$S_N^1$ and $S_N^2$

Reactions

An organic chemistry workshop for the ARC
This workshop will address:

- SN2 reactions
  - Break it down: what does it mean?
  - Rundown
  - Notes
- SN1 reactions
  - Unimolecular: the main difference
  - Step-by-step
- Review: SN1 vs SN2
- Resources
The $S_N 2$ Reaction

Nucleophile $\rightarrow$ Leaving Group

Substrate $\rightarrow$ Product
The $S_N^2$ Reaction

Substitution

Nucleophilic

Bimolecular
The $S_N2$ Reaction

**Substitution:** this reaction involves a substitution of players – two reactants produce two products, in which some things have been switched around:

\[ AB + C \rightarrow AC + B \]

- Tip: think of this if you get elimination (E1 and E2) reactions mixed up with substitution (SN1 and SN2) reactions.
The $S_N2$ Reaction

**Nucleophilic:** these reactions involve a nucleophile (Nuc:$-$) replacing a leaving group.

- Nucleophiles attack the substrate, donating an electron pair to the new bond, and replacing the leaving group (a substitution).

- Tip: Remember the role of a nucleophile by its Greek roots: **Nucleo**-(nucleus)-**phile**-(lover) – it is attracted to the nucleus, which is positively charged! Nucleophiles are therefore negatively charged or strongly $\delta$-. 
The $S_N2$ Reaction

**Bimolecular:** A *bimolecular* reaction is one whose rate depends on the concentrations of *two* of its reactants.

- SN2 reactions happen in one step – the nucleophile attacks the substrate as the leaving group leaves the substrate.
- Tip: Recall that the rate of a reaction depends on the slowest step. In bimolecular reactions, therefore, the slow step involves two reactants. For SN2 reactions, there are only two reactants; this means that the slow step is the *only* step.
The $S_N2$ Reaction

SN2 summary:
(1) Nucleophile back-side attacks the $\delta^+$ carbon center.
(2) Transition state forms in which nucleophile is forming bond while leaving group is breaking its bond.
(3) The leaving group leaves, forming the final product.
The $S_N2$ Reaction

Notes:

- In the SN2 reaction, the nucleophile attacks from the most $\delta^+$ region: behind the leaving group.
- This back-side attack causes an *inversion* (study the previous slide).
- The nucleophile must be able to reach the $\delta^+$ carbon center that it is attacking.

Tip: see chapter 6 of your textbook to learn what makes a good nucleophile or a good leaving group.
The $S_{N1}$ Reaction

Substrate

Carbocation Intermediate

Products
The $S_N 1$ Reaction

- Substitution
  - Nucleophilic Unimolecular
The $S_N 1$ Reaction

SN1 reactions are nucleophilic substitutions, involving a nucleophile replacing a leaving group (just like SN2).

However: SN1 reactions are **unimolecular**: the rate of this reaction depends only on the concentration of **one reactant**.

- SN1 reactions happen in two steps:
  1. The leaving group leaves, and the substrate forms a *carbocation intermediate*.
  2. The nucleophile attacks the carbocation, forming the product.
The $S_N1$ Reaction

1. The Slow Step:

First step of the SN1 reaction:
The leaving group leaves, and the substrate carbon now only has three substituents, taking on a positive charge. This is called a carbocation.

- Carbocations are most stable when there are more atoms to distribute the positive charge.
- Carbocation stability:
  \[ 3^o > 2^o >> 1^o \]

- Tip: study the difference between reaction intermediates and transition states.
The $S_N1$ Reaction

2. The Fast Step:

Second step of the $S_N1$ reaction:
The nucleophile attacks the carbocation intermediate, bringing its electron pair to resolve the positive charge.

- The substrate loses any stereospecificity during the carbocation intermediate stage, with only three substituents attached.

For this reason, both the $R$ and $S$ conformations are formed as products.
$S_N 1$ vs $S_N 2$ Reactions
Resources

- Chapter 6 of your textbook
- The Khan Academy:
  - SN2 Reactions
  - SN1 Reactions
  - all organic chemistry topics
- Organic Chemistry Portal

- workshop created by Monica

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