in chemistry are transcribed according to the rules of the Nemeth Code. [For exceptions regarding runover sites, see Section 2.3.] When chemical SYMBOLS appear in an expression, along with italic variables, use the following guidelines.

If duplicate letters are in the same alphabet and same case, but of different type form, the distinction must be preserved. This also applies to those same letters when they appear in a discussion of the expression in narrative text preceding and/or following the expression.

If such a duplicated letter is an abbreviation, or part of an abbreviation, this distinction need not be shown. [For exception, see Section 9.5.]

No distinction need be made if the duplicated letters are lowercase and one of them is part of a chemical SYMBOL.

These guidelines apply only to italics, and only to mathematical equations and expressions. Bold and script type forms must be retained. [There is one exception: see Section 9.2. Refer also to Sections 8 and 9 for type form use in other situations.]

*Example 6-1:* (equation with chemical SYMBOL and italic variables; no duplicate letters of differing type form)

dissociation constants in the same way that we expressed the number of protons bound by inorganic phosphate in equation 9.26. To compare the binding of hemoglobin with myoglobin it is convenient to use the fractional saturation  $Y$ , which in this case is  $n/4$  since four oxygen molecules may be bound:

$$Y = \frac{P_{O_2}/K_1 + 2P_{O_2}^2/K_1K_2 + 3P_{O_2}^3/K_1K_2K_3 + 4P_{O_2}^4/K_1K_2K_3K_4}{4[1 + P_{O_2}/K_1 + P_{O_2}^2/K_1K_2 + P_{O_2}^3/K_1K_2K_3 + P_{O_2}^4/K_1K_2K_3K_4]} \quad (9.52)$$



*Example 6-2:* (uppercase P shown with two different type forms, difference must be preserved; uppercase C shown with two different type forms, no distinction need be made as one is part of an abbreviation; distinctive type form of P maintained in narrative text)

The adiabatic container, thermometer, stirrer, and weighed quantity of water are represented by Cal. Since the enthalpy is a state function, the enthalpy change for the actual process may be written two ways:

$$\Delta H_A = \Delta H(T_1) + \Delta H_P = 0 \quad (2.97)$$

$$\Delta H_A = \Delta H_R + \Delta H(T_2) = 0 \quad (2.98)$$

Since the heat capacities of the reactants, products, and calorimeter may be assumed constant over the range  $T_1$  to  $T_2$ , these equations become

$$\Delta H(T_1) = -\Delta H_P = -[C_P(P) + C_P(\text{Cal})](T_2 - T_1) \quad (2.99)$$

$$\Delta H(T_2) = -\Delta H_R = -[C_P(R) + C_P(\text{Cal})](T_2 - T_1) \quad (2.100)$$

where these  $C_P$ 's are extensive properties. Thus, the results of the calorimetric

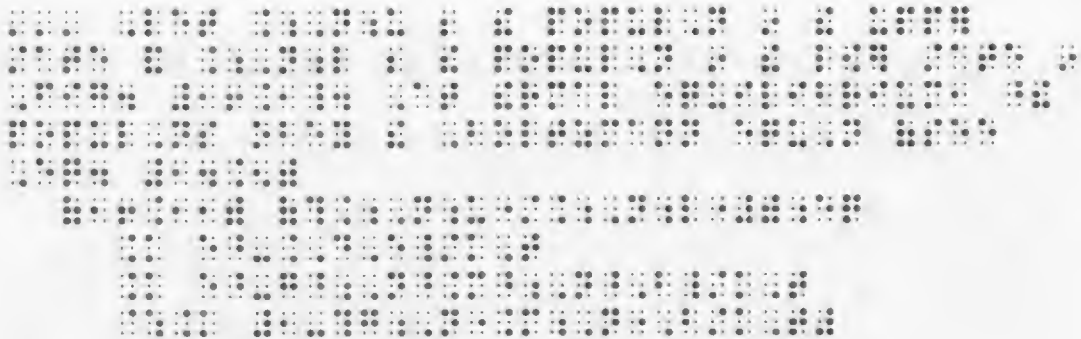




**Example 6-3:** (uppercase N shown in two type forms, distinction preserved in braille in both narrative text and equation; lowercase u and l shown in Roman type, no type form indicators needed)

to the *difference* in populations between the lower and upper levels. Let  $N_u$  be the population in the upper state and  $N_l$  be the population in the lower state in Fig. 16.1. At thermal equilibrium, these populations obey the Boltzmann equation (see Eq. 14.5)

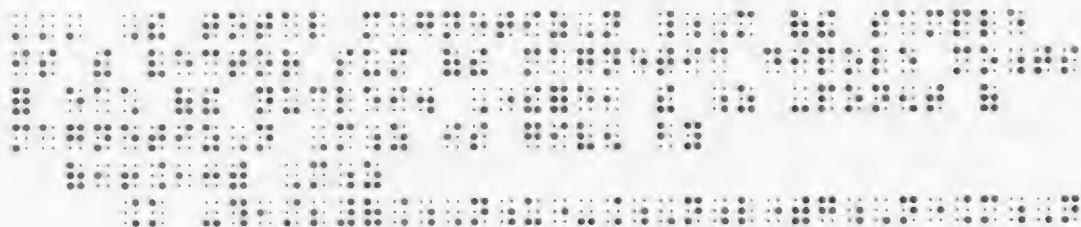
$$\left(\frac{N_u}{N_l}\right)_{\text{eq}} = e^{-\Delta E/kT} = e^{-g_N \mu_N B/kT} \cong 1 - \frac{g_N \mu_N B}{kT} \quad (16.11)$$



**Example 6-4:** (bold type form maintained for  $M$ )

**relaxation time.** The total magnetization  $M$  of the sample is the vector sum of the magnetic dipole moments for each of the nuclei. Therefore, the  $z$  component of magnetization  $M_z$  is given by

$$M_z = -\frac{1}{2} (N_u - N_l) g_N \mu_N \quad (16.13)$$



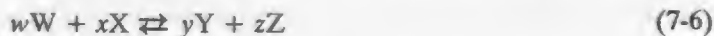
**Example 6-5:** (type forms of the upper-case P's must be maintained)

$$P_{\text{PCl}_3} P_{\text{PCl}_2} = K_{17} P_{\text{PCl}_5}$$

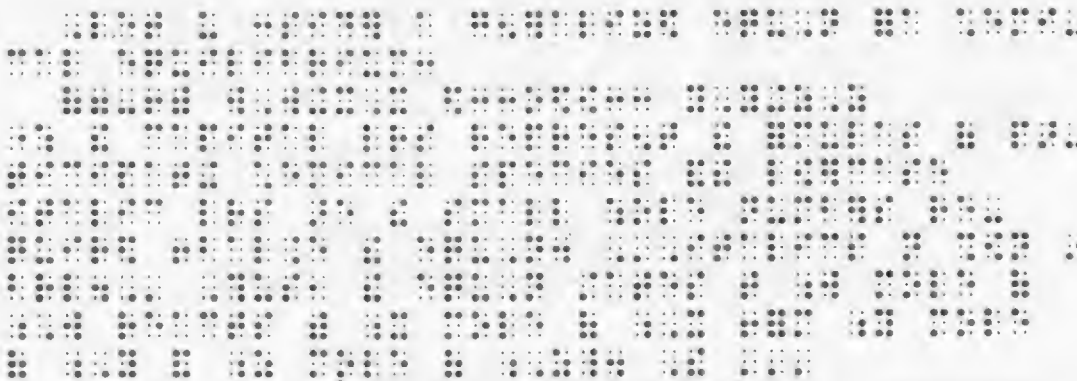


*Example 6-6:* (transcriber's note tells reader italic type form not shown in braille for lowercase letters)

Let us consider a generalized equation for a chemical equilibrium:



where the capital letters represent the formulas of participating chemical species and the lowercase italic letters are the small whole numbers required to balance the equation. Thus, the equation states that *w* mole of W reacts with *x* mole of X to form *y* mole of Y and *z* mole of Z. The . . .



*Example 6-7:* (script type maintained for  $\mathcal{E}$ )

For standard conditions

$$\Delta G^\circ = -nF\mathcal{E}^\circ$$



*Example 6-8:* (bold type maintained for E)

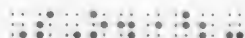
$$E = E^\ominus - \frac{0.0592}{2} \log \frac{[H^+]^2}{P_{H_2}[Zn^{2+}]}$$



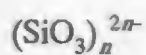




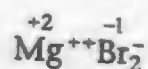
*Example 7.2-7:* (2 negative signs in a column, non-simultaneous superscripts)



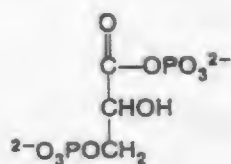
*Example 7.2-8:* (variable used with negative sign)



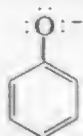
*Example 7.2-9:* (electron charges printed as superscripts; oxidation numbers directly over SYMBOLS)



*Example 7.2-10:* (electron charge in a spatial arrangement)



*Example 7.2-11:* (superscript applies to an element)



*Example 7.2-12:* (superscript applies to entire structure; transcriber's grouping symbols added)



*Example 7.2-13:* (superscript applies to entire structure; transcriber's grouping symbols added; what appears as a bold dot is used as the normal electron dot in this text)



*Example 7.2-14:* (superscript applies to entire structure)



### 7.3 Atomic Numbers and Mass Numbers. Atomic numbers and mass numbers are printed as left superscripts and subscripts. Follow the rules of the Nemeth Code.

*Example 7.3-1:*









*Example 8.2-3: N-formylmethionine*
*(N-formyl-methion-ine)**N* - protein

formyl - substituent

methion - substituent

ine - suffix

- 8.3 Division of Names of Chemical Compounds.** Sites for the division of names of chemical compounds must be carefully chosen. If possible these sites should be between substituents or functional groups, and numbers or letters preceding or within the name must be on the same line as the following substituent. In these examples, a slash represents preferred runover sites.

*Example 8.3-1: 3a,7a,2a-trihydroxycoprostone*

3a,7a,2a-tri/hydroxy/copro/stane

*Example 8.3-2: 3,5,3'-triiodothyronine*

3,5,3'-tri/iodo/thyro/nine

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*[Faint, illegible text block]*

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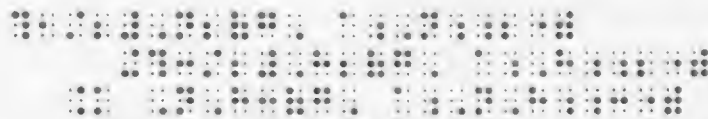
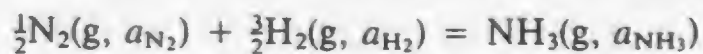


*Example 9.4-4:* ( $R$  represents reaction rate,  $T$  represents temperature,  $a$  represents activity, and  $\ln$  is natural logarithm)

$$\Delta_r G = \Delta_r G^\circ + RT \ln \frac{a_{\text{NH}_3}}{a_{\text{N}_2}^{1/2} a_{\text{H}_2}^{3/2}}$$



*Example 9.4-5:* ( $g$  means gas;  $a$  is activity)



*Example 9.4-6:* ( $\text{Ox}$  - oxidation,  $\text{Red}$  - reduction,  $\text{R}$  - right,  $\text{L}$  - left)

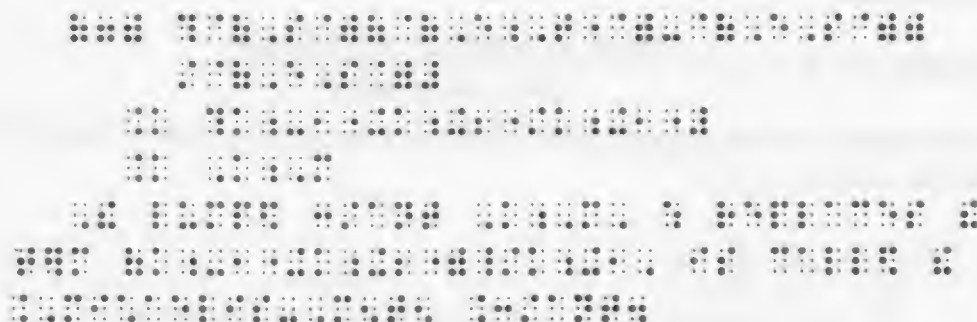




Example 9.4-7:

$$\frac{[S]([E_T] - [ES])}{[ES]} = \frac{k_{-1} + k_{+2}}{k_{+1}} = K_M \quad (7)$$

The lumped constant  $K_M$ , which replaces the term  $(k_{-1} + k_{+2})/k_{+1}$ , is called the *Michaelis-Menten constant*.

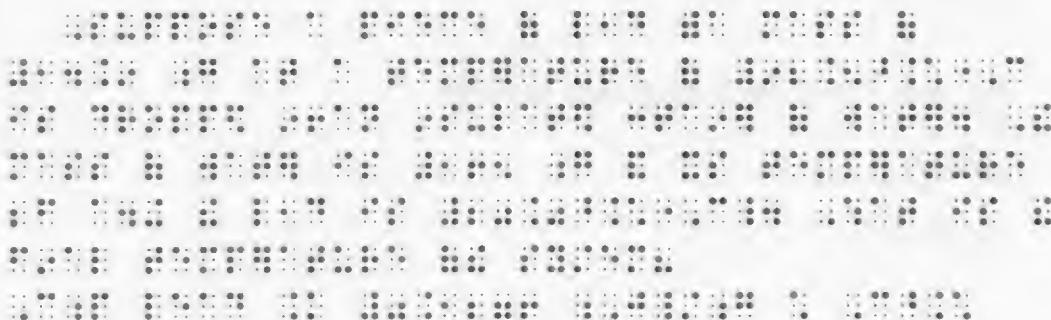


Example 9.4-8: (R represents a free radical, M a monomer, and  $k$  is a constant.)



Example 9.4-9: (mixture of letters and abbreviations)

Suppose a piece of lead with a mass of 14.9 g at a temperature of 92.5°C is dropped into an insulated container of water. The mass of water is 165 g and its temperature before adding the lead is 20.0°C. What is the final temperature of the system?  $C_p$  lead = 0.1276 J/g·C°



9.5. Letters Representing Concentration of Solutions. These letters must follow the print spacing and type form.

- $M$  Molarity (number of moles of a solute in  $1 \text{ dm}^3$  of solution)
- $m$  molality (number of moles of a solute in 1 kilogram of solvent)
- $N$  Normality (equivalent mass of solute per liter of solution)
- $F$  Formality (number of moles per liter of solution)

Example 9.5-1: ( $A$  represents a chemical group;  $F$  is Formality;  $L$  is an abbreviation)

$$\text{Formality of } A = F_A = \frac{\text{Moles } A \text{ added to the solution}}{\text{Liters of solution}}$$

For example, we can prepare  $1.00 F$  HCl by mixing water with 1 mol HCl until the volume is 1 L.



Example 9.5-2: ( $N$  is normality;  $M$  is molarity)

Since there is only one proton per molecule,  $N = M = 0.150 N$ .



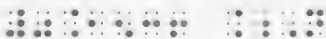
Example 9.5-3: ( $N$  is normality, unspaced)

30.0 mL of a 4.00N solution



Example 9.5-4: ( $N$  is normality, spaced)

0.1536 N







## INDEX OF BRAILLE SYMBOLS FOR CHEMICAL NOTATION

The items in this index are "alphabetized" in accordance with the list of the 63 braille symbols, arranged in their standard order, and numbered according to their rank in the list.

				Page				
23	⠠	dots 1346						
	⠠	small x electron dot	x	12				
26	⠠	dots 12346						
	⠠	pair of electron dots: right or upper regular, left or lower bold or hollow	<table style="display: inline-table; vertical-align: middle;"> <tr> <td style="padding-right: 10px;">⠠</td> <td>⠠</td> </tr> <tr> <td style="padding-right: 10px;">⠠</td> <td>⠠</td> </tr> </table>	⠠	⠠	⠠	⠠	12
⠠	⠠							
⠠	⠠							
31	⠠	dots 16						
	⠠	chemical period	⠠	19				
	⠠	single, regular electron dot	⠠	12				
33	⠠	dots 146						
	⠠	pair of electron dots: right or upper x, left or lower regular	<table style="display: inline-table; vertical-align: middle;"> <tr> <td style="padding-right: 10px;">⠠</td> <td>⠠</td> </tr> <tr> <td style="padding-right: 10px;">⠠</td> <td>⠠</td> </tr> </table>	⠠	⠠	⠠	⠠	12
⠠	⠠							
⠠	⠠							
34	⠠	dots 1456						
	⠠	pair of regular electron dots	⠠	12				
35	⠠	dots 156						
	⠠	pair of electron dots: right or upper bold or hollow, left or lower x	<table style="display: inline-table; vertical-align: middle;"> <tr> <td style="padding-right: 10px;">⠠</td> <td>⠠</td> </tr> <tr> <td style="padding-right: 10px;">⠠</td> <td>⠠</td> </tr> </table>	⠠	⠠	⠠	⠠	13
⠠	⠠							
⠠	⠠							

36	dots 1246		Page
	⠠⠠	pair of electron dots: right or upper regular, left or lower x	13
	⠠⠠⠠⠠	ring structure: circle (broken outline)	18
	⠠⠠⠠⠠⠠⠠	ring structure: hexagon (broken outline)	18
	⠠⠠⠠⠠⠠	plus sign within a circle: used as a modifier	19
	⠠⠠⠠⠠⠠	minus sign within a circle: used as a modifier	19
	⠠⠠⠠	chemical arrow: up-pointing regular	11
	⠠⠠⠠⠠⠠	chemical arrow: regular up-pointing followed by regular down- pointing	11
	⠠⠠⠠⠠⠠⠠	chemical arrow: regular up-pointing followed by bold down- pointing	11
	⠠⠠⠠	chemical arrow: regular down- pointing	11
	⠠⠠⠠⠠⠠	chemical arrow: horizontal dipole, left-pointing	12
	⠠⠠⠠⠠	chemical arrow: vertical or oblique dipole, up- pointing	11
	⠠⠠⠠⠠	chemical arrow: vertical or oblique dipole, down- pointing	11

36	⠠⠠⠠⠠⠠⠠ (cont.)			Page
	⠠⠠⠠⠠⠠⠠	chemical arrow: horizontal dipole, right-pointing	+→ +→	12
	⠠⠠⠠⠠⠠⠠⠠⠠	chemical arrow: half-barb up-pointing followed by half-barb down-pointing	↑↓	11
	⠠⠠⠠⠠	chemical arrow: bold up-pointing	↑	11
	⠠⠠⠠⠠⠠⠠	chemical arrow: bold up-pointing followed by regular down-pointing	↑↓	11
	⠠⠠⠠⠠	chemical arrow: bold down-pointing	↓	11
37	⠠⠠⠠⠠⠠⠠ dots 12456			
	⠠⠠⠠	closing indicator for a chemical bond		1
	⠠⠠	pair of electron dots: right or upper bold or hollow, left or lower regular	⠠⠠   ⠠⠠ ⠠⠠   ⠠⠠	12
38	⠠⠠⠠⠠⠠⠠ dots 1256			
	⠠⠠⠠	triplet of regular electron dots (three pairs)	⠠⠠⠠   ⠠⠠⠠	13
39	⠠⠠⠠⠠⠠⠠ dots 246			
	⠠⠠	pair of electron dots: x's	⠠⠠   ⠠	12
	⠠⠠⠠	vertices (any unlabeled vertex)		18

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51	⠠⠨	dots 34	
	⠠	single electron dot: bold or hollow	12
	⠠⠠⠠⠠	crossed arrow	12
53	⠠⠨	dots 3456	
	⠠	pair of electron dots: bold or hollow	12
	⠠⠠	runover locator ( <i>n</i> represents an upper number assigned by the transcriber)	1
54	⠠⠨	dots 345	
	⠠	pair of electron dots: right or upper x, left or lower bold or hollow	13
57	⠠	dot 4	
	⠠⠠	partition line: vertical, dotted	19
	⠠⠠⠠⠠	partition line: double vertical, dotted	19
	⠠⠠⠠	partition line: vertical, jagged	19
	⠠⠠⠠	small capital letter indicator	19
	⠠⠠⠠	crossed O	19
	⠠⠠⠠⠠	barred capital letter indicator	19
59	⠠⠨	dots 456	
	⠠	opening indicator for a horizontal bond	1



59	⠠⠠⠠ (cont.)		Page
	⠠	vertical single bond	16
	⠠⠠	vertical single bond: jagged	16
	⠠⠠⠠	vertical double bond: jagged	16
	⠠⠠⠠⠠	horizontal double bond: jagged (including indicators)	14
	⠠⠠⠠	horizontal single bond: jagged (including indicators)	14
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