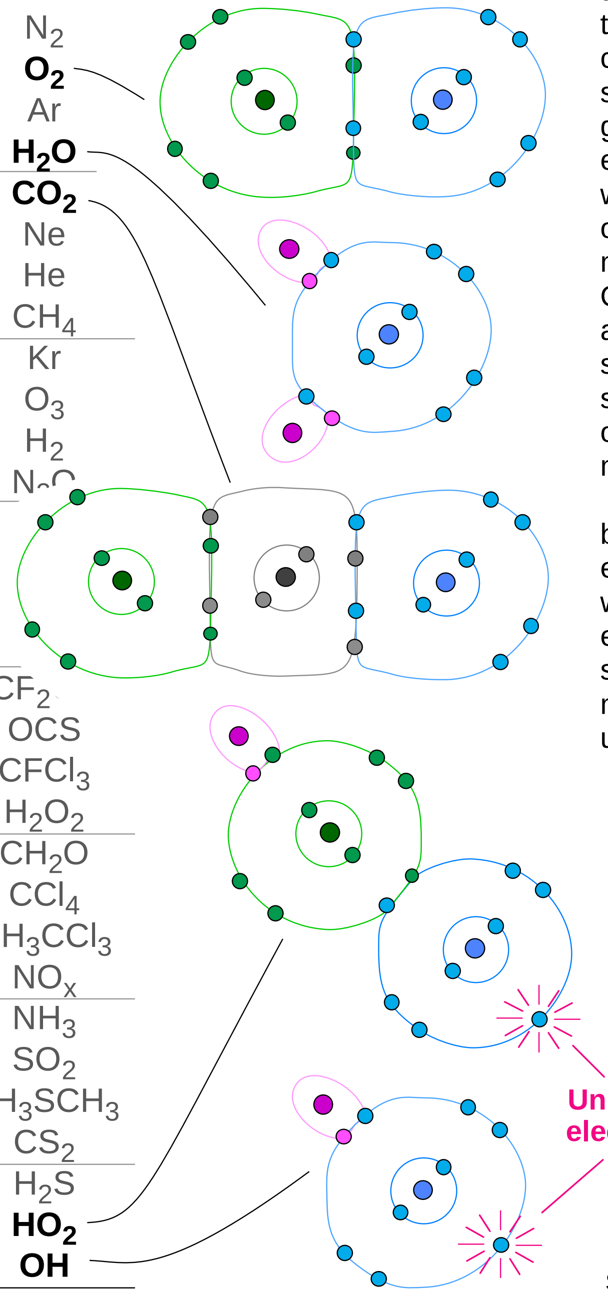
The chemical composition of Earth's atmosphere VII: the O-bearing radicals

Mole %	*Name*	*Chemical formula*
78.084	Nitrogen	N_2
20.948	**Oxygen**	**O_2**
0.934	Argon	Ar
0.004 - 4	**Water vapor**	**H_2O**
0.0385 (385 ppm)	**Carbon dioxide**	**CO_2**
0.001818 (18.18 ppm)	Neon	Ne
0.000524 (5.24 ppm)	Helium	He
0.00017 (1.7 ppm)	Methane	CH_4
0.000114 (1.14 ppm)	Krypton	Kr
0.00005 - 0.0010	Stratospheric ozone	O_3
0.000055 (0.55 ppm)	Hydrogen	H_2
0.000033 (0.33 ppm)	Nitrous oxide	N_2O
0.0000050 - 0.0000200	Carbon monoxide	
0.0000087 (87 ppb)	Xenon	
0.0000010 - 0.0000500	Tropospheric ozone	
0.0000005 - 0.0000020	NMHC	
0.0000000540 (540 ppt)	CFC12	CF_2
0.00000005 (500 ppt)	Carbonyl sulfide	OCS
0.0000000265 (265 ppt)	CFC11	$CFCl_3$
0.00000001 - 0.000001	Hydrogen peroxide	H_2O_2
0.00000001 - 0.0000001	Formaldehyde	CH_2O
0.0000000098 (98 ppt)	Carbon tetrachloride	CCl_4
0.0000000065 (65 ppt)	Methylchloroform	CH_3CCl_3
0.000000001 - 0.0001	Nitrogen oxides	NO_x
0.000000001 - 0.0000001	Ammonia	NH_3
0.000000001 - 0.0000001	Sulfur dioxide	SO_2
0.000000001 - 0.00000001	Dimethyl sulfide	CH_3SCH_3
0.0000000001 - 0.00000003	Carbon disulfide	CS_2
0.0000000005 - 0.00000005	Hydrogen sulfide	H_2S
0.0000000002 (2 ppt)	**Hydroperoxyl radical**	**HO_2**
0.000000000005 (0.05 ppt)	**Hydroxyl radical**	**OH**

Electron-dot diagrams



Elemental oxygen contains eight electrons, two in its inner shell and six in its outer shell. However, that outer shell is most stable if it contains eight electrons, a full outer shell, and thus achieves the noble-gas configuration of neon. In O_2, each atom shares two electrons with its mate, so that each has eight outer-shell electrons, and a stable molecule is achieved. In water, an O atom shares two electrons with H atoms, each of which likewise share an electron with the O atom, so that again the O atom has eight outer-shell electrons and a stable molecule is achieved.

That's not the case with the O-bearing radicals HO_2 and OH. In each, an O atom shares electrons with one hydrogen atom, but in each an O atom is left with just seven outer-shell electrons. That means that those O atoms have an unpaired electron, which is an unstable and highly reactive state. These radicals thus have short residence times and react readily with species able to surrender an electron (i.e., with the not-fully-oxidized species). That has important implications for atmospheric chemistry, as we'll see in our next page in this series.

Sources: see Part I of this series.