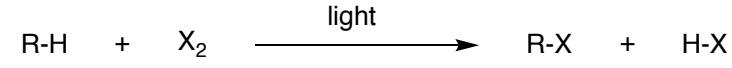
Substitution Reactions

Remember: Radical Substitution

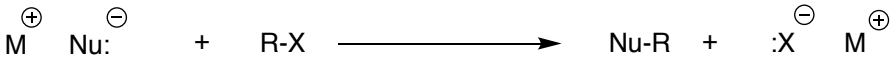


Proceeds by a radical mechanism

Alkane X=F, Cl, Br Not I

Alkyl Halide

Ionic Substitution:



Nucleophile (Seeks positive charge)

Alkyl Halide

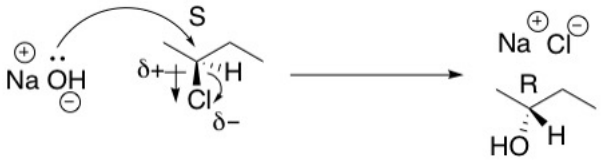
Nucleophile is a substance that seeks positive charge

Types of Nucleophilic Substitution (S_N)

S_N1 - rate depends on 1 concentration

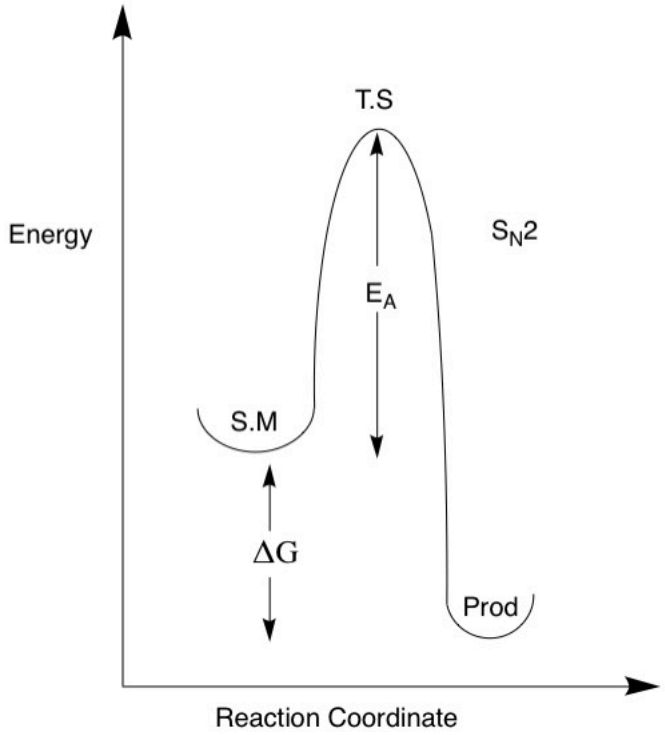
S_N2 - The rate is dependent on the concentration of the nucleophile and the nucleophile (2 concentrations)

Sn2 Mechanism



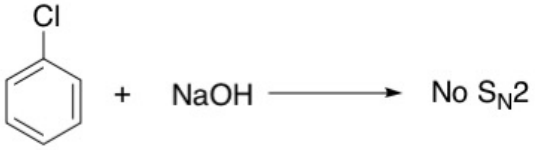
Reverse reaction will not occur.
- Inversion of configuration.
- **Concerted**: The bonds of the starting material break at the same time that the product bonds form.
- **Stereospecific**: stereochemistry of the starting material determines the stereochemistry of the product.

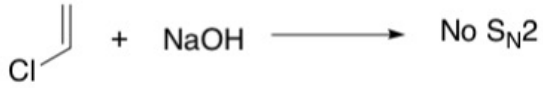
Energy Diagram of S_N2 Reaction

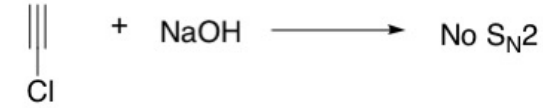


There is no intermediate in the S_N2 reaction, as it is concerted

S_N2 will **not** occur on carbon sites that have multiple bonds.





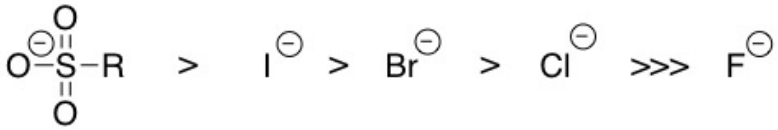


SUMMARY
- S_N2 is stereospecific – proceeds with inversion of configuration (known as Walden inversion)
- Rate depends on two concentrations (bimolecular)
- Best if 1º halide, OK if 2º, Never on 3º, or C=C.

Never leaving groups: (negative charge not stabilized):

Fluorine, though electronegative, is a bad leaving groups as it is small and poorly solvated.

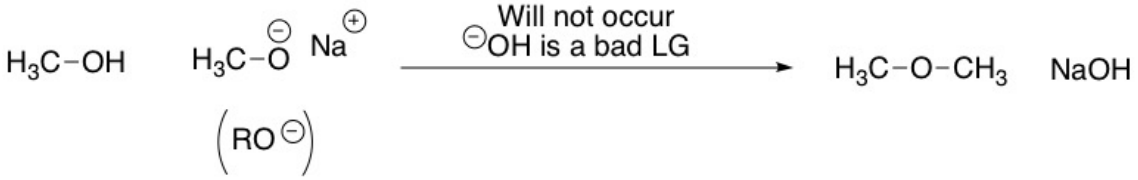
Good leaving groups



-OH or -OR can also act as leaving groups but they must first be transformed into H_2O or HOR by a strong acid

OH and OR can ONLY leave as water (HOH) or alcohol (HOR) never as anions

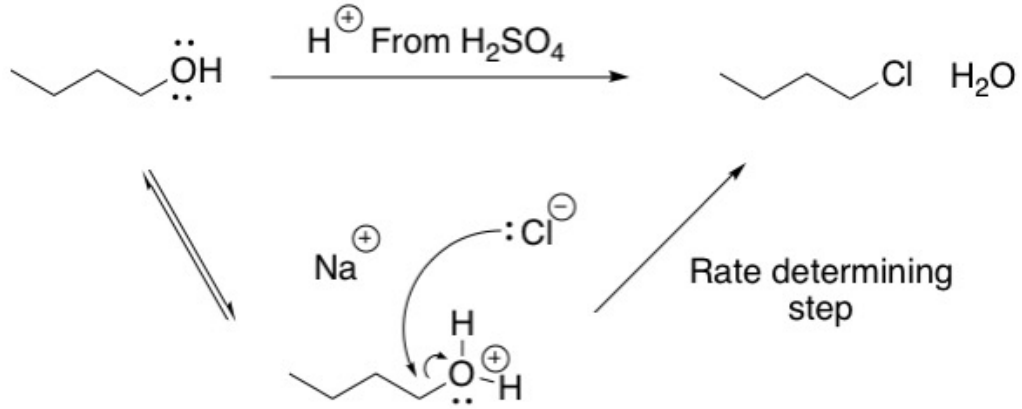
Example 1 (will not proceed to products)



- The reverse reaction will also not occur as $^{(-)}$OR is also a bad leaving group (LG).

Example 2 (will give products by S_N2 due to prior protonatgioon with HOH as leaving group)

Alcohols require an acid catalyst to transform them into a good leaving group (H_2O)



Examples 3 & 4 (S_N2 Reactions)

Top one has achiral starting material and gives achiral product

Bottom one has single diastereomer (trans-1-chloro-4-methylcyclohexane starting material is not chiral due to plane of symmetry within molecule). S_N2 Reaction gives inversion of configuration to produce single cis diastereomer (cis-4-methylcylohexan-1-ol ; you need not know how to name this yet)