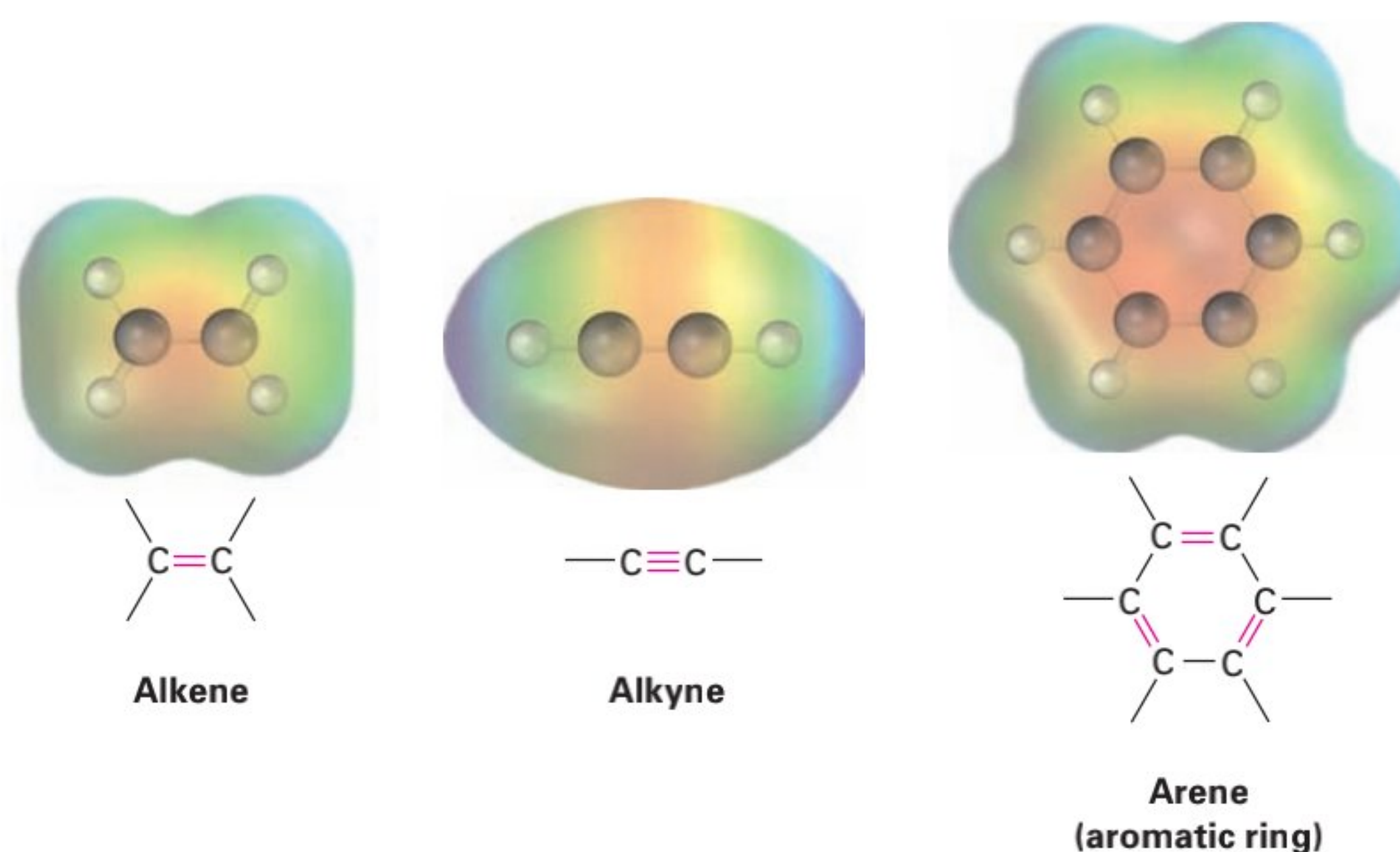


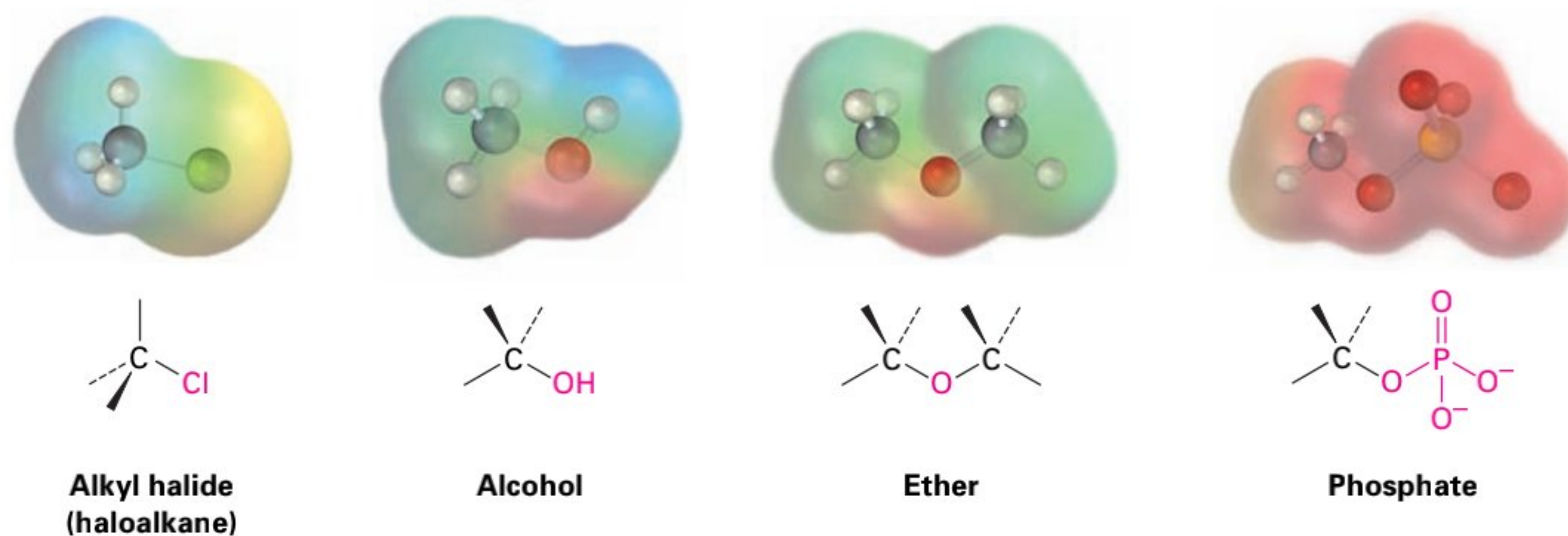
Functional Groups with Carbon–Carbon Multiple Bonds

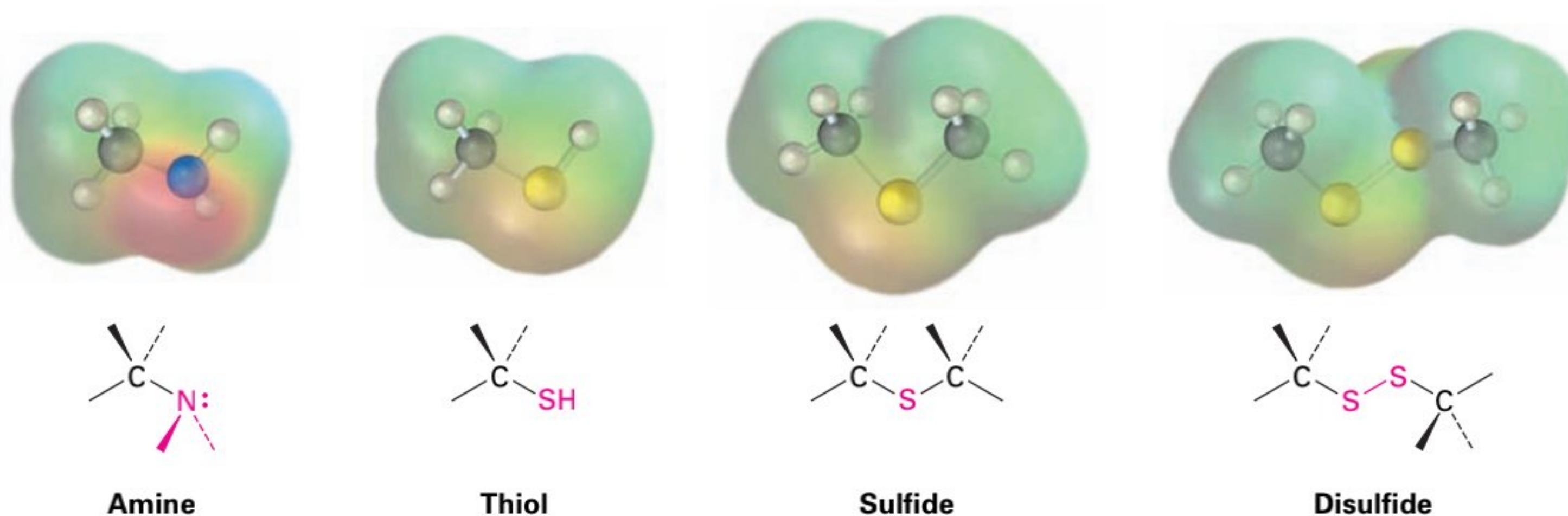
Alkenes, alkynes, and arenes (aromatic compounds) all contain carbon–carbon multiple bonds. *Alkenes* have a double bond, *alkynes* have a triple bond, and *arenes* have alternating double and single bonds in a six-membered ring of carbon atoms. Because of their structural similarities, these compounds also have chemical similarities.



Functional Groups with Carbon Singly Bonded to an Electronegative Atom

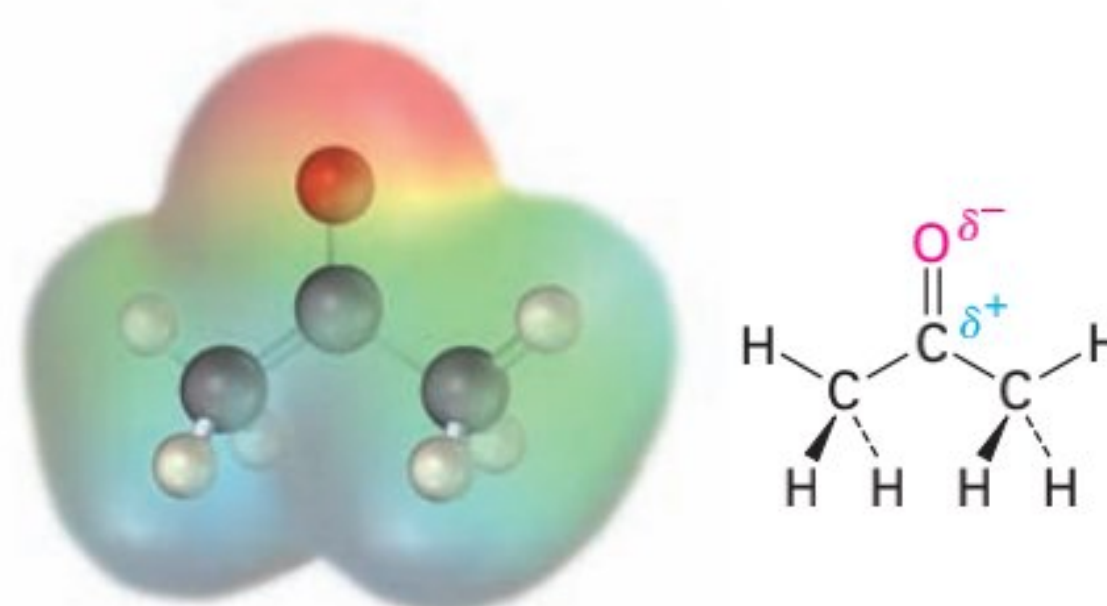
Alkyl halides (haloalkanes), alcohols, ethers, alkyl phosphates, amines, thiols, sulfides, and disulfides all have a carbon atom singly bonded to an electronegative atom—halogen, oxygen, nitrogen, or sulfur. Alkyl halides have a carbon atom bonded to halogen (–X), alcohols have a carbon atom bonded to the oxygen of a hydroxyl group (–OH), ethers have two carbon atoms bonded to the same oxygen, organophosphates have a carbon atom bonded to the oxygen of a phosphate group (–OPO₃^{2–}), amines have a carbon atom bonded to a nitrogen, thiols have a carbon atom bonded to the sulfur of an –SH group, sulfides have two carbon atoms bonded to the same sulfur, and disulfides have carbon atoms bonded to two sulfurs that are joined together. In all cases, the bonds are polar, with the carbon atom bearing a partial positive charge (δ+) and the electronegative atom bearing a partial negative charge (δ–).





Functional Groups with a Carbon–Oxygen Double Bond (Carbonyl Groups)

The *carbonyl group*, $\text{C}=\text{O}$ (pronounced car-bo-**neel**) is common to many of the families listed in Table 2.1. Carbonyl groups are present in the great majority of organic compounds and in practically all biological molecules. These compounds behave similarly in many respects but differ depending on the identity of the atoms bonded to the carbonyl-group carbon. Aldehydes have at least one hydrogen bonded to the $\text{C}=\text{O}$, ketones have two carbons bonded to the $\text{C}=\text{O}$, carboxylic acids have one carbon and one $-\text{OH}$ group bonded to the $\text{C}=\text{O}$, esters have one carbon and one ether-like oxygen bonded to the $\text{C}=\text{O}$, amides have one carbon and one nitrogen bonded to the $\text{C}=\text{O}$, acid chlorides have one carbon and one chlorine bonded to the $\text{C}=\text{O}$, and so on. The carbonyl carbon atom bears a partial positive charge (δ^+), and the oxygen bears a partial negative charge (δ^-).



Acetone—a typical carbonyl compound

