Modulo 1 – Química Orgânica

2. Grupos funcionais e características das moléculas orgânicas

Função e grupos funcionais
Isomeria, isómeros de constituição, Isomeria cis-trans. Carbono assimetrico. Estereoisomeria.
Polarização das ligações covalentes, cargas parciais, momento dipolar das moléculas.
Interações intermoleculares: pontes de hidrogénio, ligação dipolo-dipolo, forças de van der Waals, ligações iónicas.
Influência nas propriedades físicas. Solubilidade.

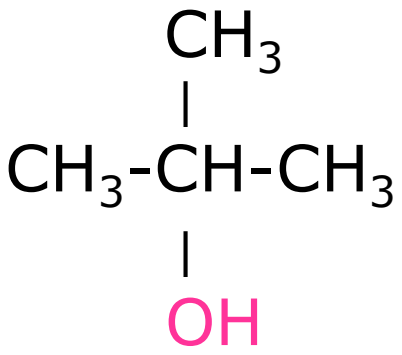
Função e grupos funcionais

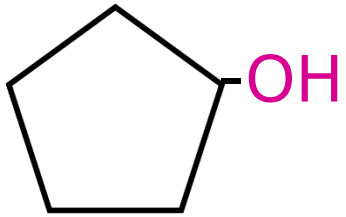
Compostos do mesmo grupo funcional são compostos orgânicos que têm elementos de estrutura química semelhante que lhes confere comportamento químico e propriedades também semelhantes.

Em compostos da mesma função são encontrados arranjos iguais entre determinados elementos:

CH_3-CHOH-CH_3

CH_2OH-CH_2-CH_2-CH_3





Função e grupos funcionais

TABLE 11.4 Compounds Containing a Carbon–Heteroatom Single Bond

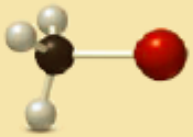
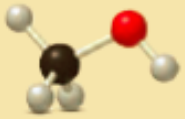
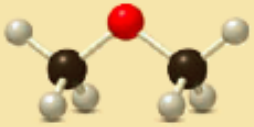
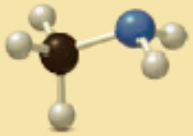
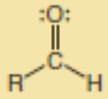
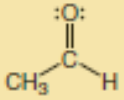
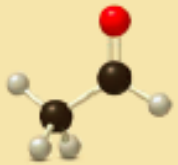
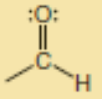
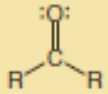
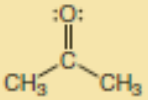
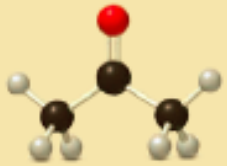
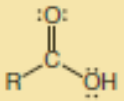
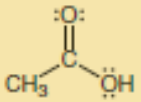
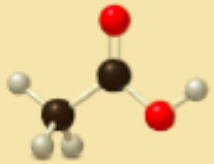
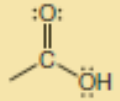
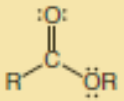
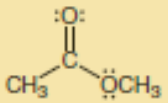
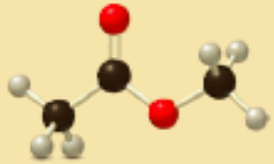
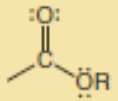
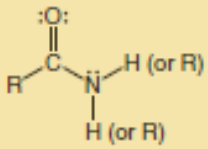
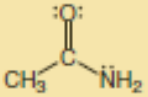
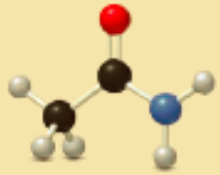
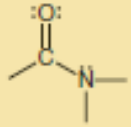
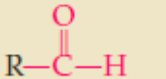
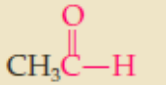
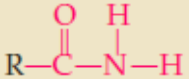
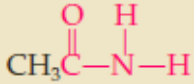
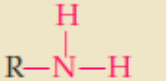
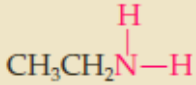
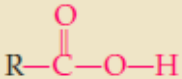
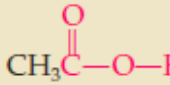
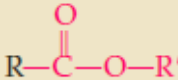
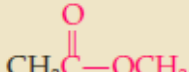
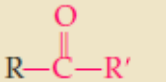
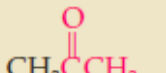
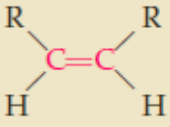
Type of Compound	General Structure	Example	3-D Structure	Functional Group
Derivados Halogenados	R—$\ddot{X}$: (X = F, Cl, Br, I)	CH_3—$\ddot{Br}$:		–X
Alcoois	R—$\ddot{O}$H	CH_3—$\ddot{O}$H		–OH hydroxyl group
Éteres	R—$\ddot{O}$—R	CH_3—$\ddot{O}$—CH_3		–OR
Aminas	R—$\ddot{N}H_2$ or $R_2\ddot{N}H$ or $R_3\ddot{N}$	CH_3—$\ddot{N}H_2$		–NH_2 amino group

TABLE 11.5 Compounds Containing a C=O Group

Type of Compound	General Structure	Example	3-D Structure	Functional Group
Aldeídos				
Cetonas				
Ácidos carboxilicos				 carboxyl group
Estéres				
Amidas				

Função e grupos funcionais

TABLE 10.2 Common Functional Groups

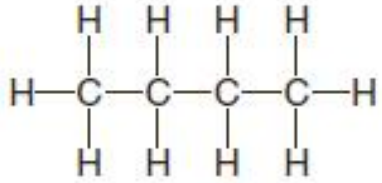
Type of compound	Structural formula	Condensed formula	Structural formula	Example I.U.P.A.C. name	Common name
Alcohol	R—O—H	ROH	CH_3CH_2—O—H	Ethanol	Ethyl alcohol
Aldehyde		RCHO		Ethanal	Acetaldehyde
Amide		$RCONH_2$		Ethanamide	Acetamide
Amine		RNH_2		Aminoethane	Ethyl amine
Carboxylic acid		RCOOH		Ethanoic acid	Acetic acid
Ester		RCOOR′		Methyl ethanoate	Methyl acetate
Ether	R—O—R′	ROR′	CH_3OCH_3	Methoxymethane	Dimethyl ether
Halide	R—Cl (or —Br, —F, —I)	RCl	CH_3CH_2Cl	Chloroethane	Ethyl chloride
Ketone		RCOR′		Propanone	Acetone
Alkene		RCHCHR	$CH_3CH{=}CH_2$	Propene	Propylene
Alkyne	R—C≡C—R	RCCR	$CH_3C{\equiv}CH$	Propyne	Methyl acetylene

Isomeria, isómeros de constituição

Compostos diferentes com a mesma fórmula molecular

Isómeros de constituição diferem na forma como os átomos se ligam entre si

C_4H_{10}



butane

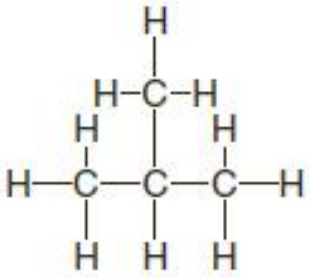
=

$CH_3CH_2CH_2CH_3$

4 C's in a row

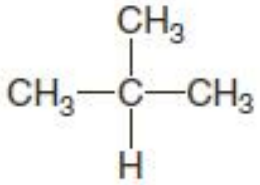
straight-chain alkane

C_4H_{10}



isobutane

=

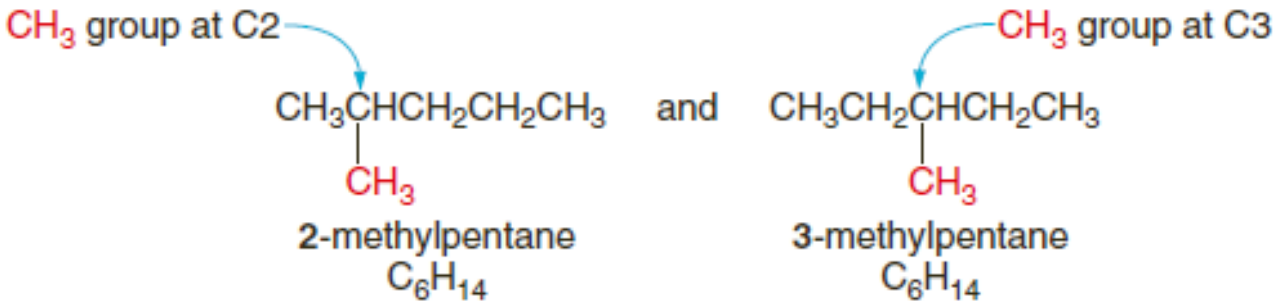


3 C's with a one-carbon branch

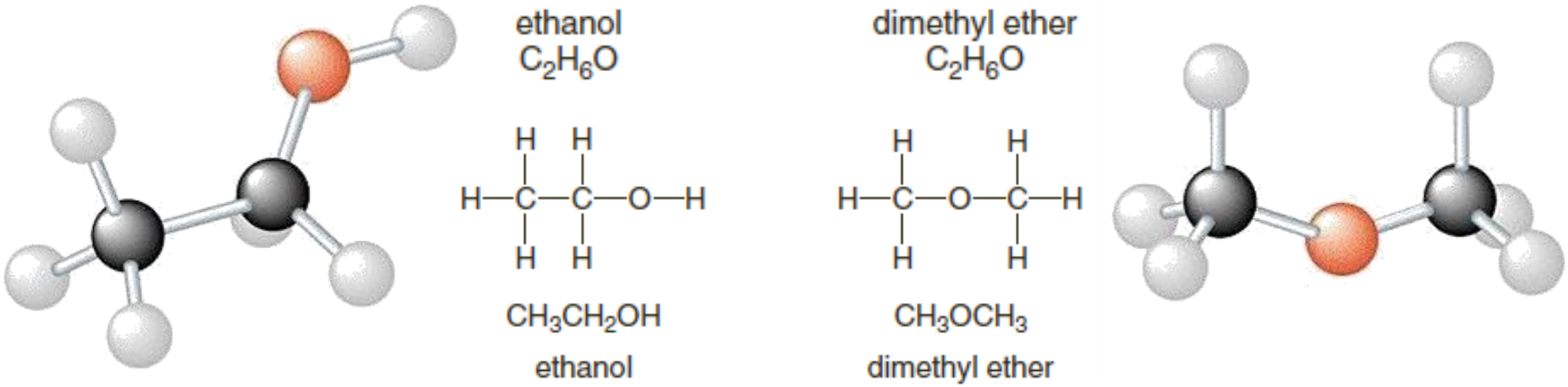
branched-chain alkane

Isómeros de constituição:

A **Constitutional isomers with the same functional group**

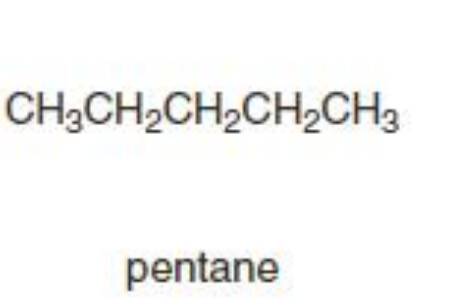


B **Constitutional isomers with different functional groups**

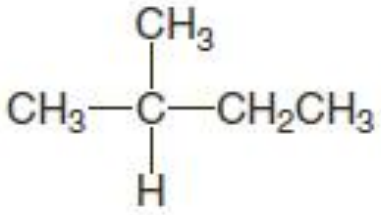


Isómeros de constituição:
-diferem na posição de elementos, grupos substituintes, grupos funcionais

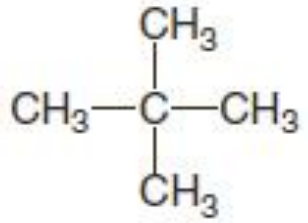
-diferem na posição de grupos substituintes:



pentane



isopentane
(2-methylbutane)



neopentane
(2,2-dimethylpropane)

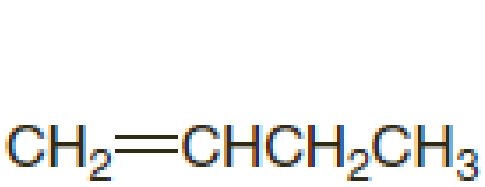
- diferem na posição de grupos funcionais:

CH_3-CHOH-CH_2-CH_3 e CH_2OH-CH_2-CH_2-CH_3

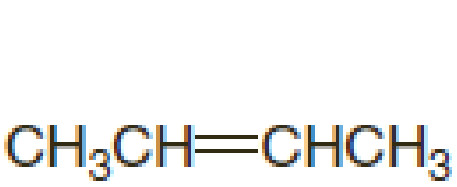
São alcoois: -Reactividade química semelhante;
-Características físicas diferentes (por exemplo, temperatura de fusão e de ebulição)

- diferem na posição da insaturação:

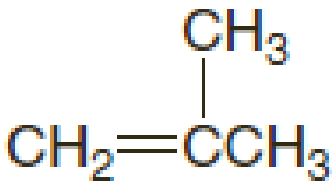
CH_3-CH_2-CH=CH_2 e CH_3-CH=CH-CH_3



1-butene



2-butene



2-methylpropene

difere na posição da insaturação e dos substituintes

Exemplo:

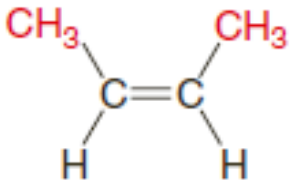
Formula molecular: $C_4H_8O_2$

CH_3-CH_2-CH_2-COOH	ácido
HOH_2C-CH=CH-CH_2OH	di-álcool
CH_3-CHOH-CH_2-CHO	aldeído-álcool

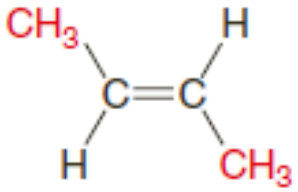
Isomeria cis-trans (geométrica):
-isomeria de especifica de alcenos e alguns ciclos

C

One example of stereoisomers—Isomers at a double bond



cis-2-butene

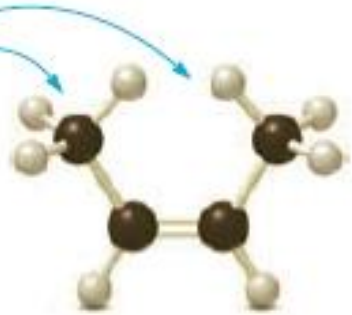


trans-2-butene

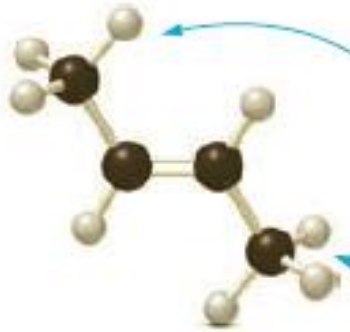
2-buteno
$CH_3CH=CHCH_3$

two CH_3 groups on the **same** side

Dois grupos CH_3 no mesmo lado



cis-2-butene



trans-2-butene

two CH_3 groups on **opposite** sides

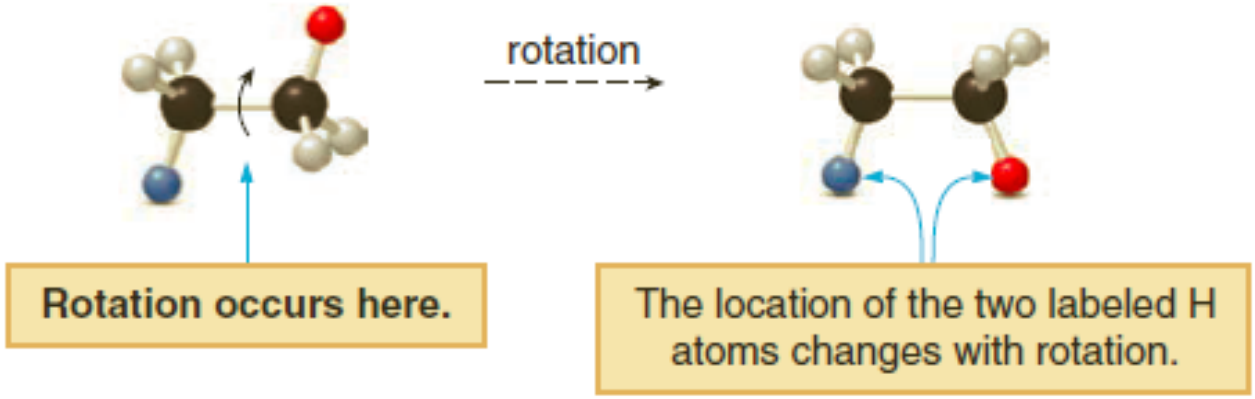
Dois grupos CH_3 em lados opostos

different compounds

Isomeria cis-trans

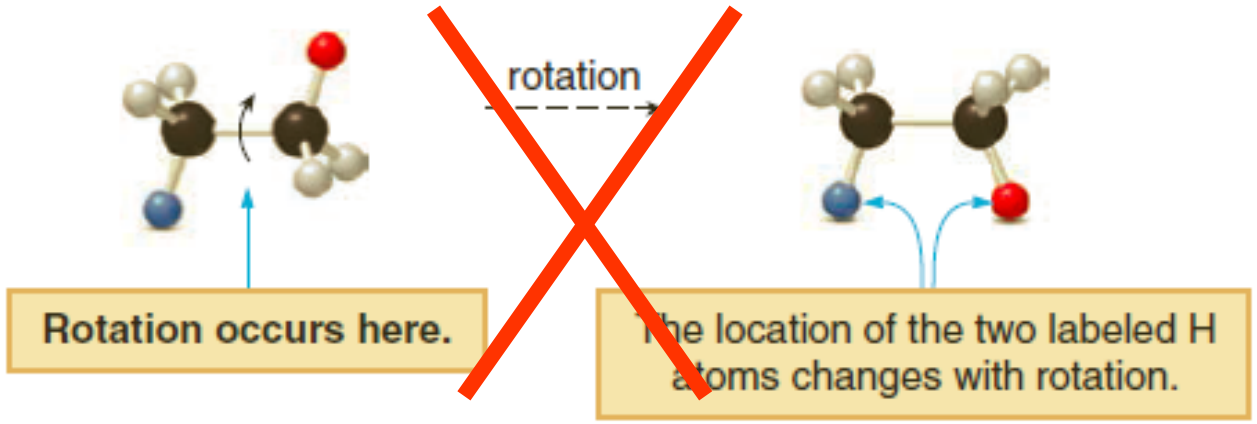
Força da ligação σ = 3-6 kcal mol^{-1}

Alcanos, ligação C–C covalente simples (orbital molecular sigma)



Força da ligação π = 63 kcal mol^{-1}

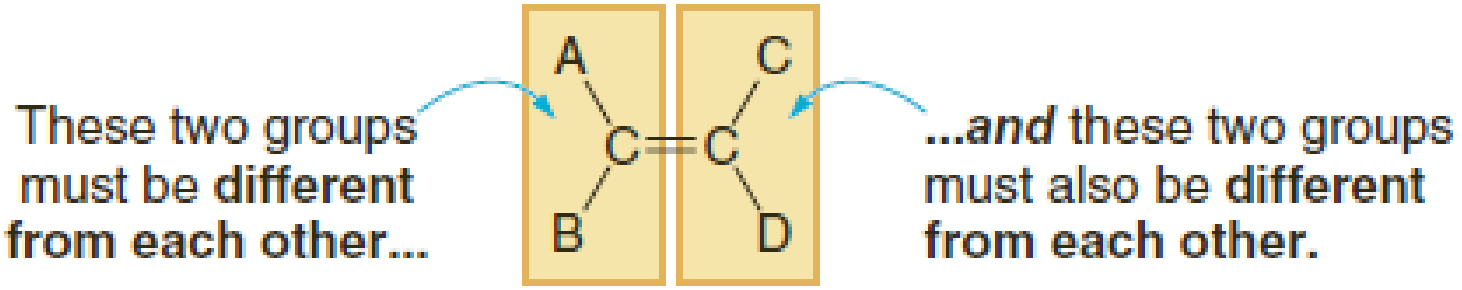
Alcenos, ligação C=C covalente dupla (orbital molecular σ, orbital molecular π)

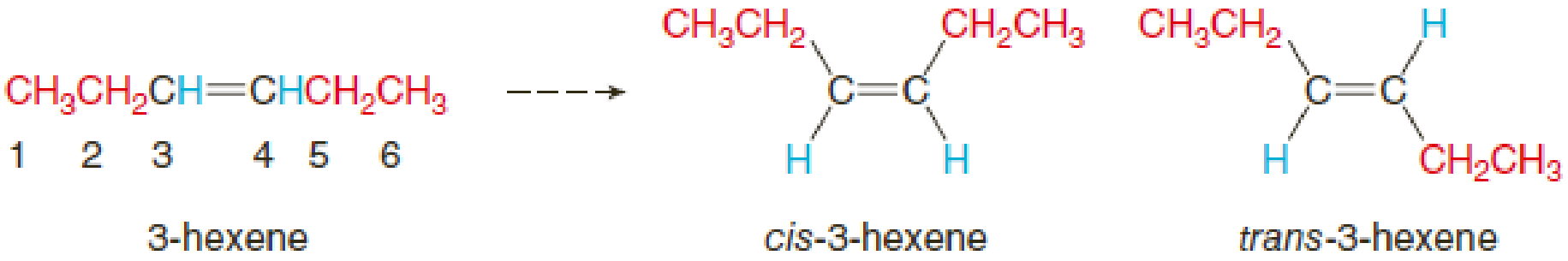


Há restrições à rotação

Isomeria cis-trans

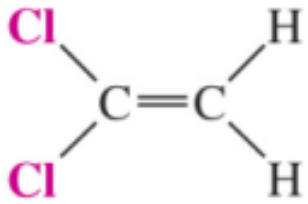
é gerada por restrição à rotação da ligação C=C que origina isómeros quando há substituintes diferentes nos atomos de C envolvidos na ligação

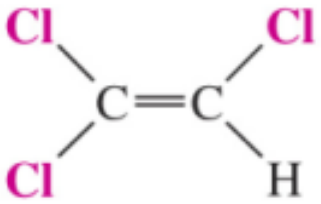




No caso da dupla ligação os dois átomos de carbono e os quatro átomos (ou grupos de átomos) a eles diretamente ligados são mantidos num mesmo plano pela dupla ligação

Se um dos carbonos da dupla ligação tem 2 substituintes iguais **não há isomeria *cis-trans***



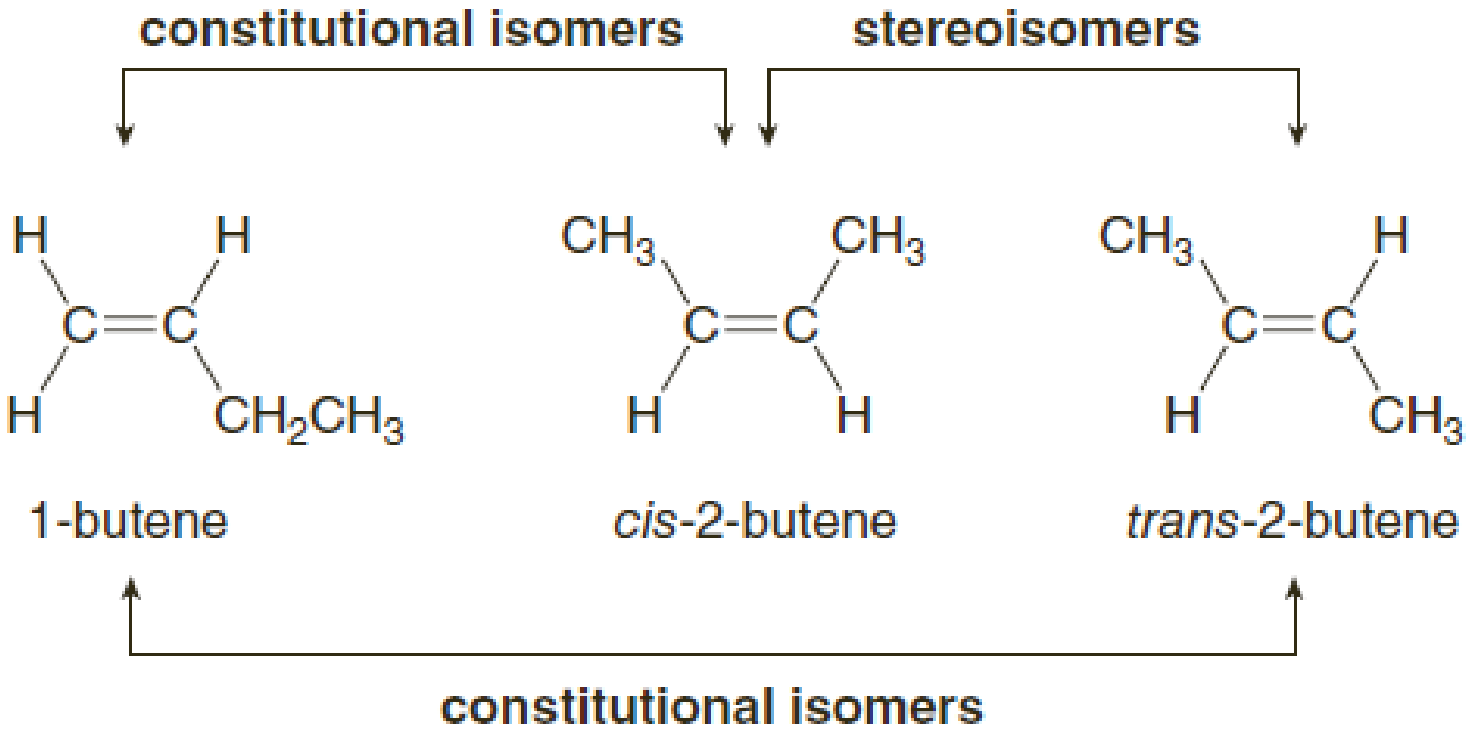


- **CIS**, os dois substituintes idênticos estão "acima" da dupla ligação ou do mesmo lado do plano da dupla ligação.
- **TRANS**, os dois substituintes idênticos estão "em lados opostos" do plano da dupla da ligação.

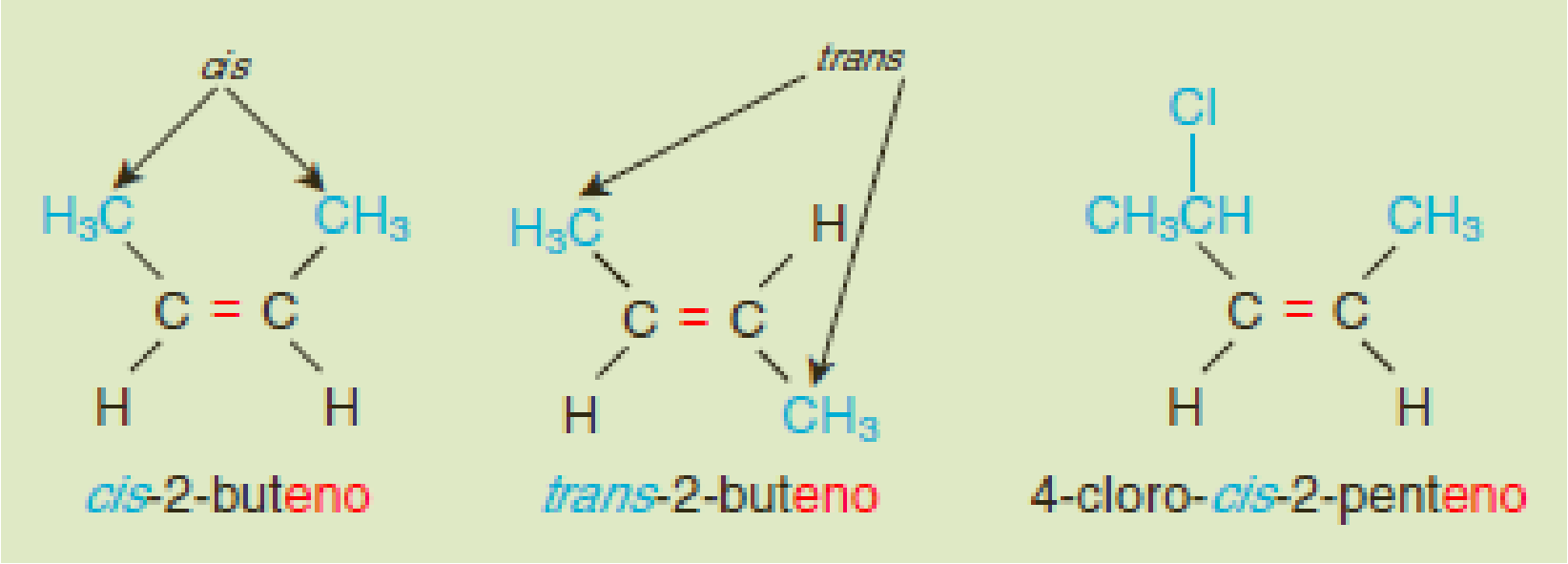
As formas **CIS** e **TRANS** diferem nas propriedades físicas e químicas

Que tipo de isómeros são:

1-buteno *cis*-2-buteno *trans*-2-buteno



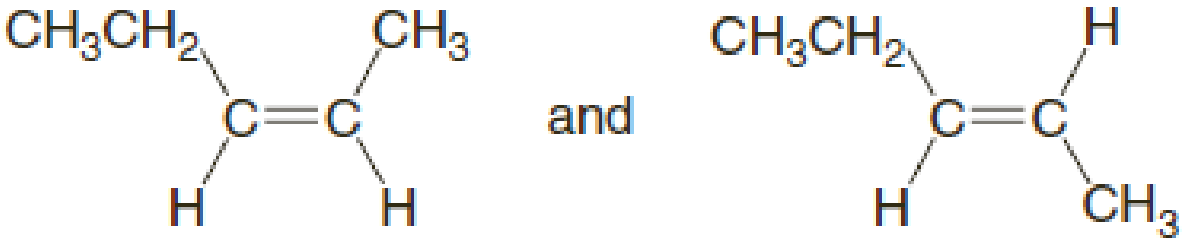
Exemplo de isomeros *Cis* e *Trans*:

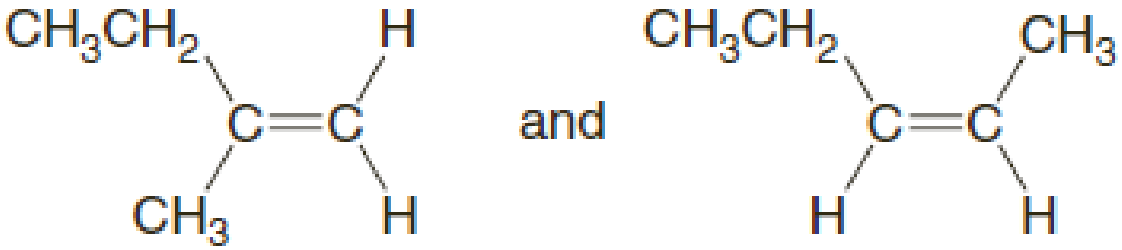


Exercicio: Identificar o tipo de isomeria

i) isomeria de constituição
ii) isomeria cis-trans

a. $CH_3CH{=}CHCH_2CH_3$ and $CH_2{=}CHCH_2CH_2CH_3$

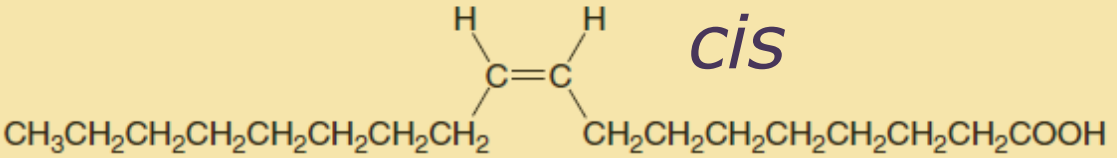
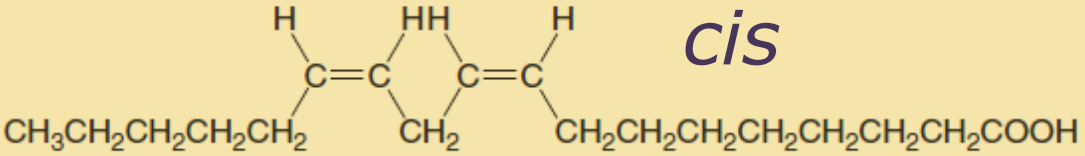
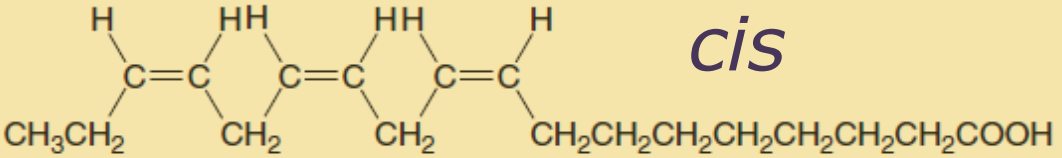
b. 

c. 

Moléculas orgânicas no nosso dia-a-dia

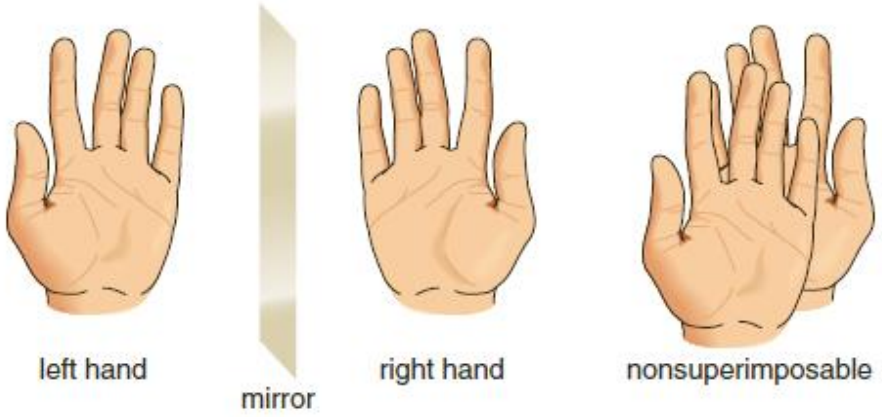
Os ácidos gordos insaturados isomeria *cis-trans*
Nas gorduras naturais todas as ligações duplas são *CIS*

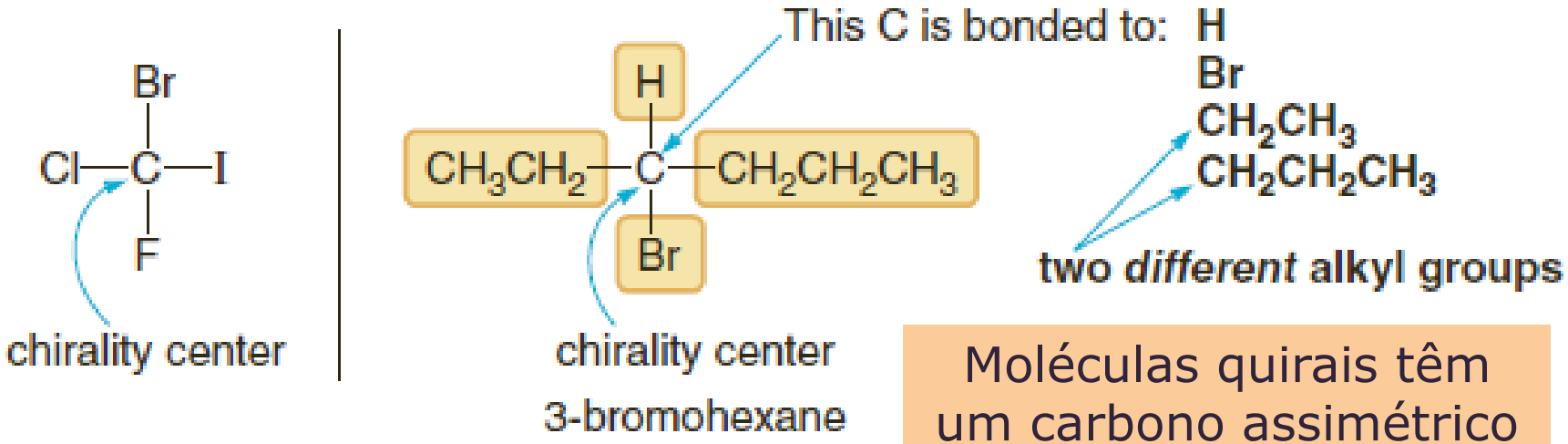
TABLE 13.1 Common Saturated and Unsaturated Fatty Acids

Name	Structure
Stearic acid (0 C=C)	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH$
Oleic acid (1 C=C)	 *cis*
Linoleic acid (2 C=C)	 *cis*
Linolenic acid (3 C=C)	 *cis*

Estereoisomeria (isomeria ótica)

Molécula quiral:
não se sobrepõe com imagem no espelho





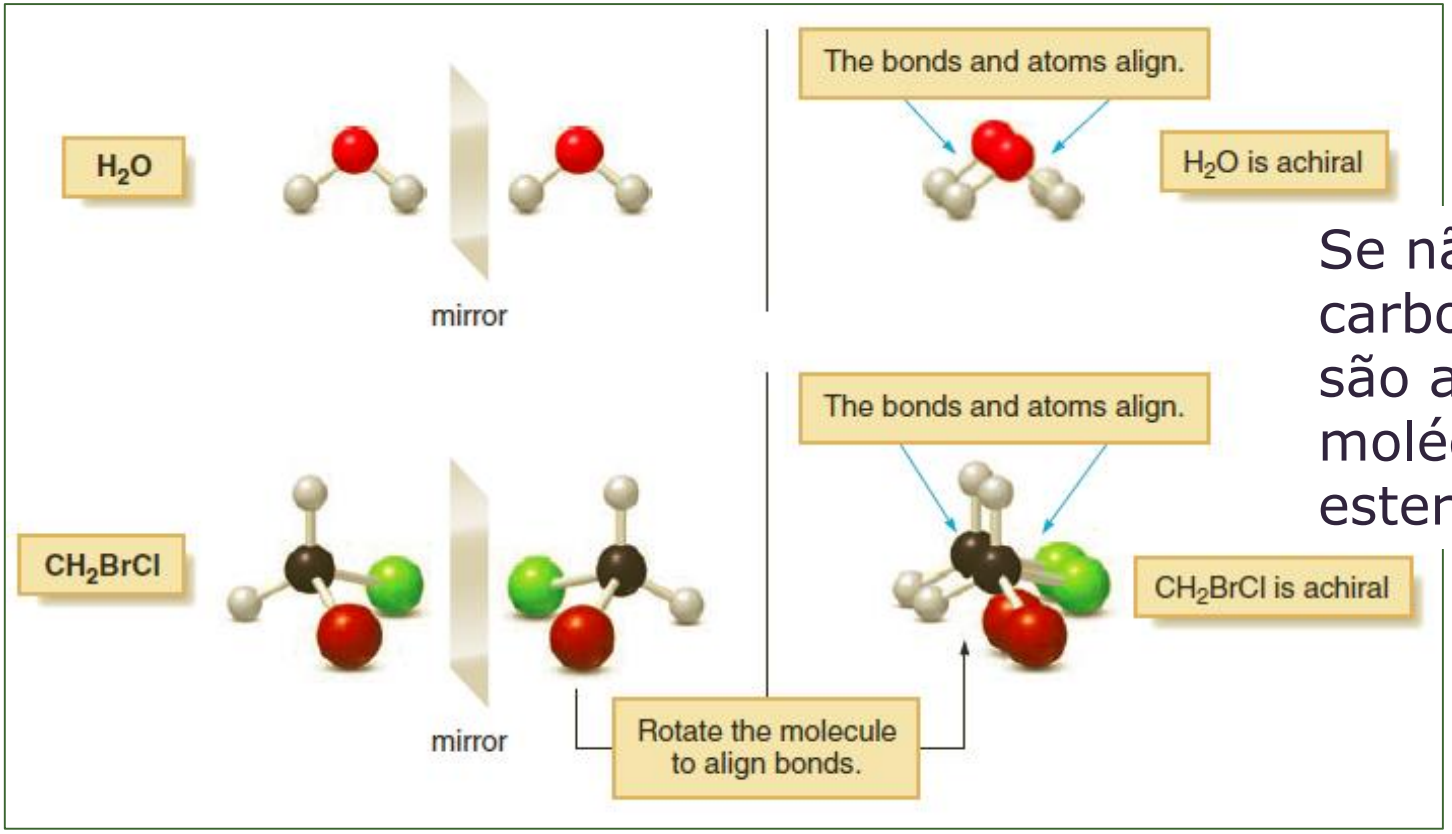
Moléculas quirais têm um carbono assimétrico (C com 4 substituintes diferentes)

Organic Chemistry Lesson: Stereochemistry 1

http://www.youtube.com/watch?v=4-4K5OJv3ik

Estereoisómeros

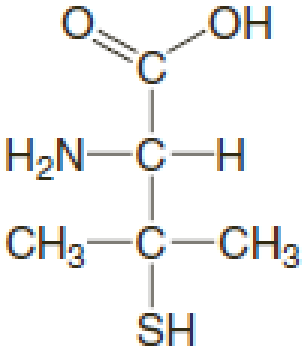
Compostos constituídos pelos mesmos tipos e números de átomos, ligados entre si na mesma sequência, mas com arranjos espaciais diferentes.



Se não existir carbono assimétrico são a mesma molécula não há estereoisomeria

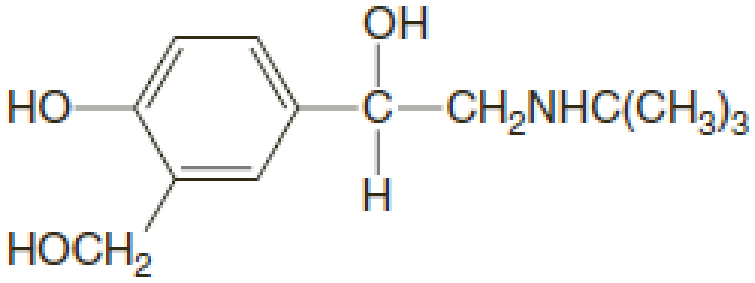
Identificar os carbonos assimétricos (centro de quiralidade) das seguintes moléculas:

a.



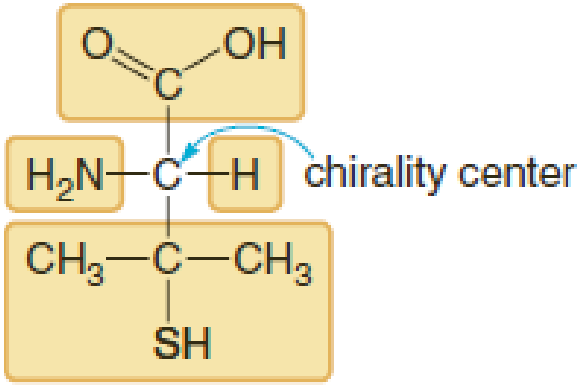
penicillamine

b.



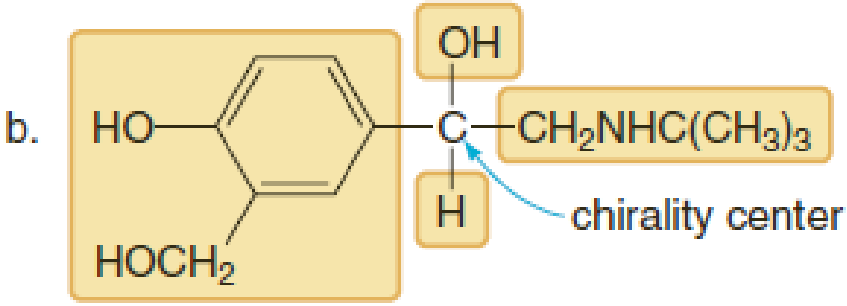
albuterol

a.



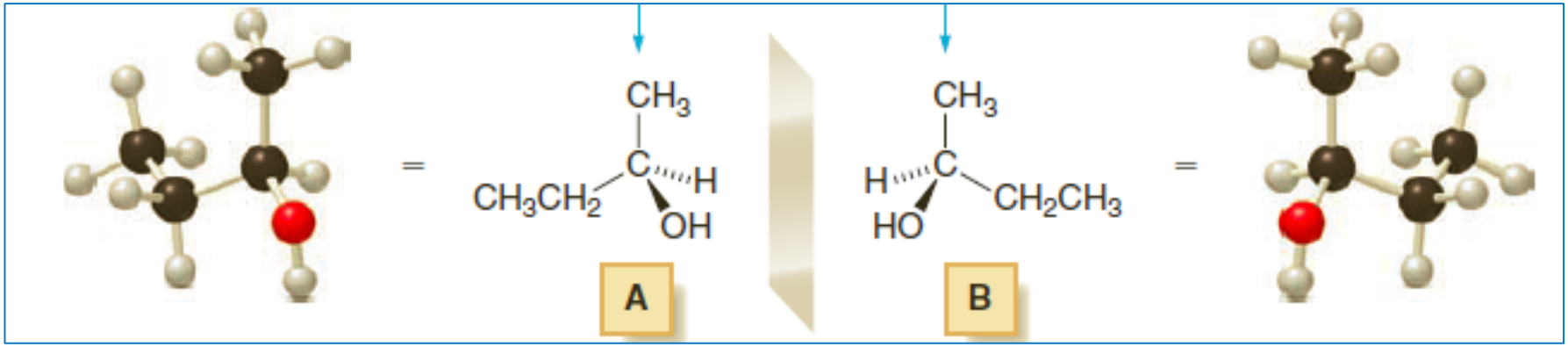
penicillamine

b.

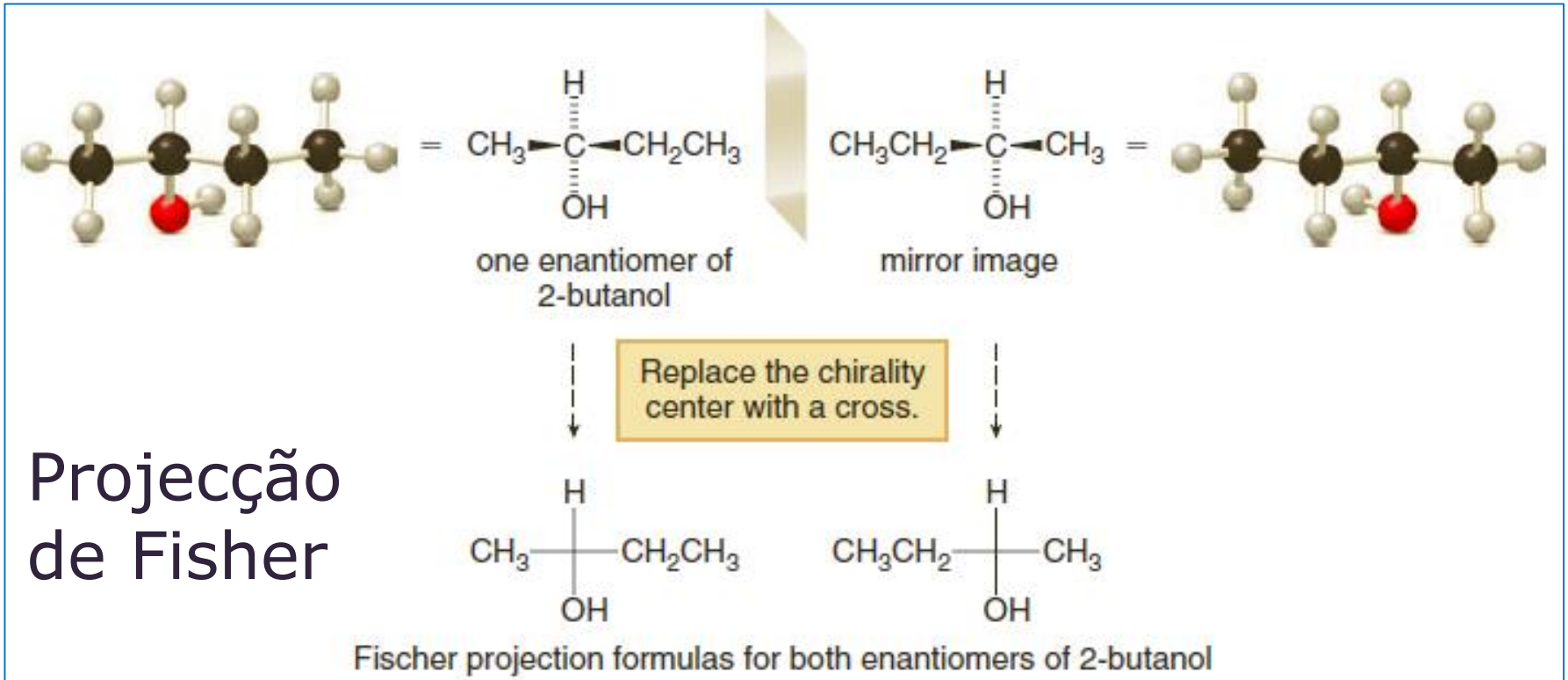


albuterol

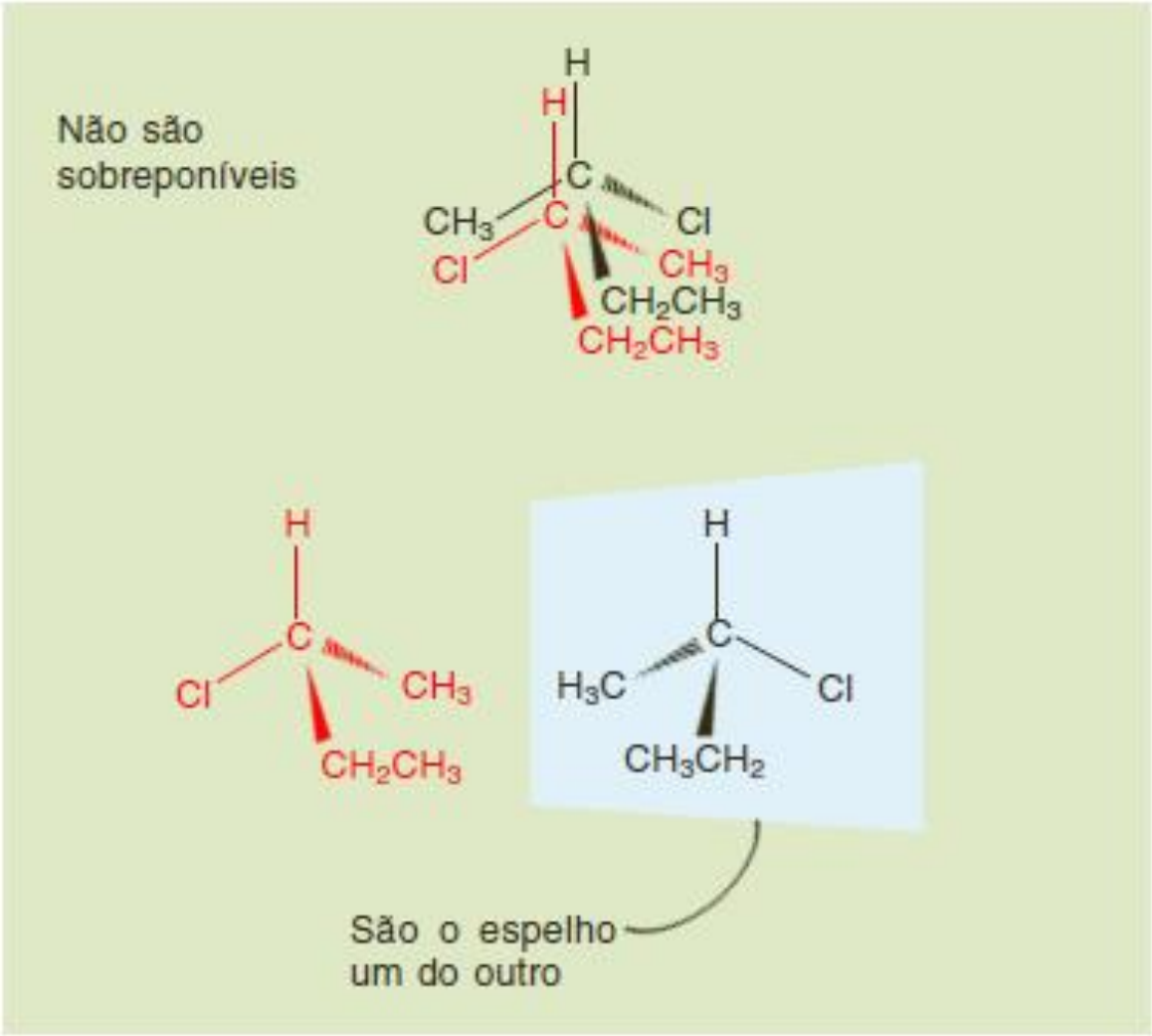
Enantiómeros



Projecção de Fisher



Exemplos de enantiómeros

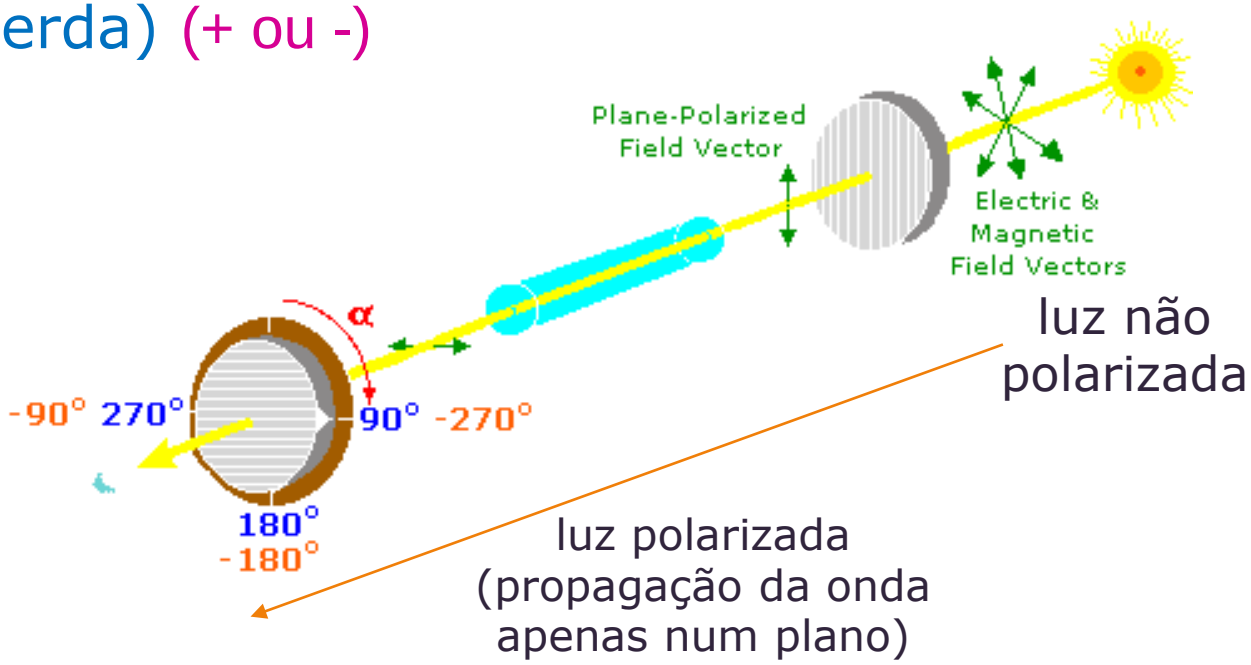


Estereoisómeros são substâncias oticamente ativas

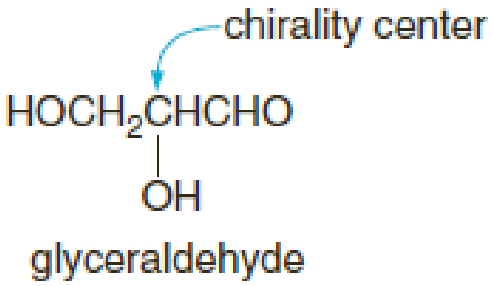
-Apresentam diferente atividade ótica (capacidade de desviar o plano da luz polarizada de forma carateristica)

-Desviam o plano da luz polarizada num dado sentido (direita ou esquerda) (+ ou -)

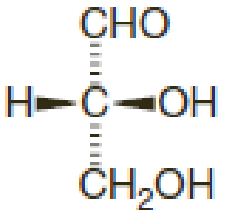
diferenciam-se pelo desvio causado no plano da luz polarizada que incide numa molécula



Enantiómeros D e L

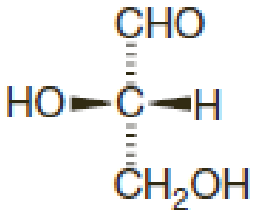


Draw the compound.

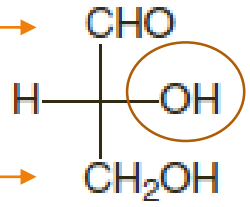


- Horizontal bonds come forward.
- Vertical bonds go back.

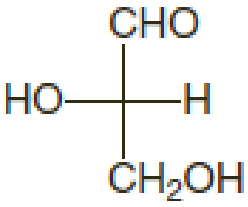
Then, draw the mirror image.



Projecção de Fisher



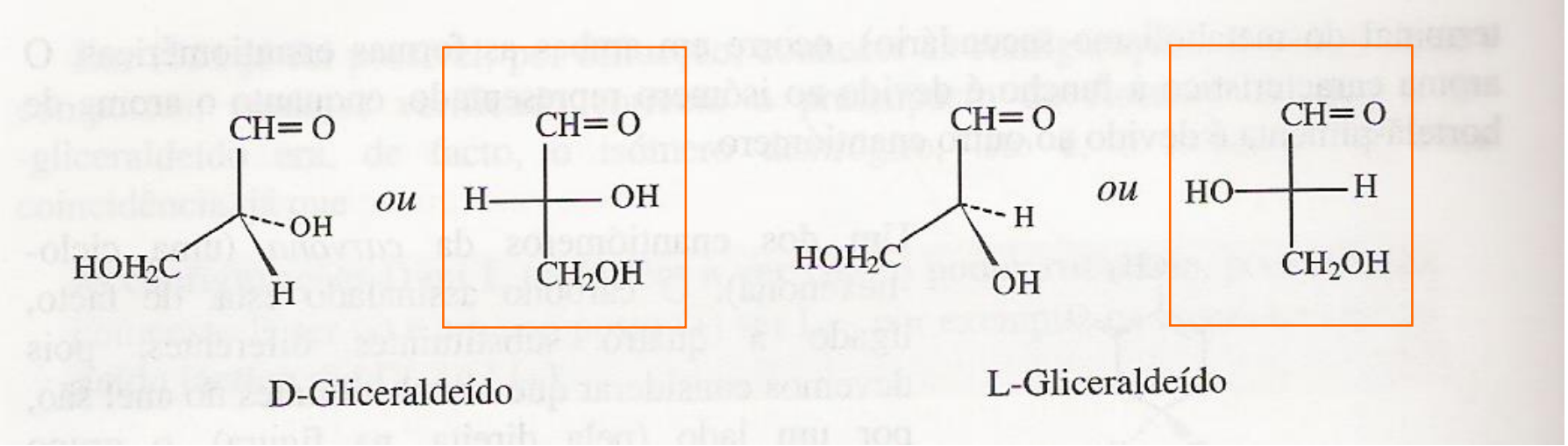
Fischer projection of one enantiomer



Fischer projection of the second enantiomer

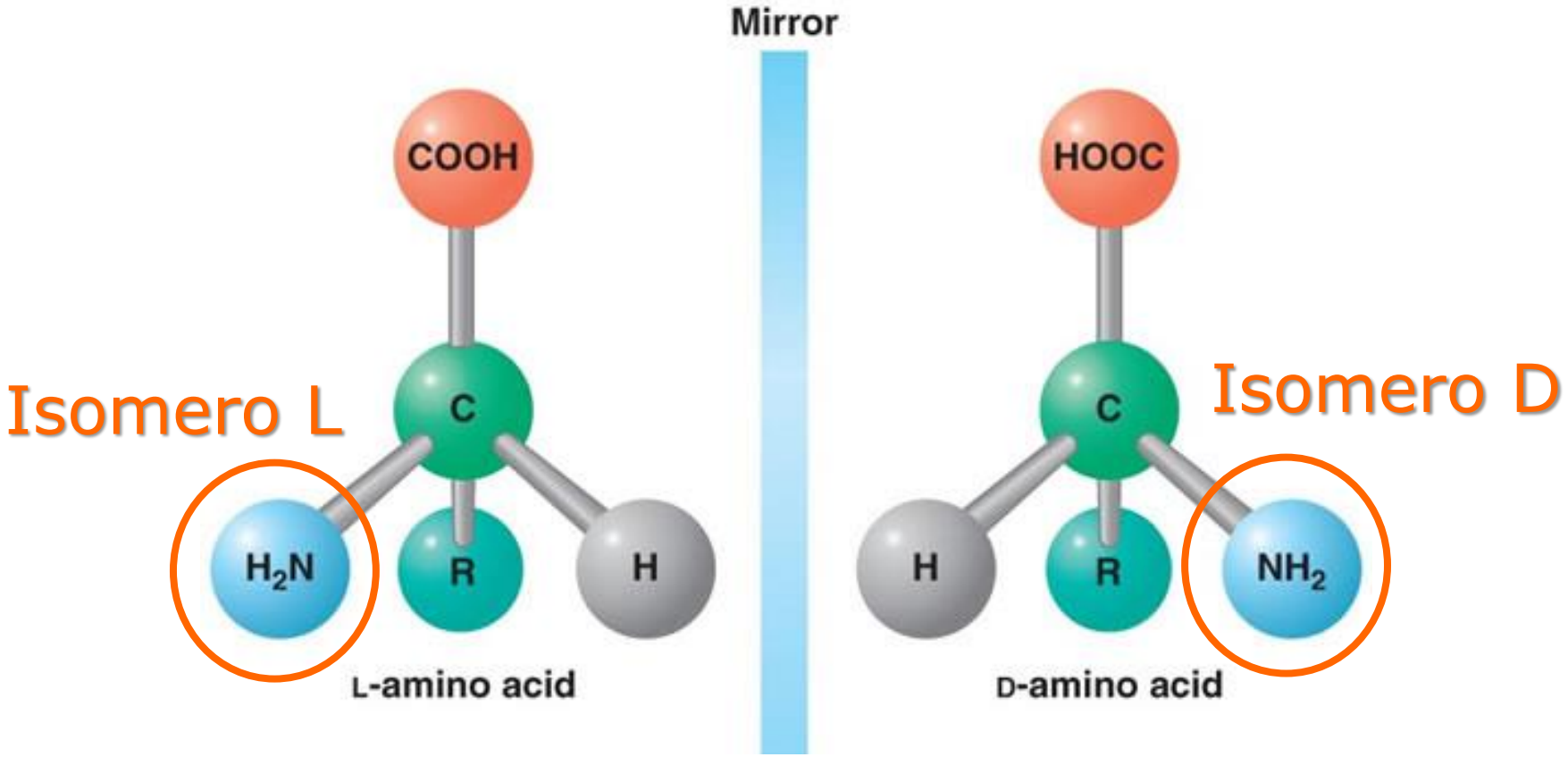
Representação de Fisher

- Tem regras próprias

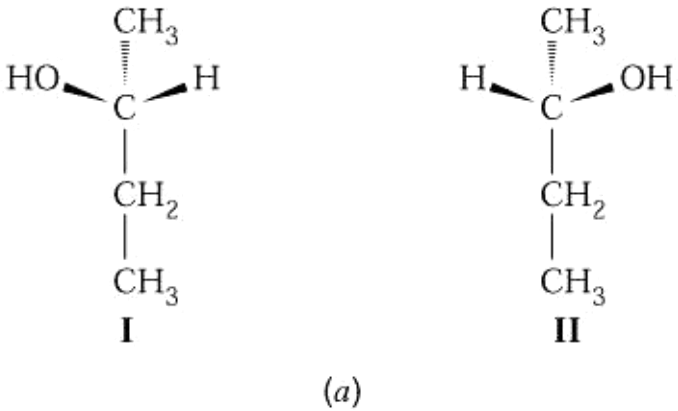


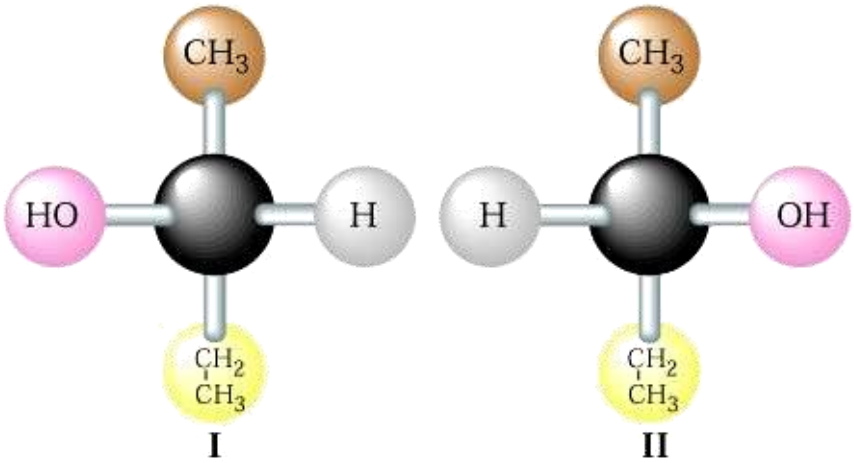
Nos aminoácidos há estereoisomeria

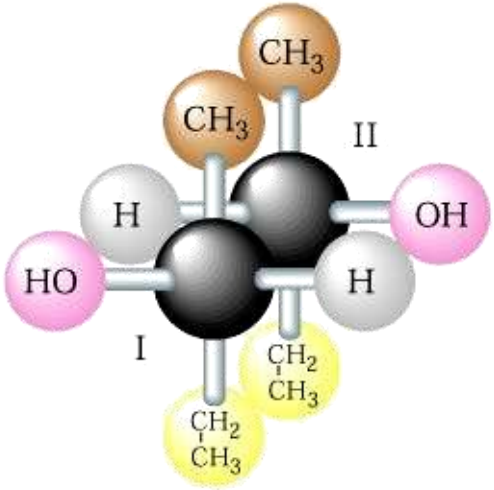
- Os aminoácidos proteicos são isomeros L



I e II são enantiómeros

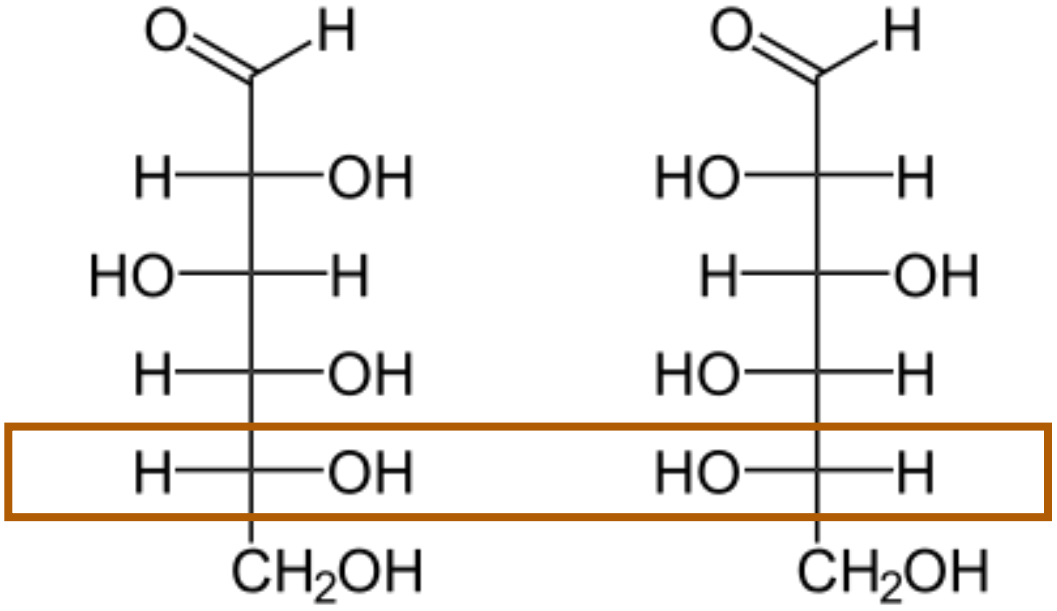






Uma mesma molécula pode conter mais do que um carbono assimétrico: o caso dos glúcidos

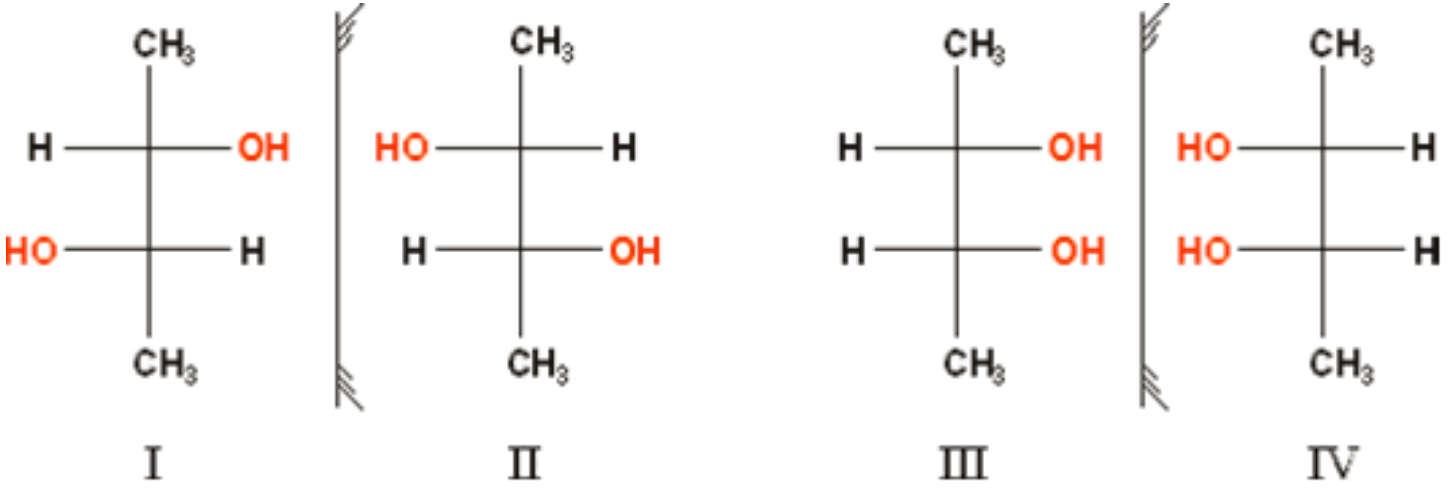
Glucidos simples são isomeros D



D-Glucose L-Glucose

A presença de ambos os enantiómeros designa-se **mistura racémica**

Uma mesma molécula pode conter mais do que um carbono assimétrico

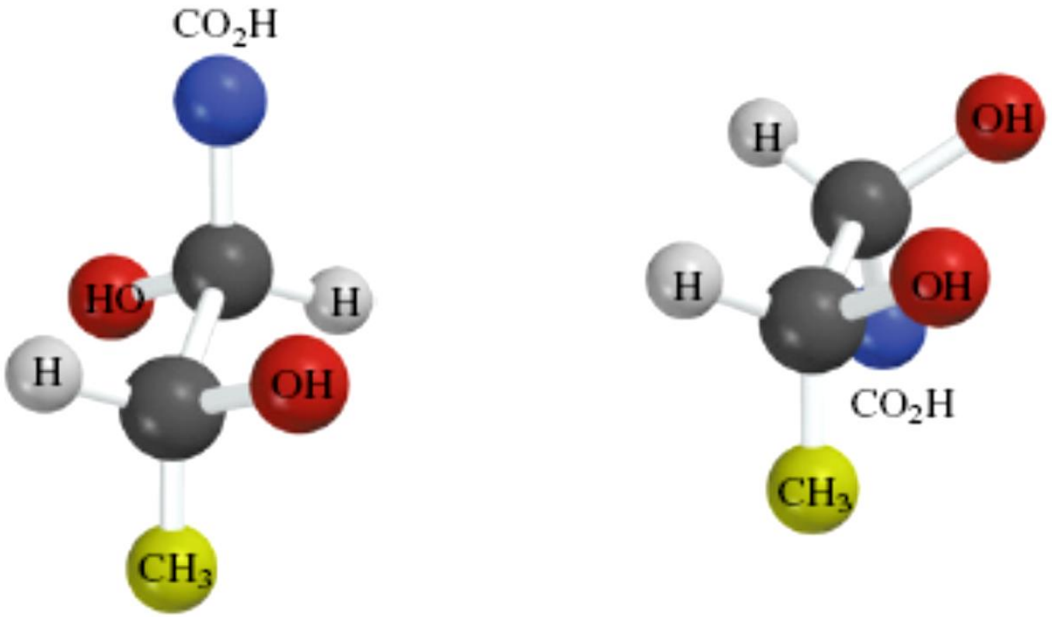


I e II são **enantiómeros**, não são sobreponíveis

Compare III e IV:
São a mesma estrutura ou são diferentes???

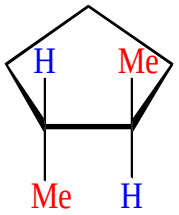
Compare a estrutura III com I e com II.
A estrutura III não tem relação objecto-imagem, nem com I nem com II.
Dizemos que **I e III** (ou **II e III**) são **diastereómeros**.

a) e b) são diastereómeros

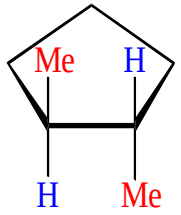


Estereoisómeria em ciclos:

Enantiómeros são estereoisómeros cujas moléculas **são imagens não sobreponíveis *uma da outra***

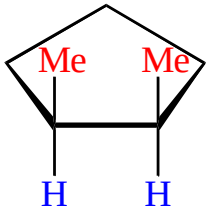


trans-1,2-Dimeticiclopentano (C_7H_{14})

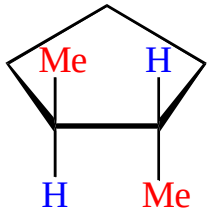


trans-1,2-Dimetilciclopentano (C_7H_{14})

Diastereómeros são estereoisómeros cujas moléculas **não são imagem uma da outra num espelho**

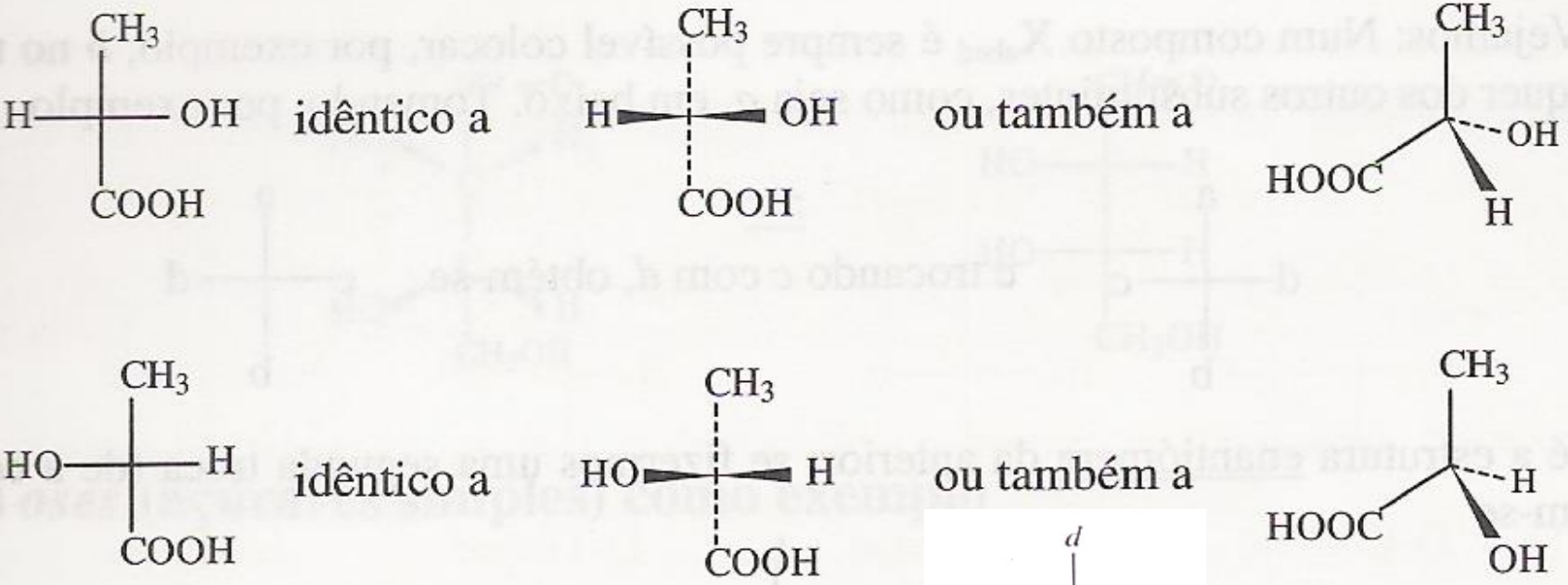


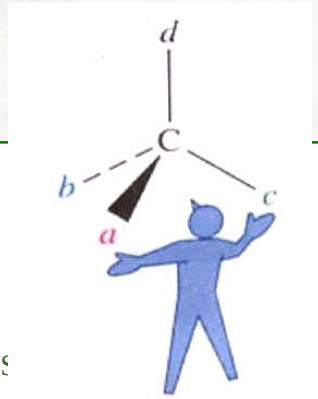
cis-1,2-Dimetilciclopentano (C_7H_{14})



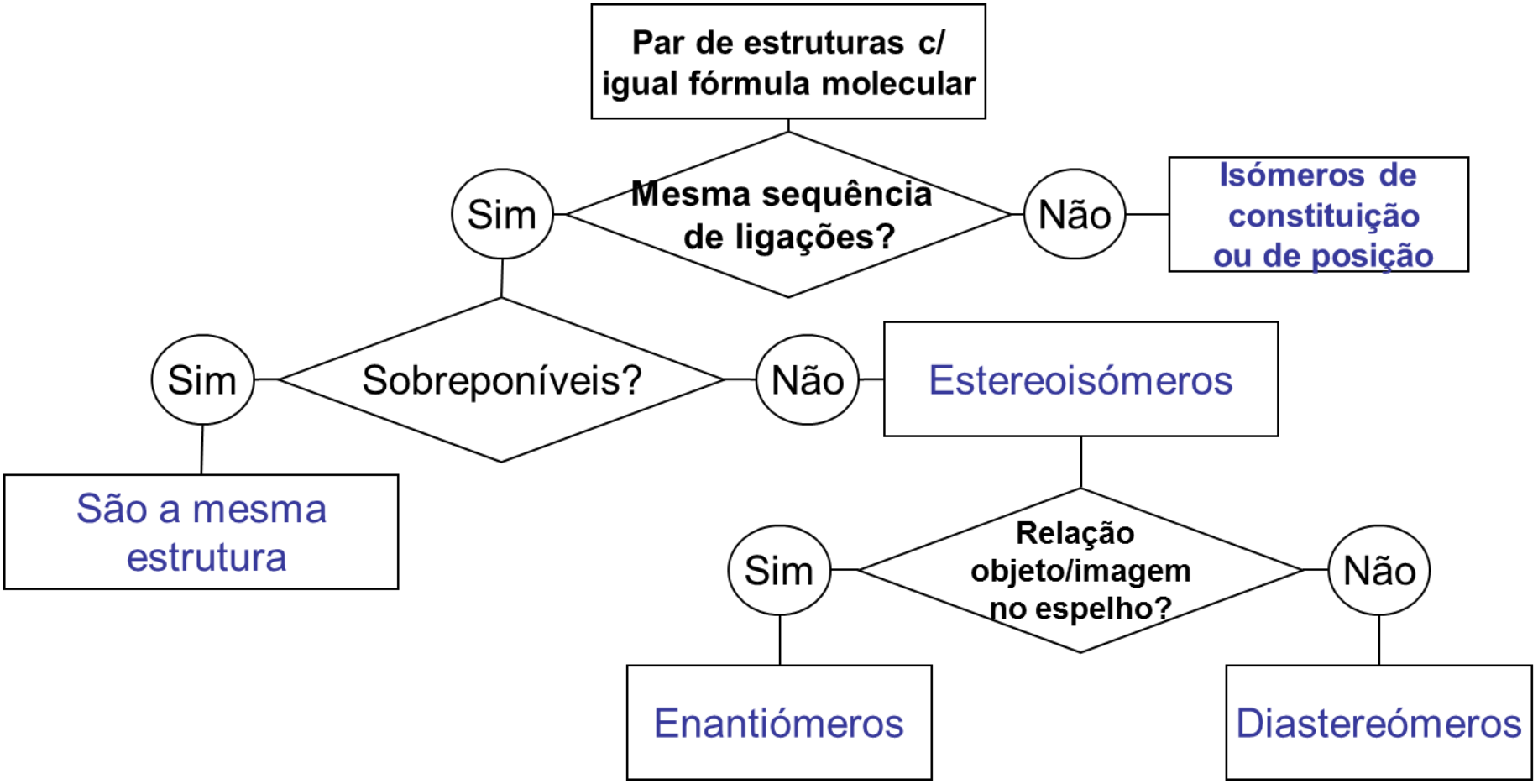
trans-1,2-Dimetilciclopentano (C_7H_{14})

Representação de dois isómeros do ácido láctico



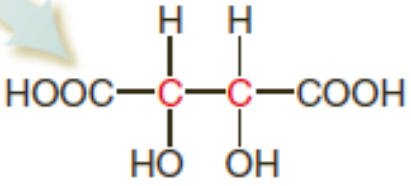


Representação em perspetiva

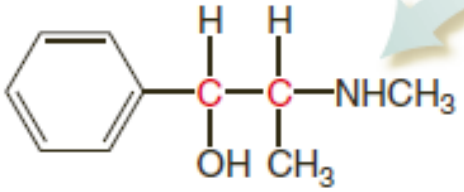

Par de estruturas c/ igual fórmula molecular
Mesma sequência de ligações?
Sim
Não
Isómeros de constituição ou de posição
Sobreponíveis?
Sim
Não
Estereoisómeros
São a mesma estrutura
Relação objeto/imagem no espelho?
Sim
Não
Enantiómeros
Diastereómeros

Moléculas orgânicas no nosso dia-a-dia

Larger organic molecules can have two, three, or even hundreds of chirality centers. Tartaric acid, isolated from grapes, and ephedrine, isolated from the herb ma huang (used to treat respiratory ailments in traditional Chinese medicine), each have two chirality centers. Once a popular drug to promote weight loss and enhance athletic performance, ephedrine use has now been linked to episodes of sudden death, heart attack, and stroke.



tartaric acid



ephedrine
(bronchodilator, decongestant)

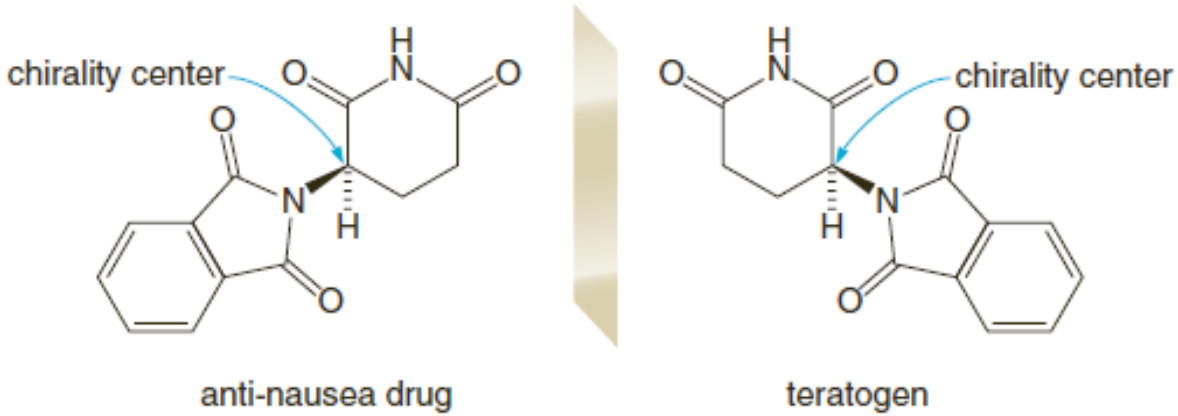
[Chirality centers are labeled in red.]

Moléculas orgânicas no nosso dia-a-dia
- O caso dramatico da talidomida

15.4B FOCUS ON HEALTH & MEDICINE
THE UNFORGETTABLE LEGACY OF THALIDOMIDE

Many biologically active compounds contain one or more chirality centers on ring carbons. For example, **thalidomide,** which contains one such chirality center, was once used as a sedative and anti-nausea drug for pregnant women in Europe and Great Britain from 1959–1962.

Two enantiomers of thalidomide



anti-nausea drug teratogen

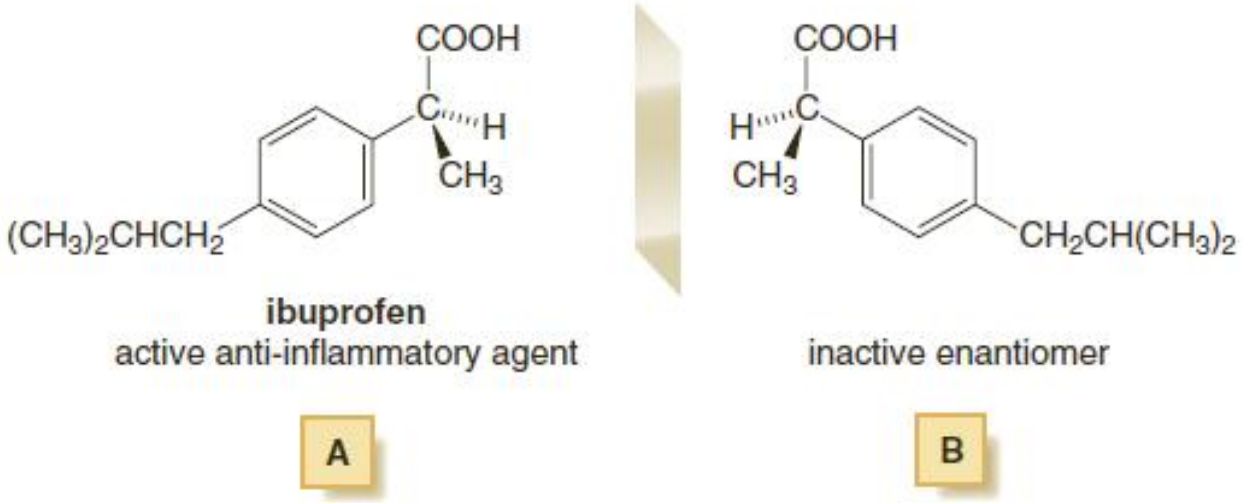
Unfortunately, thalidomide was sold as a mixture of its two enantiomers, and each of these stereoisomers has a different biological activity, a property not uncommon to chiral drugs, as we will see in Section 15.5. While one enantiomer has the desired therapeutic effect, the other enantiomer was responsible for thousands of catastrophic birth defects in children born to women who took the drug during pregnancy. Thalidomide was never approved for use in the United States due to the diligence of Frances Oldham Kelsey, a medical reviewing officer for the Food and Drug Administration, who insisted that the safety data on thalidomide were inadequate.

Moléculas orgânicas no nosso dia-a-dia

Ibuprofen and naproxen are nonsteroidal anti-inflammatory drugs (NSAIDs) that illustrate how two enantiomers can have different biological activities. Both drugs are common over-the-counter remedies that relieve pain and fever, and reduce inflammation.

Ibuprofen is the generic name for the pain relievers known as Motrin and Advil. Ibuprofen has one chirality center, and thus exists as a pair of enantiomers. Only one enantiomer, labeled **A**, is an active anti-inflammatory agent. Its enantiomer **B** is inactive. **B**, however, is slowly converted to **A** in the body. Ibuprofen is sold as a mixture of both enantiomers. **An equal mixture of two enantiomers is called a *racemic mixture*** (pronounced ra-see′-mik).

Ibuprofen is commonly used to relieve headaches, and muscle and joint pain.



Polarização das ligações covalentes

A polaridade de uma ligação covalente resulta da diferença de **eletronegatividade** dos atomos que a formam

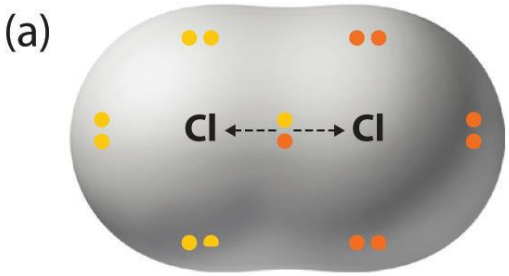
Escala de eletronegatividade de Pauling

Período \ Grupo	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	H 2,1																	He
2	Li 1,0	Be 1,5											B 2,0	C 2,5	N 3,0	O 3,5	F 4,0	Ne
3	Na 0,9	Mg 1,2											Al 1,5	Si 1,8	P 2,1	S 2,5	Cl 3,0	Ar
4	K 0,8	Ca 1,0	Sc 1,3	Ti 1,5	V 1,6	Cr 1,6	Mn 1,5	Fe 1,8	Co 1,9	Ni 1,8	Cu 1,9	Zn 1,6	Ga 1,6	Ge 1,8	As 2,0	Se 2,4	Br 3,0	Kr
5	Rb 0,8	Sr 1,0	Y 1,2	Zr 1,4	Nb 1,6	Mo 1,8	Tc 1,9	Ru 2,2	Rh 2,2	Pd 2,2	Ag 1,9	Cd 1,7	In 1,7	Sn 1,8	Sb 1,9	Te 2,1	I 2,5	Xe
6	Cs 0,7	Ba 0,9	*	Hf 1,3	Ta 1,5	W 1,7	Re 1,9	Os 2,2	Ir 2,2	Pt 2,2	Au 2,4	Hg 1,9	Tl 1,8	Pb 1,9	Bi 1,9	Po 2,0	At 2,2	Rn
7	Fr 0,7	Ra 0,9	**	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo

É a tendência de um átomo para atrair os eletrões numa ligação

Polarização das ligações covalentes

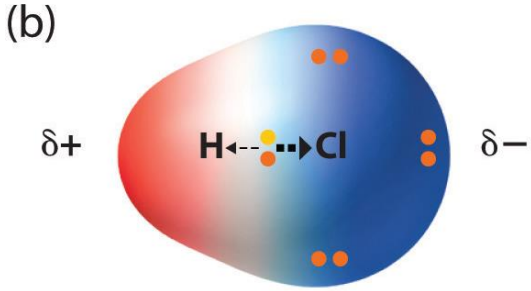
Ligação covalente apolar
-não constitui dipolo elétrico
-forma-se entre átomos com eletronegatividade igual ou semelhante



Nonpolar covalent bond

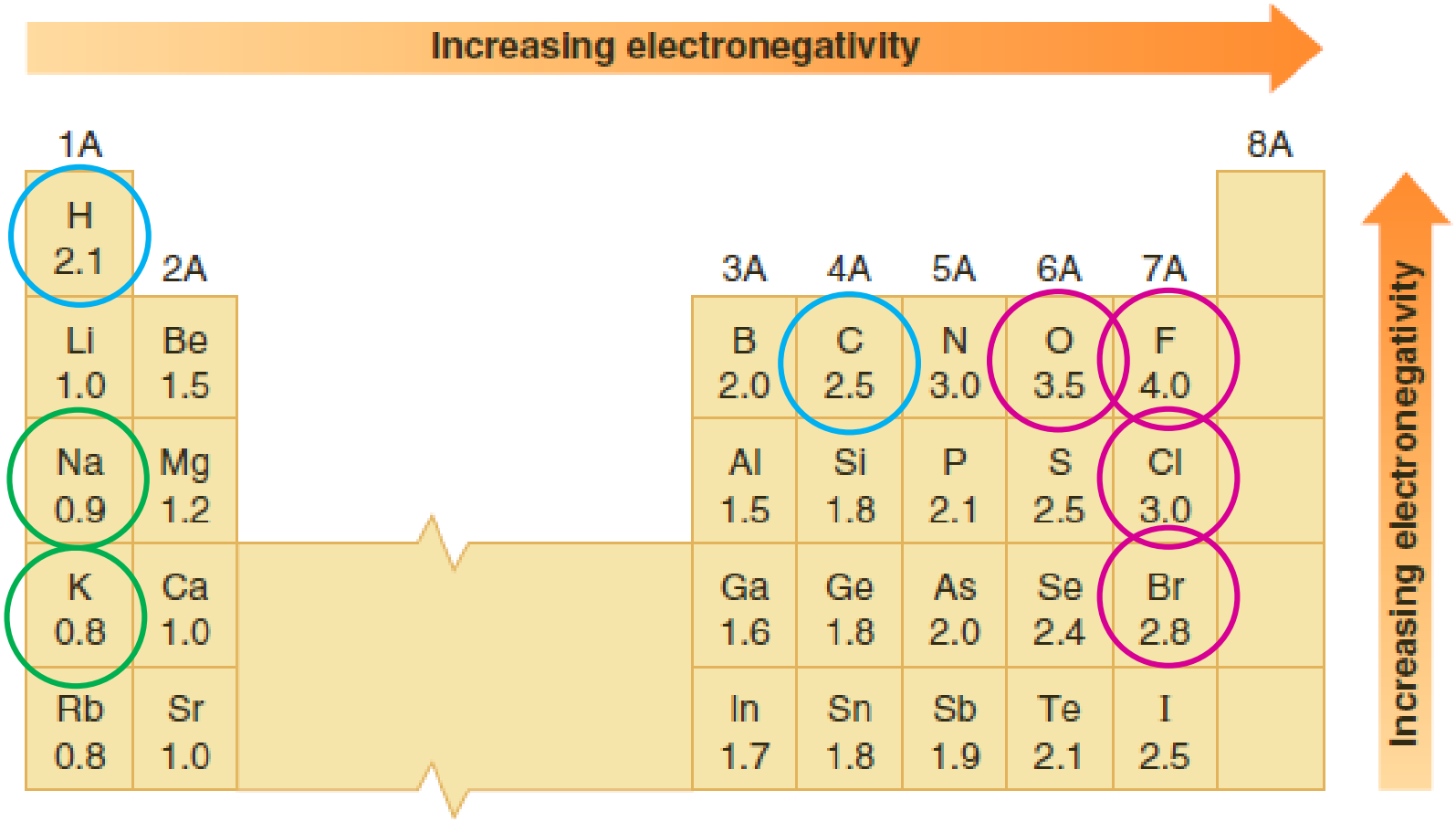
Bonding electrons shared equally between two atoms. No charges on atoms.

Ligação covalente polar
Constitui um dipolo elétrico
Forma-se quando as eletronegatividades dos elementos ligados são bastante diferentes



Polar covalent bond

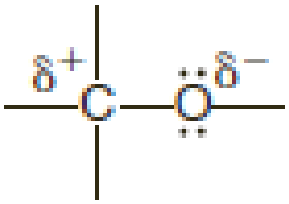
Bonding electrons shared unequally between two atoms. Partial charges on atoms.

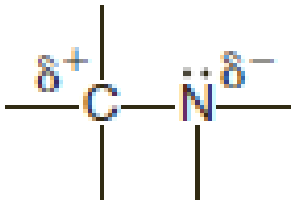


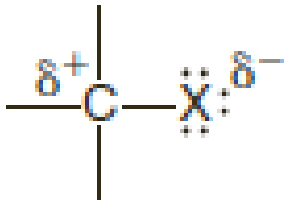
Polarização das ligações covalentes

As ligações C-C e C-H não têm polarização → a eletronegatividades dos átomos ligados é semelhante, não origina dipolos eléctricos

As ligações C-O e C-N têm polarização → a eletronegatividades dos átomos ligados é diferente, a ligação covalente origina dipolos eléctricos







A ligação covalente polar origina um dipolo elétrico

X = halogen

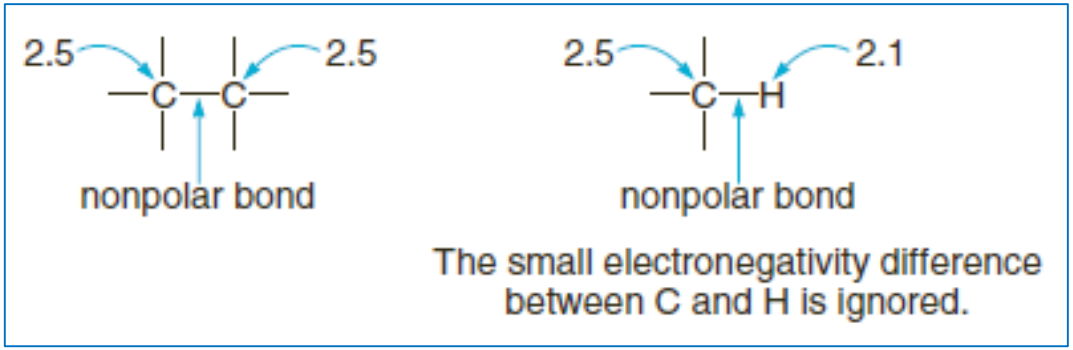
na ligação covalente polar surgem pólos distintos (representados pela letra δ)

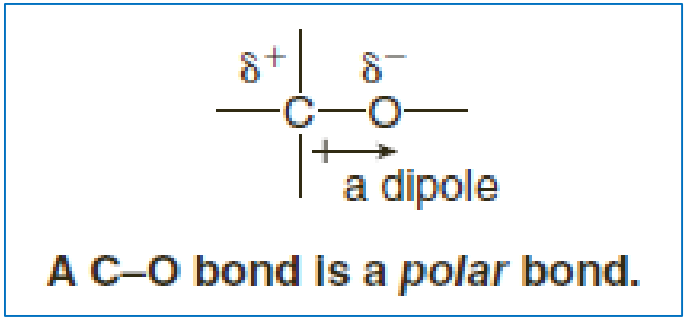
δ+ carga parcial positiva (elemento menos eletronegativo)

δ− carga parcial negativa (elemento mais eletronegativo)

A ligação covalente polar ocorre:

- entre elementos de eletronegatividade diferente
- o mais eletronegativo apresenta maior capacidade de atrair o par de eletrões
- cria-se nesse extremo uma maior densidade eletrónica





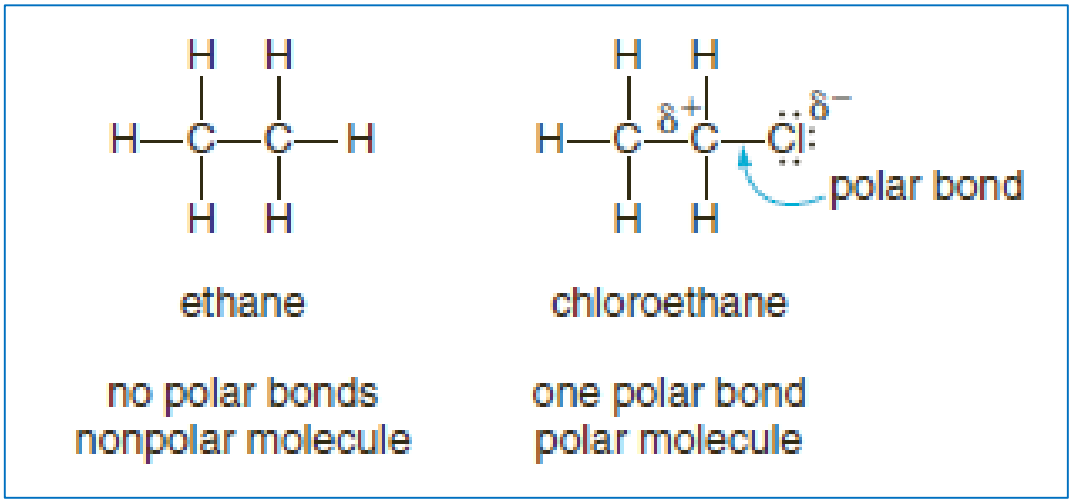
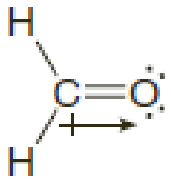


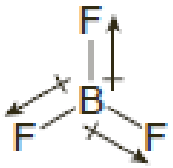
TABLE 4.3 Electronegativity Difference and Bond Type

Electronegativity Difference	Bond Type	Electron Sharing
Less than 0.5 units	Nonpolar	Electrons are equally shared.
0.5–1.9 units	Polar covalent	Electrons are unequally shared; they are pulled towards the more electronegative element.
Greater than 1.9 units	Ionic	Electrons are transferred from the less electronegative element to the more electronegative element.



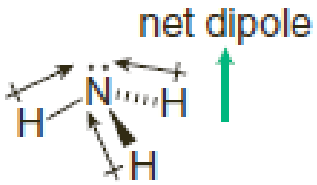
one polar bond

polar molecule



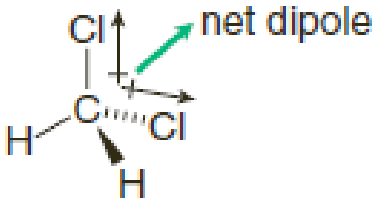
three polar bonds
All dipoles cancel.
NO net dipole

nonpolar molecule



three polar bonds
All dipoles reinforce.

polar molecule



two polar bonds
Two dipoles reinforce.

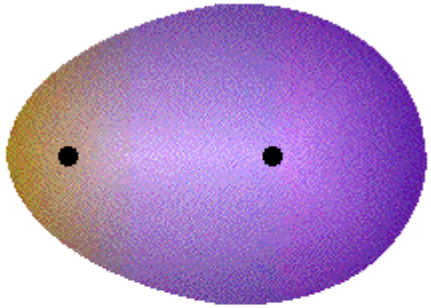
polar molecule

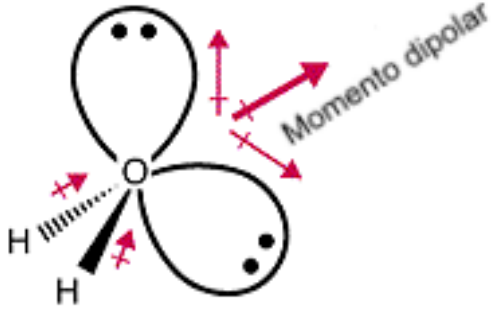
Momento dipolar

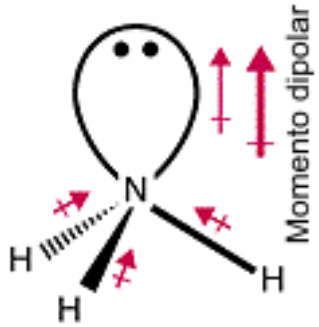
Magnitude do caráter polar da ligação covalente

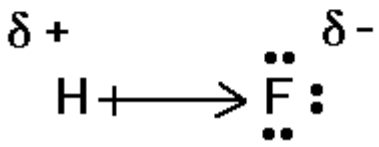
Momento dipolar = carga x distância

$$\mu = e \times d$$









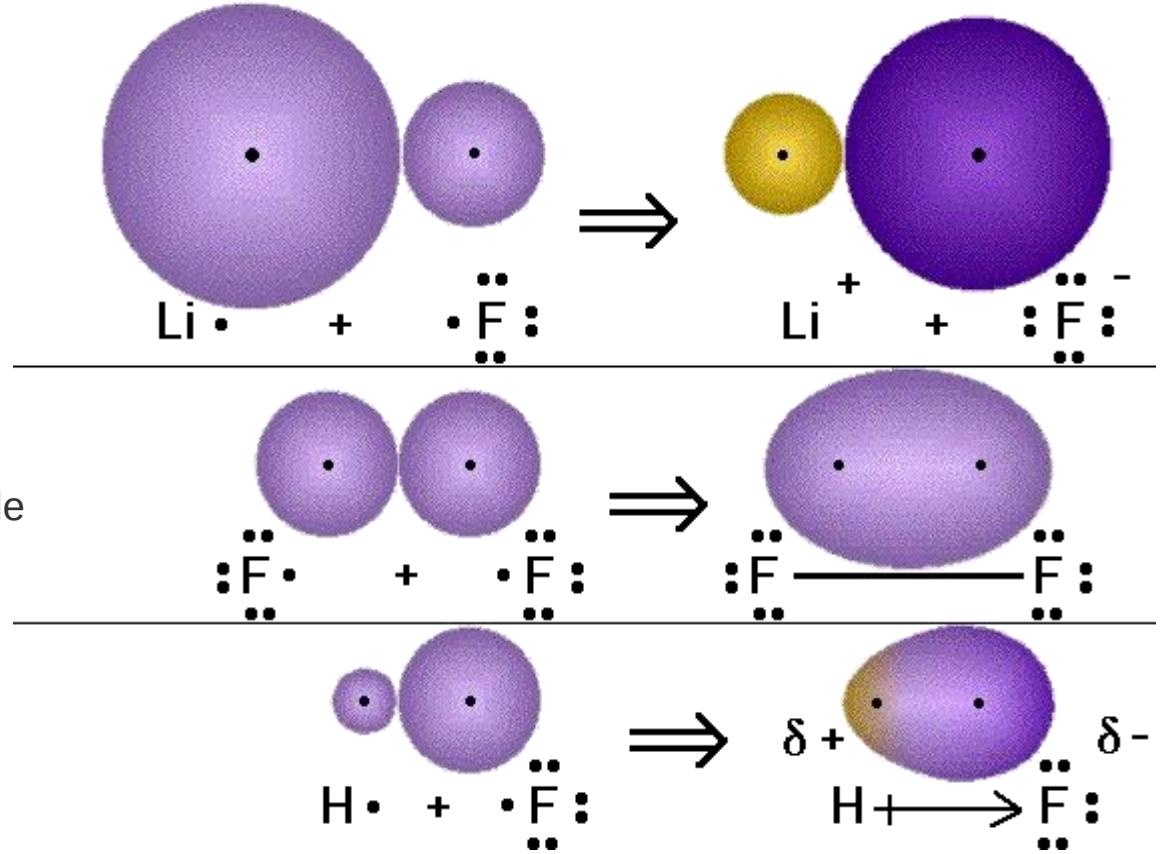
- Origina cargas parciais (δ), $0<|\delta|<1$
- Origina a formação de dipolos permanentes (na maior parte das moléculas orgânicas)

Tipo de ligação em função da diferença de **eletronegatividade** entre os átomos

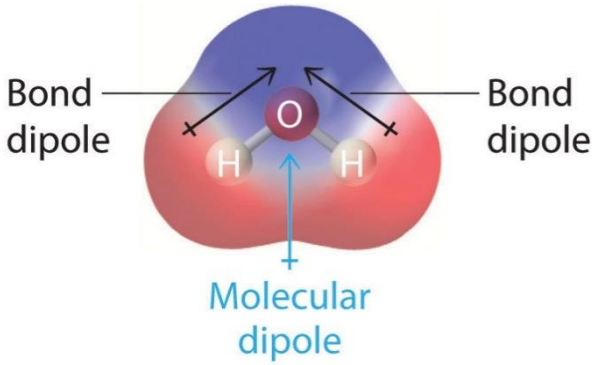
IÓNICA
Maior que 2

COVALENTE
(**apolar** – eletronegatividade semelhante)

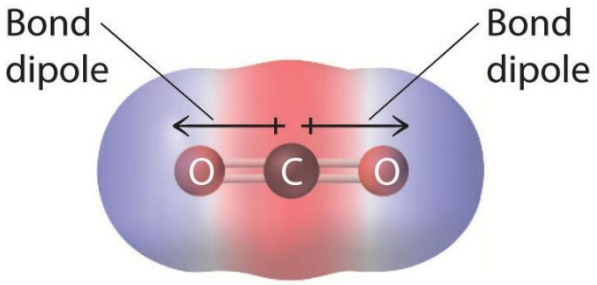
COVALENTE
(**polarizada** – diferente eletronegatividade)



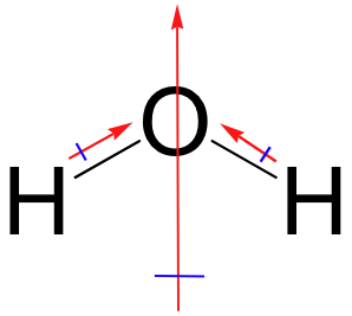
Polarização das moléculas



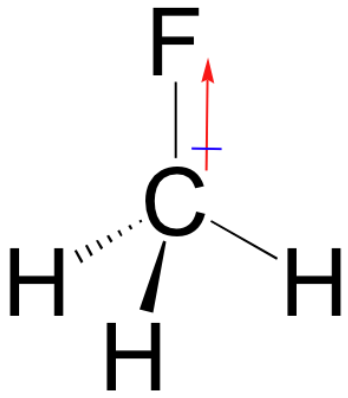
(b) Net dipole moment

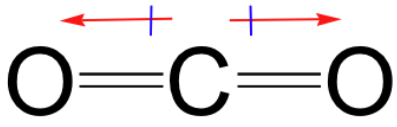


(a) No net dipole moment

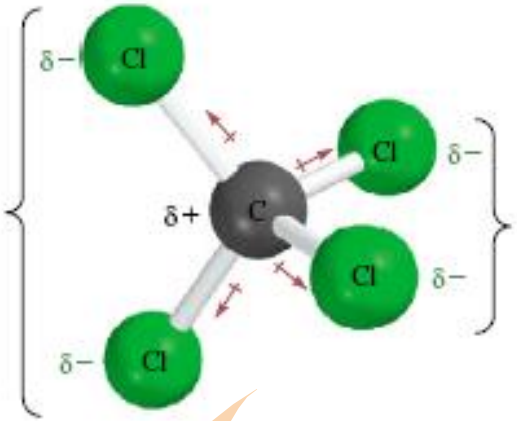


molecular dipole moment





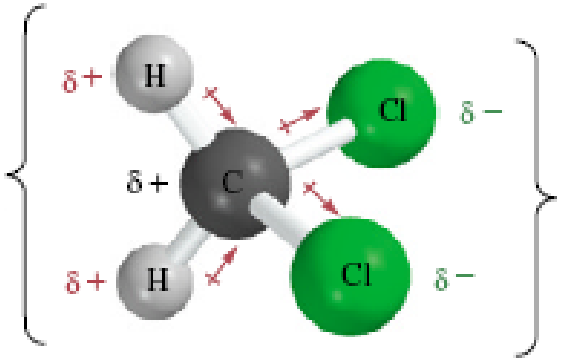
Polarização e momento dipolar das moléculas



$\mu = 0$

Os vetores dos momentos dipolares de cada ligação podem anular-se, resultando uma molécula sem momento dipolar

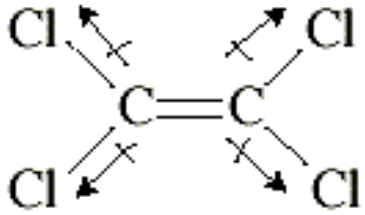
A contribuição das ligações C-H é desprezável, sendo o momento dipolar praticamente devido à ligação C-Cl



$\mu = 1{,}87$ D

Explique porque é que a molécula $CCl_2 = CCl_2$ não apresenta momento dipolar

A soma dos vetores é zero pois anulam-se dois a dois, tal como se pode observar na representação:



O MOMENTO DIPOLAR das moléculas determina propriedades especificas

REATIVIDADE
ESTADO FÍSICO
SOLUBILIDADE

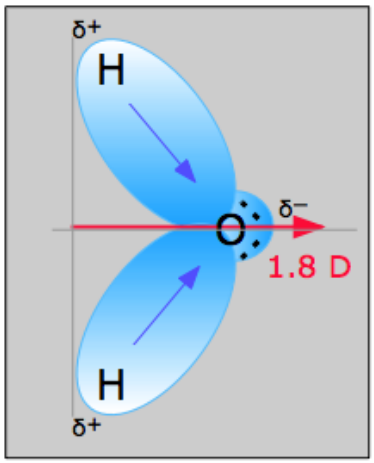
Molécula	Geometria	Momento dipolar
HF	Linear	1,92
HCl	Linear	1,08
HBr	Linear	0,78
HI	Linear	0,38
H_2O	Angular	1,87
H_2S	Angular	1,10
NH_3	Piramidal	1,46
SO_2	Angular	1,60

MOMENTO DIPOLAR DE ALGUMAS MOLECULAS ORGÂNICAS

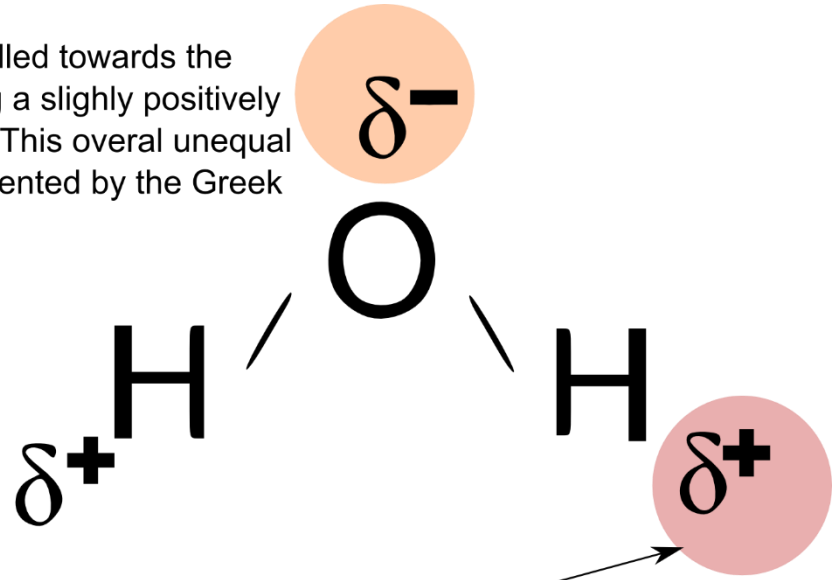
Molécula	μ (D)
CH_4	0
CH_3	1,87
CH_2Cl_2	1,55

Molécula	μ (D)
$CHCl_3$	**1,02**
CCl_4	**0**
NH_3	**1,47**

O caso da água:



electrons are pulled towards the oxygen, creating a slighly positively charged region. This overal unequal charge is represented by the Greek delta, for dipole



electrons are pulled away from the hydrogen towards the oxygen, creating a slighly positively charged region

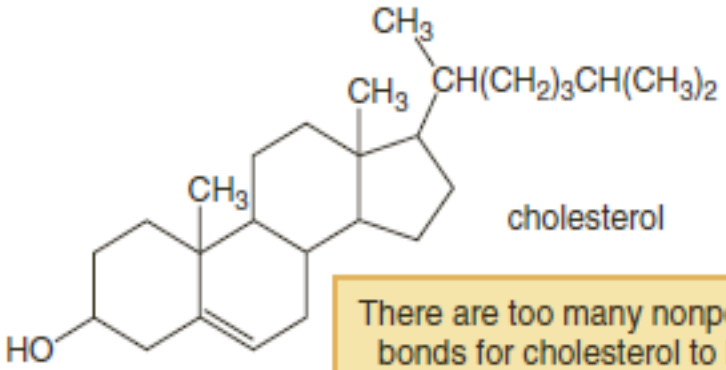
Comparar propriedades físico-químicas da água e outros compostos:

MOLECULE	DIPOLE MOMENT (D)	MELTING POINT (°C)	BOILING POINT (°C)
H_2O	1.85	0	100
NH_3	1.47	− 78	− 33
HCl	1.08	− 115	− 85
HBr	0.80	− 88	− 67
HI	0.42	− 51	− 35

Solubilidade é determinada por interaçoes intermoleculares

TABLE 11.7 The Solubility Characteristics of Three Representative Organic Molecules

Compound	Solubility in an Organic Solvent	Solubility in Water
$CH_3CH_2CH_2CH_2CH_2CH_3$ Hexane	Soluble	Insoluble
CH_3CH_2OH Ethanol	Soluble	Soluble
Cholesterol	Soluble	Insoluble



cholesterol

There are too many nonpolar C—C and C—H bonds for cholesterol to be soluble in water.

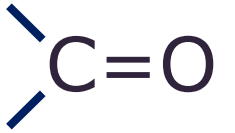
H_2O insoluble

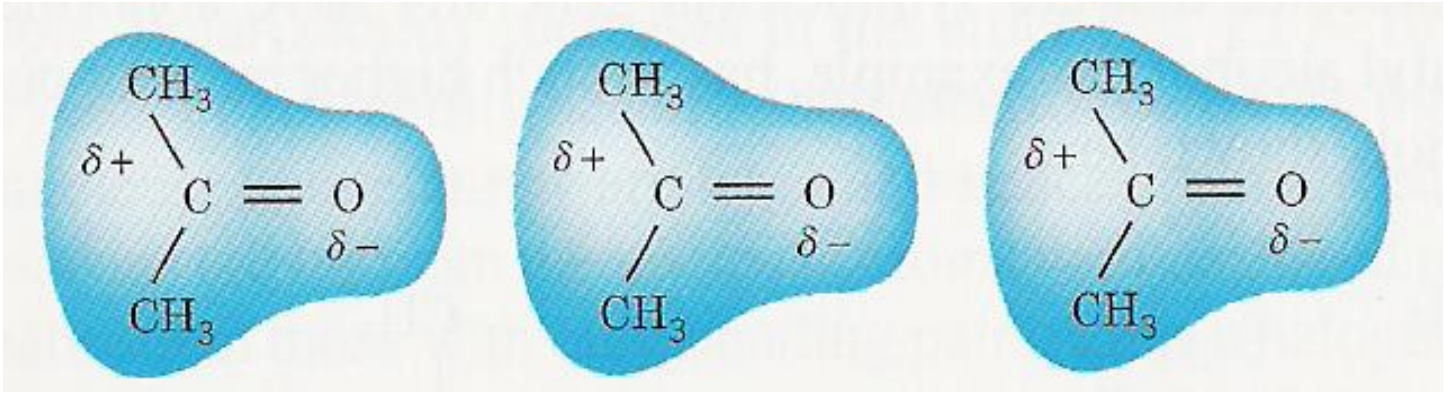
As propriedades físicas dependem do *tipo* e *intensidade* das forças intermoleculares

-Interações iónicas
-Interações dipolo-dipolo
-Pontes de hidrogénio
-Forças de van der Waals

Interações dipolo-dipolo

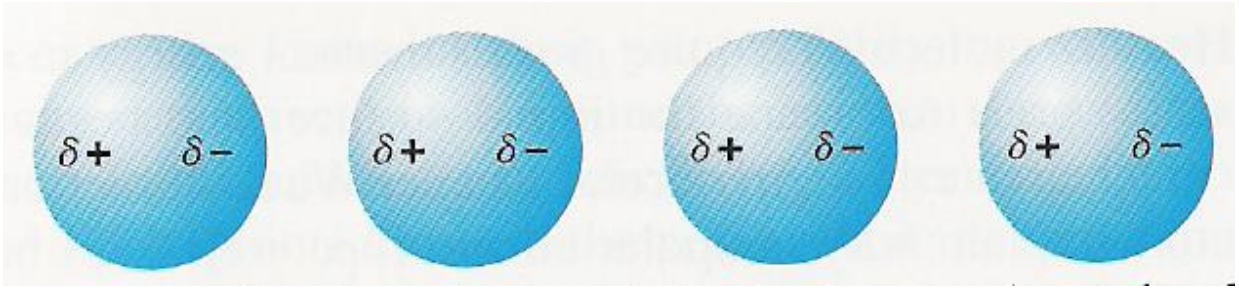
Ex: cetonas e aldeídos (grupo carbonilo é dipolo permanente)





**-17: Dipole Forces: https://www.youtube.com/watch?v=cERb1d6J4-M&list=PLllVwaZQkS2op2kDuFifhStNsS49LAxkZ&index=17

Forças de van der Waals (ou forças de London)

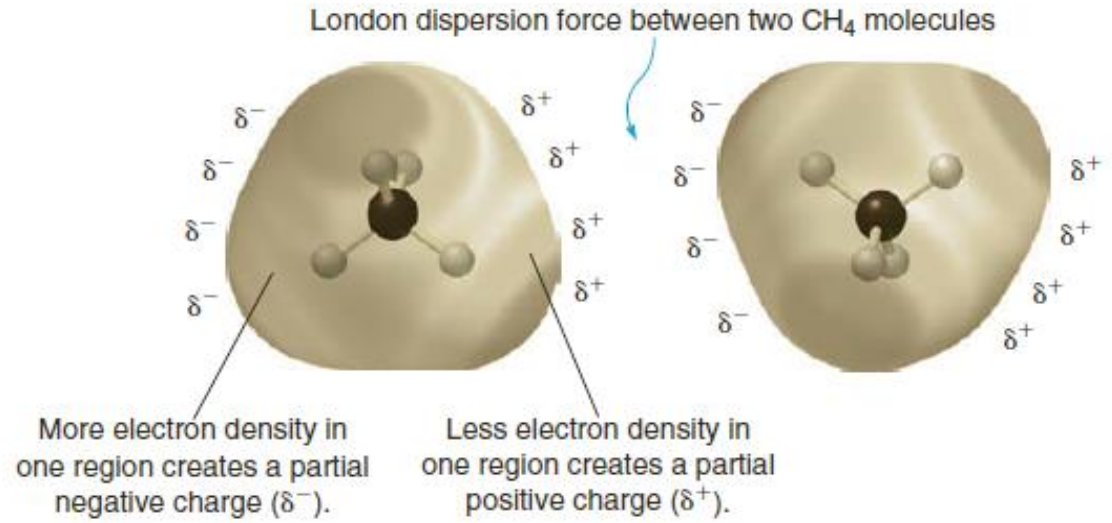


(dipolos instantâneos-dipolos induzidos)

Dipolos temporários em moléculas não polares causam distribuição não uniforme dos eletrões num dado instante)

Ex: alcanos

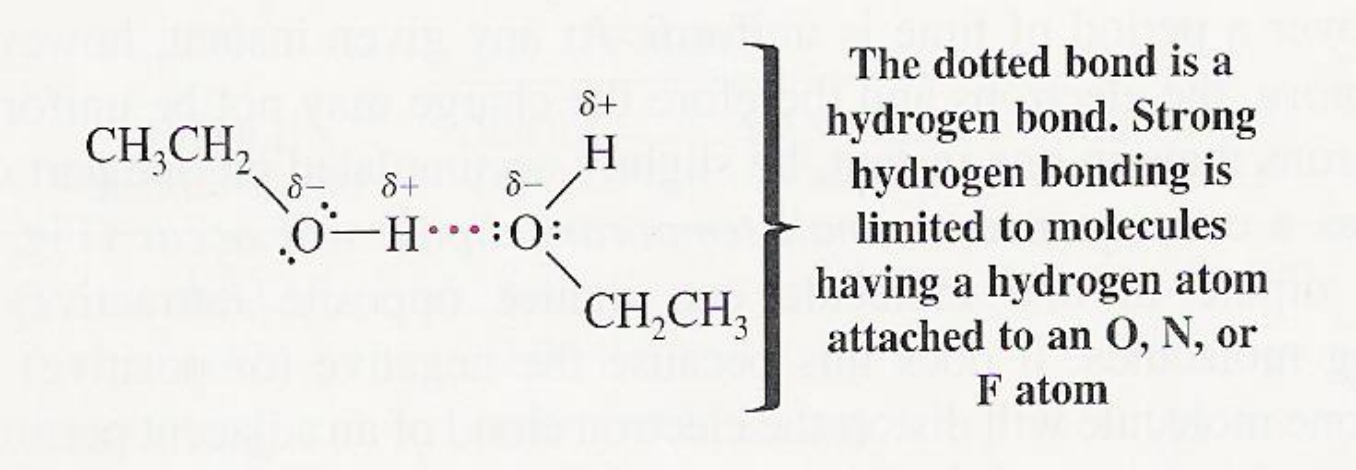
dipolos temporários geram forças atrativas entre moléculas (forças fracas)



**-16: London Dispersion Forces:

https://www.youtube.com/watch?v=1iYKajMsYPY&list=PLllVwaZQkS2op2kDuFifhStNsS49LAxkZ&index=16

Pontes de hidrogénio:
H ligado a um elemento fortemente eletronegativo



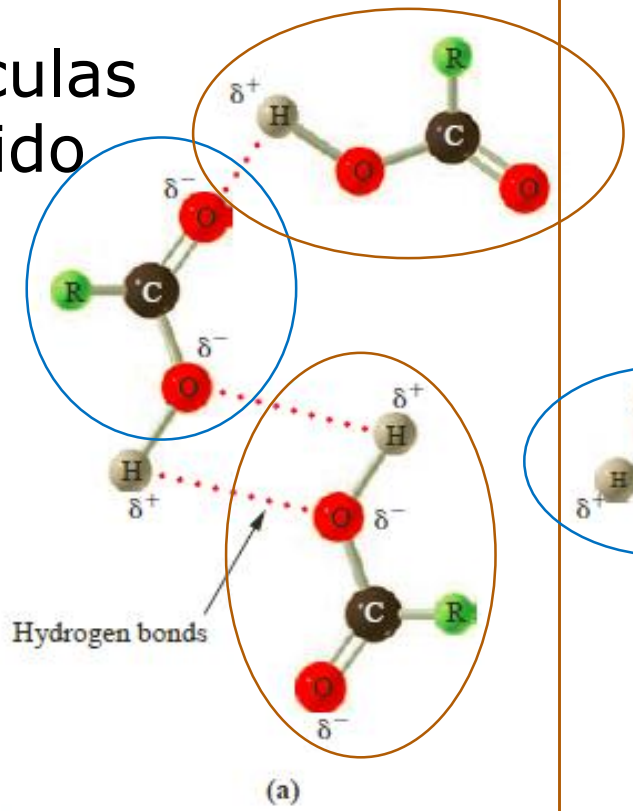
Ex: Comparação entre propriedades físicas de 2 isómeros C_2H_6O:

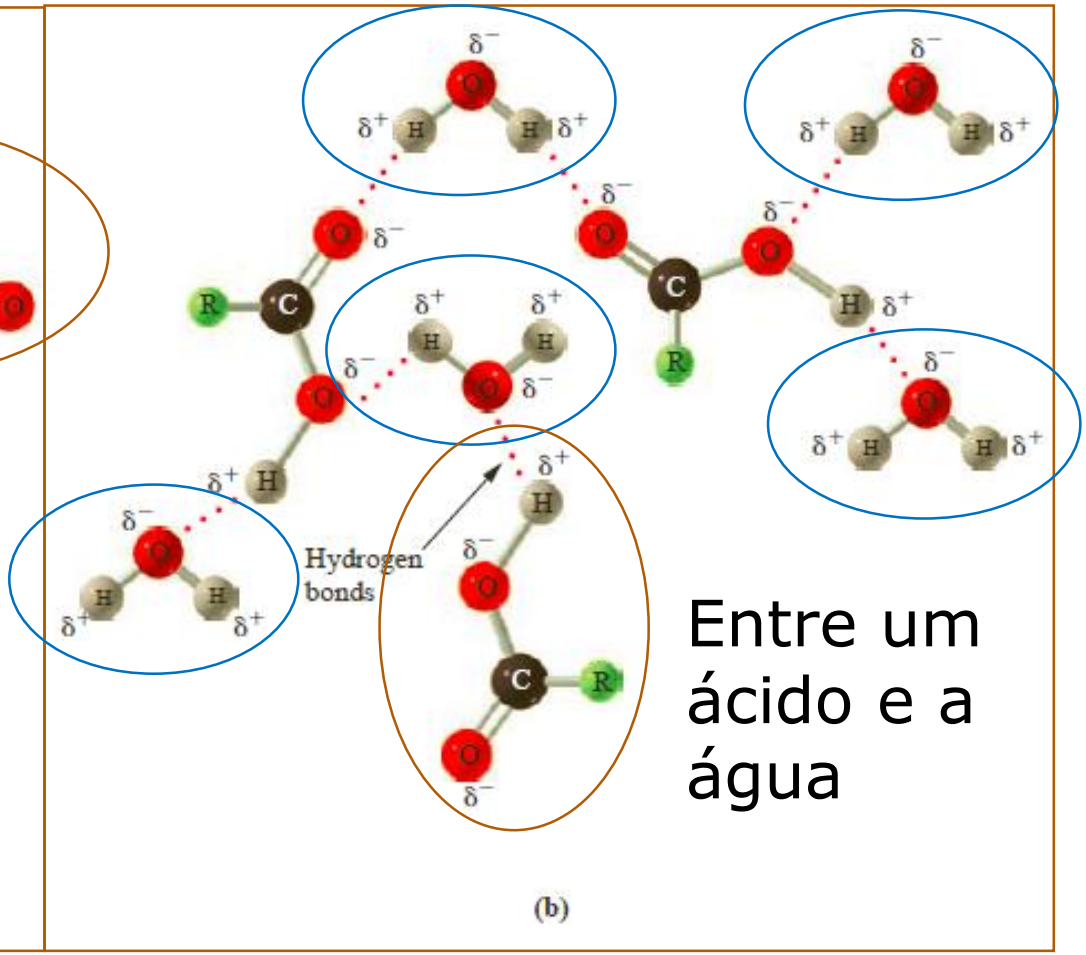
etanol ($P_{ebulição}$=78,5ºC) CH_3CH_2OH

éter dimetílico ($P_{ebulição}$=-24,9ºC) CH_3OCH_3

Pontes de hidrogénio:

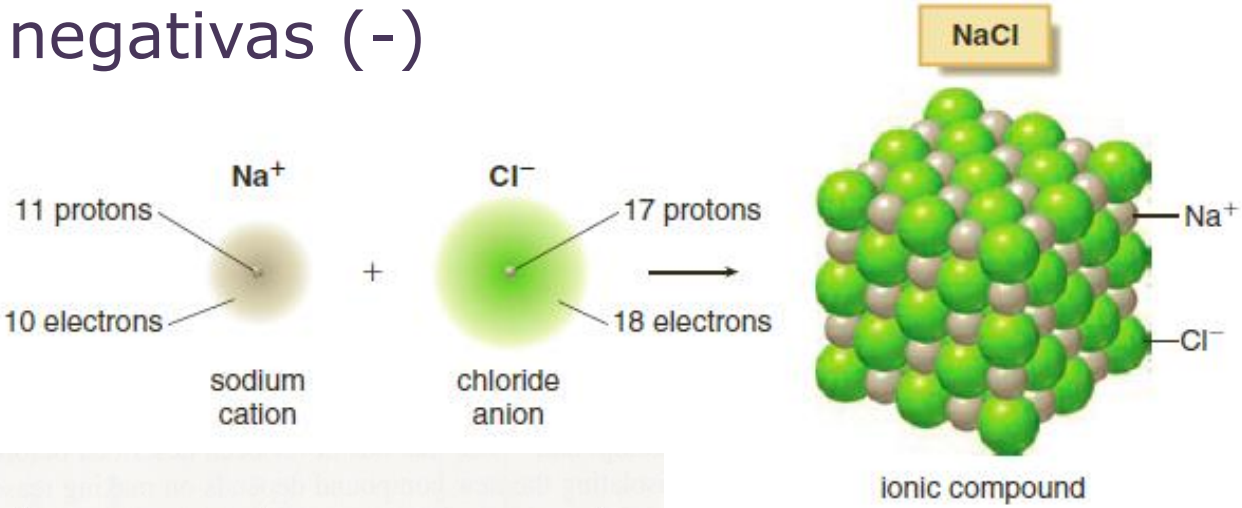
Entre moléculas de ácido





Entre um ácido e a água

Interações iónicas:
Forças de atração entre compostos com cargas positivas (+) e negativas (-)



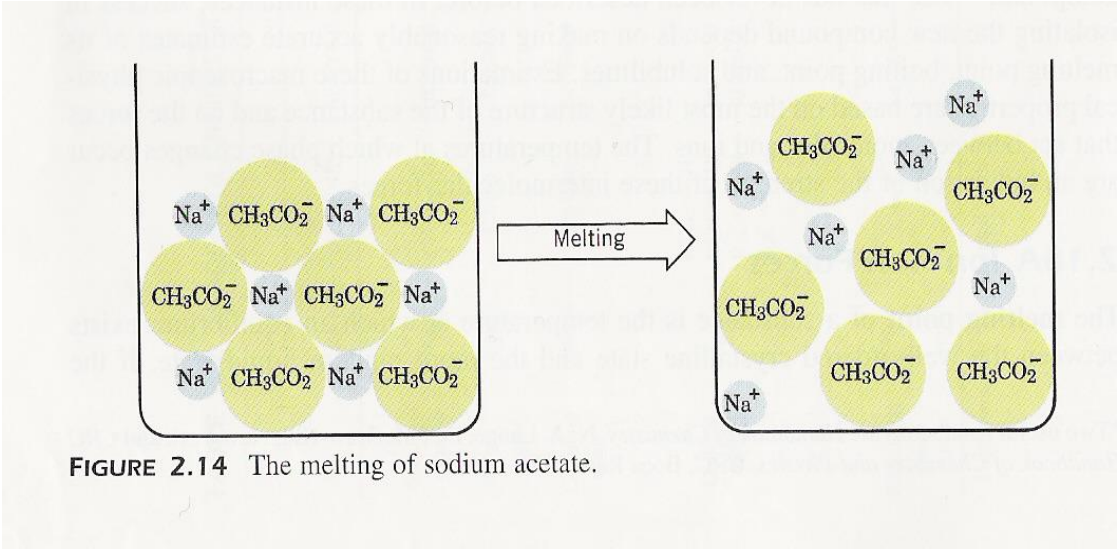
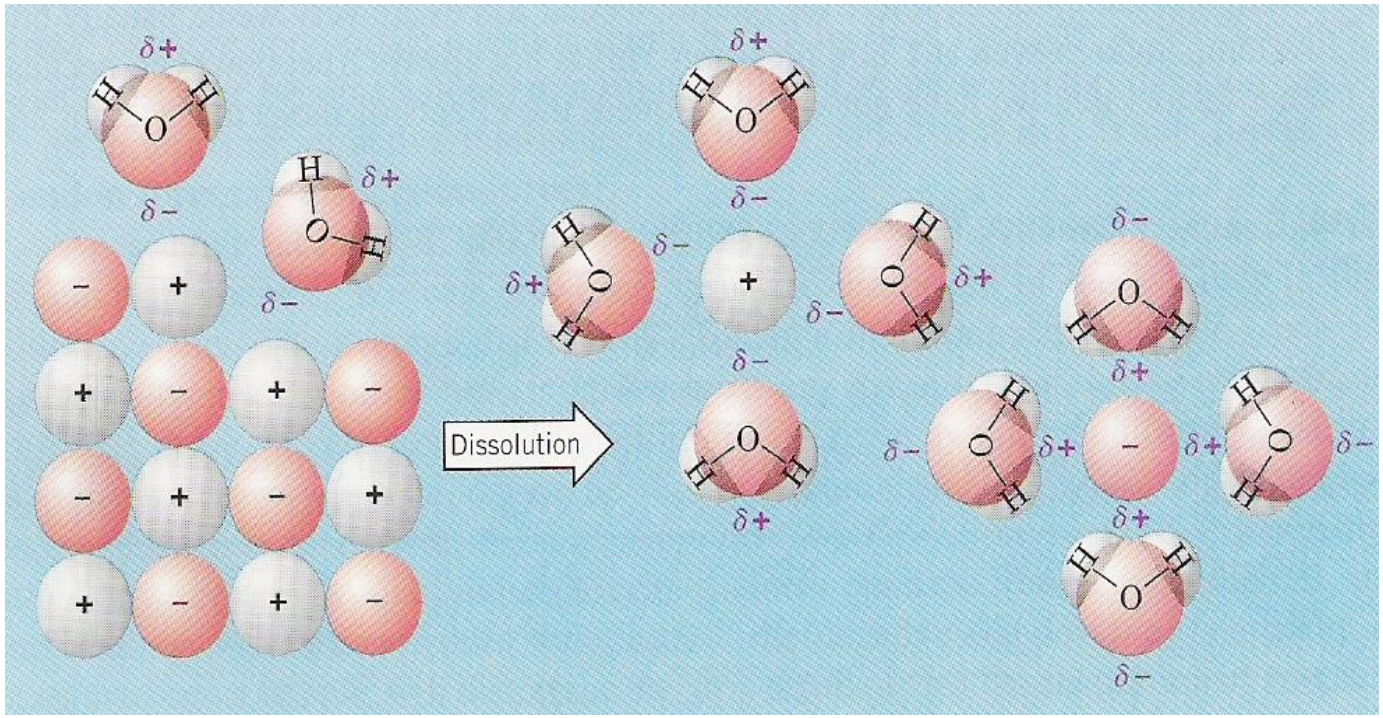


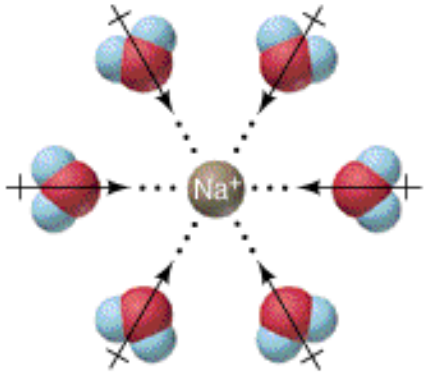
FIGURE 2.14 The melting of sodium acetate.

Ex:
solubilidade do acetato de sódio

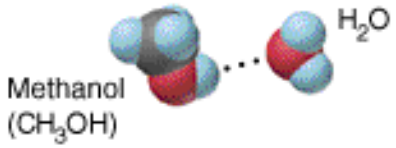
Solubilidade de um sal iónico em água:

Solvatação do NaCl

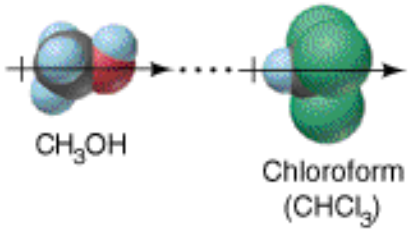




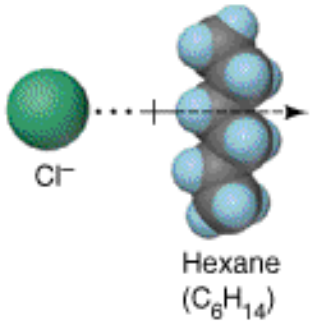
Interações iónicas



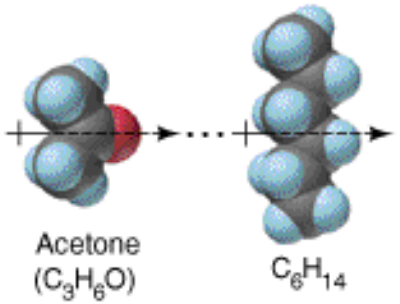
Ponte de hidrogénio



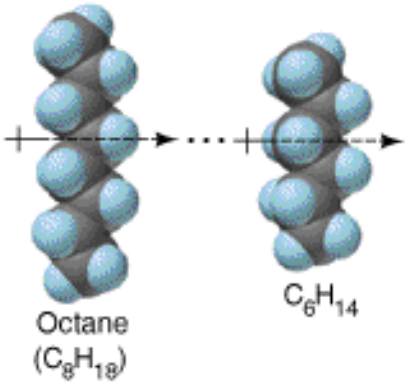
Dipolo induzido



Dipolo induzido

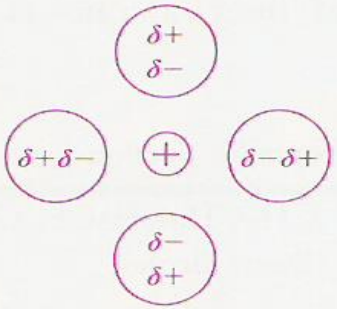
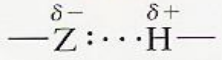
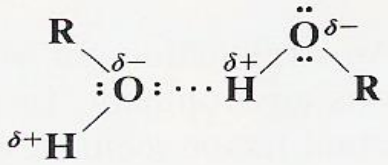


Dipolo induzido



Dipolo induzido

TABLE 2.5 Attractive electric forces

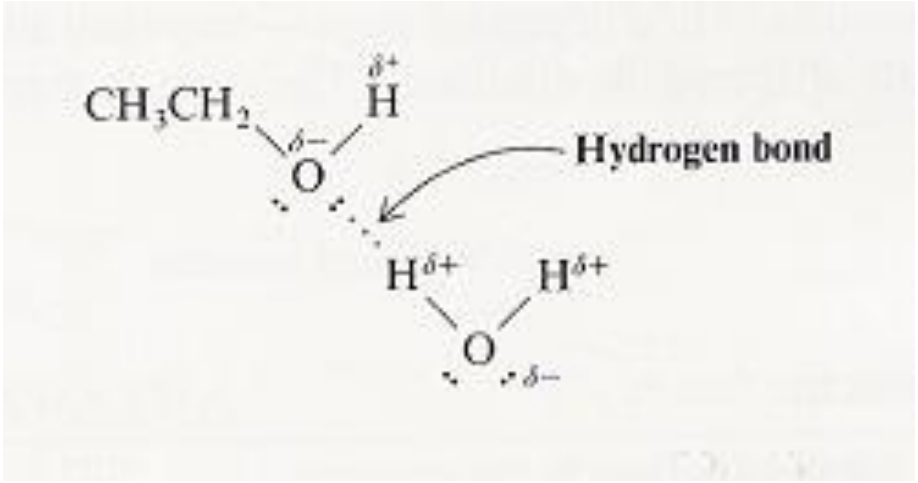
ELECTRIC FORCE	RELATIVE STRENGTH	TYPE	EXAMPLE
Cation–anion (in a crystal)	Very strong		Lithium fluoride crystal lattice
Covalent bonds	Strong (36–125 kcal mol^{-1})	Shared electron pairs	H—H (104 kcal mol^{-1}) CH_3—CH_3 (88 kcal mol^{-1}) I—I (36 kcal mol^{-1})
Ion–dipole	Moderate		Na^+ in water (see Fig. 2.18)
Dipole–dipole (including hydrogen bonds)	Moderate to weak (1–9 kcal mol^{-1})	 and 	 and 
van der Waals	Variable	Transient dipole	Interactions between methane molecules

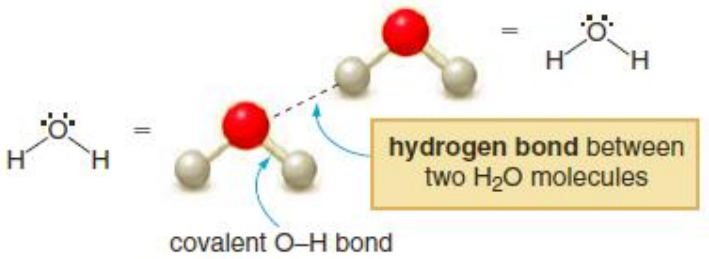
Solubilidade de ácidos e álcoois em água

- H ligado a um elemento eletronegativo pode formar **pontes de hidrogénio**

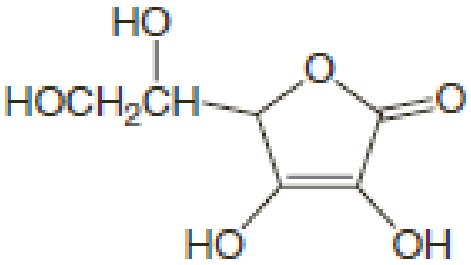
Solubilidade do etanol em água

CH_3CH_2OH

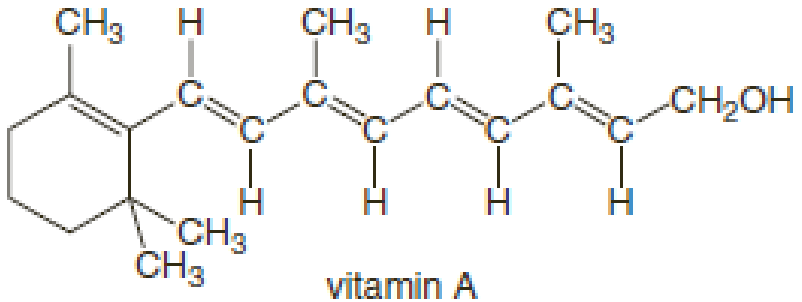




É solúvel em água?



vitamin C
(ascorbic acid)



vitamin A

**-16: London Dispersion Forces:
https://www.youtube.com/watch?v=1iYKajMsYPY&list=PLllVwaZQkS2op2kDuFifhStNsS49LAxkZ&index=16

**-17: Dipole Forces: https://www.youtube.com/watch?v=cERb1d6J4-M&list=PLllVwaZQkS2op2kDuFifhStNsS49LAxkZ&index=17

**-18: Intermolecular Forces: https://www.youtube.com/watch?v=-QqTwJzi7Wo&index=18&list=PLllVwaZQkS2op2kDuFifhStNsS49LAxkZ

**-19: Covalent Bonding:
https://www.youtube.com/watch?v=Mo4Vfqt5v2A&index=19&list=PLllVwaZQkS2op2kDuFifhStNsS49LAxkZ

**-20: Ionic Bonding:
https://www.youtube.com/watch?v=hiyTfhjeF_U&list=PLllVwaZQkS2op2kDuFifhStNsS49LAxkZ&index=20