Announcements – Lecture XIII – Monday, June 8th

1. Fourth Lab: Tuesday, June 9th, ISB 155B
2. Exam II: Friday, June 12th, In Class

Quiz 10 Class #: ____ Last Name: _____

1. Draw the Lewis structure for ozone, O_3, if applicable show any Resonance Structures.

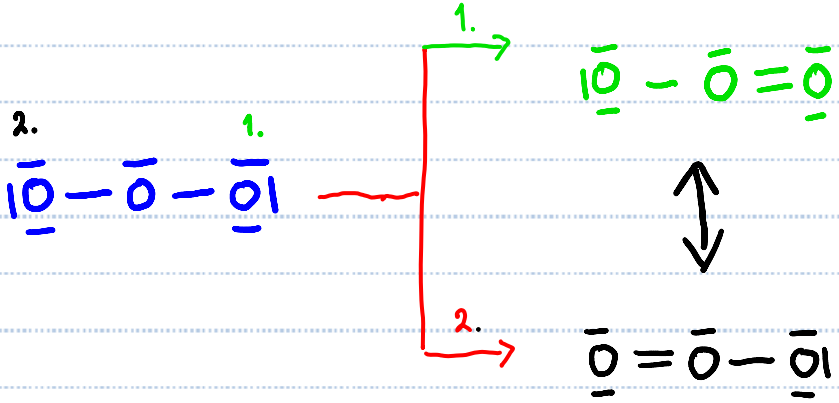
O_3

O: 3x6 = 18

2xBP −4 = 14

6xLP −12 = 2

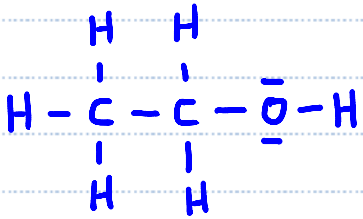
1xLP −2 = 0



8.2 Lewis Structures

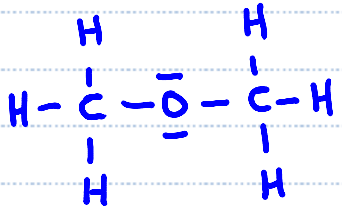
C: Organic Molecules

CH_3CH_2OH



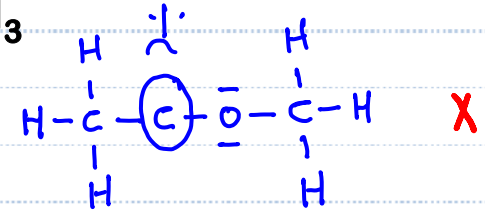
Ethanol : Boiling Point, 78.4°C

CH_3OCH_3

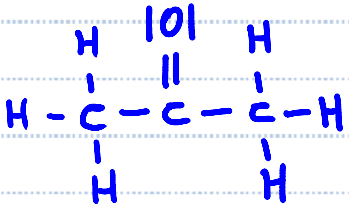


Dimethyl ether : Boiling Point, -23°C

CH_3COCH_3

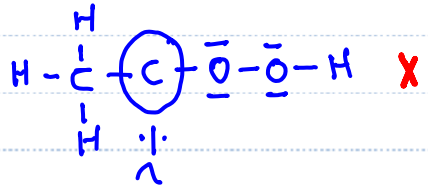


X

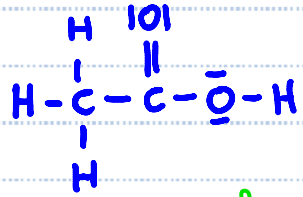


Ketone .. Acetone

CH_3COOH



X



Carboxilic acid

Acetic acid.

8.3 Bond Properties

A: Bond Order , Bond Length, Bond Energy

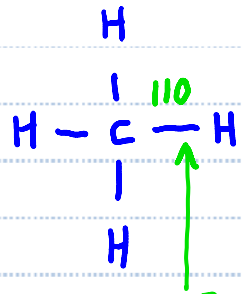
Average Single Bond Lengths (Picometers)

	H	C	N	O	F	Si	P	S	Cl	Br	I
H	74	110	98	94	92	145	138	132	127	142	161
C		154	147	143	141	194	187	181	176	191	210
N			140	136	134	187	180	174	169	184	203
O				132	130	183	176	170	165	180	199
F					128	181	174	168	163	178	197
Si						234	227	221	216	231	250
P							220	214	209	224	243
S								208	203	218	237
Cl									200	213	232
Br										228	247
I											266

Average Multiple Bond Lengths (Picometers)

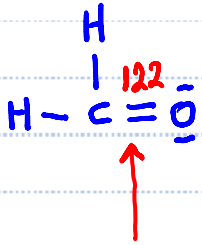
C = C	134	C ≡ C	121
C = N	127	C ≡ N	115
C = O	122	C ≡ O	113
N = O	115	N ≡ O	108

$1\ pm = 1 \times 10^{-12}\ m$



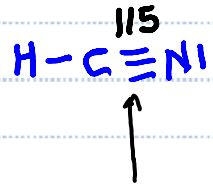
Single bond

Bond Order = 1



Double bond

Bond Order = 2



Triple bond

Bond Order = 3

8.3 Bond Properties

A: Bond Order , Bond Length, Bond Energy

Average Single Bond Lengths (Picometers)

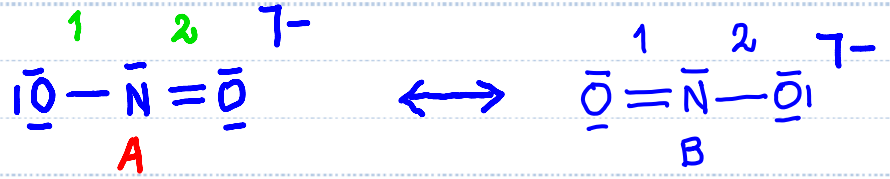
	H	C	N	O	F	Si	P	S	Cl	Br	I
H	74	110	98	94	92	145	138	132	127	142	161
C		154	147	143	141	194	187	181	176	191	210
N			140	136	134	187	180	174	169	184	203
O				132	130	183	176	170	165	180	199
F					128	181	174	168	163	178	197
Si						234	227	221	216	231	250
P							220	214	209	224	243
S								208	203	218	237
Cl									200	213	232
Br										228	247
I											266

Average Multiple Bond Lengths (Picometers)

C = C	134	C ≡ C	121
C = N	127	C ≡ N	115
C = O	122	C ≡ O	113
N = O	115	N ≡ O	108

$1\ pm = 1 \times 10^{-12}\ m$

NO_2^- :



	Bond Order	Bond Order	Weighted average
1	1	2	1½
2	2	1	1½

Expected N-O bond length : >115pm and <136pm

8.3 Bond Properties

A: Bond Order , Bond Length, Bond Energy

Average Single Bond Energies (kJ per mole)

	H	C	N	O	F	Si	P	S	Cl	Br	I
H	436	414	389	464	569	293	318	339	431	368	297
C		347	293	351	439	289	264	259	330	276	238
N			159	201	272		209		201	243	
O				138	184	368	351		205		201
F					159	540	490	285	255	197	
Si						176	213	226	360	289	
P							213	230	331	272	213
S								213	251	213	
Cl									243	218	209
Br										192	180
I											151

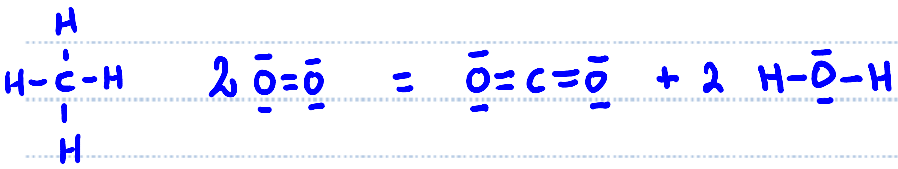
Average Multiple Bond Energies (kJ per mole)

N = N	418
N ≡ N	946
N = O	590
C ≡ N	891
O = O	498

C = C	611
C ≡ C	837
C = O	803
C = O	745
C ≡ O	1075

In CO_2 Only

$CH_4(g) + 2O_2(g) = CO_2(g) + 2H_2O(g)$



Σ Bonds broken − Σ Bonds formed

$4(C-H) + 2(O=O) - \{2(C=O) + 4(O-H)\}$

$4(414) + 2(498) - \{2(803) + 4(464)\}$

$1656 + 996 - \{1606 + 1856\}$

$2652 - 3462$

$-810\ kJ.mol^{-1}$

↑

Exothermic ... gives off heat

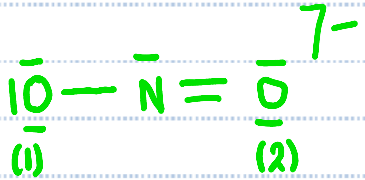
8.4 Electron Distribution in Molecules

A: Formal Charge Vs Oxidation Numbers – Oxidation Numbers

Electron book-keeping where electrons in a bond are considered to belong solely to the most electronegative atom in the bond ... very useful in electrochemistry.

Oxidation number = Group Number – Lone Pair electrons – Bond Pair electrons

NO_2^-



O: More electronegative than N

O1: 6 – 6 – 2 = -2
N : 5 – 2 – 0 = +3
O2: 6 – 4 – 4 = -2

H_2O_2 ... peroxide

O: More electronegative than H

H: 1 – 0 – 0 = +1
O: 6 – 4 – (2+1) = -1

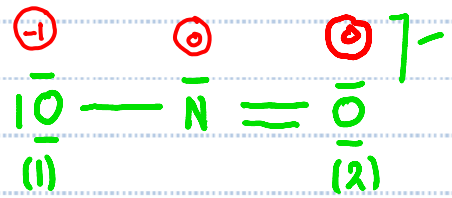
8.4 Electron Distribution in Molecules

A: Formal Charge Vs Oxidation Numbers – Formal Charge

Formal Charge, an electron book-keeping system where the electrons in a bond are considered to equally shared between the atoms forming the bond.

FORMAL CHARGE = GROUP NUMBER – LONE PAIR ELECTRONS – ½ BOND PAIR ELECTRONS

NO_2^- :



O1: $6 - 6 - \frac{1}{2}(2) = -1$

N: $5 - 2 - \frac{1}{2}(6) = 0$

O2: $6 - 4 - \frac{1}{2}(4) = 0$

a) Sum of the Formal Charges in a molecule must equal the charge on the molecule.

b) Ideally like to see the smallest charge separation possible.

c) Like to see negative formal charges on the most electronegative atom(s).