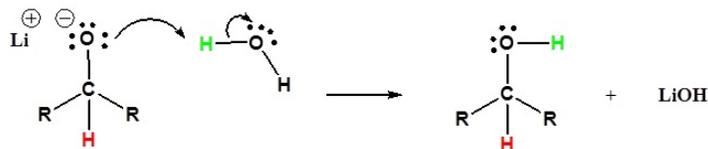
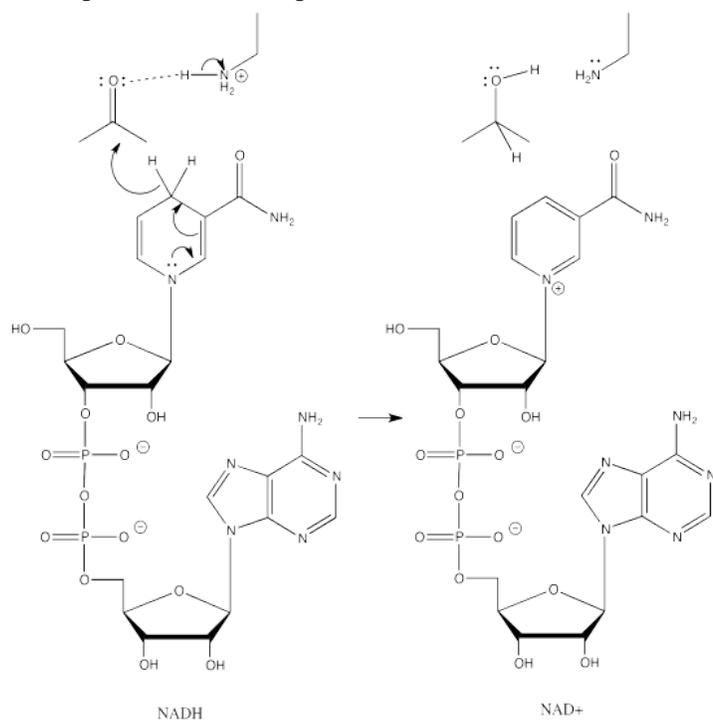


2) The alkoxide is protonated.



BIOLOGICAL REDUCTION

Addition to a carbonyl by a **semi-anionic** hydride, such as NaBH_4 , results in conversion of the carbonyl compound to an alcohol. The hydride from the BH_4^- anion acts as a nucleophile, adding H^- to the carbonyl carbon. A proton source can then protonate the oxygen of the resulting alkoxide ion, forming an alcohol.

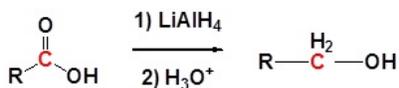


Aldehydes, ketones and alcohols are very common features in biological molecules. Converting between these compounds is a frequent event in many biological pathways. However, semi-anionic compounds like sodium borohydride don't exist in the cell. Instead, a number of biological hydride donors play a similar role.

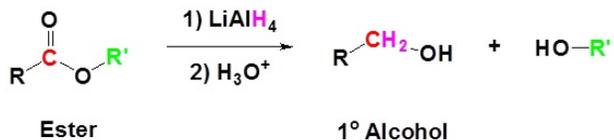
NADH is a common biological reducing agent. NADH is an acronym for nicotinamide adenine dinucleotide hydride. Instead of an anionic donor that provides a hydride to a carbonyl, NADH is actually a neutral donor. It supplies a hydride to the carbonyl under very specific circumstances. In doing so, it forms a cation, NAD^+ . However, NAD^+ is stabilized by the fact that its nicotinamide ring is aromatic; it was not aromatic in NADH.

REDUCTION OF CARBOXYLIC ACIDS AND ESTERS

Carboxylic acids can be converted to 1° alcohols using Lithium aluminum hydride (LiAlH_4). Note that NaBH_4 is not strong enough to convert carboxylic acids or esters to alcohols. An aldehyde is produced as an intermediate during this reaction, but it cannot be isolated because it is more reactive than the original carboxylic acid.



Esters can be converted to 1° alcohols using LiAlH₄, while sodium borohydride (NaBH₄) is not a strong enough reducing agent to perform this reaction.



REDUCTION REACTION SUMMARY

The table below summarizes the reduction reactions covered so far in our text. It is important to distinguish between functional group reactivity as we add more multiple-step synthetic pathways.

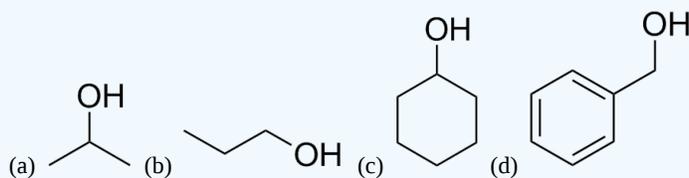
Reduction Reaction Summary

Reactant	Reduction Product with Specified Reagents		
	H ₂ with Pt, Pd or Ni	1) NaBH ₄ 2) H ₃ O ⁺	1) LiAlH ₄ 2) H ₃ O ⁺
	RCH ₂ -OH	RCH ₂ -OH	RCH ₂ -OH
	RCH ₂ -OH	RCH ₂ -OH	RCH ₂ -OH
	RCH ₂ -OH	RCH ₂ -OH	RCH ₂ -OH
	no rxn	no rxn	RCH ₂ -OH
	no rxn	no rxn	

Exercise

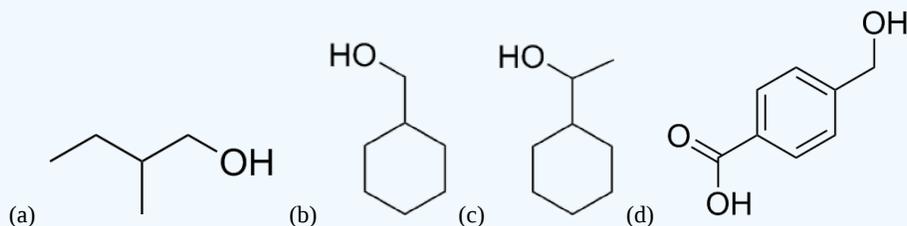
11.

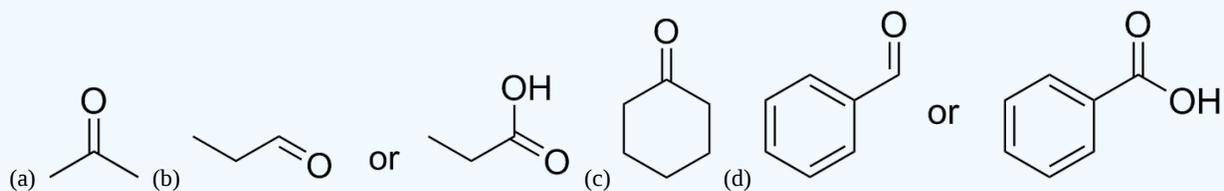
Give the aldehyde, ketone, or carboxylic acid (there can be multiple answers) that could be reduced to form the following alcohols.



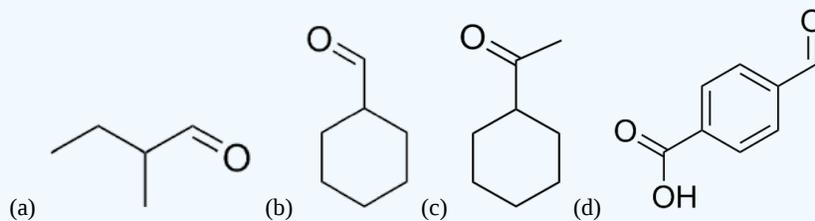
12.

Given the following alcohol, draw the structure from which it could be derived using only NaBH₄



Answer
11.

12.

Note, NaBH_4 is only a strong enough reducing agent to reduce ketones and aldehydes.


CONTRIBUTORS AND ATTRIBUTIONS

- [Dr. Dietmar Kennepohl](#) FCIC (Professor of Chemistry, [Athabasca University](#))
- [Prof. Steven Farmer](#) ([Sonoma State University](#))
- [Chris P Schaller, Ph.D.](#), ([College of Saint Benedict / Saint John's University](#))

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