

1. Answer True or False to the following questions.

(a) A nucleophile is an electron-rich species.

- (a) True
- (b) False

(b) A nucleophile must always have a full, negative charge.

- (a) True
- (b) False

(c) Nucleophilicity decreases when the nucleophile has large, bulky, groups.

- (a) True
- (b) False

(d) (2 points) Good nucleophiles are in general low-energy species.

- (a) True
- (b) False

(e) (2 points) Good nucleophiles are in general highly reactive.

(a) TRUE: A nucleophile is an electron-rich species.

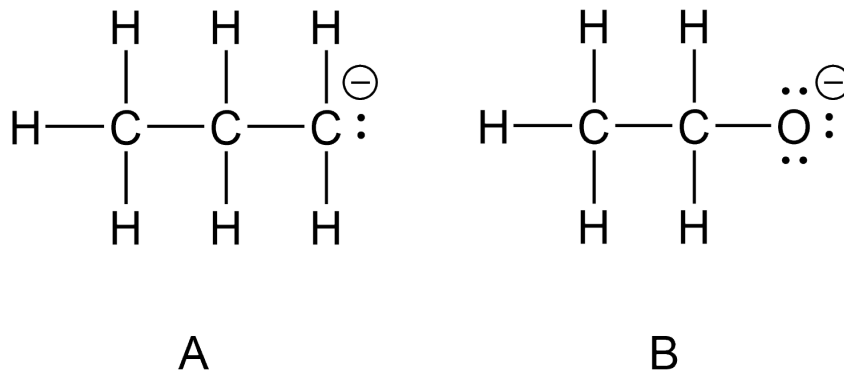
(b) FALSE: A nucleophile can have a negative or partial negative charge.

(c) TRUE: Nucleophilicity decreases when the nucleophile has large, bulky, groups.

(d) FALSE: Good nucleophiles are high-energy species.

(e) TRUE: Good nucleophiles are in general highly reactive.

2. Shown below are two nucleophiles.



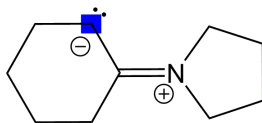
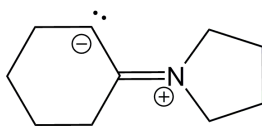
(a) Which nucleophile is stronger?

- (a) Nucleophile A
- (b) Nucleophile B

(b) Explain your answer above.

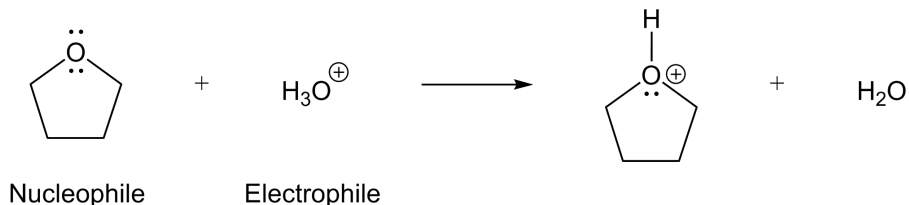
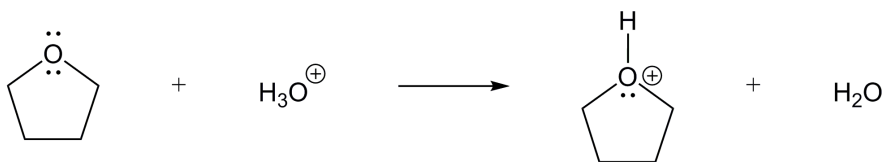
(a) and (b) Nucleophile A is stronger since carbon is less electronegative than oxygen and can accommodate less the negative charge. This makes the carbon nucleophile higher in energy and more reactive (stronger nucleophile).

3. Circle the most nucleophilic atom in the following molecule. This type of molecule is called an enamine.



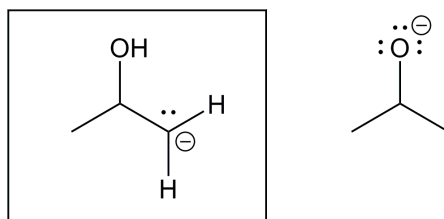
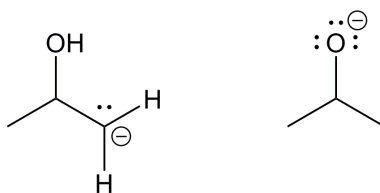
A carbon ion (carbanion) is very nucleophilic since carbon is not very electronegative. As a result the electrons on carbon are higher in energy and therefore more reactive and more nucleophilic.

4. Identify the nucleophile and electrophile in the following reaction.



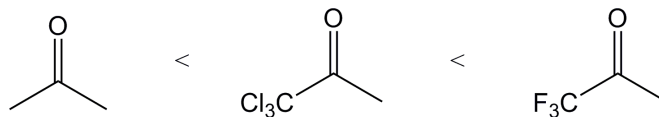
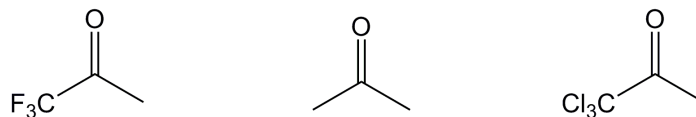
Tetrahydrofuran (THF) is the nucleophile since it has a lone pair on the oxygen atom. The hydronium ion is the electrophile since the oxygen atom has a positive charge. Note, that oxygen has at least one electron lone pair in both THF and the hydronium ion. Therefore, not all electron lone pairs are nucleophilic!

5. Which anion a stronger nucleophile?



The first species is a stronger nucleophile. Carbon is not as electronegative as oxygen. Therefore, an electron lone pair on a carbon atom is higher in energy (more reactive/more nucleophilic) than an electron lone pair on oxygen.

6. Rank the following molecules in order of increasing electrophilicity.

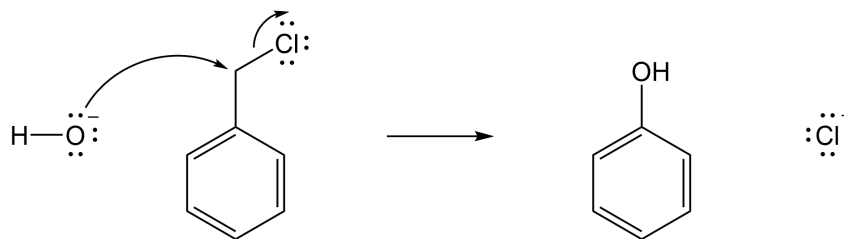


Least Electrophilic

Most Electrophilic

In all three molecules the most electrophilic atom is the atom of the carbonyl. For acetone, there are no electron-withdrawing halides that further reduce the electron density of the carbonyl carbon. Trichloroacetone is more electrophilic than acetone since chlorine is an electronegative atom. Since fluorine is the most electronegative element, trifluoroacetone is the most electrophilic molecule.

7. Shown below is the mechanism for a substitution reaction.



Fill in the blanks.

Hydroxide is *nucleophilic/electrophilic*. The carbon of the $\text{C}-\text{Cl}$ bond is *nucleophilic/electrophilic*. Cl is/is not a leaving group.

Hydroxide is *nucleophilic*. The carbon of the $\text{C}-\text{Cl}$ bond is *electrophilic*. Cl is a leaving group.

