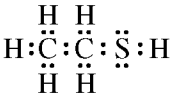
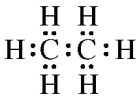
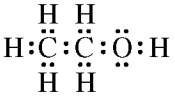
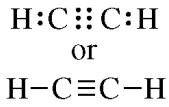
AP® CHEMISTRY
2010 SCORING GUIDELINES

Question 5
(8 points)

Use the information in the table below to respond to the statements and questions that follow. Your answers should be in terms of principles of molecular structure and intermolecular forces.

Compound	Formula	Lewis Electron-Dot Diagram
Ethanethiol	CH_3CH_2SH	
Ethane	CH_3CH_3	
Ethanol	CH_3CH_2OH	
Ethyne	C_2H_2	 or

(a) Draw the complete Lewis electron-dot diagram for ethyne in the appropriate cell in the table above.

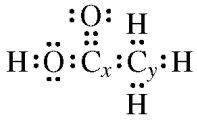
See the lower right cell in the table above.	One point is earned for the correct Lewis structure.

(b)Which of the four molecules contains the shortest carbon-to-carbon bond? Explain.

Ethyne, which contains a triple bond, has the shortest C-to-C bond. The other molecules have single C-to-C bonds, and triple bonds are shorter than single bonds.	One point is earned for the correct choice. One point is earned for the correct explanation.

Question 5 (continued)

(c) A Lewis electron-dot diagram of a molecule of ethanoic acid is given below. The carbon atoms in the molecule are labeled *x* and *y*, respectively.



Identify the geometry of the arrangement of atoms bonded to each of the following.

(i) Carbon *x*

Trigonal planar	One point is earned for the correct geometry.

(ii) Carbon *y*

Distorted tetrahedral, tetrahedral or trigonal pyramidal	One point is earned for the correct geometry.

(d) Energy is required to boil ethanol. Consider the statement "As ethanol boils, energy goes into breaking C−C bonds, C−H bonds, C−O bonds, and O−H bonds." Is the statement true or false? Justify your answer.

The statement is false. All of the bonds described are intramolecular; these bonds are not broken during vaporization. When ethanol boils, the added energy overcomes intermolecular, not intramolecular, forces.	One point is earned for the correct choice with justification.

(e) Identify a compound from the table above that is nonpolar. Justify your answer.

Either ethane or ethyne may be identified as nonpolar. The ethane/ethyne molecule is nonpolar because all of the bond dipoles in the molecule cancel. ***OR*** The ethane/ethyne molecule is nonpolar because the molecule is symmetric. Note: Explanation must refer to the shape of the molecule. Statements such as: "all hydrocarbons are nonpolar', "the carbons are surrounded by hydrogens" or "there are no lone pairs" do not earn this point.	One point is earned for a correct choice with justification.

Question 5 (continued)

(f) Ethanol is completely soluble in water, whereas ethanethiol has limited solubility in water. Account for the difference in solubilities between the two compounds in terms of intermolecular forces.

Ethanol is able to form strong hydrogen bonds with water whereas ethanethiol does not have similar capability. The formation of hydrogen bonds increases the attraction between molecules of ethanol and molecules of water, making them more soluble in each other. Note: The answer must clearly focus on the solute-solvent interaction. Just the mention of hydrogen bonding does not earn the point.	One point is earned for the correct explanation.