النادي الطبي

Organic chemistry

Lec: All the Lectores

Done by: Noor Al-Ta'ani

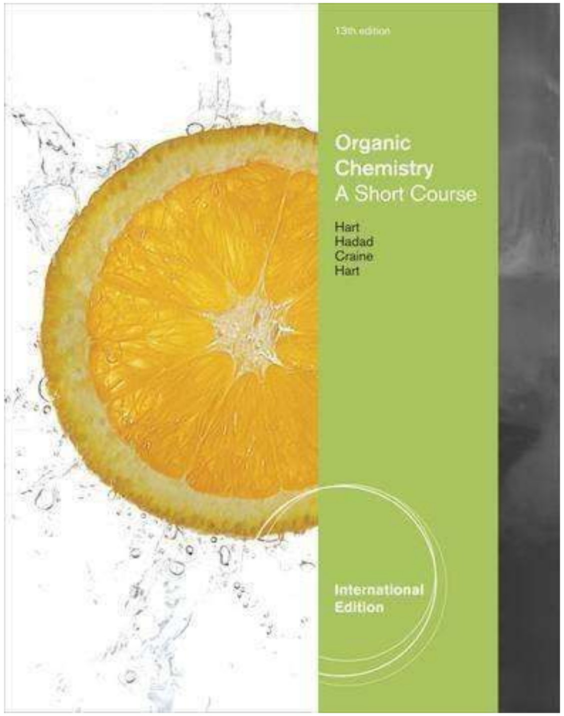
Chem 237 Basics of Organic Medicinal Chemistry

- **Course description**

This is the first year organic chemistry course, introducing basic concepts and principles of organic chemistry (chapters 1 – 11).

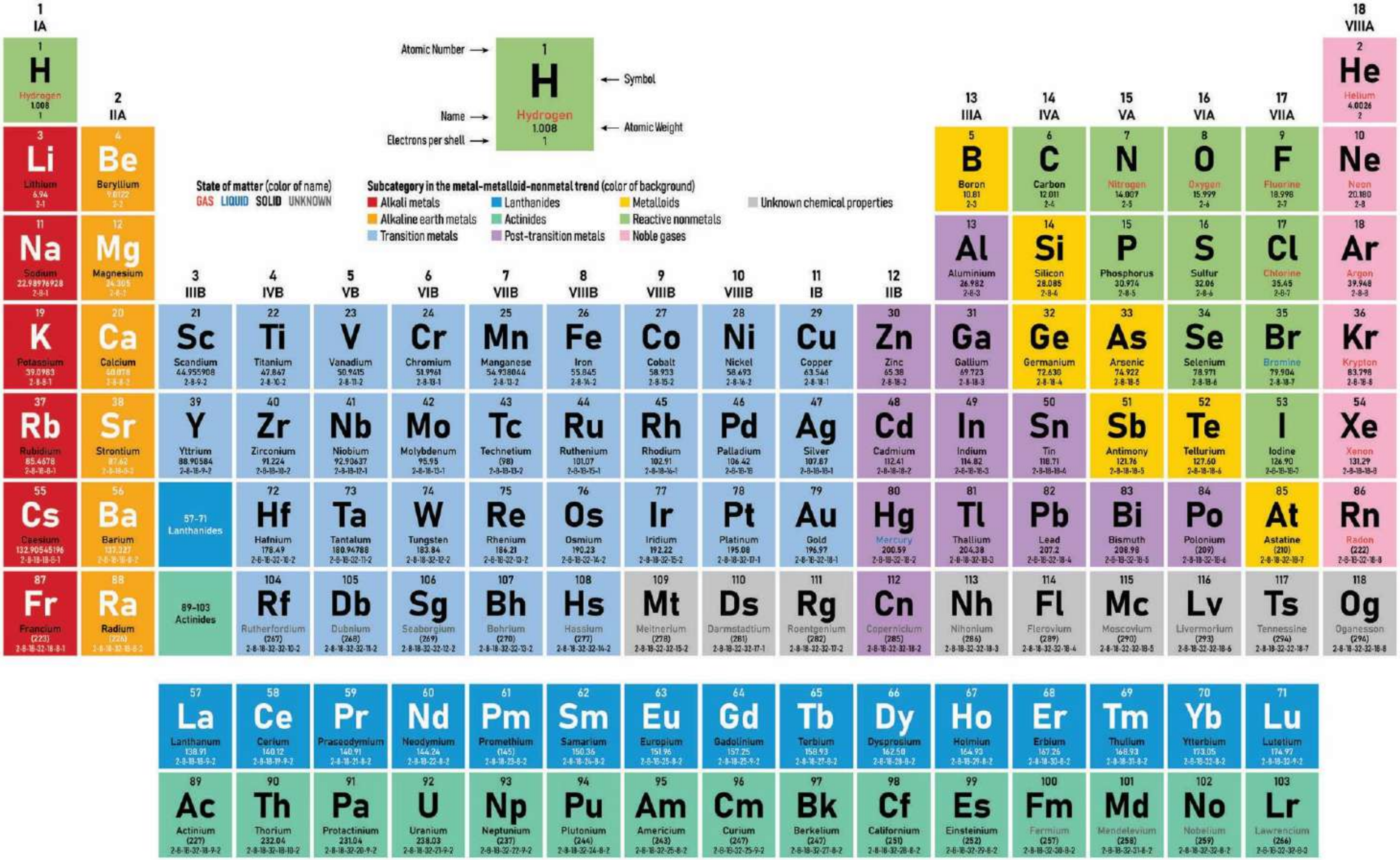
- **Texts**

Hart, Craine, Hart and Hadad, Organic Chemistry, A Short Course, 13th Edition (Brooks/Cole, Cengage Learning, CA 94002-3098 USA, 2012).



Dr. Eyad Younes

Periodic Table of the Elements



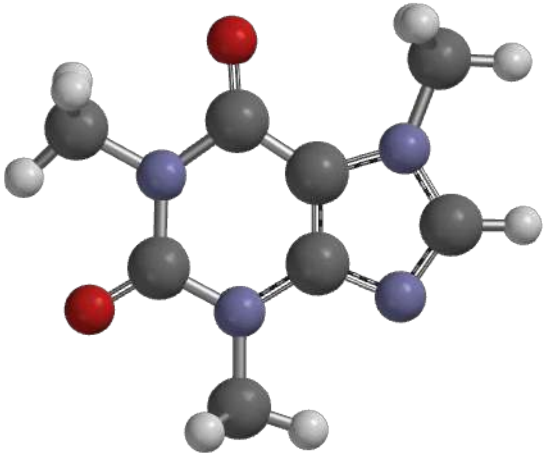
Atomic Number → 1
H ← Symbol
Name → Hydrogen
1.008 ← Atomic Weight
Electrons per shell → 1

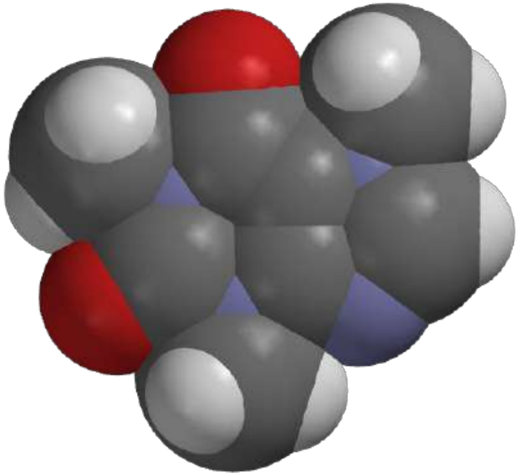
State of matter (color of name)
GAS LIQUID SOLID UNKNOWN

Subcategory in the metal-metalloid-nonmetal trend (color of background)
- 🟥 Alkali metals
- 🟧 Alkaline earth metals
- 🟦 Transition metals
- 🟦 Lanthanides
- 🟩 Actinides
- 🟪 Post-transition metals
- 🟨 Metalloids
- 🟩 Reactive nonmetals
- ■ Noble gases

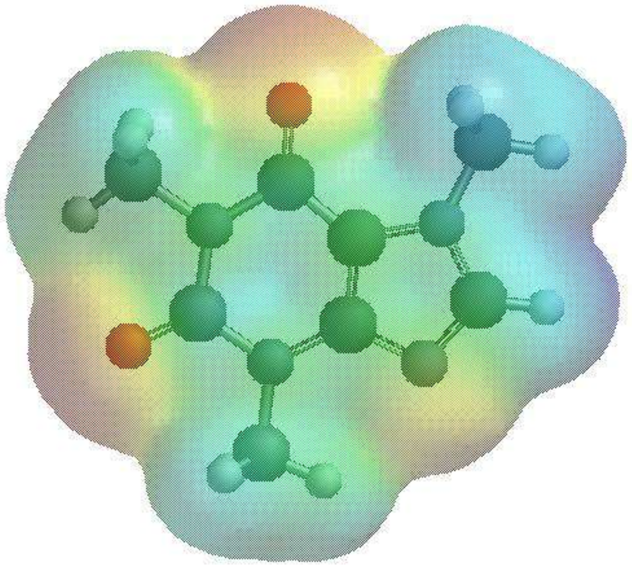
⬜ Unknown chemical properties

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 H Hydrogen 1.008 1																	2 He Helium 4.0026 2
3 Li Lithium 6.94 2-1	4 Be Beryllium 9.0122 2-2											5 B Boron 10.81 2-3	6 C Carbon 12.011 2-4	7 N Nitrogen 14.007 2-5	8 O Oxygen 15.999 2-6	9 F Fluorine 18.998 2-7	10 Ne Neon 20.180 2-8
11 Na Sodium 22.98976928 2-8-1	12 Mg Magnesium 24.305 2-8-2											13 Al Aluminium 26.982 2-8-3	14 Si Silicon 28.085 2-8-4	15 P Phosphorus 30.974 2-8-5	16 S Sulfur 32.06 2-8-6	17 Cl Chlorine 35.45 2-8-7	18 Ar Argon 39.948 2-8-8
19 K Potassium 39.0983 2-8-8-1	20 Ca Calcium 40.078 2-8-8-2	21 Sc Scandium 44.955908 2-8-9-2	22 Ti Titanium 47.867 2-8-10-2	23 V Vanadium 50.9415 2-8-11-2	24 Cr Chromium 51.9961 2-8-13-1	25 Mn Manganese 54.938044 2-8-13-2	26 Fe Iron 55.845 2-8-14-2	27 Co Cobalt 58.933 2-8-15-2	28 Ni Nickel 58.693 2-8-16-2	29 Cu Copper 63.546 2-8-18-1	30 Zn Zinc 65.38 2-8-18-2	31 Ga Gallium 69.723 2-8-18-3	32 Ge Germanium 72.630 2-8-18-4	33 As Arsenic 74.922 2-8-18-5	34 Se Selenium 78.971 2-8-18-6	35 Br Bromine 79.904 2-8-18-7	36 Kr Krypton 83.798 2-8-18-8
37 Rb Rubidium 85.4678 2-8-18-8-1	38 Sr Strontium 87.62 2-8-18-8-2	39 Y Yttrium 88.90584 2-8-18-9-2	40 Zr Zirconium 91.224 2-8-18-10-2	41 Nb Niobium 92.90637 2-8-18-12-1	42 Mo Molybdenum 95.95 2-8-18-13-1	43 Tc Technetium (98) 2-8-18-13-2	44 Ru Ruthenium 101.07 2-8-18-15-1	45 Rh Rhodium 102.91 2-8-18-16-1	46 Pd Palladium 106.42 2-8-18-18	47 Ag Silver 107.87 2-8-18-18-1	48 Cd Cadmium 112.41 2-8-18-18-2	49 In Indium 114.82 2-8-18-18-3	50 Sn Tin 118.71 2-8-18-18-4	51 Sb Antimony 121.76 2-8-18-18-5	52 Te Tellurium 127.60 2-8-18-18-6	53 I Iodine 126.90 2-8-18-18-7	54 Xe Xenon 131.29 2-8-18-18-8
55 Cs Caesium 132.90545196 2-8-18-18-8-1	56 Ba Barium 137.327 2-8-18-18-8-2	57-71 Lanthanides	72 Hf Hafnium 178.49 2-8-18-32-10-2	73 Ta Tantalum 180.94788 2-8-18-32-11-2	74 W Tungsten 183.84 2-8-18-32-12-2	75 Re Rhenium 186.21 2-8-18-32-13-2	76 Os Osmium 190.23 2-8-18-32-14-2	77 Ir Iridium 192.22 2-8-18-32-15-2	78 Pt Platinum 195.08 2-8-18-32-17-1	79 Au Gold 196.97 2-8-18-32-18-1	80 Hg Mercury 200.59 2-8-18-32-18-2	81 Tl Thallium 204.38 2-8-18-32-18-3	82 Pb Lead 207.2 2-8-18-32-18-4	83 Bi Bismuth 208.98 2-8-18-32-18-5	84 Po Polonium (209) 2-8-18-32-18-6	85 At Astatine (210) 2-8-18-32-18-7	86 Rn Radon (222) 2-8-18-32-18-8
87 Fr Francium (223) 2-8-18-32-18-8-1	88 Ra Radium (226) 2-8-18-32-18-8-2	89-103 Actinides	104 Rf Rutherfordium (267) 2-8-18-32-32-10-2	105 Db Dubnium (268) 2-8-18-32-32-11-2	106 Sg Seaborgium (269) 2-8-18-32-32-12-2	107 Bh Bohrium (270) 2-8-18-32-32-13-2	108 Hs Hassium (277) 2-8-18-32-32-14-2	109 Mt Meitnerium (278) 2-8-18-32-32-15-2	110 Ds Darmstadtium (281) 2-8-18-32-32-17-1	111 Rg Roentgenium (282) 2-8-18-32-32-17-2	112 Cn Copernicium (285) 2-8-18-32-32-18-2	113 Nh Nihonium (286) 2-8-18-32-32-18-3	114 Fl Flerovium (289) 2-8-18-32-32-18-4	115 Mc Moscovium (290) 2-8-18-32-32-18-5	116 Lv Livermorium (293) 2-8-18-32-32-18-6	117 Ts Tennessine (294) 2-8-18-32-32-18-7	118 Og Oganesson (294) 2-8-18-32-32-18-8
		57 La Lanthanum 138.91 2-8-18-18-9-2	58 Ce Cerium 140.12 2-8-18-19-9-2	59 Pr Praseodymium 140.91 2-8-18-21-8-2	60 Nd Neodymium 144.24 2-8-18-22-8-2	61 Pm Promethium (145) 2-8-18-23-8-2	62 Sm Samarium 150.36 2-8-18-24-8-2	63 Eu Europium 151.96 2-8-18-25-8-2	64 Gd Gadolinium 157.25 2-8-18-25-9-2	65 Tb Terbium 158.93 2-8-18-27-8-2	66 Dy Dysprosium 162.50 2-8-18-28-8-2	67 Ho Holmium 164.93 2-8-18-29-8-2	68 Er Erbium 167.26 2-8-18-30-8-2	69 Tm Thulium 168.93 2-8-18-31-8-2	70 Yb Ytterbium 173.05 2-8-18-32-8-2	71 Lu Lutetium 174.97 2-8-18-32-9-2	
		89 Ac Actinium (227) 2-8-18-32-18-9-2	90 Th Thorium 232.04 2-8-18-32-18-10-2	91 Pa Protactinium 231.04 2-8-18-32-20-9-2	92 U Uranium 238.03 2-8-18-32-21-9-2	93 Np Neptunium (237) 2-8-18-32-22-9-2	94 Pu Plutonium (244) 2-8-18-32-24-8-2	95 Am Americium (243) 2-8-18-32-25-8-2	96 Cm Curium (247) 2-8-18-32-25-9-2	97 Bk Berkelium (247) 2-8-18-32-27-8-2	98 Cf Californium (251) 2-8-18-32-28-8-2	99 Es Einsteinium (252) 2-8-18-32-29-8-2	100 Fm Fermium (257) 2-8-18-32-30-8-2	101 Md Mendelevium (258) 2-8-18-32-31-8-2	102 No Nobelium (259) 2-8-18-32-32-8-2	103 Lr Lawrencium (266) 2-8-18-32-32-8-3	





Chapter 1: Bonding and Isomerism

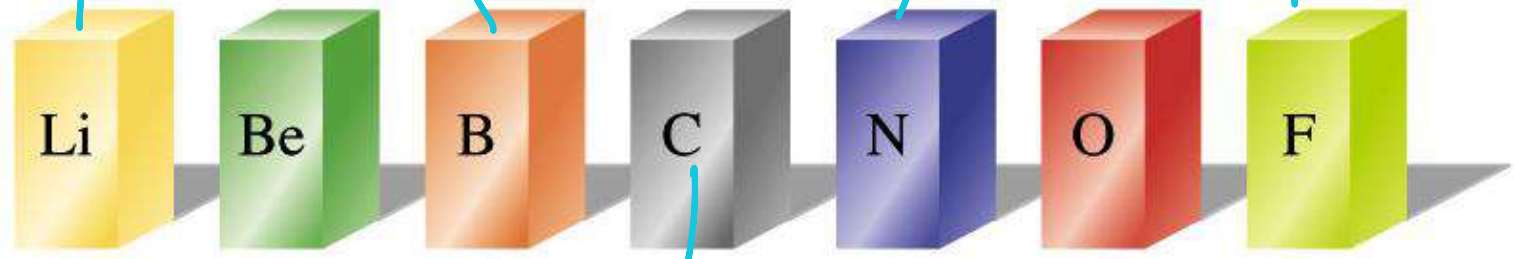


Organic Chemistry

- Organic compounds are compounds containing carbon

بحبوا يعطوا e

بحبوا يكسبوا e



the second row of the periodic table

جاي بالنص ما عنده رغبة لا اعطاء ولا كسب

بعمل الـ sharing.

وبسبب الـ sharing بيصير عندي تنوع بالمركبات.

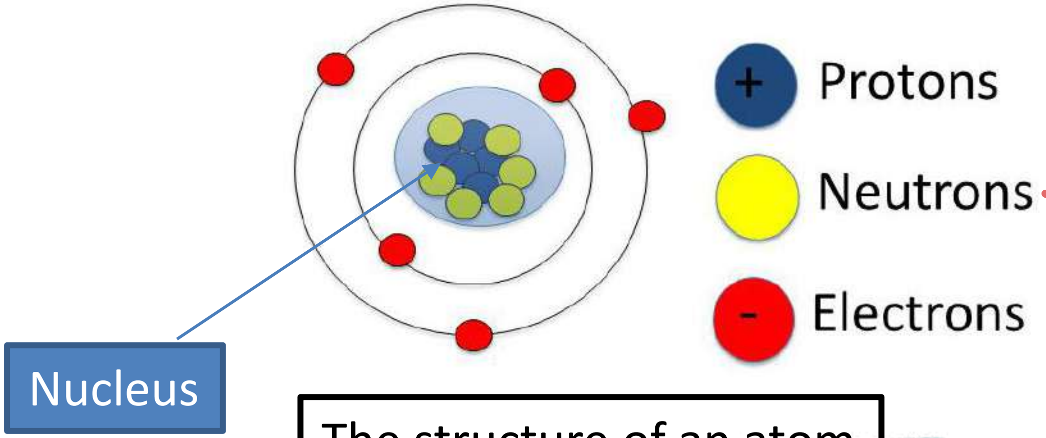
  - Atoms to the left of carbon give up electrons.
  - Atoms to the right of carbon accept electrons.
  - Carbon shares electrons.

Bonding and Isomerism

1.1 How Electrons Are Arranged in Atoms

- An atom is: the *smallest particle* of an element that retains all of the chemical properties of that element.

- An atom consists of negatively charged electrons, positively charged protons, and neutral neutrons



→ متعادلة الشحنة

The structure of an atom

العدد الذري

وممكن العدد الذري بيمثل عندي عدد ال e^- لما شحنة الذرة متعادلة

- **Atomic number**: numbers of protons in its nucleus and it's the number of electrons in the neutral atom.

- **Mass number**: the sum of the protons and neutrons of an atom.

(Protons and neutrons are ~1837 times the mass of an e^-)

- Isotopes have the same atomic number but different mass numbers (^{12}C and ^{13}C)

تحديد أ صرية مكانة ال e

- Electrons are located in atomic orbitals (S, P, d, f).

- Orbitals tell us the energy of the electron and the volume of space around the nucleus where an electron is most likely to be found.

هي مواطنة ال e^-

- Orbitals are grouped in shells .

محل ما كانت ال shells أبعد عن النواة كل ما كانت ال potential energy أعلى

Each orbital can hold a maximum of $2e^-$ and the two electrons have opposite spin

Table 1.1 Distribution of Electrons in the First Four Shells That Surround the Nucleus

	First shell	Second shell	Third shell	Fourth shell
Atomic orbitals	*s*	*s*, *p*	*s*, *p*, *d*	*s*, *p*, *d*, *f*
Number of atomic orbitals	1	1, 3	1, 3, 5	1, 3, 5, 7
Maximum number of electrons	2	8	18	32

s^2 p^6

Example :

^{1}H: $1s^1$

^{6}C $1s^2\ 2s^2\ 2p^2$

الالكترونات الموجودة في آخر مدار

Valence electrons (VE) are located in the outermost shell. They are involved in chemical reactions.

عندي طريقتين لتحديد VE

Atomic number-
Group number-

VE = Group number

باخد الي الموجودة في آخر مدار

ودي في آخر فلك

عشان هيك جواب ٩ غلط.

Examples:	VE	Lewis symbol of atom
^{1}H: Is^{1}	1	H·
^{8}O: $IS^{2}\ 2S^{2}\ 2P^{4}$	6	:Ö:
^{6}C: ______		

Table 1.3 Valence Electrons of the First 18 Elements

Group	I	II	III	IV	V	VI	VII	VIII
	H·							He:
	Li·	Ḃe·	·Ḃ·	·Ċ· (with dot below)	·Ṅ:	·Ö:	:F̈:	:N̈e:
	Na·	Ṁg·	·Ȧl·	·Ṡi·	·Ṗ:	·S̈:	:C̈l:	:Ä̈r:

الـ
Nobal gasses
وضعهم انهم
مستقرين
لشي ؟ لأنه مدارهم
الأخير final shell
مكتمل.

- **Chemical Bonds**

A – B

1. Ionic Bonding

تتكون لما يكون عندي انتقال كامل لالكترون أو الكترونات من A الى B أو العكس.

An ionic bond is an electrostatic attraction between positive & negative ions resulting from e⁻ transfer.

وأصلاً عنده رغبة يفقد ال e.

$$^{11}Na:\ [Ne]\,3s^1 \xrightarrow{-e} \overset{\oplus}{Na}\ :\ [Ne]$$

$$^{17}Cl:\ [Ne]\,3s^1\,3p^5 \xrightarrow{+e} Cl\,\overset{\ominus}{:}\ \ [Ar]$$

ال 1e انتقلت من ال Na لل Cl Na-Cl

صرنا ال Na عندها خيارين تكسب 7e وتصير زي Ar أو تفقد 1e وتصير زي ال Ne الأسهل أكثر والي بده أقل طاقة هو انه تفقد 1e

ال Cl لما يفقد 7e وبيصير زي Ne أو يسحب 1e وبيصير زي Ar.

The resulting e⁻ configuration of both ions are those of the nearest noble gas, Ne and Ar respectively, both satisfy the octet rule.

أي عنصر عشان يوصل الاستقرار بده يكون توزيعه الالكتروني زي واحد من Nobal gases

وعملية الوصول للاستقرار تتم عن طريق chemical reactions [تكوين روابط كيميائية]

2. Covalent Bonding

- Ionic bonds occur when an e^- is transferred between a metal and nonmetal.

بسبب تشود ال Covalent bonds

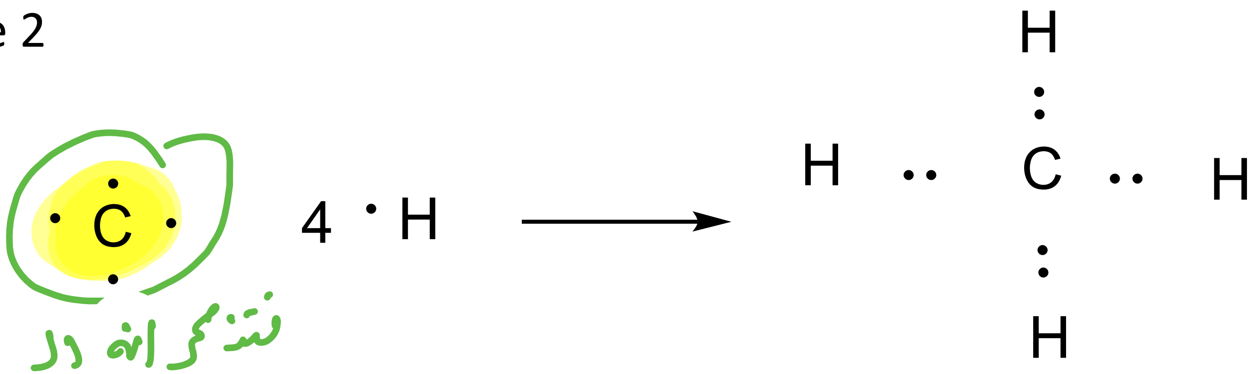
- Covalent bonds are resulting from sharing e^-

$$2\ H\cdot \longrightarrow H{\cdot\cdot}H$$

The result is both atoms have a [He] e^- configuration, *i.e.*

The bond is commonly display as a line rather than a pair of e^- (:), *i.e.* H - H rather than H : H

Example 2

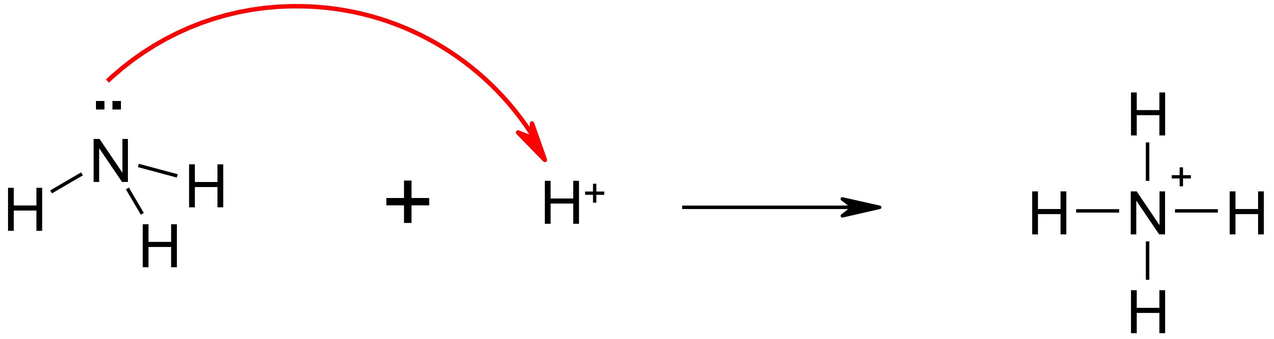


نتذكر انه ال Carbon يحب ال sharing

A second general version of a covalent bond is possible. This occurs when BOTH e$^-$ come from one atom: a coordinate covalent bond

i.e.

$NH_3 + H^+ \rightarrow NH_4^+$



Electronegativity (EN) : measures the tendency of an atom to attract a shared pair of electrons (or electron density).

هي قدرة الذرة على جذب أو سحب الالكترونات

A—B جزيء

Covalent Bond

واحد من الـ A أو B الها قدرة أكثر من الثانية انها تسحب الـ e⁻ نحوها.

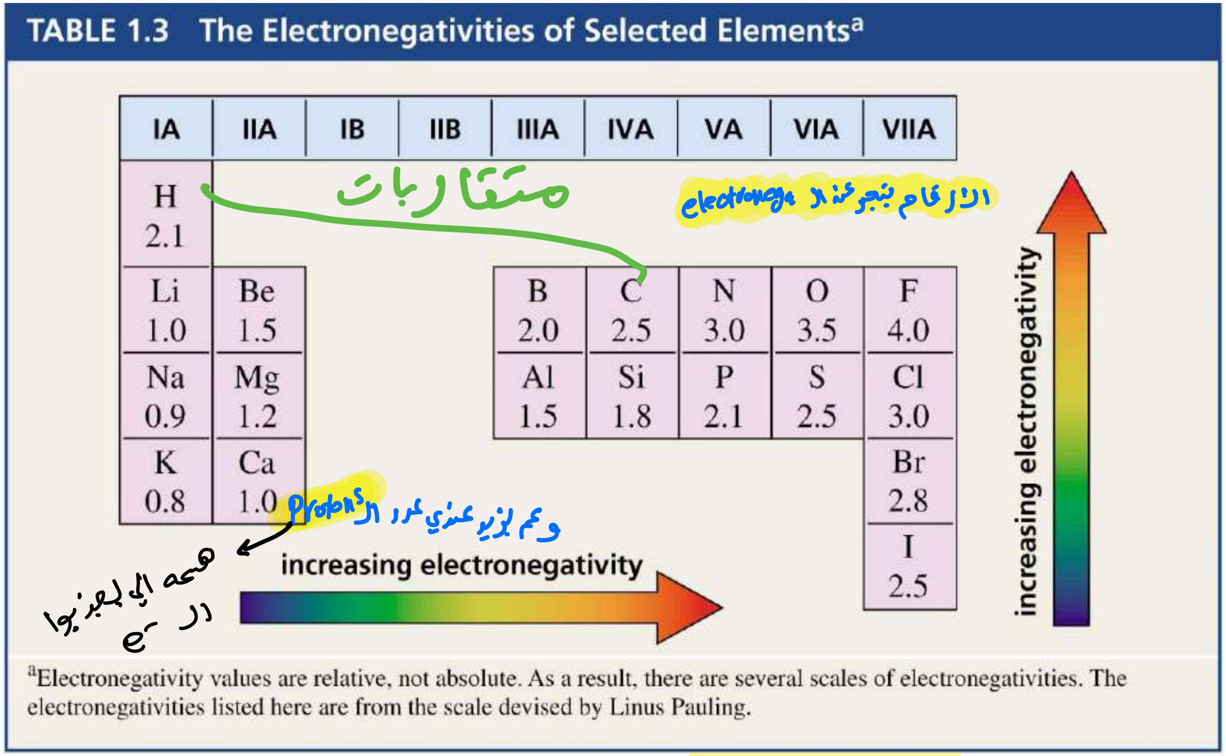


TABLE 1.3 The Electronegativities of Selected Elements[a]

IA	IIA	IB	IIB	IIIA	IVA	VA	VIA	VIIA
H 2.1								
Li 1.0	Be 1.5			B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2			Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0							Br 2.8
								I 2.5

متقاربات

الأرقام بتعبر عن الـ electronega

وكم بزيد عندي عدد الـ protons

هسه الي بيجذبوا الـ e⁻

[a] Electronegativity values are relative, not absolute. As a result, there are several scales of electronegativities. The electronegativities listed here are from the scale devised by Linus Pauling.

والشي بيعتمد على
قوة النواة بالتالي
كل ما كانت النواة
أقوى كانت أقدر
على جذب الـ e⁻

تفسير زيادة الحجم
مع زيادة Electro...
هو انه النواة بتصير
أبعد عن الـ e⁻
بالتالي قلّ جذب الـ protons للـ e⁻
وقلت الـ Electro .

Covalent bonds can be classified as

0.5
منعتبرها
polar

A. Nonpolar covalent bond (Δ EN = 0-0.5)

اذا كانة الفرق بينة الزرتين

Examples C-C C-H

يعني هون الالكترونات بتكون في الوسط

B. Polar covalent bond (Δ EN = 0.5 1.9)

صورة الـ e بتكون مزاحة نحو
الـ atom الي En الها اكبر وتحمل $-\delta$.

O–H　　　　N–H

$-\delta$　$+\delta$

A polar bond has a negative end and a positive end

كانت تكون الـ $\Delta EN > 1.9$ مثلاً Li F
$\Delta EN = 3$ صورته صار عنده فقد وكسب
بالكامل للالكترونات والرابطة بطلت
Covalent.

dipole moment (D) = μ = *e* x *d*

(*e*) : magnitude of the charge on the atom

(*d*) : distance between the two charges

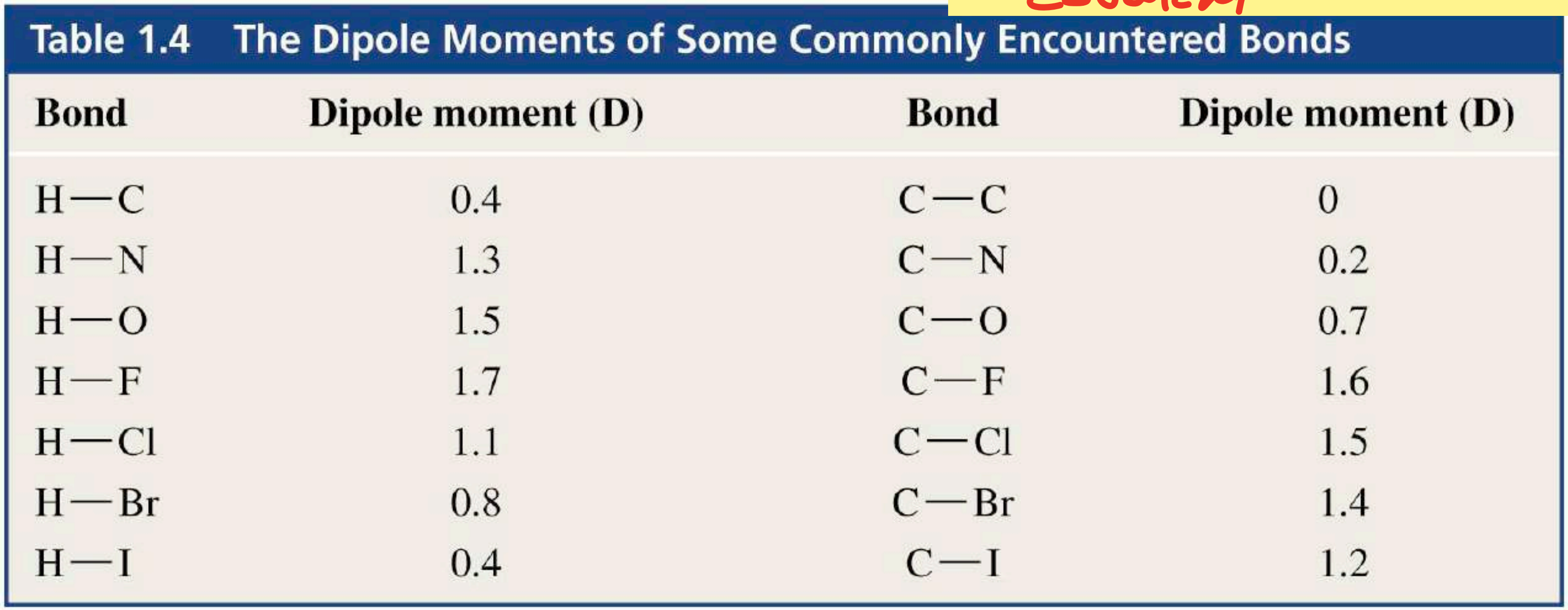


Table 1.4 The Dipole Moments of Some Commonly Encountered Bonds

Bond	Dipole moment (D)	Bond	Dipole moment (D)
H—C	0.4	C—C	0
H—N	1.3	C—N	0.2
H—O	1.5	C—O	0.7
H—F	1.7	C—F	1.6
H—Cl	1.1	C—Cl	1.5
H—Br	0.8	C—Br	1.4
H—I	0.4	C—I	1.2

if The Δ EN increases the polarity increases and Dipole moment increases

Note : If Δ EN is more than 1.9then the bond is ionic　Ex: Li-F

هون الحكي عن المركبات قبل عن الروابط.

Bond Polarity & Electronegativity (cont'd)

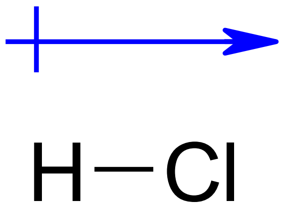
The result of polar covalent bonding is that the e⁻ pair spend more time near the more EN atom. This means it will acquire a permanent excess negative charge. The other atom acquires a permanent excess positive charge. This is indicated by a δ^+ or δ^- (where δ means a "partial charge") or a dipole arrow which points from the positive end of the bond to the negative end.

ال tail هو ال element الأقل كهروسالبية

وال head هو ال element الأكبر كهروسالبية

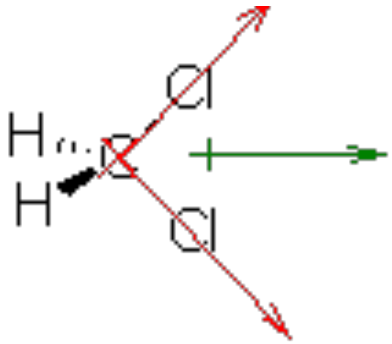
δ^+ δ^-

H—Cl

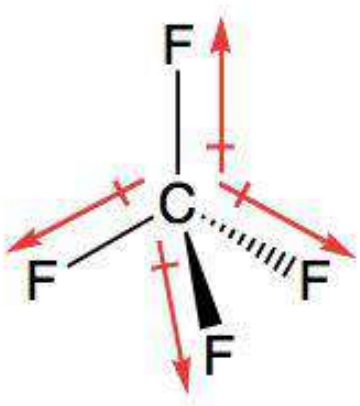


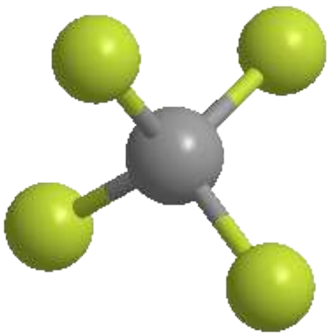
Bond Polarity & Electronegativity (cont'd)

The more polar the molecule the stronger the dipole moment. The molecular dipole moment is the vector sum of the bond moments, *i.e.*



Net dipole moment





Net dipole moment =0

Lewis Structures

It only deals with VE

Procedure for obtaining good Lewis structures: eg. CO_2

1) determine total number of valence shell e^- (including ionic charge if present).

$$CO_2 = 4+2(6) = 16.$$

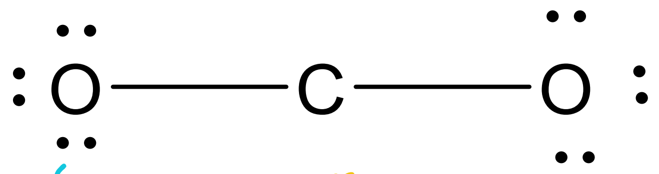
2) Chose a cental atom and draw a skeleton of the molecule connected with single bonds. (the central **atom** is usually the **least electronegative element** in the **molecule** or **ion**; hydrogen and the halogens are usually terminal.

O——C——O

3) determine number of remaining e^-. complete the octet of the terminal atoms.

$$16 - 4 = 12$$

كما ذكرنا الذرة مستقرة بس يكون
مدارها الاخير مكتمل يعني فيه
8e

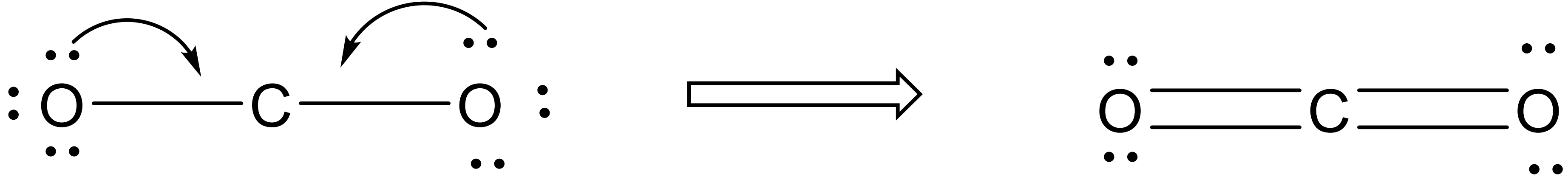


$$:\ddot{O}-C-\ddot{O}:$$

بده كمان 4e
رح نجيبهم من خلال ال multiple bond

صارت ذرتي الاكسجين مستقرين
لأنه حوليهم 8e لكن الكربون غير مستقر

4) Complete the octet Use lone pair e^- from terminal atoms to create multiple bonds.



صار المركب مستقر

بالتالي شحنته الكلية بتكون = صفر

5) determine the formal charges of all atoms.

Formal charge =
number of valence electrons – (number of lone pair electrons +1/2 number of bonding electrons)

طريقة الحساب

VE − (dots + dashes)

Group number

عدد الـ e^- اي حول الذرة

عدد الروابط اي حول الذرة

حوله الـ

dotes 4
dashes 2

For O 6-6 =0

dotes 0
dashes 4

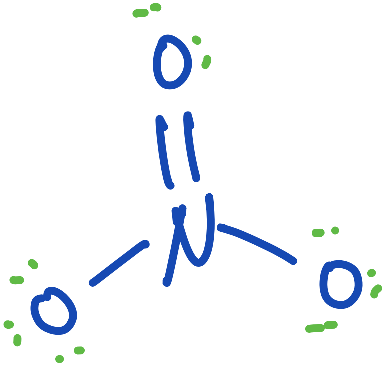
For C   4-4 =0

Ex: NO_3^- → اكتسب e^- فمنضيفه

1. VE= 5+6*3+1=24

أول اشي حددنا الذرة الأقل Electro
عشان رح تكون الذرة المركزية

ثاني اشي وزعنا الـ ٢٤ e
Single bonds بالبداية ومنشوف قديش استهلكنا
منه ال total الي هو 24 ومنطرح منها
استهلكنا 6e ← 24-6=18
ال 18 منوزعها حول ذرات الأكسجين
وعندي ٣ ذرات ← 18÷3=6
كل ذرة O رح توخذ $6e^-$



ذرة ال N بدها 2e
عشان تستقر
فبنعمل multiple bond
مع اي ذرة O

هي التركيب عنا ورح نكرن ال
formal charge = -1

for N $5-(0+4)=5-6=1$

for O $6-(6+1)=-1$

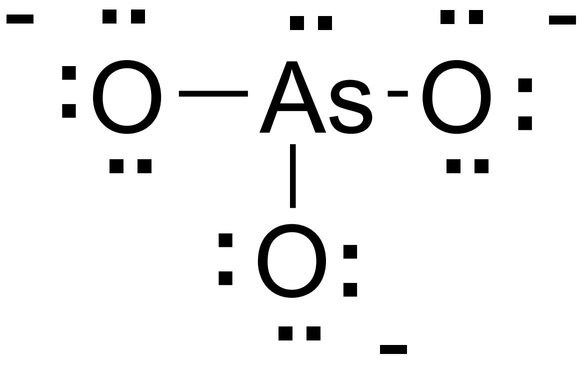
الي بتحتوي O مع double bond $6-(4+2)=0$

Σ formal charge $=1-1-1+0=-1$

Lewis Structures (other examples)

Example 2: AsO_3^{3-}

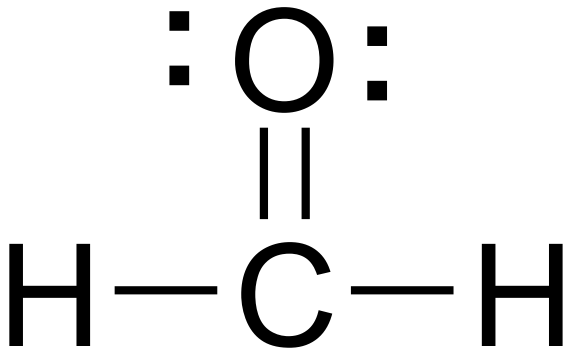
1) # e^-: 5 + 3(6) + 3 = 26
2) form 3 single bonds
3) 20 e^- remain
4) O needs 6, As needs 2
5) All octets
6) Formal charges



Lewis Structures (cont'd)

Example 3: CH_2O

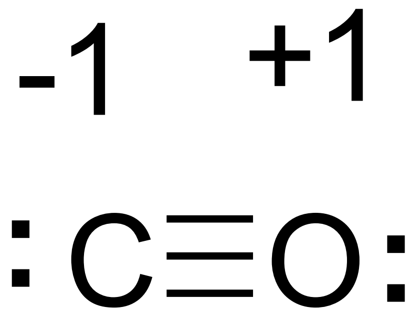
1) # e^-: 4 + 2(1) + 6 = 12
2) try 3 single bonds
3) 6 e^- remain
4) O 6 but C?
5) Form a double bond
6) Both O & C octets
7) Formal charges



Lewis Structures (cont'd)

Example 4: CO

1) # e^-: 4 + 6 = 10
2) try 1 single bond
3) 8 e^- remain
4) C needs 6 as does O short 4 e^-
5) Share 4 more e^- - triple bond
6) Octets
7) Formal charges



$$\overset{-1}{:C}\equiv\overset{+1}{O:}$$

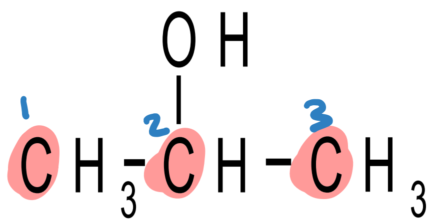
1.8 Isomers

Structural or **constitutional** isomers have same molecular formula but different structural formula.

They have different physical and chemical properties:

$\overset{1}{C}H_3-\overset{2}{C}H_2-\overset{3}{C}H_2-O-H$

1-propanol
(bp 97.4 C)



$\overset{1}{C}H_3-\overset{\overset{\overset{OH}{|}}{2}}{C}H-\overset{3}{C}H_3$

2-propanol
(bp 82.4 C)

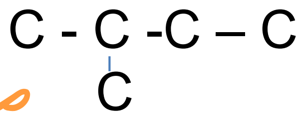
1.9 Writing Structural Formulas

write out all possible structural formulas that correspond to the molecular formula C_5H_{12}.

C - C - C -C - C

مستمر

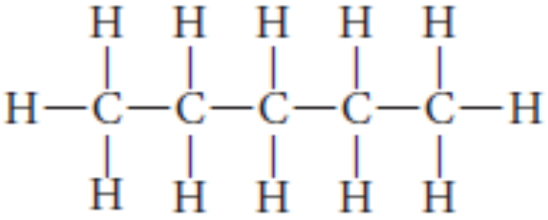
Continuous chain



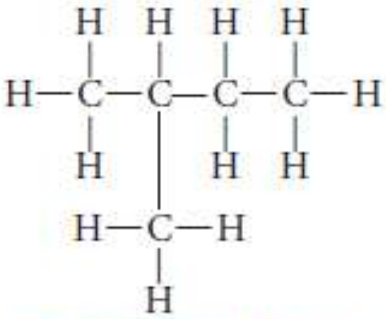
$$\begin{array}{l}C - \underset{\displaystyle C}{\underset{|}{C}} - C - C\end{array}$$

متفرعة

Branched chain



pentane, bp 36°C



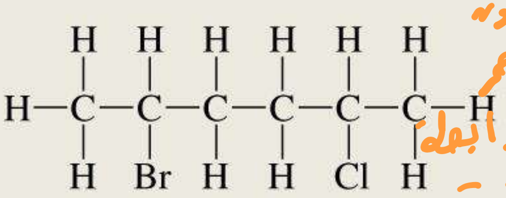
2-methylbutane, bp 28°C
(isopentane)

C forms 4 covalent bonds

Dash formula

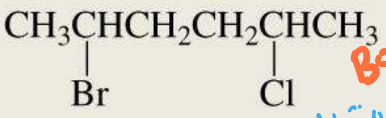
Kekul structur e | **Condensed structures** | **Bond line formula**

Atoms bonded to a carbon are shown to the right of the carbon. Atoms other than H can be shown hanging from the carbon.



هون بتظاهر كل رابطة وكل ذرة

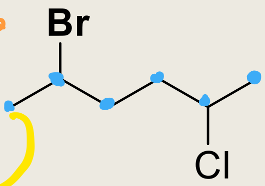
$CH_3CHBrCH_2CH_2CHClCH_3$ or



$$\underset{\displaystyle Br}{CH_3CH}CH_2CH_2\underset{\displaystyle Cl}{CH}CH_3$$

هون ما بظهر ال C ولا ال H

فقط ال Bonds

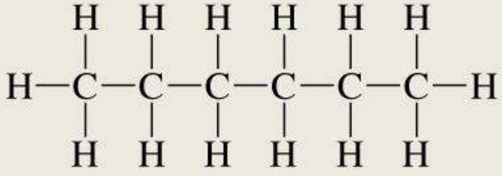


كل هدول النقاط بيمثلوا ال carbon

كونه كل نقطة بتمثل C والروابط ظاهرة بإمكاني احددهم وبعرف انه الكربون لازم يكون معه 4 Bonds

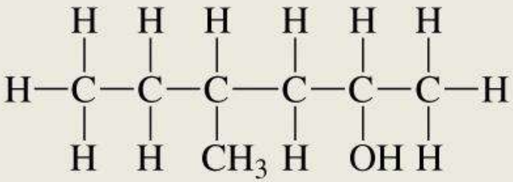
اي الاطراف ظاهر عندي بس رابطة معناتو ناقصها 3 رح يكونوا H .

Repeating CH_2 groups can be shown in parentheses.

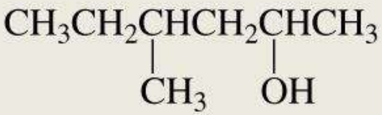


$CH_3CH_2CH_2CH_2CH_2CH_3$ or $CH_3(CH_2)_4CH_3$

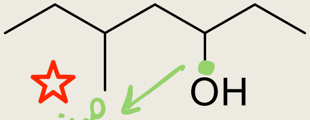
Groups bonded to a carbon can be shown (in parentheses) to the right of the carbon, or hanging from the carbon.



$CH_3CH_2CH(CH_3)CH_2CH(OH)CH_3$ or

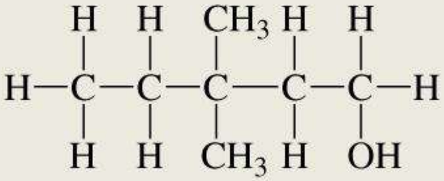


$$CH_3CH_2\underset{\displaystyle CH_3}{CH}CH_2\underset{\displaystyle OH}{CH}CH_3$$

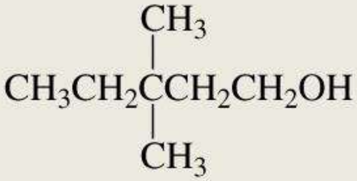


هون النقطة لا تمثل كربون

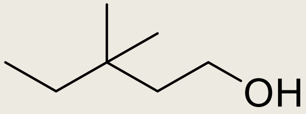
Groups bonded to the far-right carbon are not put in parentheses.



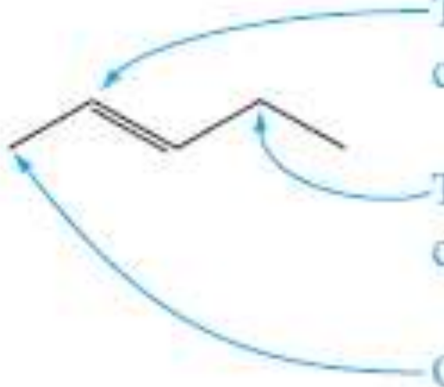
$CH_3CH_2C(CH_3)_2CH_2CH_2OH$ or



$$CH_3CH_2\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{C}}CH_2CH_2OH$$



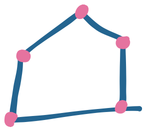
$CH_3CH{=}CHCH_2CH_3$



Three line segments emanate from this point; therefore, this carbon has one hydrogen (4 − 3 = 1) attached to it.

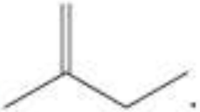
Two line segments emanate from this point; therefore, this carbon has two hydrogens (4 − 2 = 2) attached to it.

One line segment emanates from this point; therefore, this carbon has three hydrogens (4 − 1 = 3) attached to it.

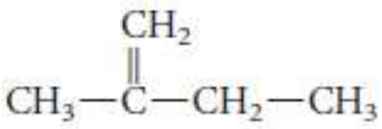


صورة كل نقطة بتمثل CH_2

EXAMPLE 1.12

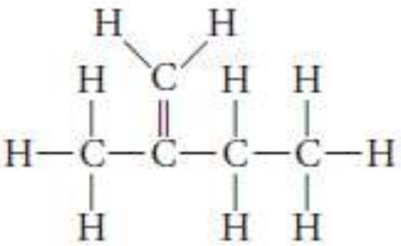
Write a more detailed structural formula for  .

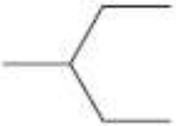
Solution



$$CH_3{-}\overset{\overset{\displaystyle CH_2}{\|}}{C}{-}CH_2{-}CH_3$$

or



PROBLEM 1.23 Write a more detailed structural formula for  .

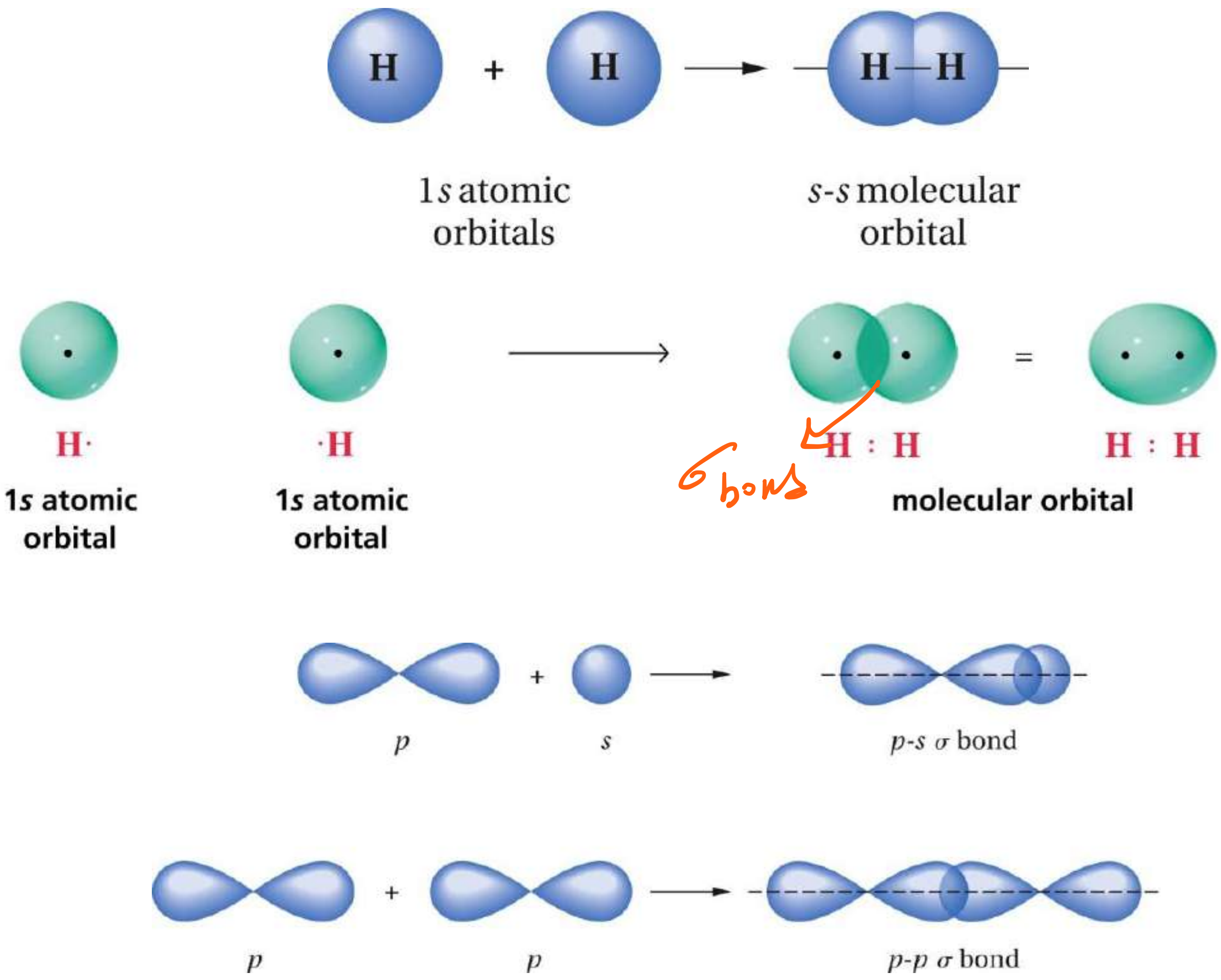
1.14 The Orbital View of Bonding; the Sigma Bond

Sigma (σ) bonds: are characterized by a region of high e$^-$ density along the internuclear axis.

بصير عندي تداخل بين ال

atomic orbitals

وبكون تداخل مباشر.

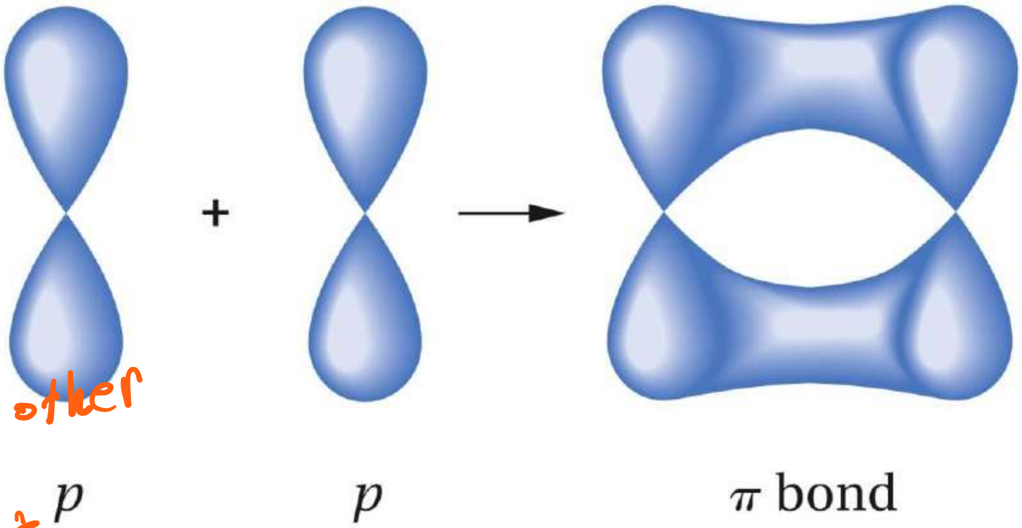


Orbitals approach each other in a **head to head** fashion

1.14 The Orbital View of Bonding; the pi (π) bond

There is one other type of bond, a pi (π) bond. In contrast to a sigma bond the e⁻ density in a pi bond is not located on the internuclear axis, but rather on either "side" of it.

π bonds are formed by the **side to side overlap** of 2 "p" orbitals



صرنه شرط التداخل بين **2p**

ويكونوا parrarel to each other

Px لوكانه واحد

Px شرطاي

شرطا يكونوا

ال 2

Px Px

Py Py

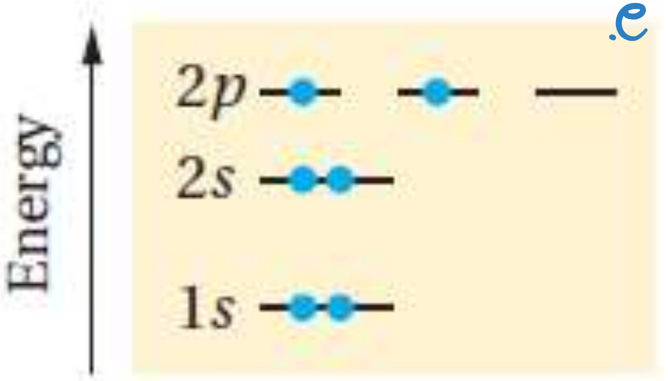
Pz Pz

Carbon sp^3 Hybrid Orbitals

الدكتور سأل لما نوزع الـ e^-
ليش منبدأ بالـ first shell لبين ما نعبيها دغري بالـ second one ؟

حسب الـ Energy level كونه الـ first shell أقرب للنواة بالتالي طاقته أقل لازم أزوده بالـ e^-

$^6C: 1S^2\ 2S^2\ 2P^2$

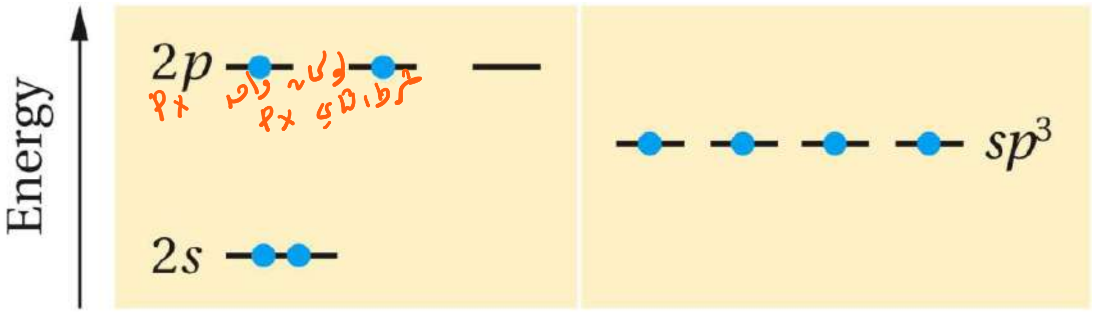


Distribution of the six electrons in a carbon atom. Each dot stands for an electron.

Q: Should the carbon form only two bonds !!!

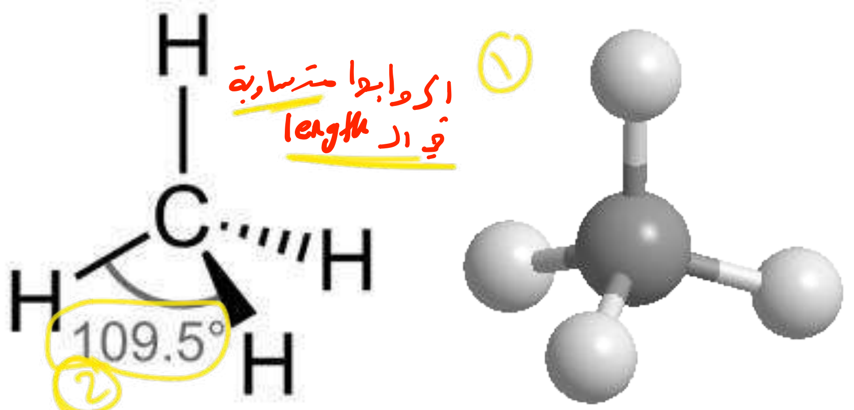
A: We know from experience that carbon usually forms *four* single bonds, and often these bonds are all equivalent, as in CH_4

بالنسبة للمستوى الثاني اي حيوصلكينه p و s
صح انه صدول الفلكين بنفس المستوى لكنه ا 2s أقل طاقة من 2P
ليش؟ لأنه امنطقي أزوده بـ e^- بعدين انتقل لـ p



Atomic orbitals of carbon

Four equivalent sp^3 hybrid orbitals



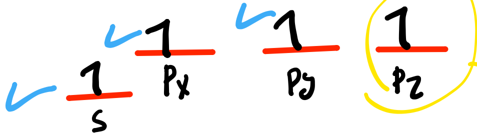
الروابط متساوية في الـ length

3D Structure of Methane Molecule

Mix or combine the four atomic orbitals of the valence shell to form four identical hybrid orbitals

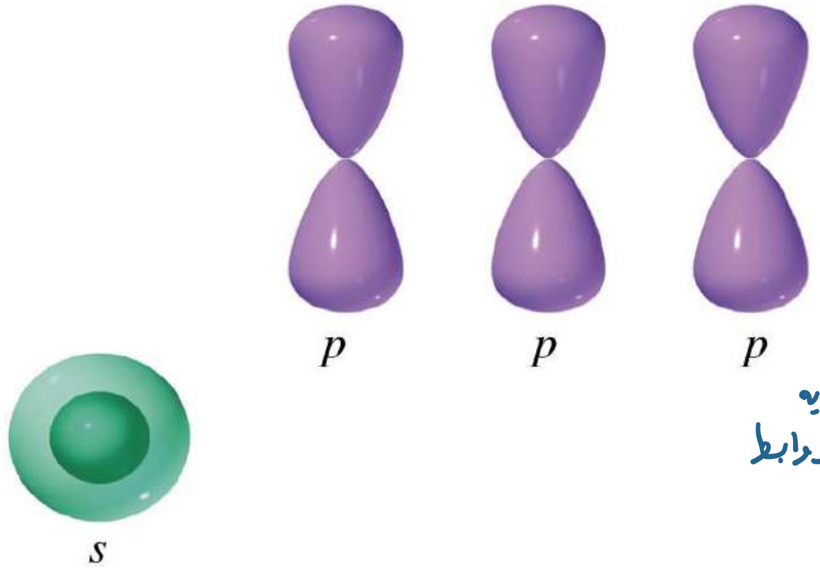
methode of electron

ولعمل mixing
بينهار 1 (S)
3 (P)



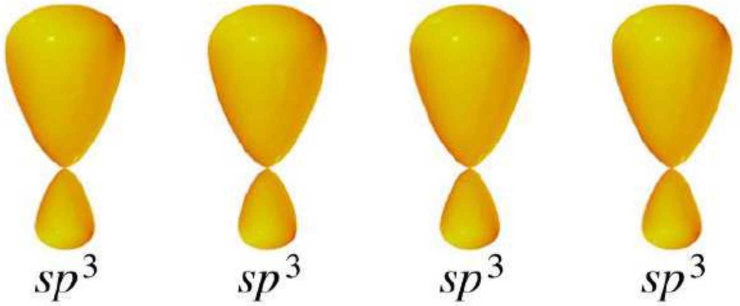
for π orbital

• بستخدم عشانه أعمل سيغا



hybridization →

نظرية جادت لتفسر ظاهرة وجود تناسق وتشابه في شكل وطول عدد الروابط



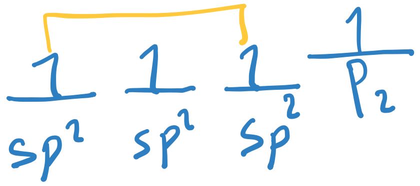
الـ double bond عبارة عن

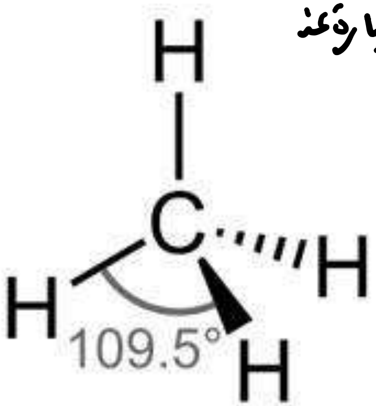
σ وحدة

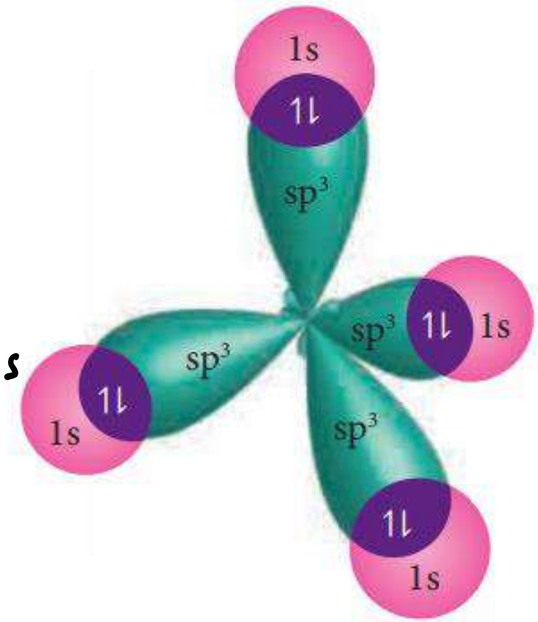
π وحدة

الـ π يتكونه 2P orbitals

للسيغا

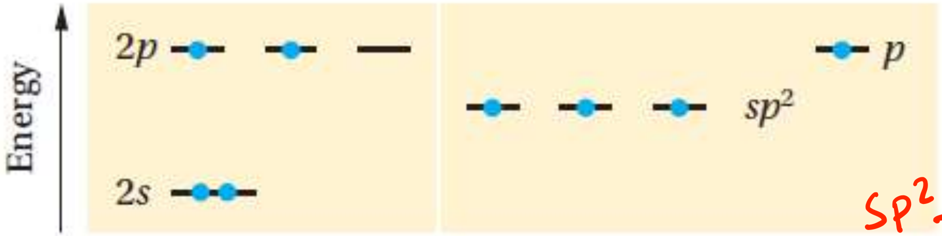






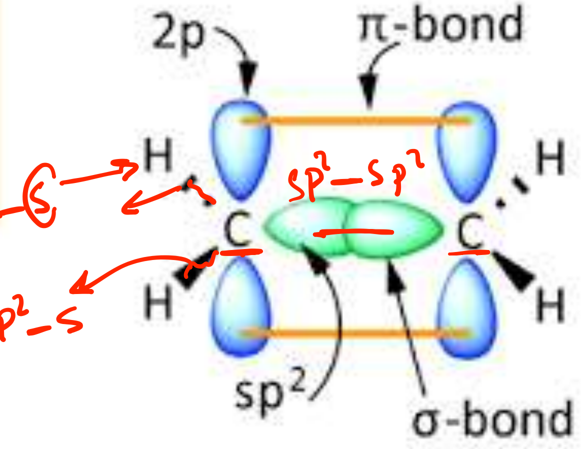
*SP*²-Hybridized orbitals

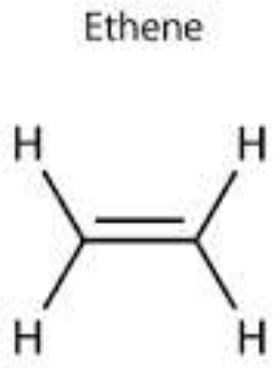
One part *s* and two parts *p* in character and are directed toward the three vertices of an equilateral triangle.

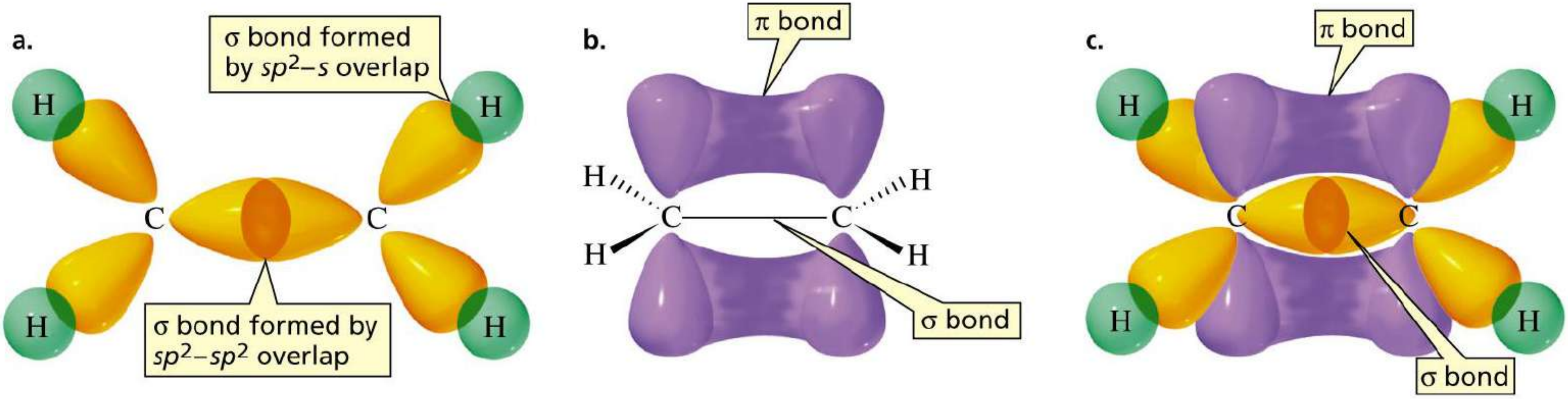


Atomic orbitals of carbon

The 2*s* and two 2*p* orbitals are combined to form three hybrid *sp*² orbitals, leaving one electron still in a *p* orbital.



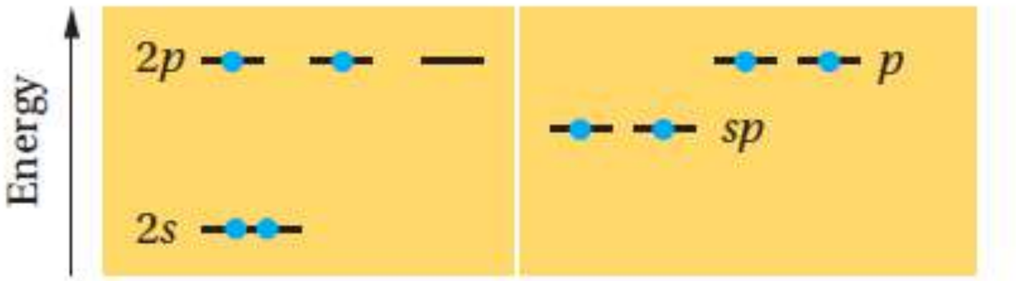




SP-Hybridized orbitals

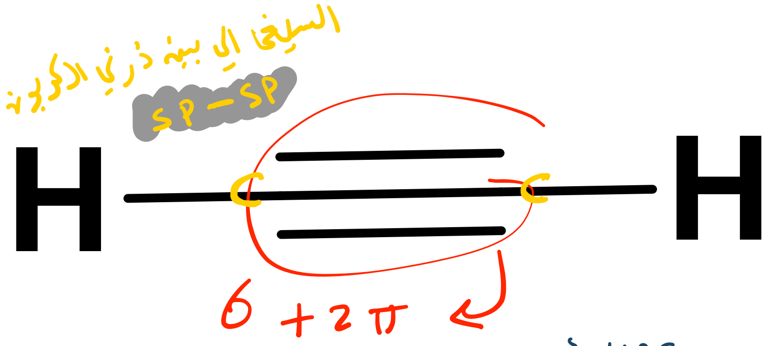
Bonding in Ethyne: **A Triple Bond**

- A triple bond consists of one σ bond and two π bonds



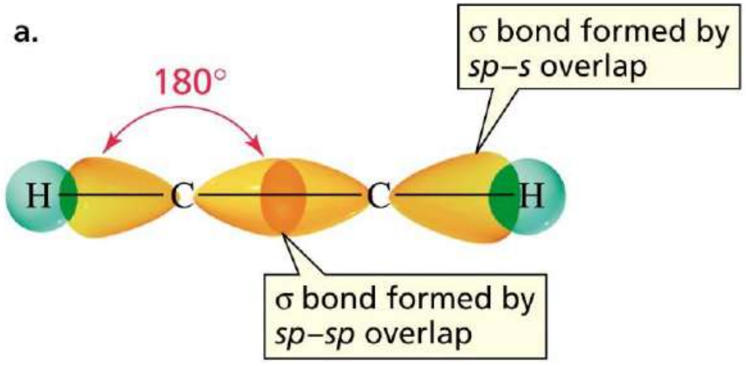
Atomic orbitals of carbon

The 2*s* and one 2*p* orbital are combined to form two hybrid *sp* orbitals, leaving one electron in each of two *p* orbitals.



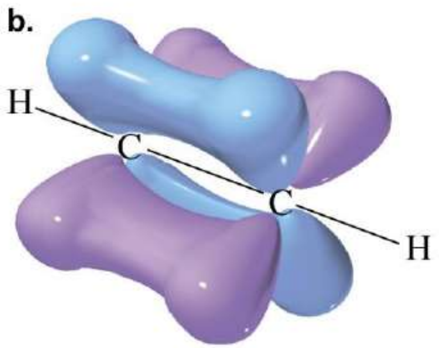
عشان أعمل π Bond
كنت آخذ p orbital من كل واحد
عشان أعمل 2π Bonds
باخذ 2p orbitals من كل واحد

sp orbitals forms a sigma bond between the two carbons, and lateral overlap of the properly aligned *p* orbitals forms two pi bonds



σ bond formed by *sp*–*s* overlap

σ bond formed by *sp*–*sp* overlap



Valence Bond Theory (cont'd)

Orbitals are combined in various portions to make equivalent hybrid orbitals, *i.e.*

AOs(#(s, p))	hybrid	Angle	orientation
1, 1	2 sp	180^{o}	linear
1, 2	3 sp^2	120^{o}	trigonal planar
1, 3	4 sp^3	109^{o}	tetrahedral

1.12 Resonance

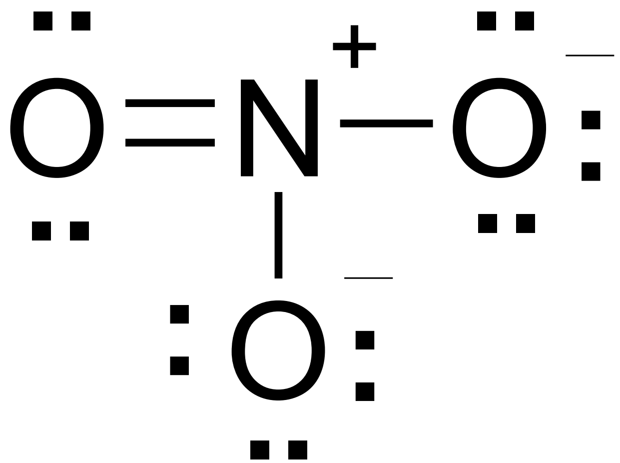
There are molecules (or ions) for which more than one correct Lewis structure can be drawn, these equivalent Lewis structures are resonance structures.

The assumption in these diagrams is that the atom positions do not change, we are only allowed to change the distribution of e^-, *i.e.* the bonds and lone pairs.

Lewis structures do not always explain properties of molecules. Resonance theory is a second layered approach.

Resonance (cont'd)

Example 1: NO_3^-



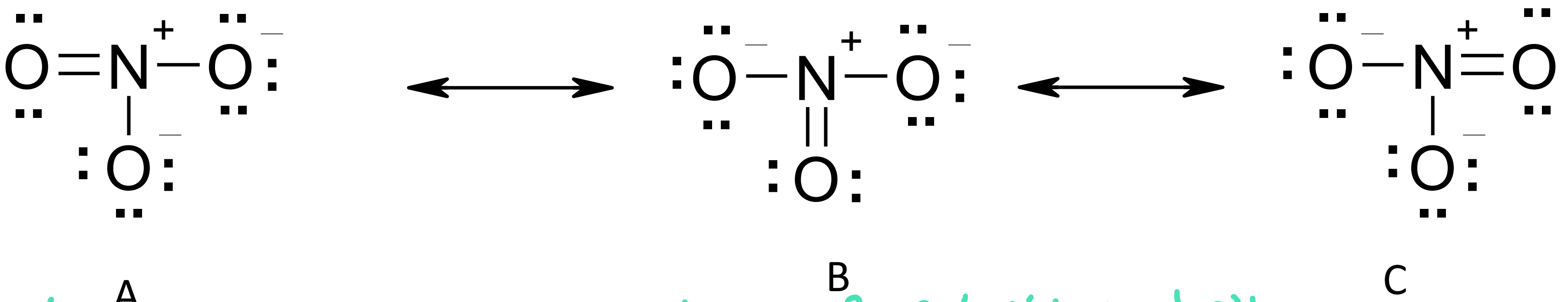
1) # e^-: 5 + 3(6) + 1 = 24
2) try 3 single bonds
3) 18 e^- remain
4) Each O needs 6, leave 2 short
5) Share 1 pair but which one?
6) Pick one O, octets
7) Formal chargall es

Resonance (cont'd)

Example 1: NO_3^- (cont'd)

Depending on your choice of the double bond to oxygen, there are three possible structures differing in the location of the double bond and charges on the oxygen.

الاقتراز بينه A,B,C هو مكانه وجود ال douple bond

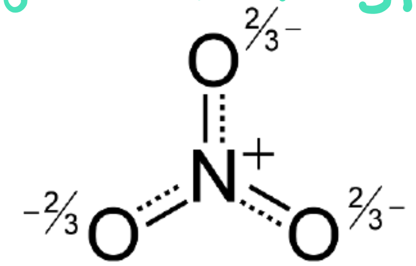


ال hybrid structure ماخذه من A و B و C يعني انه ماعندي douple bond ثابتة موزعه على ABC

In real the structure is hybrid of all (A, B and C)

el Douple Bond Shorther than Single one.

وال real structure



A resonance hybrid

ولازم نعرف انه ما صار Change the Position of atoms

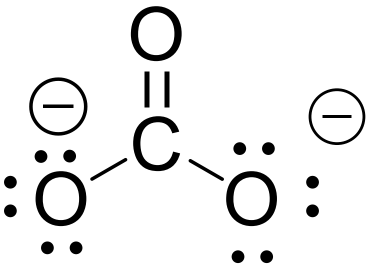
The Lewis structure can be converted to other by changing the position of electrons

Rules for drawing resonance structures :

1) Electrons only can be oved (lone pair / π electrons)

2) Electrons move toward SP/ SP^2 hybridized atom only.

Examples: Write a second resonance structure for the following compounds?



كا بوي أنقل douple bond

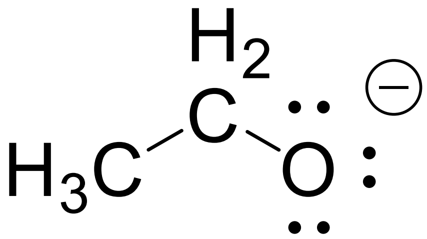
بده يصير نقل لل e^-

بتنقل الـ e^-

SP/SP^2

بده يكون عنده

مجال تنقل e^-



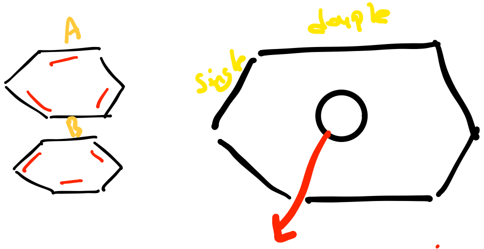
صورة عندي

٤ روابط تسيخا بالتالي

تهجينه ال C sp^3

والروابط مكتملة حول C

فما بيزبط أعمل douple bond



ليش منرسم الدائرة هاي ؟

البنزين هو حلقة سداسية

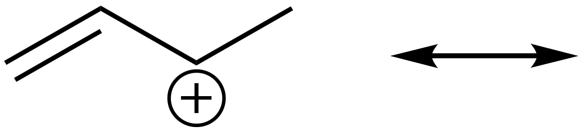
لكنه بسبب الـ Resonance وانه الـ douple Bonds

الهم Rotation داخل الحلقة

بالتالي ممكنه ارسمه ب A / B, فالدائرة بتعبر عنه الـ Rotation

وانه مكانه الـ douple Bonds مش ثابتة

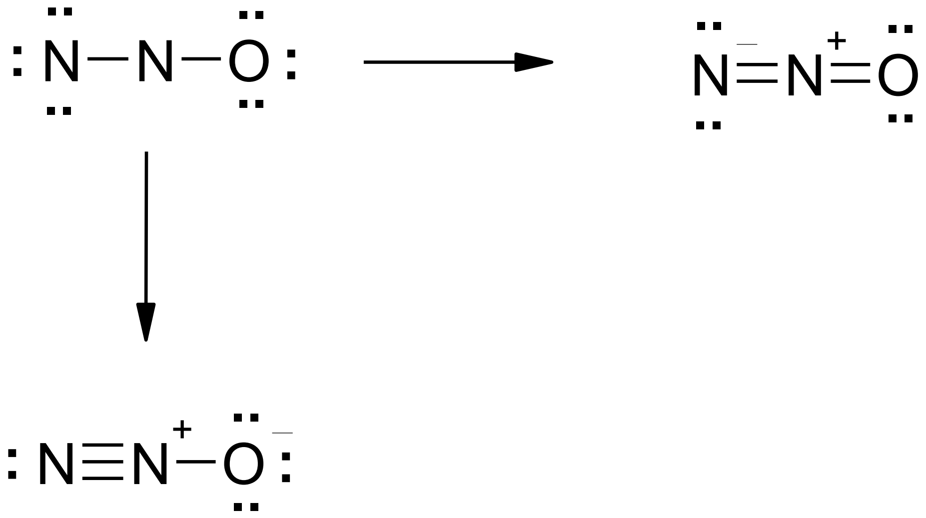
Exercise



Resonance (cont'd)

Example 2: N_2O

1) # e^-: 2(5) + 6 = 16
2) try 2 single bonds
3) 12 e^- remain
4) 16 e- for octets – 4 short
5) Options – 2 double bonds, 1 triple & 1 single
6) Octets
7) Formal charges
8) Which is better and why?



دائماً التصنيف بكونه بسبب تسهيل
دراسة الأمور

1.17: Classification According to Molecular Framework

التصنيف الأول حسب الشكل الكامل للمركب

- The three main classes of molecular frameworks for organic structures are **acyclic**, **carbocyclic**, and **heterocyclic** compounds.

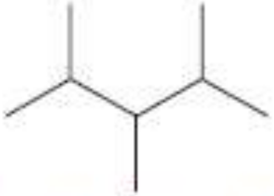
كونه عددهم كبير دخلناهم بمجموعات

الـ A للنفي cyclic

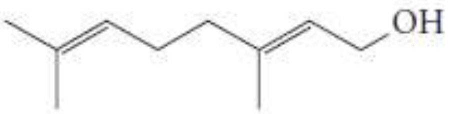
1.17.a Acyclic Compounds (*not cyclic*): contain chains that may be unbranched or branched.

لا يوجد حلقات

unbranched chain of
eight carbon atoms



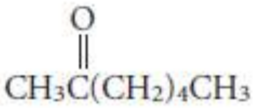
branched chain of
eight carbon atoms



geraniol
(oil of roses)
bp 229–230°C

$CH_3(CH_2)_5CH_3$

heptane
(petroleum)
bp 98.4°C

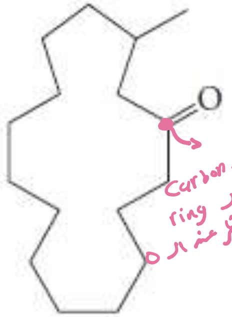


$CH_3C(=O)(CH_2)_4CH_3$

2-heptanone
(oil of cloves)
bp 151.5°C

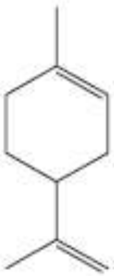
1.17b: Carbocyclic Compounds: contain rings of carbon atoms

صحيح بكونه حلقي لكنه الحلقة لازم يكونوا ال components
لازم يكونوا carbon



صحيح ال carbon
منه ضمن ال
ring
بغض النظر عن ال O

muscone
(musk deer)
bp 327–330°C



limonene
(citrus fruit oils)
bp 178°C

benzene
(petroleum)
mp 5.5°C, bp 80.1°C

لما استبدلنا صار اسمها بدل ال Carbo

1.17.c Heterocyclic Compounds

(In heterocyclic compounds, at least one atom in the ring must be a heteroatom, an atom that is *not* carbon: *eg*. N, O,S...)

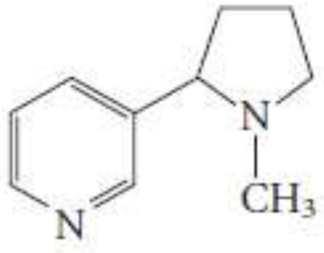
استبدل مكانه Carbon atom احدى ال atoms

N

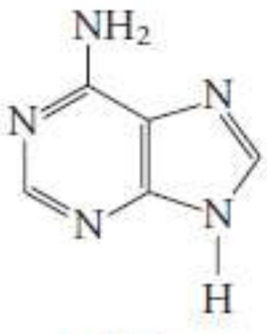
O

S

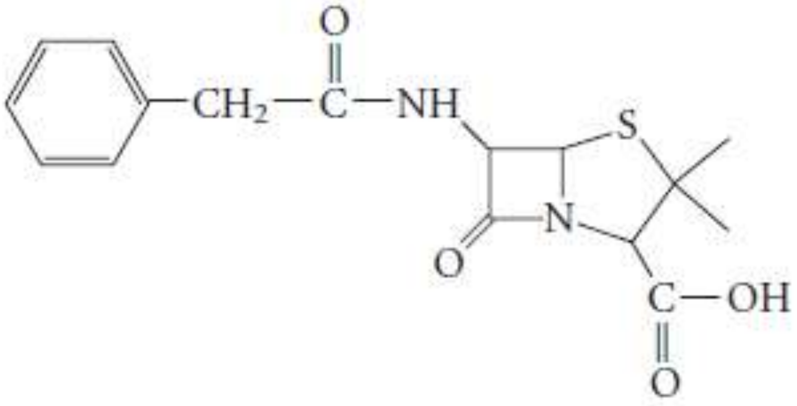
......



nicotine
bp 246°C



adenine
mp 360–365°C
(decomposes)



penicillin-G
(amorphous solid)

مش مطلوب حفظ الأشكال

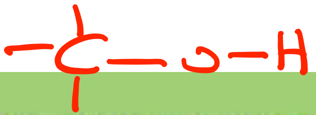
بس نعرف نصنفهم ولأي عيلة بنتموا

Classification According to Functional Group

التصنيف الثاني حسب المجموعة الوظيفية

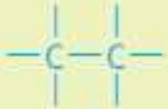
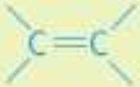
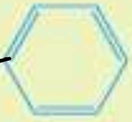
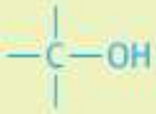
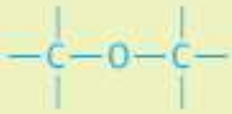
A functional group is an arrangement of atoms with distinctive **physical** and **chemical** properties.

يعني ترتيب معينة لذرات معينة بطريقة معينة



عرفنا ال C و O مع بعض لكنه بسبب اختلاف الطريقة اختلفت الوظيفة

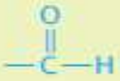
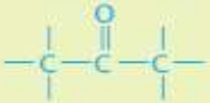
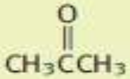
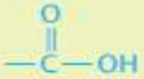
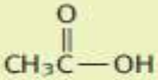
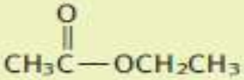
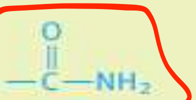
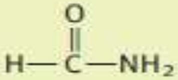
Table 1.6 ■ The Main Functional Groups

	Structure	Class of compound	Specific example	Common name of the specific example
A. Functional groups that are a part of the molecular framework	 $-\overset{\vert}{\underset{\vert}{C}}-\overset{\vert}{\underset{\vert}{C}}-$	alkane	CH_3-CH_3	ethane, a component of natural gas
		alkene	$CH_2=CH_2$	ethylene, used to make polyethylene
	$-C\equiv C-$	alkyne	$HC\equiv CH$	acetylene, used in welding
		arene		benzene, raw material for polystyrene and phenol
B. Functional groups containing oxygen				
1. With carbon–oxygen single bonds	 $-\overset{\vert}{\underset{\vert}{C}}-OH$	alcohol	CH_3CH_2OH	ethyl alcohol, found in beer, wines, and liquors
	 $-\overset{\vert}{\underset{\vert}{C}}-O-\overset{\vert}{\underset{\vert}{C}}-$	ether	$CH_3CH_2OCH_2CH_3$	diethyl ether, once a common anesthetic

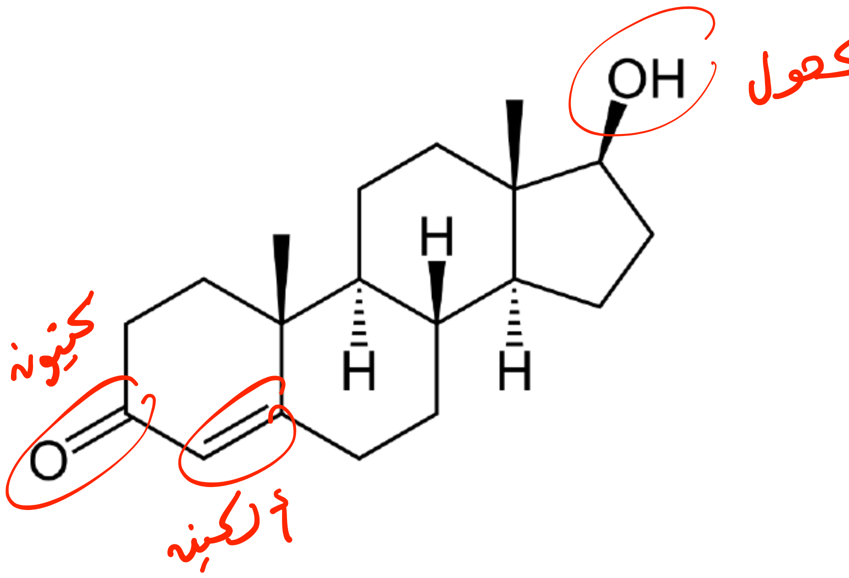
ال structures اللي الهم نفس functional group الهم similar physical properties

رح نتعلم بشابتر 2

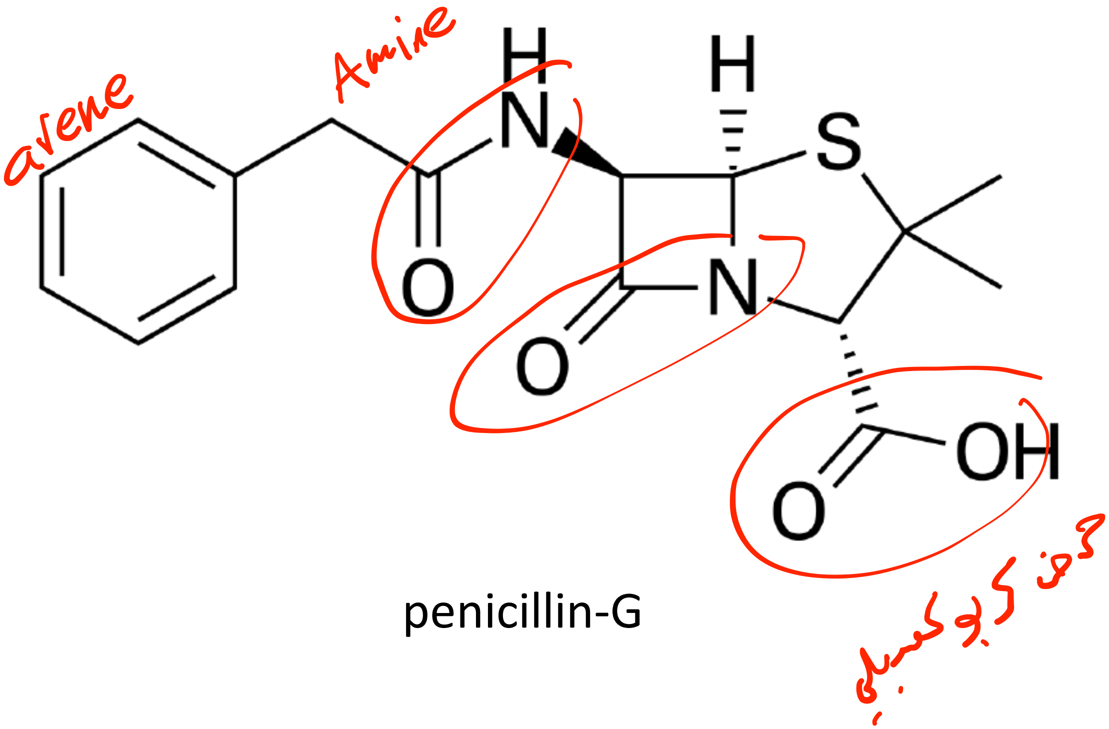
Table 1.6 continued

	Structure	Class of compound	Specific example	Common name of the specific example
$R-\overset{O}{\overset{\|}{C}}-H$ *2. With carbon–oxygen double bonds**	 $-\overset{O}{\overset{\|}{C}}-H$	aldehyde	$CH_2{=}O$	formaldehyde, used to preserve biological specimens
$R-\overset{O}{\overset{\|}{C}}-R$	 $-\overset{\|}{\underset{\|}{C}}-\overset{O}{\overset{\|}{C}}-\overset{\|}{\underset{\|}{C}}-$	ketone	 $CH_3\overset{O}{\overset{\|}{C}}CH_3$	acetone, a solvent for varnish and rubber cement
3. With single and double carbon–oxygen bonds	 $-\overset{O}{\overset{\|}{C}}-OH$ COOH	carboxylic acid	 $CH_3\overset{O}{\overset{\|}{C}}-OH$	acetic acid, a component of vinegar
	 $-\overset{O}{\overset{\|}{C}}-O-\overset{\|}{\underset{\|}{C}}-$ COO R	ester	 $CH_3\overset{O}{\overset{\|}{C}}-OCH_2CH_3$	ethyl acetate, a solvent for nail polish and model airplane glue
*C. Functional groups containing nitrogen***	$-\overset{\|}{\underset{\|}{C}}-NH_2$	primary amine	$CH_3CH_2NH_2$	ethylamine, smells like ammonia
	$-C{\equiv}N$	nitrile	$CH_2{=}CH-C{\equiv}N$	acrylonitrile, raw material for making Orlon
D. Functional group with oxygen and nitrogen	 $-\overset{O}{\overset{\|}{C}}-NH_2$	primary amide	 $H-\overset{O}{\overset{\|}{C}}-NH_2$	formamide, a softener for paper
E. Functional group with halogen	$-X$ F Cl Br I	alkyl or aryl halide	CH_3Cl	methyl chloride, refrigerant and local anesthetic
F. Functional groups containing sulfur†	$-\overset{\|}{\underset{\|}{C}}-SH$	thiol (also called mercaptan)	CH_3SH	methanethiol, has the odor of rotten cabbage
	$-\overset{\|}{\underset{\|}{C}}-S-\overset{\|}{\underset{\|}{C}}-$	thioether (also called sulfide)	$(CH_2{=}CHCH_2)_2S$	diallyl sulfide, has the odor of garlic

Ex. What functional groups can you find in the following natural products?



testosterone



penicillin-G