

# Reactions of Amines and Epoxides

## Preparation of Amines

Amination of alcohols: Polyalkylation is a serious problem for indirect synthesis of amines



A summary of Ring-Opening Reactions of Epoxides with Strong and Weak Nucleophiles



## Bond Types, Strength, Length, Polarity and Dipole Moment

### Two different bond types

There are two types of bonding: **ionic bonding** and **covalent bonding**

- **Ionic bonds** are formed by the transfer of electrons from one element to another (ionization potential) and electron affinity) (examples)



- **Covalent bonds** are formed by sharing of electrons between two atoms



### The Relative Electronegativity of an



### Bonded and Unbonded electron pairs



### Electron movement



### There are two main categories

1. Definition of electron pair



## Sigma (σ) and pi (π) bonds

Covalent bonds are classified in **sigma (σ) bonds** and **pi (π) bonds**

- **Sigma bonds** are formed by head-on (frontal) overlap of orbitals
- **π bonds** are formed by side-on overlap of orbitals
- **Any single bond** is a **sigma bond**
- **Any multiple bond** consists of one **sigma** and **n** **pi** bonds



π bonds are stronger than σ bonds

## Polar and Nonpolar Covalent Bonds

Depending on the difference in the electronegativity values, covalent bonds can be **polar** and **nonpolar**.



- If the difference in electronegativity is **less than 0.5**, the electrons are shared equally (nonpolar) between the two atoms, forming a **nonpolar covalent bond** (two important examples are the C-C and C-H bonds)

- If the difference in electronegativity is **between 0.5 and 1.7**, we have a **polar covalent bond** (three important examples are chloroform, carbon tetrachloride, and carbon disulfide)

- A difference of **1.7 or higher** can be high that the electrons are not longer shared and a **ionic bond** is formed

## Dipole Moment

The polarity of a bond is described by the **dipole moment (μ)**



- The **dipole moment** is defined as a vector pointing from the less electronegative to the more electronegative atom
- The more electronegative atom has a partial negative charge (δ<sup>-</sup>) and the less electronegative atom has a partial positive charge (δ<sup>+</sup>)
- **δ<sup>-</sup>** (delta minus) indicates an electron deficient atom
- **δ<sup>+</sup>** (delta plus) indicates an electron rich atom

## Molecular Dipole

To determine the **molecular polarity**, the vector sum of the dipoles is used

The geometry of the molecule is important. Symmetrical molecules are nonpolar (even for dipole moments are cancelled). A good example is carbon dioxide



Cancel the vector as the other pointing point in the same way

## Bond Length and Bond Strength

As the bond length increases, the bond strength decreases

| Bond     | H-H        | H-Cl       | H-Br       | H-I        |
|----------|------------|------------|------------|------------|
| Length   | 109 pm     | 127 pm     | 141 pm     | 154 pm     |
| Strength | 436 kJ/mol | 431 kJ/mol | 366 kJ/mol | 298 kJ/mol |

Double bonds are stronger than single bonds in the same row and a stronger bond

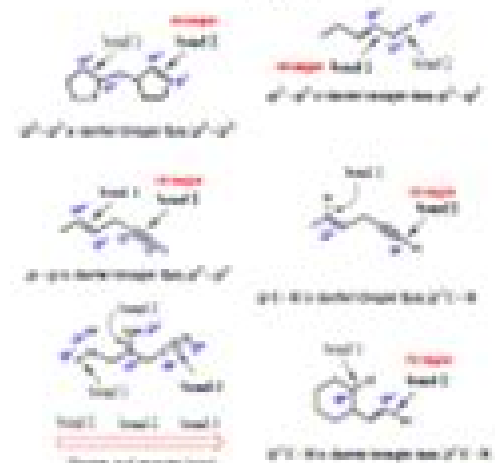


As the bond length increases, the bond strength decreases

| Average values of C-C and C-H bonds depending on hybridization |                 |                 |             |
|--|-----------------|-----------------|-------------|
| C-C Bond   | $sp^3-sp^3$ C-C | $sp^2-sp^2$ C-C | $sp-sp$ C-C |
| Hybridization  | $sp^3-sp^3$     | $sp^2-sp^2$     | $sp-sp$     |
| Length   | 153 pm          | 134 pm          | 120 pm      |
| Strength   | 376 kJ/mol      | 611 kJ/mol      | 837 kJ/mol  |
| Hybridization  | $sp^3-sp^3$     | $sp^2-sp^2$     | $sp-sp$     |
| C-H Bond   | $sp^3-sp^3$     | $sp^2-sp^2$     | $sp-sp$     |
| Length   | 153 pm          | 134 pm          | 120 pm      |
| Strength   | 413 kJ/mol      | 505 kJ/mol      | 558 kJ/mol  |

Higher s character = stronger and shorter bond

## Examples



# Organic Chemistry Smith 3rd Study Guide

**John Bingham Roberts**



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