

Reaction Learning Checklist

SHALLOW

Relatively easy to memorize

(mostly factual)

- What bonds form, and what bonds break?
- What functional group is in the starting material, and what functional group is in the product?
- What reagent(s) are used in the reaction?
- What byproducts are formed in the reaction?
- Are there any changes in the stereochemistry of the product?
- Is the reaction “regioselective”? (Is there a pattern to where certain bonds form, e.g. Markovnikov’s rule)
- What is the solvent in the reaction? (not always important)
- Can you find at least 3 other examples of the same reaction?
- Given the product and reactants, can you give the starting material?
- Given the starting material and product, can you give the reagents?
- What’s the mechanism of the reaction (if known)?

INTERMEDIATE

Requires *active practice* (skills and concepts)

See the Skills and Concepts checklists (next page)

- Can you explain the reaction mechanism, step by step? [see page 3 for checklist]
- Will the reaction produce stereoisomers (e.g. enantiomers, diastereomers)?
- What’s the “driving force” for this reaction?
- Which sites on the substrate (reactant) are electron-rich (nucleophilic), and which are electron-poor (electrophilic)?
- What’s the best nucleophile present in the reaction?
- What’s the best electrophile present in the reaction?
- What’s the most acidic proton present in the reaction?
- Is the reaction catalyzed by acid or base? If so, why might that speed the reaction?
- How might you change the substrate to increase its rate of reaction?
- How might you change the reagent to increase or decrease the reaction rate?
- Are there any competing reactions, or side-reactions that are possible here?
- What is the most stable conformation of the starting material? (most important for cyclohexanes)
- Is the reaction an equilibrium? If so, how might you drive it in the opposite direction?
- What’s the most important resonance form of the substrate? (If applicable)
- Would the reaction rate change if you moved from a polar protic solvent to polar aprotic solvent, or vice-versa? Why?

DEEP

Relatively difficult to memorize

(Requires *application* of skills and concepts)

Reactions: Skills and Concepts

Some Important Skills Required To Learn Reactions

note - many of these bullet points link to (hopefully) helpful external web pages

- see “hidden” hydrogens and lone pairs in line drawings of molecules
- recognize an atom’s hybridization (sp, sp², sp³)
- calculate formal charge of an atom
- recognize electron rich and poor areas of molecules (dipoles) by applying relative electronegativities
- interpret and draw curved arrows to show electron flow, and bonds forming/breaking
- draw resonance structures of a molecule, and convert them using curved arrows
- identify the most important resonance forms of a molecule
- given pKa values, be able to predict which direction an acid-base reaction will proceed
- given an acid, draw the conjugate base
- given a base, draw the conjugate acid
- recognize primary, secondary, tertiary alcohols and alkyl halides
- interpret and draw rings and cyclohexanes (especially the cyclohexane chair conformation)
- recognize whether molecules are enantiomers, diastereomers, or the same

Some Important Concepts Required To Understand Reactions

- Why do atoms adopt different geometries (tetrahedral, trigonal planar, linear...)
- What factors influence the stability of different conformations (alkyl chains and cyclohexane rings)
- What factors affect the relative importance of different resonance forms?
- What factors influence the stability of rings? (hint: angle strain, torsional strain)
- What factors influence acidity and basicity?
- What factors influence nucleophilicity?
- What makes something a “good” leaving group?
- What factors influence the stability of carbocations and free radicals ?
- Under what conditions do carbocation rearrangements occur?
- What is steric hindrance, and under what conditions can it affect reactivity?

Learning A Mechanism: Deeper Questions

- What bonds form and what bonds break in each curved arrow of the mechanism?
- Can the sequence of curved arrows be broken down into discrete “steps” ? Do these “steps” have names?
- What bonds form and break in each “step” of the mechanism (this is slightly different from the first question!)
- For each step: can you identify a nucleophile and an electrophile? (usually, but not always possible)
- What’s the slowest step of the mechanism?
- How does the mechanism explain the reason for why the reaction has a given stereochemistry (e.g. syn, anti) [if applicable]
- How does the mechanism explain the reason for why the reaction has a given regiochemistry (e.g. Markovnikov’s rule, Zaitsev’s rule) [if applicable]

Bonus Questions After Learning A Reaction

- Can you come up with an “intramolecular” version of this reaction?
- Of the individual “steps” - can you find other reaction mechanisms that share these key steps? It can be very helpful to group these reactions together into families - many patterns repeat!
- Try to come up with 3 reactions that involve the product of the reaction. E.g. if the reaction forms an alkene... can you come up with 3 reactions where this alkene could be a starting material?
- Try to come up with at least 3 reactions where the reactant in the reaction would be a product of a different reaction. For example, if your reaction starts with an alkyl halide... can you find 3 reactions where this alkyl halide would be a product?