



## comparing the same element

	charge	resonance
<b>nucleophilicity</b>	negative charge → better Nu	resonance → worse Nu (charge is stabilized)
<b>basicity</b>	negative charge → stronger base	resonance → weaker base (charge is stabilized)
<b>leaving-group ability</b>	positive charge → better LG (more willing to accept electrons)	resonance → better LG (charge will be stabilized)

## comparing different elements

	same row	same column
<b>big difference</b>	electronegativity	size
<b>nucleophilicity</b>	less electronegative → better Nu (willing to donate electrons)	bigger → better Nu (usually) (big Nu's are less hindered by solvent, more polarizable)
<b>basicity</b>	less electronegative → stronger base (willing to donate electrons)	bigger → weaker base (large base can spread out and stabilize electron density)
<b>leaving-group ability</b>	more electronegative → better LG (willing to accept electrons)	bigger → better leaving group (big LG's can spread out and stabilize electron density)

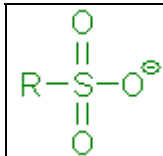
## nucleophiles, leaving groups, bases

nucleophiles				leaving groups							
N	O	F	NC <sup>-</sup>	N <sup>-</sup>	O <sup>-</sup>	F <sup>-</sup>	good Nu (S <sub>N</sub> 2 or S <sub>N</sub> 1)	N <sup>+</sup>	O <sup>+</sup>	-OSO <sub>2</sub> R	good LG
P	S	Cl	P <sup>-</sup>	S <sup>-</sup>	Cl <sup>-</sup>		poor Nu (S <sub>N</sub> 1)	P <sup>+</sup>	S <sup>+</sup>	Cl	not a LG
	Se	Br		Se <sup>-</sup>	Br <sup>-</sup>		not a Nu			Br	
		I			I <sup>-</sup>					I	
bases											
N	O	F	N <sup>-</sup>	O <sup>-</sup>			strong base (E2)	Nucleophiles and bases shown with charges before attacking.			
P	S	Cl	P <sup>-</sup>	S <sup>-</sup>	Cl <sup>-</sup>		weak base (E1)	Leaving groups shown with charges before leaving.			
		Br			Br <sup>-</sup>		not a base	The tables for individual atoms assume no resonance.			
		I			I <sup>-</sup>			Resonance makes atoms into worse nucleophiles and bases and into better leaving groups.			

## how to find nucleophiles and electrophiles

1. The nucleophilic atom will have a negative charge or lone pair.
2. The electrophilic atom is a *carbon* with a partial or full positive charge, and will be bonded to a good leaving group. When a carbon is bonded to a more electronegative atom that has a positive formal charge, the *carbon* is the electrophilic atom, while the atom with the positive formal charge is a good leaving group.

## resonance-stabilized leaving groups



This is a sulfonate (shown with charge after leaving). Because of resonance stabilization of the negative charge, sulfonates are good leaving groups. The  $\alpha$ -carbon attaches to the O, not to the S.

how to determine S<sub>N</sub>2 vs. E2 vs. S<sub>N</sub>1/E1

NUCLEOPHILE OR BASE  $\alpha$ -CARBON	no Nu H <sub>2</sub> SO <sub>4</sub> + $\Delta$ (alcohol substrate)	poor Nu (O)	good Nu		
			weak base (N, S, Se, Cl <sup>-</sup> , Br <sup>-</sup> , I <sup>-</sup> , <sup>-</sup> CN, S <sup>-</sup> , Se <sup>-</sup> )	strong base (N <sup>-</sup> , O <sup>-</sup> )	
				non-bulky base	bulky base (LDA, t-butyl-O <sup>-</sup> )
<b>methyl</b>	no reaction	no reaction	S <sub>N</sub> 2	S <sub>N</sub> 2	S <sub>N</sub> 2
<b>1°</b>	no reaction	no reaction	S <sub>N</sub> 2	S <sub>N</sub> 2	E2
<b>1° with 3° <math>\beta</math>-carbon</b>	no reaction	no reaction	S <sub>N</sub> 2      no reaction if $\beta$ -carbon is 4°	E2	E2
<b>2°</b>	E1	S <sub>N</sub> 1/E1	S <sub>N</sub> 2      no reaction if $\beta$ -carbon is 4°	E2	E2
<b>3°</b>	E1	S <sub>N</sub> 1/E1	S <sub>N</sub> 1/E1	E2	E2

“S<sub>N</sub>1/E1” means both S<sub>N</sub>1 and E1 occur. The ratio of S<sub>N</sub>1 to E1 is generally about 95 to 5, so the E1 reaction is often not mentioned.

This table assumes the  $\alpha$ -carbon has a good leaving group; otherwise, there will be no reaction.

The table displays the major reaction for each case—in some cases there may be significant levels of minor competing reactions.

The table may not give the correct answer in all situations, but it will generally be accurate for the questions that are typical of exams.