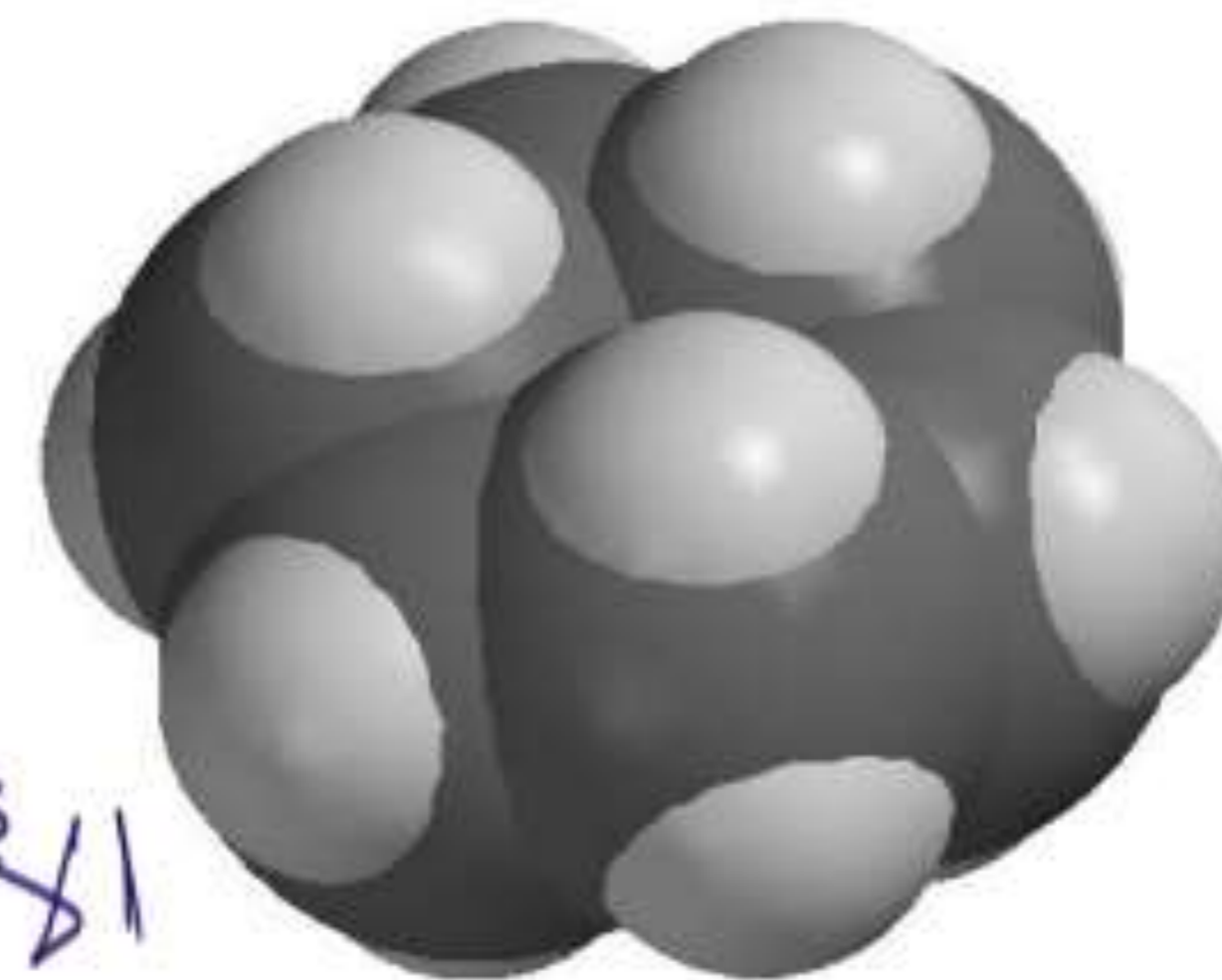
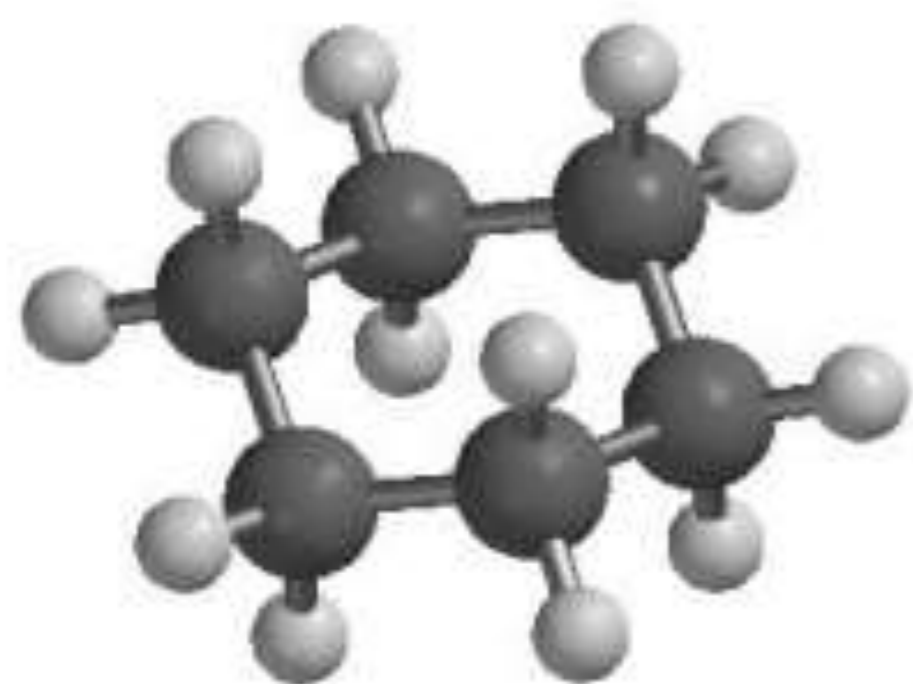




# Organic chemistry

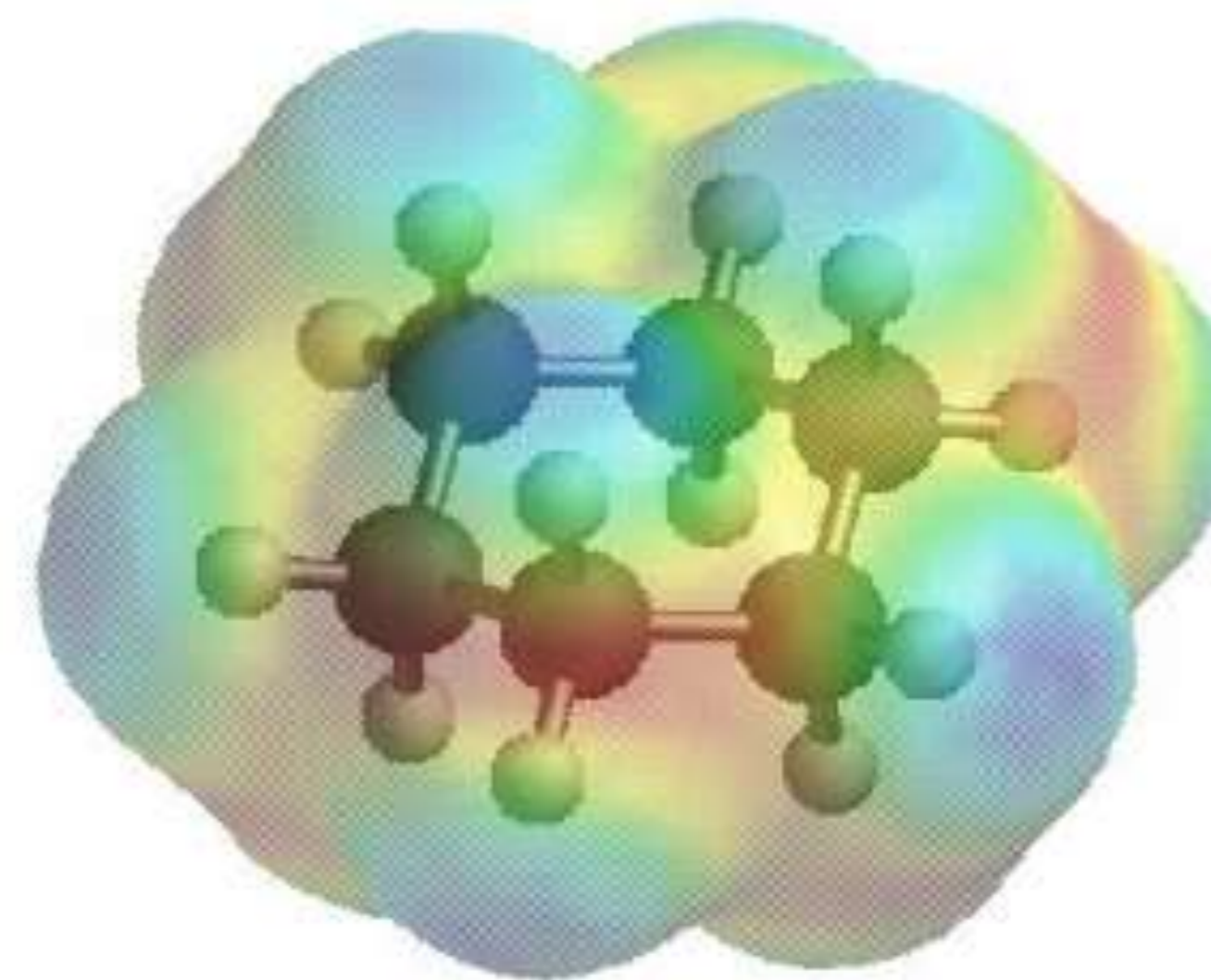
Lec: 5

Done by: Yasser Yaghi



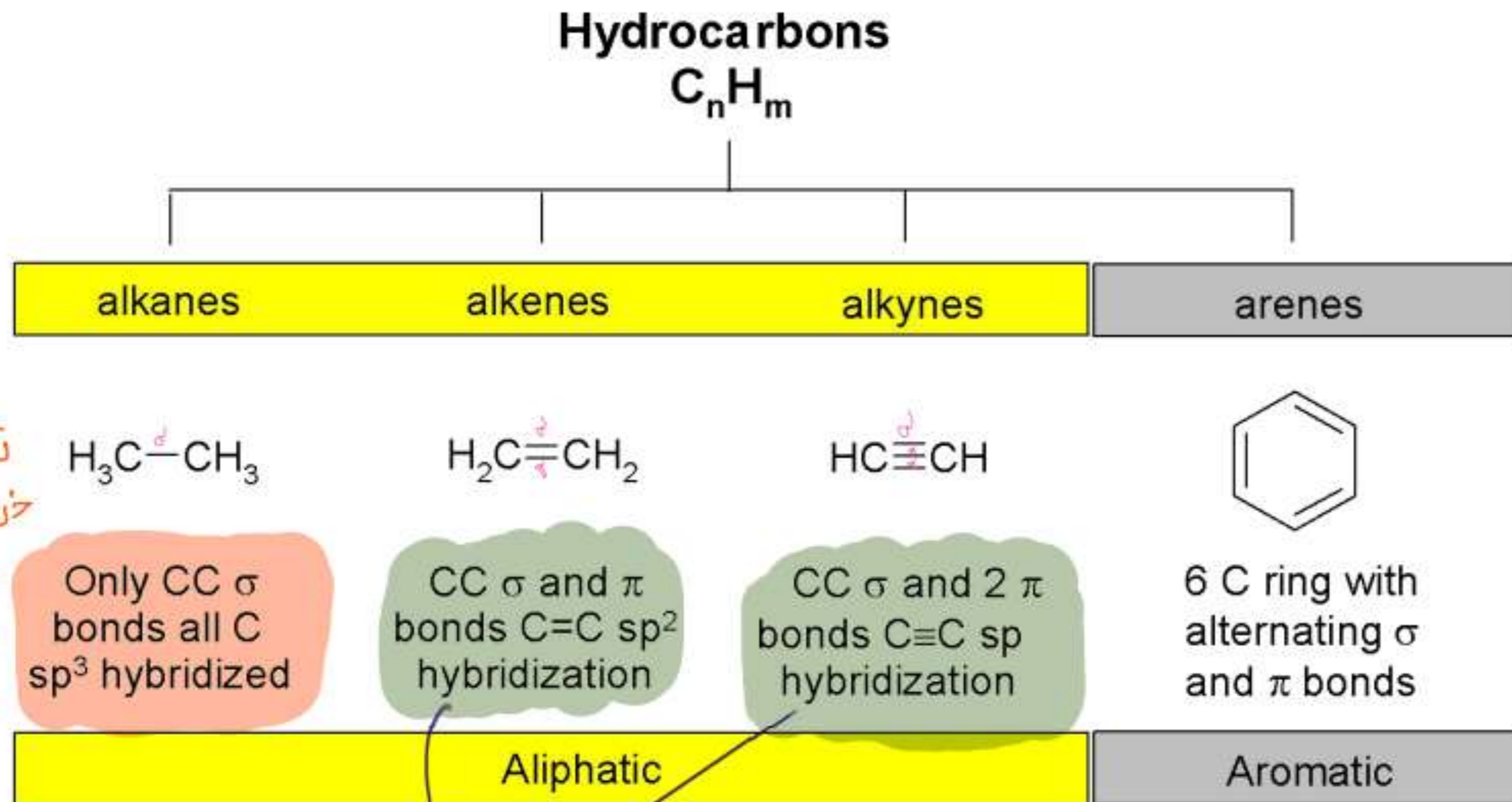
الألكانات و الألكانات الحلقيّة

**Chapter 2: Alkanes and Cycloalkanes:**  
**Conformational and Geometric**  
**Isomers**



# Types of Hydrocarbons

Hydrocarbons are compounds that only contain C and H atoms.



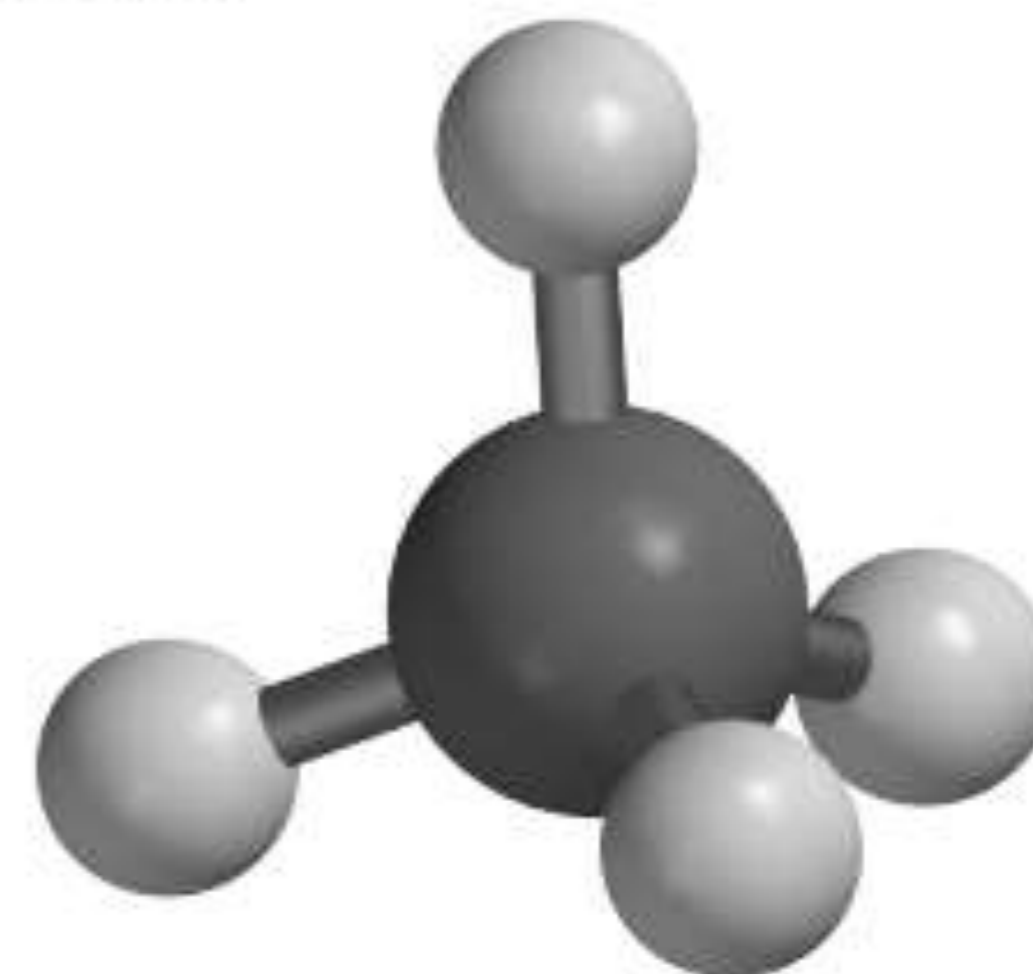
لا تعتبر أيضا  
Unsaturated hydrocarbons  
لها خيانتين غير متجانستين  
لها خيانتين كامل

تحتوي فقط على  
ذرات الكربون والهيدروجين  
حيث تكون نوع  
الرابطه احماسه  
نوع التهجيزه  
 $sp^3$   
هذا النوع من المركبات  
Saturated hydrocarbons  
نظف عليه اسم

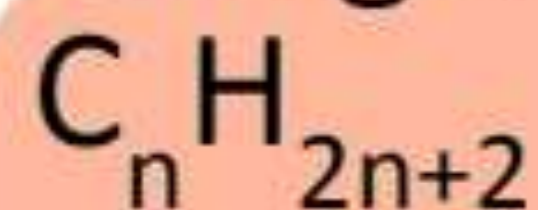
unsaturated hydrocarbons

# Structure of Alkanes

Alkanes are **saturated** hydrocarbons, that is they contain **the maximum number of H atoms possible for the number of C atoms present.**

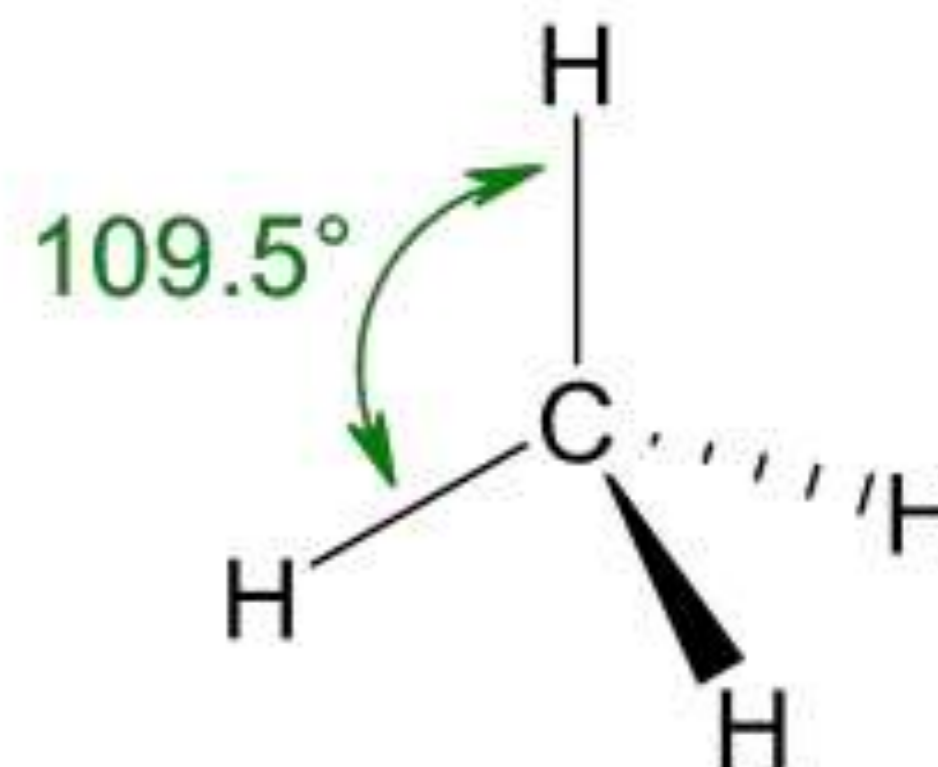


The generic formula for an alkane is:



*This is the Saturated formula*

This means every C atom is  $sp^3$  hybridized with bond angles of  $\sim 109.5^\circ$



\* نستطيع معرفة الصيغة الجزيئية للألكانات من خلال

معرفة عدد ذرات الكربون المكونة لها ثم نطبق على الصيغة العامة  $C_nH_{2n+2}$  حيث  $n$  عدد ذرات الكربون

ع.م : مركب يتكون من 3 ذرات كربون  $\therefore C_3H_8$

Test yourself

An alkane contains 14 atoms of hydrogen

So the number of carbon atoms in the same compound is :

a- 4

b- 5

c- 6

d- 7

14H ومن الصيغة العامة

الجواب  c لأن المركب يحتوي



$$2n+2=14$$

$$2n=12$$

$$n=6$$

There are 2 kinds of Alkanes:

① Open chain Alkanes

"السلسلة الكربونية"

unbranched  
(normal)

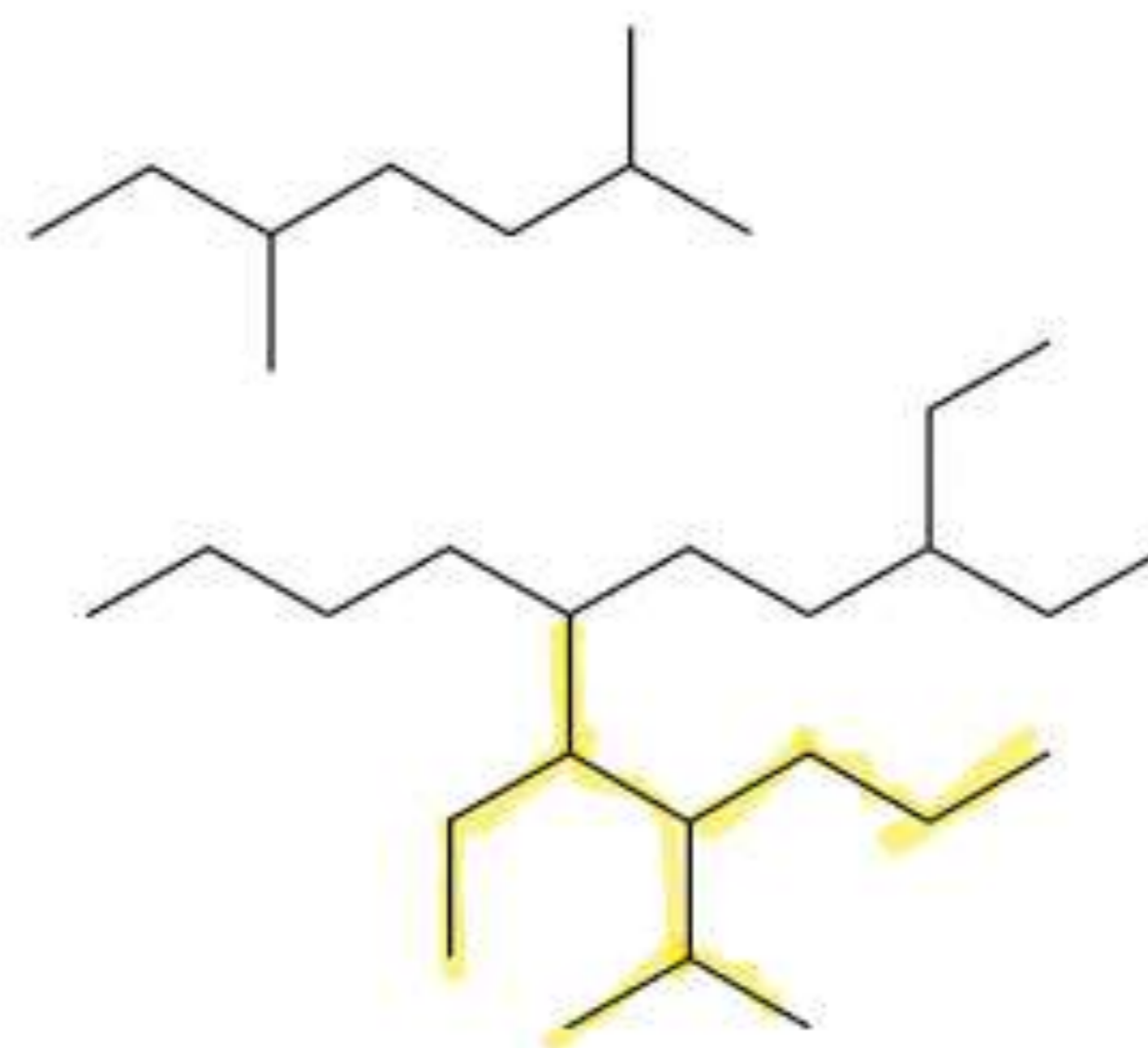
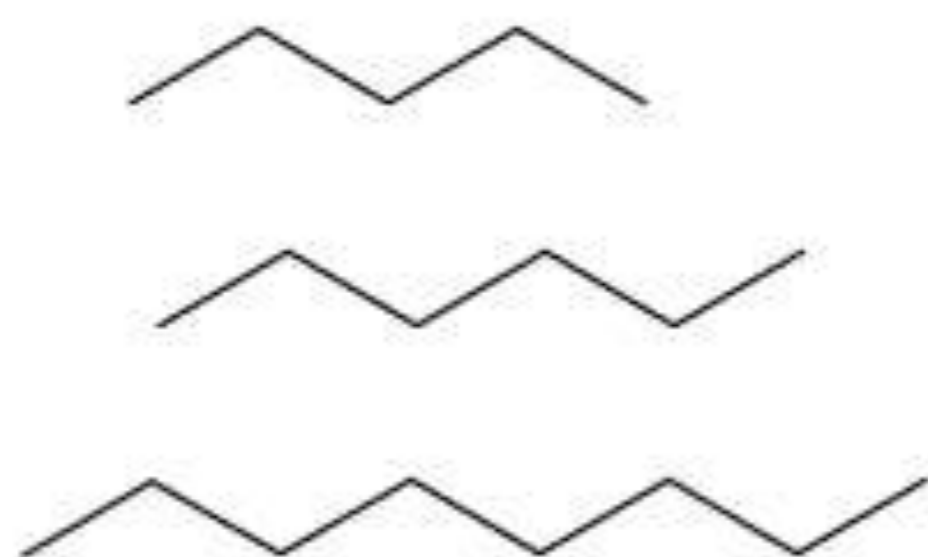
سلسلة  
بدون تفرعات

branched  
متفرعة

cycloalkanes

## Structure of Alkanes (cont'd)

Alkanes can come in two forms, **normal (or unbranched)** and **branched**. Branched alkanes can have branched branches. Therefore the number of isomers possible grows quickly



# Structure of Alkanes (cont'd)

The large number of isomers possible is due to carbon's ability to form strong C-C bonds.

Molecular Formula	Number of Isomers
$\text{CH}_4$	1
$\text{C}_2\text{H}_6$	1
$\text{C}_3\text{H}_8$	1
$\text{C}_4\text{H}_{10}$	2
$\text{C}_5\text{H}_{12}$	3
$\text{C}_6\text{H}_{14}$	5
$\text{C}_7\text{H}_{16}$	9
$\text{C}_8\text{H}_{18}$	18
$\text{C}_9\text{H}_{20}$	35
$\text{C}_{10}\text{H}_{22}$	75
$\text{C}_{15}\text{H}_{32}$	4,347
$\text{C}_{20}\text{H}_{42}$	336,319
$\text{C}_{30}\text{H}_{62}$	4,111,846,763



# Nomenclature

1- International Union of Pure and Applied Chemistry; they are known as the **IUPAC**

The IUPAC name of any compound contains 3 parts :

IUPAC name = Prefix + parent + suffix

**Prefix** : What and where substituents.

**Parent (Root)** : longest chain

**Suffix** : functional group.

2- Common names.

عدد المركبات العضوية التي كانت مكتشفة  
قبل بداية القرن العشرين كانت قليلة  
لذلك ظهرت (الأسماء الشائعة) ولكن

بسبب زيادة اكتشاف المركبات العضوية العالمية دعت الحاجة إلى إيجاد نظام عالمي لتسمية المركبات.

# الأبسطة لتسمية

## A- Unbranched Alkanes

1. The general name for acyclic saturated hydrocarbons is alkanes. The **-ane** ending is used for all saturated hydrocarbons. This is important to remember because later other endings will be used for other functional groups. Such as: -ene
2. Alkanes without branches are named according to the number of carbon atoms. These names, up to ten carbons, are given in the first column of Table 2.1.

**Table 2.1** Names and Formulas of the First Ten Unbranched Alkanes

Name	Number of carbons	Molecular formula	Structural formula	Number of structural isomers
methane	1	CH <sub>4</sub>	CH <sub>4</sub>	1
ethane	2	C <sub>2</sub> H <sub>6</sub>	CH <sub>3</sub> CH <sub>3</sub>	1
propane	3	C <sub>3</sub> H <sub>8</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>	1
butane	4	C <sub>4</sub> H <sub>10</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	2
pentane	5	C <sub>5</sub> H <sub>12</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	3
hexane	6	C <sub>6</sub> H <sub>14</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>3</sub>	5
heptane	7	C <sub>7</sub> H <sub>16</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>5</sub> CH <sub>3</sub>	9
octane	8	C <sub>8</sub> H <sub>18</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CH <sub>3</sub>	18
nonane	9	C <sub>9</sub> H <sub>20</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH <sub>3</sub>	35
decane	10	C <sub>10</sub> H <sub>22</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>8</sub> CH <sub>3</sub>	75

عند

علماً أنه بادرة كل اسم تسير في  
 عدد ذرات الكربون في المركب  
 meth → 1C  
 ----  
 hexa → 6C  
 etc ...

## B- Branched Alkanes



1- نحدد أطول سلسلة كربون مستمرة

3. For alkanes with branches, the **root (parent)** name is that of the longest continuous chain of carbon atoms. For example, in the structure.



في هذه الحالة  
أطول سلاسل  
تكونت من 5 ذرات C

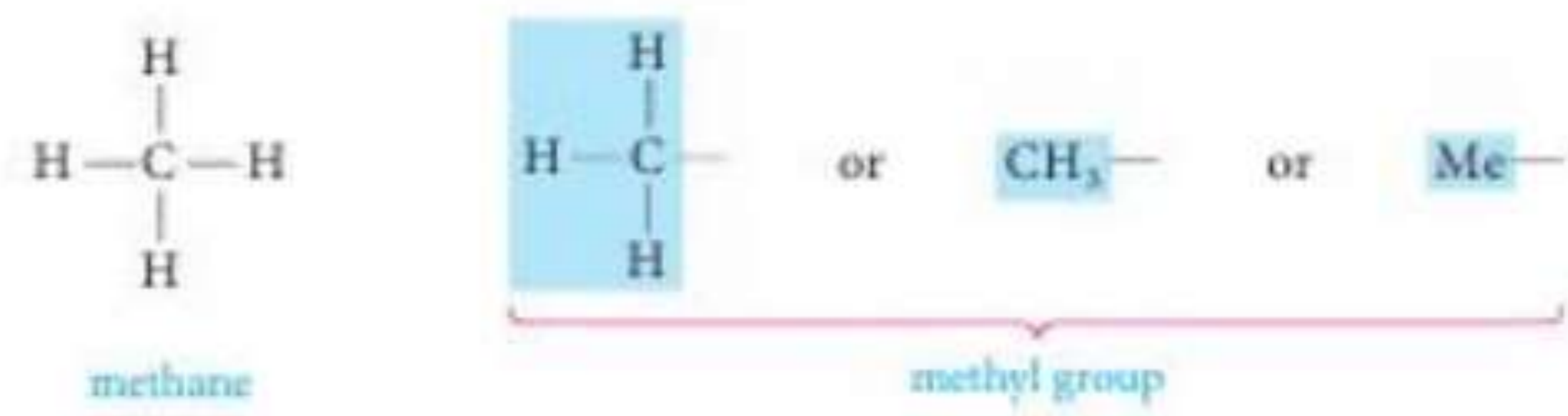
Root or parent = pentane

بذلك تكون سلاسل  
التصنيف المكونة من السلاسل  
المتبقية

4. Groups attached to the main chain are called **substituents**. Saturated substituents that contain only carbon and hydrogen are called **alkyl groups**. An **alkyl group** is named by taking the name of the alkane with the same number of carbon atoms and changing the -ane ending to -yl.

تفرعات

مجموعة الألكيل alkyl group



هي عبارة عن  
Alkane - H

eg  $\text{CH}_4 - \text{H} : \text{CH}_3$   
ونسبيل مقطع -ane إلى -yl

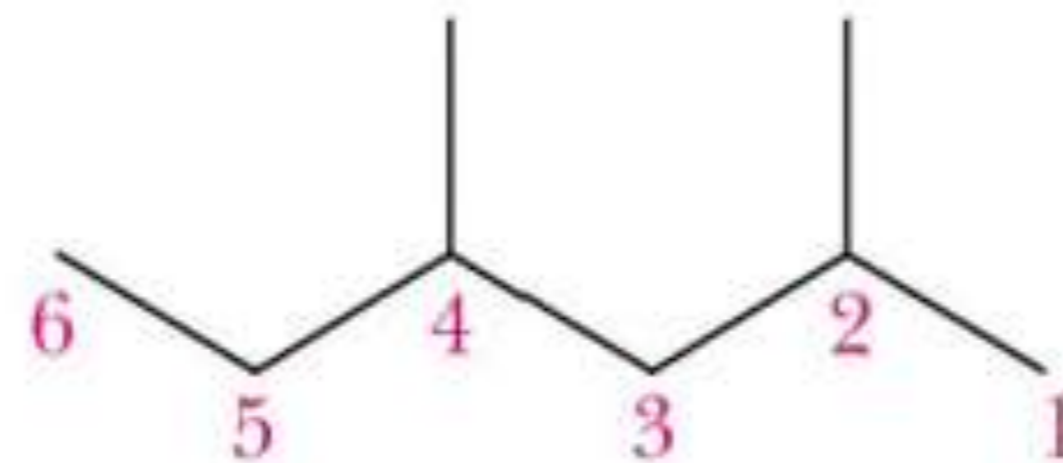
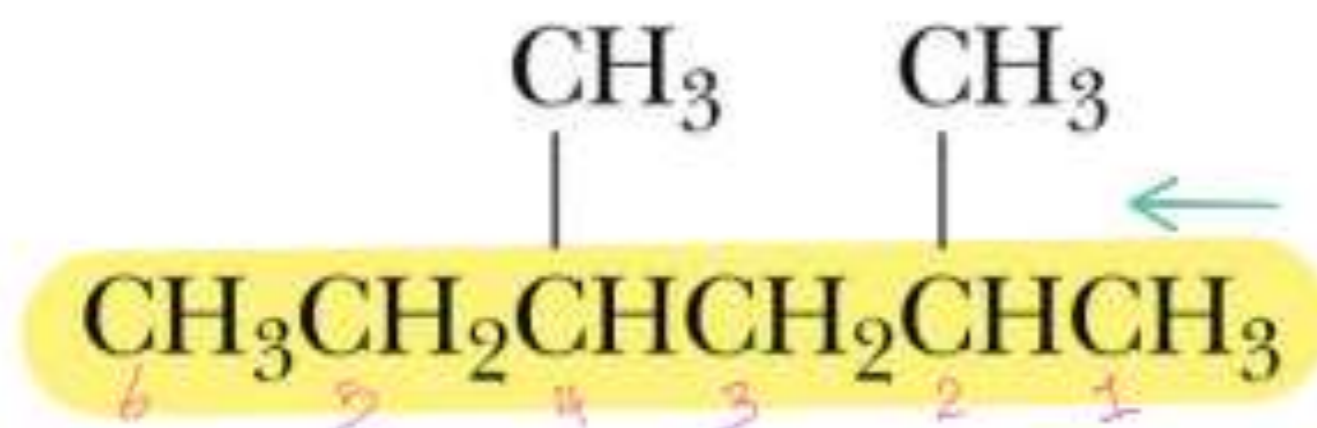
5- ترقيم السلسلة الأول بعين تعطي أول تفرع أقل عدد ممكن انظر المثال أسفل الصفحة لتوضيح هذه الخطوة ↓

5. The main chain is numbered in such a way that **the first substituent** encountered along the chain **receives the lowest possible number**.

When two or more **identical groups** are attached to the main chain, **prefixes such as di-, tri-, and tetra-** are used.

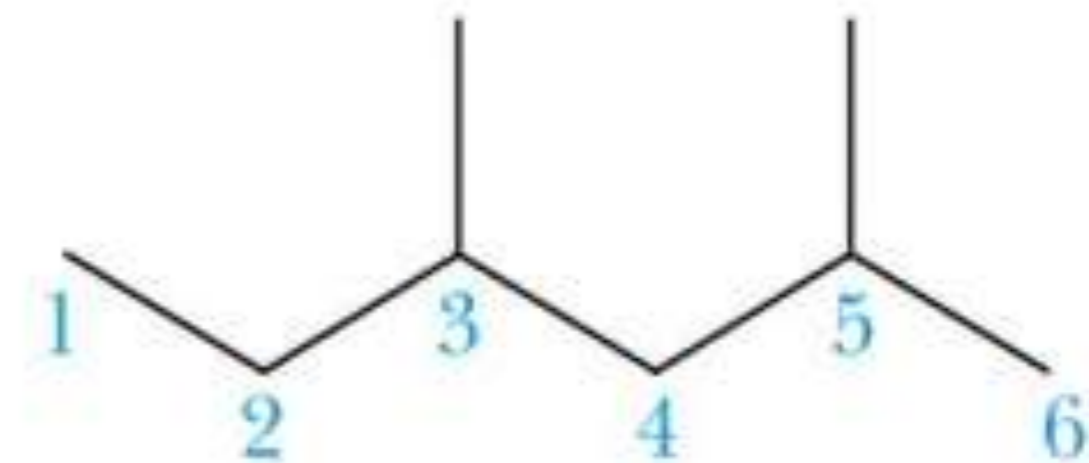
ثنائي ثلاثي رباعي

Every substituent must be named and numbered, even if two identical substituents are attached to the same carbon of the main chain.



2,4-Dimethylhexane

Capital letter



(not 3,5-dimethylhexane)

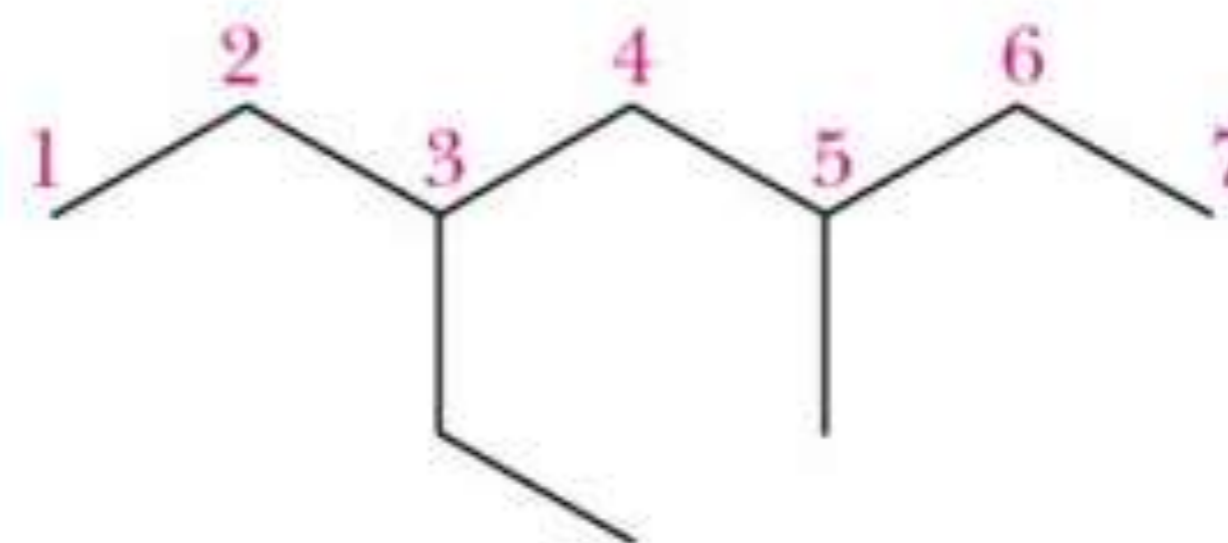
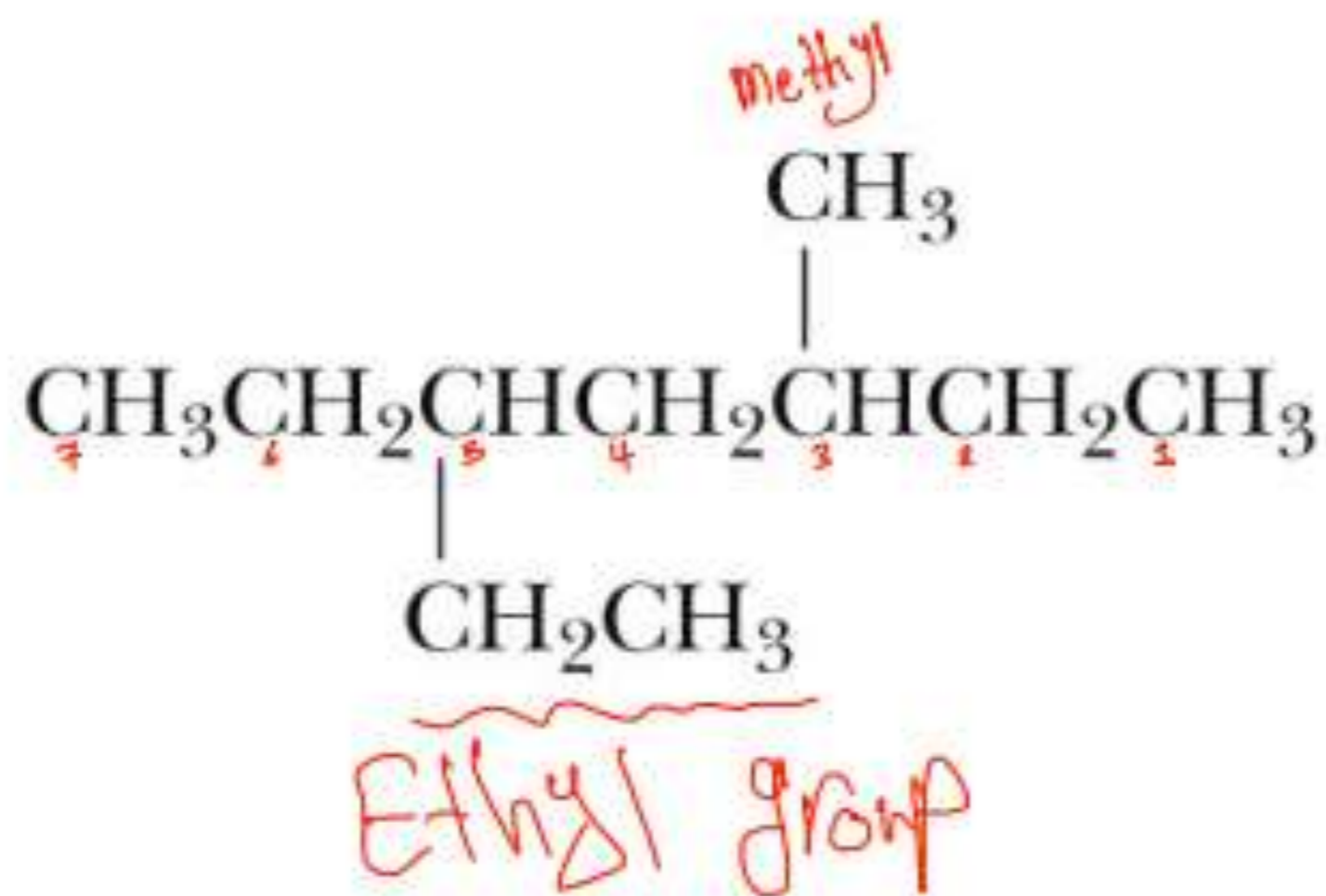
\* في هذا المركب، وبعد أن حددنا السلسلة الأول نجد أنه يوجد تفرعان، ولكي نحدد من أي جهة نعد، نجد أننا لو بدأنا العد من اليمين لأعطينا التفرع الأول من جهة اليمين رقم 2 ولو بدأنا العد من اليسار أعطينا للتفرع الأول من جهة اليسار رقم 3 وبما أن 2 < 3، نبدأ العد من جهة اليمين.

6. If there are two or more different substituents,

إذا كان لدينا فروع مختلفة نرتبهم حسب الترتيب الأبجدي.

– list them in alphabetical order.

– number from the end of the chain that gives the substituent encountered first the lower number.



3-Ethyl-5-Methyl heptane

3-Ethyl-5-methylheptane

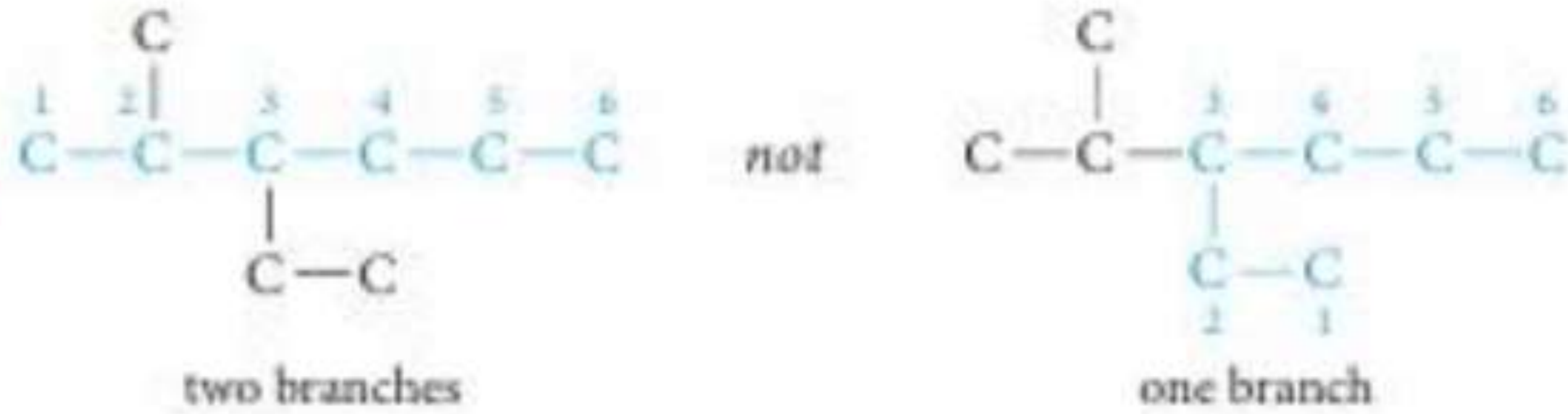
بين الأعداد والأحرف

نلاحظ في هذا المركب لو بدأنا تسمية من اليمين أو اليسار تعطى الأرقام نفسها للفروع، وفي هذه الحالة نبدأ من الجهة الأخرى للتفرع الذي أول حرف فيه يسبق بالترتيب الأبجدي.

الـ E أول حرف وهو يسبق الحرف M في الترتيب الأبجدي.

إذا واجهنا عند تحديد السلسلة الأول في المركب سلسلتين نفس عدد ذرات الكربون فإننا ننظر إلى عدد التفرعات في كل منها ونختار السلسلة التي عدد تفرعات فيها أكثر.

If there are two equally long continuous chains, select the one with the most branches. For example,



2-Methyl-3-Ethyl hexan.

If there is a branch equidistant from each end of the longest chain, begin numbering nearest to a third branch:



عند بدء العد من اليمين

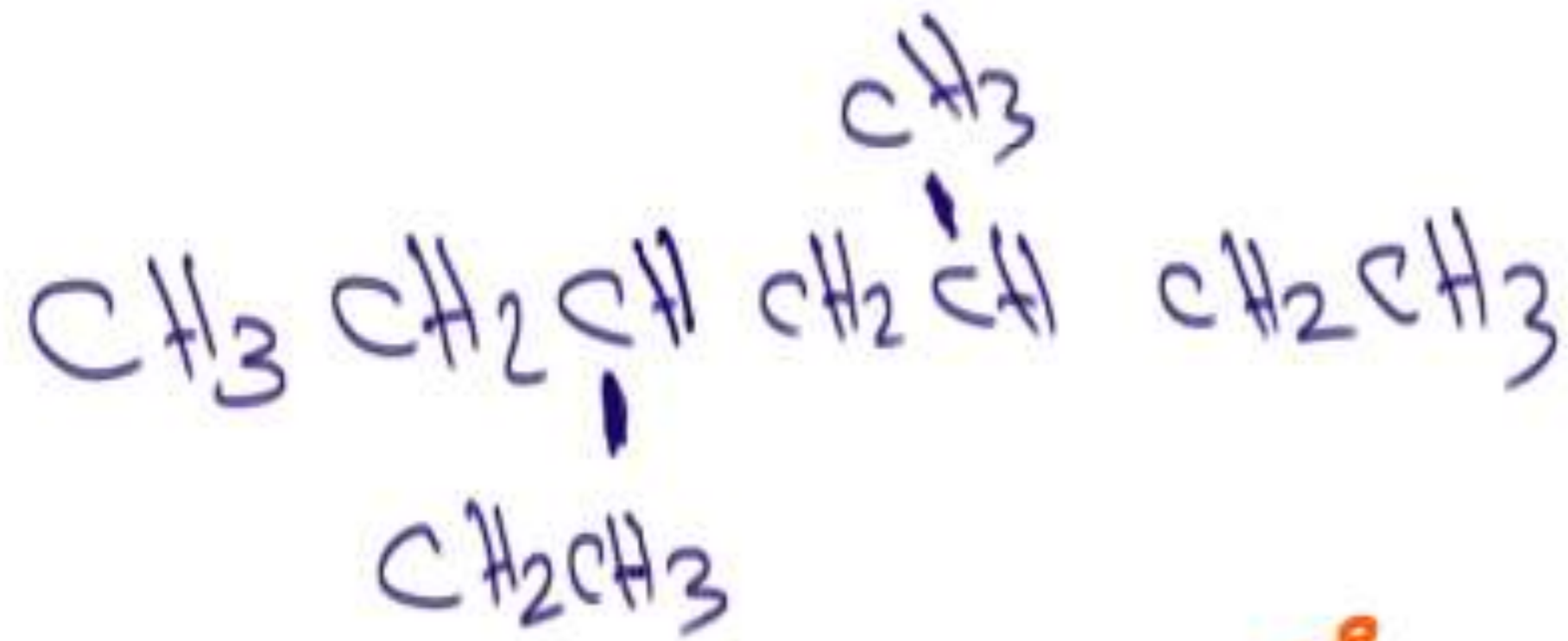
\* إذا كان في المركب 3 تفرعات نبدأ العد من الجهة التي تعطي أقل مجموع أرقام التفرعات جميعها في هذا المثال إذا بدأنا من اليمين سيكون المجموع  $2+3+6=11$  وإذا بدأنا من اليسار  $2+5+6=13$  لذلك نبدأ من اليمين في السلسلة من اليسار.

# ملحوظة هامة

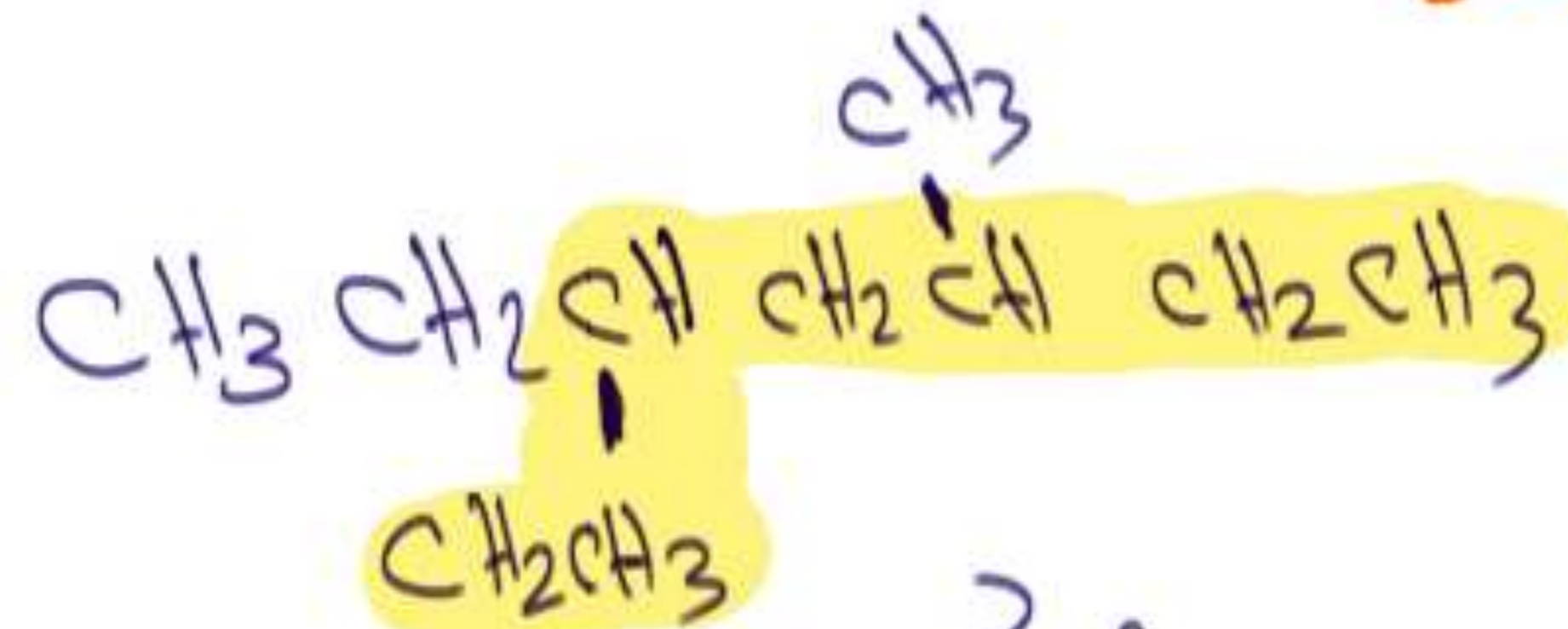
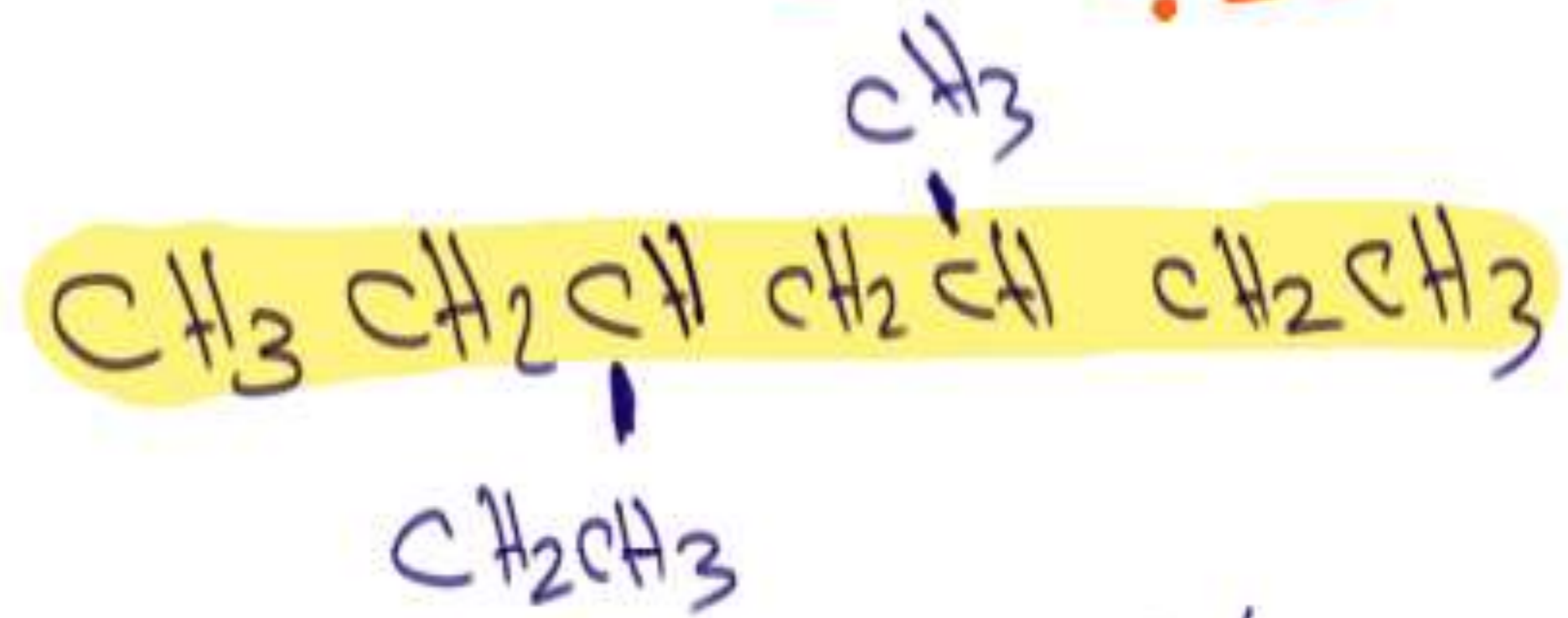
سأعطيكم مثالاً ولا حظوا مني :

حدد سلسلة الكربون الأطول

جواب: أكثد



جواب: هدى



برأيكم من منها على جواب؟ نعم كلاهما على جواب لأن كلا السلسلتين تتكون من 7 ذرات كربون والأهم أن من كل سلسلة يتفرع تفرعان؛ لذلك تسمية أحد المركب معاملة تافاً لتسمية هدى، جرب بنفسك بالطريقتين إلا سم النتائج سوف يكون

3-Ethyl-5-Methylheptan

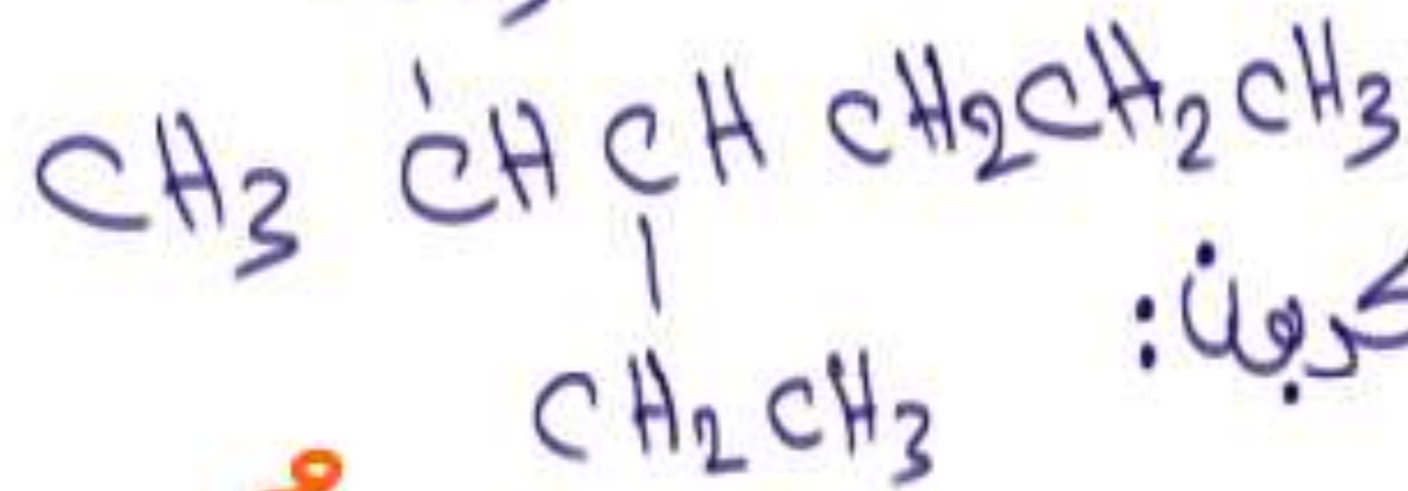
تابع ↓

If there are two equally long continuous chains, select the one with the most branches. For example,



ولكنه ذكرنا في قبل ذلك  
أنه في بعض الحالات خرد السلسلة  
التي يخرج منها أكبر عدد من التفرعات

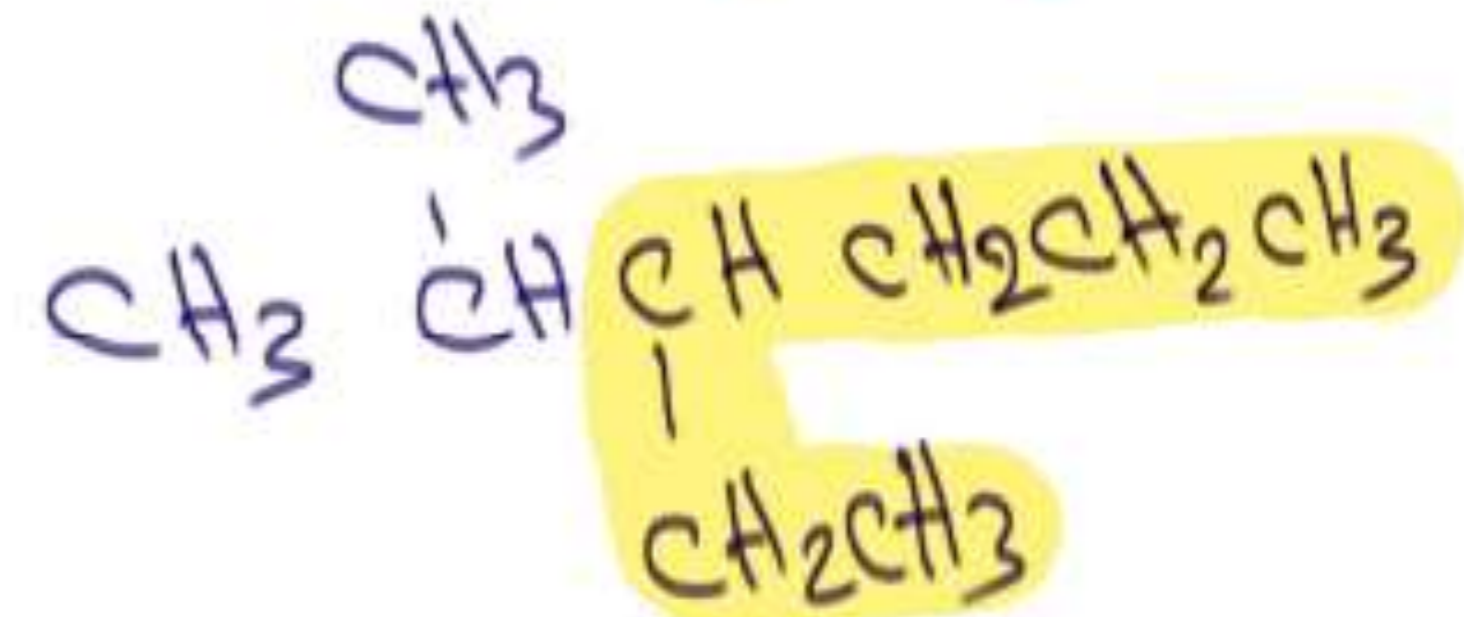
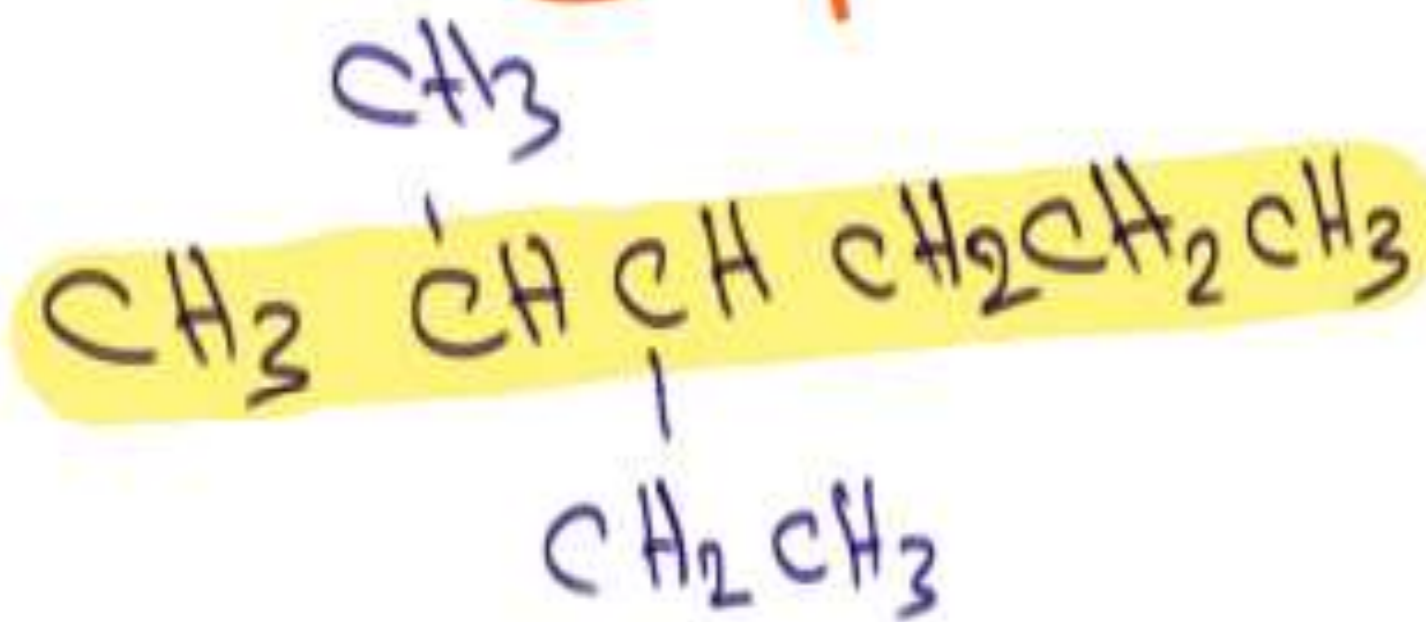
فلنر من المركب هذا



على أكثر وهدي ونظ من هنا تحديد أول سلسلة كربون:

هدي

أكثر



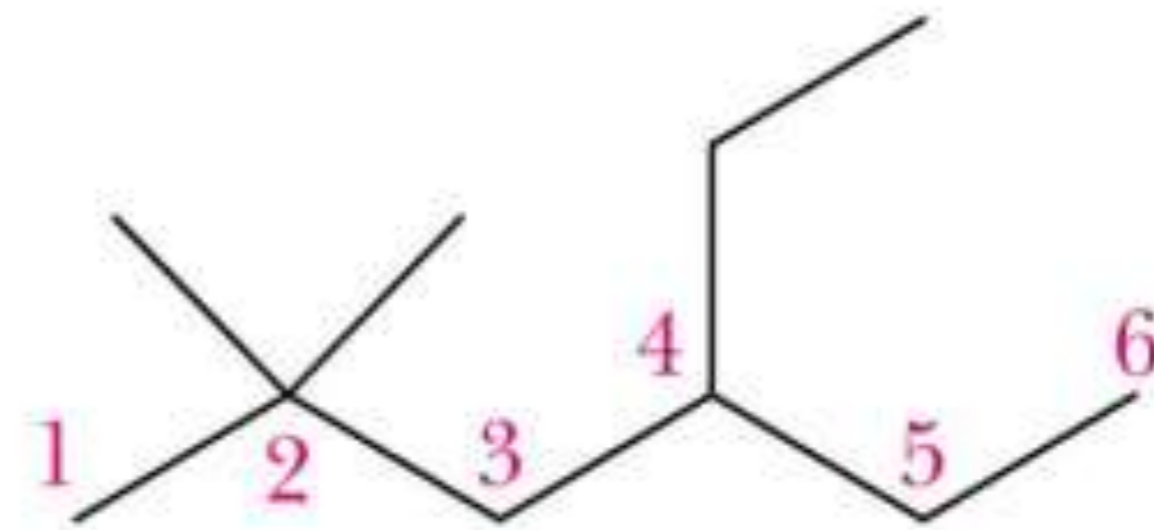
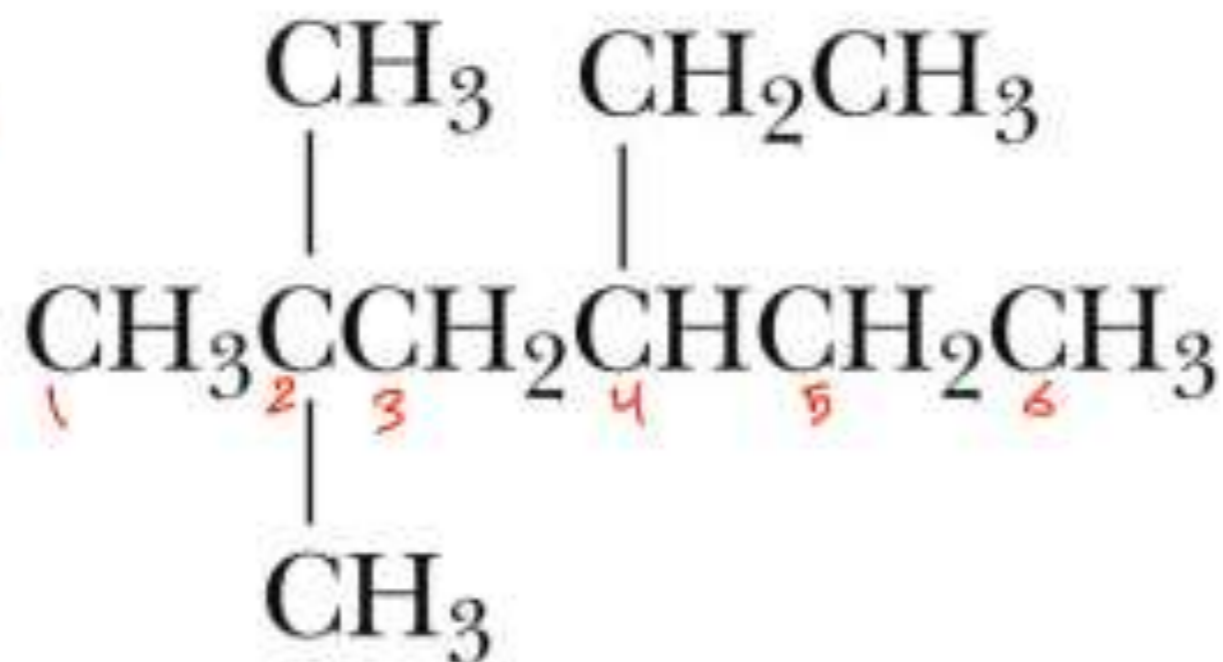
في هذه الحالة كلا السلسلتين تحتوي 6 C ولكن نلاحظ أنه سلسلة هدي تفتح منها  
تفرعان وسلسلة أكثر تفرع واحد ← وبناءً على القاعدة الموجودة أعلى الصفحة  
والتي وضعناها سابقاً يكون تحديد هدي للسلسلة صحيحاً وتحديد أكثر خاطئاً.  
وهذا الاختلاف في تحديد السلسلة ينبع عنه اختلاف في التسمية لذلك وجب التنبية!



لا تؤخذ في عين الاعتبار في ترتيب التسمية أبعدياً

7. The prefixes *di-*, *tri-*, *tetra-*, *sec-*, *tert-* etc. are not included in alphabetization. *Iso*, as in isopropyl, is included in alphabetization. In the following example, the alphabetizing names are ethyl and methyl.

\* تبدأ التسمية من الأعداد الأولى بفرع



4-Ethyl-2,2-dimethylhexane  
(not 2,2-dimethyl-4-ethylhexane)

\* تبدأ التسمية من الأعداد الأولى بفرع  
\* التسمية  
\* ونقول

لا تؤخذ بعين الاعتبار  
نقسم بالحرف الذي بعدها

## Alkyl and Halogen Substituents

- **Alkyl group**: A substituent derived by removal of a hydrogen from an alkane; given the symbol **R-**.
- $\text{CH}_4$  becomes  $\text{CH}_3-$  (methyl).
- $\text{CH}_3\text{CH}_3$  becomes  $\text{CH}_3\text{CH}_2-$  (ethyl).
- Halogen substituents are named by changing the -ine ending of the element to -o.

F—	Cl—	Br—	I—
fluoro-	chloro-	bromo-	iodo-

حفظ

## Names of the Most Common Alkyl Groups

Name	Condensed Structural Formula	Name	Condensed Structural Formula
methyl	$-\text{CH}_3$	isobutyl	$-\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3$
ethyl	$-\text{CH}_2\text{CH}_3$	sec-butyl	$-\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
propyl	$-\text{CH}_2\text{CH}_2\text{CH}_3$	tert-butyl	$-\text{C}(\text{CH}_3)_3$
isopropyl	$-\text{CH}(\text{CH}_3)_2$		
butyl	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$		

وإذا أخذنا في عين الاعتبار عند التسمية

لا يؤخذ في الاعتبار عند التسمية أبدياً

abbreviation for "secondary"

abbreviation for "tertiary"

\* إذا حذفنا ذرة الهيدروجين من أول سلسلة في البروبان  $-\text{CH}_2\text{CH}_2\text{CH}_3$

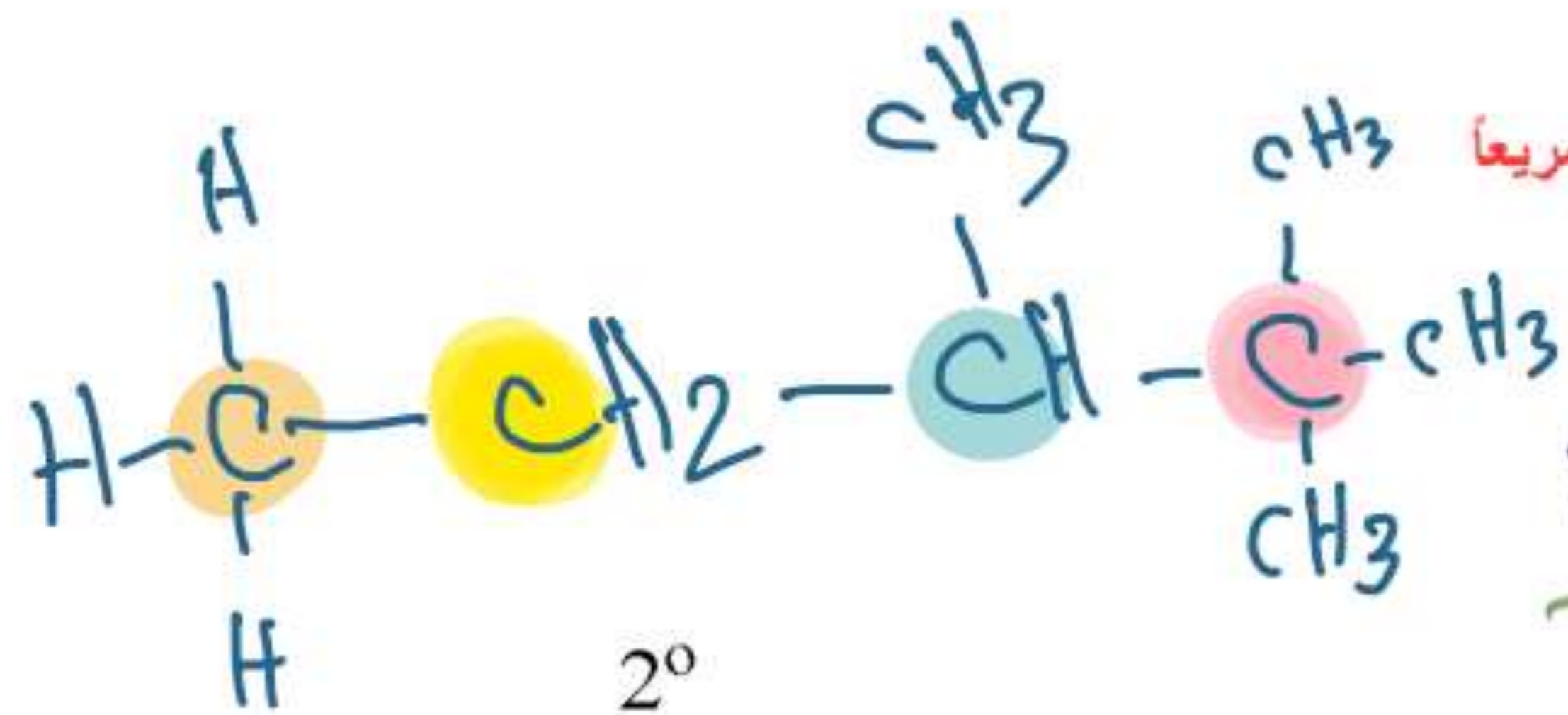
isopropyl

وهنا

تؤخذ بعين الاعتبار في التسمية «الأبوية»

إذا حذفنا ذرة H من ثاني ذرة في البروبان

طريقة التفريق بين (isobutyl و secbutyl)  
 الذرة الأولى مرتبطة methyl group  
 الذرة الثانية مرتبطة methyl group



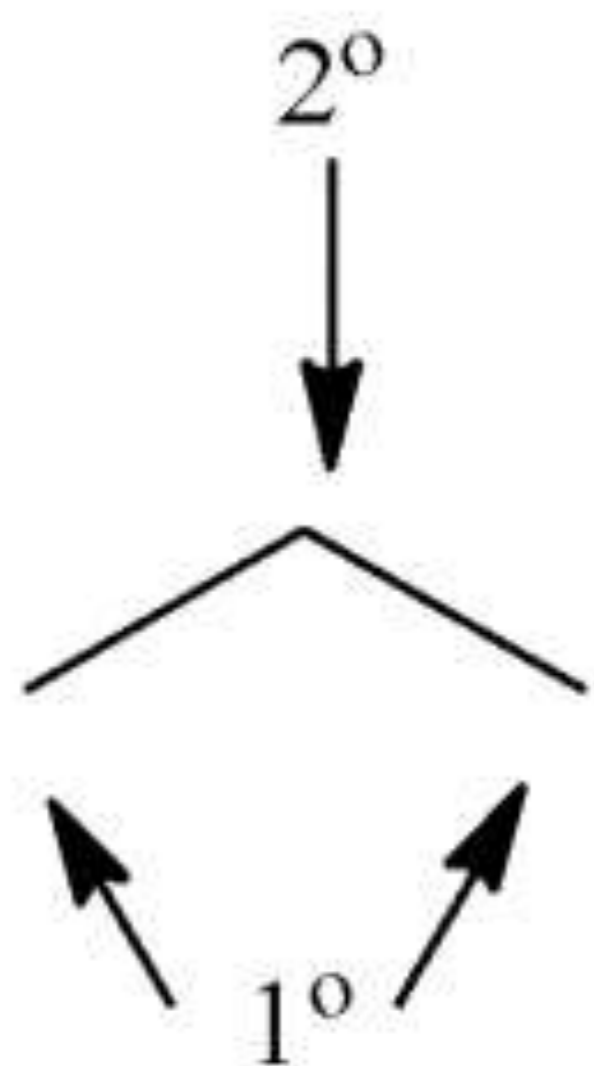
هناك موضوع شرحه الدكتور بـعجالة وقال انه غير مهم ولكن سأقوم بشرحه سريعاً

المرتبط بـ 3 ذرات H وذرة كربون تسمى  
Primary Carbon

المرتبط بـ 2 ذرة H تسمى  
Secondary Carbon

المرتبط بذرة H واحدة تسمى  
Tertiary Carbon

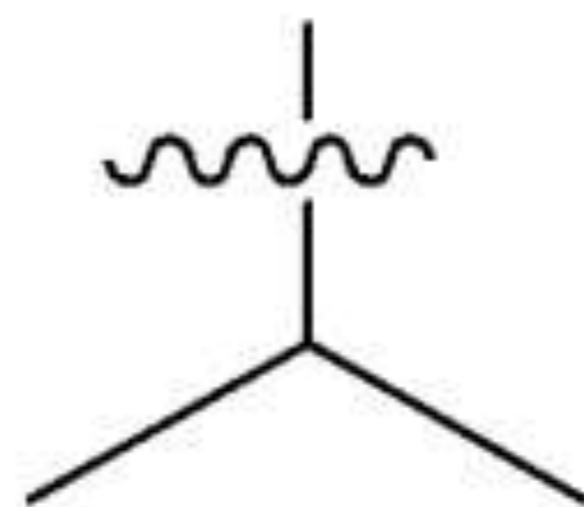
ليست مرتبطة بأي ذرة H تسمى  
quaternary carbon



Propane



Propyl

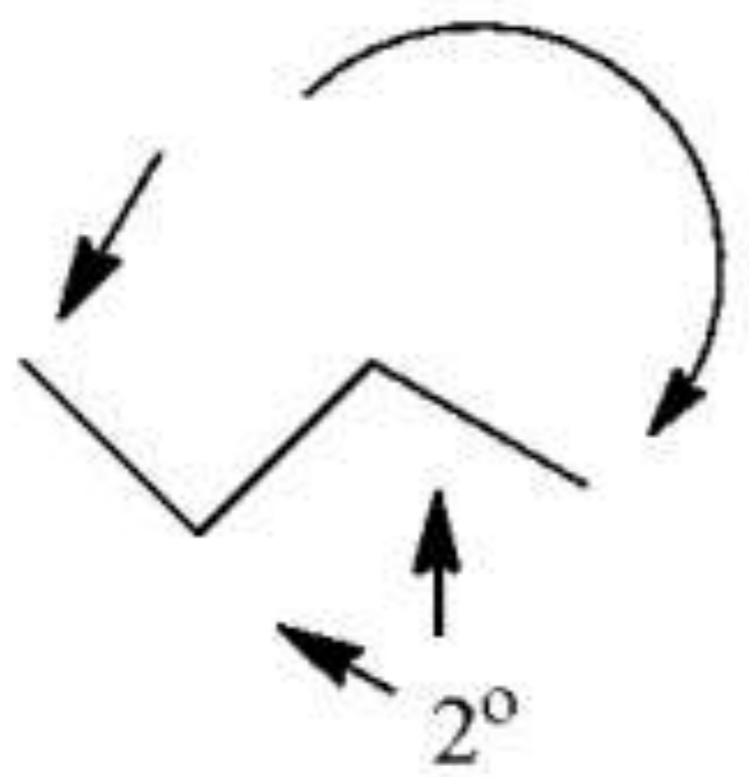


isopropyl

\* ما طلبه الدكتور هو حفظ الجدول السابق

فم يشرح التفصيل

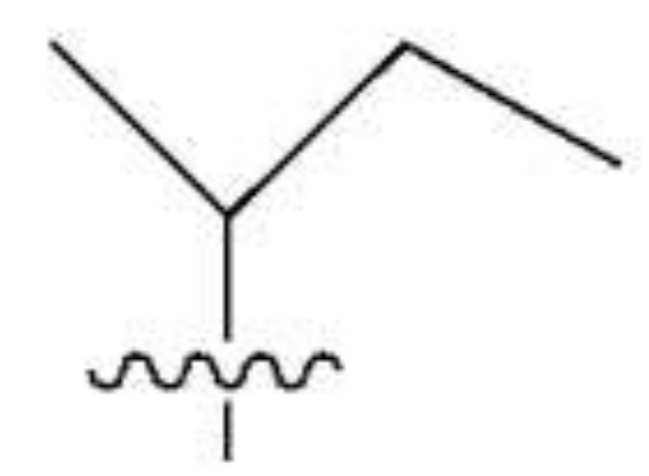
گروہ مطلوب



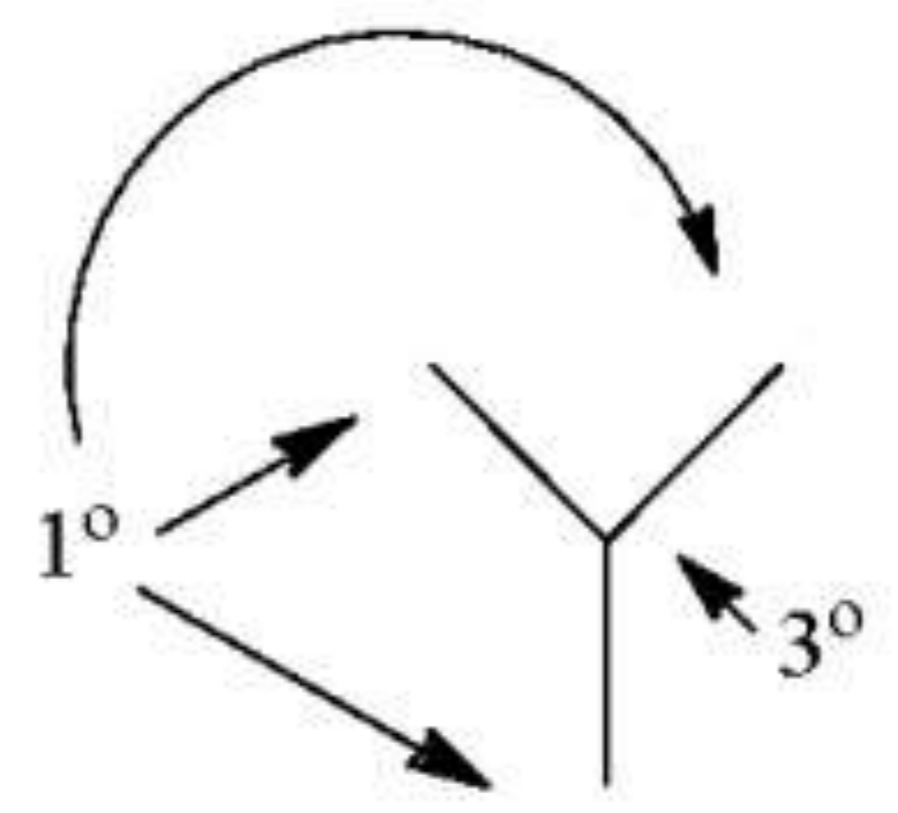
Butane



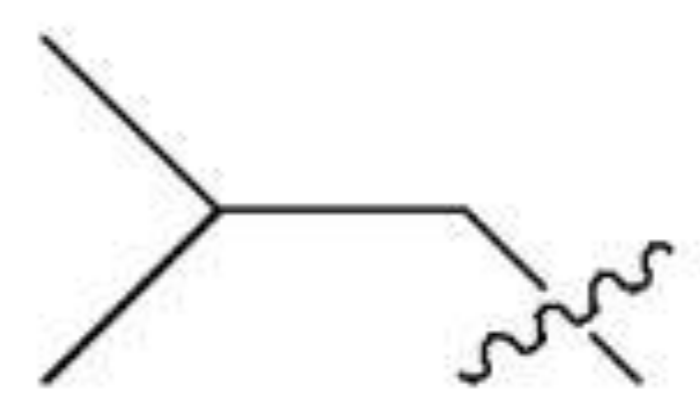
butyl



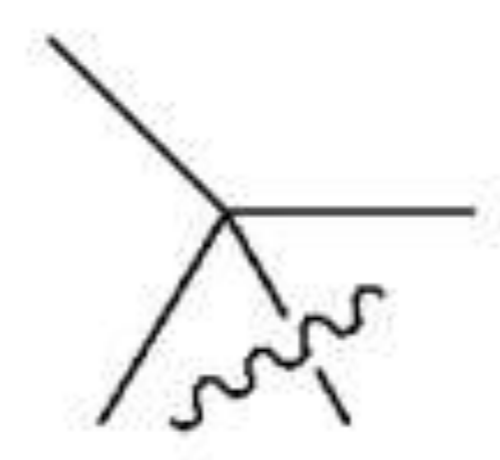
sec-butyl



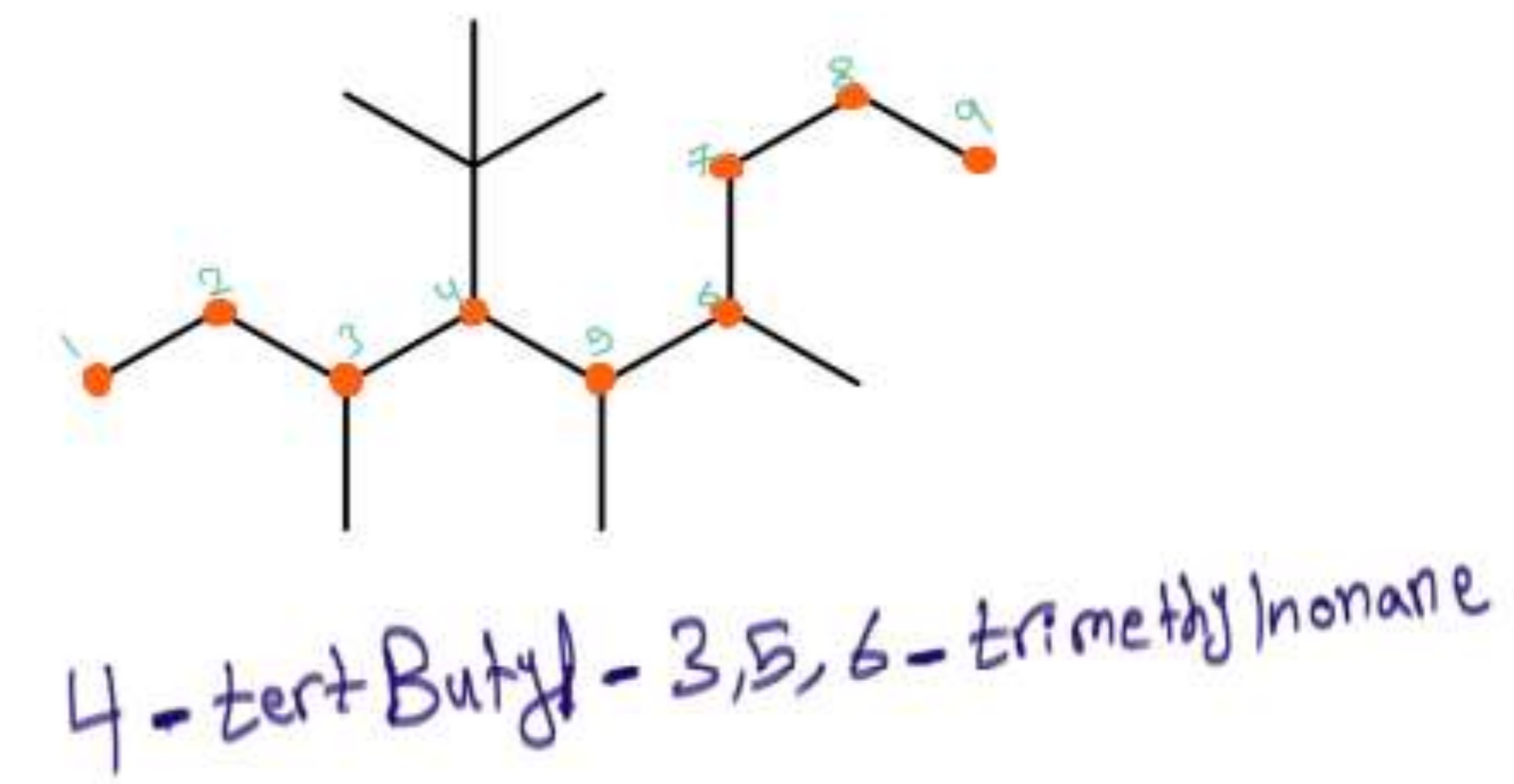
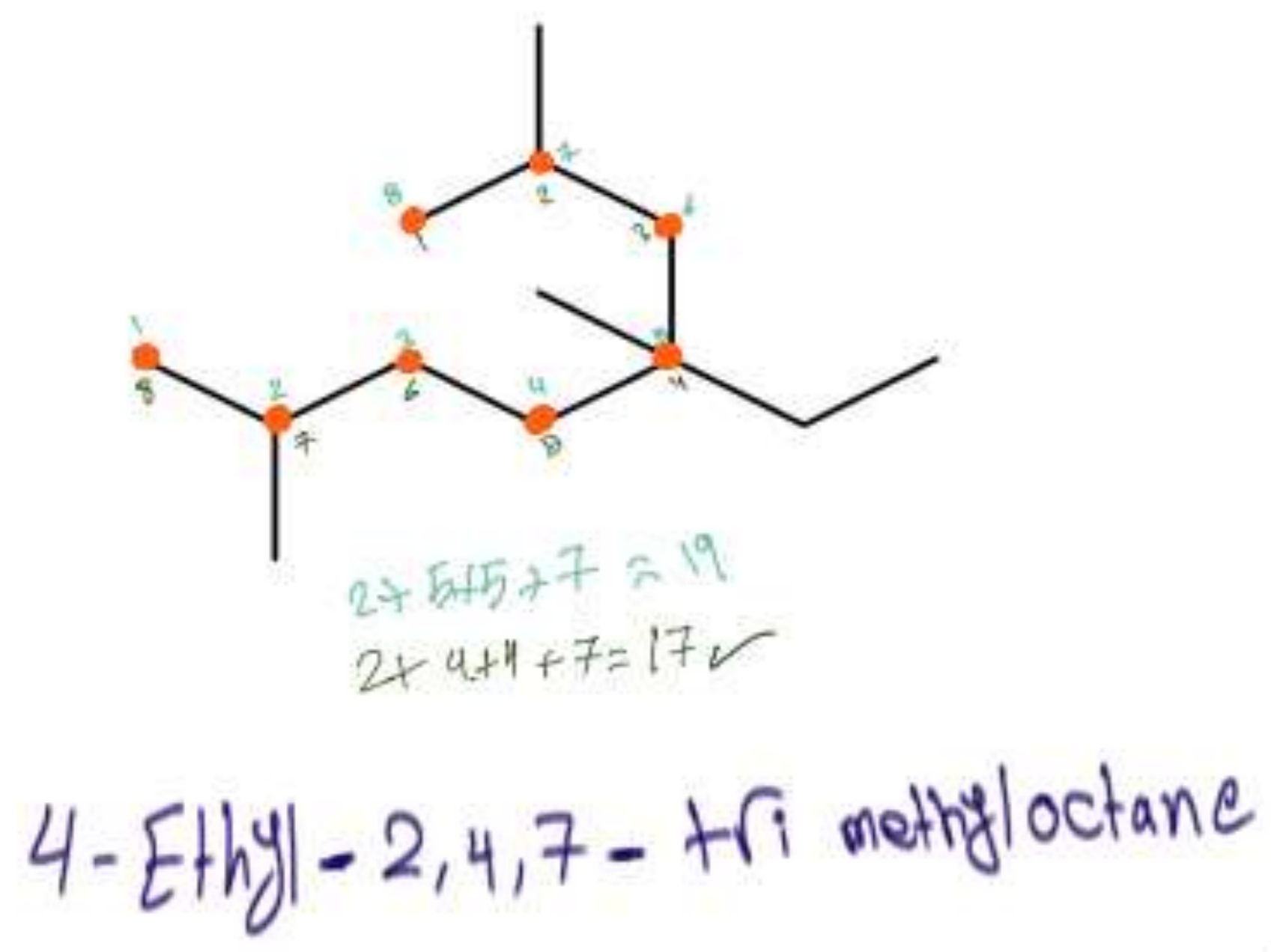
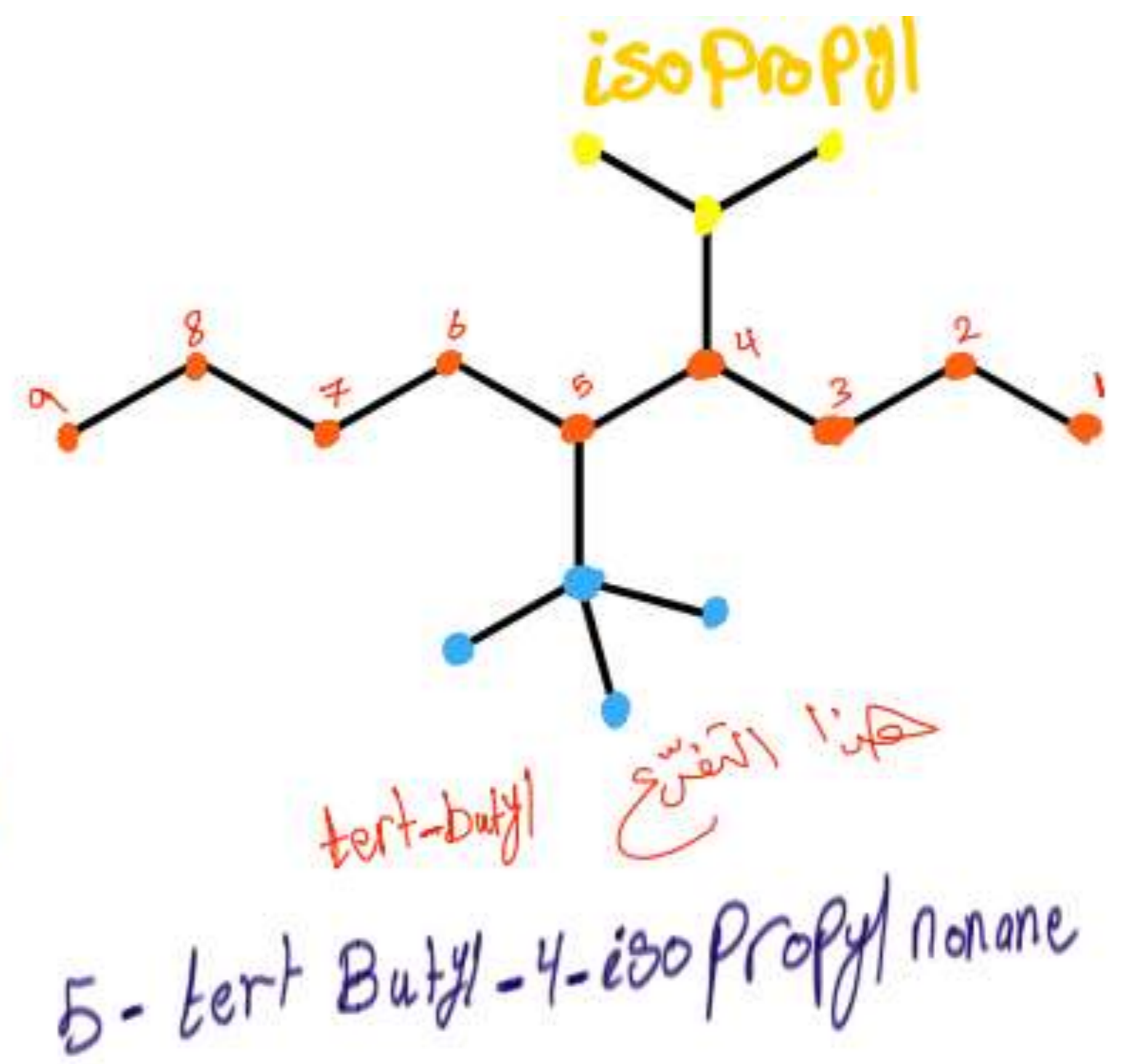
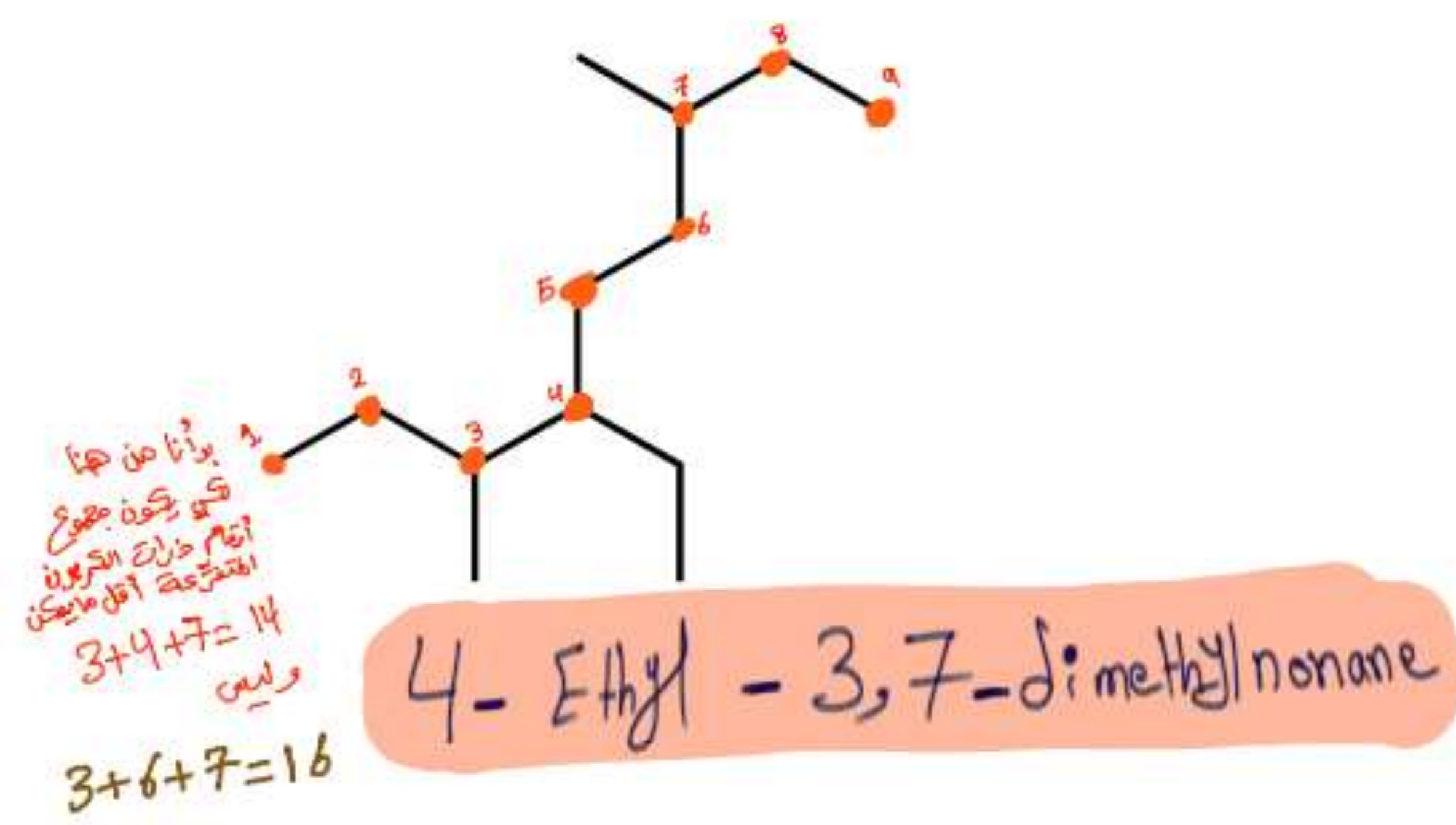
Isobutane



isobutyl

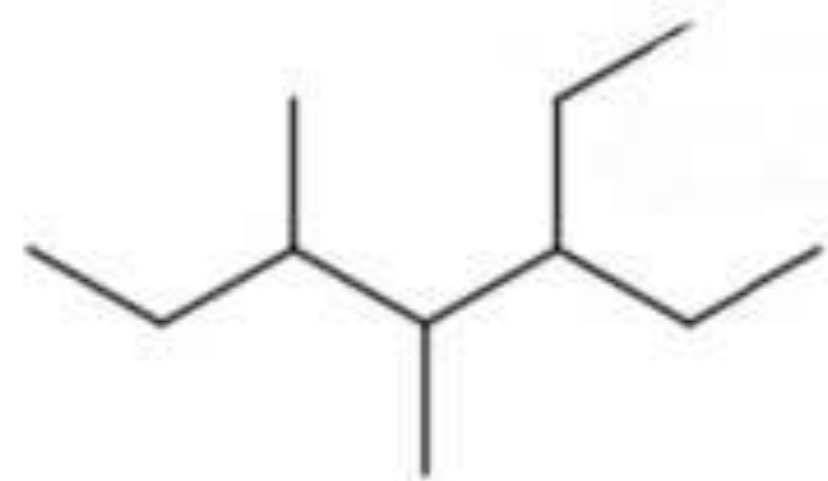


tert-butyl



# Test yourself

Name the following compounds according to IUPAC nomenclature 8



3-Ethyl-4,5-dimethylheptane



4-Isopropylheptane



# Organic chemistry

Lec: 6

Done by: Yasser Yaghi



# Sources of Hydrocarbons

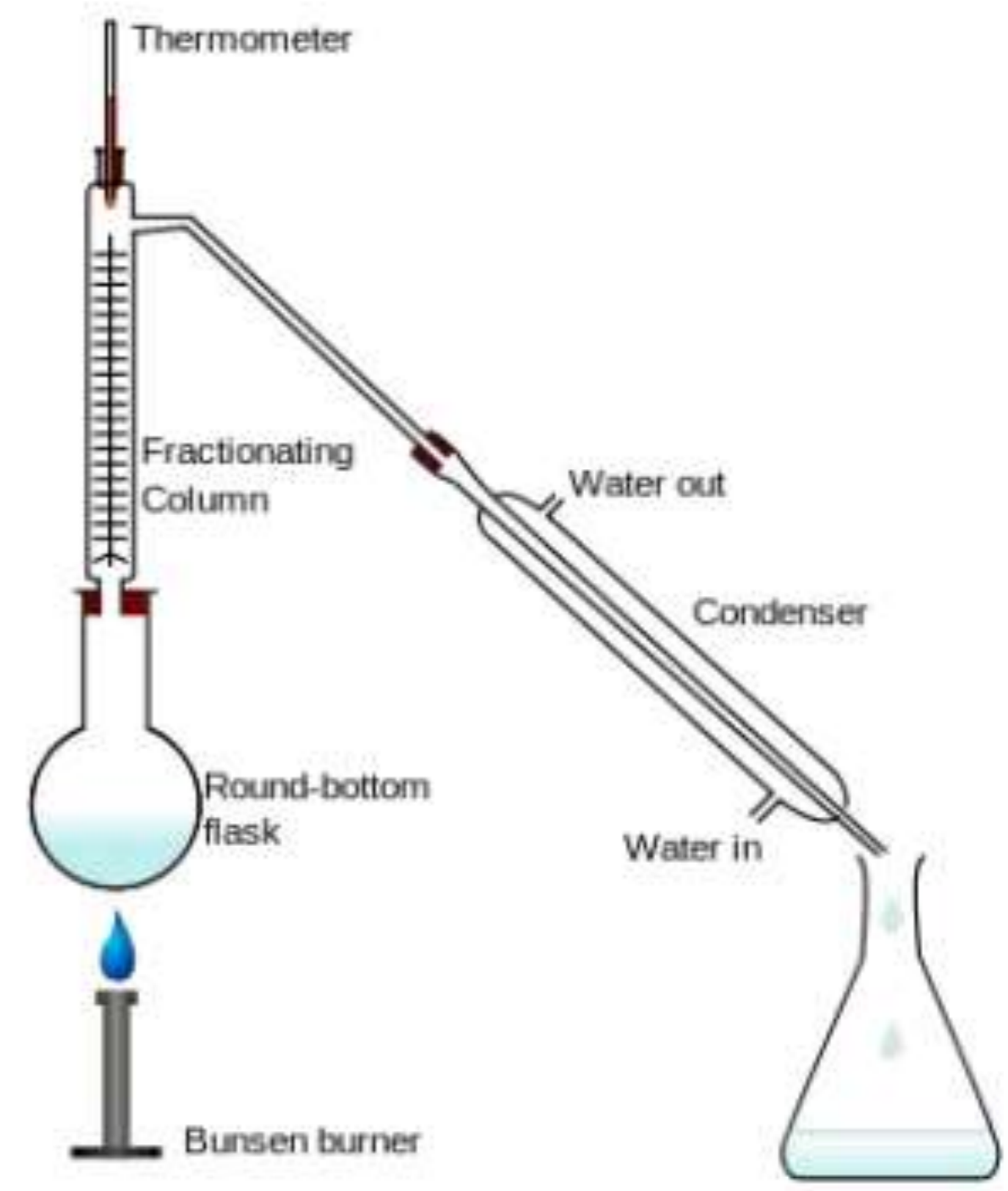
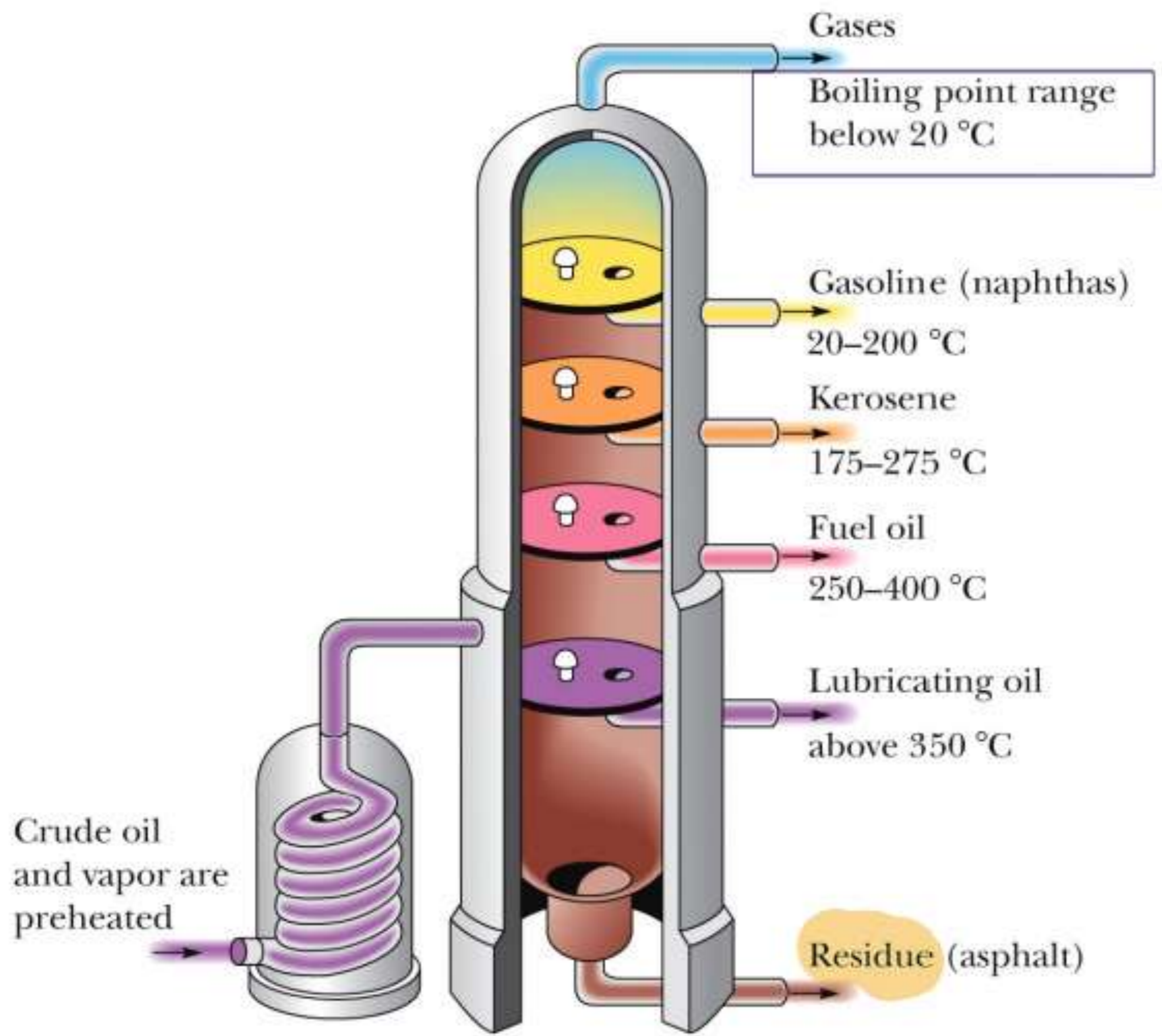
Hydrocarbons are found in crude oil and natural gas. Both are mixtures of different hydrocarbons and they are separated by "fractional distillation" a process where the different compounds are separated in a long distilling column based on their boiling points. Heavy fractions can be "cracked" into small lighter, hydrocarbons using heat and/or catalysts.

التقطير التجزيئي

محفزات

تسمى عملية distillation بجمع نخرج المركبات الأقل كثافة أولاً

تليها الأعلى فالأعلى حتى يتبقى Residue (الاسفلت) في القاع لأن لها Molar mass عالية



# قوة الترابط بين الجزيئات

## Intermolecular Forces

The physical properties of molecules are in part dependent on the type's of intermolecular forces (IMF) present.

Boiling points (BP) are also dependent on the mass of the molecule.

القدرة على الذوبان

Solubility, the ability to dissolve into a solvent is dependent on IMFs.

The strength of the interaction between molecules is also dependent on the overall shape of the molecule.

# Intermolecular Forces

There are 3 types of IMFs, by decreasing strength they are:

ترتيب القوى تنازلياً :

- 1) Hydrogen bonding <sup>أقوى رابطة</sup>  
الرابطة الهيدروجينية
- 2) Dipole-dipole <sup>رابطة ثنائية القطب</sup>
- 3) Van der Waals or London Dispersion <sup>قوى لندن</sup>

مطلوبه زهبيه

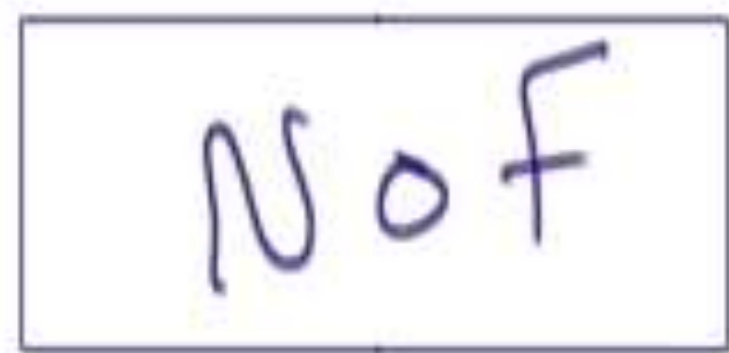
لا تخرب

بين القوى بين الجزيئات والقوى بين الذرات .  
هيدروجينية ثنائية القطب لندن  
تأهية  
أيونية فلزية

# Hydrogen Bonding

*Hydrogen bonding* is a complex interaction that includes dipole-dipole, as well as orbital interactions and the transfer of electron density between molecules.

These are the strongest of the IMFs and range from 5 – 25 kJ/mol



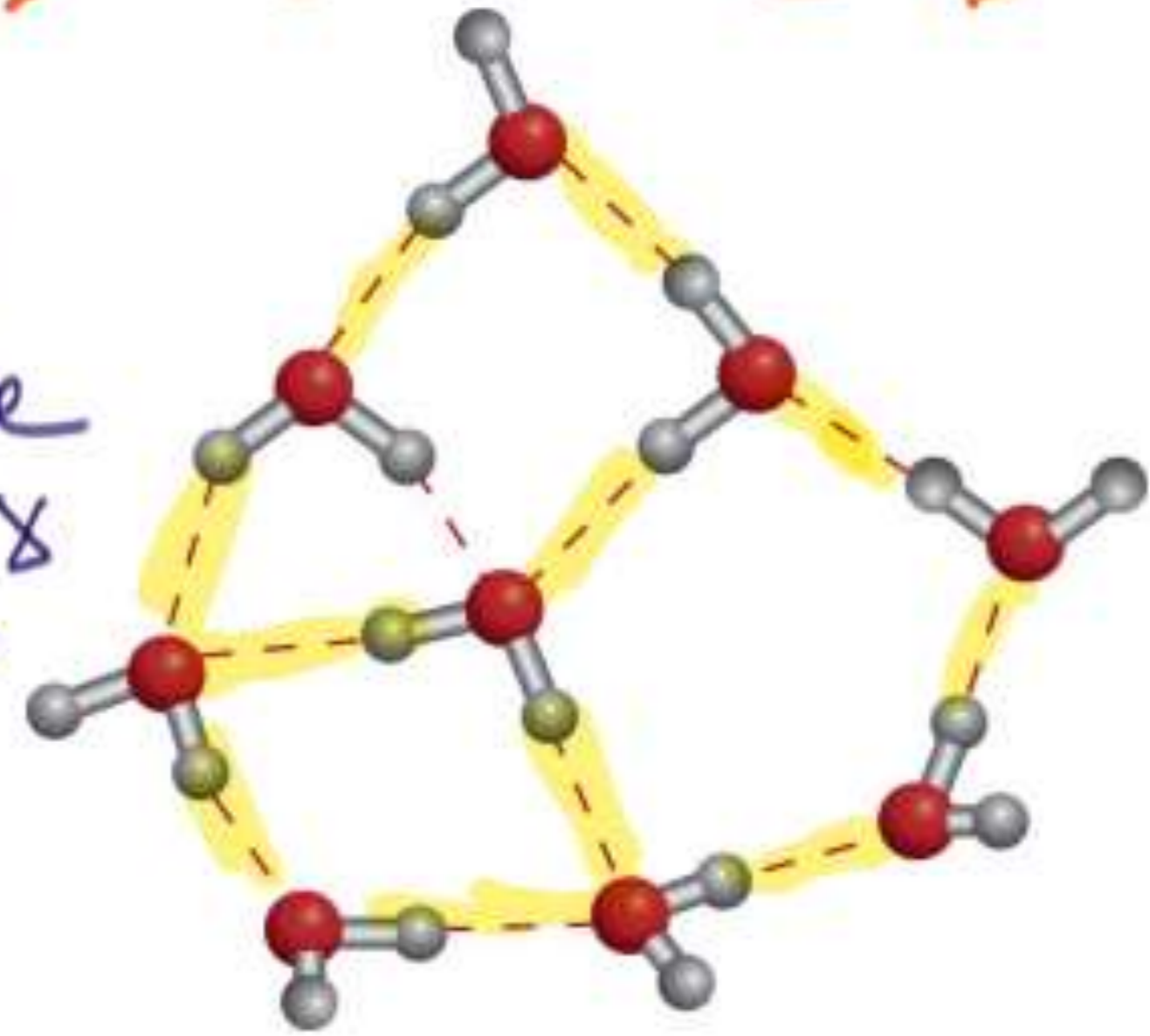
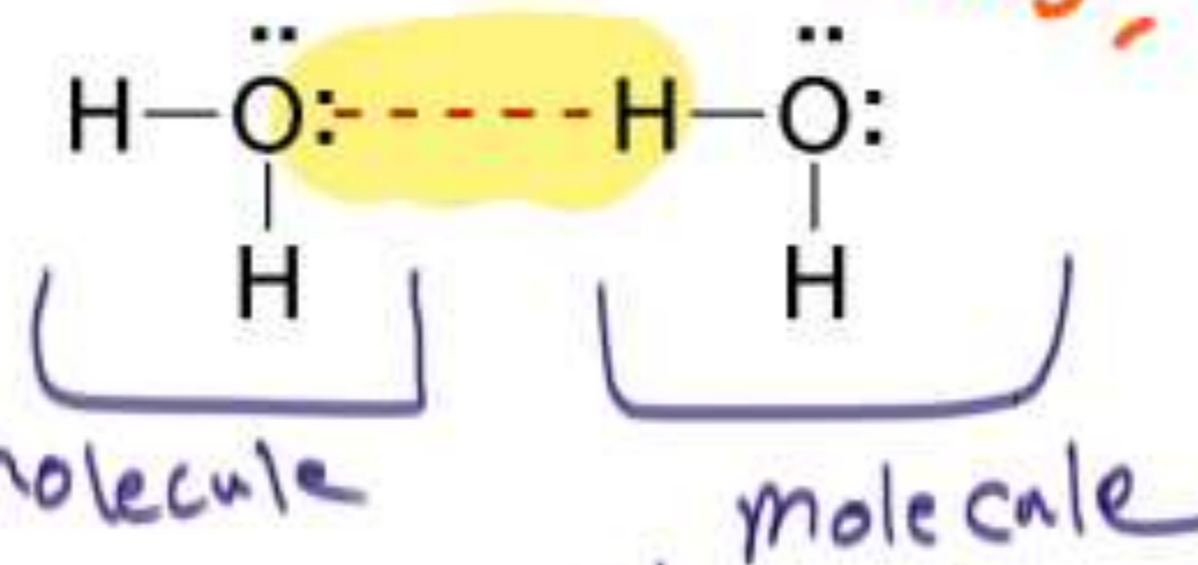
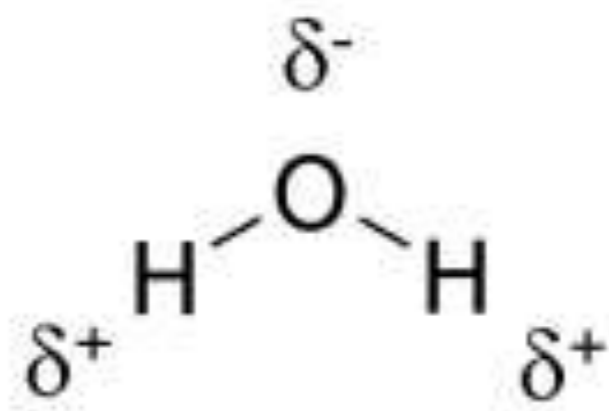
العناصر الأعلى EN هي F و O و N احفظهم بكلمة

# Hydrogen Bonding

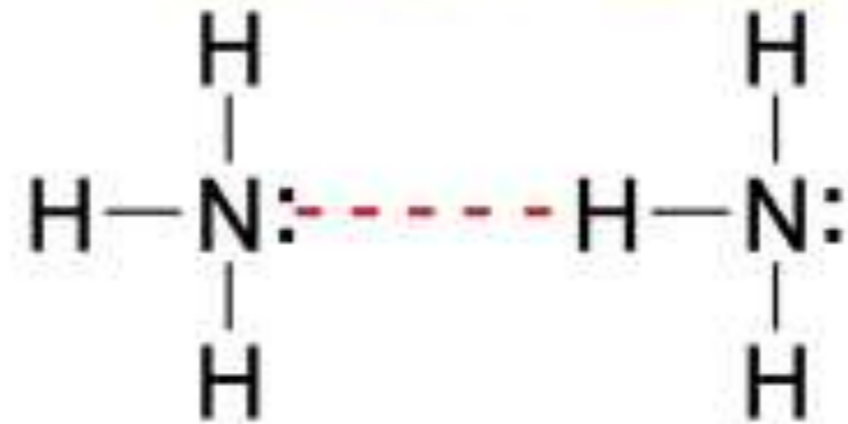
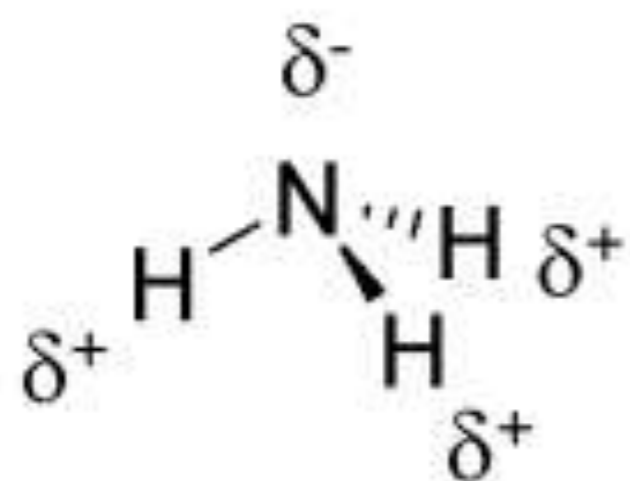
هذه الرابطة موجودة في المركبات التي ترتبط مع N, O, F مع الهيدروجين

Occur primarily between OH, NH and FH. The more EN the atom the stronger the interaction. (The atom H is attached to usually has a lone pair of e<sup>-</sup>)

بعض كنجذب ذرة H إلى ذرة أخرى من جزيء مقابل يعطى زوج الكروان غير رابطة



لا حظ الرابطة بين جزيء وجزيء آخر وليس بين الذرات.



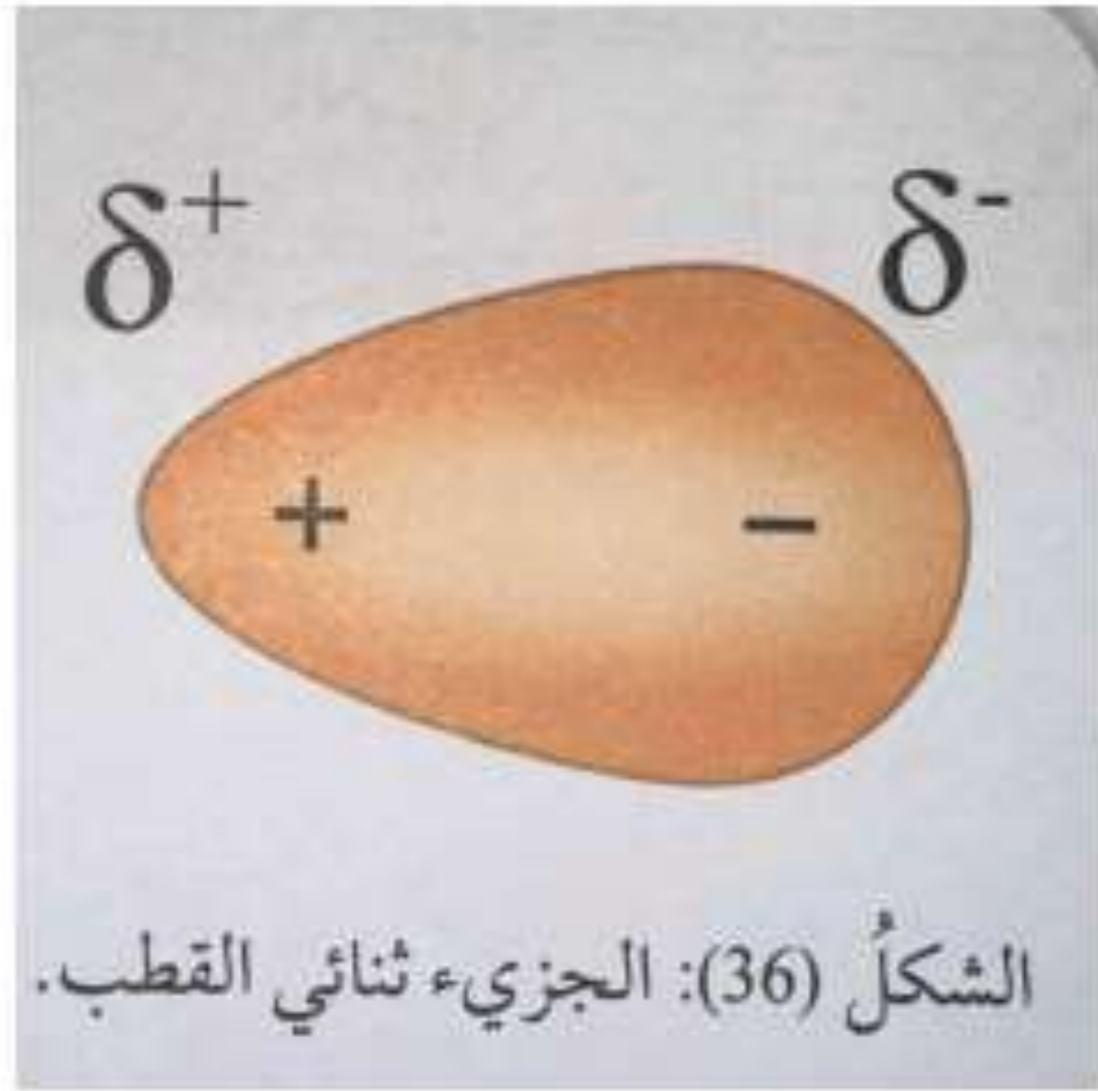
# Dipole-dipole

*Dipole-dipole* forces arise from the attraction of oppositely charged atoms (other than H) in molecules. These molecules may have a permanent dipole moment. Generally in organic molecules they result from the presence of **C-X** bonds where X is more electronegative than C.

These are generally weaker than H-bonding, ranging from about 5-10 kJ/mol.

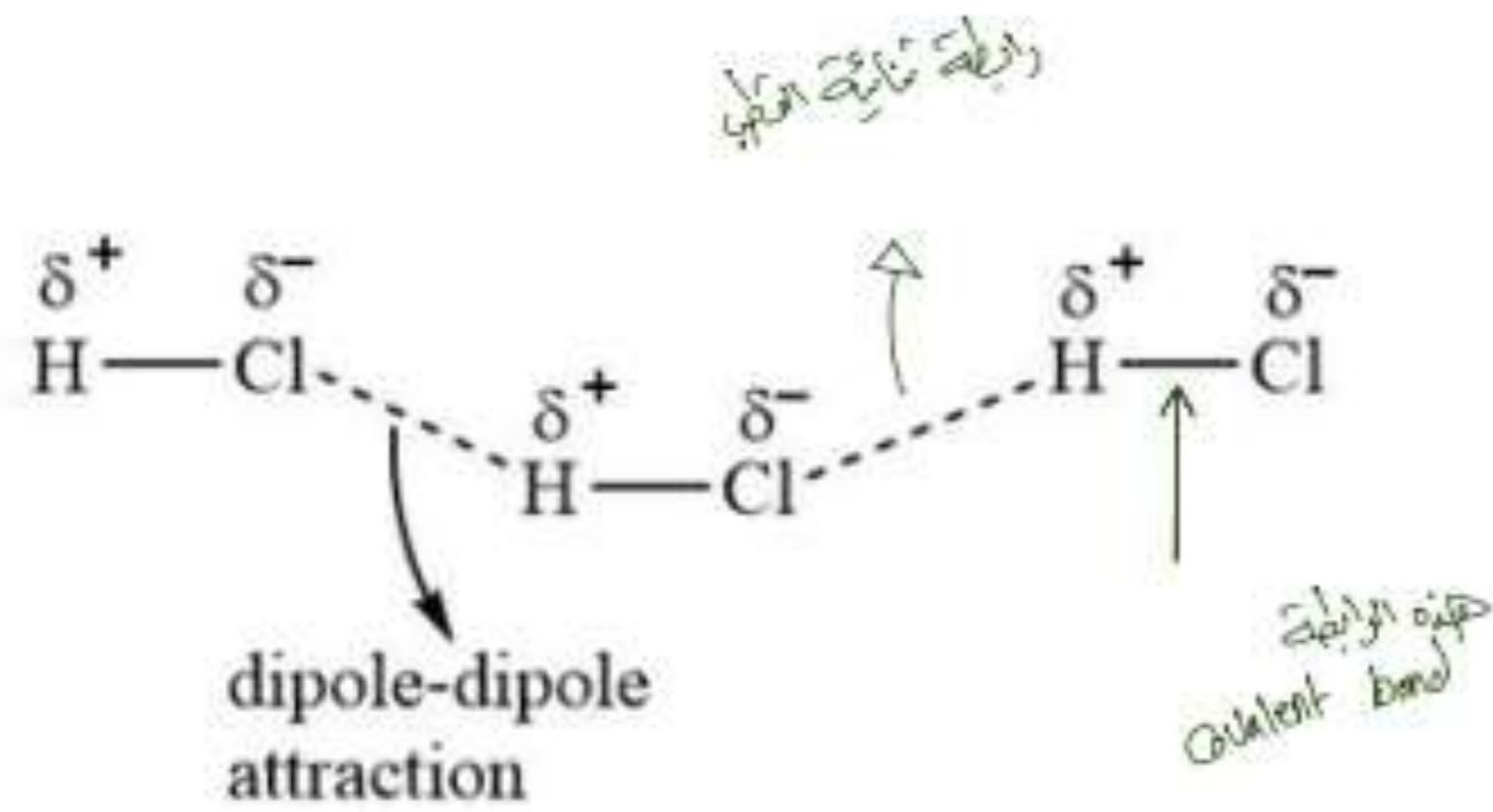
Therefore, compounds whose molecules are linked by dipole-dipole bonds have a lower boiling point than H-bonding, taking into account molar masses

عرفت في ما سبق أن <sup>أي</sup> للتديد من الجزيئات عزماً قطبياً،  
 وتوهم بأنها جزيئات قطبية تسمى جزيئات ثنائية القطب.



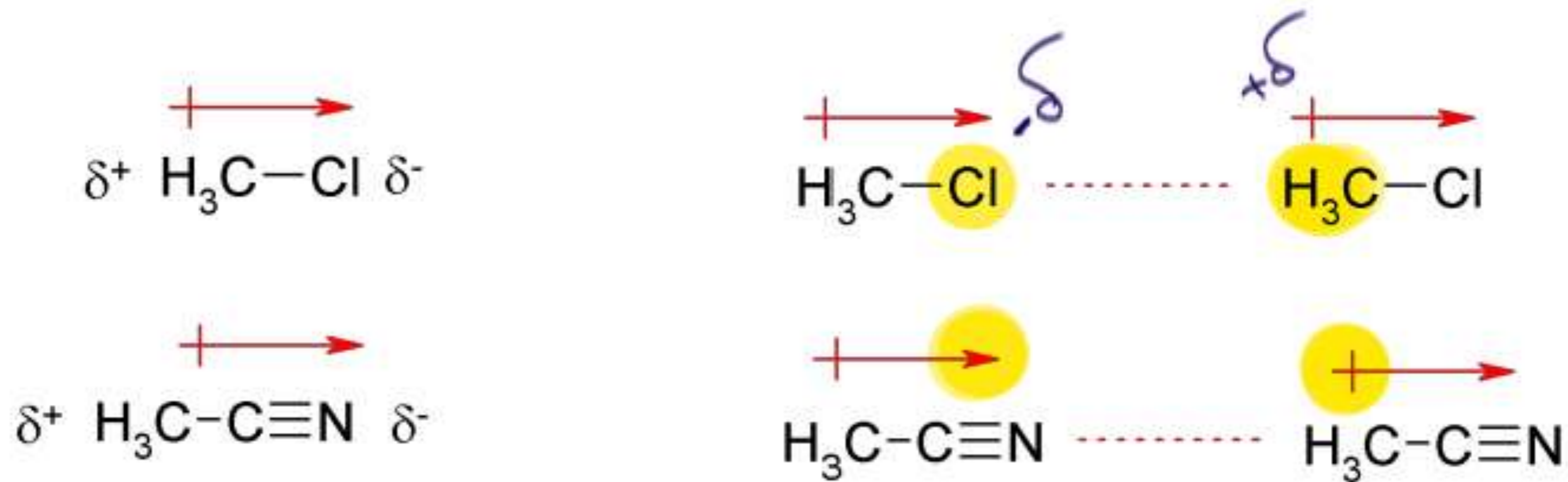
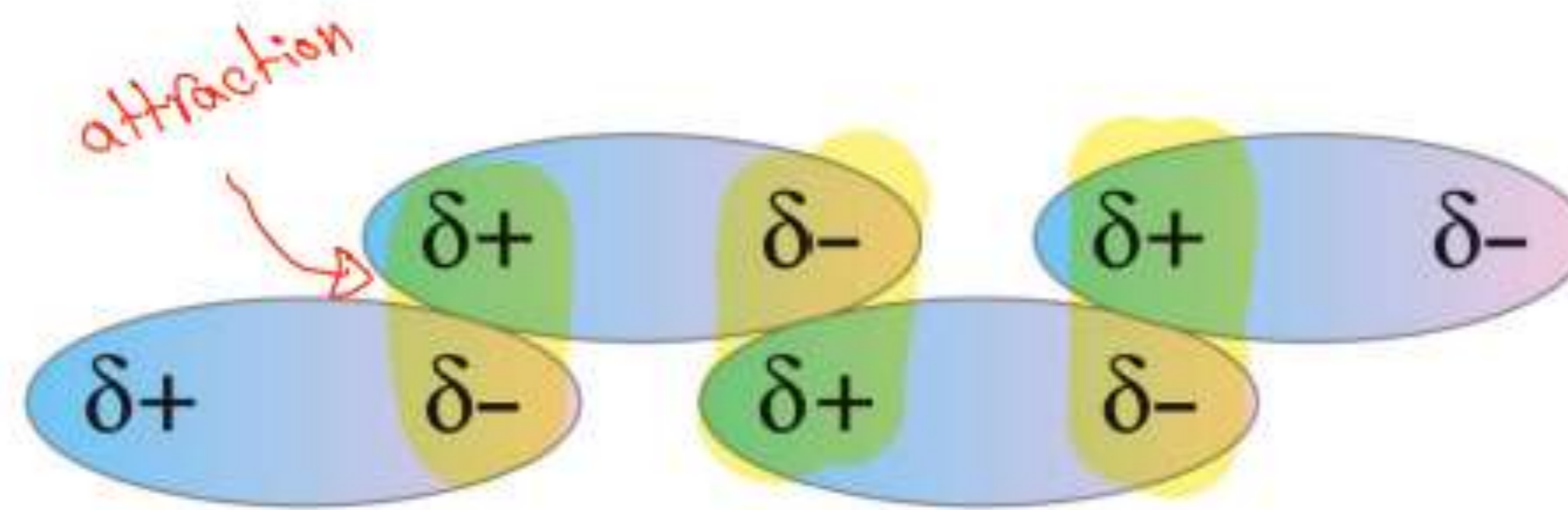
ينشأ تجاذب بين الطرفين السالب للجزيء والطرف  
 الموجود لجزيء مجاور، وتكون نتيجة ذلك  
 شبكة من قوى التجاذب بين هذه الجزيئات يُطلق عليها  
 قوى ثنائية القطب **Dipole-Dipole Forces**

e.g.:





# Dipole-dipole



$\text{CH}_4$

# Van der Waals (dispersion)

*Van der Waals* or (London) *dispersion* forces arise from the movement of electrons within a molecule. This natural motion can produce an uneven distribution of the electrons (polarization of the distribution) resulting in a temporary dipole moment in the molecule. This will induce the movement of electrons in adjacent molecules producing a dipole moment in them. These "induced" dipole moments are very brief as they disappear when the electrons move to new locations within the molecule, so they forces are very brief and weak, only 2-5 kJ/mol.

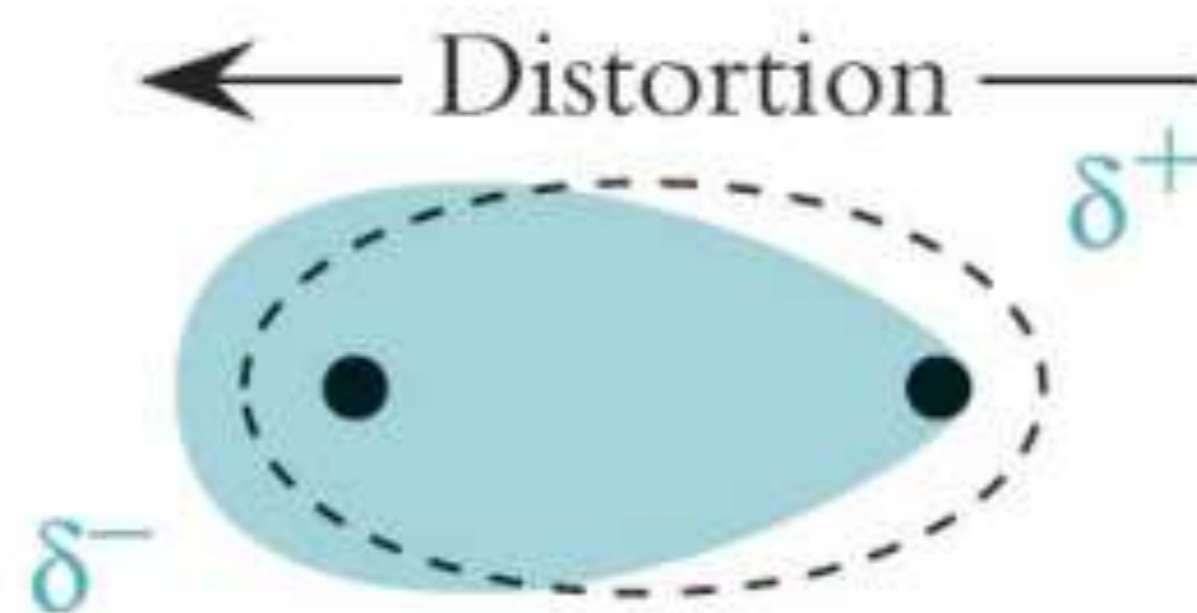
توزيع غير منتظم  
للإلكترونات

تحدث نتيجة  
الاستقطاب  
اللحظي  
للجزيئات أو الذرات

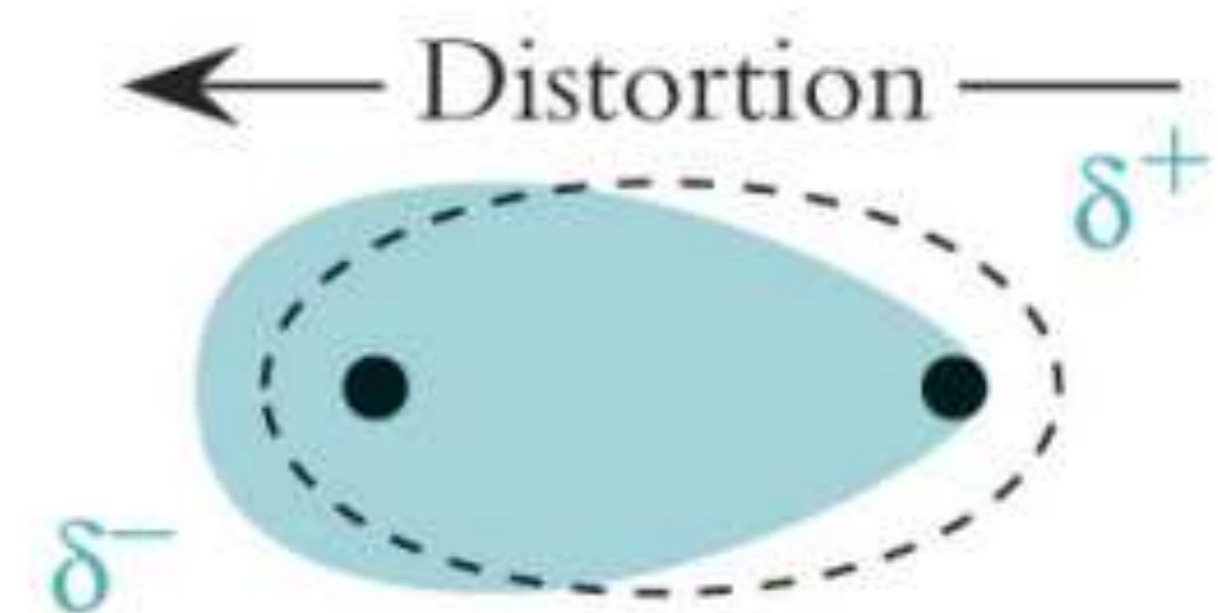
Cl-Cl



Isolated molecule



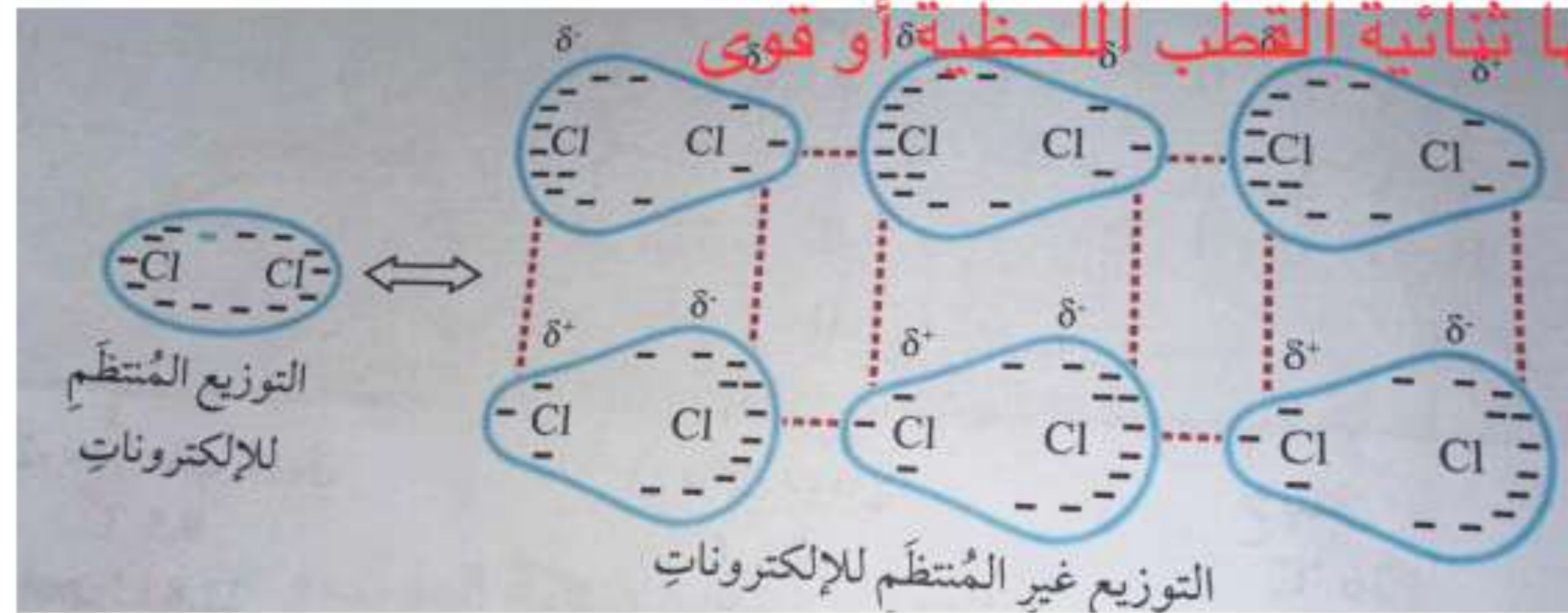
Neighboring molecule



يحدث الاستقطاب اللحظي نتيجة توزيع الإلكترونات غير المنتظم في الجزيئات أو الذرات؛ فمثلاً، جزيء الكلور  $Cl_2$  غير قطبي؛ لأن ذرتيه متساويتان في السالبية الكهربائية، وبسبب حركة أن الإلكترونات المستمرة في الذرة قد يزداد عدد الإلكترونات في أحد أطراف الجزيء عن الطرف الآخر في لحظة ما، فتزداد الكثافة الإلكترونية في ذلك الطرف ويكتسب شحنة جزئية سالبة، وفي تلك اللحظة تظهر على الطرف الآخر شحنة جزئية موجبة، ويصبح جزيء الكلور ( $Cl_2$ ) قطبياً، إلا أنه سرعان ما تعود الإلكترونات إلى حالة التوزيع المنتظم ويفقد الجزيء قطبيته، ولذلك توصفُ قطبية الجزيء بالقطبية اللحظية، التي تؤثر في الجزيئات المجاورة

لتنشأ فيها قطبيةً لحظيةً أُخرى، وبذلك تنشأ بين جزيئات الكلور قوى

تجاذب لحظية كما في الشكل، يُطلق عليها ثنائية القطب اللحظية أو قوى



ملحوظة: قوى لندن موجودة في كل الجزيئات ولكنها تظهر جلياً في المركبات غير القطبية، لأنها لا تحتوي غيرها.

كلما زاد عدد الالكترونات في الجزيئات كلما زادت قوة لندن  
 وتفسير ذلك أنه بزيادة عدد الالكترونات تزداد احتمالية الحركة العشوائية  
 لها ما يزيد فرصة حدوث استقطاب للمركب

تتمدد قوة رابطة لندن على كل من:  
 1- عدد الالكترونات في المركب  
 2- حجم المركب  
 3- شكل المركب

The larger the molecule the greater it's

Dispersion Forces are.

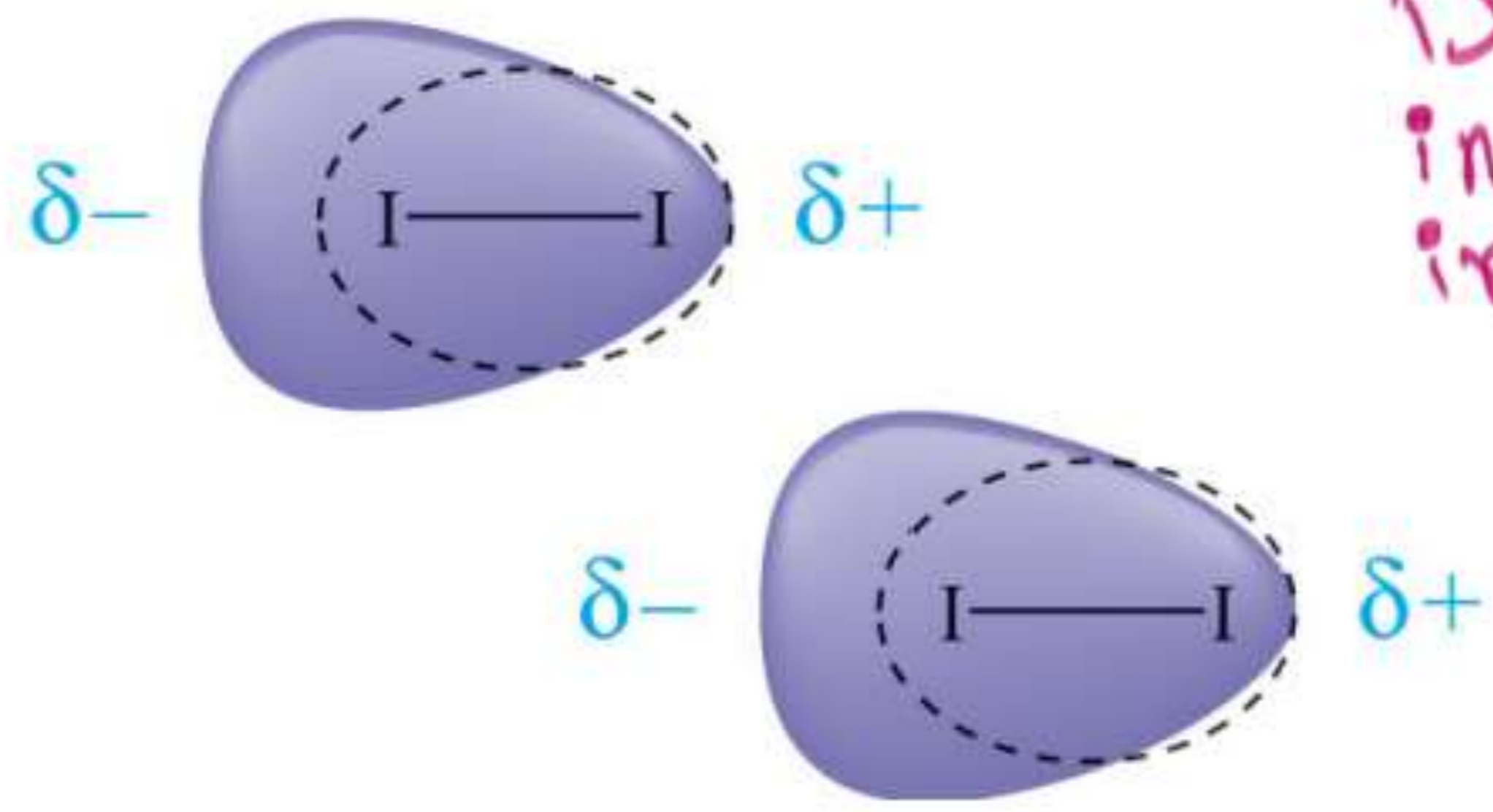
= London forces

Gas



Iodine has electrons more than  $F$  and also its size larger than  $F$  therefore the

Solid



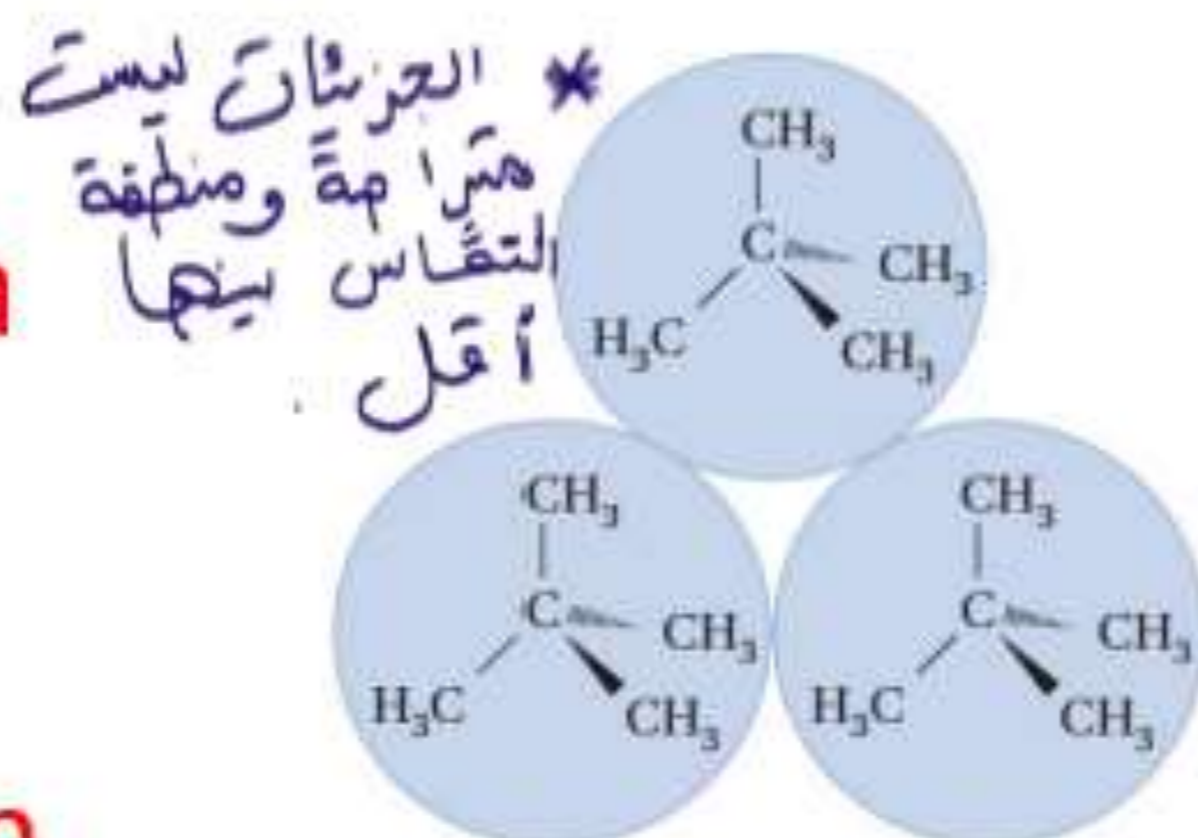
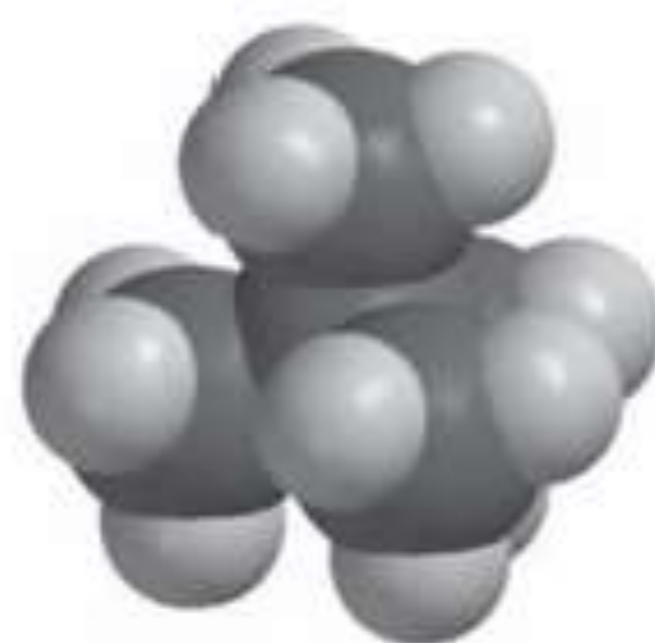
Dispersion forces in iodine more than in fluorine.

\* قوى التجاذب تؤثر على الحالة الفيزيائية للمادة.

# Structural Effects on IMFs

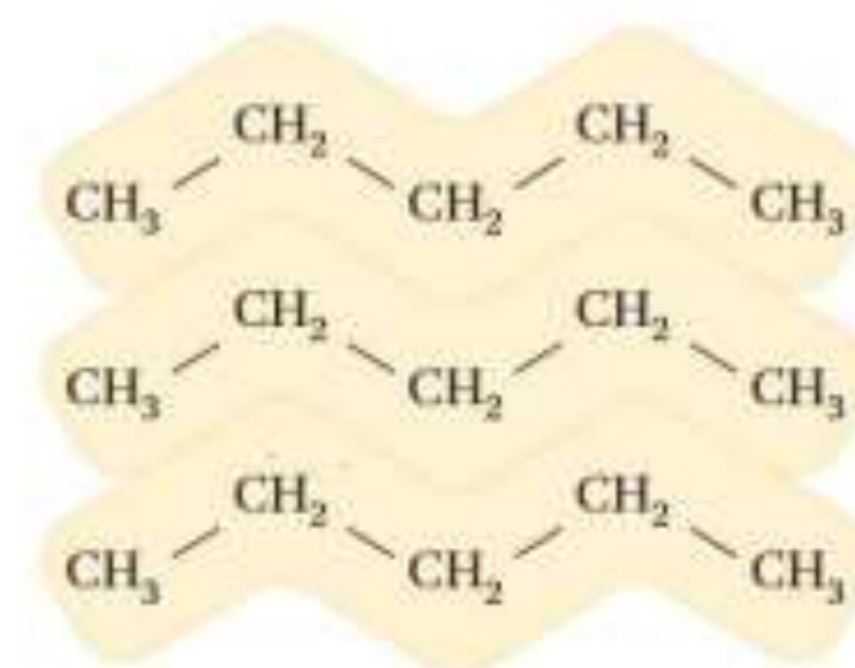
The strength of the IMFs depend on the amount of contact between the molecules, especially for **dispersion forces**.

Hence the shape of the molecule can affect the surface area of contact, long thin molecules have more surface in contact than spherical molecules.



2,2-dimethylpropane  
bp 10°C

(a)



pentane  
bp 36°C

(b)

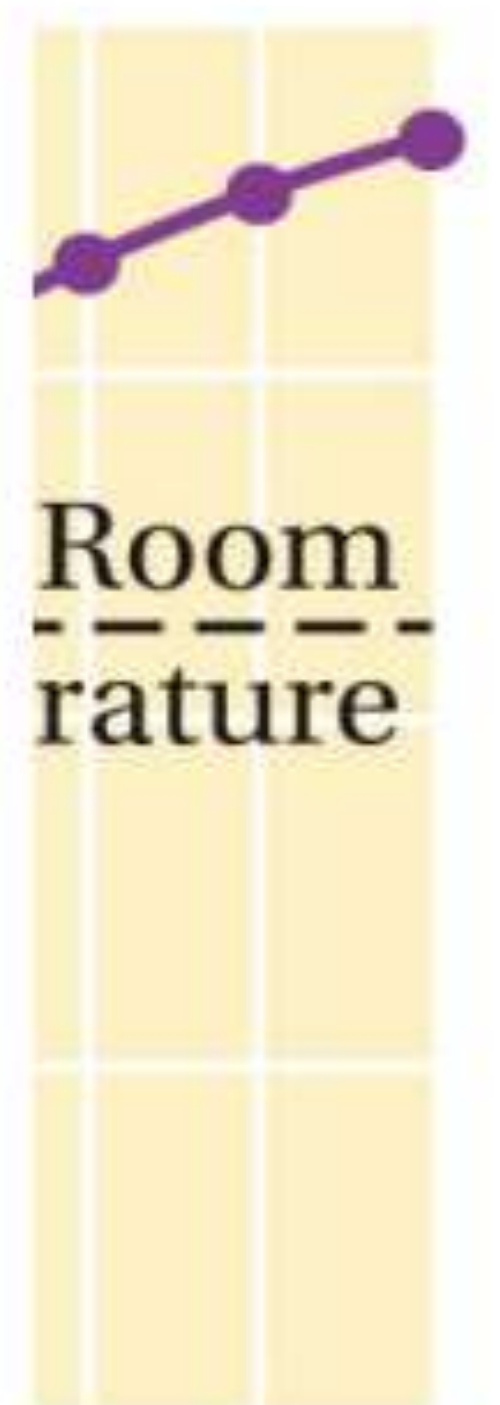
الجزئيات متراصة وقوة التجاذب بينها عالية، منطقة تماس الجزئيات عالية

لذلك bp لها أعلى

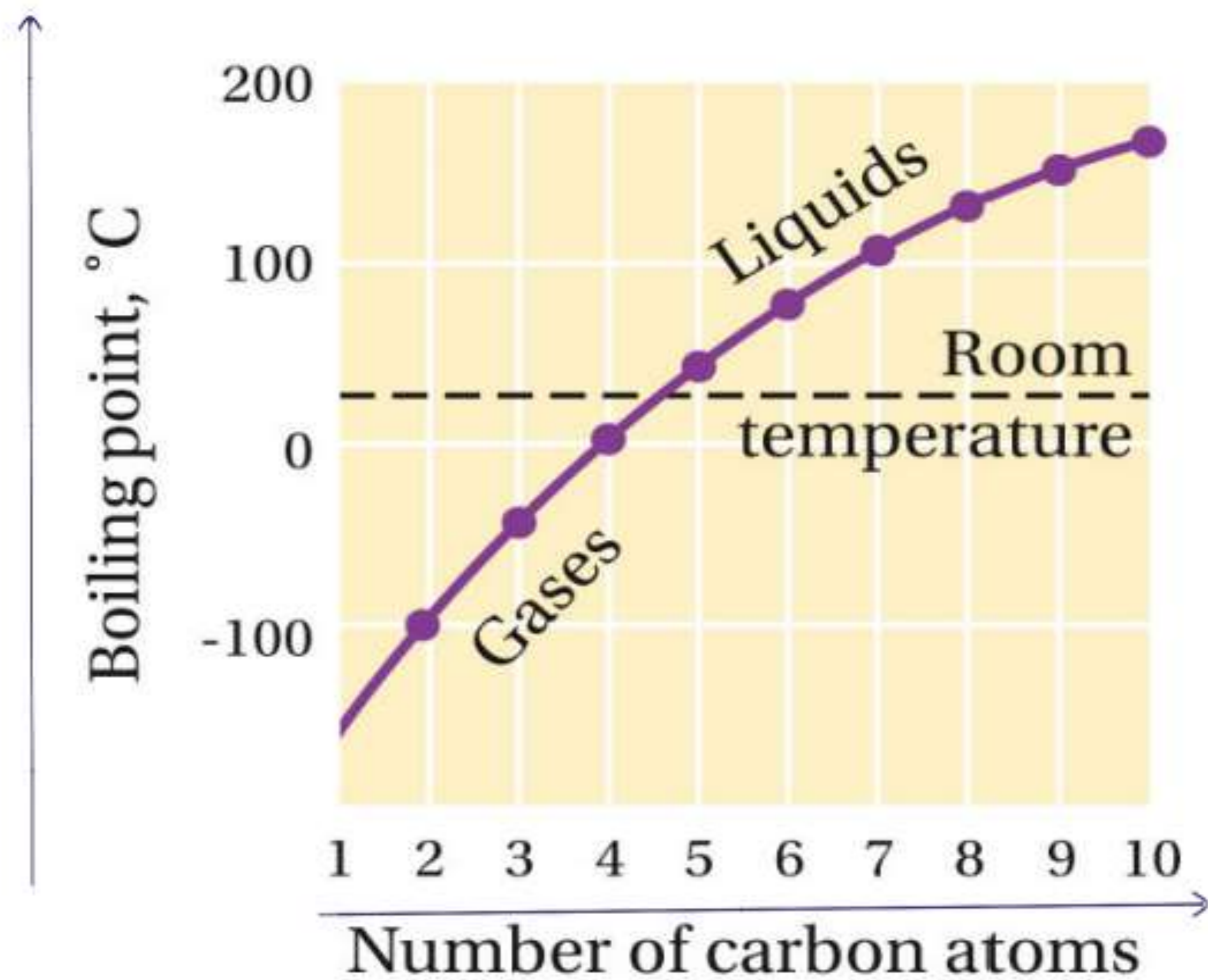
isomer

لاحظ المركبان متساويان ولهما نفس ال molar mass لذلك

# Effects on Physical Properties



Name	Formula	Boiling point, °C
pentane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	36
2-methylbutane (isopentane)	$\begin{array}{c} \text{CH}_3\text{CHCH}_2\text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	28
2,2-dimethyl- propane (neopentane)	$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3 - \text{C} - \text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	10



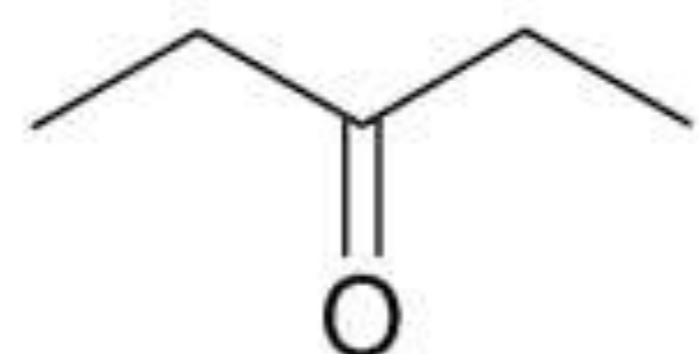
Name	
pentane	$\text{CH}_3(\text{CH}_2)_4\text{CH}_3$
2-methylbutane (isopentane)	$\text{CH}_3(\text{CH}_2)_2\text{CH}(\text{CH}_3)_2$
2,2-dimethyl- propane (neopentane)	$\text{C}(\text{CH}_3)_4$

# Effects on Physical Properties (cont'd)

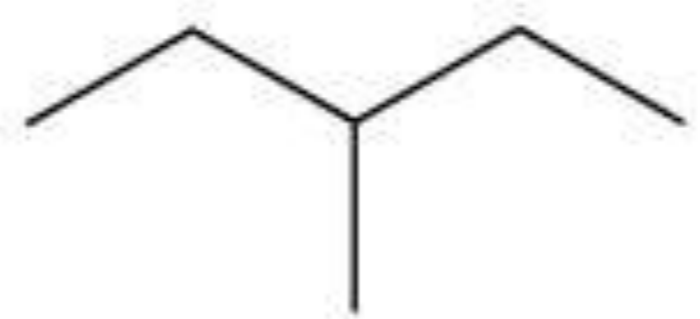
Dipole forces: much strong IMFs so the BP is higher when dipole-dipole interactions are present, i.e.

IMFs  
dipole-dipole

نوع



mass = 86 amu  
BP = 101.7 °C



mass = 86 amu  
BP = 63.3 °C

نوع الرابطة

London

لأن أي مركب يحتوي على C و H فقط يكون غير قطبي

قد يسأل سائل لماذا ليست هيدروجينية؟

لكن تكونا هيدروجينية يجب أن ترتبط H مع O تذكر الرابطة الهيدروجينية H-O و N-H و F-H



# Effects on Physical Properties (cont'd)

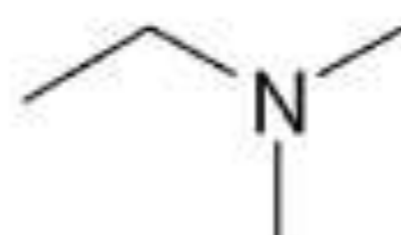
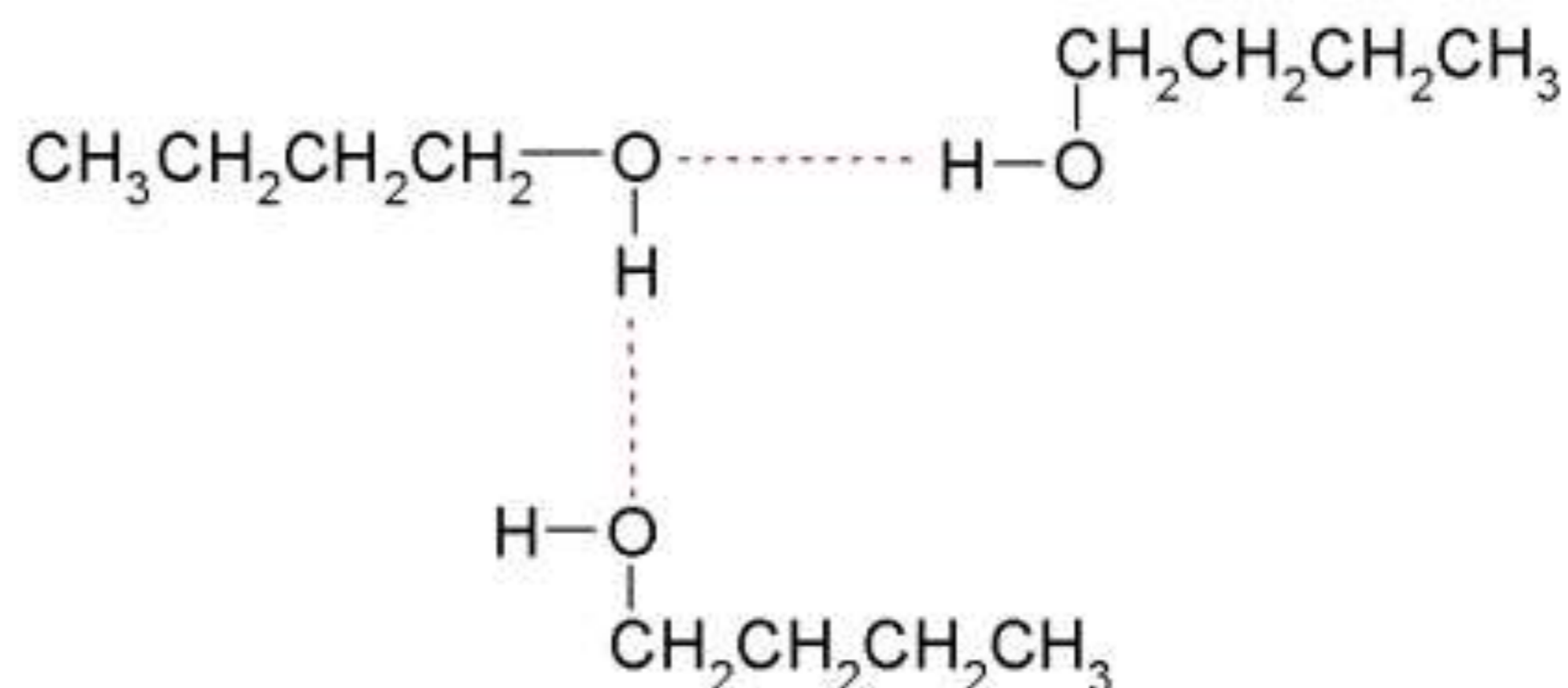
Hydrogen bonding:  
strongest  
intermolecular  
forces so BP are  
very high for  
equivalent MW  
compounds, i.e.



mass = 72 amu  
BP = 36.1 °C



mass = 74 amu  
BP = 117 °C



mass = 73 amu  
BP = 36 °C



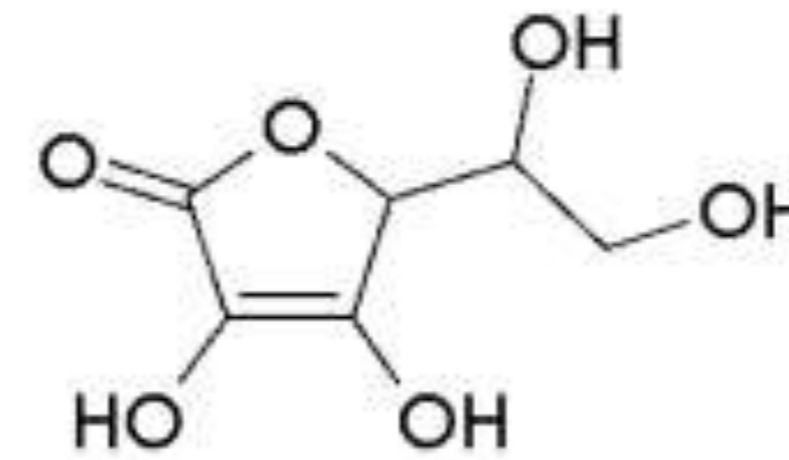
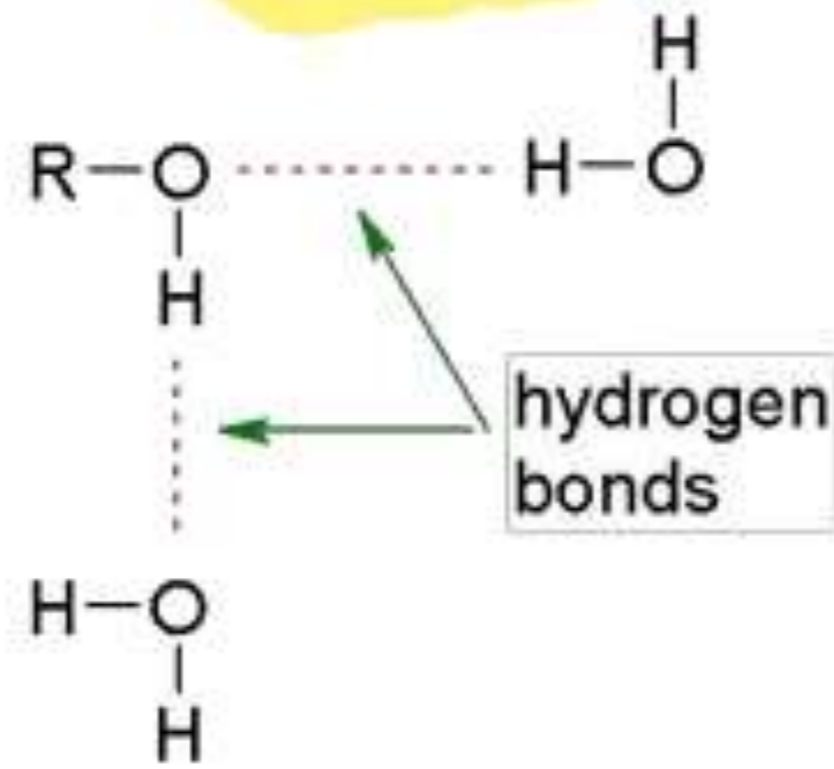
mass = 73 amu  
BP = 78 °C

# Effects on Physical Properties (cont'd)

قاعدة : المثل يُذيب المثل

Solubility: "like dissolves like" **solute** must have the same types of **IMFs** as the **solvent**, i.e.

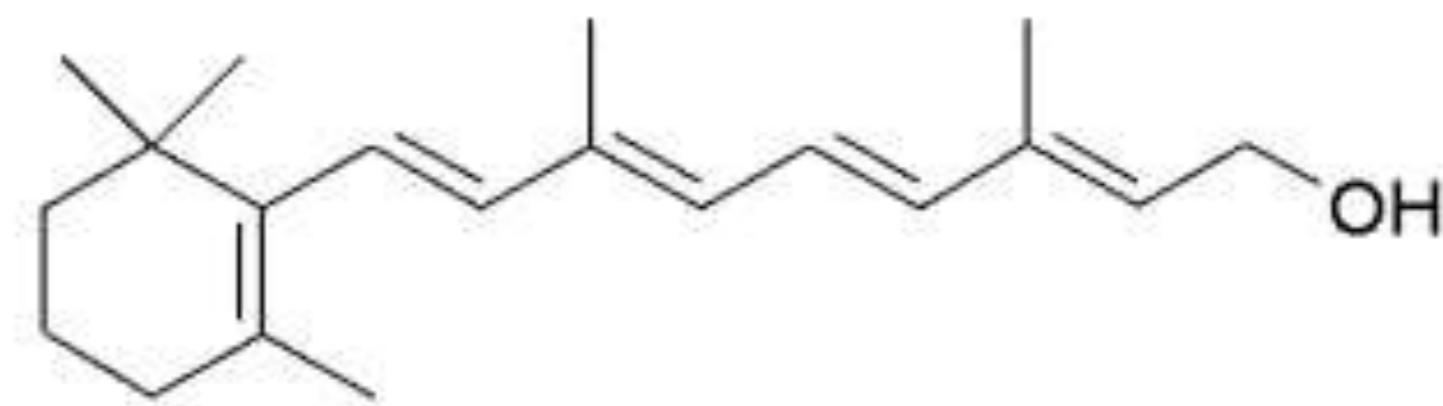
Alcohol



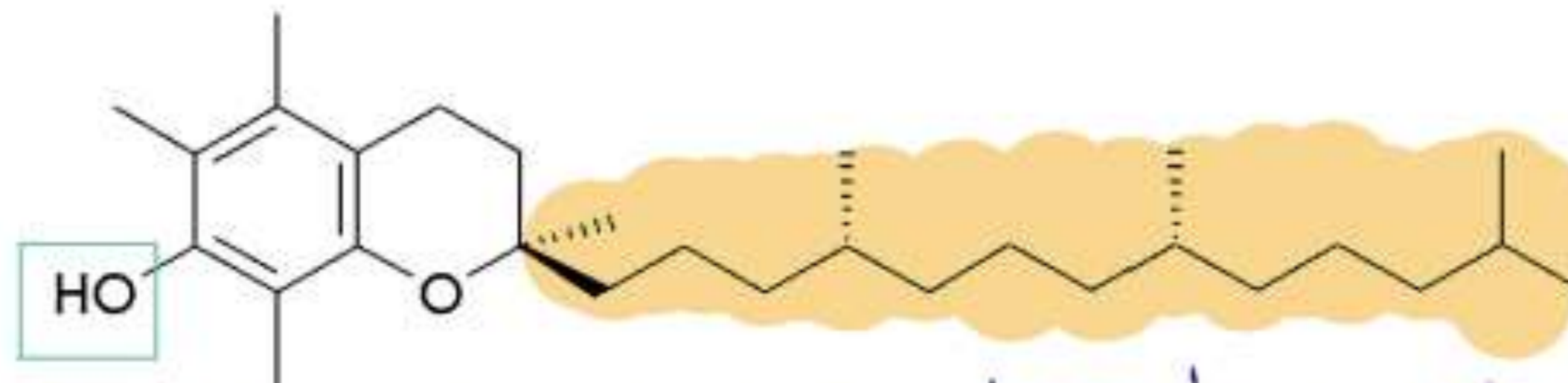
vitamin C

ليدوب باطاس  
يشبه

vitamin A



vitamin E



يتنوع في الماء  
ولكن بشكل أقل

هذه السلاسل غير القطبية تقلل من القدرة على الذوبان

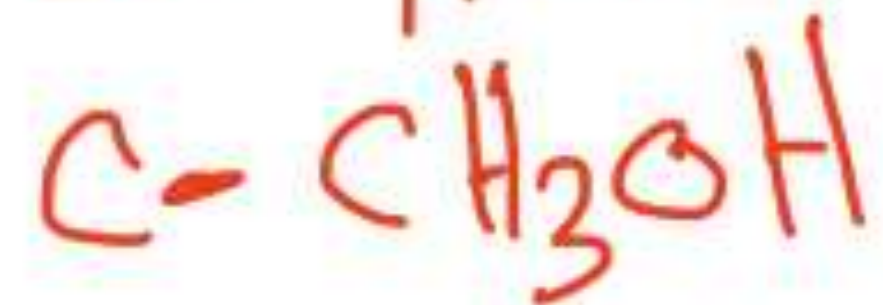
## Test yourself

1-The correct descending order of bond strength in the

following molecules :  $C_2H_6$ ,  $HCl$ ,  $CH_4$ ,  $CH_3OH$



2-Which of the following molecules is MOST likely to exhibit hydrogen bonding?



3-Which intermolecular force is present in all molecules, regardless of their polarity?

a) Ionic bonds

b) Van der Waals forces

c) Dipole-dipole forces

d) Hydrogen bonds

4-Which statement about London dispersion forces is TRUE?

a) They are strongest in molecules with high polarity.

b) They are only present in non-polar molecules.

Answers : 1-d      2-C      3-b      4-C

# Conformational Isomers

Rotation around **تنتج عن حركات** *من rotation*

**Conformational isomers** (**rotamers** or conformers) are compounds with the same constitution (atoms are bonded in the same order) but the atoms are located in different places in space.

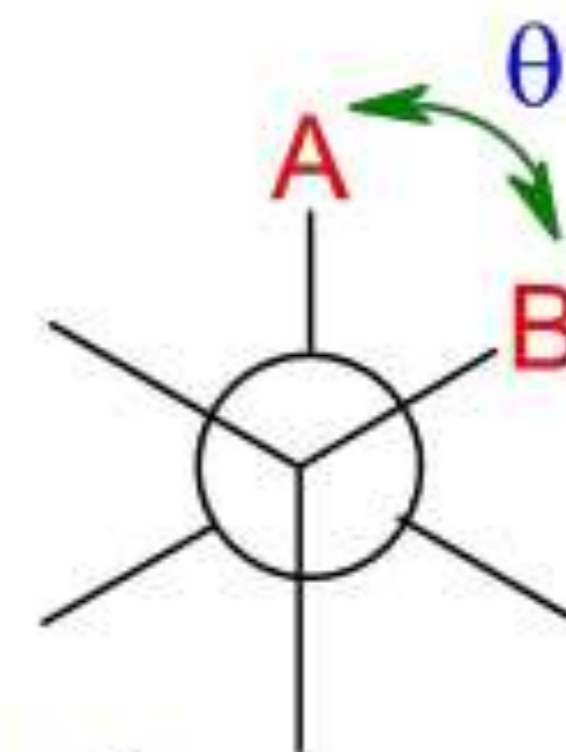
This is achieved by rotating about C-C single ( $\sigma$ ) bonds or the dihedral (or torsion) angle ( $\theta$ ).

C-C ( $\sigma$ ) **أي** rotation تحدث للرابطة **3D structure**

sp<sup>3</sup> هي ينتج عنها **فالتى نوع** **تجيبها**

rotamer / conformer

جدد **أي** **3D structure**

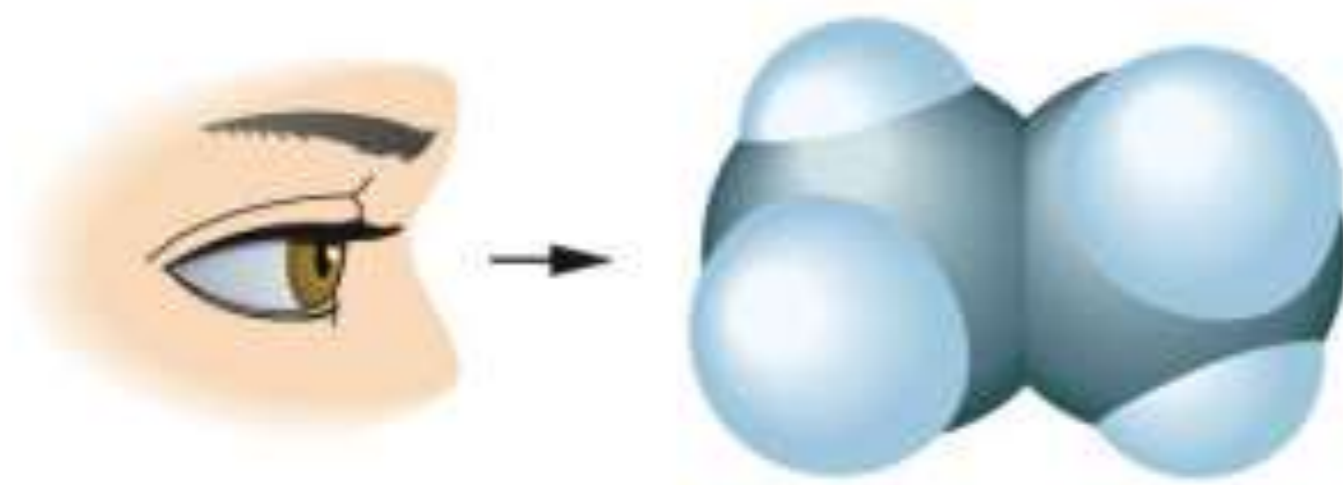


# Conformational Isomers (cont'd)

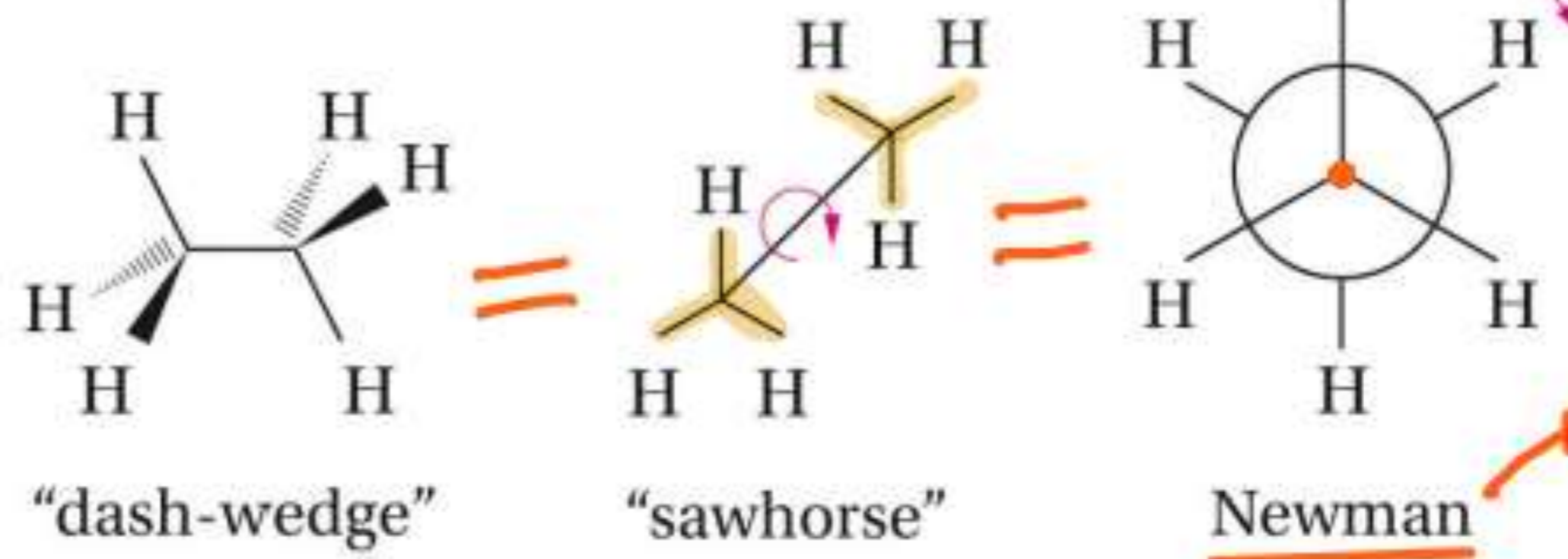
Two extremes exist for ethane: staggered & eclipsed

Two different rotamers

مَرَّةً فَتَلَّة

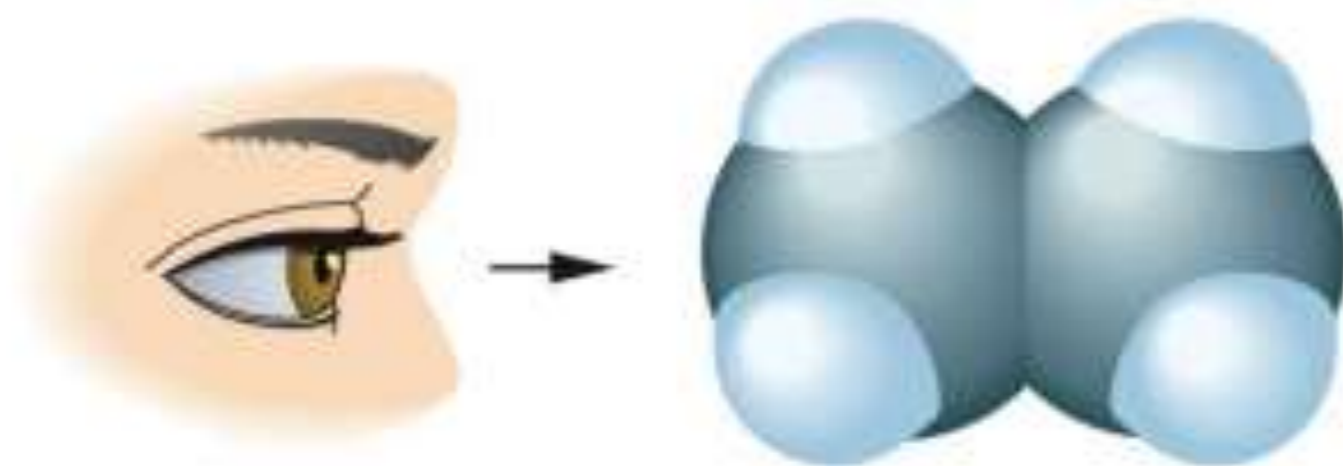


staggered

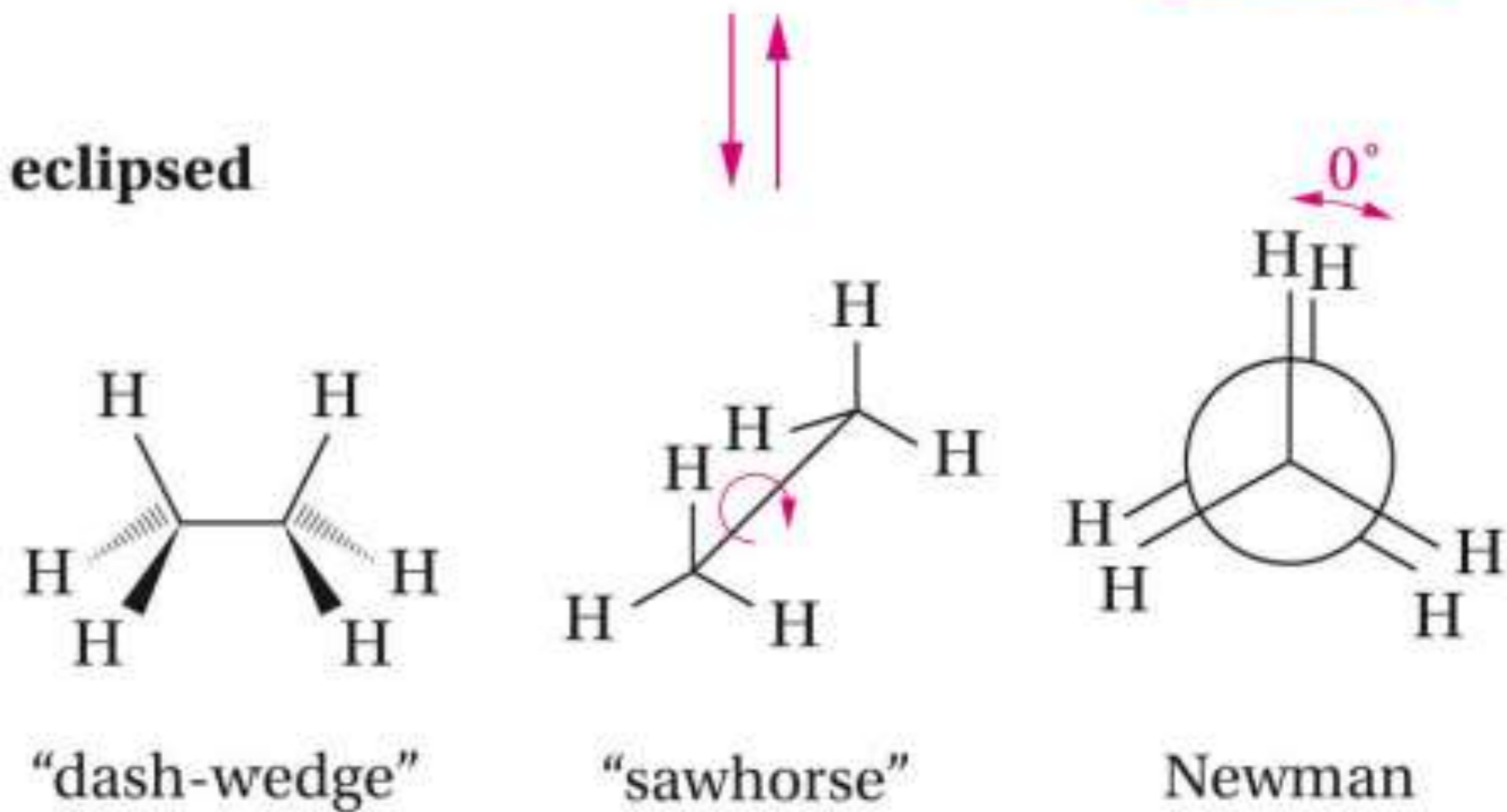


نغير عن زاوية C  
المغطاة للناظر  
بـ نقطة

والتي بدائرة



eclipsed



\* كأي هنا فضائية المصورة السادسة \*



# Organic chemistry

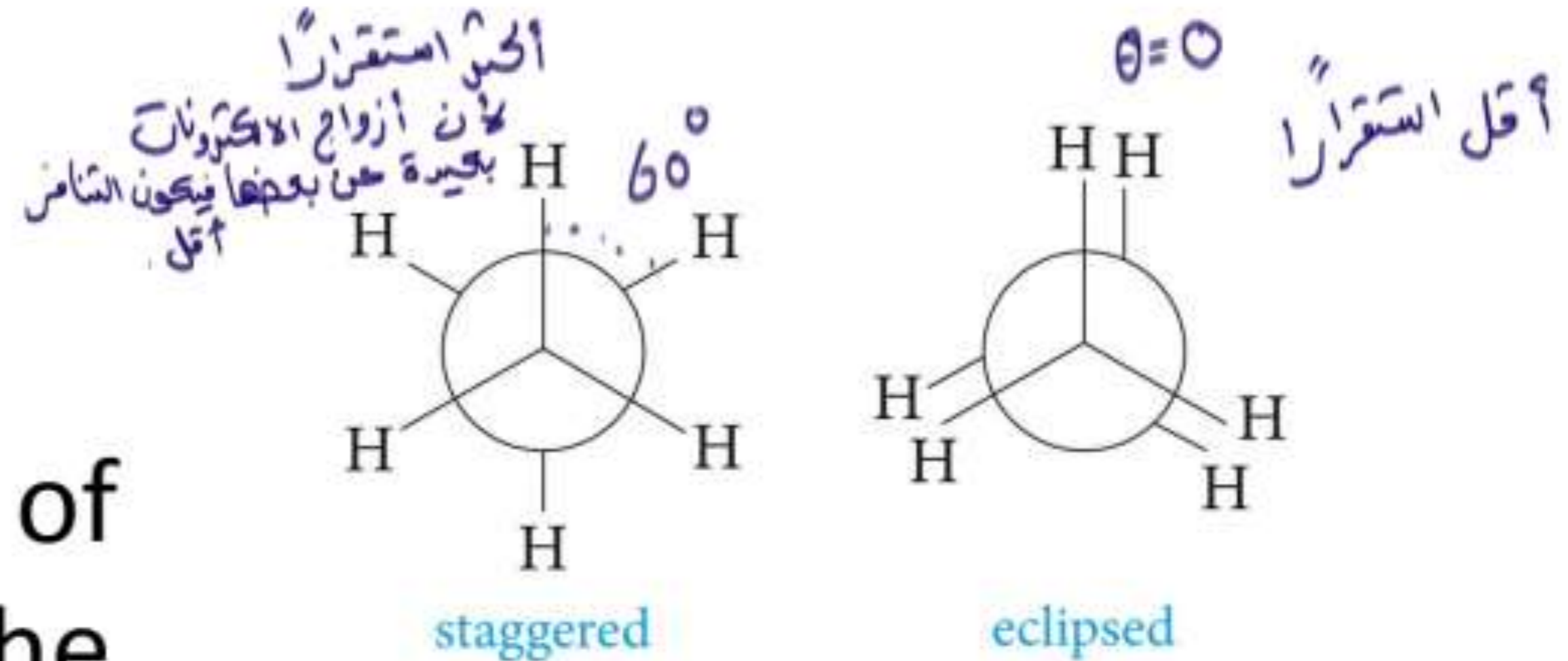
Lec: 7

Done by: Yasser Yaghi

# Conformational Isomers (cont'd)

Energy  $\propto \frac{1}{\text{Stability}}$   
تناسب عكسي

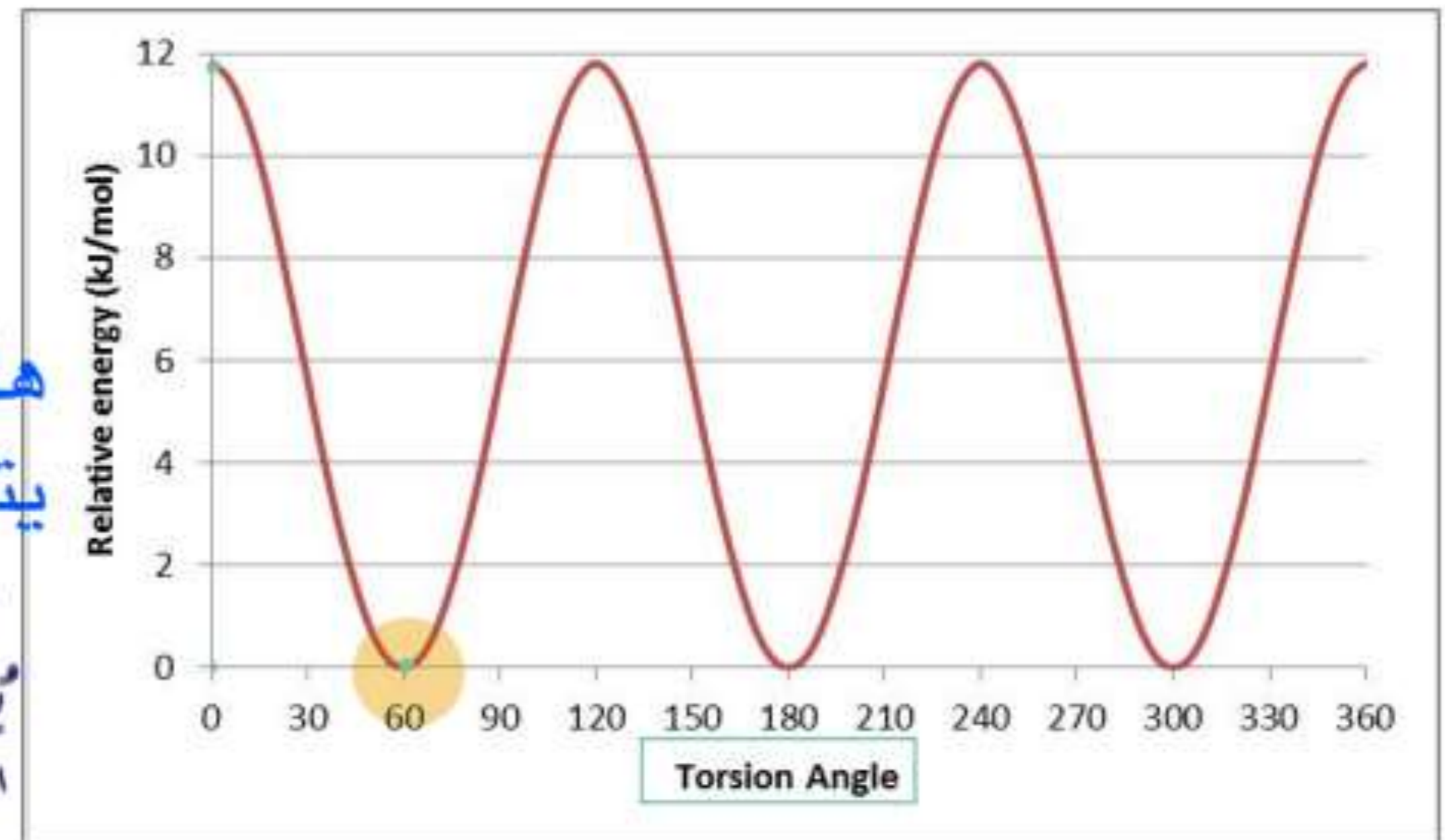
These two extremes represent high and low energy "conformations" of ethane. The "high" E is the eclipsed and low E the staggered.



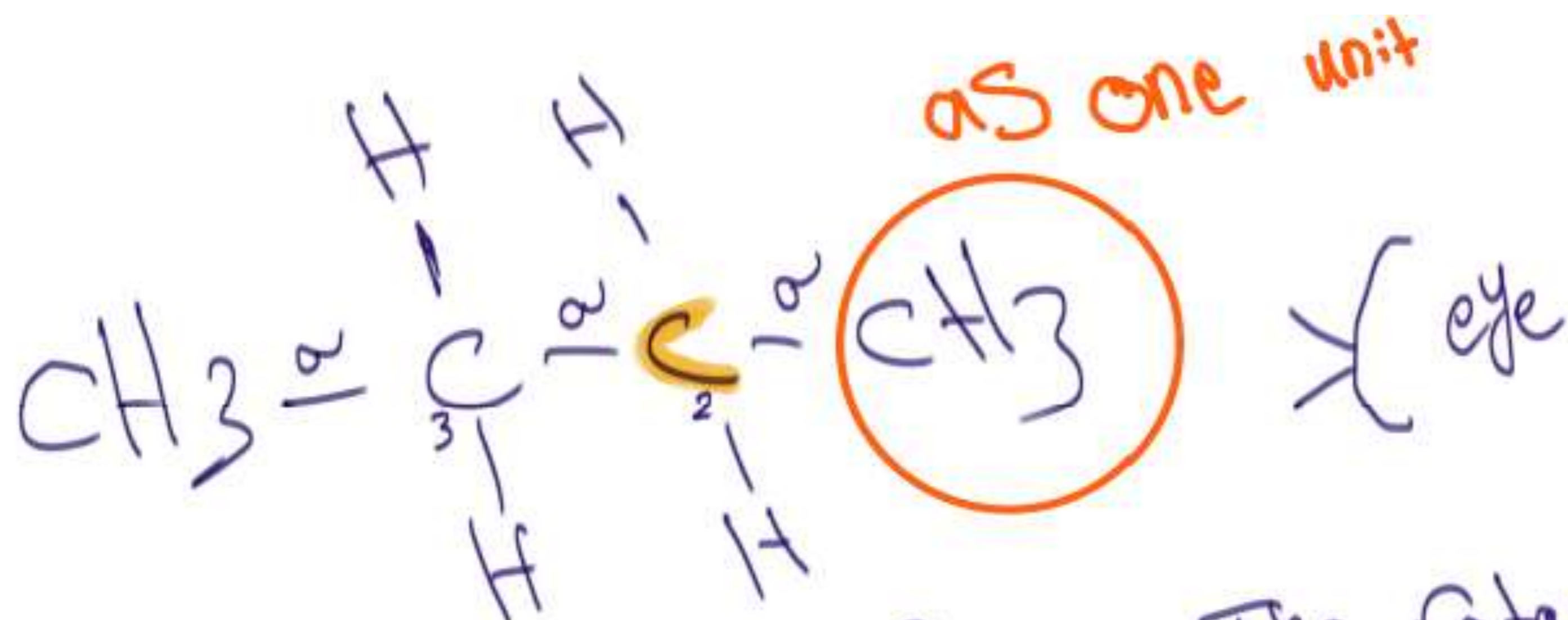
## "Torsional Strain"

هل الايثان ال staggered دائماً أم ممكن يتحول إلى eclipsed والعكس؟

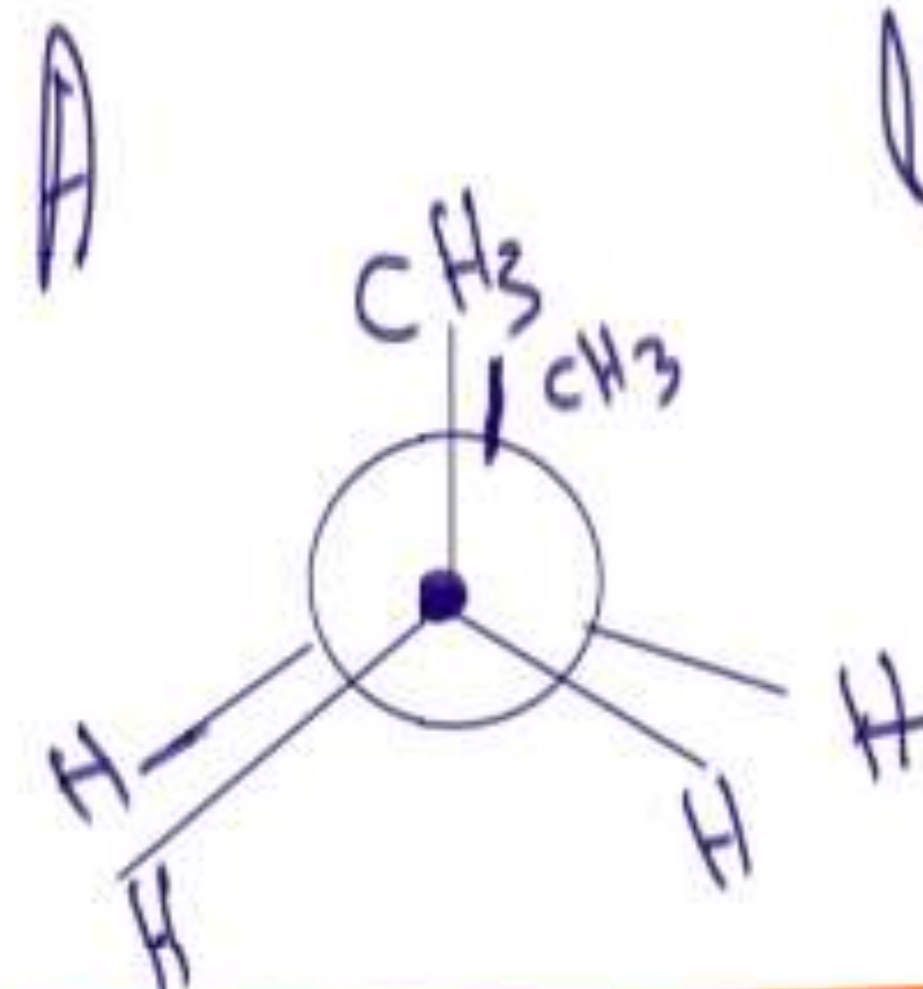
نعم يمكن ذلك، فرق الطاقة بين ال conformers قليلة لذلك يمكن أن يتناسب ال conformer الأكثر استقراراً (الأقل طاقة) الطاقة ويصبح أقل استقراراً (أعلى طاقة). والعكس صحيح.



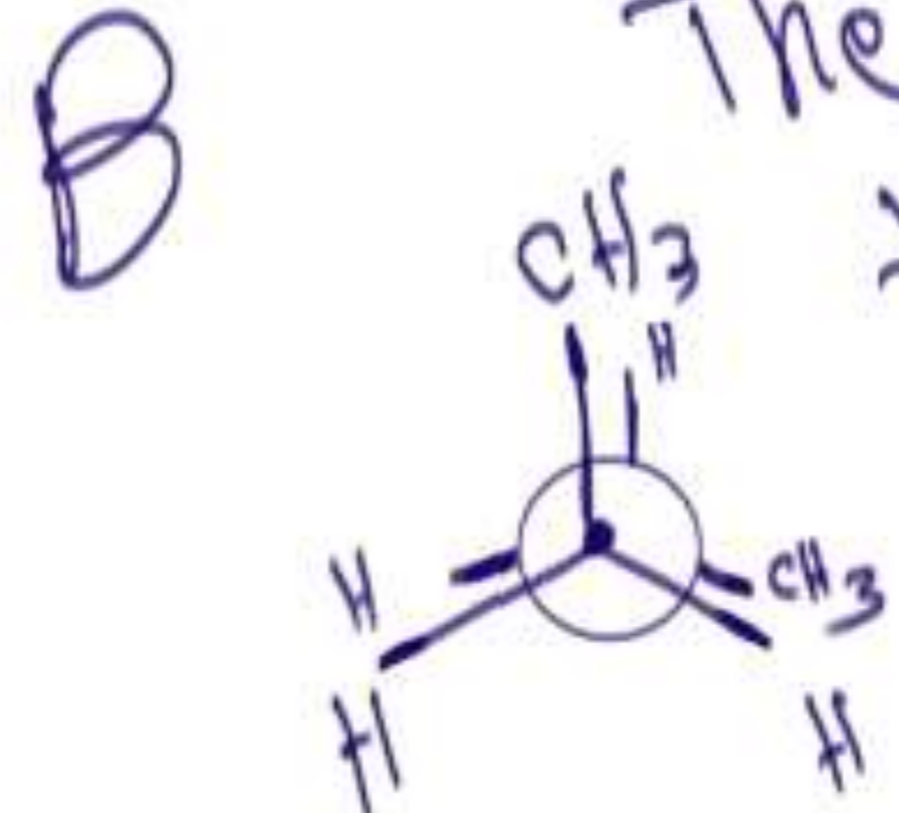




In case  $\theta = 0$



VS.



The rotamer A is less stable than B because the Repulsion between  $\text{CH}_3 \times \text{CH}_3$  is more than between  $\text{CH}_3 \times \text{H}$

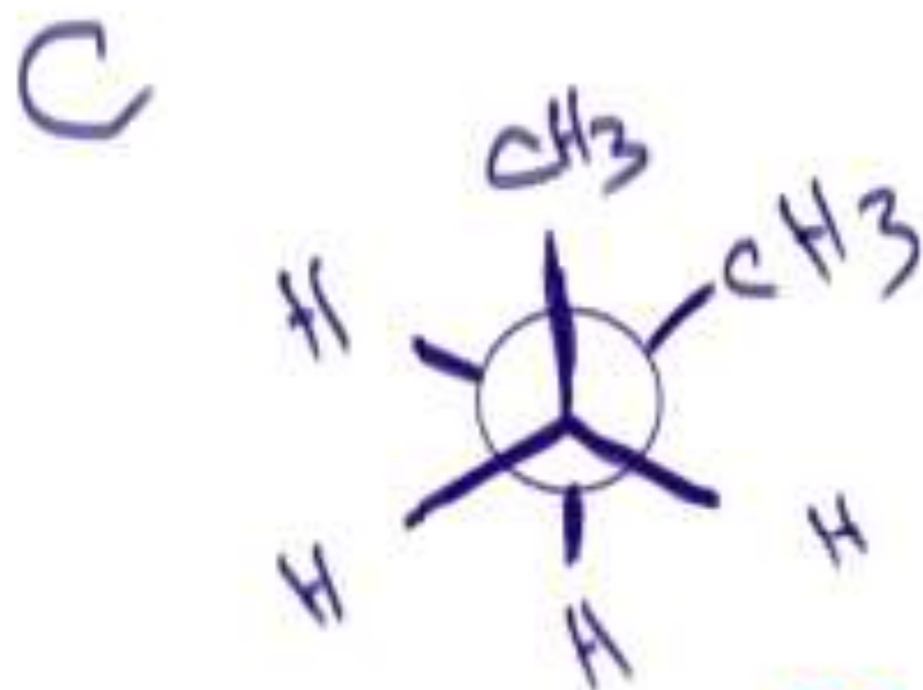
Order of the four conformers in terms of stability



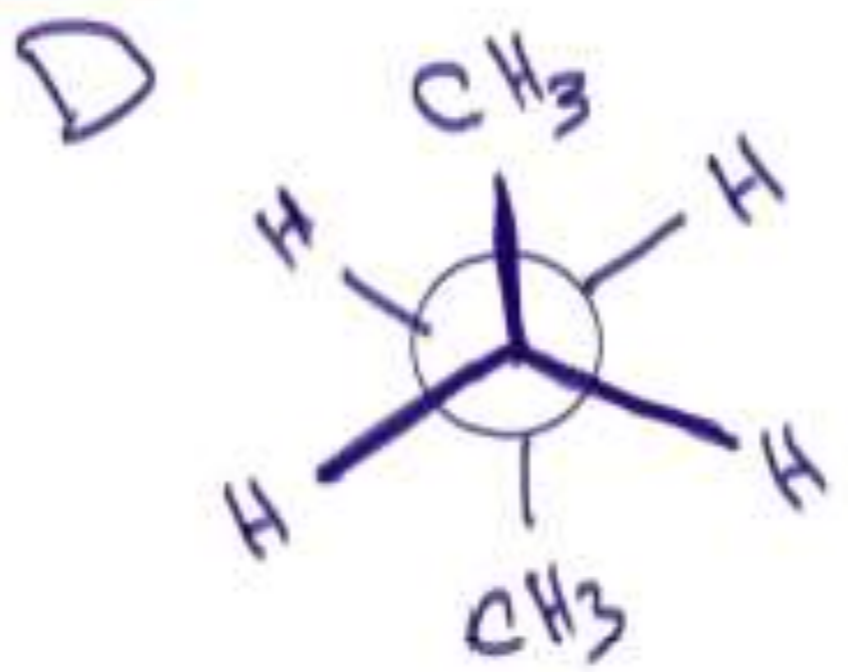
While according to the energy



In case  $\theta = 60^\circ$



VS.

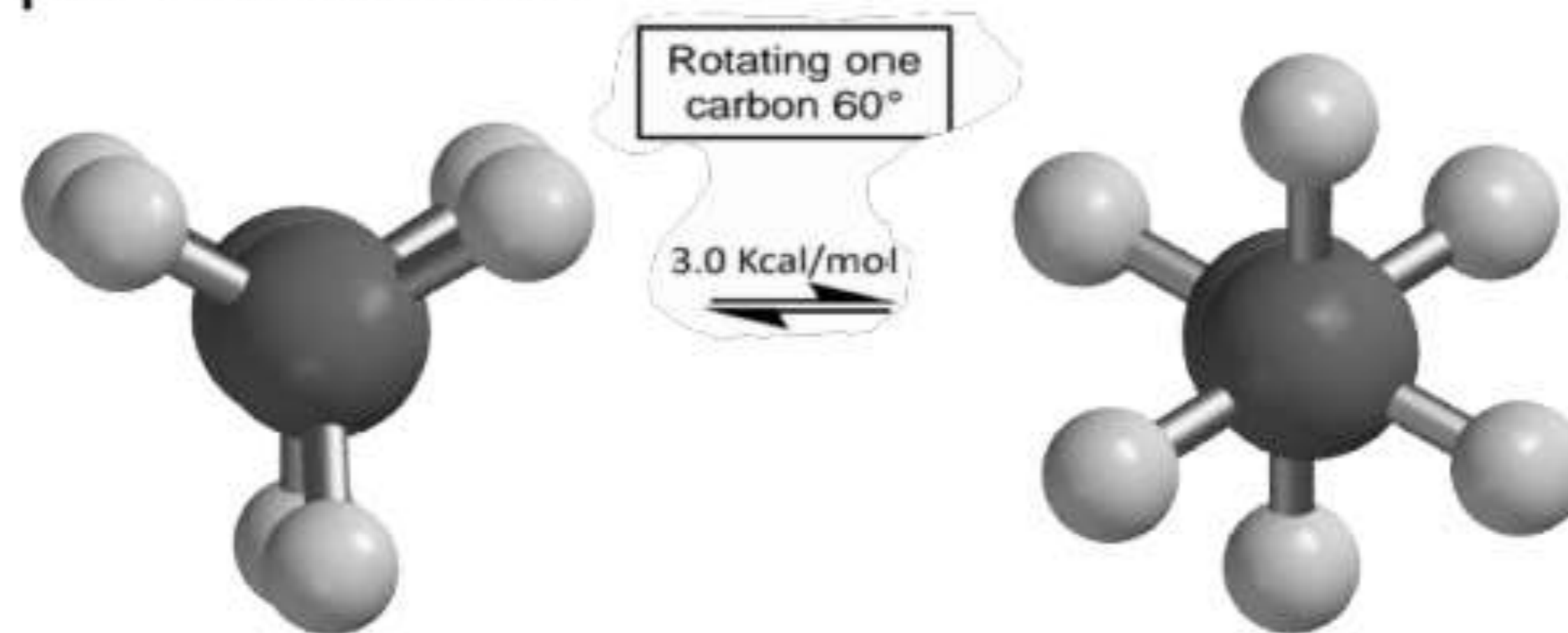


D أكثر استقراراً من C

# Conformational Isomers (cont'd)

The difference in energy is caused by “**steric**” interactions between the H atoms. Steric interactions are repulsions caused when two atoms are too close together in space and their valence shell electrons repel each other.

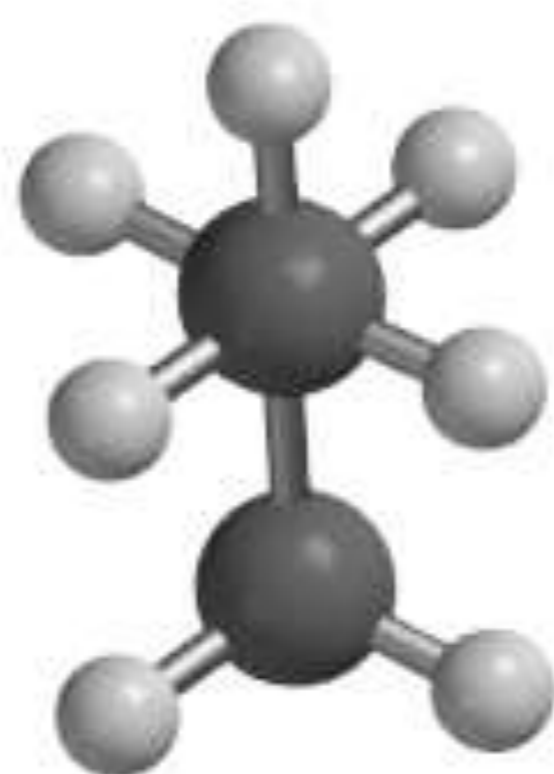
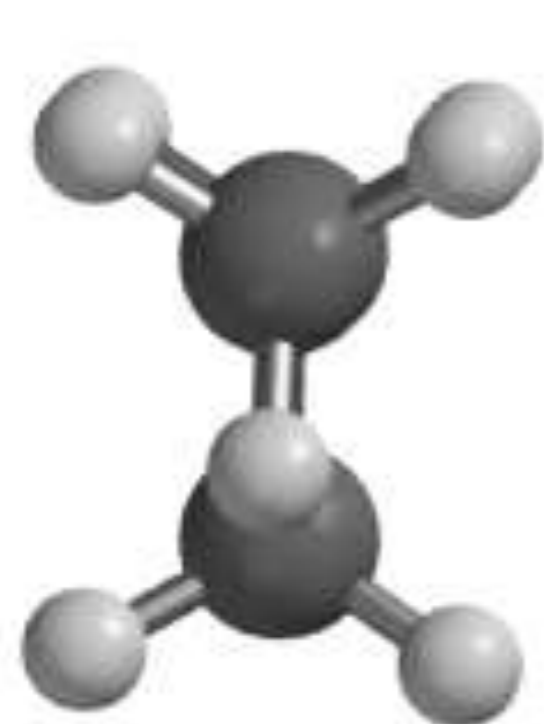
steric effect  
التداخل الفراغي



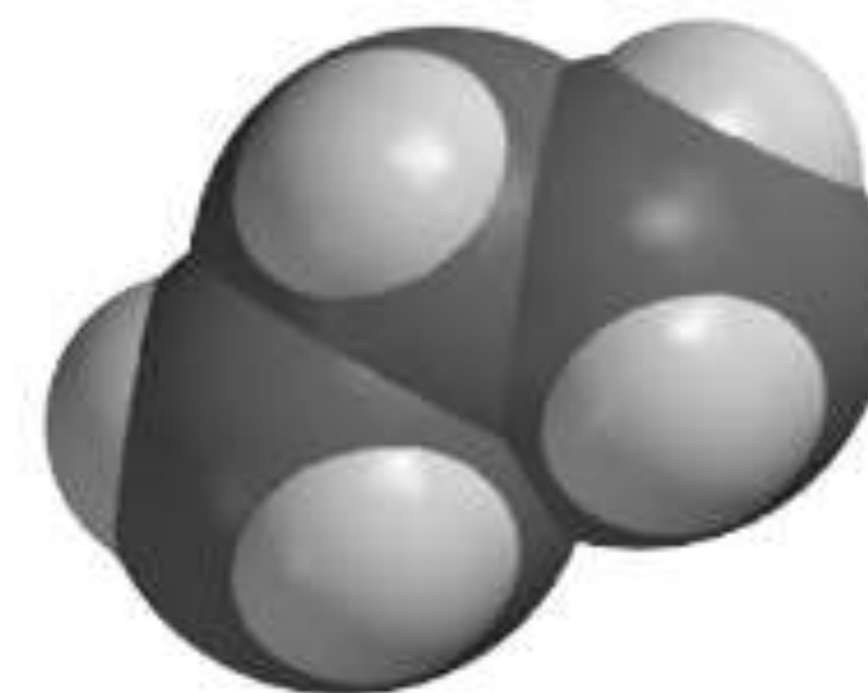
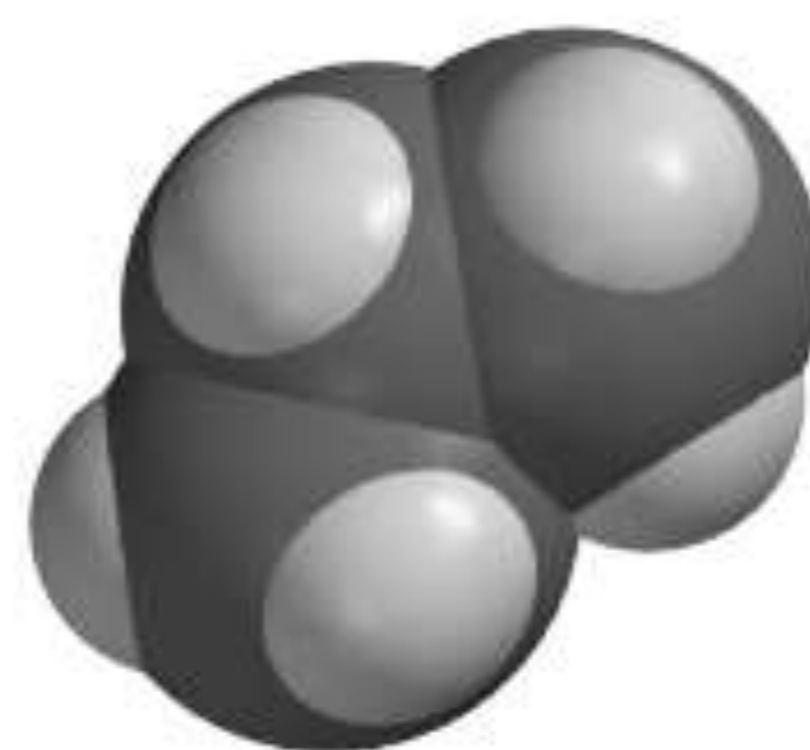
The H – H distance in the eclipsed is 2.36 Å and 2.54 Å in the staggered.

## Conformational Isomers (cont'd)

The problem is worse in propane as a methyl group is larger than a H atom. The eclipsed is on the left in both sets of images.

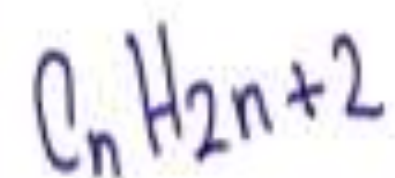


ball & stick



space filling

Alkanes



# Cycloalkanes

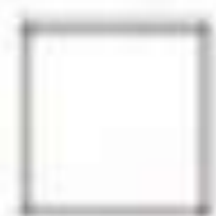
- General formula  $C_n H_{2n}$ 
  - Five- and six-membered rings are the most common.
- Structure and nomenclature
  - Prefix the name of the corresponding open-chain alkane with **cyclo-**, name each substituent on the ring.
  - If only one substituent, no need to give it a number.
  - If two substituents, number the ring from the substituent of lower alphabetical order.
  - If three or more substituents, number the ring to give them the lowest set of numbers, and then list them in alphabetical order.



3c



cyclopropane  
bp  $-32.7^{\circ}\text{C}$



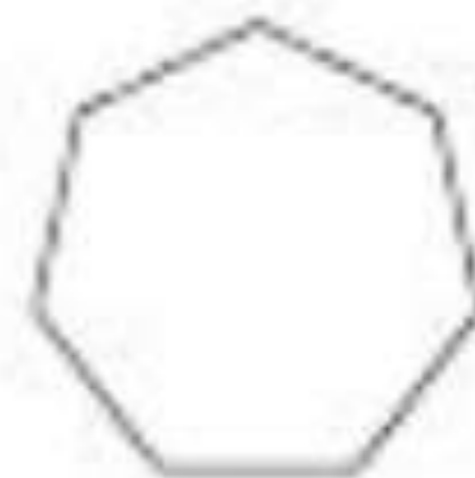
cyclobutane  
bp  $12^{\circ}\text{C}$



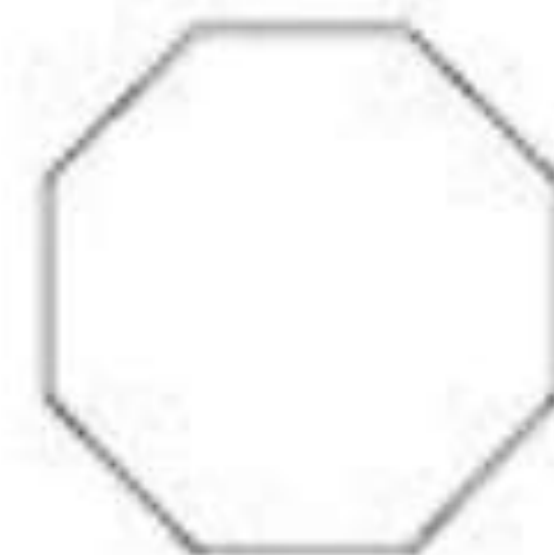
cyclopentane  
bp  $49.3^{\circ}\text{C}$



cyclohexane  
bp  $80.7^{\circ}\text{C}$

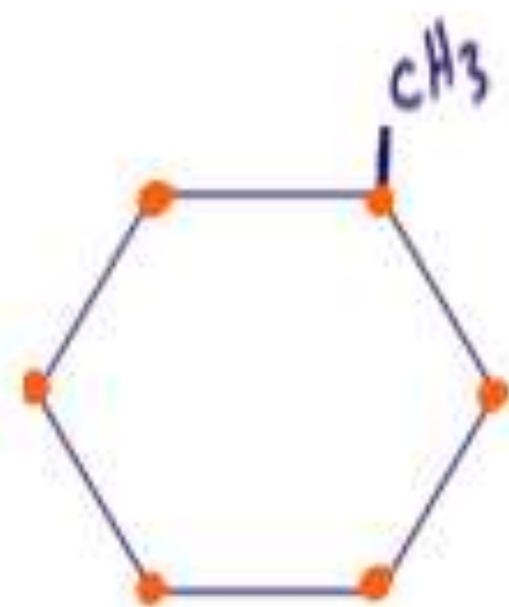


cycloheptane  
bp  $118.5^{\circ}\text{C}$



cyclooctane  
bp  $149^{\circ}\text{C}$

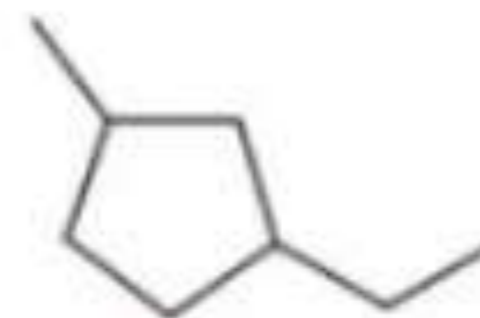
The simplest  
cycloalkane



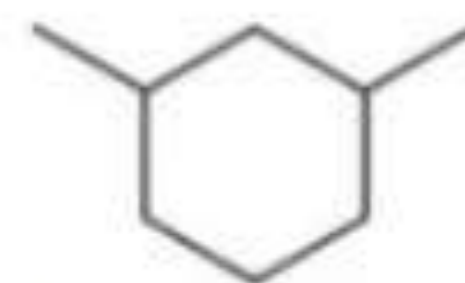
Methylcyclohexane



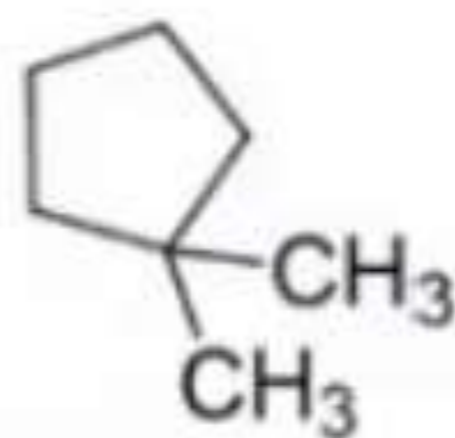
1-Methyl-2-propylcyclopentane



1-Ethyl-3-methylcyclopentane

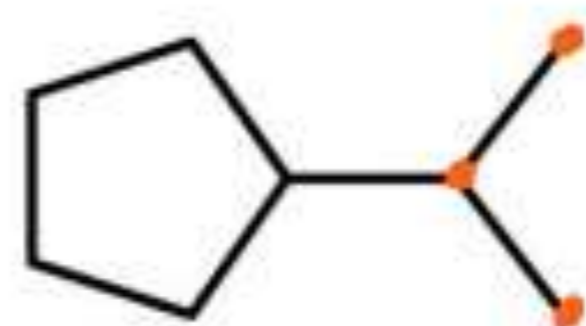


1,3-dimethylcyclohexane

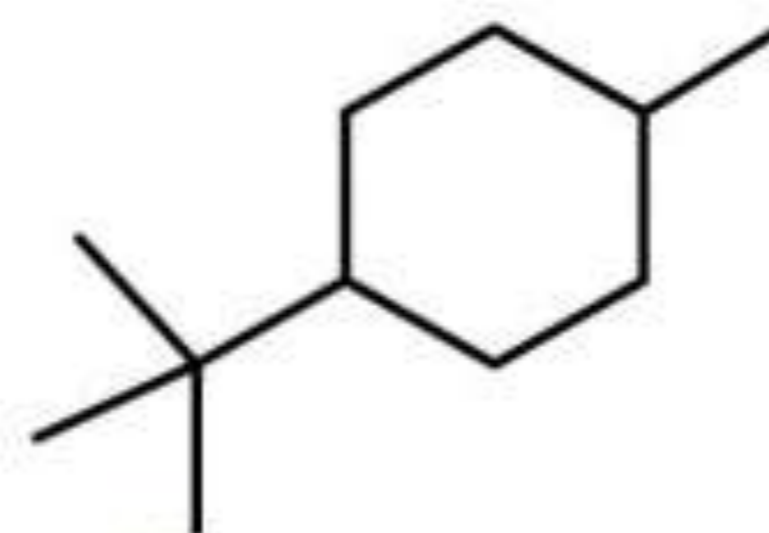


1,1-dimethylcyclopentane

- examples:



**Isopropylcyclopentane**



**1-*tert*-Butyl-4-methyl-  
cyclohexane**



**1-Isobutyl-2-methyl-  
cyclohexane**



**1-Ethyl-1-methyl-  
cyclopropane**

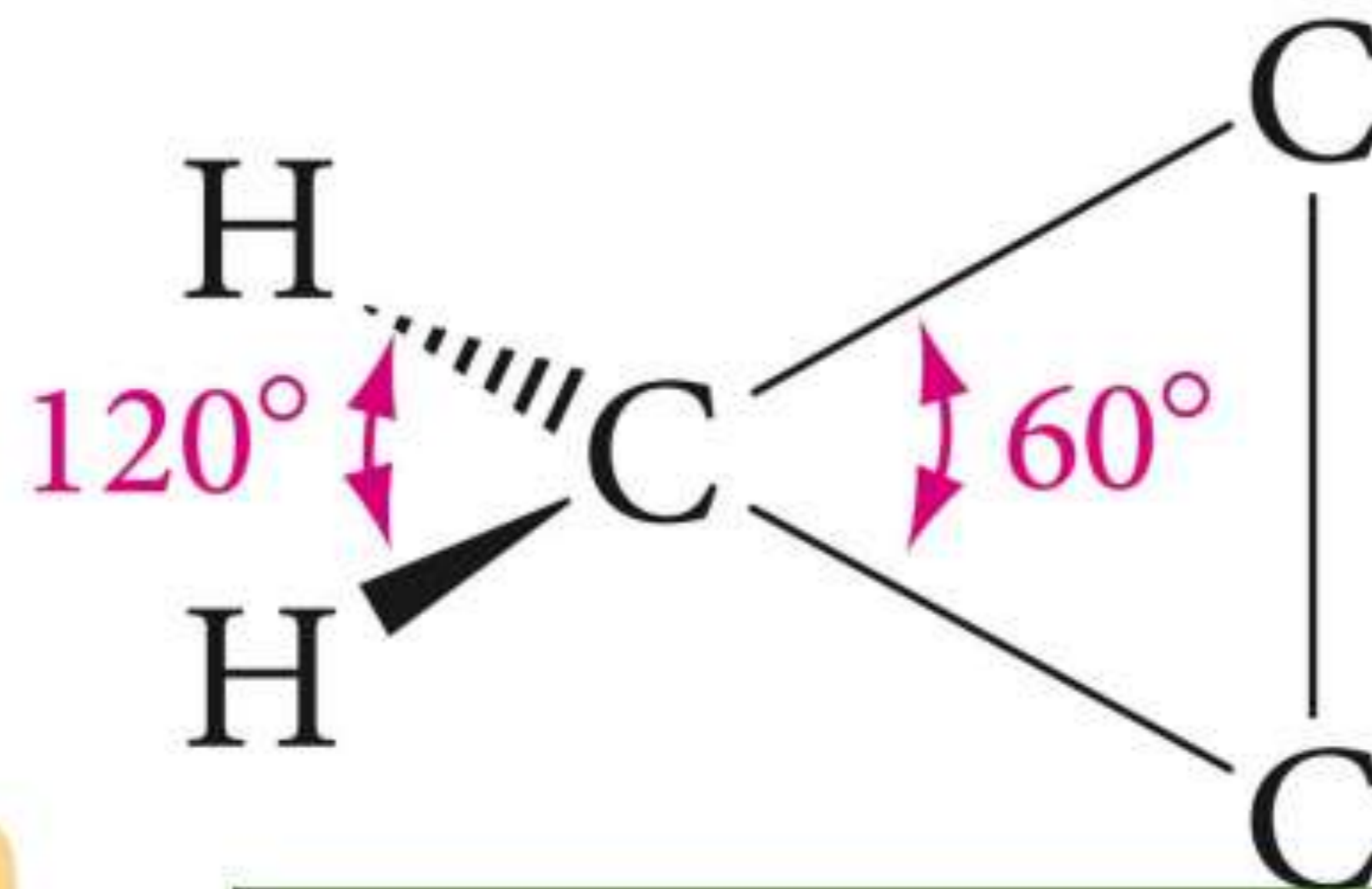
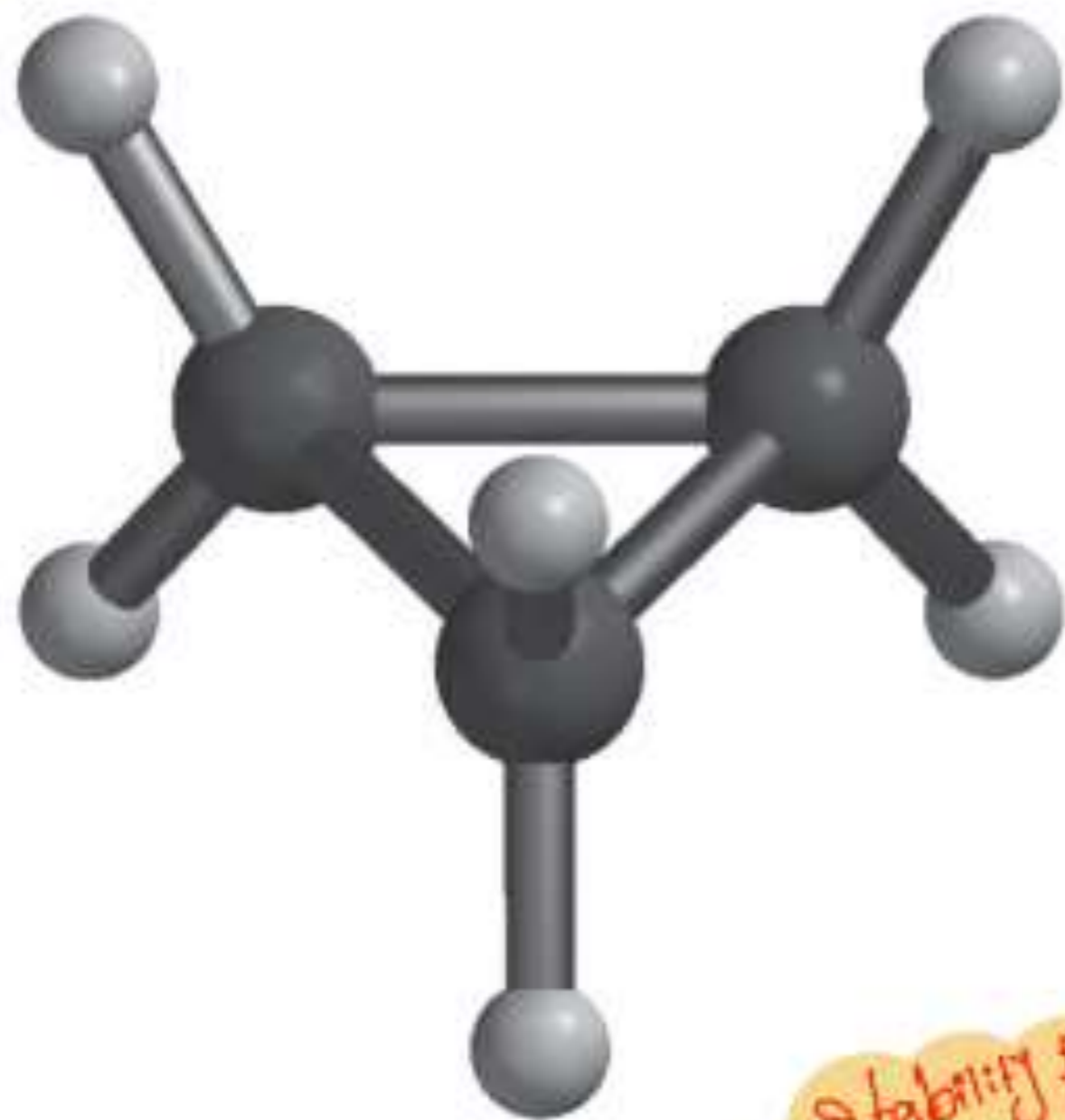
# Cycloalkanes

cyclopropane – is the smallest ring structure possible.

- It is rigid and very highly strained <sup>توتر</sup> as the bond angles ( $60^\circ$ ) are distorted from ideals ( $109.5^\circ$ )
- It is **more reactive** than a linear alkane as the strained C-C bonds are easier to break (**angle strain**)

\* Cyclopropane is the most reactive cycloalkane.

↑ reactive ↓ stability ↑ Energy



Stability for cycloalkanes is less than alkanes because the ring strain is high.

$$\uparrow \text{Ring Strain} = \text{Angle} + \text{Torsional}$$

\* No rotation here \*

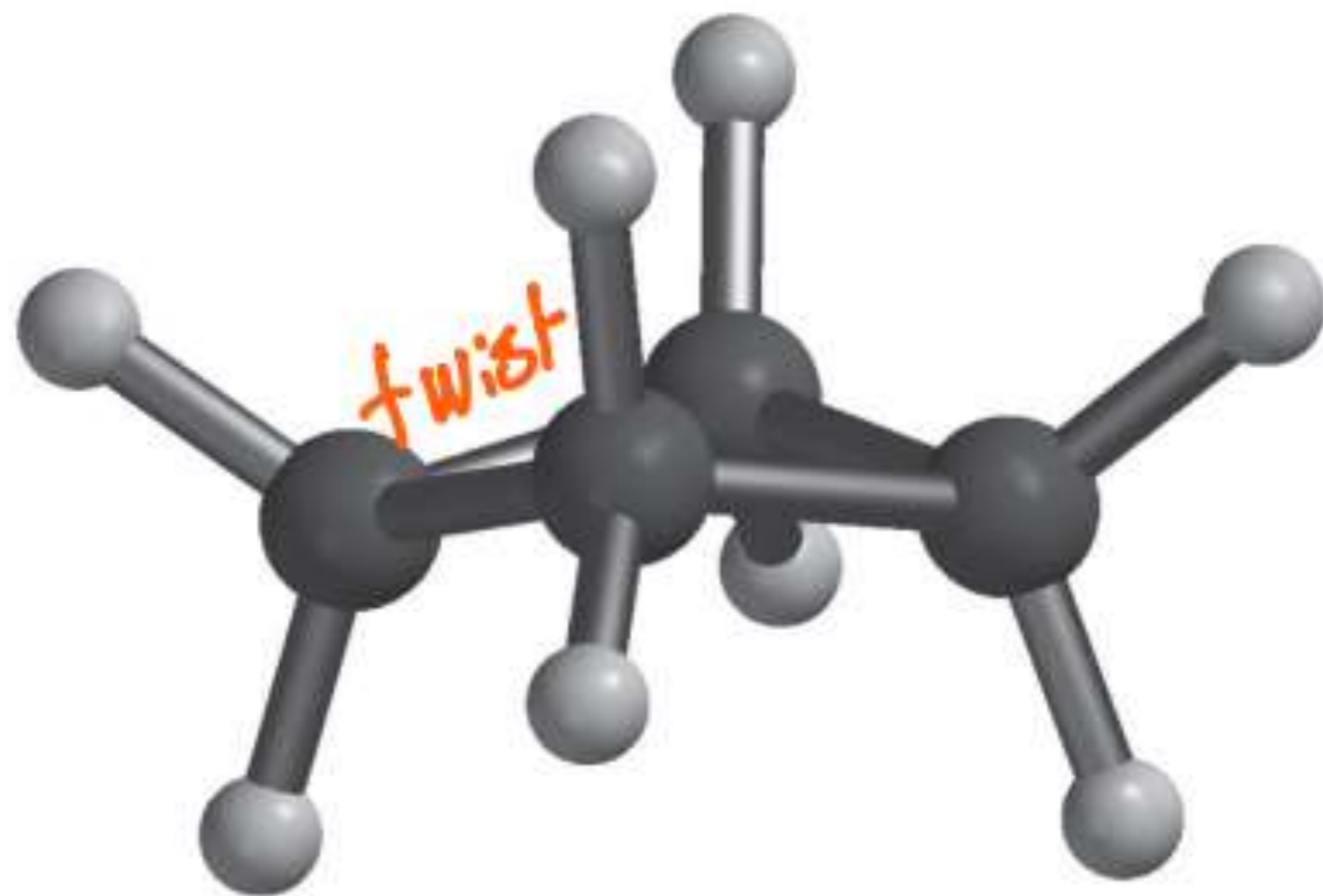
# Cycloalkanes

cyclopropane  
إحدى استقراراً من

flexibility  $\propto$  stability

cyclobutane – “puckered” conformation

- It is more flexible than cyclopropane and is not flat although it is commonly drawn that way.
- It is more reactive than a linear alkane as the strained C-C bonds are easier to break, bond angle  $\sim 90^\circ$



common



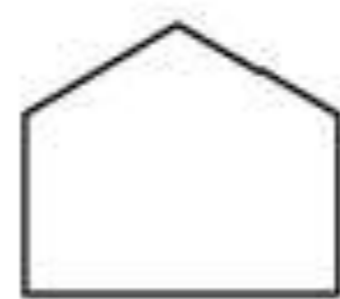
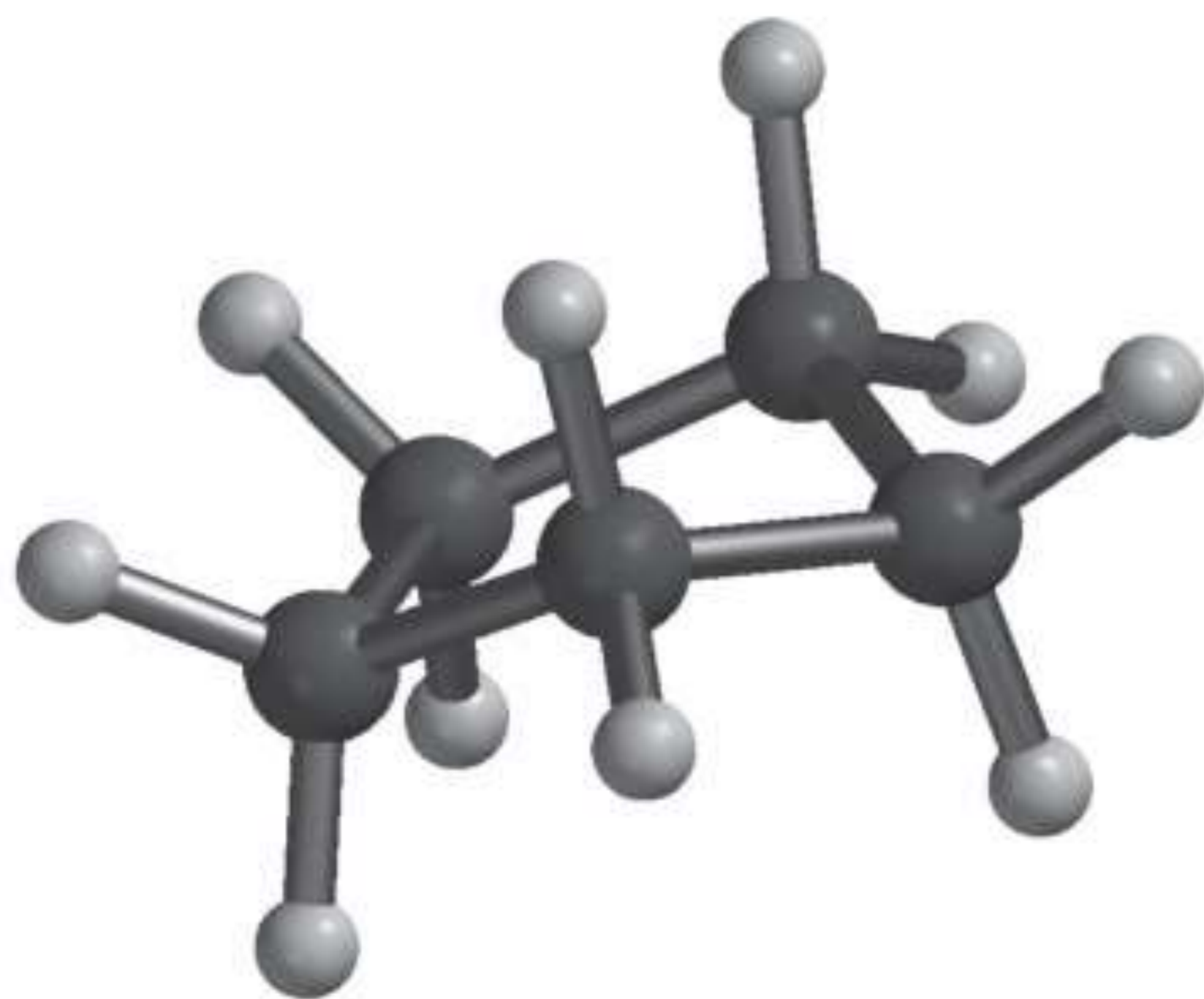
better



# Cycloalkanes

cyclopentane – “envelope” conformation

- It is more flexible than cyclobutane and bond angles are  $\sim 105^\circ$ , and less strained



poor



better



good



best

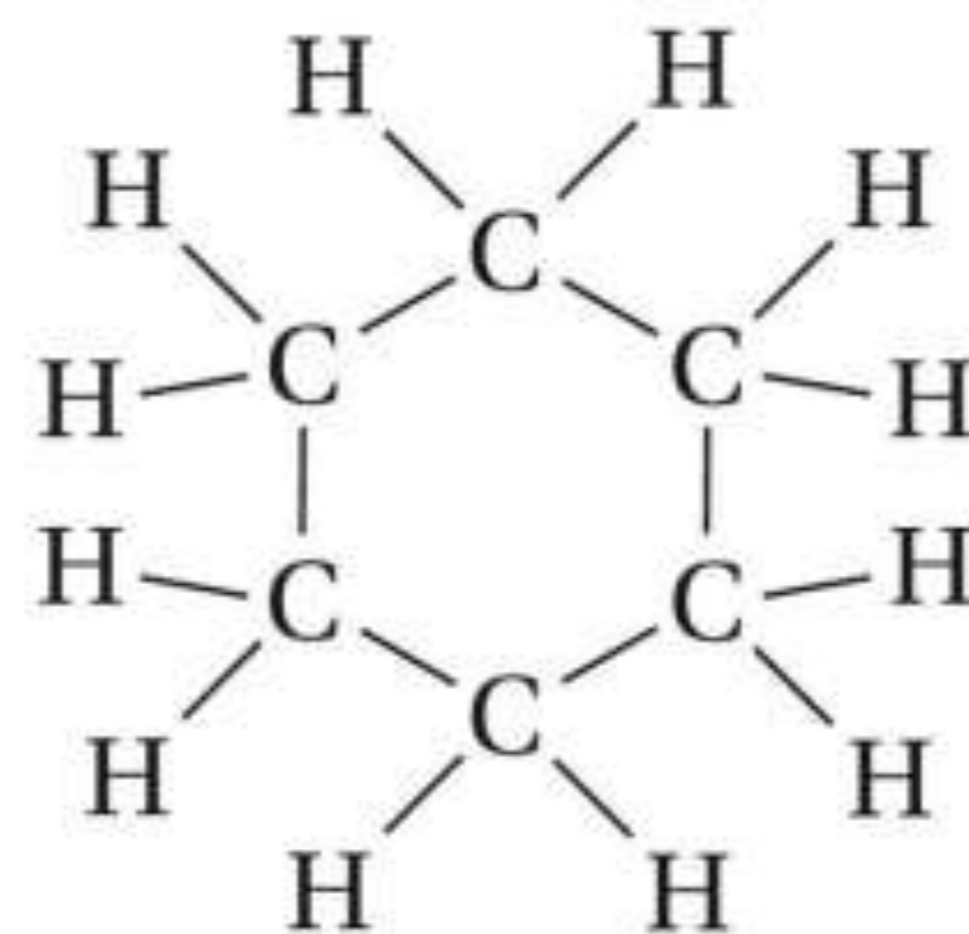
# Cycloalkanes

*The most stable cycloalkane.*

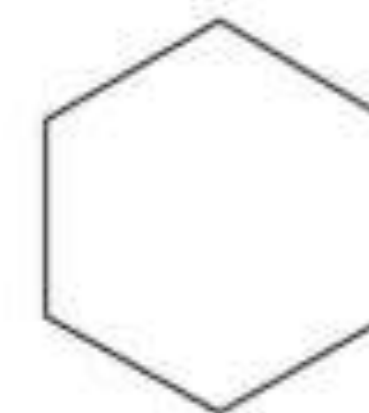
## cyclohexane – “chair”

- It is highly flexible and can adopt a strain free non-planar conformation with bond angle of  $109.5^\circ$
- It is very common in nature so understanding its conformations is important.

Although commonly drawn as a hexagon, implying a flat six-membered ring this is not the common conformation seen.



or

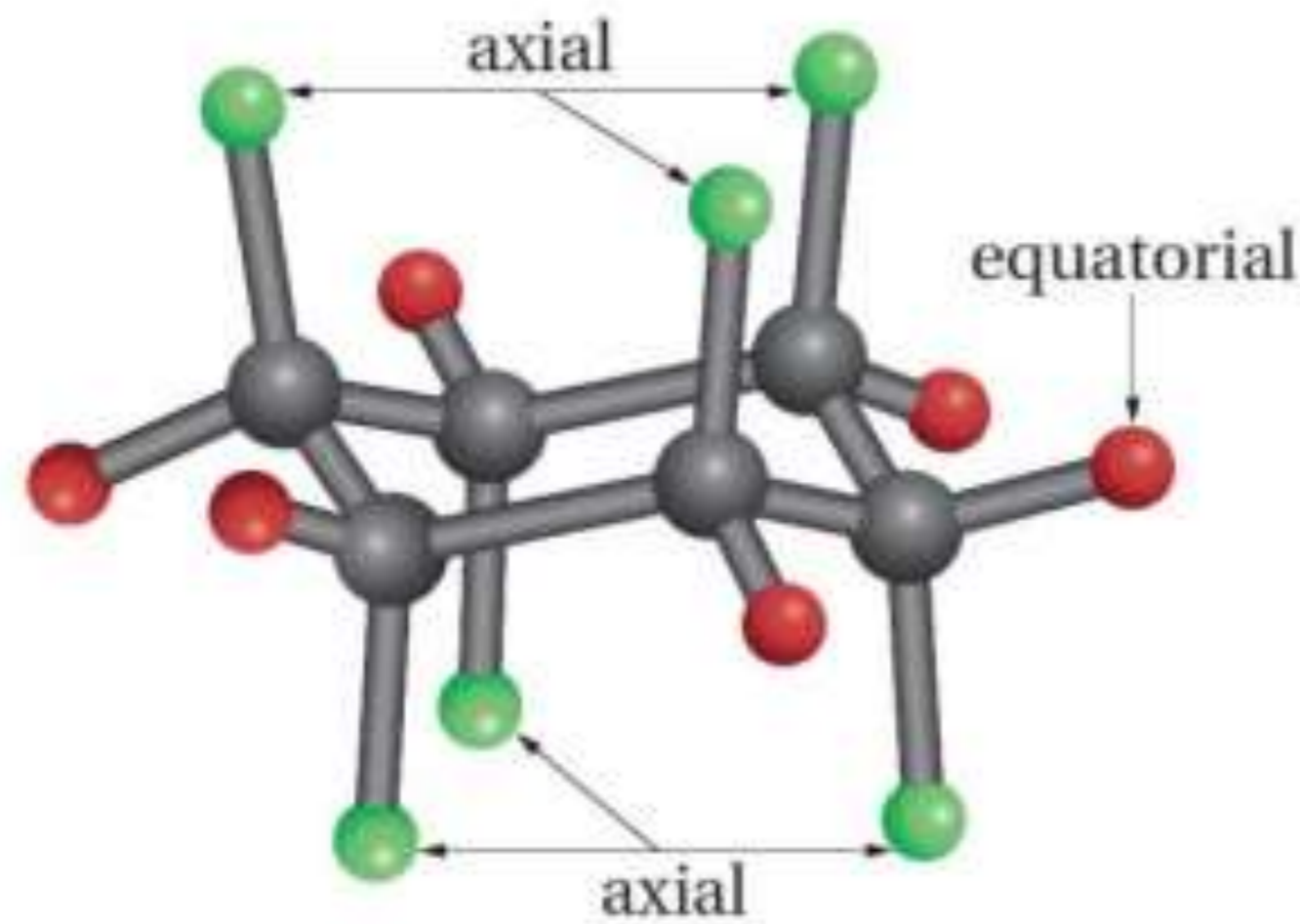


Structural and abbreviated structural formulas for cyclohexane

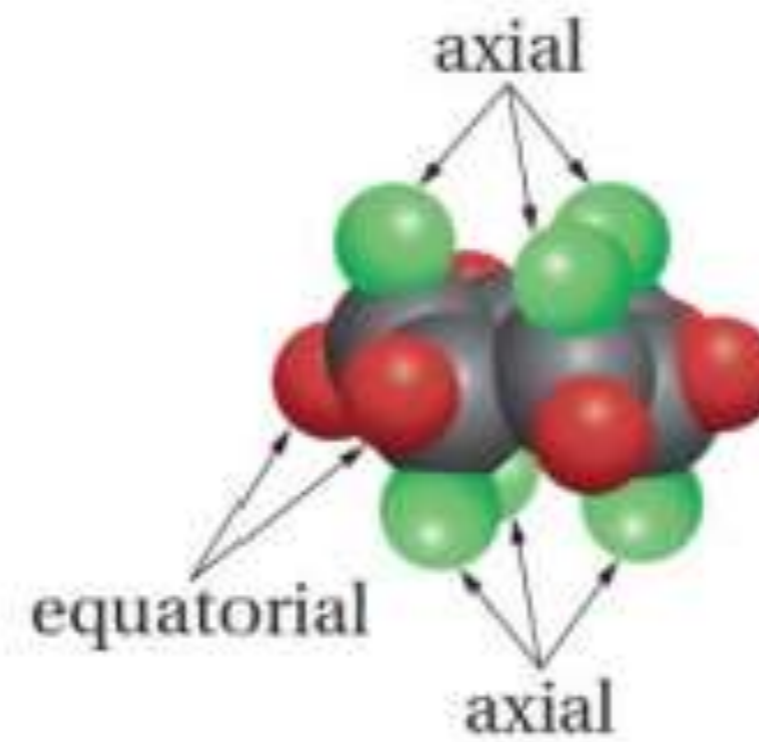
*Ring strain free.*

## Cyclohexane cont'd:

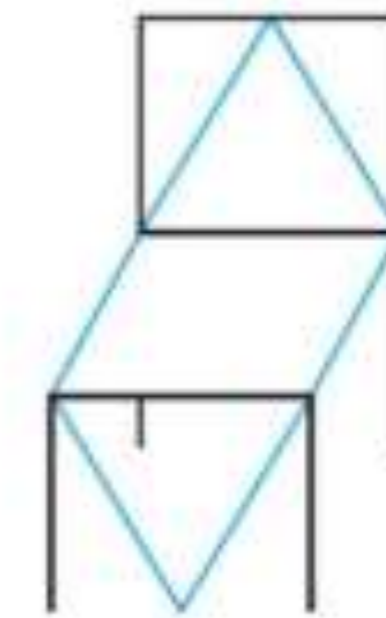
The most common conformation of cyclohexane is the “chair” conformation. In this geometry the C bonds are all  $\sim 109.5^\circ$  as opposed to the  $120^\circ$  in a planar structure.



ball-and-stick model



space-filling model



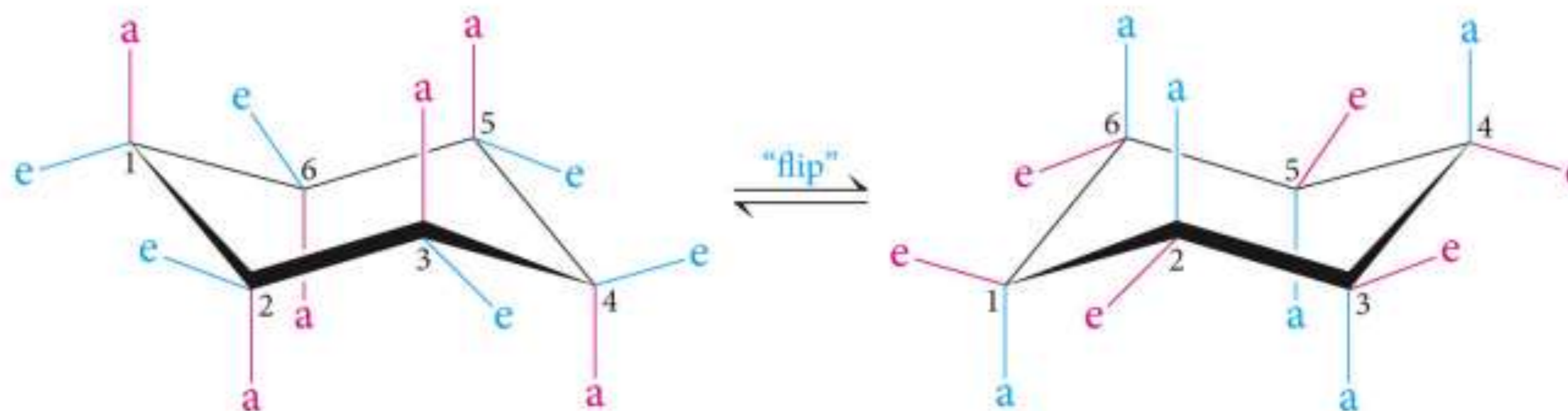
chair framework  
(has a chair shape)

This structure creates two subsets of hydrogen atoms, those lying in the same plane as the C atoms, the equatorial H and those lying above and below that plane, the axial H atoms

## Cyclohexane cont'd:

Cyclohexane cont'd:

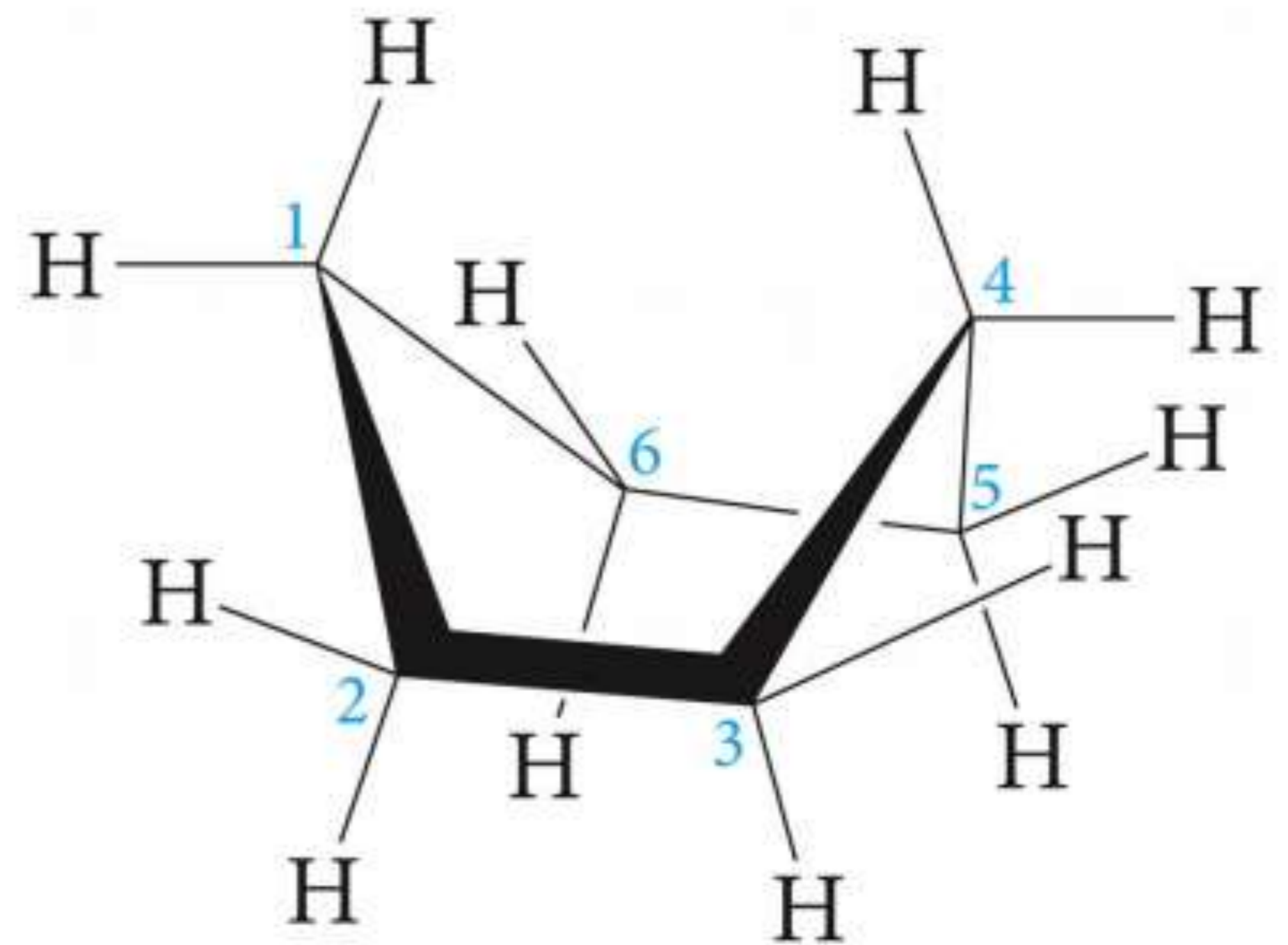
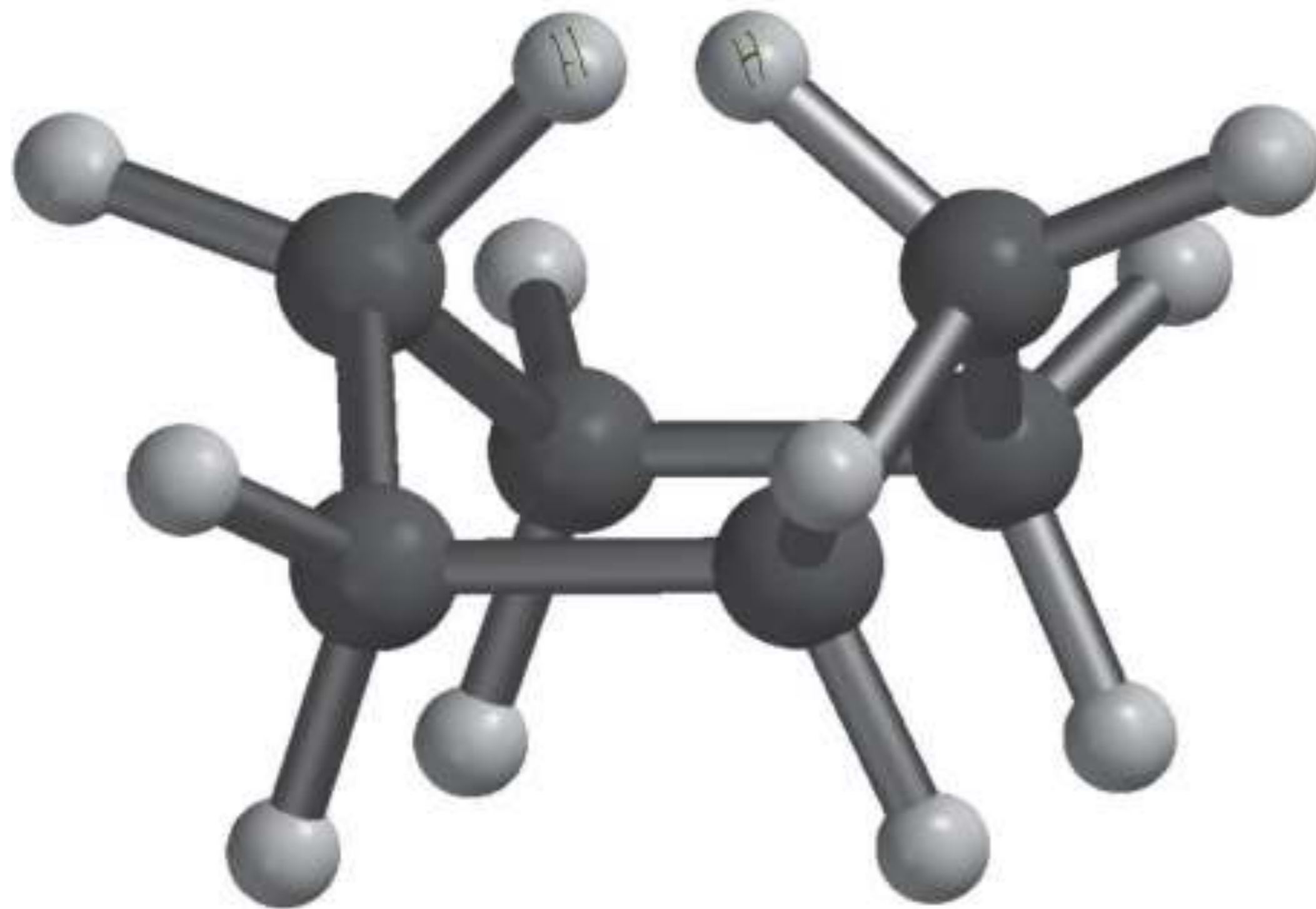
Since the C-C bonds are all single ( $\sigma$ ) bonds, it is possible to rotate about these bonds. This process is known as a ring inversion or a "chair-chair" flip. In the process of the inversion all equatorial H become axial and axial become equatorial.



Axial bonds (red) in the left structure become equatorial bonds (red) in the right structure when the ring "flips."

## Cyclohexane cont'd:

Other conformations of cyclohexane are possible but they are higher in energy and less stable, i.e. the "boat" conformation

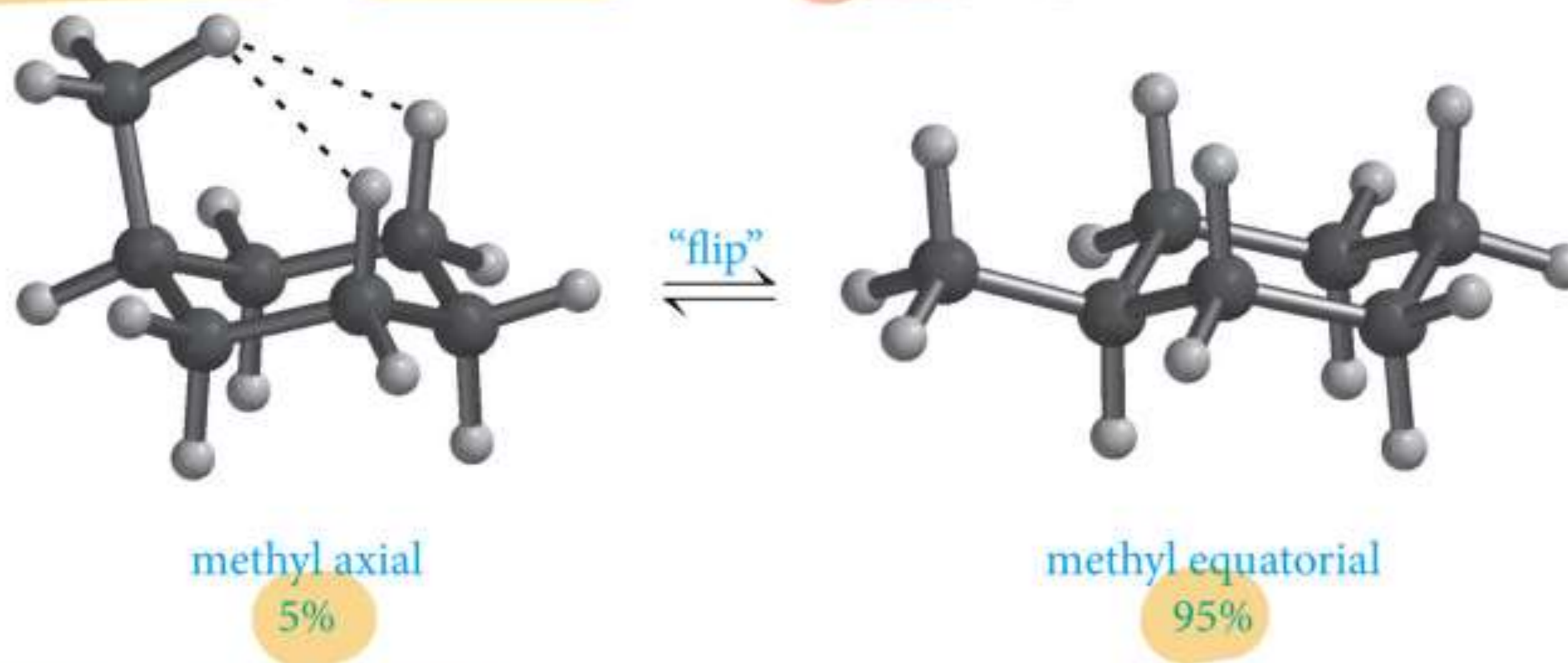


boat cyclohexane

## Cyclohexane cont'd:

Substituted cyclohexane:

The addition of a methyl group on cyclohexane (methylcyclohexane) can have two conformations, the methyl can be axial or equatorial, i.e.



The equatorial is preferred as there is significantly less steric interactions than when in the axial position. This will be true for any group on a cyclohexane ring and has implications for the chemical reactivity of the compound.

# Geometric Isomers

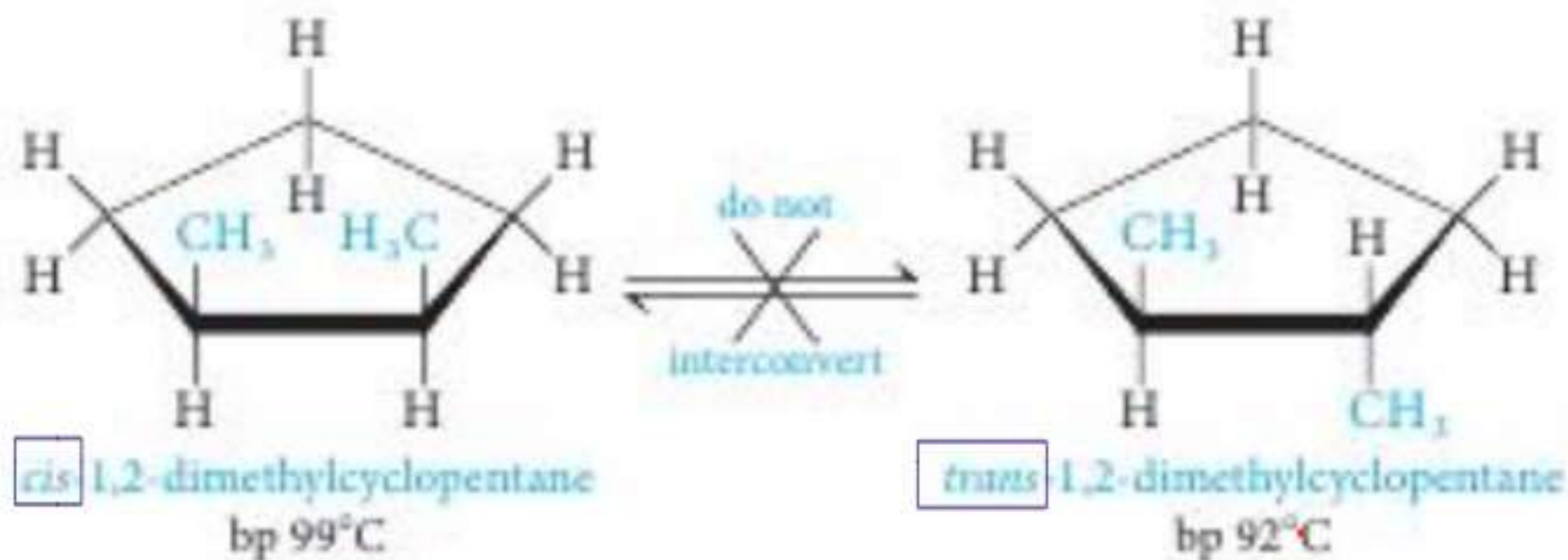
*Stereoisomerism* deals with molecules that have the same order of attachment of the atoms, but different arrangements of the atoms in space.

*Geometric isomers* (configurational isomers, or diastereomers, a subset of stereoisomers) are molecules which have the same chemical formula, the atoms are bonded in the same order, but located in different positions in space.

chapter 4  
مستقل  
8 حقا

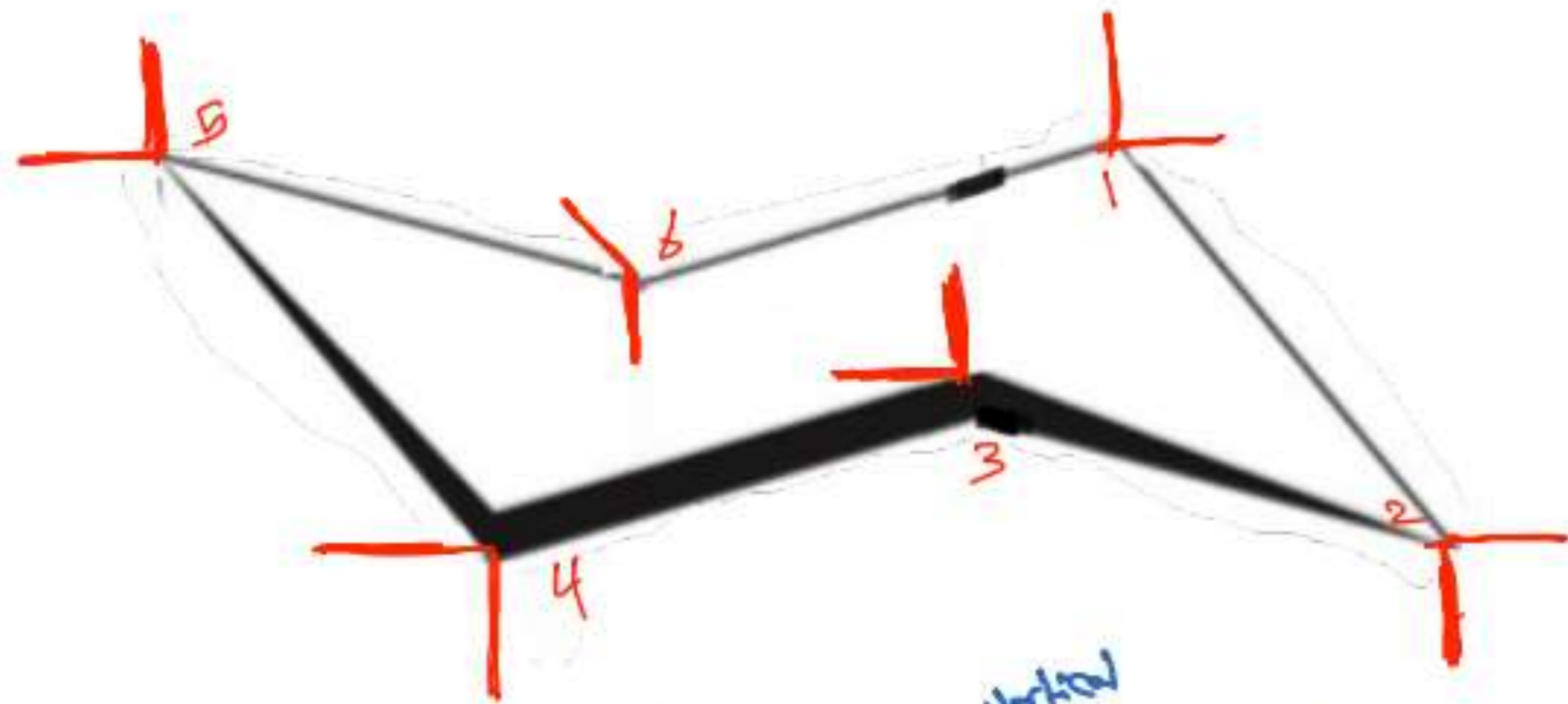
## Cis–trans isomers = Geometric Isomers

An example of this is 1,2-dimethylcyclopentane



These structures can not interconvert without breaking a C-C bond.





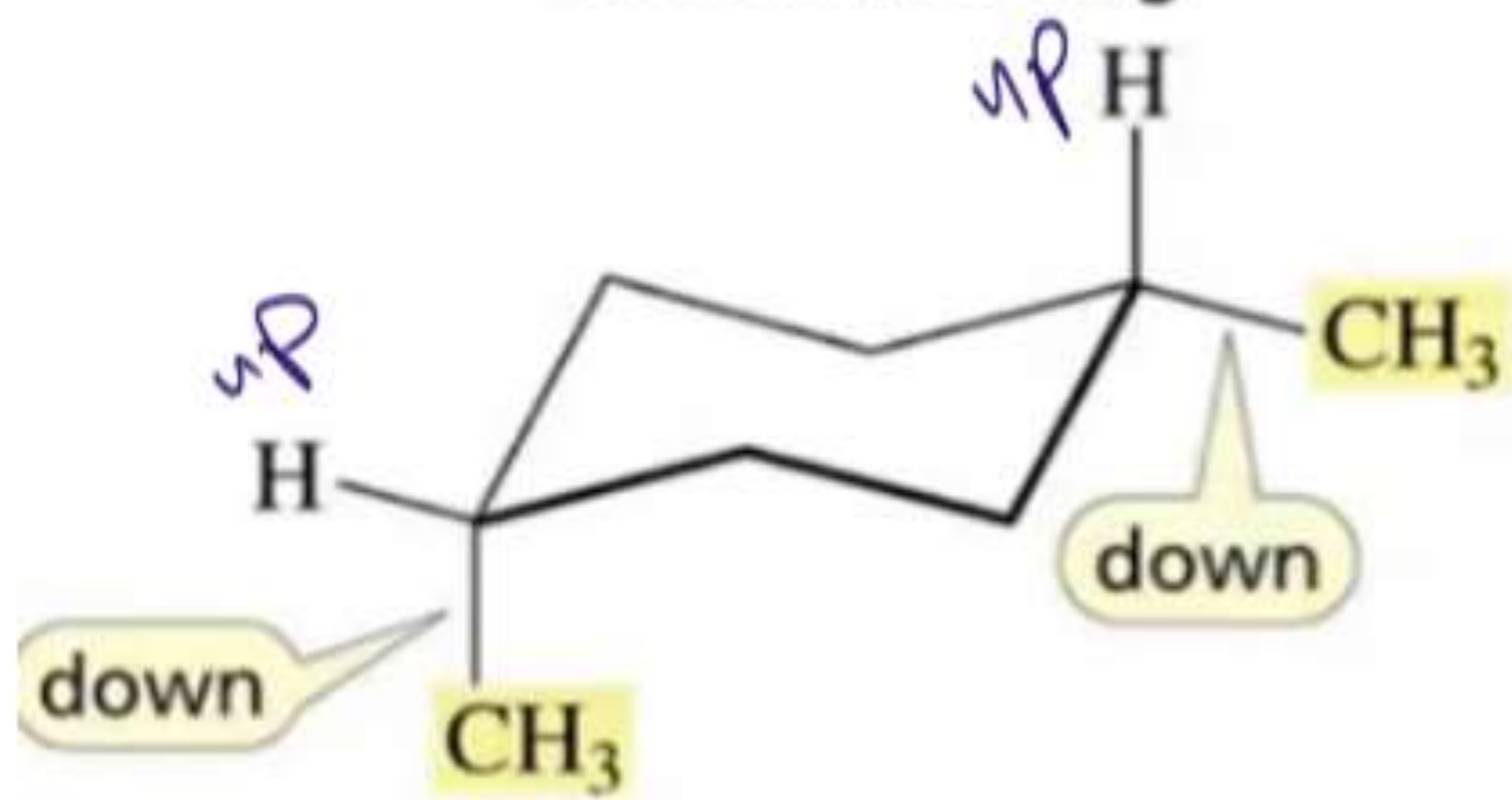
ذرة الكربون رقم 1 vertical horizontal نفس رقم 3 ، 5  
 ذرة الكربون رقم 2 vertical horizontal نفس رقم 4 ، 6 .

حيث يكون مجموع التفرجات 12 .

6 "Axial" للأعلى والأعلى (بالنسبة 3 لأعلى و 3 لأسفل)  
6 "Equatorial" لليمين واليسار

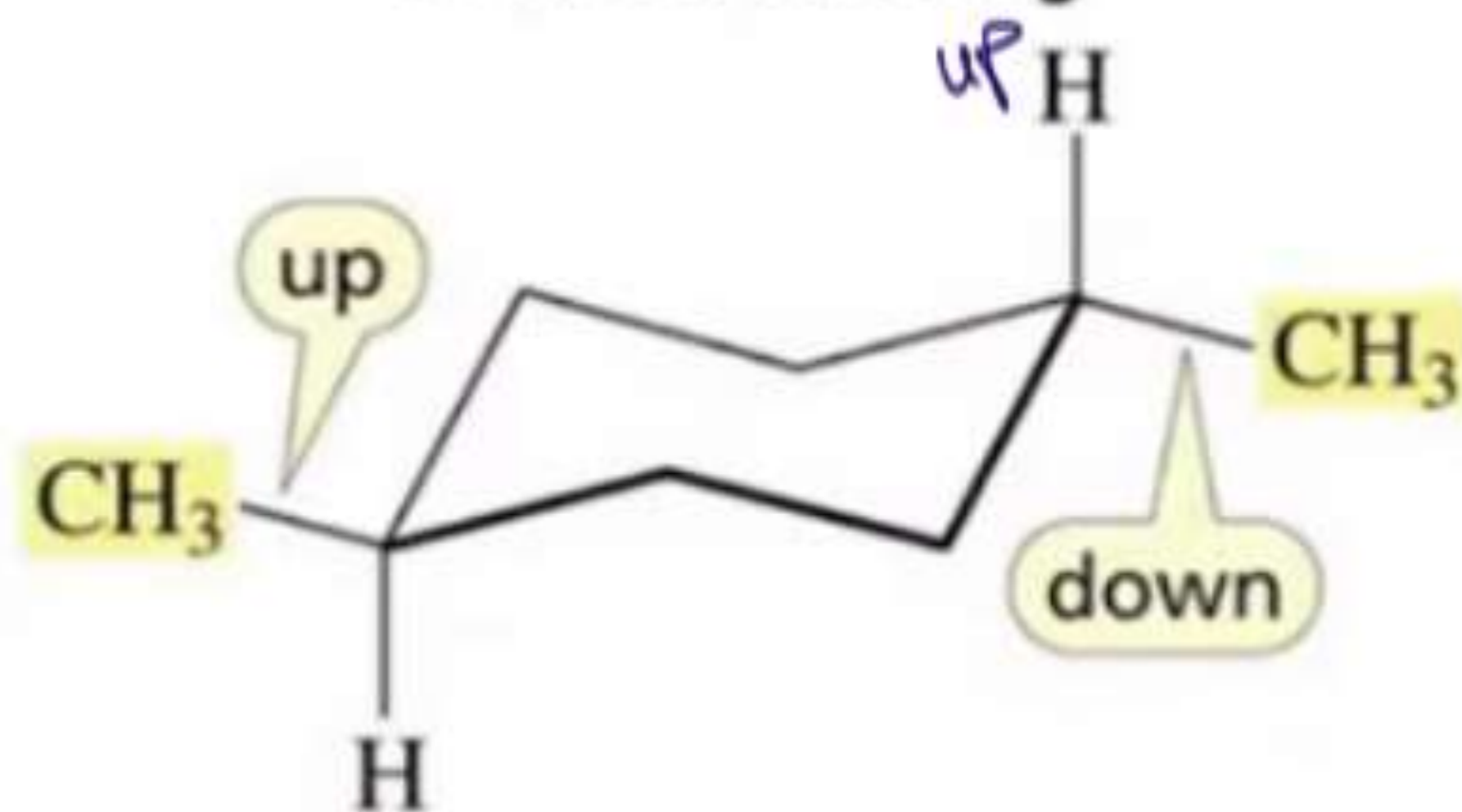
## Cis and Trans Isomers

two methyl groups are on the same side of the ring

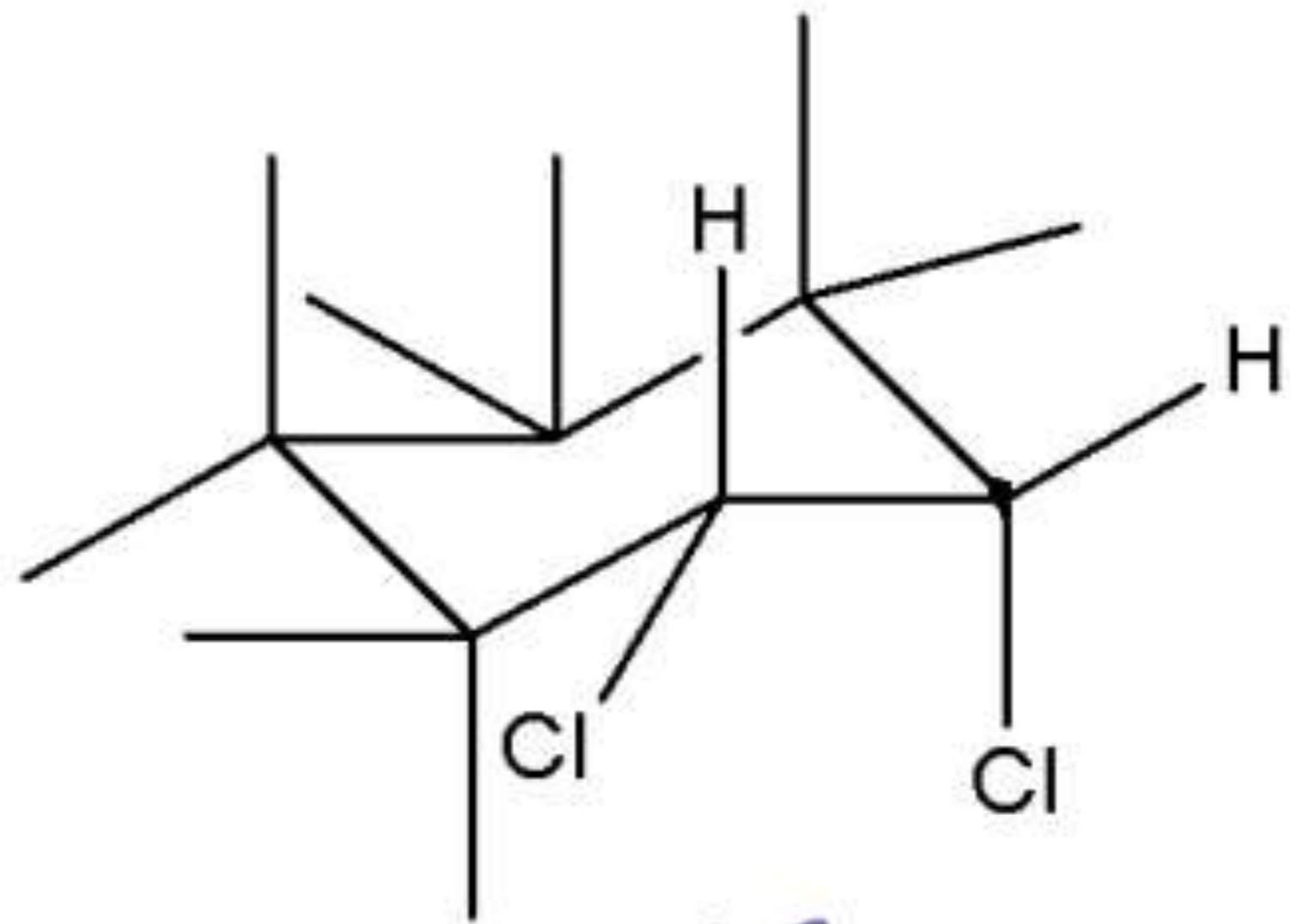


*cis*-1,4-dimethylcyclohexane

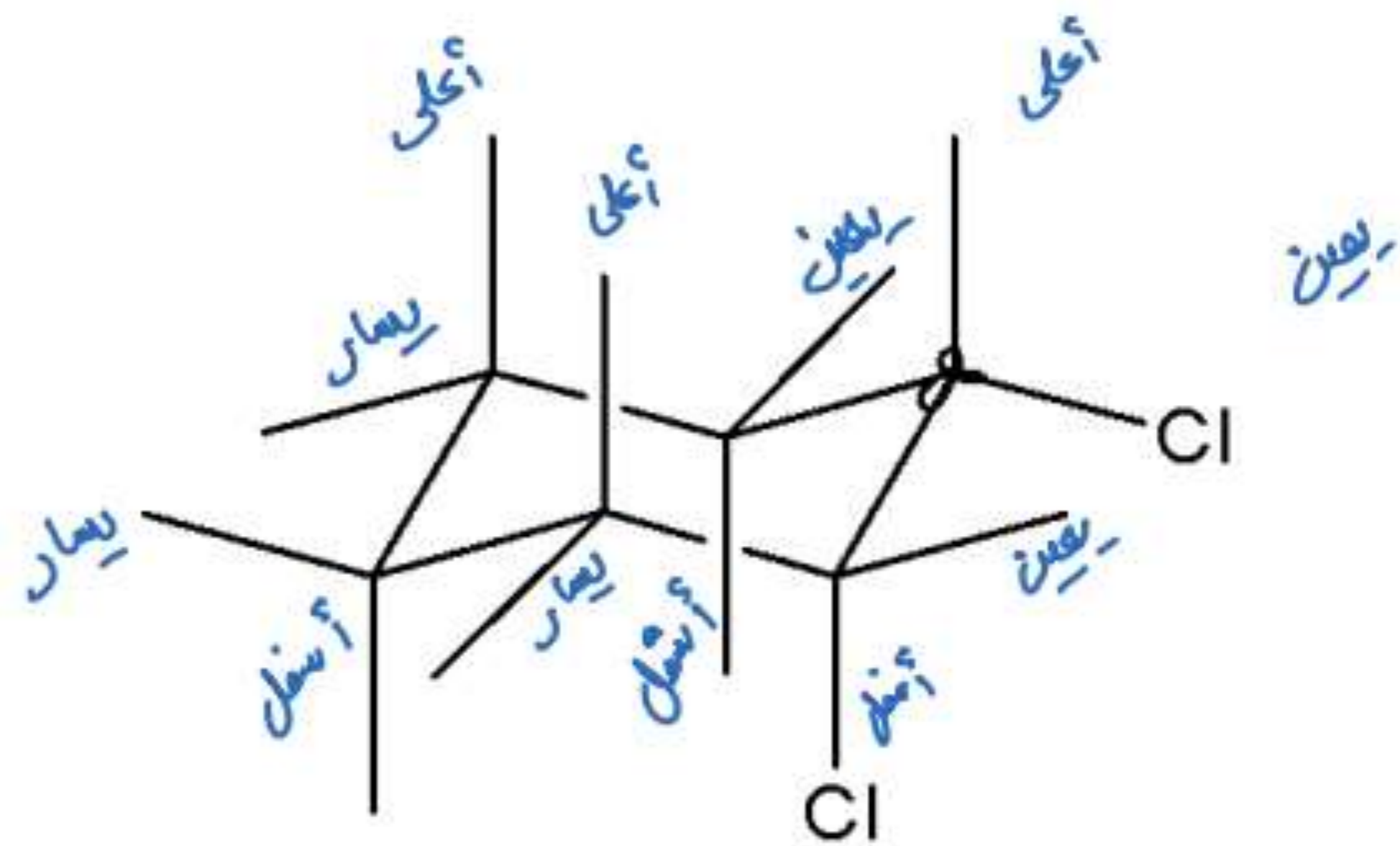
two methyl groups are on opposite sides of the ring



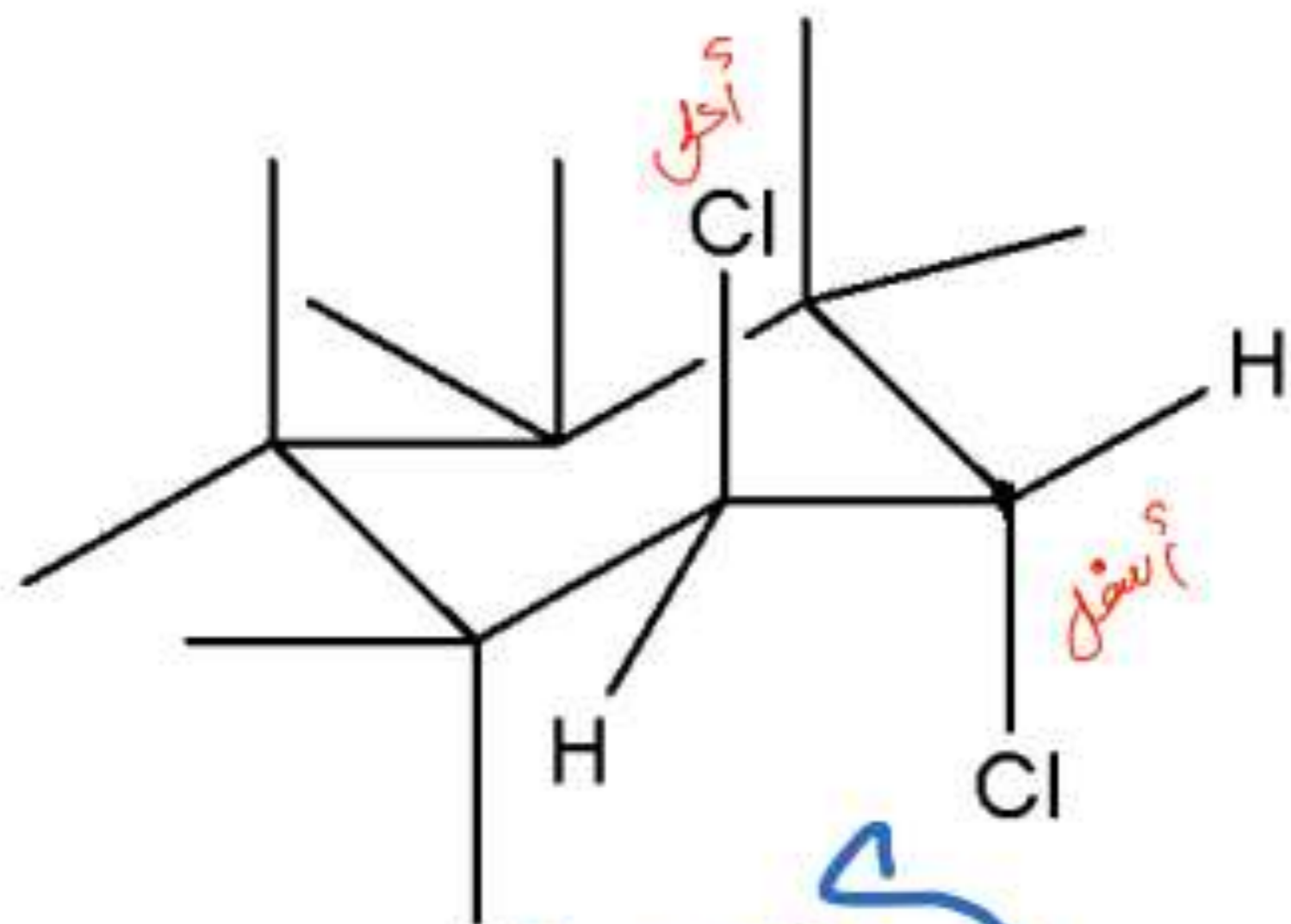
*trans*-1,4-dimethylcyclohexane



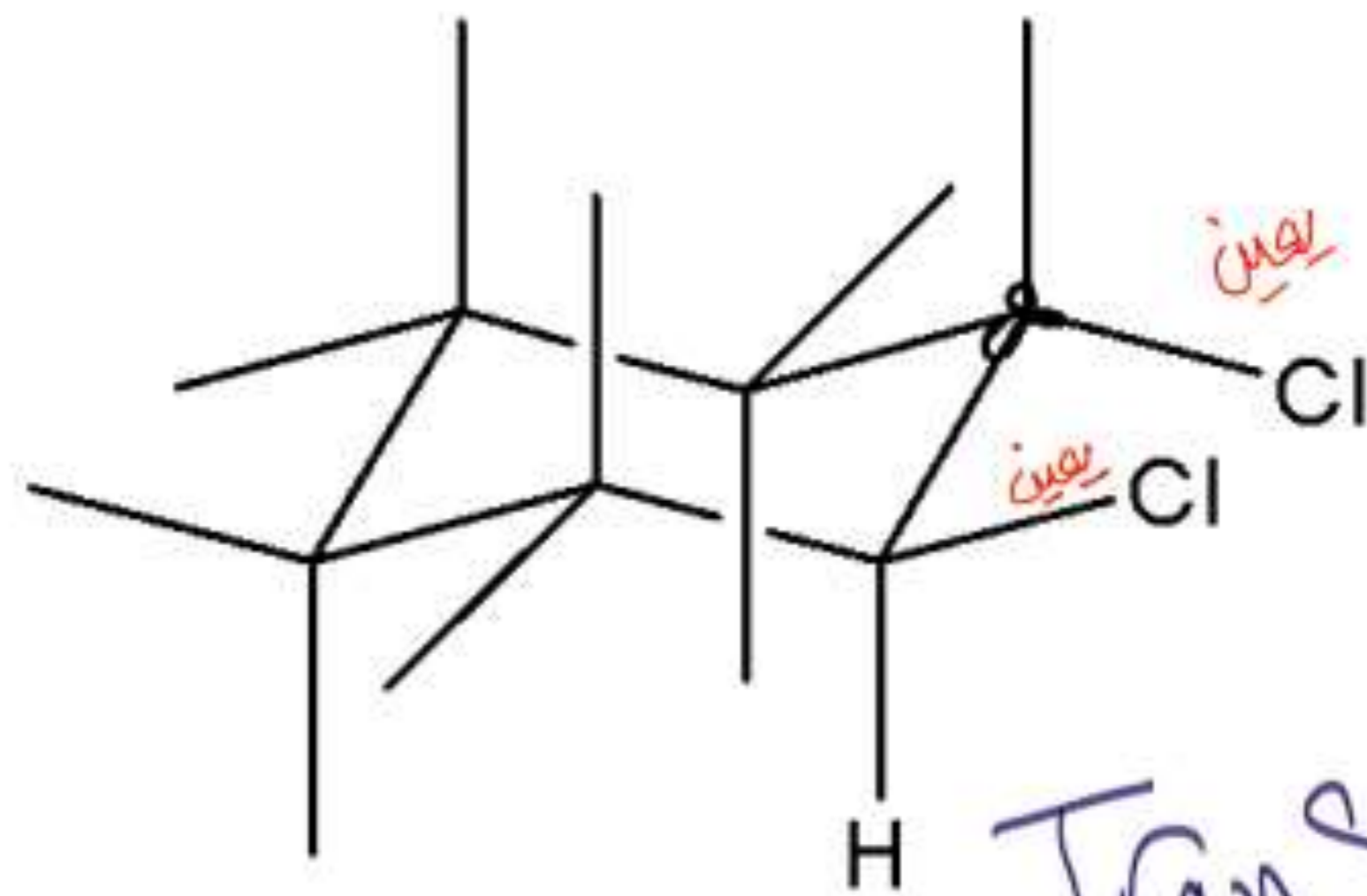
Cis



Cis

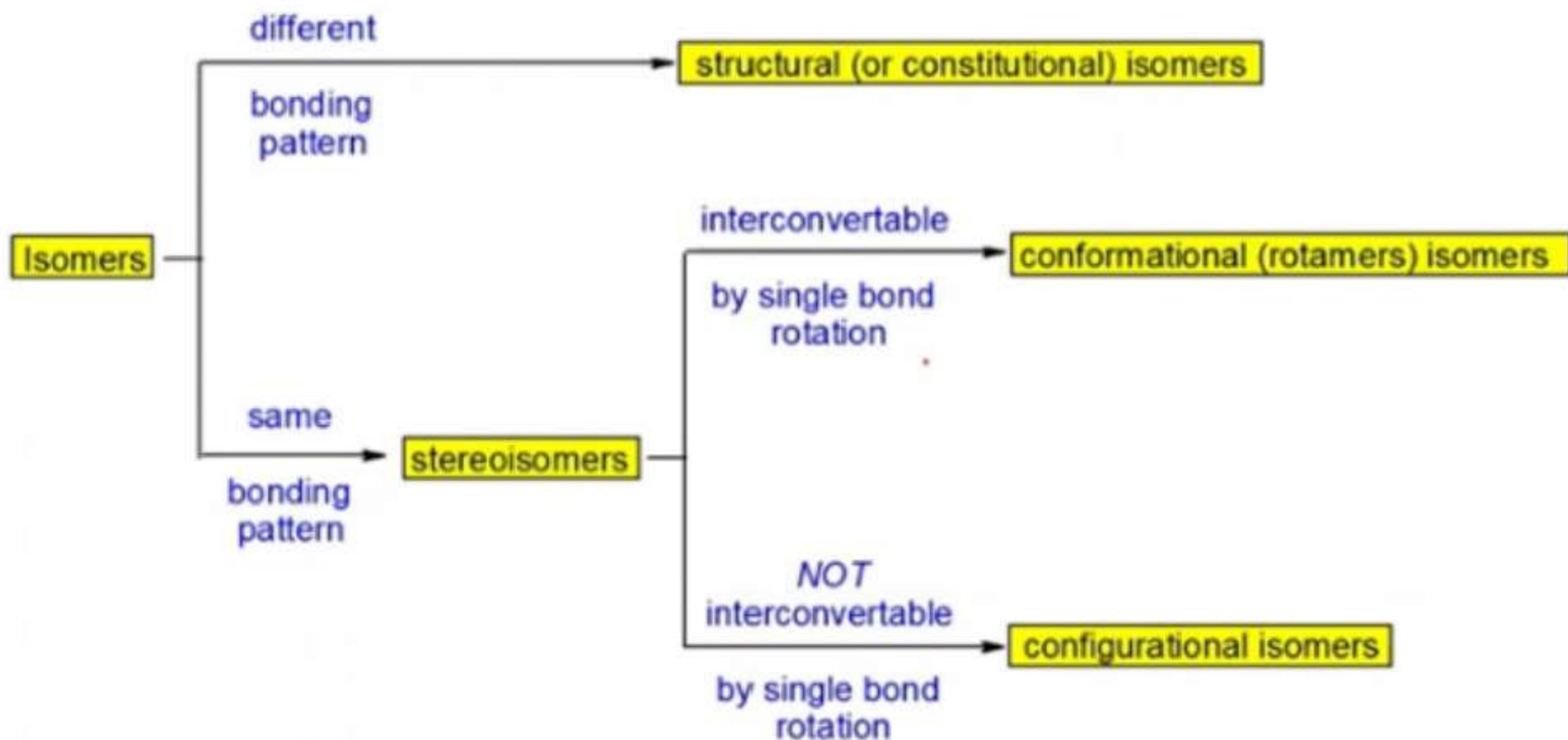


trans



Trans

# Summary of Isomers (to date)



# Chemical Reactions of Alkanes

In general, because of their strong non-polar covalent bonds alkanes are fairly inert. They do not react with most common acids, bases, oxidizing or reducing reagents. They means they do make good solvents for extraction, recrystallization or as a reaction solvent. They do however have two substances they react with; molecular oxygen and halogens.

# Oxidation Reactions

All chemical processes are redox (oxidation / reduction) reactions. Formally oxidation is the loss of electrons (increase in oxidation state) and reduction the gain of electrons (decrease in oxidation state). The two processes are coupled since whatever gains the electrons must gain them from somewhere and whatever loses the electrons must lose them to somewhere.

## Oxidation Reactions (cont'd)

For the C atom, oxidation involves increasing the number of C-O (or other atoms more EN than C) bonds and/or decreasing the number of C-H bonds.

Reduction will be the opposite, a decrease in the number of C-O bonds or increase in the number of C-H bonds.

# Oxidation and combustion

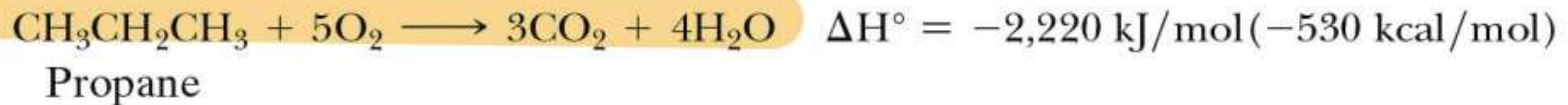
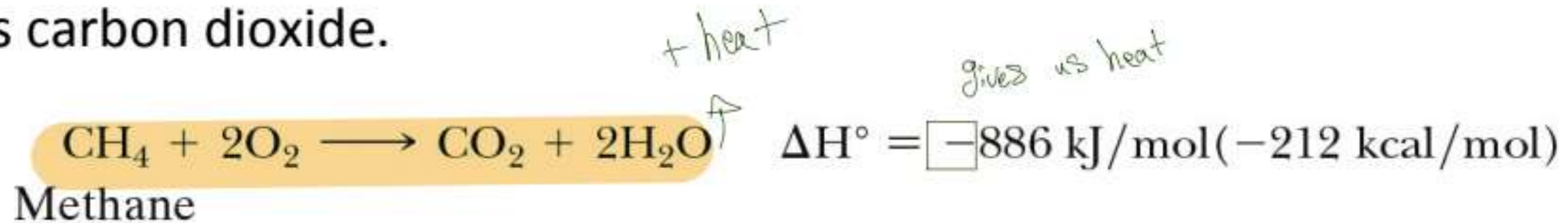
The most important use of alkanes is as a fuel. The light weight ones are gases and intermediate weight liquids which makes them handy for storage and transportation. Natural gas is composed primarily of methane with varying amounts of ethane, propane and butanes. It is commonly used to heat homes. The liquid hydrocarbons are used as gasoline, kerosene and jet fuels.



الاحتراق كسب : زيادة في المحتوى الأوكسجيني أو نقصان في المحتوى الهيدروجيني

## Oxidation Reactions (cont'd)

The energy of the hydrocarbon is released when combusted or burned. This is an oxidation process and requires atmospheric oxygen. The final oxidation product (assuming sufficient oxygen) is carbon dioxide.



هالوجنة الألكانات

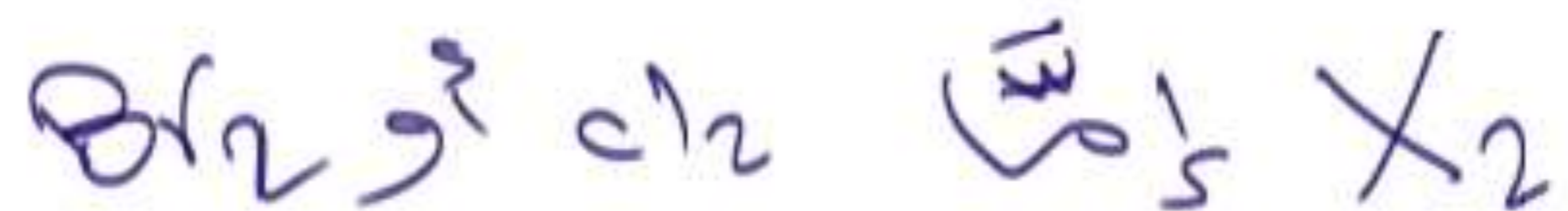
## Halogenation of Alkanes

Besides combustion, the only other useful chemical reaction that alkanes undergo is halogenation.

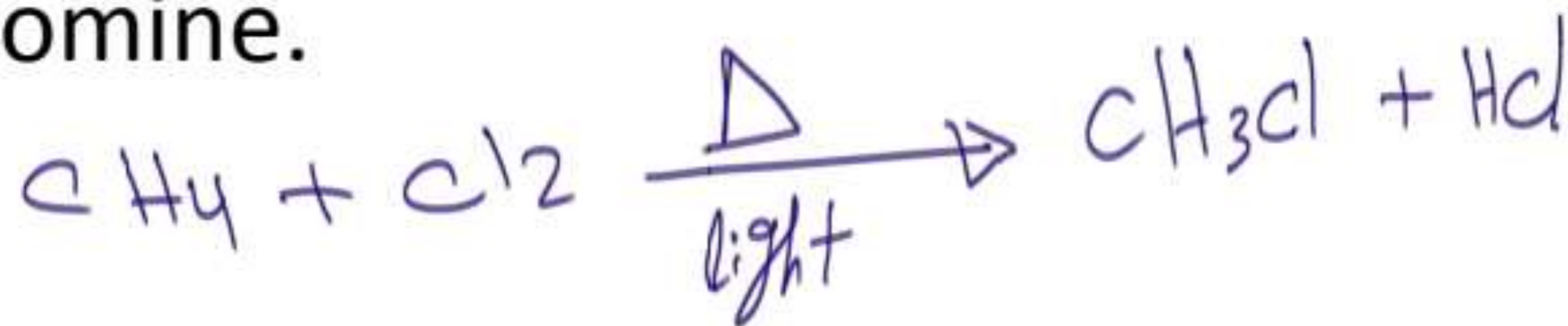
This is a free radical process in which heat or light is used to break a halide-halide bond forming two halide free radicals.

# Halogenation of Alkanes (cont'd)

This type of reaction is a *substitution reaction* where a halide atom is substituted for a H atom in the alkane.



The two common halides used are chlorine and bromine.

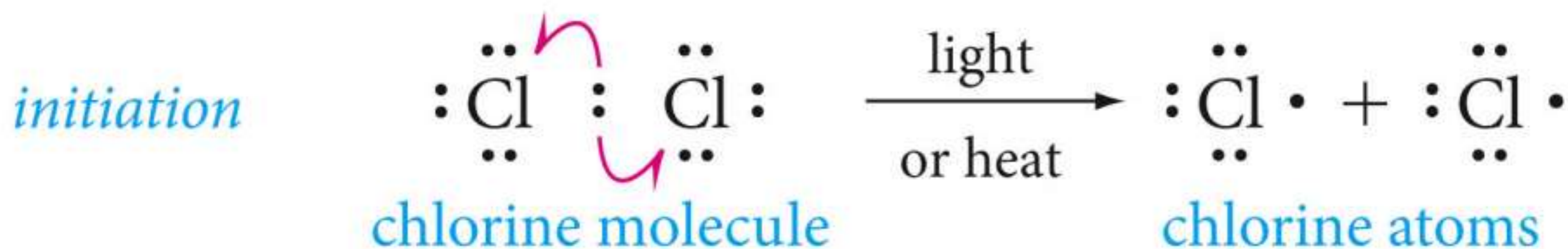


محرزوف

# Halogenation of Alkanes (cont'd)

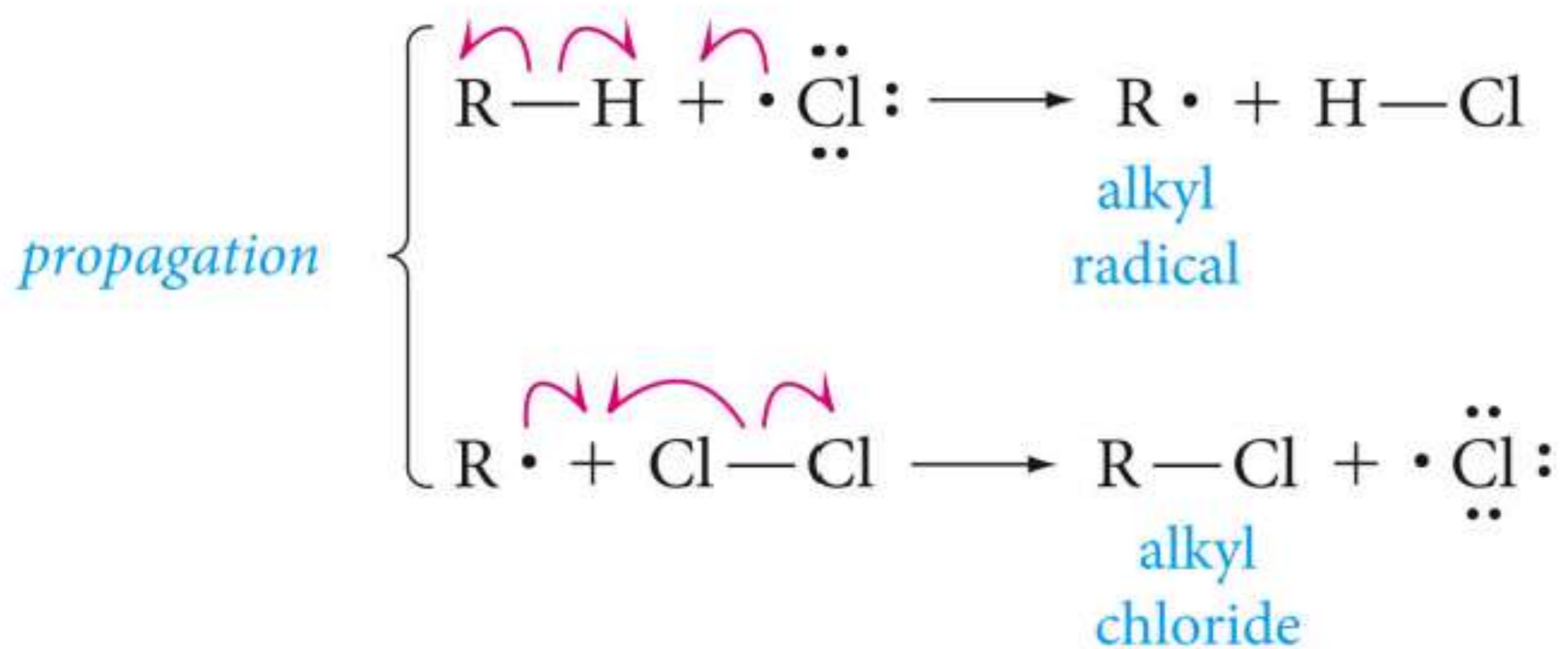
The process involves three steps:

- 1. initiation:** this is where the free radical is formed: note we generate 2 free radical atoms in this process.



# Halogenation of Alkanes (cont'd)

2. **Propagation:** this is where the halide free radical reacts with the hydrocarbon, extracting a H atom, generating an intermediate C radical, and then adding a halide atom. This process can repeat many times depending on the amount of halide radical available.



# Halogenation of Alkanes (cont'd)

3. **Termination**: this is the final step where the remaining free radicals are consumed. It can involve the halide radical reacting with another halide radical, a carbon radical or two carbon radicals combining.

*termination*

