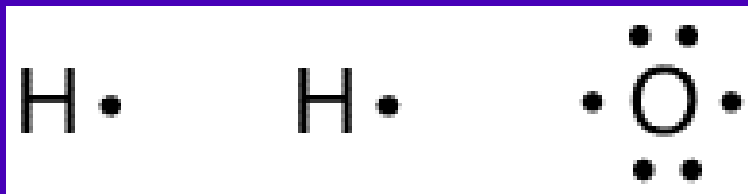


Example: water (H_2O)

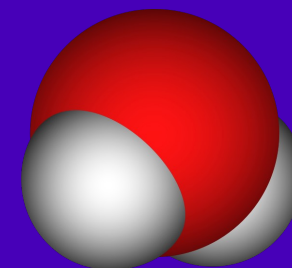
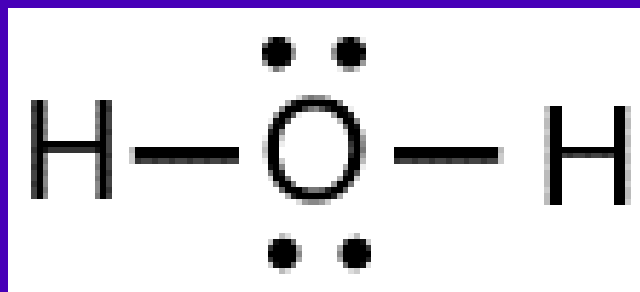
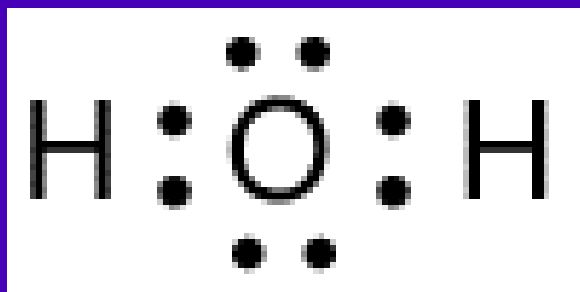
Lewis structures for
two H's and one O:



Hydrogen is an exception to the octet rule. It only needs **2** electrons to be stable.

How could you put these atoms together so that the oxygen has 8 electrons and the two hydrogens have 2 electrons?

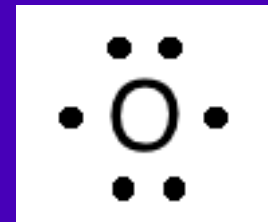
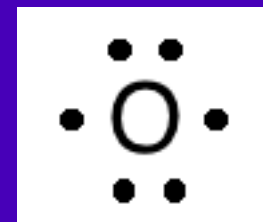
Lewis structure:



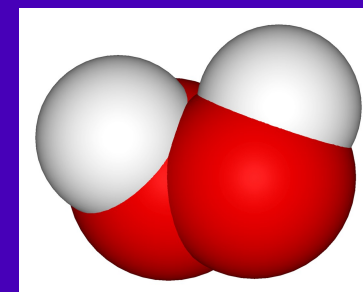
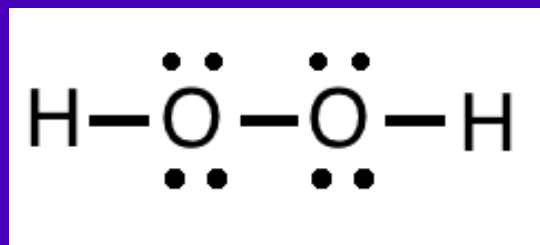
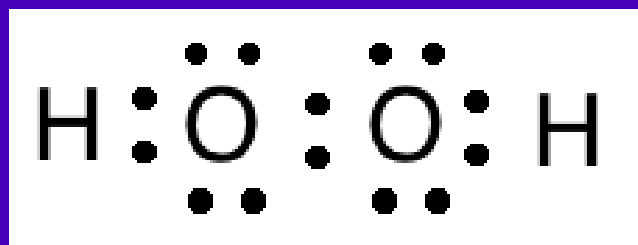
Every time there is a single electron on a side, it must be joined with a single electron on another atom to form a bond.

Example: hydrogen peroxide (H_2O_2)

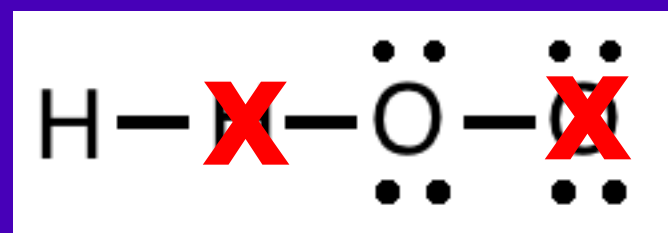
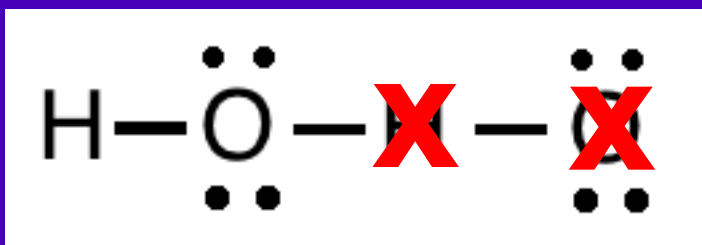
Lewis structures for the atoms:



How could you put these atoms together so that they are all stable?



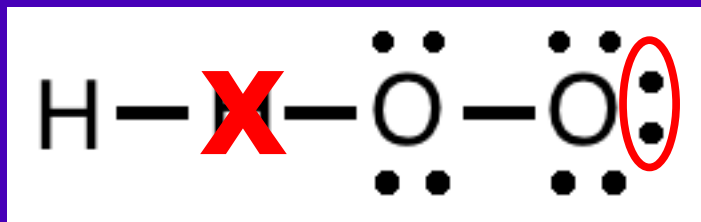
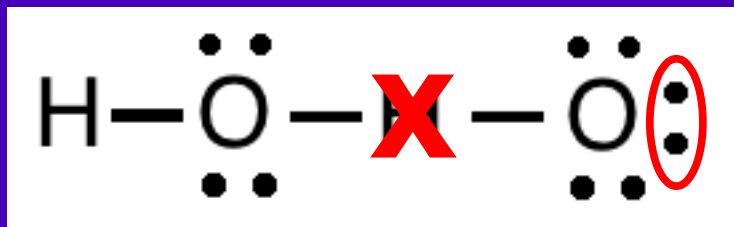
What is wrong with these structures?



H can't have 2 bonds

O on the end is unstable

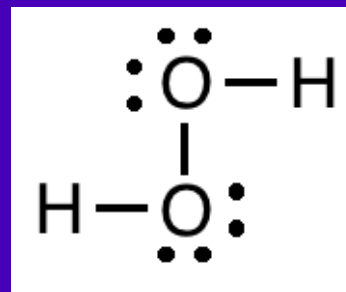
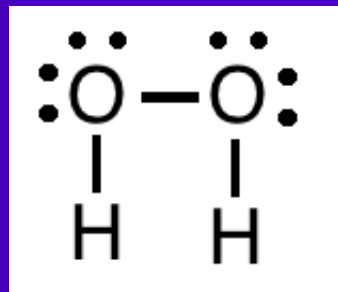
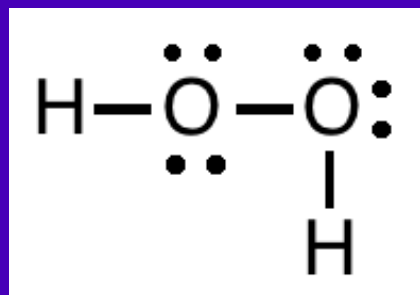
What about these?



H still can't have 2 bonds

O's on the end are stable, but where did the extra electrons come from?

Are these OK?



yes!

As long as the same atoms are connected, and the same electrons are around each atom, it is the same molecule.

Other compounds with hydrogen:

If nitrogen forms a compound with hydrogen, what formula will it have?

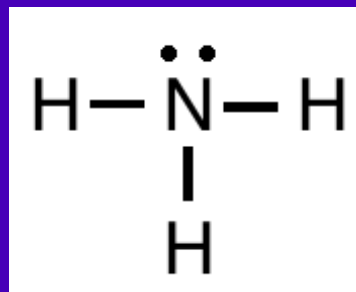
Lewis structure of nitrogen:



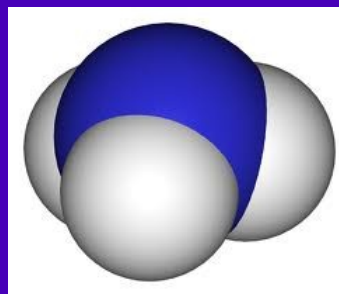
How many H's will be needed?



Draw a Lewis structure for the compound:

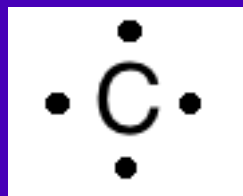


What is the formula? NH_3

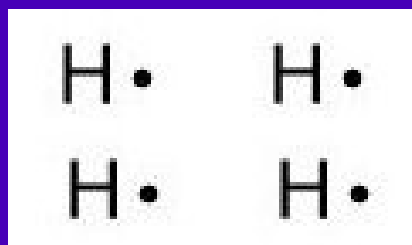


If carbon forms a compound with hydrogen, what formula will it have?

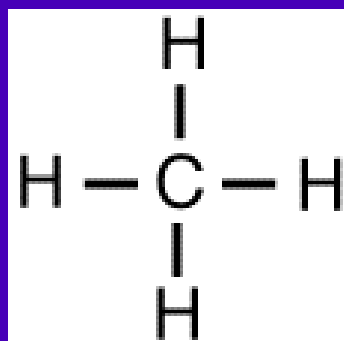
Lewis structure of carbon:



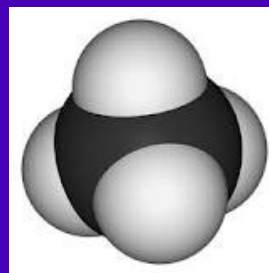
How many H's will be needed?



Draw a Lewis structure for the compound:



What is the formula? **CH₄**



What about chlorine?

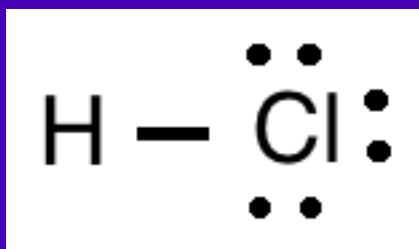
Lewis structure
of chlorine:



How many H's
will be needed?

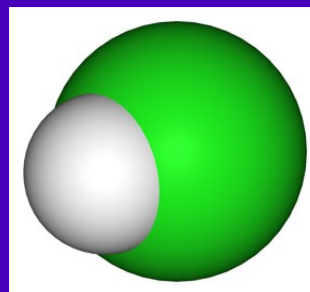


Draw a Lewis structure
for the compound:



What is the formula?

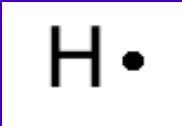


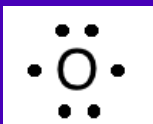
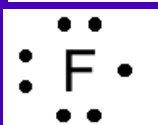
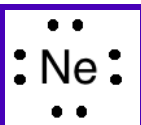
HCl



Why are some formulas written with the H's last, and others first?

if they are acids, the H is first

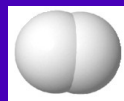
What is the relationship between the number of valence electrons and the number of bonds that an atom can form?

	valence electrons		number of bonds
hydrogen	1		1
carbon family	4		4
nitrogen family	5		3
oxygen family	6		2
halogens	7		1
noble gases	8		0

For every valence electron an atom is short, it will form one bond.

Example: **hydrogen gas**

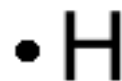
formula: H_2



Lewis structure for hydrogen atom:



Two atoms joined together:



Lewis structure for H_2 :

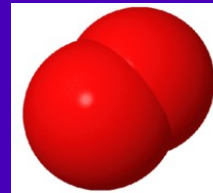


Number of bonds between atoms: **1 – single bond**

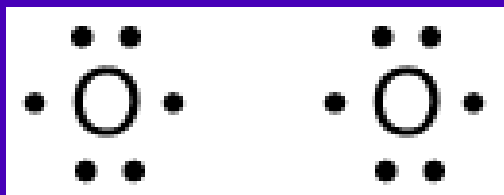
Example: **oxygen gas**



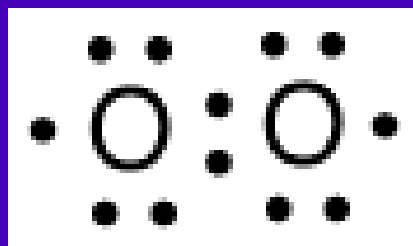
formula: **O₂**



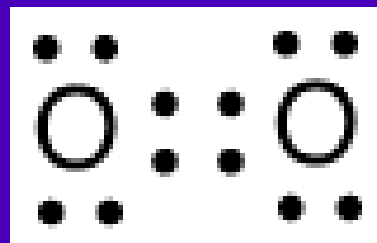
Lewis structure for
two oxygen atoms:



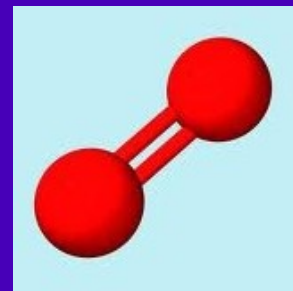
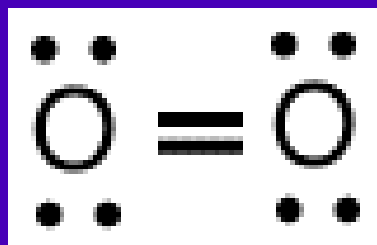
sharing one pair
of electrons:



sharing two pairs
of electrons:



Lewis structure:

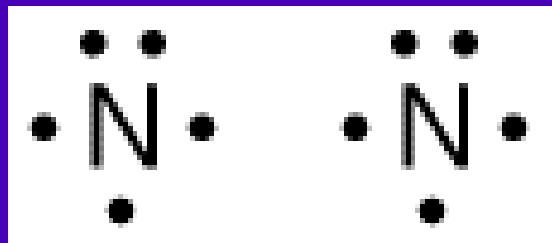


Number of bonds shared between atoms: **2 – double bond**

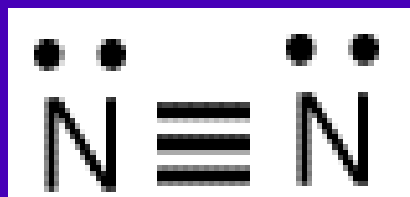
Example: **nitrogen gas**

formula: **N_2**

Lewis structure for
two nitrogen atoms:



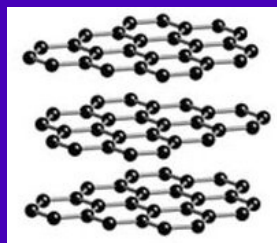
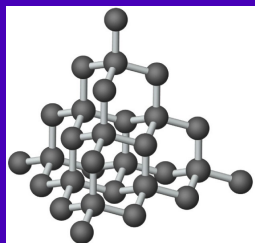
Lewis structure
for the molecule:



Number of bonds shared between atoms: **3 – triple bond**

Is it possible to have four bonds between two atoms? **no**

Why does carbon form complex molecules like diamond and graphite?



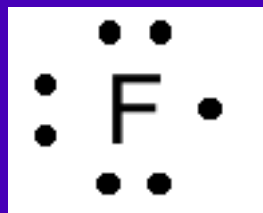
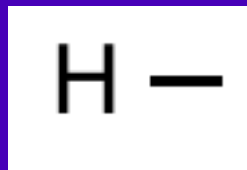
It can't form diatomic molecules!

Which atoms can have double bonds? H **C** **N** **O** F

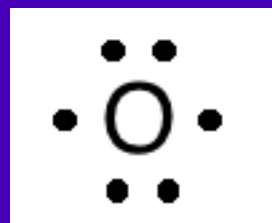
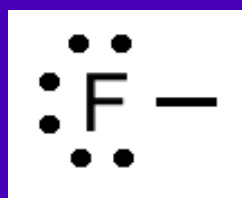
Which atoms can have triple bonds? H **C** **N** O F



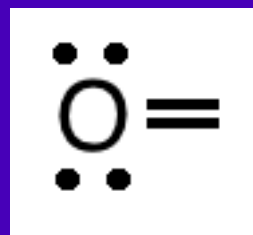
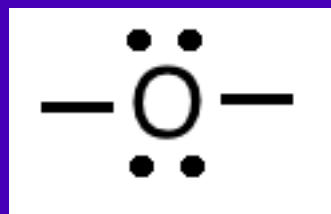
1 bond



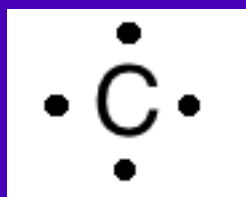
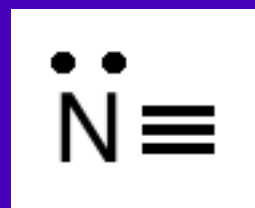
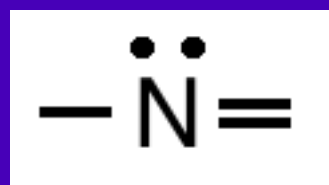
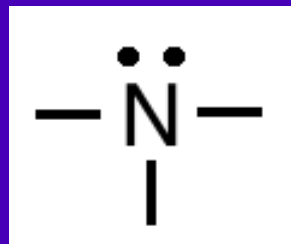
1 bond



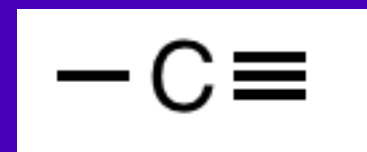
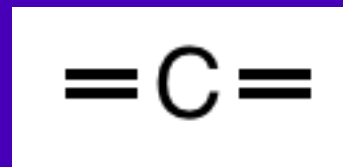
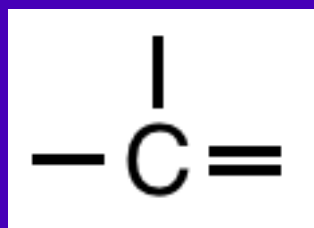
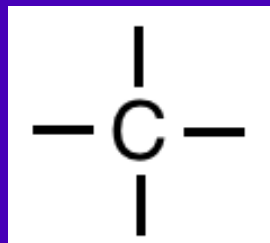
2 bonds



3 bonds



4 bonds



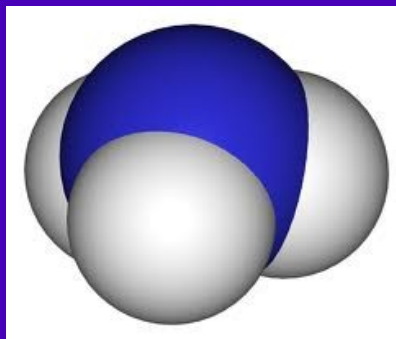
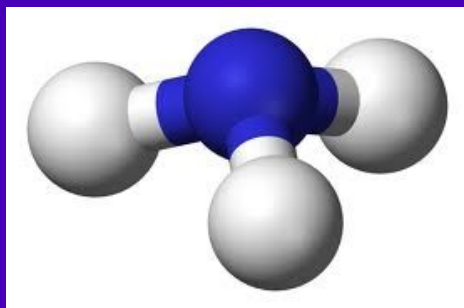
3 – New molecules

In the examples above, which of the molecules are you already familiar with?



What about the others?

NH_3 : Ammonia is found in cleaning products, where it has a strong characteristic smell.



CH₄: Methane gas is the main component of natural gas. It is also formed in swamps, and given off by cows.



N₂: Nitrogen gas makes up 78% of the earth's atmosphere. Oxygen is the next 21%, and followed by argon (1%) and carbon dioxide (0.04%).

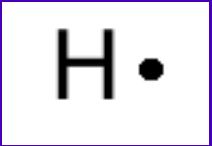
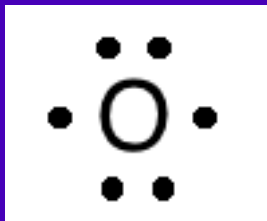
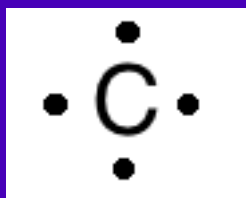


Try your hand at creating Lewis structures for the following molecules:

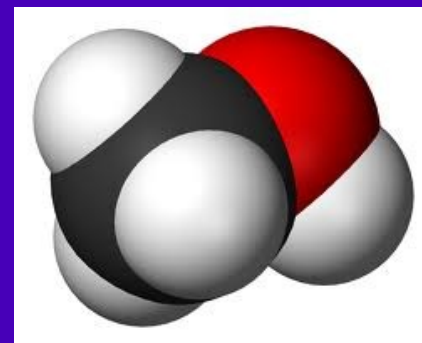
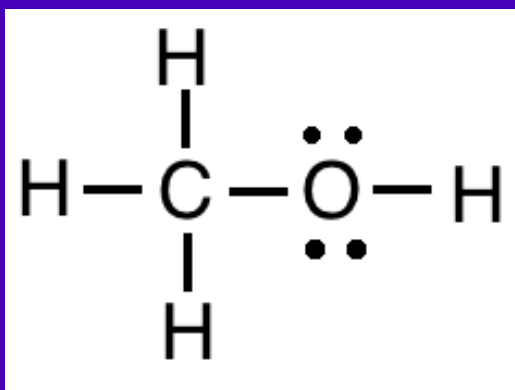
methanol CH_4O : called wood alcohol
first thing that burns out of wood
used in race car fuel
twice as poisonous as ethanol



Lewis structure of atoms:



Lewis structure of the molecule:



formaldehyde (CH_2O):

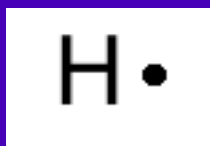
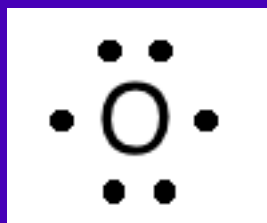
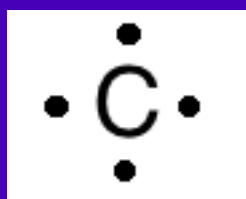
used in embalming and preserving tissues

found in the glues used in plywood and particle board

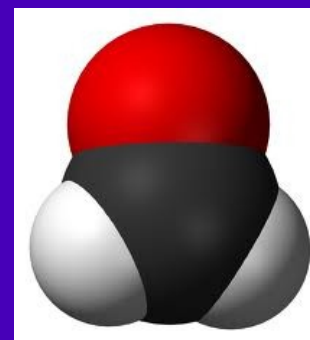
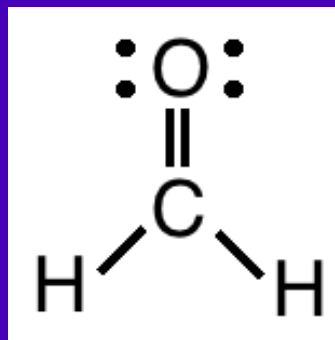
toxic to humans



Lewis structure of atoms:



Lewis structure of the molecule:

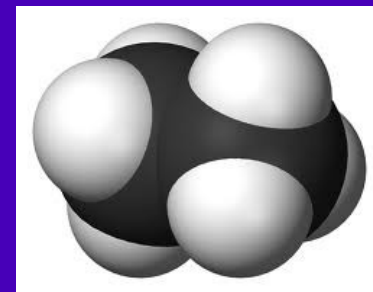
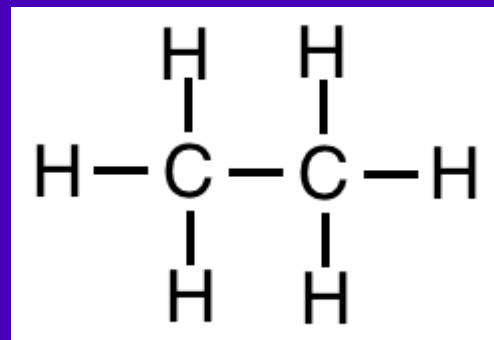
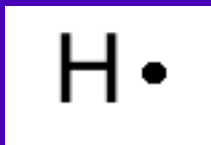
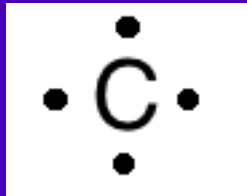
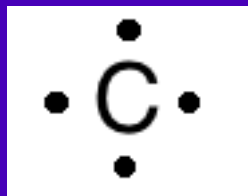


Why does formaldehyde have a double bond, but methanol does not?

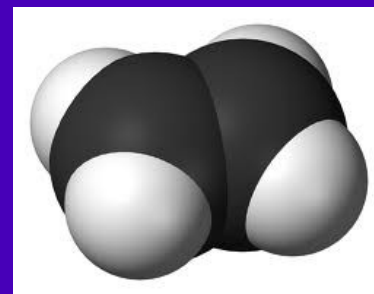
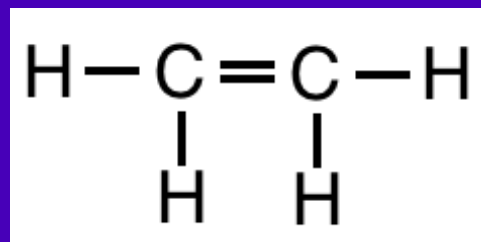
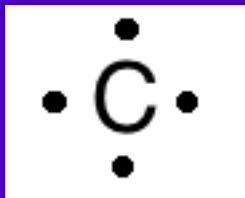
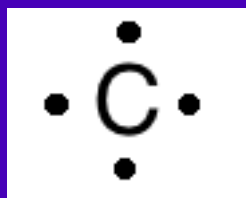
CH_4O vs CH_2O – formaldehyde has two less H's

Draw a Lewis structure for each of the following formulas:

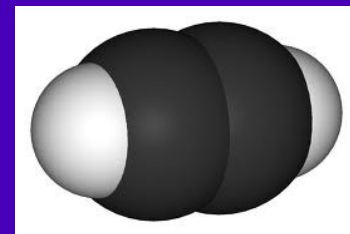
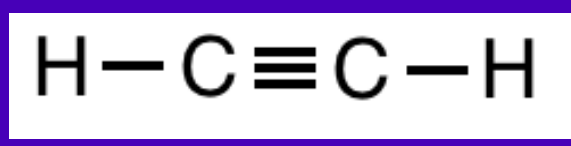
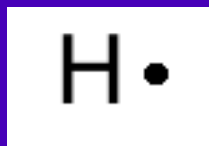
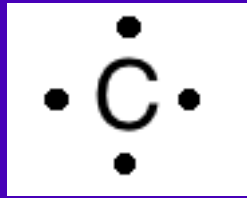
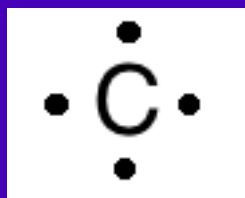
ethane: C_2H_6



ethylene: C_2H_4

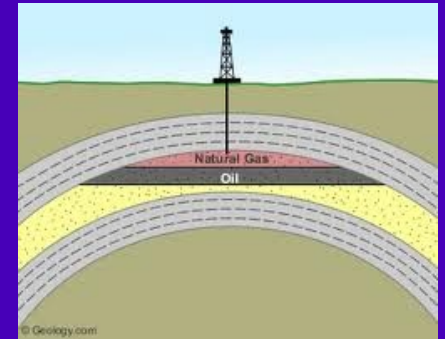


acetylene: C_2H_2



Where are these compounds found?

ethane: found in natural gas (1-6%)
extracted to use in making ethylene



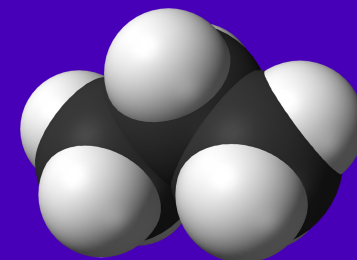
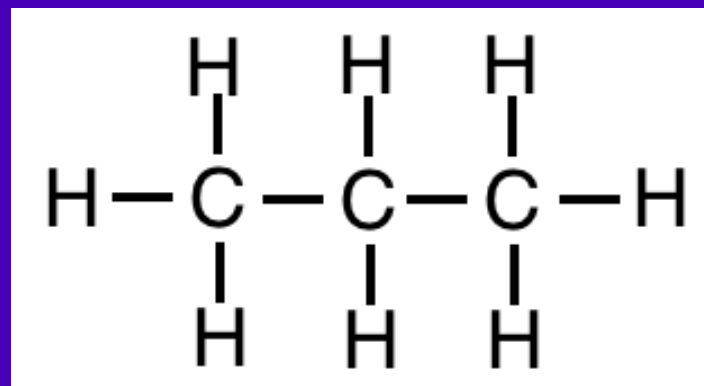
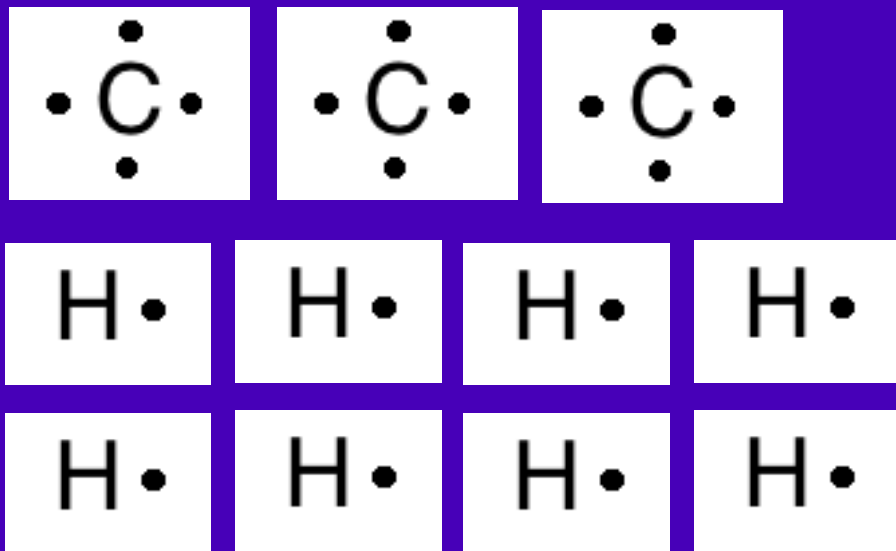
ethylene: over 100 million tons produced worldwide,
used to make plastic, antifreeze
a plant hormone that induces ripening of fruit



acetylene: used in welding and cutting torches
flame temperature of 3300°C



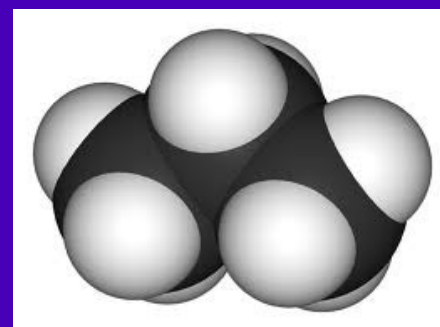
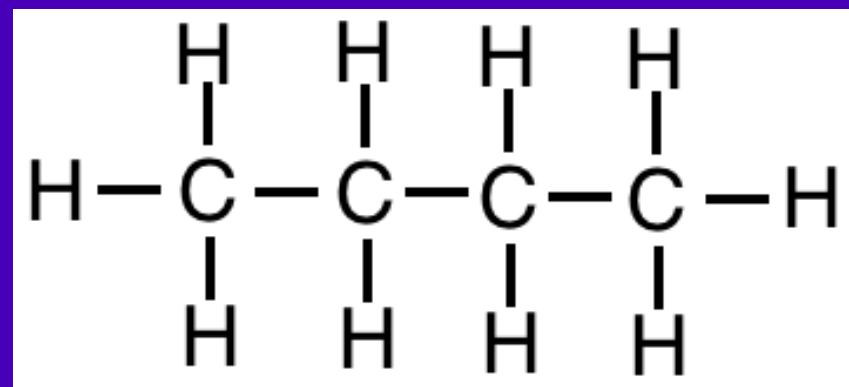
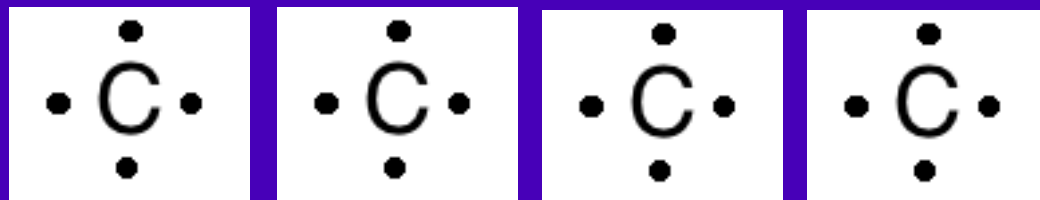
propane (C_3H_8):



Propane is obtained from natural gas and petroleum refining. It is burned in barbeques, heaters, motor vehicles, refrigerators, etc.



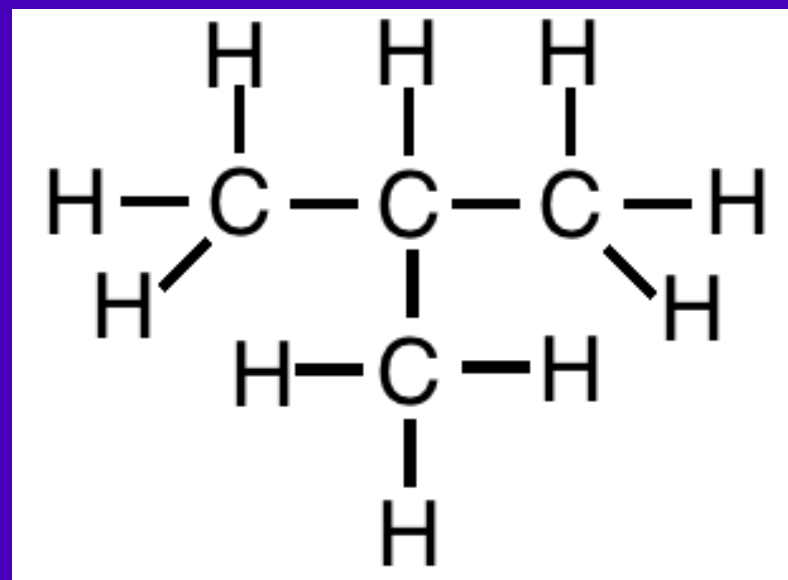
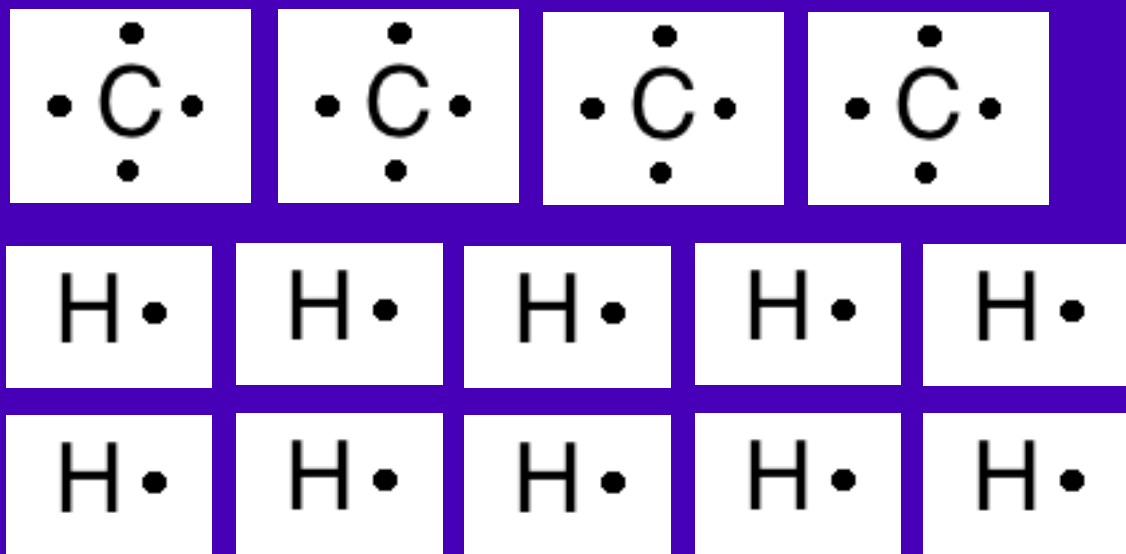
butane C_4H_{10}



Butane is used in lighters, torches, as a propellant in aerosol cans, cordless curling irons, etc.



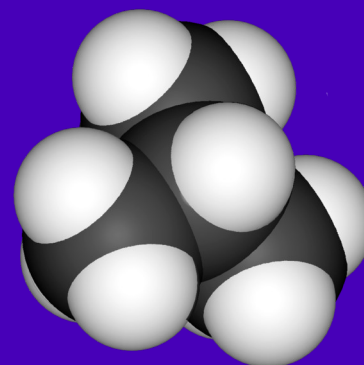
There is actually more than one compound with the formula C_4H_{10} .
Can you think of another way to put these atoms together?



This compound is called **isobutane**.

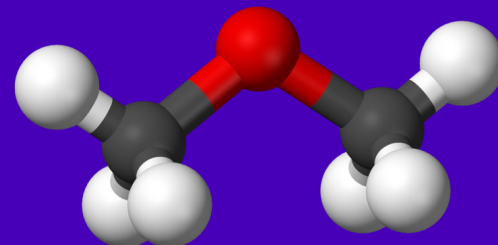
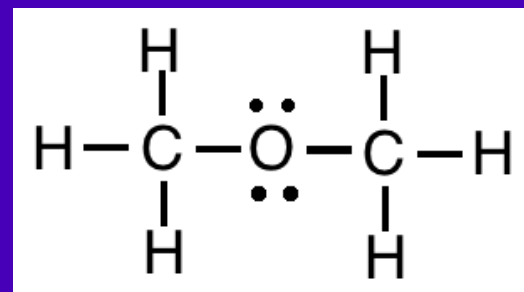
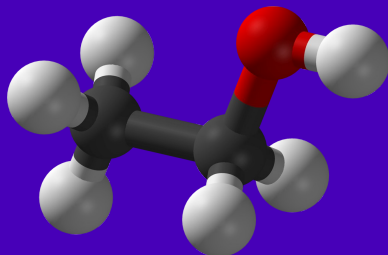
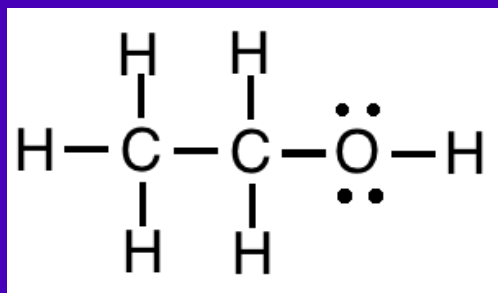
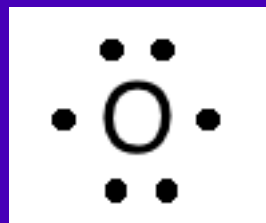
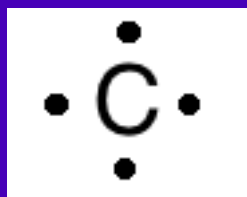
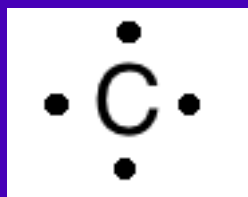
boiling point of butane: **-0.5°C**

boiling point of isobutane: **-11.7°C**



When there are two different molecules that have the same formula, these compounds are called **isomers**.

There are two isomers with the formula C_2H_6O . Can you draw them both?

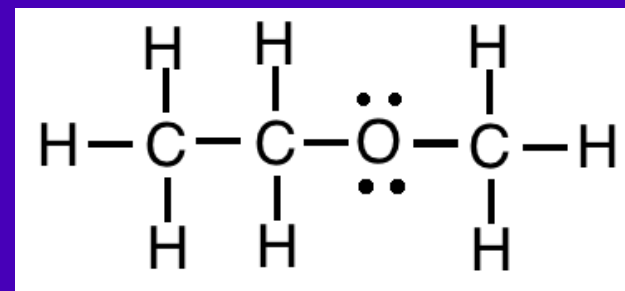
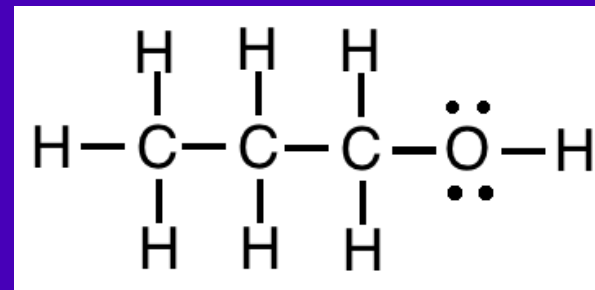
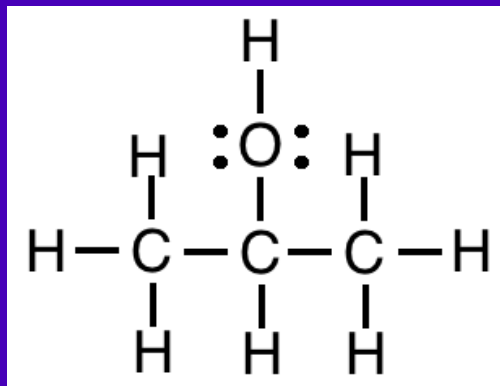
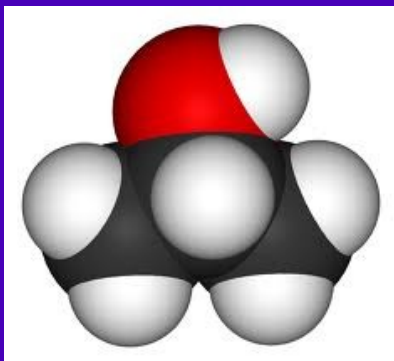


ethanol
alcoholic beverages, fuel
boiling point $78^{\circ}C$

dimethyl ether
fuel, refrigerant, propellant
boiling point $-24^{\circ}C$

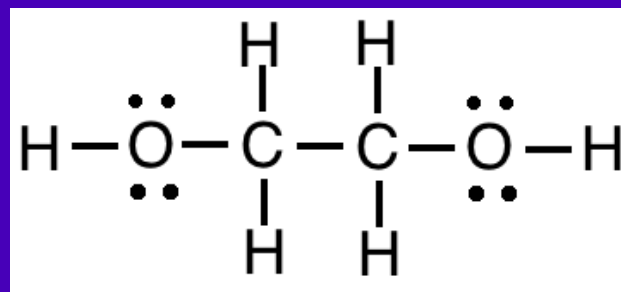
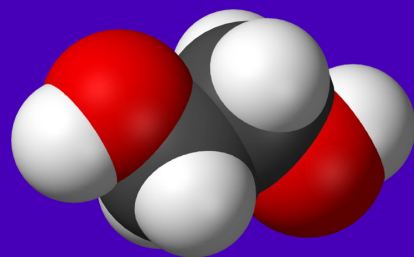


How many isomers does isopropyl alcohol have?



What about ethylene glycol?

3 isomers

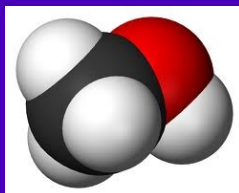
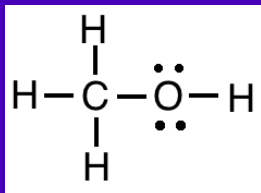


5 isomers

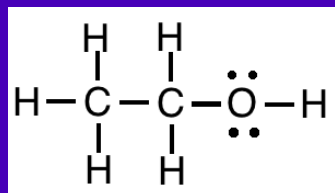
The more atoms you get, the larger the number of possible isomers!

What patterns do you see here?

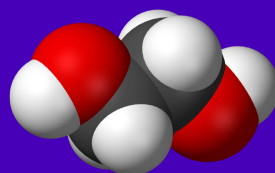
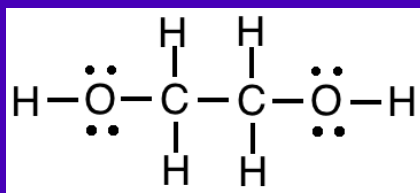
methanol



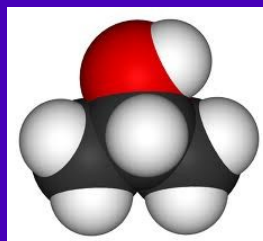
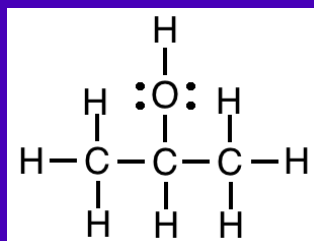
ethanol



ethylene glycol



isopropyl alcohol



Compounds with a C-O-H are called alcohols.

Their names often end in “ol” or “alcohol.”

Patterns like this are called **functional groups**.

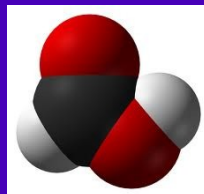
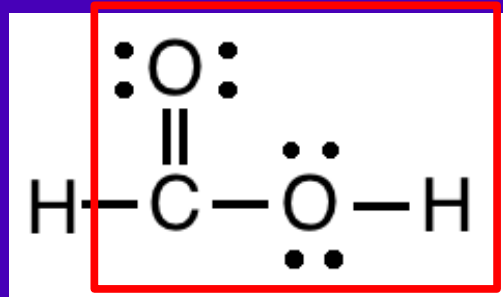
Sucrose contains many C-O-H's.



Another common functional group is the **carboxylic acid**.

Find the common pattern in these two examples:

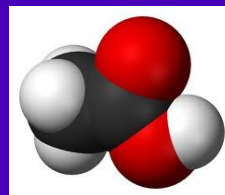
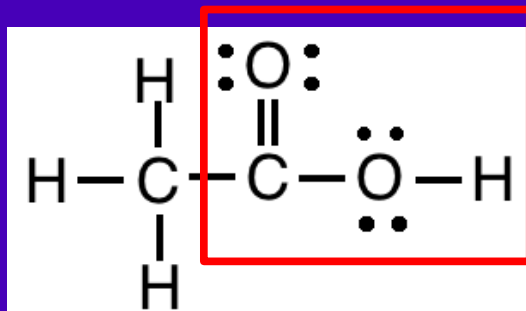
formic acid:



**what red ants inject
when they bite**



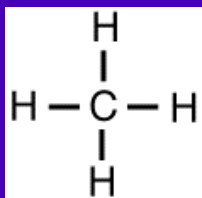
acetic acid:



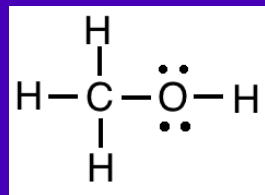
found in vinegar



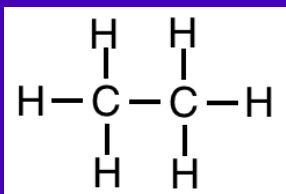
methane



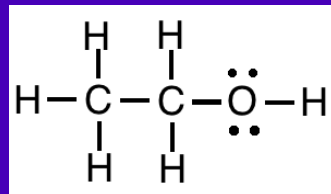
methanol



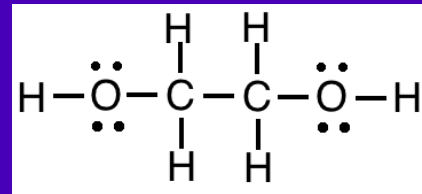
ethane



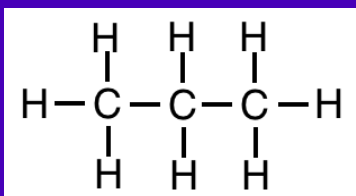
ethanol



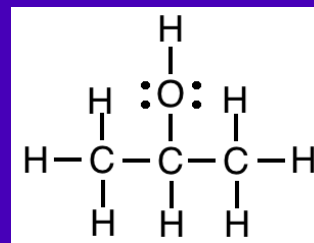
ethylene glycol



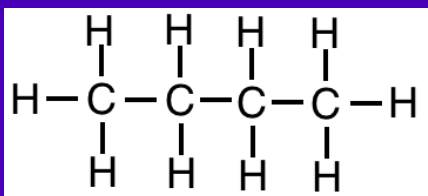
propane



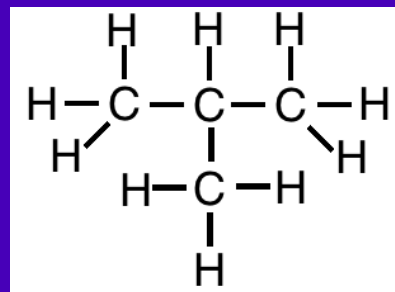
isopropyl alcohol



butane



isobutane



Compounds with one carbon start with “meth”.
Compounds with two carbons start with “eth”.
Compounds with three carbons contain “prop”.
Compounds with four carbon contain “but”.