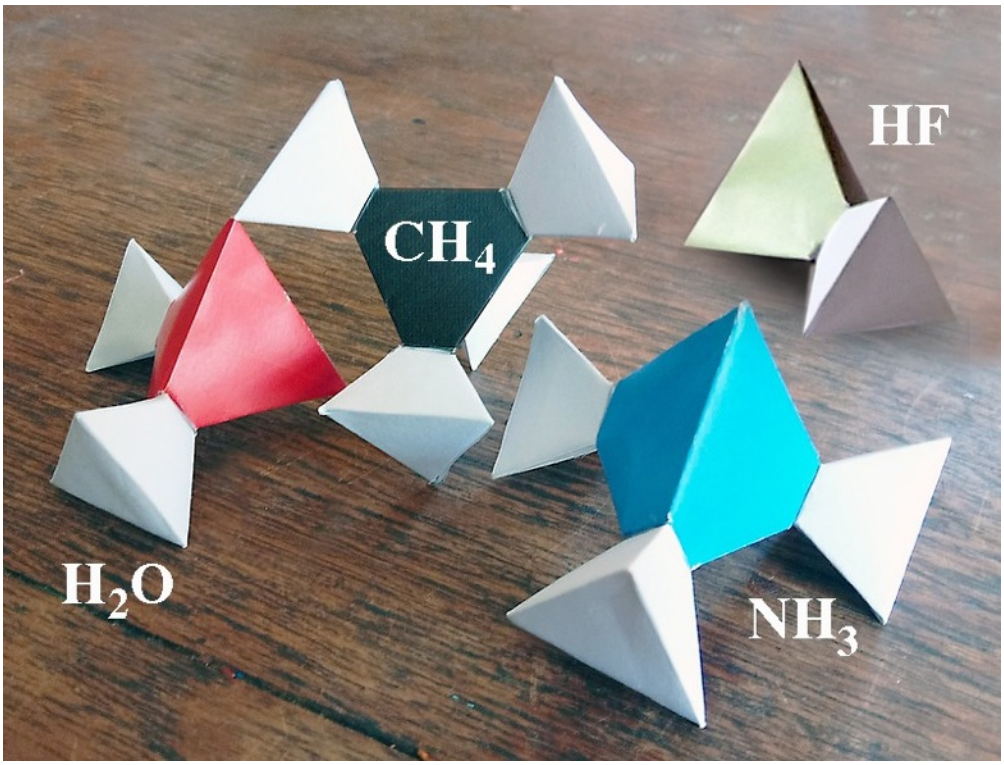
Lewis dot diagrams

Shannon and Ian Jacobs

Four models of molecules that I made with my Dad's nets are shown below.



CH_4 (methane), **NH_3** (ammonia), **H_2O** and **HF** (hydrogen fluoride).

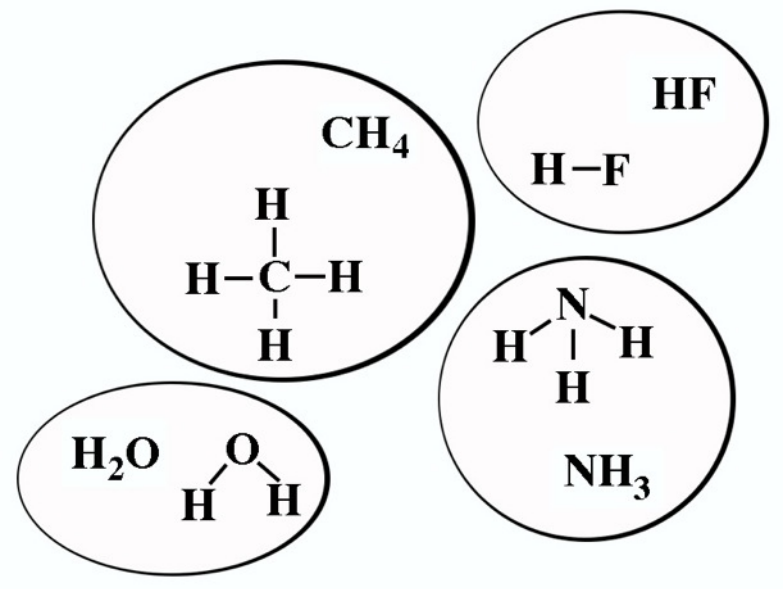
These models are not molecules. They are 3D diagrams, not the real thing. Atoms aren't multicoloured, they are not tetragonal, but they're not spherical either and the models do have bond angles.

The real CH_4 molecule is tetrahedral.

The real H_2O molecule is bent like that.

The real NH_3 molecule is not blue and white, but it does have a ring of three hydrogens a little above or below the centre of mass.

The simplest molecular model is a stick diagram on paper. Stick diagrams don't look like three dimensional molecules, but they do have the right number of atoms.



We make the stick diagrams look as much like the paper models as we can on a flat page.

Lewis dot diagrams

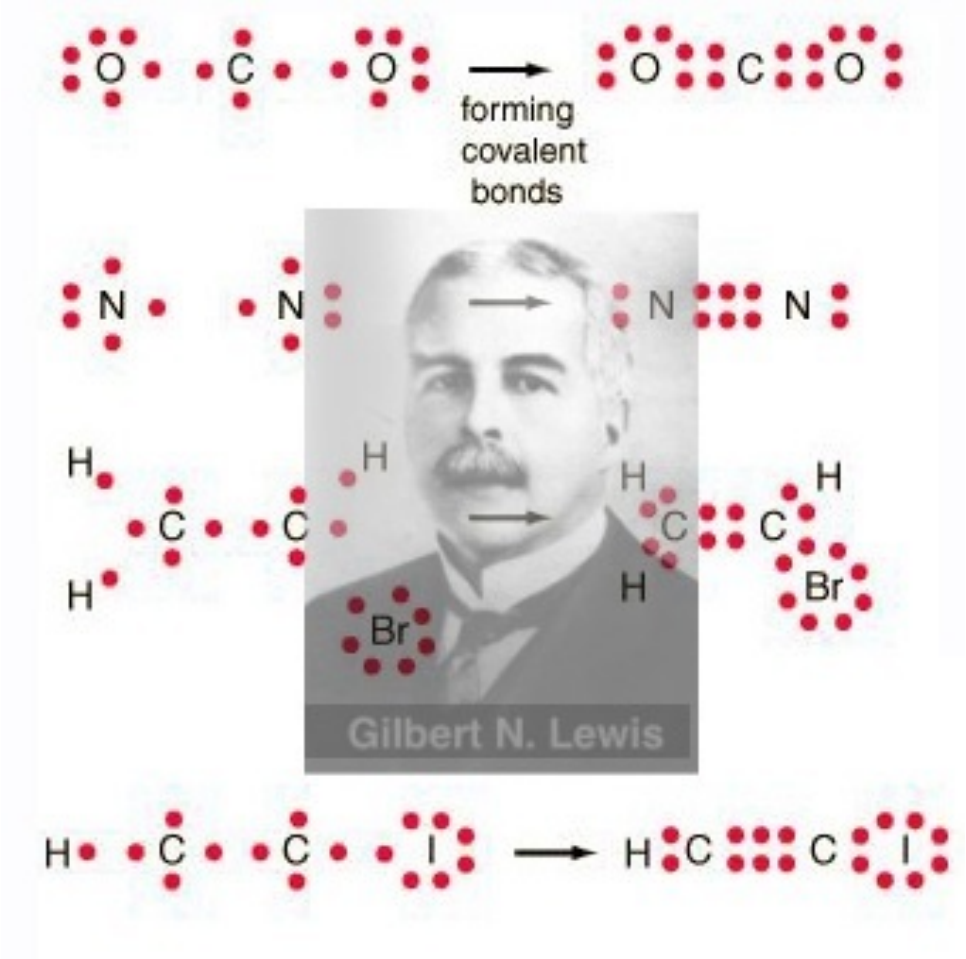
Dad says he knows how to draw these. What he means is that someone told him, then he read about it in books, and after ten years he came to think it was obvious. He says I'm starting on that road: so *pay attention!*

1 *Atoms have a tiny heavy positive nucleus with a set number of positively charged protons. A carbon nucleus has 6 protons, nitrogen has 7, oxygen has 8 and fluorine has 9.*

2 *Atoms have shells of negative electrons around the nucleus. The first shell is full if it has 2 electrons. The next shell is full if it has 8 and the third shell outside that is full if it has 8. After that it gets complicated.*

3 *Atoms of H, C, N, O and F form* ***covalent bonds*** *by sharing electrons in their outer shells to make the numbers up to 2 for hydrogen and 8 for the others.*

Professor Lewis drew diagrams with electrons represented by dots. He called the sharing of electrons between outer shells *covalent bonds*. He died in 1946, (a long time ago), but we still refer to *Lewis dot diagrams*.



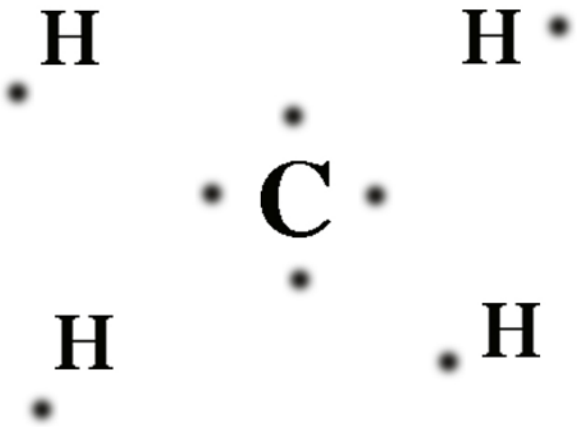
Lewis and his diagrams with electrons shown as dots in shells.

Electrons are not dots or little round balls and they don't whizz around the nucleus like moons around a planet. Electron shells are in fact very strange things with peculiar properties that we still don't directly understand.

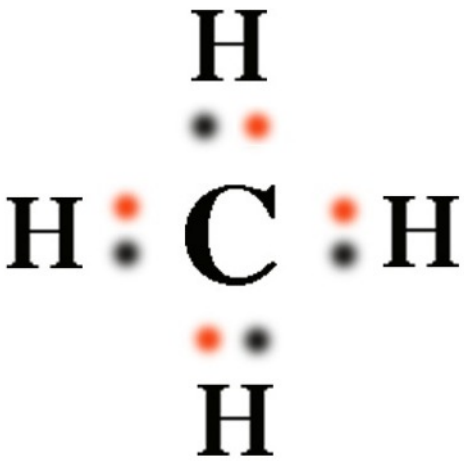
As I realised some time ago, what interests me are the things I don't understand. Everything else is obvious and not worth thinking about in the night.

So we can count electrons we draw dots, and we only draw what are called *valence electrons* in the outer shells. Because it helps to remember where a shared electron came from we will use a little colour coding.

A carbon atom and four separate hydrogen atoms.



The Lewis model of methane: CH_4

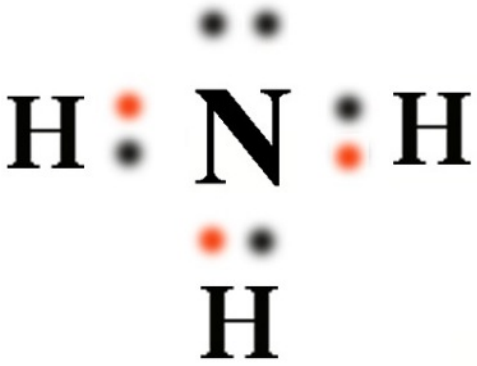


Elections that came from the hydrogen atoms are colour-coded red.

The carbon atom effectively now has eight electrons in the outer shell and each hydrogen has two. The shells are full. We say that the hydrogen atoms have formed single *covalent bonds* with the carbon atom.

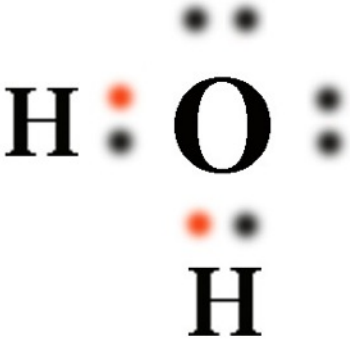
Methane molecules are stable, but they burn in air (oxygen) to form one molecule of carbon dioxide and two of water (see below).

The Lewis model of ammonia: NH_3



The Lewis dot diagram can be drawn in only one way but no information is implied about the bond angles.

The Lewis model of water: H_2O



The diagram for water would be drawn in a straight line but we know from studies over two centuries that water is in fact a bent molecule with positive and negative regions. The paper model for water has a bond angle of 109.5º close to the actual angle of 104º. Because we know that the molecule is bent the Lewis diagram is drawn this way.

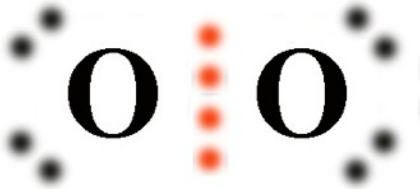
The Lewis model of hydrogen fluoride: HF

Hydrogen fluoride is a simple molecule. The hydrogen shares its single electron into the outer shell of fluorine with 7 electrons to make up the 8 required for stability. Now you know how, you could draw your own Lewis dot diagram for this one.

The Lewis model of hydrogen: H_2

The hydrogen molecule is formed by sharing one electron from each hydrogen to make complete inner shells for both atoms. The shared electrons are colour-coded red. The H-H link is called a *single bond*.

The Lewis model of oxygen: O_2



Oxygen atoms have six electrons in the outer shell. To make up the eight required for stability, two electrons from each atom are shared. The oxygen=oxygen link has two pairs of shared electrons and is called a *double bond*.

The Lewis model of carbon dioxide: CO_2

The carbon dioxide molecule is bonded by sharing two electrons from each oxygen into the half-full outer shell of the carbon atom. The result is an effective eight electrons in the three outer shells of the three atoms. The oxygen=carbon=oxygen links each have two pairs of shared electrons and are called *double bonds*.