

Objective 11: Apply reactivity principles to Substitution and Elimination reactions. Compare size and strength of nucleophile to predict major product.

Quiz Practice problems

Key ideas:

Substitution and Elimination reactions involve similar structural features in the reactant. Look for the following structural features: alpha carbon, H bonded to a beta carbon, leaving group, and nucleophile.

You want to determine whether the major product is the substitution product or elimination product.

These factors help you determine the major product:

- Type of substrate: 1°, 2°, 3° RX or ROH or other organic compound with a leaving group.
- Strength of nucleophile: strong or weak – see pK_a table.
- Size of nucleophile: big or small.

In general, the elimination product is favored because it is easier for a nucleophile to react at the H bonded to the beta carbon than at the (crowded) alpha carbon.

2° and 3° R-X + strong base favor elimination.

1° R-X + small, strong bases (e.g., NaOC₂H₅) favor substitution.

1° R-X + large, strong bases (e.g., NaOC(CH₃)₃) favor elimination.

1° and 2° R-X + weak base favor substitution. Weak Base is a base weaker than OH⁻.

3° R-X without anionic base favor substitution. Use solvent as Nu:⁻.

Skills:

Identify alpha carbon in a compound.

Identify H bonded to beta carbon in a compound.

Identify alpha carbon as 1°, 2°, 3°.

Identify leaving group in a compound.

Identify leaving group as good or poor.

Describe how to make a poor leaving group into a good leaving group.

Identify a nucleophile as strong or weak.

Identify a nucleophile as big or small.

Given reactants, use curved arrows to show how nucleophile reacts at alpha carbon to form substitution products.

Given reactants, use curved arrows to show how nucleophile reacts at H bonded to beta carbon to form elimination products.

Identify the major product. Give reasons based on substrate type, size and strength of nucleophile.

1. Determine whether the bases (nucleophiles) in Table 1 are strong or weak, big or small.

Table 1. Nucleophile (Base) Strength and Size

Nucleophile	Strength (strong or weak)	Size (big or small)
Cl ⁻		
OH ⁻		
H ₂ O		
CH ₃ O ⁻		
CH ₃ CH ₂ OH		
(CH ₃) ₃ CO ⁻		
NH ₃		
CH ₃ COO ⁻		
CN ⁻		
HCC: ⁻		

2. For each reaction,

(i) State the type of substrate: 1°, 2°, or 3°.

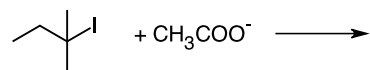
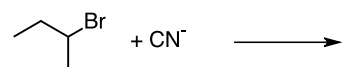
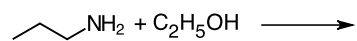
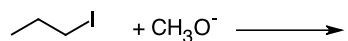
(ii) Draw the structure of the substitution and elimination product. Use curved arrows to show how each reaction occurs.

(iii) Which product, substitution or elimination, is the major product? Give reasons based on substrate type, size and strength of nucleophile.

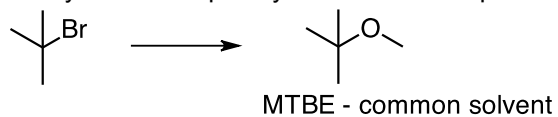
Reaction

Substitution Product

Elimination Product



3. Identify the nucleophile you would use to produce a high yield of product. Give reasons for your choice.



4. One method works; the other does not. Which one works? Give reasons. (From Klein, "Organic Chemistry", 1st ed., Problem 7.62) Hint: what structural features are in each reactant?

