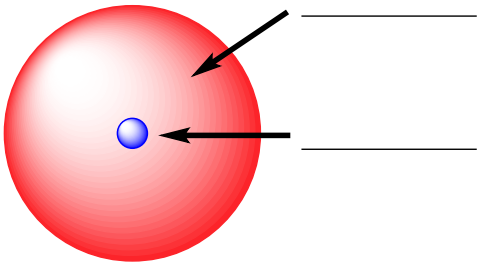
Organic Chemistry Prep Workshop – Day 1

Atomic Structure



	Mass	Relative Charge	Symbol
Proton			
Neutron			
Electron			

Atomic Number (Z) = Number of protons
Mass Number = Number of protons + neutrons
Atomic Weight = Weighted average of the isotopes present in nature.

^{12}C vs ^{13}C vs ^{14}C

6	7	8
C	N	O
12.011	14.007	15.999

You Try 1-1

For each species below, determine the number of protons, neutrons, and electrons.

^{15}N _____ p^+ _____ e^- _____ n^o

$^{32}S^{2-}$ _____ p^+ _____ e^- _____ n^o

$^{39}K^+$ _____ p^+ _____ e^- _____ n^o

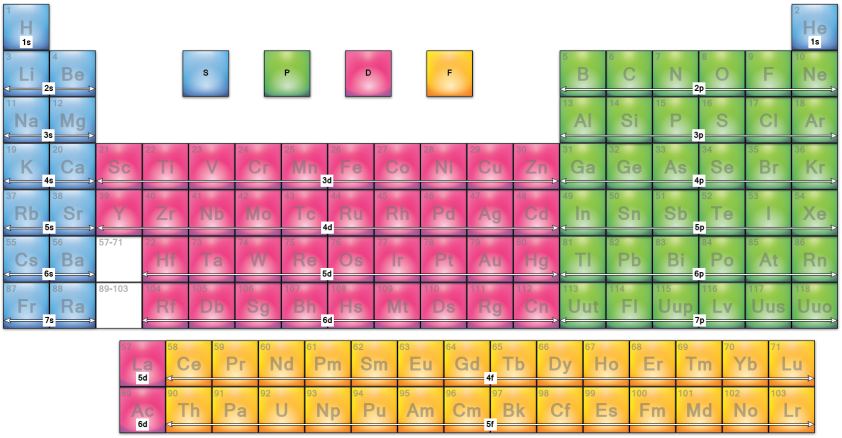
^{21}Ne _____ p^+ _____ e^- _____ n^o

Electrons

The outermost electron shell (valence shell) is responsible for bonding. The inner shell (core shell) does not participate in bonding.

Electron Configuration: **Li**

Electron Configuration: **Br**



You Try 1-2	
Write the abbreviated electron configuration for each of the following:	
Na	**S**
Na^+	**S^{2-}**
C	

Ionic Bonds

Octet Rule - An atom will donate, accept, or share electrons in order to obtain a filled outer shell.

Ionic bonds involve the transfer of electrons typically between a metal and a non-metal.

Example: LiBr

Hydrogen – An Exception to the Octet Rule

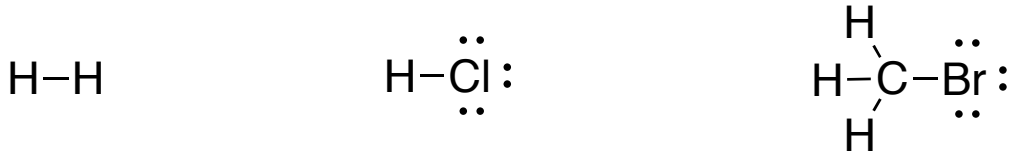
A stable configuration for hydrogen has either zero or two valence electrons.

Covalent Bonds

A **covalent Bond** results from two atoms sharing electrons.

Covalent bonds occur between elements of similar electronegativity and typically involve two non-metals.

Examples:



Electronegativity

Describes the tendency of an atom to attract electrons towards itself.

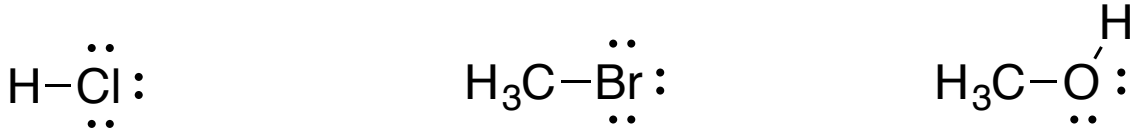
hydrogen 1 H 1.0079																	helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305											aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 **	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	unununium 111 Uuu [272]	ununbium 112 Uub [277]		ununquadium 114 Uuq [289]				

*Lanthanide series	lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
**Actinide series	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

Covalent Bond Types

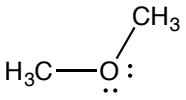
Nonpolar Covalent – bonds between atoms of the same electronegativity.

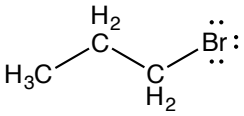
Polar Covalent – bonds between atoms of different electronegativity.

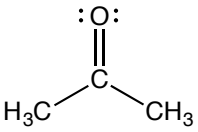


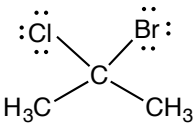
You Try 1-3

For each polar covalent bond below, write in "δ-, δ+" notation and draw in the bond dipole arrows.









How Many Bonds Can an Atom Have?

Draw an electron dot symbol.
Group # = # of Valence Electron

	IA	IIA		IIIA	IVA	VA	VIA	VIIA
Element	H	Mg		B	C	N	O	F
Valence e-								
Symbol								
# Bonds								

Lewis Structures

Show us the bonding arrangement of atoms in a molecule. All bonds and lone pairs are drawn in a Lewis structure.

Basic Rules:

1. Draw only the valence electrons
2. Hydrogen can have only 2 electrons (duet)
3. 2nd row elements can have no more than 8 electrons (octet)

Strategy:

1. Add up the total number of valence electrons for all atoms.
   - Add 1 to the electron count for a negative charge.
   - Subtract 1 from the electron count for a positive charge.
2. Divide the number by two to get the total number of bonds/lone pairs to use.
3. Arrange the atoms
   - C, N, O, S, B in the middle
   - H and halogens on the periphery (they only form 1 bond!)
4. Connect the atoms with bonds. Then add lone pairs until all atoms (except H) have an octet.
5. If any atoms still do not have an octet, use a lone pair to form a double (or triple) bond to that atom.

Example 1: $C_2H_4Br_2$

Example 2: C_2H_6O

Example 3: C_3H_6

Example 4: CH_6N^+

Example 5: NO_3^-

Octet Rule Exceptions

An uncharged group IIIA element (B, Be) can have less than an octet of electrons.

Example: BH_3

Period 3 elements and beyond can have expanded valence shells (i.e. more than an octet of electrons).

Example: PCl_5

You Try 1-4		
Draw a valid Lewis structure for each of the following		
C_3H_9N	**C_4H_6**	**HCO_3^-**
C_4H_8 (acyclic)	**C_4H_8 (ring)**	**$C_2H_7O^+$**

Lewis Structures for Larger Molecules

As molecules become larger, counting up and distributing the valence electrons becomes increasingly cumbersome. Solution = just arrange electron dot symbols

Example 1: $C_5H_{12}O$

Example 2: C_4H_7N (cyclic structure)

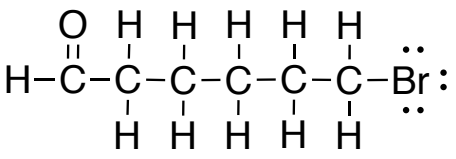
Example 3: $C_6H_{11}OBr$ (containing C=O)

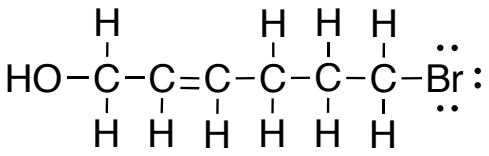
Example 4: $C_6H_{11}OBr$ (containing C=C)

Constitutional Isomers

These two Lewis structures represent constitutional isomers – molecules with the same molecular formula, but different atom connectivity.

Constitutional isomers are <u>different</u> molecules.





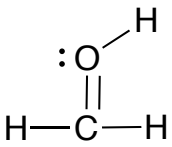
You Try 1-5		
Draw two valid Lewis structure for each of the following		
$C_5H_{13}N$	**C_7H_{14} (with 5 C ring)** **C_7H_{14} (acyclic)**	**$C_5H_8O_2$**

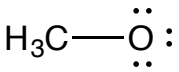
Formal Charge

Formal Charge – a charge assigned to an individual atom in a molecule.

Formal Charge = Group # - # bonds - # lone pair electrons

Examples:





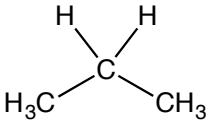
*Pro Tip – an atom with an unusual number of bonds typically carries a formal charge!

Example: CH_2N_2 – Draw the Lewis structure and assign any formal charges.

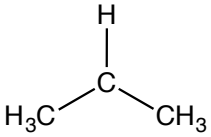
Charges on Carbon

You will frequently encounter relatively unstable molecules that contain a carbon atom with a positive or negative charge.

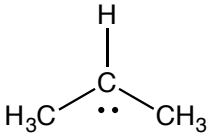
- **A charge on carbon (+ or -) will take the place of one bond.**
- **A "+" on carbon is a site of electron deficiency.**
- **A "-" carbon has a lone pair of electrons.**



C_3H_8

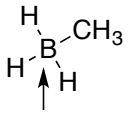
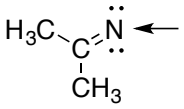
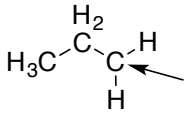
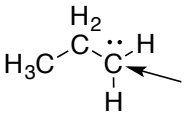
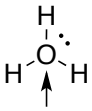
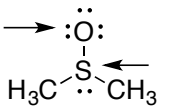


C_3H_7



C_3H_7

Example: Draw a Lewis structure for $C_3H_6Br^+$ with the positive charge residing on a carbon.

You Try 1-6		
Determine the formal charge on each of the indicated atoms.		
		
		

You Try 1-7	
Draw a valid Lewis structure for each of the charged molecules below.	
$C_4H_{11}O^+$ (+ on oxygen)	**$C_4H_9O^+$** (+ on carbon)
$C_4H_{10}N^-$ (- on nitrogen)	**$C_4H_{10}N^-$** (- on carbon)