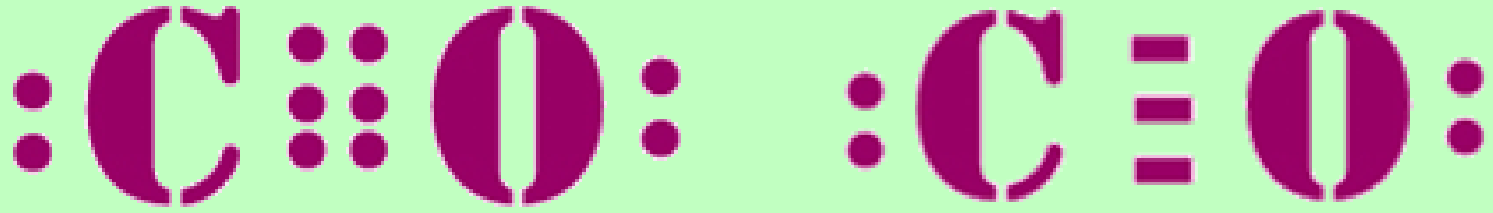
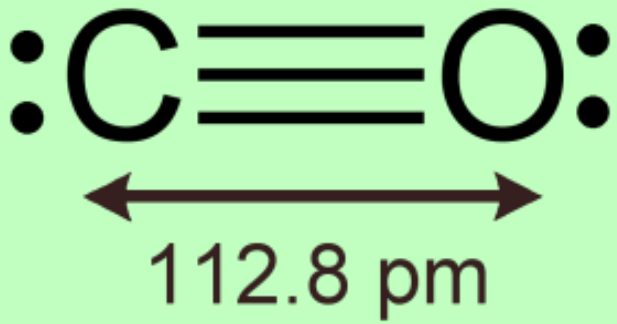
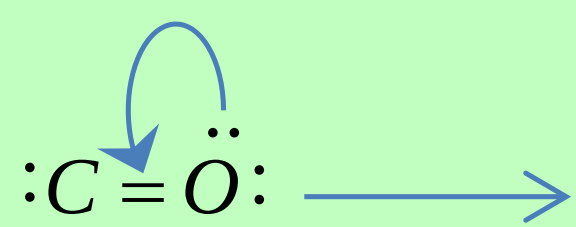
High Level Chemistry

Draw the Lewis structure for carbon monoxide.



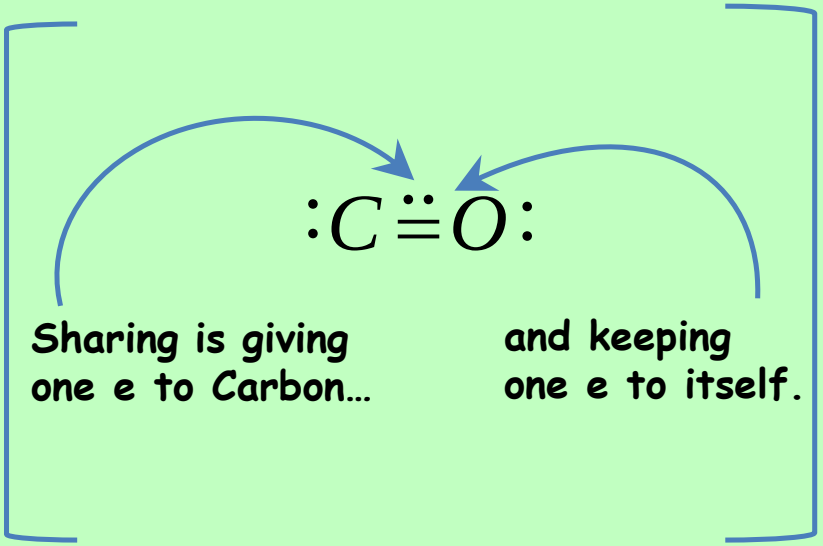


Explain the mechanism to draw the Lewis structure for carbon monoxide.

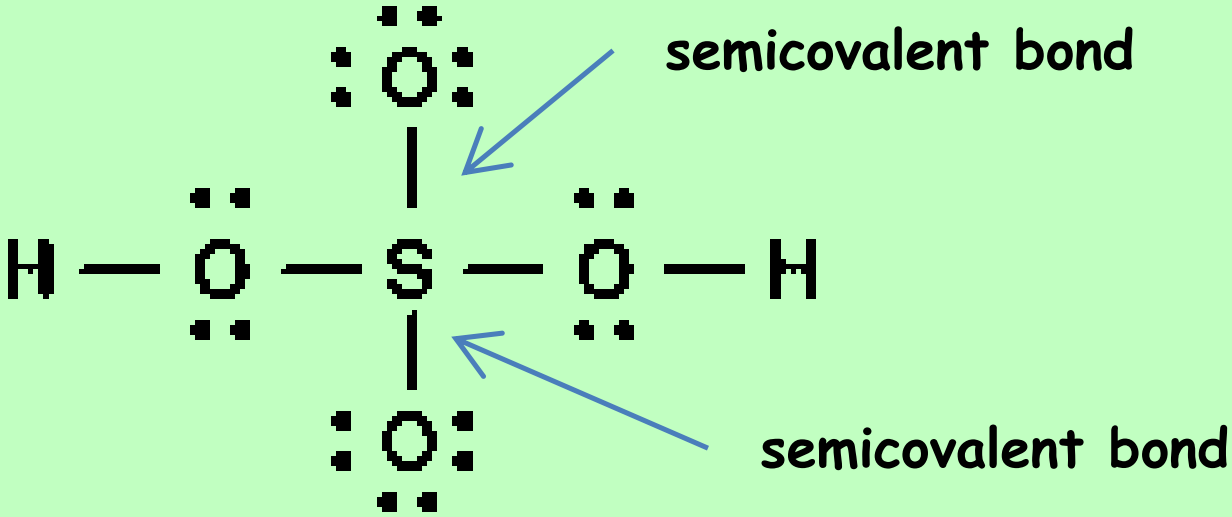


Oxygen donates an elecron pair to Carbon.

Oxygen shares an elecron pair with Carbon.



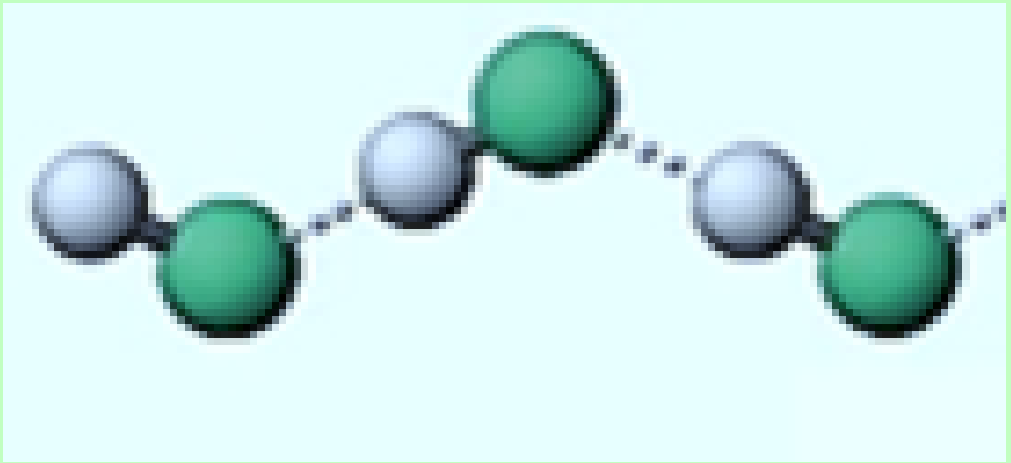
How many semicovalent bonds are there in sulfuric acid molecule? Draw the Lewis structure of sulfuric acid. (2)

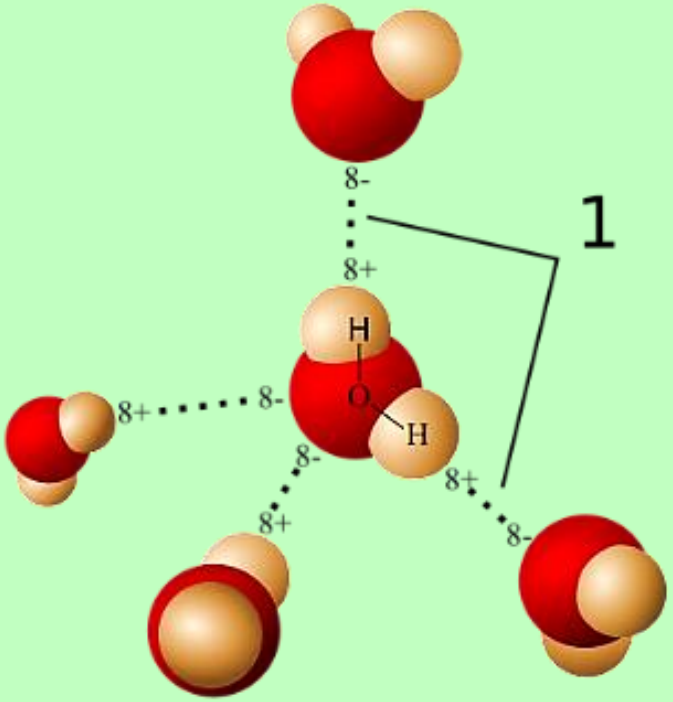


H_2SO_4

Explain why the boiling point of H_2O is much higher than that of HF.

Each molecule of HF forms H-bonds by contributing at the most with two other molecules of HF, but each H_2O molecule forms H-bonds by using its two Hydrogen atoms and the two non-bonding electrons of its oxygen atom, thus it's surrounded with four other water molecules.





Define the term dielectric constant.

The dielectric constant measures the ability of a solvent to separate oppositely charged ions.

Additional information

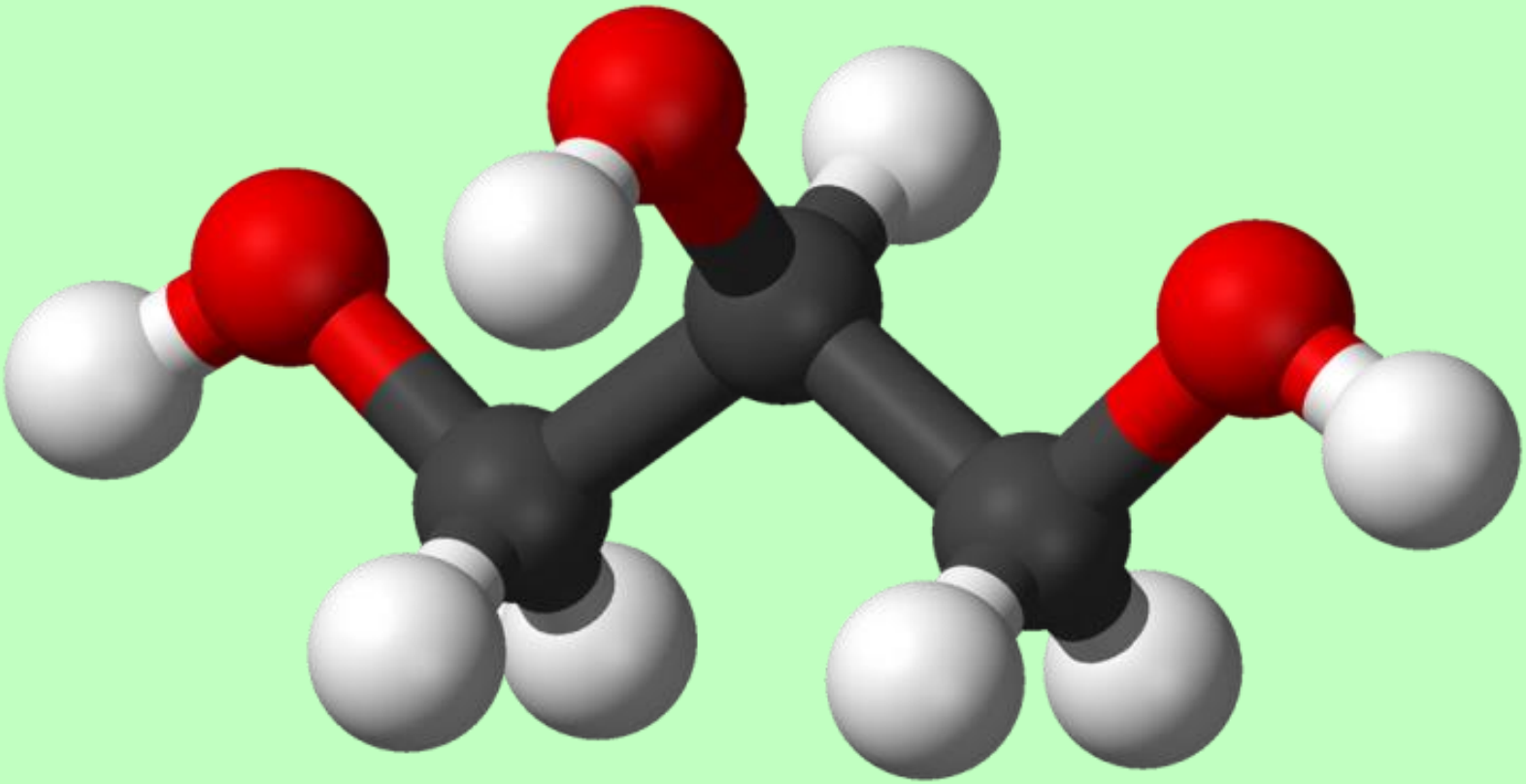
Solvents with high dielectric constants tend to be more polar.

How is dielectric constant related to the ability of a solvent to dissolve an ionic solute.

Solvents with high dielectric constants tend to be more polar, so they may have the ability to dissolve an ionic solute. A good solvent for an ionic solute (i.e. for a salt) not only should have a high dielectric constant, but should be able to H-bond to the anion as well.

Explain why glycerol, $CH_2OHCHOHCH_2OH$ is a very viscous liquid.

Glycerol molecules with three OH groups, form hydrogen bonds with each other in long chains with many interlocking crosslinkages.



What is viscosity of a liquid?

Viscosity of a liquid is a measure of its inability to flow, and this is measured in $N \cdot s \cdot m^{-2}$ (SI Units) or *poise* (P) or centipoise (cP).

1 P = 0.1 N s m^{-2}

1 cP = 0.001 N s m^{-2}

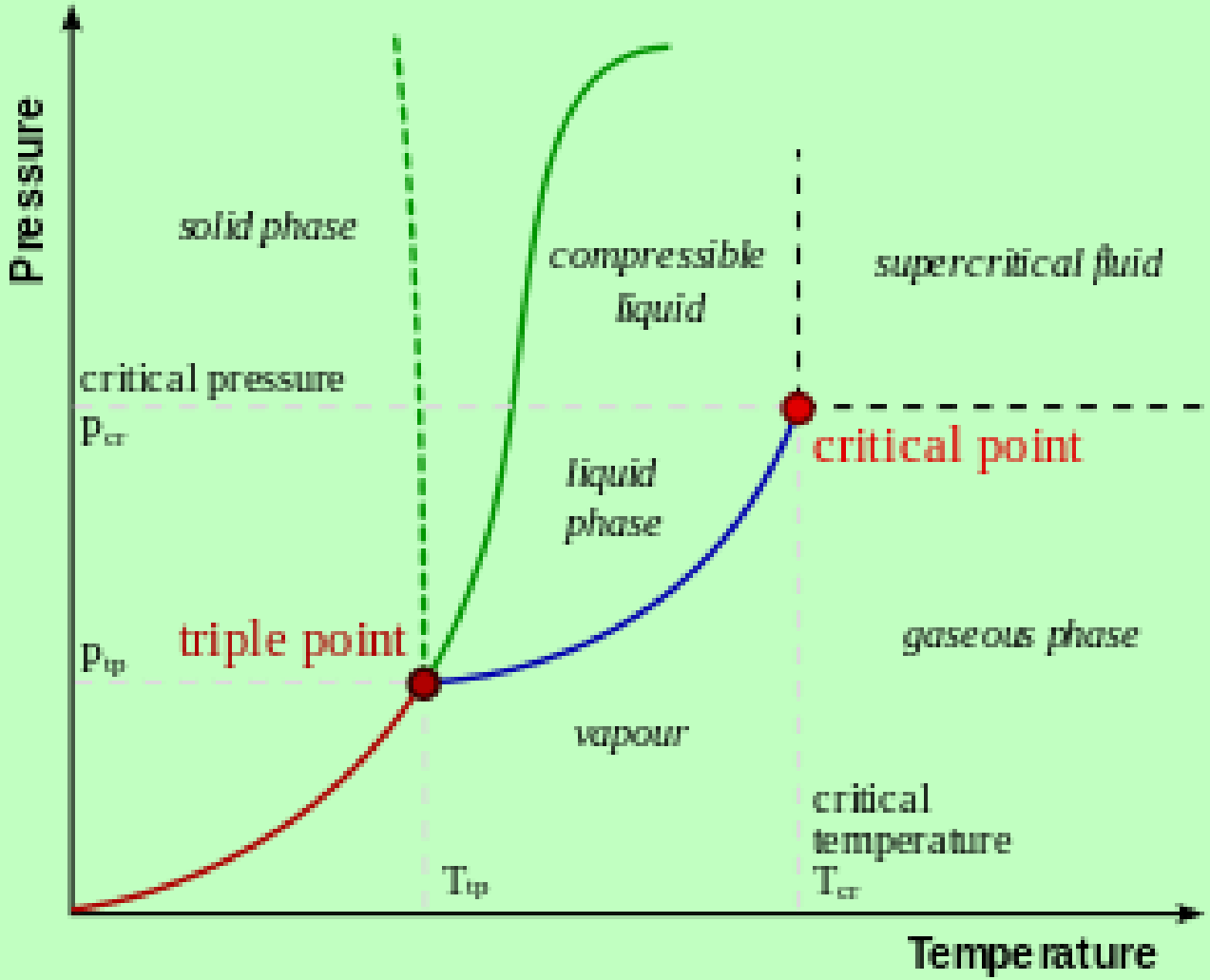
Describe capillary action.

When a small tube is dipped into a liquid, the level in the tube is usually higher or lower than that of the bulk liquid. If adhesion force between the tube material and the liquid is stronger than the cohesion force, the level is higher. Otherwise, the level is lower. Such phenomena are called capillary action. Capillary action is one of the factors responsible for transport of liquid and nutrients in plants, and sometimes in animals. Next time when you dip a straw into your drink, watch the levels and explain the phenomenon.
Capillary action is often a topic of study in grade schools, and this link connects you with this action in everyday life.

A drop of water is placed in a large flask which is under vacuum. Water soon evaporates. Why does this happen?

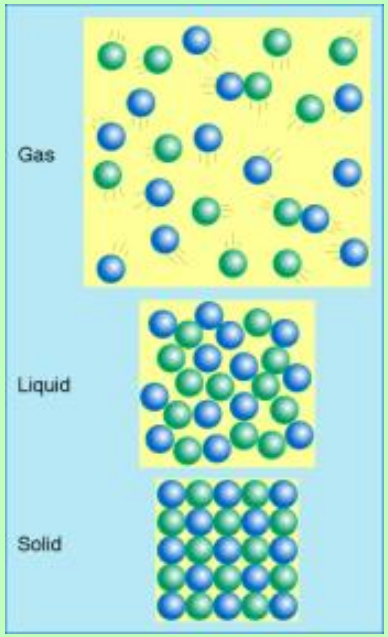
At low pressure gas is the stable phase.

Draw a phase diagram and indicate with a dotted line the abnormal behavior of water.



In which physical state do molecules possess the highest kinetic energy?

In the Gas state.



Additional information

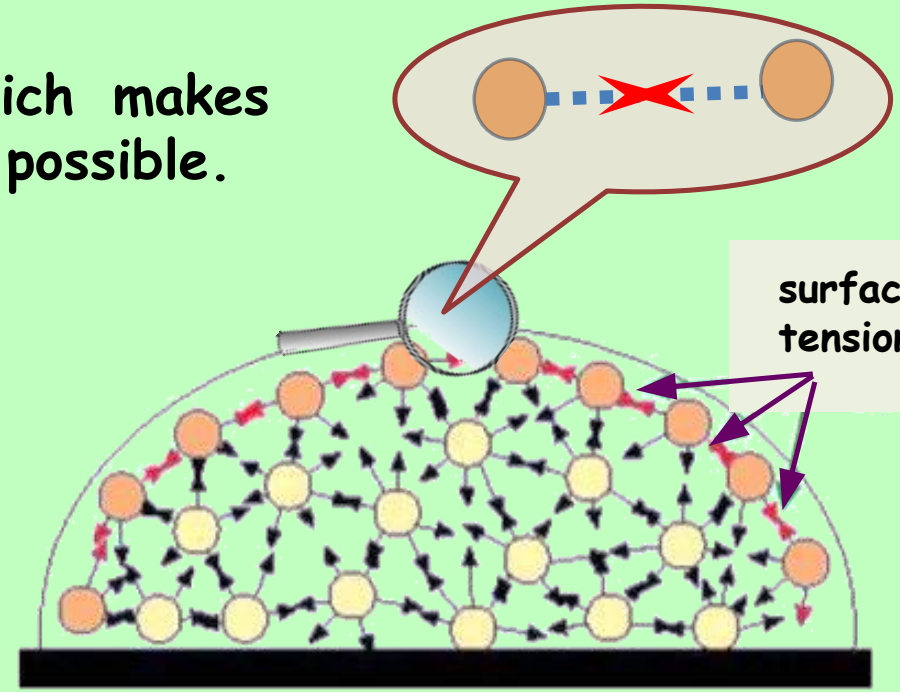
Molecules in the solid state possess only vibrational and rotational kinetic energy, not translational kinetic energy.

How does viscosity of water change as the temperature increases?

Decreases

What is surface tension?

The elastic tendency of liquids which makes them acquire the least surface area possible.

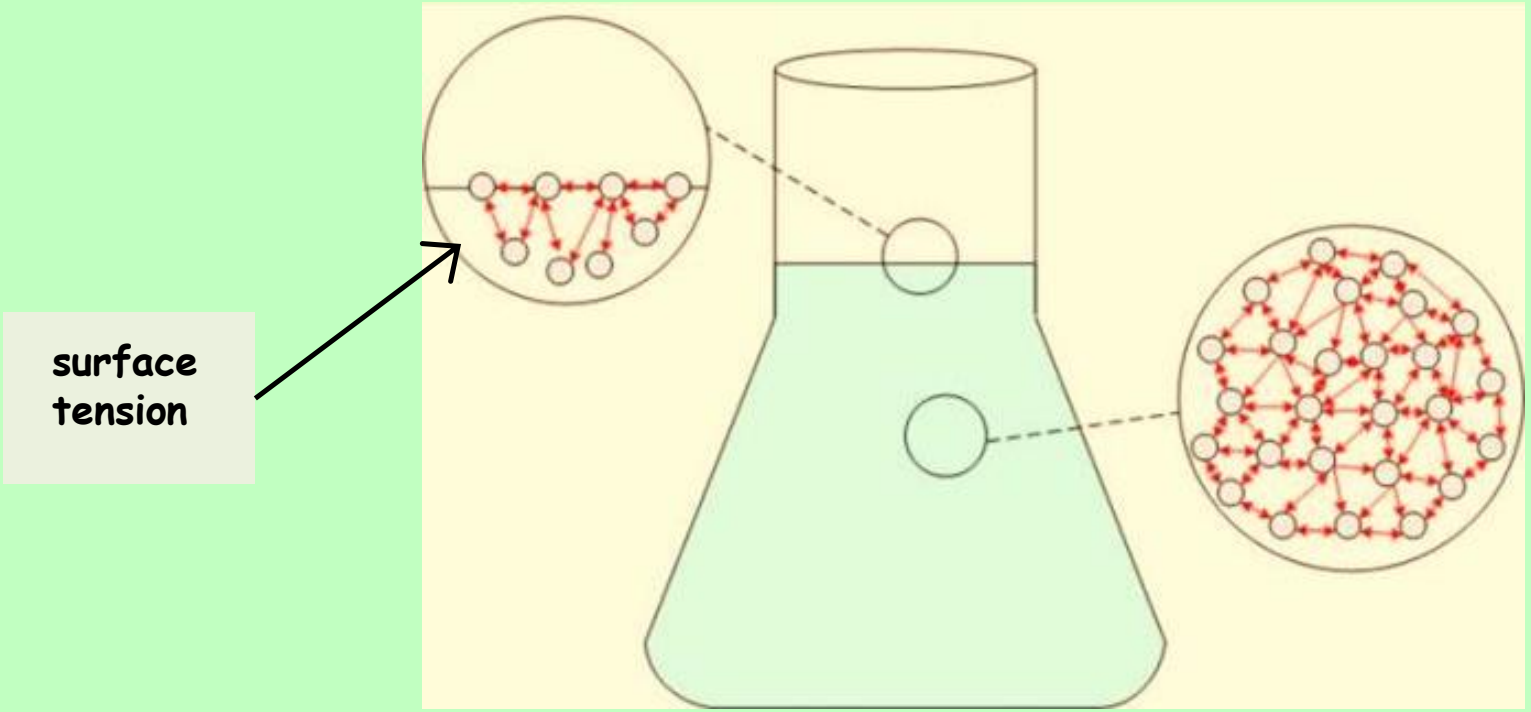


Additional information

Surface tension is an important property that markedly influences many ecosystems. It is exposed, for example, any time an insect (e.g. water striders) or an object that is denser than water is able to float or run along the water surface. It has the dimension of force per unit length, or of energy per unit area. The two are equivalent—but when referring to energy per unit of area, people use the term surface energy—which is a more general term in the sense that it applies also to solids and not just liquids. In materials science, surface tension is used for either surface stress or surface free energy.

Draw a figure to explain the surface tension on the surface of a liquid.

Particles in the bulk of the liquid are pulled in all directions by intermolecular forces. Particles on the surface are pulled from below but not from above. This unbalanced force is the surface tension.

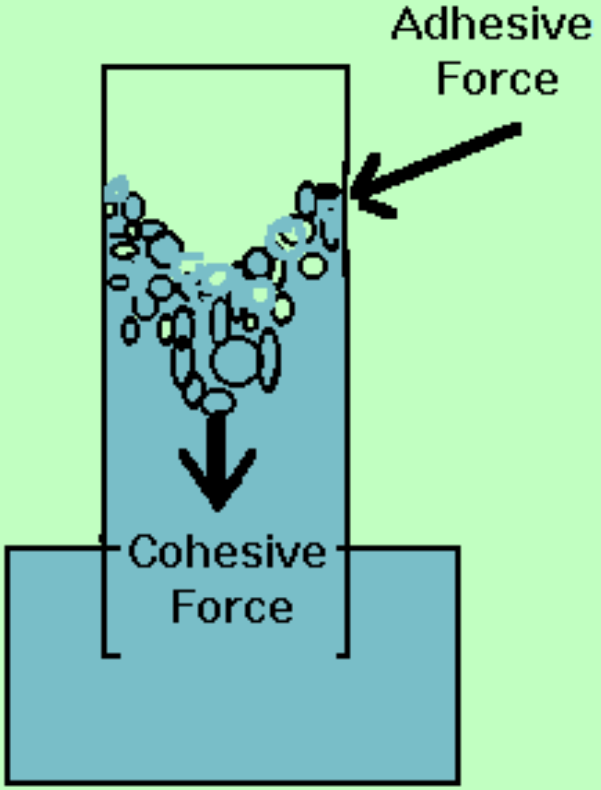


What are Cohesive Forces?

Cohesive forces are the intermolecular forces (such as those from hydrogen bonding and Van der Waals forces) which cause a tendency in liquids to resist separation. These attractive forces exist between molecules of the *same* substance.

Additional information

For instance, rain falls in droplets, rather than a fine mist, because water has strong cohesion which pulls its molecules tightly together, forming droplets. This force tends to unite molecules of a liquid, gathering them into relatively large clusters due to the molecules' dislike for its surrounding.

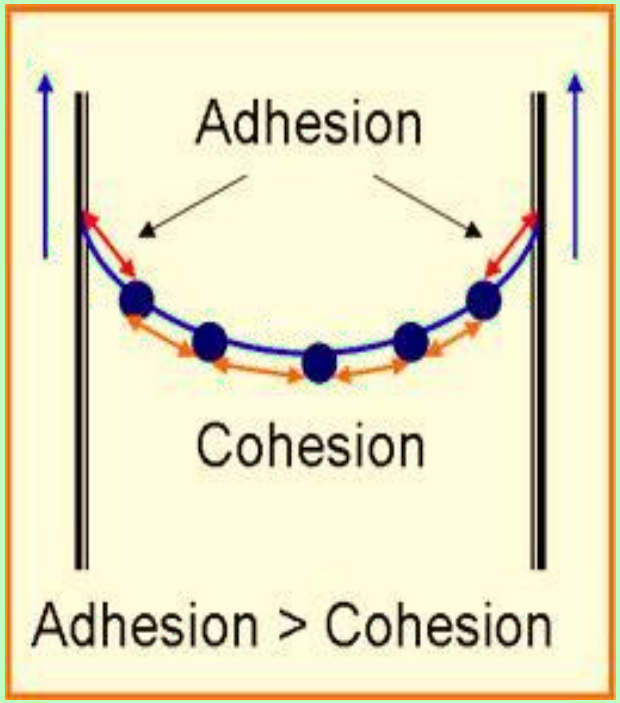


What are Adhesive Forces?

Adhesive forces are the attractive forces between unlike molecules. They are caused by forces acting between two substances, such as mechanical forces (sticking together) and electrostatic forces (attraction due to opposing charges).

Additional information

In the case of a liquid wetting agent, adhesion causes the liquid to cling to the surface on which it rests. When water is poured on clean glass, it tends to spread, forming a thin, uniform film over the glasses surface. This is because the adhesive forces between water and glass are strong enough to pull the water molecules out of their spherical formation and hold them against the surface of the glass, thus avoiding the repulsion between like molecules.



In a glass graduated cylinder, water presents a upwardly concaved meniscus. However, when water is filled to the tip of the cylinder, the water level could maintain higher than the wall of the cylinder without pouring out resembling a concave down meniscus. Use the principles of cohesive and adhesive forces to explain this situation.

Since water forms a concave up meniscus, the adhesion of the molecules to the glass is stronger than the cohesion among the molecules. However, in the absence of the adhesive force (when water reaches the tip of the glass), the cohesive force remains present. Thus cohesive force alone proves that it can still hold itself in place without pour in out of the cylinder. This example emphasizes the importance of that cohesive force and adhesive force does not simply cancel each other out yet it is the difference between the two that determines the characteristic of the liquid.

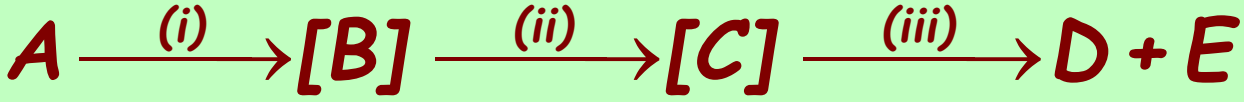
What is a reaction mechanism?

A reaction mechanism provides a detailed step by step description of a reaction.

How does a reaction mechanism differ from a balanced chemical equation?

A balanced equation provides the number of moles of both reactants and products. A reaction mechanism provides a detailed step by step description of a reaction.

What information is provided by a reaction mechanism?
It is given the diagram:



The information is the following:

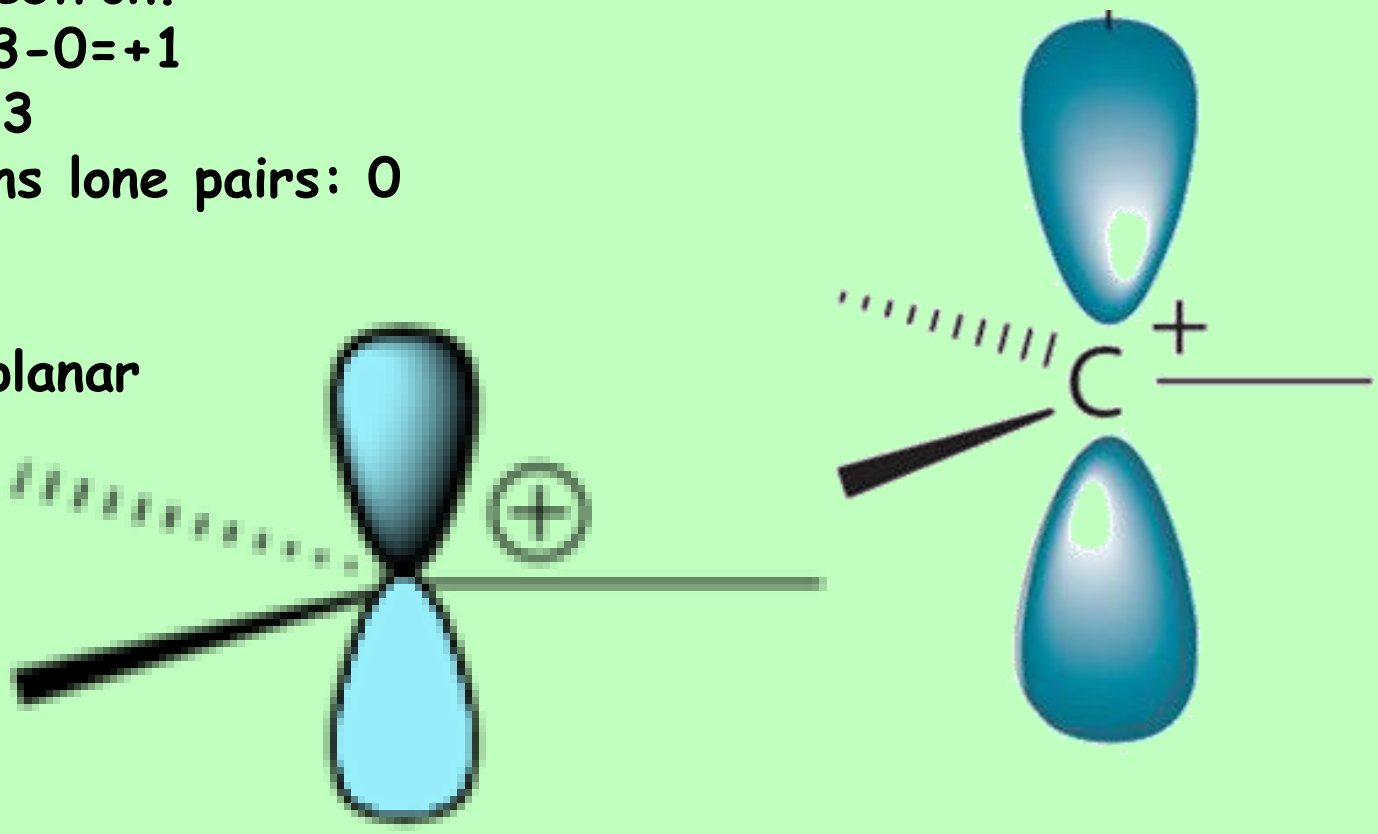
1. The bonds broken and formed.
2. The discrete steps in the conversion of reactant (substrate) A to products D and E which may proceed through several steps (i), (ii) and (iii), as it is shown in the given diagram.
3. The reaction intermediates [B] and [C], which are formed during the intermediate steps.
4. The relative rates of the discrete steps, especially the slowest one.

Additional information

Once an intermediate is formed it must react further. If only some of it did, the balance would accumulate and become a product.

For the reactive carbon intermediate carbocation, draw its simplified structure, calculate its formal charge, find its number of bonds, number of electrons lone pairs, number of hybridized orbitals (HON), type of hybridization (HO's) and its shape.

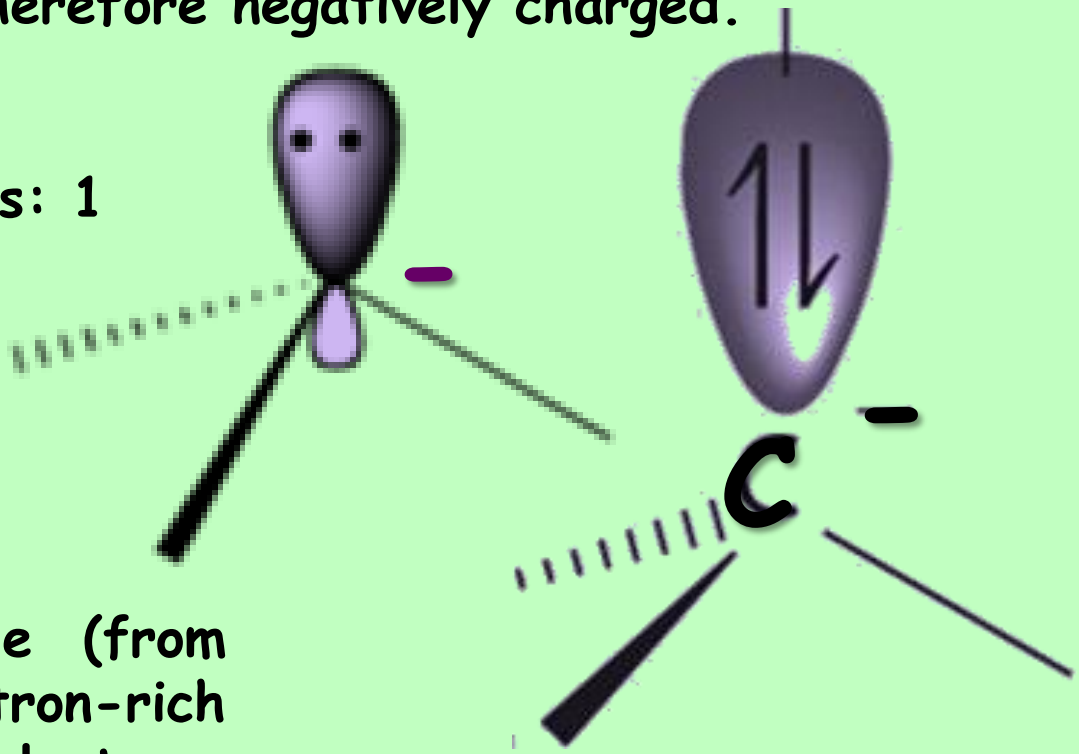
A carbocation contains a carbon atom with a positive charge because it is missing one electron.
Formal charge: 4-3-0=+1
Number of bonds: 3
Number of electrons lone pairs: 0
HON's used: 3
HO's: sp^2
Shape: trigonal coplanar



For the reactive carbon intermediate carbanion, draw its simplified structure, calculate its formal charge, find its number of bonds, number of electrons lone pairs, number of hybridized orbitals (HON), type of hybridization (HO's) and its shape.

A carbanion contains a carbon atom that has one more electron than normal and is therefore negatively charged.

Formal charge: 4-3-2=-1
Number of bonds: 3
Number of electrons lone pairs: 1
HON's used: 4
HO's: sp^3
Shape: pyramidal

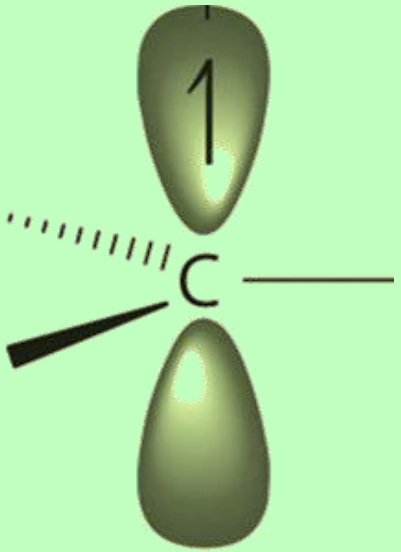


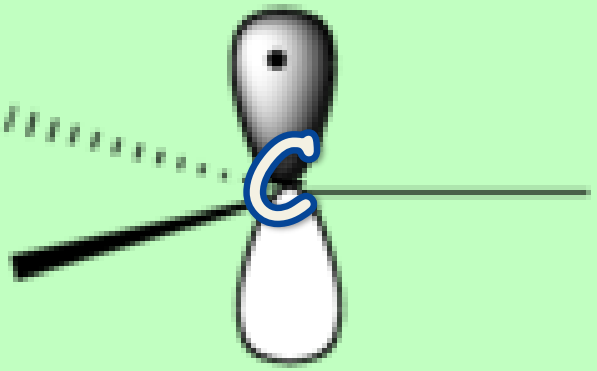
Additional information

A carbanion is a nucleophile (from "nucleus" and *phile*), an electron-rich species that has a pair of electrons available to share with another atom.

For the reactive carbon intermediate radical, draw its simplified structure, calculate its formal charge, find its number of bonds, number of electrons lone pairs, number of hybridized orbitals (HON), type of hybridization (HO's) and its shape.

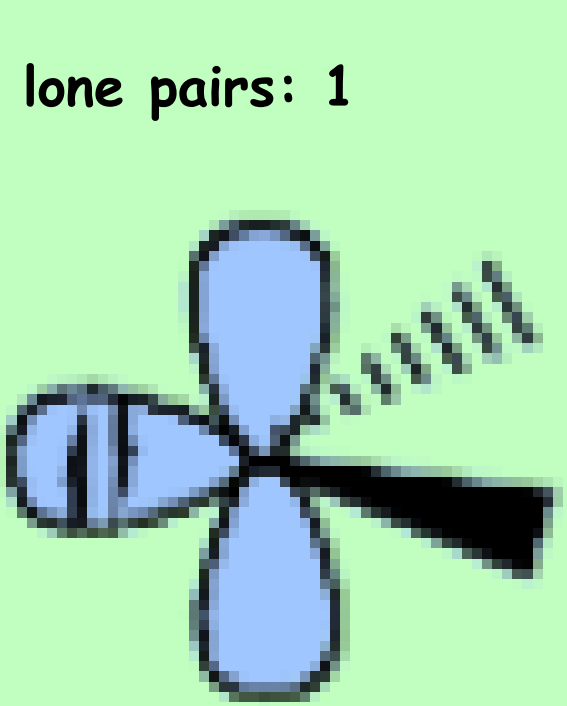
Formal charge: 4-3-1=0
Number of bonds: 3
Number of electrons lone pairs: 0
HON's used: 3
HO's: sp^2
Shape: trigonal coplanar

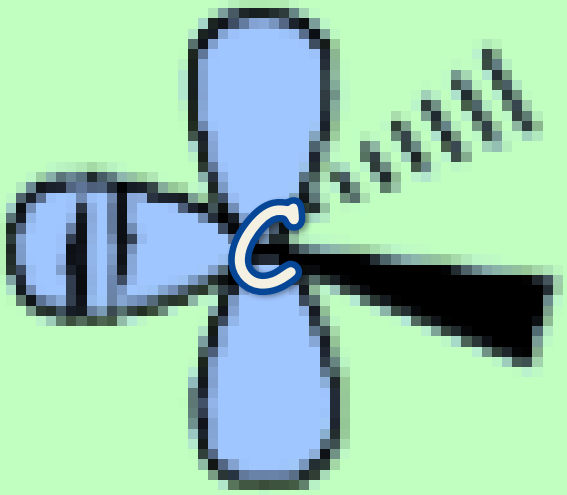




For the reactive carbon intermediate singlet carbene, draw its simplified structure, calculate its formal charge, find its number of bonds, number of electrons lone pairs, number of hybridized orbitals (HON), type of hybridization (HO's) and its shape.

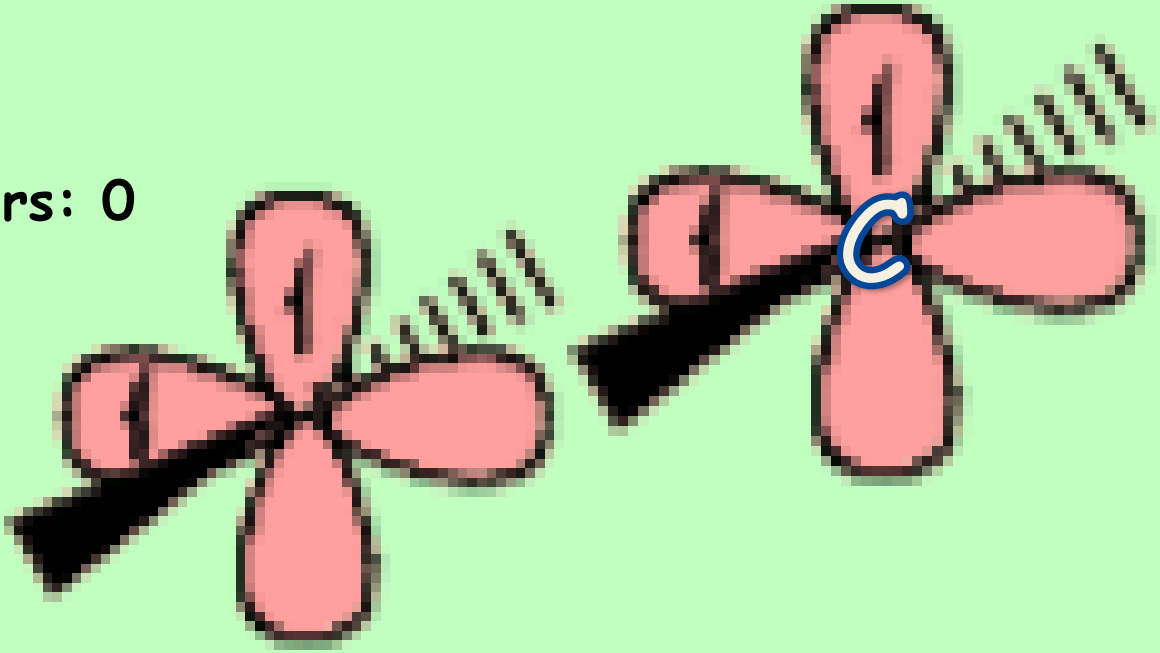
A singlet carbene contains a carbon atom without charge.
Formal charge: 4-2-2=0
Number of bonds: 2
Number of electrons lone pairs: 1
HON's used: 3
HO's: sp^2
Shape: bent





For the reactive carbon intermediate triplet carbene, draw its simplified structure, calculate its formal charge, find its number of bonds, number of electrons lone pairs, number of hybridized orbitals (HON), type of hybridization (HO's) and its shape.

Formal charge: 4-2-2=0
Number of bonds: 2
Number of electrons lone pairs: 0
HON's used: 2
HO's: sp
Shape: linear

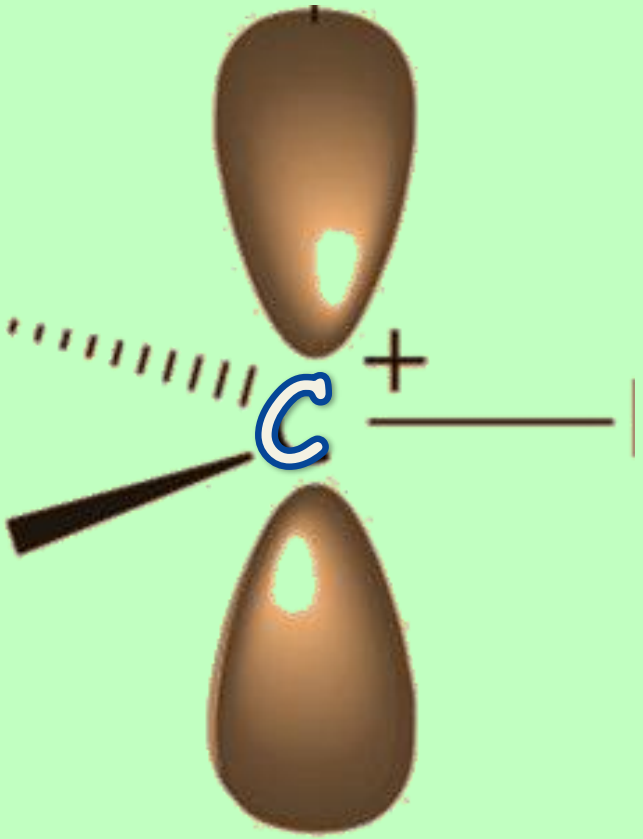


Additional information

Triplet carbenes have two unpaired electrons. Most carbenes have a nonlinear triplet ground state, except for those with nitrogen, oxygen, or sulfur atoms, and halides directly bonded to the divalent carbon.

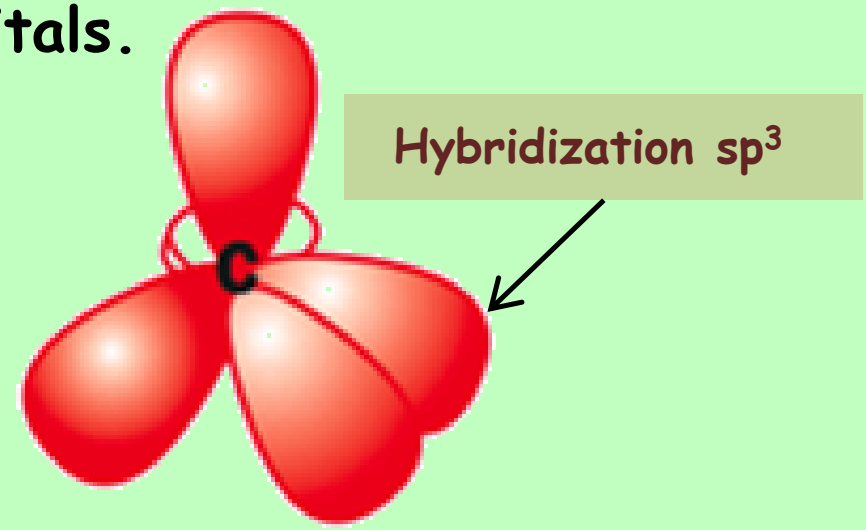
For the reactive carbon intermediate radical cation, draw its simplified structure, calculate its formal charge, find its number of bonds, number of electrons lone pairs, number of hybridized orbitals (HON), type of hybridization (HO's) and its shape.

Formal charge: 4-2-1=+1
Number of bonds: 2
Number of electrons lone pairs: 0
HON's used: 2
HO's: sp
Shape: linear



Define the term Hybridization.

Hybridization happens when atomic orbitals mix to form new atomic orbitals. The new orbitals have the same total electron capacity as the old ones. The properties and energies of the new, hybridized orbitals are an "average" of the original non hybridized orbitals.

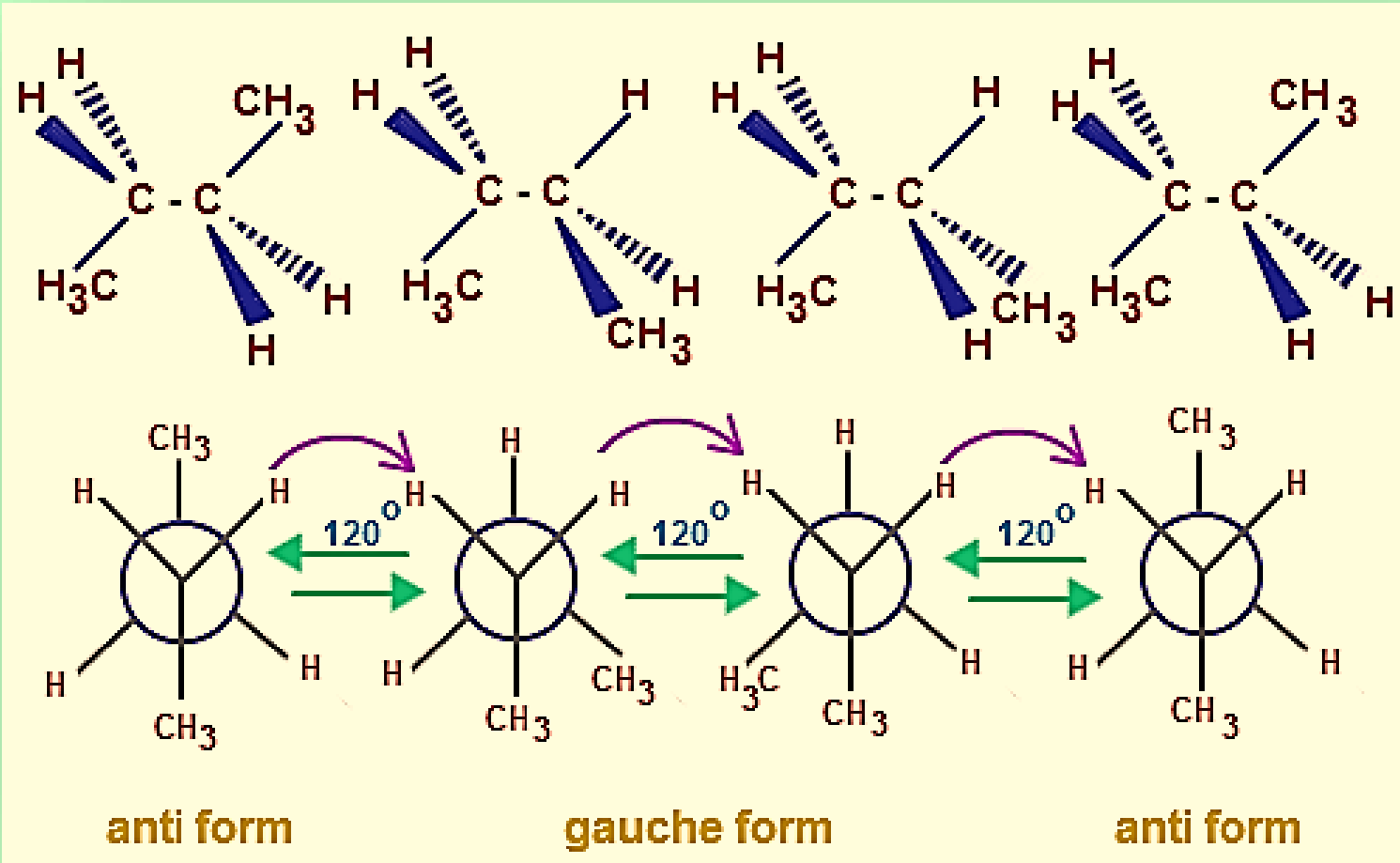


Additional information

The concept of hybridization was introduced because it was the best explanation for the fact that all of the C - H bonds in molecules like methane were identical.

Define the term conformation.

Conformations are structures arising from rotation about single bonds.



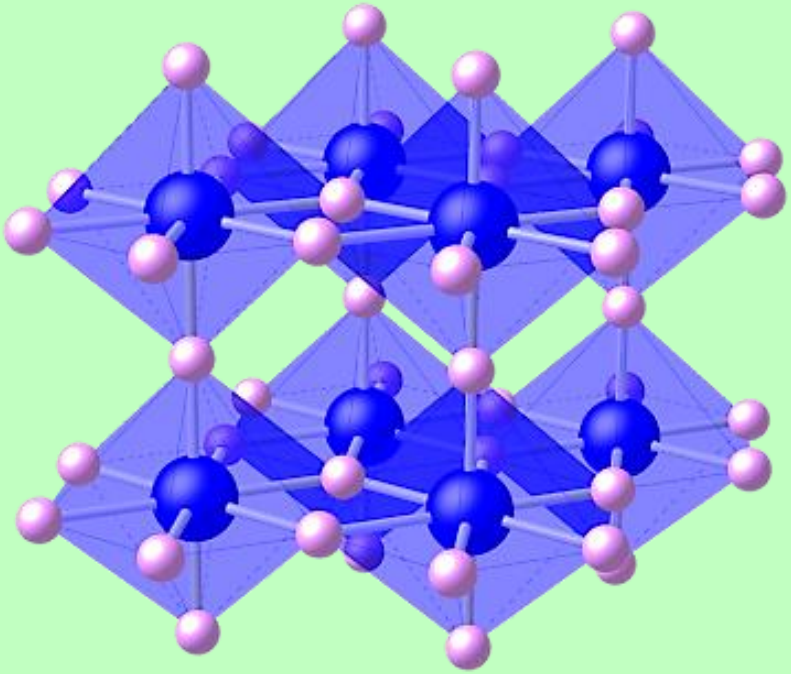
Which is the only alkali metal that reacts with Nitrogen?

Lithium (Li)

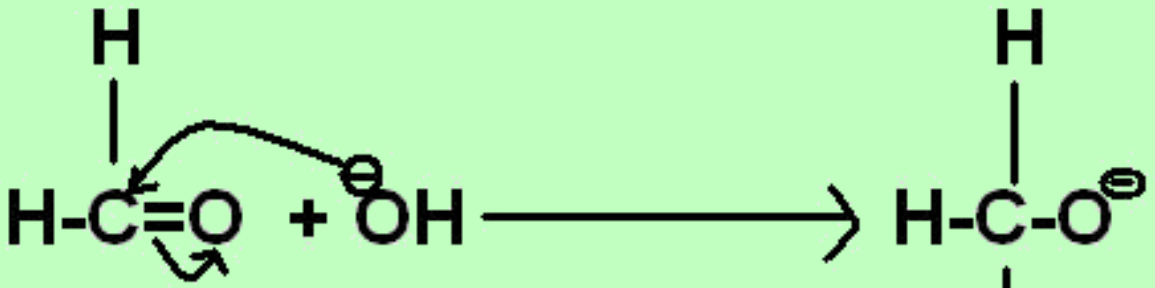
$$6Li(s) + N_2(g) \longrightarrow 2Li_3N(s)$$

Additional information

Of the alkali metals, only Lithium reacts with Nitrogen, and it forms Lithium Nitride (Li_3N). The solid is a red or purple color and has a high melting point. Lithium Nitride reacts violently with water to produce ammonia. Li_3N has an unusual crystal structure that consists of two types of layers, one sheet has the composition Li_2N^- contains 6-coordinate Li centers and the other sheet consists only of Li^+.



Write Cannizzaro's reaction.



or