

SI Organic Chemistry - Full Discipline Demo

Properties and Reactions of Alcohols

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Organic Chemistry - Full Discipline Demo
Course	SI Organic Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Identify each bond as either ionic or covalent.

⚡ Na-Cl	⚡ H-O-H	⚡ Li-Br	⚡ H-CH ₃	⚡ O=O	⚡ K-OH
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Ionic Bond	Covalent Bond
1	2

Correct answers:

1 K-OH Na-Cl Li-Br 2 H-O-H H-CH₃ O=O

Identify each compound as either polar or nonpolar.

⌘ NH ₃	⌘ CH ₃ -CH ₃	⌘ N ₂	⌘ HF	⌘ H ₂	⌘ LiCl
Polar			Nonpolar		
1			2		

Correct answers:

1 NH₃ HF LiCl 2 CH₃-CH₃ N₂ H₂

Identify the physical state of each compound at room temperature (23°C) based on its provided boiling point.

⌘ Water (100°C)	⌘ Ammonia (-33°C)	⌘ Ethanol (78°C)	⌘ Butane (-1°C)
⌘ Diethyl ether (34°C)			
Gas		Liquid	
1		2	

Correct answers:

1 Ammonia (-33°C) Butane (-1°C)
2 Water (100°C) Ethanol (78°C) Diethyl ether (34°C)

Exploration

An alcohol with three carbon groups is classified as a ____.

- ☐ primary alcohol
- ☐ secondary alcohol
- ☒ tertiary alcohol ✓
- ☐ All of the above

The reaction transformation of converting a ketone to an alcohol is classified as a(n) ____ reaction.

- ☐ oxidation
- ☒ reduction ✓
- ☐ hydrolysis
- ☐ Grignard

The addition of water across a double bond to form an alcohol is classified as a(n) ____ reaction.

- ☐ oxidation
- ☐ reduction
- ☒ hydration ✓
- ☐ Grignard

1-Butanol has a higher boiling point than tert-butyl alcohol.

- ☒ True ✓
- ☐ False

As the number of hydrogen bond donors in a molecule increase, the boiling point decreases.

- ☐ True
- ☒ False ✓

Oxygen is more electronegative than hydrogen.

☐ True



☐ False

In a solution of water, it is possible for the lone pair on the oxygen of an alcohol to function as a hydrogen bond _____.

☐ acceptor



☐ donor

☐ both

☐ neither

The intermolecular interaction between the C-H of an alcohol and the lone pair of oxygen on water is a repulsive interaction.

☐ True



☐ False

Increasing the carbon chain length of an alcohol makes an alcohol more soluble in water.

☐ True

☐ False



Exercise 1

Data Table 1: Alcohol Reaction Type
(SAMPLE ANSWER BELOW)

	Reaction Type
Reaction 1	Grignard
Reaction 2	hydration
Reaction 3	oxidation
Reaction 4	reduction

Exercise 2

What property of the alcohols affects their miscibility in water? Explain your answer by referencing the results reported in Data Table 2.

As the carbon chain length increases, its polarity decreases as more repulsive interactions between the hydrocarbon tail and the polar water molecules increase. In Data Table 2 we see miscible short-chain alcohols methanol, ethanol, propanol and isopropanol, but the longer chain alcohols are immiscible.

How can the miscibility of an alcohol in water be increased without changing the number of carbon atoms in the alcohol?

To make an alcohol more soluble in water it needs to be more polar. If you decrease the structural order of the molecule by used a branched carbon chain instead (such as switching from 1-butanol to tert-butyl alcohol), the branched alcohol will be more soluble in water. Additionally, if you add more alcohol groups to the carbon chain, it will also be more soluble.

Is a solution of water and salt more or less polar than water alone? How does the addition of salt affect the solubility of isopropanol and propanol in water? Explain your answer by referencing the results in Data Table 2.

When you add salt (NaCl) to water, the ions Na^+ and Cl^- are formed in the solution, making it more polar. The increase in polarity reduces the solubility of propanol leading to it floating above the water in the test tube. Because isopropanol is a branched chain, it is already more polar, so in a salted solution it remains soluble in water.

Describe the interface between two insoluble liquids.

Between two insoluble liquids there is a section called the meniscus where the two layers touch. It has a shape of a U.

Why does methanol have a different solubility in oil vs water? Why does hexanol have a different solubility in oil vs water? Compare these results to those of isopropanol in oil vs water.

Methanol is soluble in water but not in oil because it is a more polar molecule with a short carbon chain. Hexanol has the opposite solubilities because it is a more nonpolar molecule with a long carbon chain. Isopropanol, by contrast, is intermediate enough in its polarity that it is able to dissolve in both oil and water, maximizing its attractive forces and minimizing its repulsive forces in either solvent.

Data Table 2: Miscibility of Alcohols in Water and Oil
(SAMPLE ANSWER BELOW)

Alcohol	Miscibility in Water	Miscibility in Oil
Methanol	Miscible	Immiscible
denatured Ethanol	Miscible	Immiscible
1-Propanol	Miscible	Miscible
1-Propanol with NaCl	Immiscible	
Isopropanol	Miscible	Immiscible
Isopropanol with NaCl	Miscible	
1-Butanol	Immiscible	Miscible
1-Pentanol	Immiscible	Miscible
1-Hexanol	Immiscible	Miscible
1-Octanol	Immiscible	Miscible

Panel 1: Miscibility of oil and water
(SAMPLE ANSWER BELOW)

The oil and water do not mix and are insoluble. The oil is yellow, and the water is clear. The oil is less dense and will be the top layer and water will be the bottom layer.

Panel 2: Salt effects of propanol and isopropanol miscibility in water
(SAMPLE ANSWER BELOW)

Both propanol and isopropanol are water soluble. Upon addition of salt to these test tubes, the salt will precipitate out at the bottom. The propanol will become insoluble and form 2 layers and the isopropanol will remain soluble.

Exercise 3

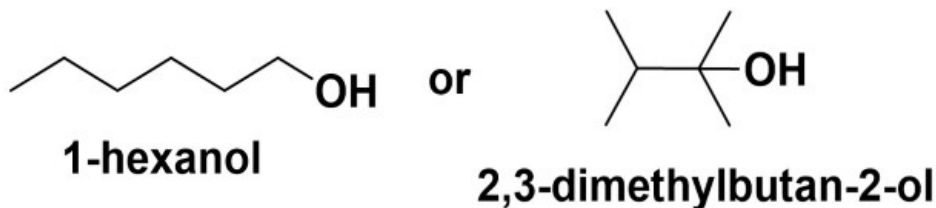
What are the three trends that increase the boiling point of an alcohol? Describe which of these trends were demonstrated by your results.

- 1) Increasing the carbon chain length
 - 2) Making the carbon chain more linear
 - 3) Adding more alcohol groups
- (1) was demonstrated in this lab

An ether is formed by the reaction of two alcohols and the loss of water. Why do ethers with the same molecular formulas as their respective alcohols have lower boiling points?

An ether with the same molecular formula as an alcohol will have a lower boiling point, because it cannot hydrogen bond with other ether molecules like an alcohol can.

Which of the illustrated compounds has the higher boiling point? Explain your answer by referencing the structure of each molecule.



These two alcohols have the same molecular formula, so the more structurally ordered (unbranched) 1-hexanol will have a higher boiling point.

Data Table 3: Boiling points of alcohols
(SAMPLE ANSWER BELOW)

Alcohol	Boiling Point (°C) (heating)	Boiling Point (°C) (cooling)
Ethanol	78.0	78.0
Isopropanol	82.0	82.0

Competency Review

For three alcohols with identical formulas, the ____ alcohol will have the highest boiling point.

- ☒ primary ✓
- ☐ secondary
- ☐ tertiary
- ☐ None of the above

An increase in hydrogen bond donors results in a(n) ____ in water solubility and a(n) ____ in boiling point.

- ☒ increase; increase ✓
- ☐ decrease; decrease
- ☐ increase; decrease
- ☐ decrease; increase

Increasing the chain length of an alcohol will make it more soluble in water.

- ☐ True
- ☒ False ✓

An interaction between the hydrogen from an alcohol and a lone pair on the oxygen of a water molecule is a repulsive force.

- ☐ True
- ☒ False ✓

The _____ is temperature at which a chemical changes from a liquid to a gas.

- ☐ freezing point
- ☒ boiling point ✓
- ☐ melting point
- ☐ sublimation

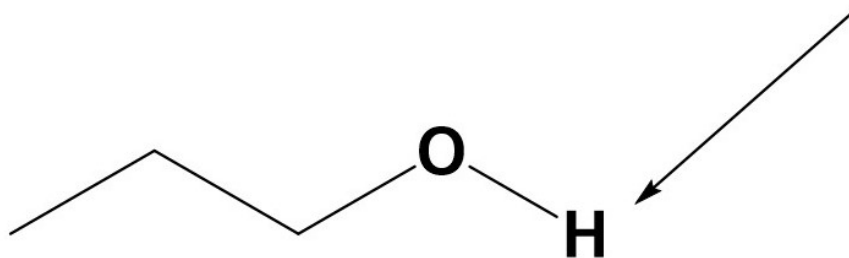
Methanol is soluble in water.

- ☒ True ✓
- ☐ False

The correct order of alcohols from most to least soluble in water is _____.

- ☐ ethanol, methanol, propanol, butanol
- ☐ propanol, ethanol, butanol, methanol
- ☒ methanol, ethanol, propanol, butanol ✓
- ☐ butanol, ethanol, methanol, propanol

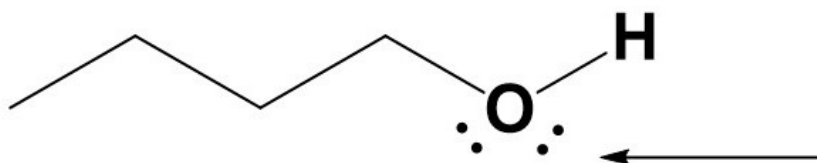
In the image of 1-propanol below, the arrow is pointing to an example of a(n) ____.



- ☐ hydrogen bond acceptor
- ☒ hydrogen bond donor
- ☐ ionic bond
- ☐ alkane

✓

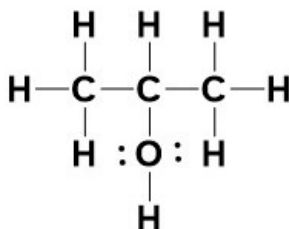
In the image of 1-butanol below, the arrow is pointing to an example of a(n) ____.



- ☒ hydrogen bond acceptor
- ☐ hydrogen bond donor
- ☐ ionic bond
- ☐ alkene

✓

The alcohol illustrated below is classified as a _____ alcohol.

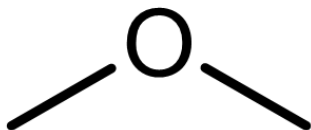


- ☐ primary alcohol
- ☒ secondary alcohol
- ☐ tertiary alcohol

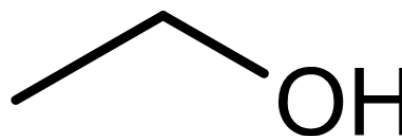
✓

Extension Questions

Ethanol, which was utilized in the experiments in Exercises 2 and 3, is a liquid with a moderately high boiling point. However, its isomer dimethyl ether is a gas at room temperature. Explain why these two sets of atoms with identical masses have such different properties.



dimethyl ether



ethanol

(SAMPLE ANSWER BELOW)

Despite having the same molecular weight, ethanol has hydrogen bonding, while dimethyl ether does not. Without the strong self-association of the hydrogen bonding that ethanol has, the dimethyl ether escapes liquid form.