

# SN2 Reaction Study Guide: Understanding Backside Attack for Organic Chemistry Exams

In this post, we'll break down the **SN2 (substitution nucleophilic bimolecular)** mechanism step by step, emphasizing stereochemistry, kinetics, solvent effects, and competition with elimination.

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## Overview

The SN2 reaction is a:

- Single-step
- Concerted
- Backside attack
- Substitution reaction

Unlike SN1:

- There is no carbocation intermediate.
- The nucleophile attacks as the leaving group leaves.

Because both substrate and nucleophile participate in the rate-determining step, SN2 reactions follow **second-order kinetics**.

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## Mechanism

### Backside Attack

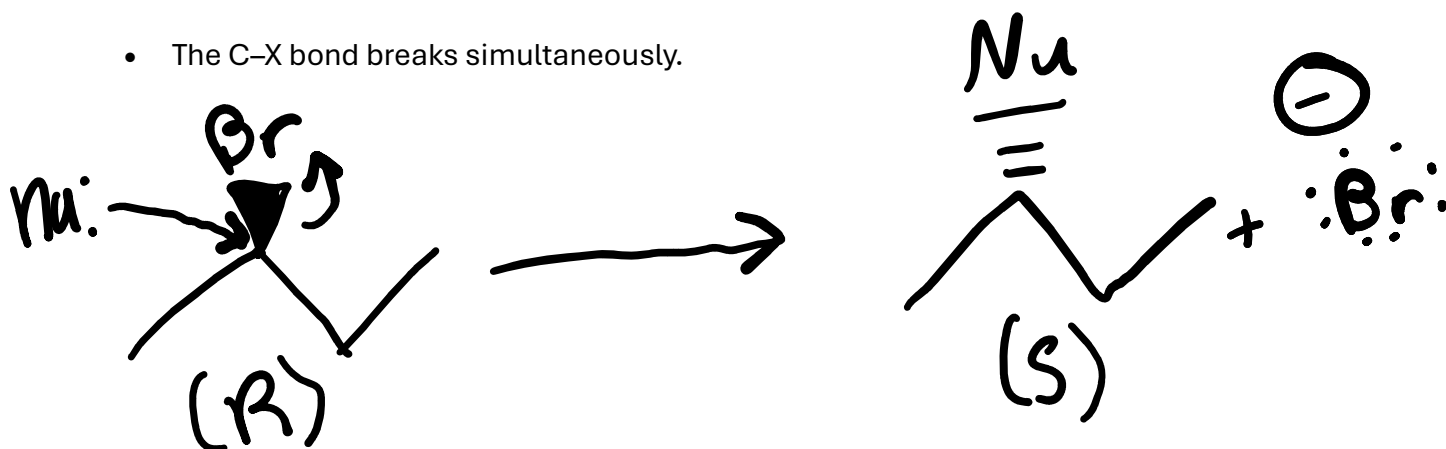
The nucleophile approaches the carbon **from the opposite side** of the leaving group.

Why?

The  $\sigma^*$  antibonding orbital of the C-X bond is accessible only from the backside.

As the nucleophile forms a bond:

- The C-X bond breaks simultaneously.



### Stereochemistry: Inversion of Configuration

SN2 reactions cause **complete inversion** at the stereocenter.

If the carbon is chiral:

- R becomes S
- S becomes R

(Unless priority order changes due to substituent changes.)

This inversion is a defining feature of SN2 and a common exam question.

### Steric Effects (Critical Concept)

SN2 requires direct access to the electrophilic carbon.

Therefore:

- ✓ Methyl → fastest
- ✓ Primary → very good
- ✓ Secondary → slower
- ✗ Tertiary → does not occur

Tertiary carbons are too sterically hindered for backside attack.

This steric sensitivity is one of the biggest distinctions from SN1.

### Kinetics

$$\text{Rate} = k[\text{substrate}][\text{nucleophile}]$$

Doubling nucleophile concentration doubles the rate.

Strong nucleophile = faster reaction.

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### **Solvent Effects**

Polar aprotic solvents favor SN2.

Examples:

- DMSO
- DMF
- Acetone

Why?

Polar aprotic solvents:

- Do not hydrogen-bond strongly to nucleophiles.
- Leave nucleophiles “naked” and reactive.

Polar protic solvents:

- Hydrogen bond to nucleophiles.
  - Decrease nucleophilicity.
  - Favor SN1 instead.
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## Energy Diagram for SN2

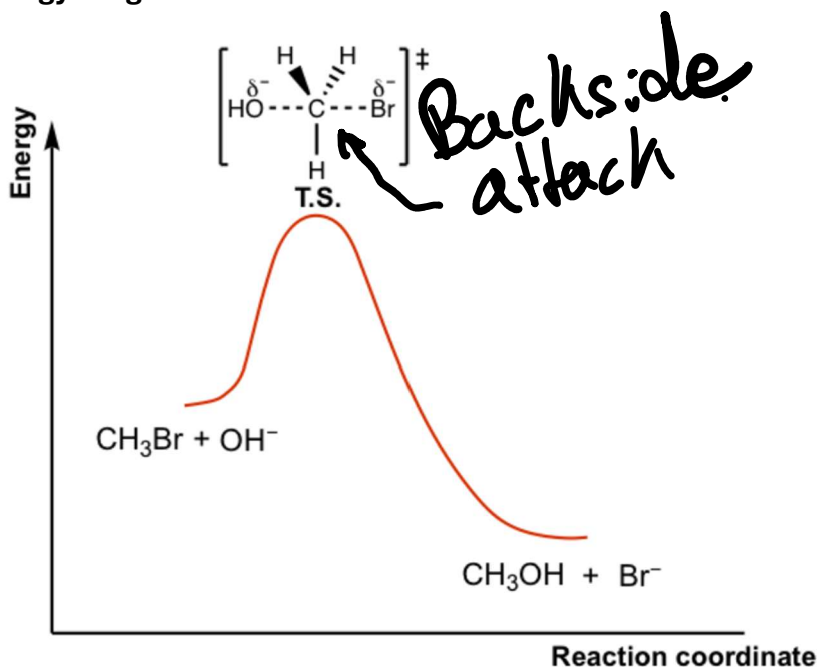


Figure 1: adapted from chemistry libre texts

[https://chem.libretexts.org/Bookshelves/Organic\\_Chemistry/Organic\\_Chemistry\\_I\\_\(Liu\)/07%3A\\_Nucleophilic\\_Substitution\\_Reactions/7.02%3A\\_SN2\\_Reaction\\_Mechanism\\_Energy\\_Diagram\\_and\\_Stereochemistry](https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Organic_Chemistry_I_(Liu)/07%3A_Nucleophilic_Substitution_Reactions/7.02%3A_SN2_Reaction_Mechanism_Energy_Diagram_and_Stereochemistry)

At the transition state:

- Carbon is partially bonded to nucleophile and leaving group.
- Geometry resembles a trigonal bipyramidal structure.

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## Factors Influencing SN2

### Substrate

- ✓ Methyl → best
- ✓ Primary → good
- ✓ Secondary → possible
- ✗ Tertiary → no reaction

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### Nucleophile Strength

Strong nucleophiles favor SN2:

- Negatively charged species

- Less sterically hindered

Examples:

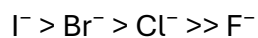
- $I^-$
- $Br^-$
- $CN^-$
- $RS^-$

Weak nucleophiles push toward SN1.

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### Leaving Group

Better leaving group  $\rightarrow$  faster SN2.



Poor leaving groups (like  $OH^-$ ) often must be protonated first.

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### Competition: SN2 vs E2

Strong nucleophile + primary substrate  $\rightarrow$  SN2

Strong bulky base  $\rightarrow$  E2

Secondary substrate  $\rightarrow$  mixture

Tertiary substrate  $\rightarrow$  E2 only

Temperature increase  $\rightarrow$  elimination favored

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### Conclusion

To master SN2, always ask:

- Is the carbon accessible?
- Is the nucleophile strong?
- Is the solvent polar aprotic?
- Could E2 compete?

If you systematically answer these questions, you'll solve most substitution/elimination problems correctly.

Practice drawing backside attack.

Practice identifying inversion.

Practice comparing with E2.

And if you want structured guidance through practice sets and reaction roadmaps, reach out about tutoring availability.