

ORGANIC FUNCTIONAL GROUPS**ESSENTIALS: Know, Understand, and Be Able To...**

- Organic acids, alcohols, esters, aldehydes, ketones, ethers, halides, amines, amides, and amino acids are categories of organic compounds that differ in their structures.
- Functional groups impart distinctive physical and chemical properties to organic compounds.
- Isomers of organic compounds have the same molecular formula but different structures and properties.
- Classify an organic compound based on its structural or condensed structural formula.
$$\begin{array}{c} \text{O} \\ | \\ \text{(i.e., CH}_3\text{COOH or CH}_3\text{-C-OH)} \end{array}$$
- Draw a structural formula with the functional group(s) on a straight chain hydrocarbon backbone, when given the IUPAC name for the compound

TEXT REFERENCE: Alcohols & Ethers – p. 730 – 36
Aldehydes & Ketones – p. 737 – 740
Organic (Carboxylic) Acids & Esters – p. 740 - 743
Amines & Amides – no good text reference

EXPLORE

- Activity: Organic Functional Groups

ELABORATE

- Assignments

ENVISION

- Moodle Assignment

EVALUATE

- Quiz
- Quiz Corrections

Activity: Organic Functional Groups



Why?

The variety of "organic" (carbon based) compounds is huge. Chemists have organized compounds with similar properties into families. A particular molecule has its properties and belongs to the family it does because of a "functional group" of atoms in its structure. Because some of these families of compounds are so common, you should become familiar with how they are categorized.

Learning Objectives:

- Recognize the organic family, given the name, or the general, condensed or structural formula.
- Associate particular properties of organic compounds to their functional group.

SUCCESS will be Measured by YOUR Ability to:

- Match family to a given name, structure or formula.
- Compare molecules in the same family in terms of polarity, solubility in water, melting/boiling points, and vapor pressure.
- Identify which families contain molecules that are able to function as:
 - Electrolytes;
 - Proton Donors;
 - Proton Acceptors.

Prerequisites:

Mastery of Practice #1 - Introductory Assignment

Vocabulary:

- | | | |
|-----------|----------------|------------|
| • Alcohol | • Ether | • Aldehyde |
| • Ketone | • Organic Acid | • Amine |

Model 1: Alcohols and Table R

1. What is the functional group for a molecule categorized as an alcohol?
2. This group of atoms is called a "hydroxyl" group by chemists. Why don't you think it is called "hydroxide?"
3. Why aren't alcohols considered bases, whereas compounds like NaOH are?
4. Draw the structural formula of 1 - propanol:

Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	-F (fluoro-) -Cl (chloro-) -Br (bromo-) -I (iodo-)	R-X (X represents any halogen)	CH ₃ CHClCH ₃ 2-chloropropane
alcohol	-OH	R-OH	CH ₃ CH ₂ CH ₂ OH 1-propanol
ether	-O-	R-O-R'	CH ₃ OCH ₂ CH ₃ methyl ethyl ether
aldehyde	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{H} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{H} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{H} \end{array}$ propanal
ketone	$\begin{array}{c} \text{O} \\ \\ -\text{C}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{R}' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \end{array}$ 2-pentanone
organic acid	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{OH} \end{array}$ propanoic acid
ester	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{O}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{O}-\text{R}' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{O}-\text{CH}_3 \end{array}$ methyl propanoate
amine	$\begin{array}{c} \\ -\text{N}- \end{array}$	$\begin{array}{c} \text{R}' \\ \\ \text{R}-\text{N}-\text{R}'' \end{array}$	CH ₃ CH ₂ CH ₂ NH ₂ 1-propanamine
amide	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{NH} \end{array}$	$\begin{array}{c} \text{O} \quad \text{R}' \\ \quad \\ \text{R}-\text{C}-\text{NH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{NH}_2 \end{array}$ propanamide

R represents a bonded atom or group of atoms.

5. Circle the functional group on your drawing above. Put a box around the part of the molecule that could be referred to as "R."
6. Draw 2 - butanol:
7. Alcohol molecules with 4 or fewer carbon atoms are considered to be "polar molecules." Explain why.

Model 2: Ethers and Table R

1. What is the general formula for a molecule categorized as an ether?
2. An ether has the condensed formula of $\text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_3$.
 - a) What is its name?
 - b) Draw its structural formula:
3. The structure you drew above and the one in Question #6 under alcohols are "isomers" of each other. Explain why:

Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	-F (fluoro-) -Cl (chloro-) -Br (bromo-) -I (iodo-)	$R-X$ (X represents any halogen)	$\text{CH}_3\text{CHClCH}_3$ 2-chloropropane
alcohol	-OH	$R-OH$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ 1-propanol
ether	-O-	$R-O-R'$	$\text{CH}_3\text{OCH}_2\text{CH}_3$ methyl ethyl ether
aldehyde	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{H} \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-\text{H} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{H} \end{array}$ propanal
ketone	$\begin{array}{c} \text{O} \\ \\ -\text{C}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-R' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \end{array}$ 2-pentanone
organic acid	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{OH} \end{array}$ propanoic acid
ester	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{O}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-\text{O}-R' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{OCH}_3 \end{array}$ methyl propanoate
amine	$\begin{array}{c} \\ -\text{N}- \end{array}$	$\begin{array}{c} R' \\ \\ R-\text{N}-R'' \end{array}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ 1-propanamine
amide	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{NH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-\text{NH} \\ \\ R' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{NH}_2 \end{array}$ propanamide

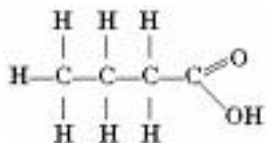
R represents a bonded atom or group of atoms.

Model 3: Aldehydes & Ketones and Table R

1. The functional group for aldehydes and ketones is the same, though its location along a chain of carbons is not. Draw the structure of the functional group for these two families:
2. Where is this functional group located on the carbon chain of an aldehyde?
3. Where is this functional group located on the carbon chain to be a ketone?
4. Draw "2 - pentanone" and "pentanal":

Model 4: Organic Acids and Table R

1. What is the functional group for an organic acid?
2. You know that acids are acids BECAUSE they produce H^{1+} ions when dissolved in water. So when an organic acid dissolves in water, what part of the functional group falls off? Circle it above.
3. When an organic acid dissolves in water, the resulting pH of the solution would be _____ (<7, >7 or = 7?).
4. What would be the name of the following organic acid? _____



** This acid smells horrible! Much like its name might suggest...

5. Circle the "H" that falls off the molecule above, and is responsible for its acidic properties.
6. Organic acids are the substances that cause many fruits and veggies to have sour tastes. The most common one is vinegar (made from grapes or apples). Its IUPAC name is "ethanoic acid." Draw its structural formula:
7. An alternate acid/base theory says that acids are "proton donors." An H atom with out its electron is an H^{1+} ion, so explain how this theory is NOT in conflict with our previous idea of acids.

Table R
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halide (halocarbon)	-F (fluoro-) -Cl (chloro-) -Br (bromo-) -I (iodo-)	$R-X$ (X represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	-OH	$R-OH$	$CH_3CH_2CH_2OH$ 1-propanol
ether	-O-	$R-O-R'$	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde	$\begin{array}{c} O \\ \\ -C-H \end{array}$	$\begin{array}{c} O \\ \\ R-C-H \end{array}$	$\begin{array}{c} O \\ \\ CH_3CH_2C-H \end{array}$ propanal
ketone	$\begin{array}{c} O \\ \\ -C- \end{array}$	$\begin{array}{c} O \\ \\ R-C-R' \end{array}$	$\begin{array}{c} O \\ \\ CH_3CCH_2CH_2CH_3 \end{array}$ 2-pentanone
organic acid	$\begin{array}{c} O \\ \\ -C-OH \end{array}$	$\begin{array}{c} O \\ \\ R-C-OH \end{array}$	$\begin{array}{c} O \\ \\ CH_3CH_2C-OH \end{array}$ propanoic acid
ester	$\begin{array}{c} O \\ \\ -C-O- \end{array}$	$\begin{array}{c} O \\ \\ R-C-O-R' \end{array}$	$\begin{array}{c} O \\ \\ CH_3CH_2COCH_3 \end{array}$ methyl propanoate
amine	$\begin{array}{c} \\ -N- \end{array}$	$\begin{array}{c} R' \\ \\ R-N-R'' \end{array}$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	$\begin{array}{c} O \\ \\ -C-NH \end{array}$	$\begin{array}{c} O & R' \\ & \\ R-C & -NH \end{array}$	$\begin{array}{c} O \\ \\ CH_3CH_2C-NH_2 \end{array}$ propanamide

R represents a bonded atom or group of atoms.

Model 5: Amines and Table R

1. Amines are derivatives of the compound "ammonia," which is NH_3 . Draw the Lewis dot diagram of NH_3 :

2. As described above, an acid can be considered a "proton donor." Conversely, a base can be a "proton acceptor." In other words, our understanding of what a base is can be expanded to include substances that have features that might attract an H^{1+} ion.

a) What can be seen on the Lewis dot structure of NH_3 that can attract an H^{1+} ion?

b) Look at Table L. Why is NH_3 listed here, even though it does not have an "-OH" ion in its formula?

3. Amines are often used as bases in organic reactions because they are not quite as "harsh" as Arrhenius bases like NaOH .

a) Draw the structural formula of methyl amine.

b) Circle the feature on the structure that is responsible for it being a "proton acceptor." Draw an H^{1+} ion near this feature and explain why it would be attracted.

Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	-F (fluoro-) -Cl (chloro-) -Br (bromo-) -I (iodo-)	$\text{R}-\text{X}$ (X represents any halogen)	$\text{CH}_3\text{CHClCH}_3$ 2-chloropropane
alcohol	-OH	$\text{R}-\text{OH}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ 1-propanol
ether	-O-	$\text{R}-\text{O}-\text{R}'$	$\text{CH}_3\text{OCH}_2\text{CH}_3$ methyl ethyl ether
aldehyde	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{H} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{H} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{H} \end{array}$ propanal
ketone	$\begin{array}{c} \text{O} \\ \\ -\text{C}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{R}' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \end{array}$ 2-pentanone
organic acid	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{OH} \end{array}$ propanoic acid
ester	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{O}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{O}-\text{R}' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{OCH}_3 \end{array}$ methyl propanoate
amine	$\begin{array}{c} \\ -\text{N}- \end{array}$	$\begin{array}{c} \text{R}' \\ \\ \text{R}-\text{N}-\text{R}'' \end{array}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ 1-propanamine
amide	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{NH} \end{array}$	$\begin{array}{c} \text{O} \quad \text{R}' \\ \quad \\ \text{R}-\text{C}-\text{NH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{NH}_2 \end{array}$ propanamide

R represents a bonded atom or group of atoms.

Essential Questions:

1. The most commonly used ketone is nail polish remover, acetone. Its IUPAC name is "propanone." Draw its structure.
2. Organic molecules tend to be "nonpolar." Explain what it means to be a nonpolar molecule:
3. Since organic molecules tend to be nonpolar, will they tend to be soluble in water, or insoluble?
4. Look at Table H.
 - a) What is the normal boiling point temperature of:
Ethanoic acid: _____
Water: _____
 - b) What does comparing these temperatures imply about the strength of intermolecular attractions? Which substance has stronger attractions?
5. Water molecules attract using hydrogen bonds. Write "YES" on the line for families that use hydrogen bond attractions as well:
 - a) Alcohols? _____
 - b) Ethers? _____
 - c) Aldehydes? _____
 - d) Ketones? _____
 - e) Organic Acids? _____
 - f) Amines? _____

Assignment: Classifying Organic Compounds



Classify each structural formula according to the family it belongs to.



1. $\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H} - \text{C} - \text{C} - \text{OH} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	6. $\begin{array}{c} \text{H} \quad \text{O} \quad \text{H} \\ \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{O} - \text{C} - \text{H} \\ \quad \quad \\ \text{H} \quad \quad \text{H} \end{array}$
2. $\begin{array}{c} \text{H} \quad \text{O} \quad \text{H} \\ \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \\ \text{H} \quad \quad \text{H} \end{array}$	7. $\begin{array}{c} \text{H} \quad \text{OH} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$
3. $\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array}$	8. $\begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{OH} \\ \quad \\ \text{H} \quad \text{H} \end{array}$
4. $\begin{array}{c} \text{H} \quad \text{O} \\ \quad \\ \text{H} - \text{C} - \text{C} - \text{OH} \\ \\ \text{H} \end{array}$	9. $\begin{array}{c} \text{H} \quad \text{O} \\ \quad \\ \text{H} - \text{C} - \text{C} - \text{H} \\ \\ \text{H} \end{array}$
5. $\begin{array}{c} \text{H} \quad \quad \text{H} \\ \quad \quad \\ \text{H} - \text{C} - \text{O} - \text{C} - \text{H} \\ \quad \quad \\ \text{H} \quad \quad \text{H} \end{array}$	10. $\begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \quad \text{H} \\ \quad \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \quad \text{H} \end{array}$

Assignment: Classifying Organic Compounds



Classify each of the organic compounds below as an alcohol, carboxylic acid, aldehyde, ketone, ether or ester, and draw its structural formula.

1. CH_3COOH	6. $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
2. CH_3COCH_3	7. $\text{CH}_3\text{CH}_2\text{COOH}$
3. $\text{CH}_3\text{CH}_2\text{OH}$	8. $\text{CH}_3\text{CH}_2\text{COOCH}_3$
4. $\text{CH}_3\text{CH}_2\text{OCH}_3$	9. $\text{CH}_3\text{CH}_2\text{COCH}_3$
5. $\text{CH}_3\text{CH}_2\text{CHO}$	10. CH_3OCH_3

Assignment: Drawing from a Name



Use the IUPAC names below and Table R in order to draw the structure of each. Classify each by family first, then draw!

1. 1-pentanol

2. 2-pentanone

3. ethyl butyl ether

4. heptanal

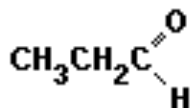
5. propanoic acid

6. methyl hexanate

7. 1-octanamine

8. butanamide

Assignment: Topic 2 Drill

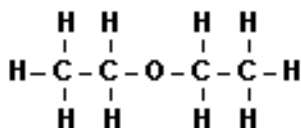


1. Which type of compound is represented by the structural formula shown above?

1. an ester
2. an ether
3. an aldehyde
4. an acid

2. Which formula represents an organic acid?

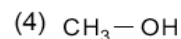
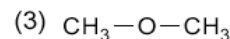
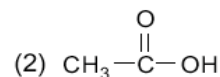
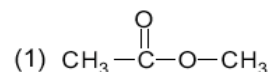
1. CH_3COOH
2. CH_3CHO
3. CH_3COCH_3
4. CH_3OH



3. Which type of compound is represented by the structural formula shown above?

1. a ketone
2. an aldehyde
3. an ester
4. an ether

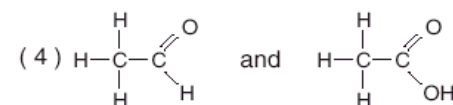
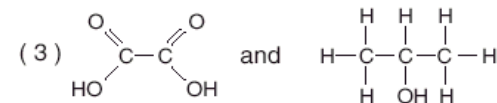
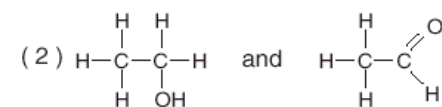
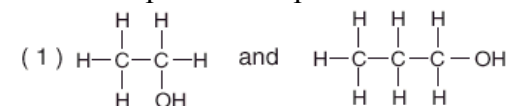
4. Which formula represents an ether?



5. Which compounds are isomers of each other?

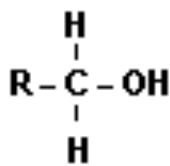
1. CH_3OH and $\text{CH}_3\text{CH}_2\text{OH}$
2. CH_4 and CCl_4
3. $\text{CH}_3\text{CH}_2\text{CHO}$ and CH_3COCH_3
4. $\text{CH}_3\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}_2\text{COOH}$

6. Which pair of compounds are alcohols?



7. Which organic compounds are often used to create fragrances for the perfume industry?

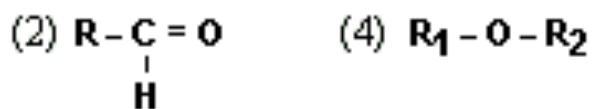
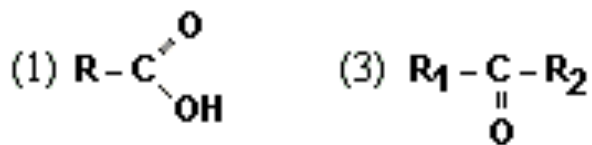
1. ethers
2. esters
3. alkanes
4. alkynes



8. In the molecule represented by the formula in the diagram, R could be

1. CH
2. CH₂
3. CH₃
4. CH₄

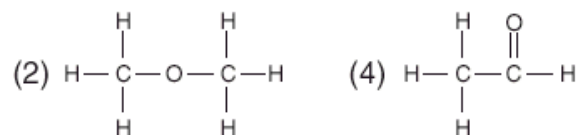
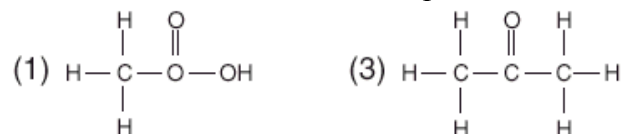
9. Which general formula represents a ketone?



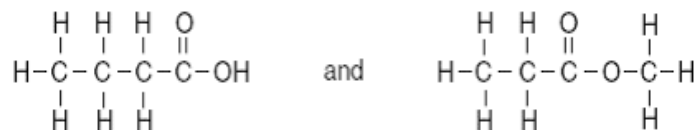
10. Which is the general formula for organic acids?



11. Which structural formula represents an ether?

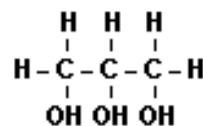


12. Given the structural formulas for two organic compounds:



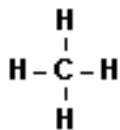
The differences in their physical and chemical properties are primarily due to their different

1. number of carbon atoms
2. number of hydrogen atoms
3. molecular masses
4. functional group



13. Which type of compound is represented by the structural formula shown in the diagram?

1. an alcohol
2. an acid
3. an ester
4. a hydrocarbon



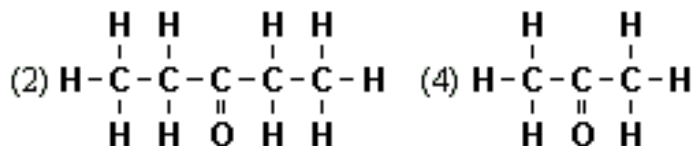
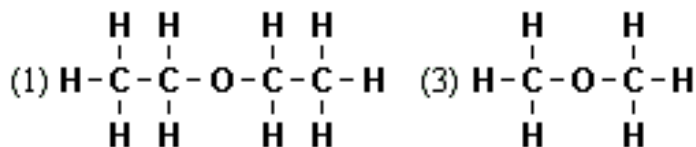
14. Replacing a hydrogen atom on the molecule shown in the diagram with the functional group $-\text{OH}$ will change the original properties of the molecule to those of an

1. ester
2. ether
3. acid
4. alcohol

15. Which compound is an ester?

1. CH_3OH
2. CH_3OCH_3
3. CH_3COOH
4. $\text{CH}_3\text{COOCH}_3$

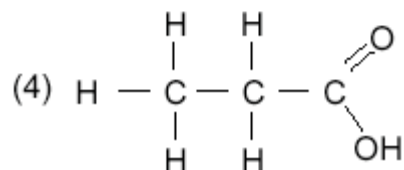
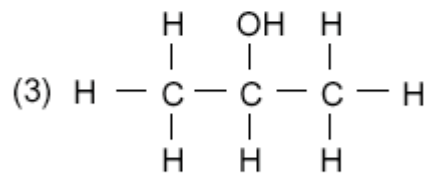
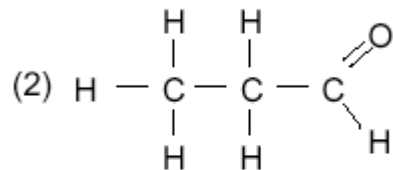
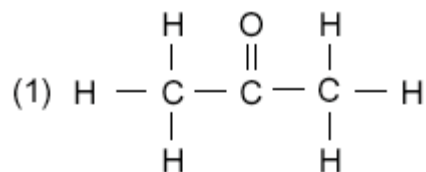
16. Which is the structural formula for diethyl ether?



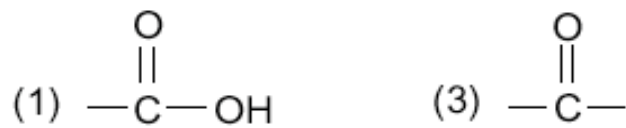
17. Which compound is classified as a hydrocarbon?

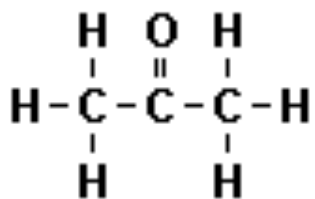
1. ethane
2. ethanol
3. chloroethane
4. ethanoic acid

18. Which structural formula represents an isomer of 1-propanol?



19. Which functional group, when attached to a chain of carbon atoms, will produce an organic molecule with the characteristic properties of an aldehyde?

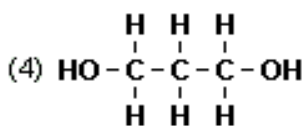
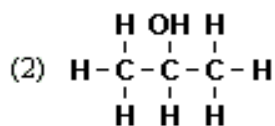
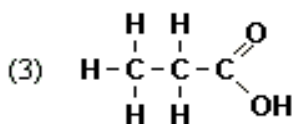
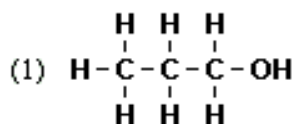




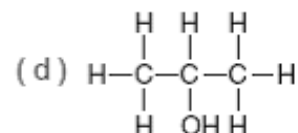
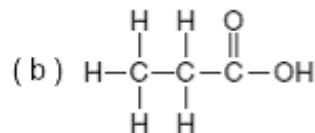
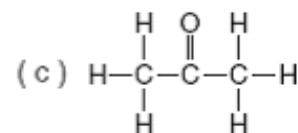
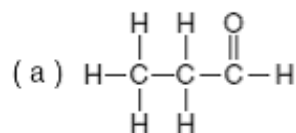
20. What is the name of the compound with the formula shown in the diagram?

1. propanone
2. propanol
3. propanal
4. propanoic acid

21. Which structural formula represents an organic acid?



22. Given the formulas of four organic compounds:



Which pair below contains an alcohol and an acid?

1. *a* and *b*
2. *a* and *c*
3. *b* and *d*
4. *c* and *d*