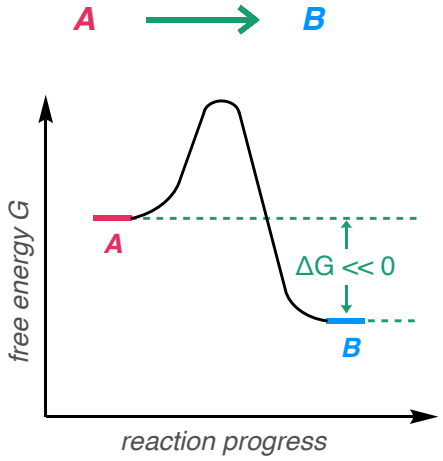
Arrows in Organic Chemistry

This document should highlight the main uses and physical meaning of various types of arrows used in organic chemistry

Reaction Arrows

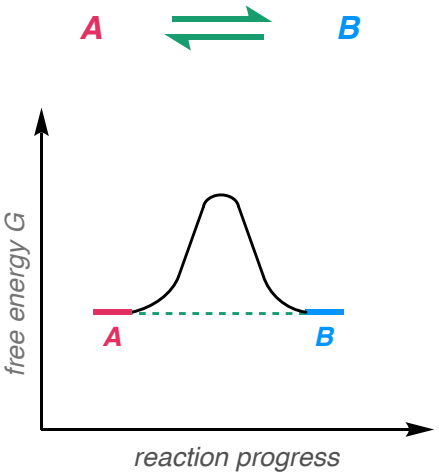
Generally, a **forward reaction arrow** or a **equilibrium reaction arrow** are used to depict the favorability of an elementary step of a reaction

Irreversible *forward reaction*



ΔG << 0
K_{eq} >> 1
Equilibrium heavily favors **B**

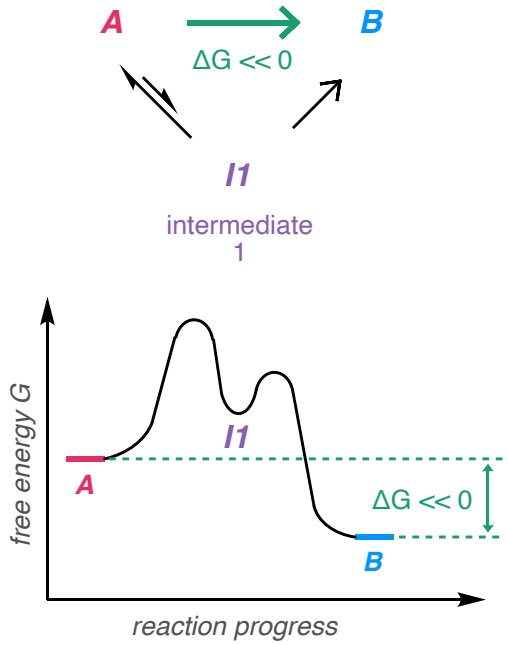
Reversible *forward reaction*



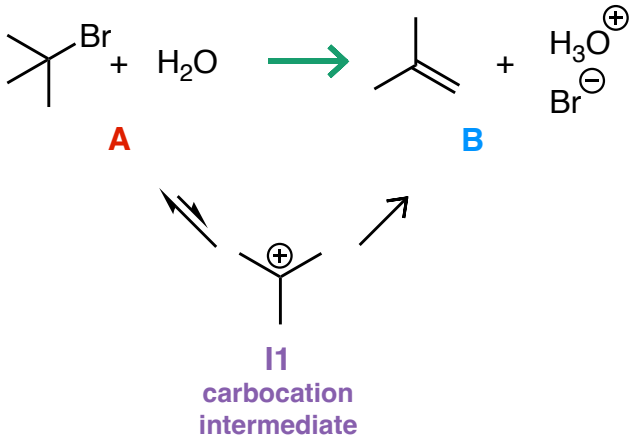
ΔG ~ 0
K_{eq} ~ 1
Neither **A** nor **B** is favored

Irreverible Reaction Arrows Indicating an Overall Transformation

An irreversible forward reaction arrow may also used to describe a favorable transformation overall (**A** to **B**), even if it contains steps that are reversible or even disfavored (e.g., **A** to **I1**)



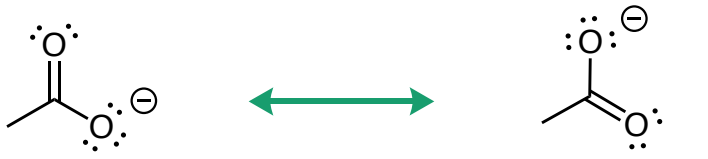
Reactions proceeding through carbocations as key intermediates are great examples of this



While the reaction overall is favorable (**A** to **B**) even though the first step has a disfavored equilibrium (**A** to **I1**)

Resonance Arrows

When drawing resonance structures, organic chemists use a resonance arrow to indicate that the two structures are resonance contributors.

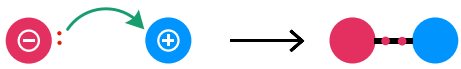


Lewis structure **1** ⟷ Lewis structure **2**

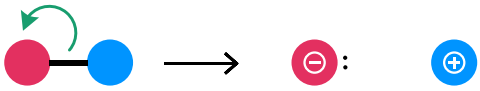
Reactions and Curved Arrows

Curved arrows are used to describe the elementary steps of a reaction mechanism

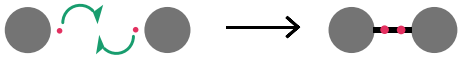
Polar reactions
Heterolytic bond formation



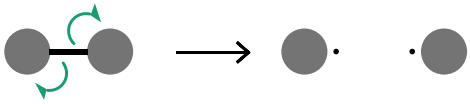
Heterolytic bond breaking



Radical reactions
Homolytic bond formation



Homolytic bond breaking



Note: Curved arrows are shown on the reactant side of the elementary reaction

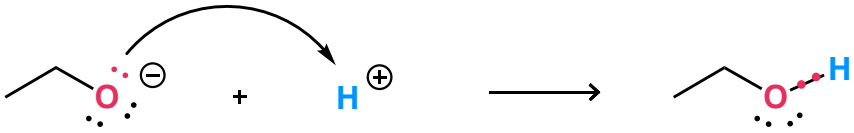
curved arrow - movement of **two electrons**
tail of arrow - where the electrons **are**
head of arrow - where the electrons **will be**

fishhook arrow - movement of **one electron**

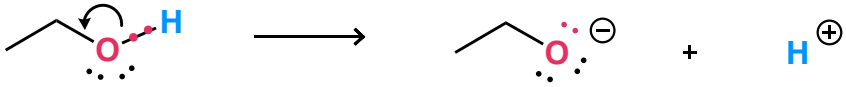
Common Patterns for Curved Arrows

These are the most common patterns for the use of curved arrows in polar reaction mechanisms

1. Lone pair electrons used to form bond



2. Bond breaks and electrons become a lone pair



3. Bond breaks and electrons become a new bond