

## Chapter 9. Haloalkanes

### Learning objectives:

1. Differentiate primary, secondary, and tertiary alkyl halides.
2. Write the general electron-pushing (arrow-pushing) mechanisms for  $S_N1$  and  $S_N2$  reactions.
3. Draw the potential energy diagrams for  $S_N1$  and  $S_N2$  reactions.
4. Predict the favored reaction between  $S_N1$  and  $S_N2$  mechanisms for a given haloalkane based on the structures of haloalkanes, the structures of nucleophiles, leaving groups, and solvents.
5. Write the general electron-pushing (arrow-pushing) mechanisms for E1 and E2 reactions.
6. Draw the potential energy diagrams for E1 and E2 reactions.
7. Predict the favored reaction between E1 and E2 mechanisms for a given haloalkane based on the structures of haloalkanes, the strengths of bases, and leaving groups.
8. Predict the major product(s), including the stereochemistry, of elimination reactions.
9. Know the application of nucleophilic substitution in chemical and biological systems

### Sections to be covered (in the order of delivery):

- 9.1 How alkyl halides react
- 9.2 The mechanism of an  $S_N2$  reaction
- 9.4 The mechanism of an  $S_N1$  reaction
- 9.3 Factors that affect  $S_N2$  reactions
- 9.5 Factors that affect  $S_N1$  reactions
- 9.6 Comparing the  $S_N1$  and  $S_N2$  reactions of alkyl halides
- 9.12 Solvent effects
- 9.7 Elimination reactions of alkyl halides
- 9.8 Products of elimination reactions
- 9.9 Comparing the E1 and E2 reactions of alkyl halides
- 9.10 Does an alkyl halide undergo  $S_N2/E2$  reaction or  $S_N1/E1$  reaction? #
- 9.11 Does an alkyl halide undergo a substitution reaction, an elimination reaction, or both substitution and elimination reactions #
- 9.13 Using substitution reaction to synthesize organic compounds
- 9.14 Biological methylating reagents

# Sections that will be skipped

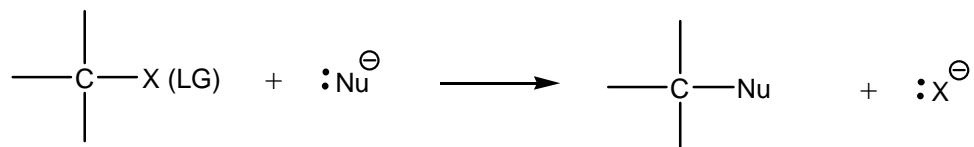
### Recommended additional problems

29-31, 34, 42, 43, 45, 47,

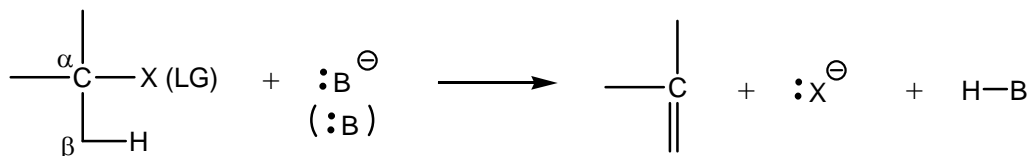
## 9.1 How alkyl halides react

**Important Terminologies:** alkyl halide, nucleophile, leaving group, nucleophilic substitution,  $\beta$ -elimination and  $\beta$ -hydrogen.

### A. General Reaction of Nucleophilic Aliphatic Substitution

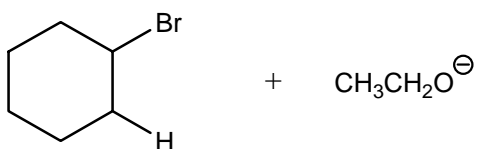


### B. General Reaction of $\beta$ -Elimination



**Note:** A nucleophile can act as a base and visa versa.

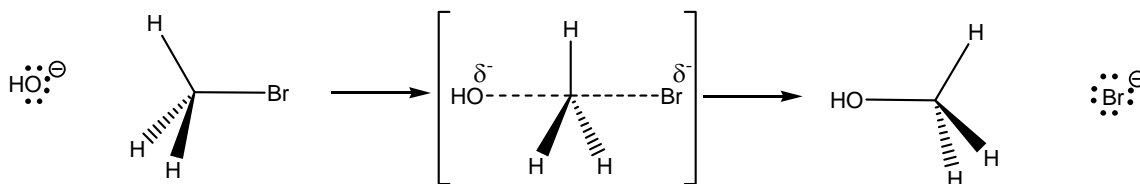
### C. Example



## 9.2 The mechanism of an S<sub>N</sub>2 reaction

$$\text{Rate} = k \cdot [\text{haloalkane}] [\text{nucleophile}]$$

### A. S<sub>N</sub>2 Mechanism



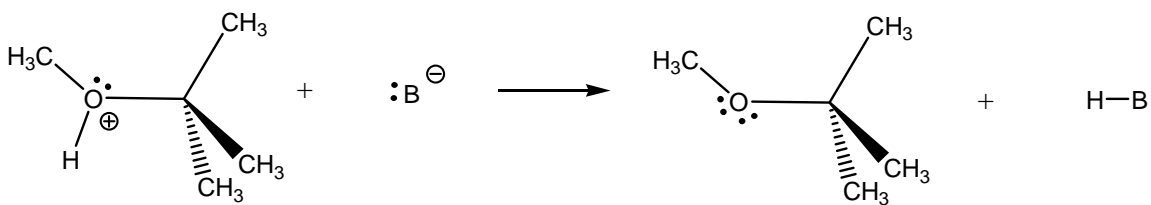
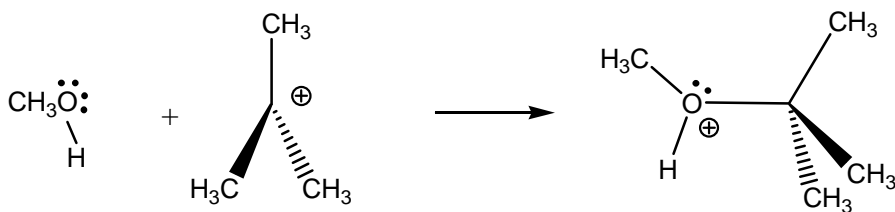
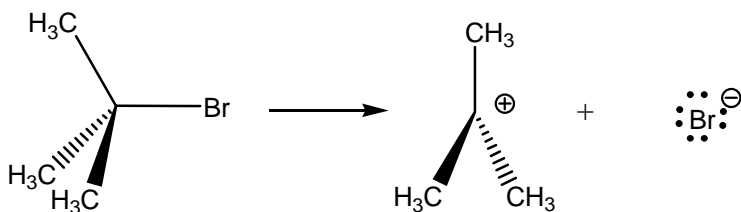
### B. Inversion of Configuration: Issue on Stereoselectivity of S<sub>N</sub>2 Mechanism

### C. Energy Diagram

## 9.4 The mechanism of an S<sub>N</sub>1 reaction

### A. S<sub>N</sub>1 Mechanism

$$\text{Rate} = k \cdot [\text{haloalkane}]$$



## B. Energy Diagram

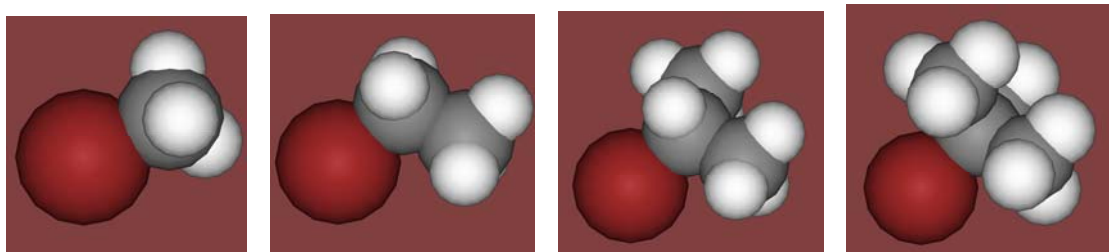
## C. Racemization of Stereocenter: Issue on Stereoselectivity of $S_N1$ Mechanism

- 9.3 Factors that affect S<sub>N</sub>2 reactions
- 9.5 Factors that affect S<sub>N</sub>1 reactions
- 9.12 Solvent effects

A. Structure of the Nucleophile

*Know how to classify strong and weak nucleophiles (relative nucleophilicity)*

B. Structure of the Haloalkane



### C. The Leaving Group

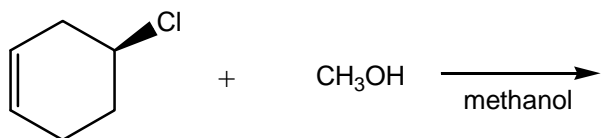
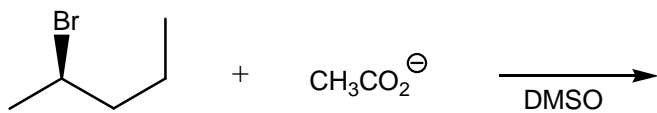
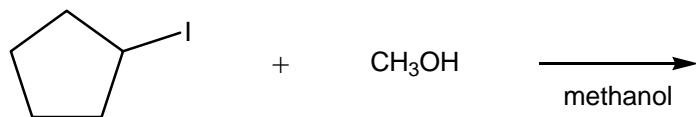
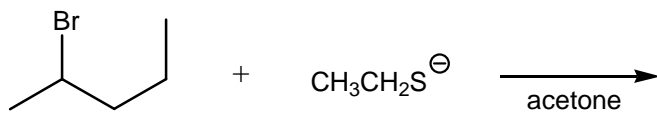
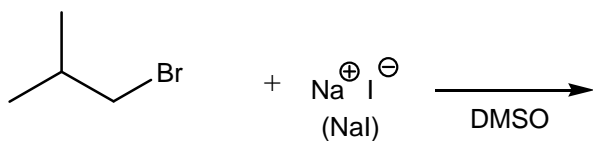
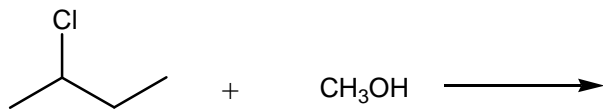
### D. The Solvent

*Know protic and aprotic solvents.*

## **9.6 Comparing the $S_N1$ and $S_N2$ reactions of alkyl halides**

A. How to predict the possible mechanism of a substitution reaction?

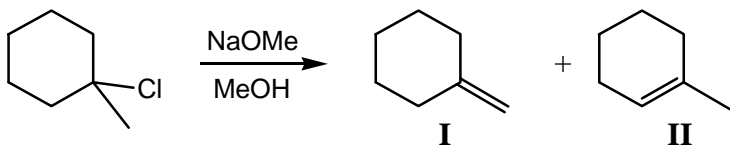
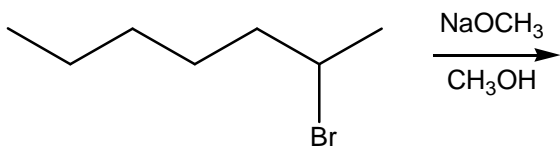
B. Examples:



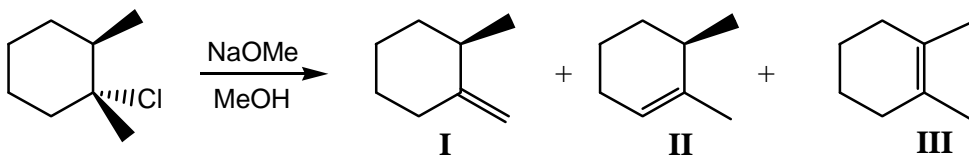
## 9.7 Elimination reactions of alkyl halides

### 9.8 Products of elimination reactions

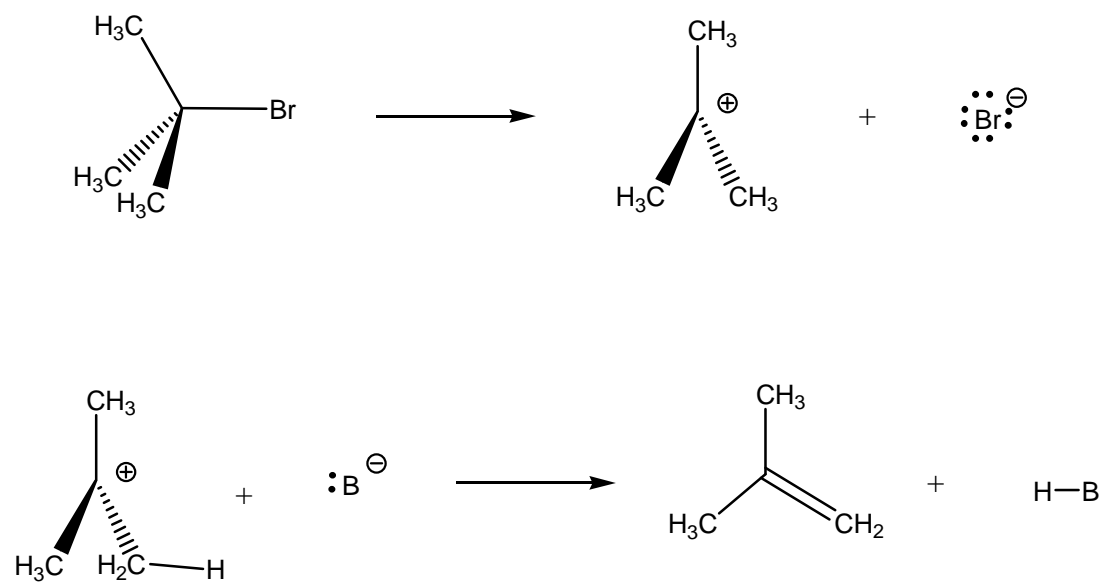
A. Zaitsev's rule:



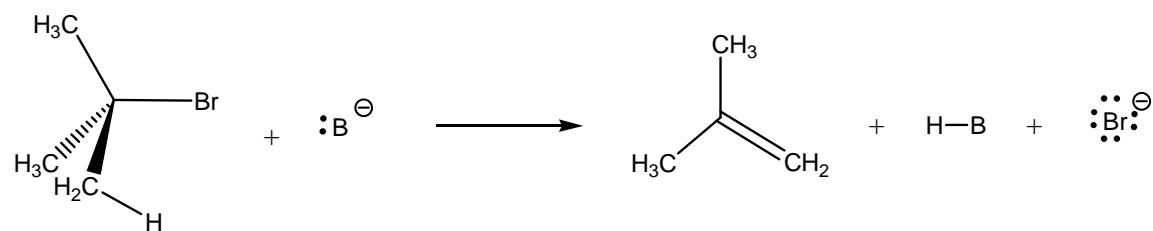
(Notice: Me =  $\text{CH}_3$ , methyl group)



### B. E1 Mechanism



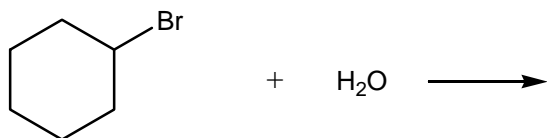
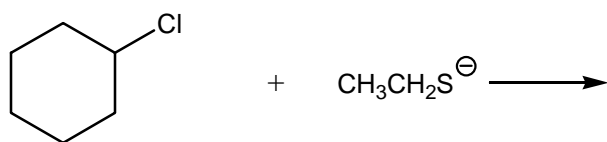
### B. E2 Mechanism



## 9.9 Comparing the E1 and E2 reactions of alkyl halides

A. How to predict the possible mechanism of an elimination reaction?

B. Examples



## 9.13 Using substitution reaction to synthesize organic compounds

### A. Williamson ether synthesis

## 9.14 Biological methylating reagents

***Know what is S-adenosylmethionine (SAM).***

