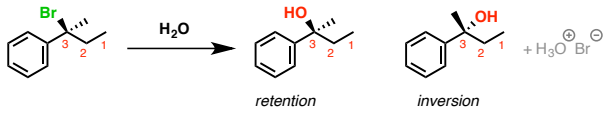
S_N1 Reaction

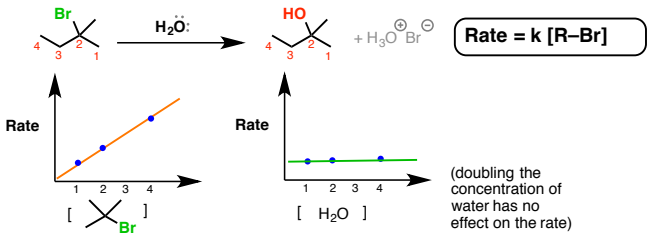
Stereochemistry

Substitution occurs with a mixture of retention and inversion at a stereocenter



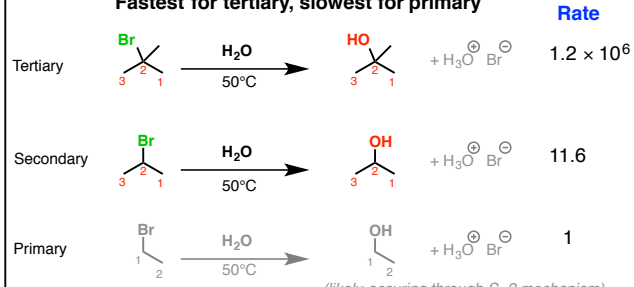
Rate Law

The rate of the reaction is ONLY sensitive to the concentration of the substrate (and not the nucleophile)



Substrate

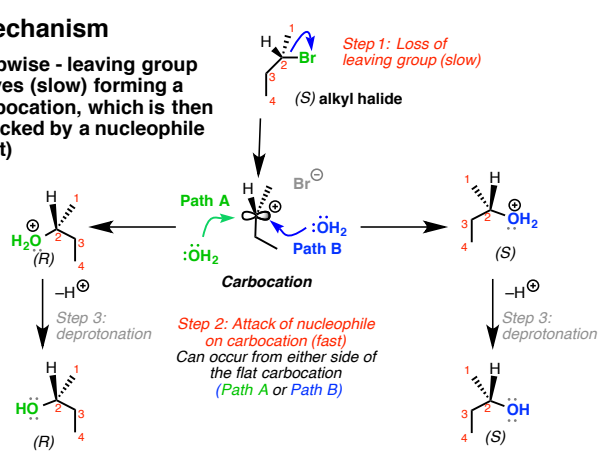
Fastest for tertiary, slowest for primary



From "March's Advanced Organic Chemistry", 5th Ed. p. 431

Mechanism

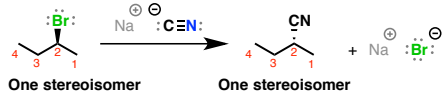
Stepwise - leaving group leaves (slow) forming a carbocation, which is then attacked by a nucleophile (fast)



S_N2 Reaction

Stereochemistry

Substitution occurs with inversion of configuration at chiral centers

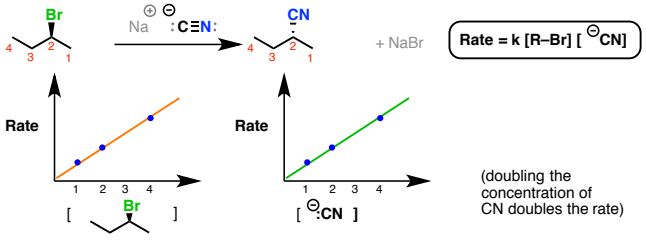


inversion!

This substitution reaction results in an inversion of configuration at C-2

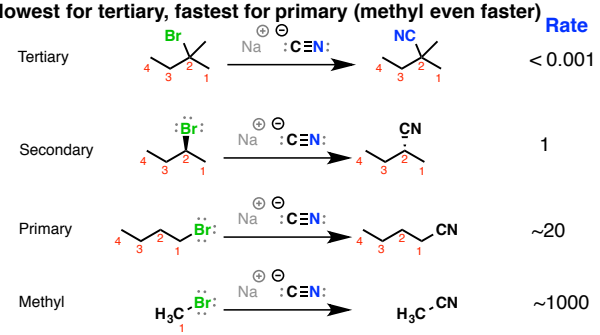
Rate Law

The rate of the reaction is sensitive to the concentration of the substrate AND the nucleophile



Substrate

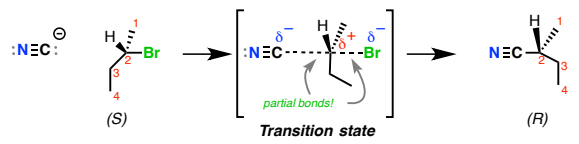
Slowest for tertiary, fastest for primary (methyl even faster)



Mechanism

One step (backside attack)

In the "backside attack", the nucleophile attacks the substrate from the backside in a single step, resulting in inversion of configuration.



- Explains bimolecular rate law (depends on conc. of nucleophile and substrate)
- Explains inversion of stereochemistry
- Explains sensitivity to steric hindrance (bulky groups slow down backside attack)

This is called the S_N2 mechanism (Substitution, Nucleophilic, bimolecular)

S_N1 vs. S_N2 Summary

	SN1	SN2
Rate Law	Unimolecular (substrate only)	Bimolecular (substrate and nucleophile)
"Big Barrier"	Carbocation stability	Steric hindrance
Alkyl halide (electrophile)	3° > 2° >>1° (fastest)	1° > 2° >>3° (fastest)
Nucleophile	Weak (generally neutral)	Strong (generally bearing a negative charge)
Solvent	Polar protic (e.g. alcohols)	Polar aprotic (e.g. DMSO, acetone)
Stereochemistry	Mix of retention and inversion	Inversion

Comparing S_N1 vs. S_N2 reactions

The key skill to start with is **identifying the leaving group**
Look for halogens (Cl, Br, I) or tosylates/mesylates (OTs, OMs)
Alternatively, look for alcohols (OH) if **acid** is present

Once you've identified the leaving group, instpect the **carbon** it is attached to. How many carbons is that carbon connected to? That will tell you if the carbon is primary, secondary, or tertiary. If there are no attached carbons, that's the special case of "methyl" (S_N2 for sure!)

If the carbon is tertiary, it's likely S_N1. You can rule out S_N2 due to steric hindrance.
If the carbon is primary, it's likely S_N2. You can rule out S_N1 due to the fact that primary carbocations are unstable [one exception: resonance stabilized carbocations].

Next, examine the **nucleophile**. A negatively charged nucleophile generally indicates an S_N2 reaction. A neutral nucleophile (such as H_2O or ROH) generally indicates an S_N1 reaction.

Finally, check the **solvent**. A polar aprotic solvent (such as DMSO, acetone, acetonitrile, or DMF) generally indicates S_N2, whereas a polar protic solvent such as H_2O or ROH generally indicates S_N1 conditions.

If you found this useful, click here to check out more great organic chemistry "cheat sheets" !

Questions, comments? james@masterorganicchemistry.com