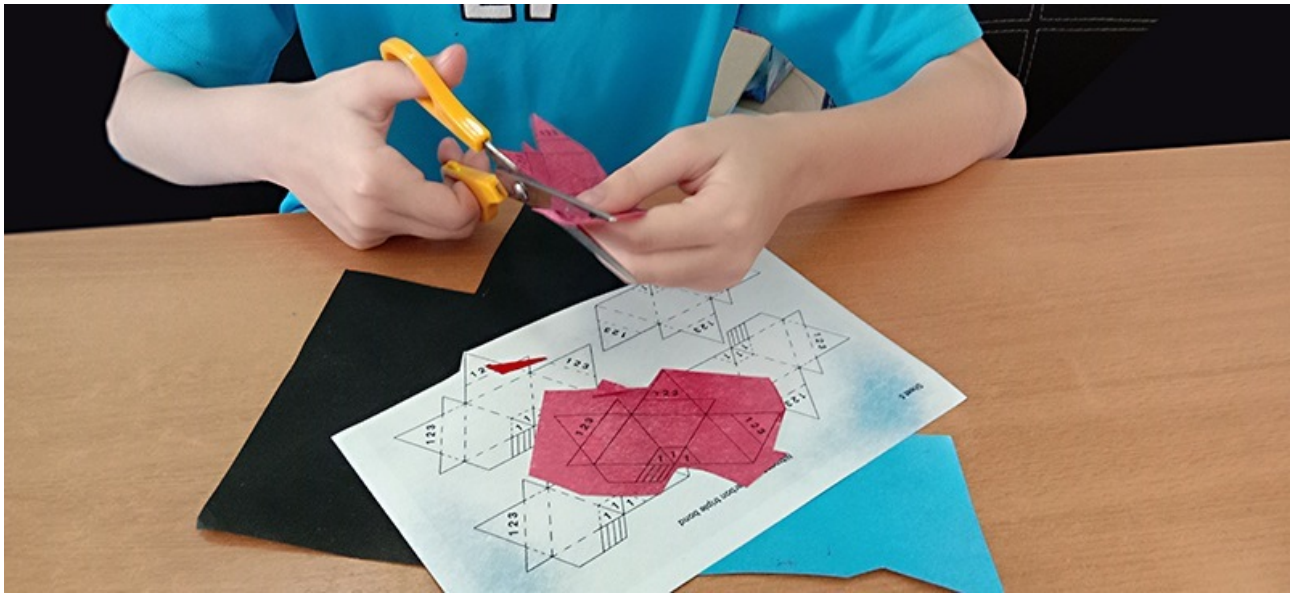
Triple bonds

Shannon and Ian Jacobs

The Lewis dot diagram of N_2 shares three pairs of electrons to give both nitrogens full outer shells of eight. To model this bond with paper the base of a tetrahedron is modified to form a snub point with a larger area than the square face used to model a double bond. A larger area suggests a stronger bond and the bond length is again reduced.

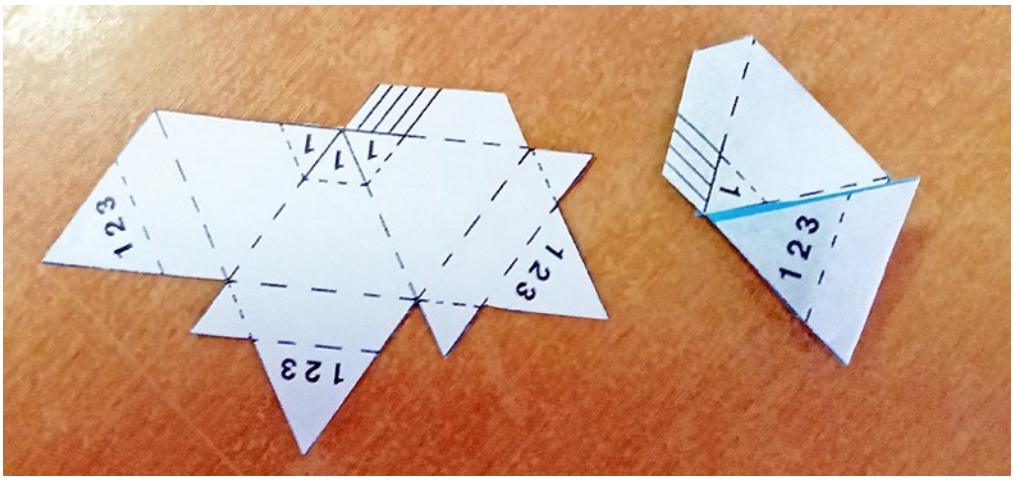
> **Note:** the areas of single, double and triple bond faces are a compromise, taking into account our natural tendency to judge the area of a figure by the length of a side and neglecting the variations in bond energy between elements. On average a double bond has some 50% more bonding energy than a single bond and triple bonds have around twice that of a double bond, but there are variations within the three categories of up to ±20%. As with the size of atoms no attempt is made to model specific bonds. One size fits all.



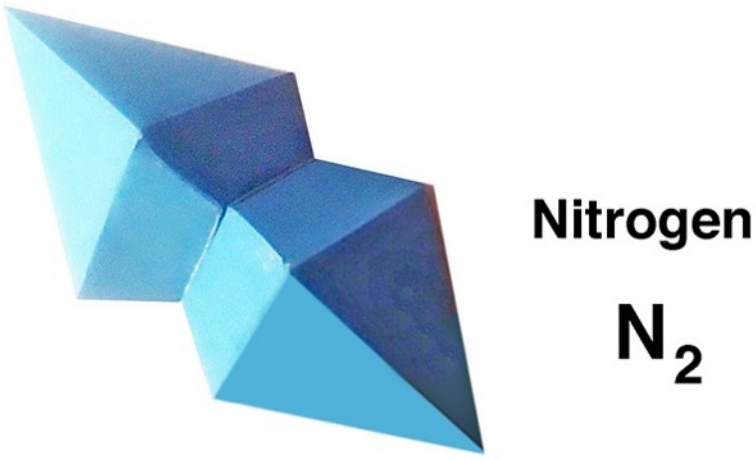
When you're ready to make models of N_2 and CO you can download the triple bond nets linked below. Print the sheet and separate the nets. Spray-paint the paper on the back with black (carbon), blue (nitrogen) and red (oxygen). Cut the red painted net as for nitrogen to make the only known oxygen triple bond that occurs in carbon monoxide.

Nitrogen

The shaded tag is left in place to model nitrogen with five valence electrons, three of which are shared leaving one lone pair.



All tags are first folded down and creased, ensuring that the folds are on the lines and the edges are sharp. The long sides are folded and creased last, being careful to line up the triangle with a dashed line below, as shown. The long tags are folded up, creased again, and glued as before.



The finished model of a nitrogen gas molecule.

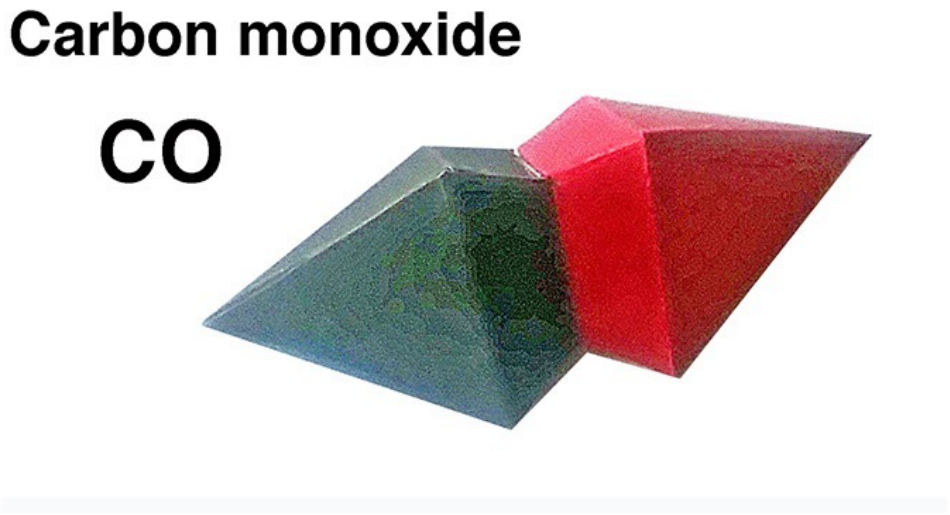
The triple bond nets have one shaded tag that is removed to model carbon atoms in compounds like acetylene C_2H_2.

$$H - C \equiv C - H$$

Carbon monoxide

Carbon has four valence electrons and oxygen has six. If in the process of bonding, one electron is transferred from the oxygen to the carbon, then each atom has five outer electrons and a bond with the electronic structure of the triple bond in N_2 becomes possible.

In this *only known example of oxygen with a triple bond* the molecule is modelled by cutting a red net and a black net as above, *without removing the shaded tag*. The finished model has the size and structure of the nitrogen model with sharp points to model the remaining single pair of electrons in carbon and oxygen outer shells, ten electrons in all. Modelling in this way emphasises the isoelectronic structure of the N_2 and CO molecules.



The carbon monoxide triple bond is the strongest chemical bond known, and 10% stronger than the nitrogen triple bond. Both N_2 and CO are *exceptionally stable*. Nitrogen is not available to plants directly from the atmosphere but enters the food chain naturally from nitrates made by bacteria and the oxides of nitrogen formed in the intense heat of a lightning flash.

Carbon monoxide is not an active poison and is not toxic to most life forms. It is a danger to mammals (us) because the CO molecule bonds to iron centres in haemoglobin much more strongly than oxygen, preventing blood from carrying and distributing oxygen around the body.