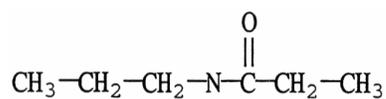


**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

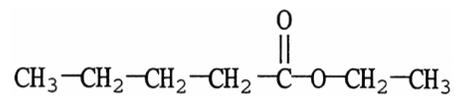
1) Which molecule is a carboxylic acid?

1) \_\_\_\_\_

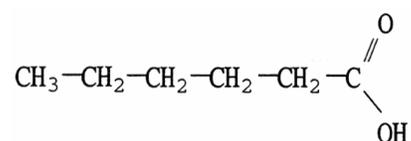
A)



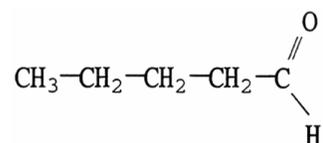
B)



C)



D)

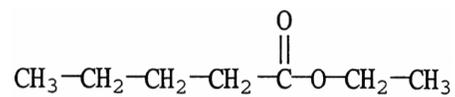


E)  $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NH}_2$

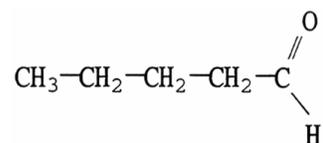
2) Which molecule is an ester?

2) \_\_\_\_\_

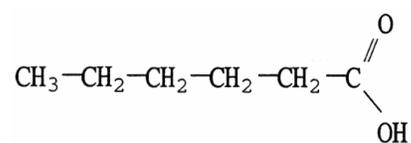
A)



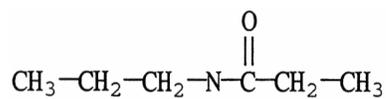
B)



C)



D)



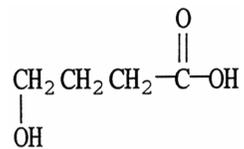
E)  $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{NH}_2$



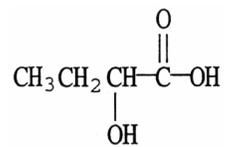
6) Which molecule shown is  $\beta$ -hydroxy butyric acid?

6) \_\_\_\_\_

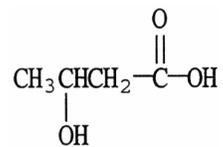
A)



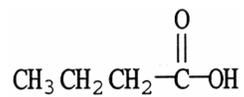
B)



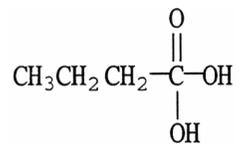
C)



D)



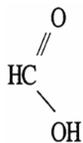
E)



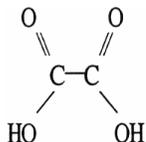
7) Which molecule is formic acid?

7) \_\_\_\_\_

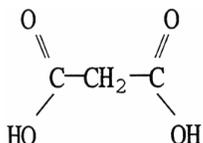
A)



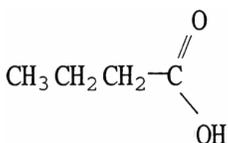
B)



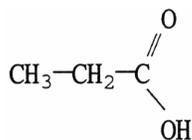
C)



D)



E)



8) All of the statements concerning citric acid are true **except**

8) \_\_\_\_\_

- A) It is produced only by plants.
- B) It contains three carboxylic acid groups because its carbon skeleton is branched.
- C) Its salts are used in many consumer products.
- D) It is a weak acid.
- E) It is very soluble in water.

9) Which of the following bonds is **not** present in a carboxylic acid functional group?

9) \_\_\_\_\_

- A) O-H
- B) C-O
- C) C=O
- D) C=C
- E) none of the above

10) Which compound is a carboxylic acid?

10) \_\_\_\_\_

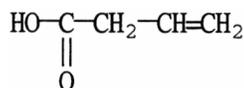
- A)  $\text{CH}_3\text{COOH}$
- B)  $(\text{CH}_3\text{CO})_2\text{O}$
- C)  $(\text{CH}_3)_2\text{CHOOCH}_3$
- D)  $\text{CH}_3\text{COO}^-\text{K}^+$
- E)  $(\text{CH}_3)_2\text{O}$

11) All of the statements about carboxylic acids are true **except** 11) \_\_\_\_\_  
A) At low molecular weights they are liquids with sharp stinging odors.  
B) When they behave as acids, the -OH group is lost leaving the CO<sup>-</sup> ion.  
C) They react with bases to form salts which are often more soluble than the original acid.  
D) They undergo substitution reactions involving the -OH group.  
E) They form hydrogen bonds, causing their boiling points to be higher than expected on the basis of molecular weight.

12) Which acid would be expected to have the **lowest** boiling point? 12) \_\_\_\_\_  
A) stearic, CH<sub>3</sub>(CH<sub>2</sub>)<sub>16</sub>CO<sub>2</sub>H  
B) acetic, CH<sub>3</sub>CO<sub>2</sub>H  
C) benzoic, C<sub>6</sub>H<sub>5</sub>CO<sub>2</sub>H  
D) oxalic, (CO<sub>2</sub>H)<sub>2</sub>  
E) formic, HCO<sub>2</sub>H

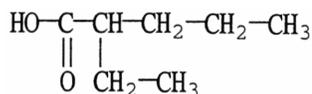
13) Which acid would be expected to have the **highest** boiling point? 13) \_\_\_\_\_  
A) oxalic, (CO<sub>2</sub>H)<sub>2</sub>  
B) benzoic, C<sub>6</sub>H<sub>5</sub>CO<sub>2</sub>H  
C) stearic, CH<sub>3</sub>(CH<sub>2</sub>)<sub>16</sub>CO<sub>2</sub>H  
D) acetic, CH<sub>3</sub>CO<sub>2</sub>H  
E) formic, HCO<sub>2</sub>H

14) What is the IUPAC name of the compound shown? 14) \_\_\_\_\_



- A) 4-butanoic acid
- B) 1-butenic acid
- C) 3-butenic acid
- D) 1-butanoic acid
- E) none of the above

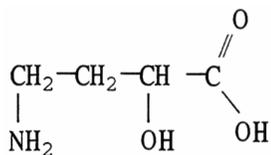
15) What is the IUPAC name of the compound shown? 15) \_\_\_\_\_



- A) 2-ethyl pentanoate
- B) 2-ethylpentanoic acid
- C) 3-hexanoic acid
- D) 4-heptanoic acid
- E) 3-heptanoic acid

16) What is the **common** name of the molecule shown?

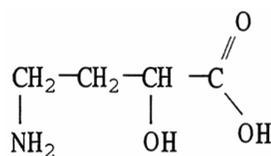
16) \_\_\_\_\_



- A) 4-amino-2-hydroxybutanoic acid
- B)  $\alpha$ -amino- $\gamma$ -hydroxybutyric acid
- C)  $\gamma$ -amino- $\alpha$ -hydroxybutyric acid
- D) 1-amino-3-hydroxybutanoic acid
- E) none of these

17) What is the **IUPAC** name of the molecule shown?

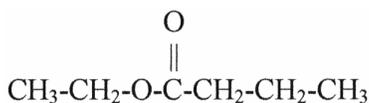
17) \_\_\_\_\_



- A)  $\gamma$ -amino- $\alpha$ -hydroxybutyric acid
- B) 4-amino-2-hydroxybutanoic acid
- C) 1-amino-3-hydroxybutanoic acid
- D)  $\alpha$ -amino- $\gamma$ -hydroxybutyric acid
- E) none of these

18) What is the **IUPAC** name of the molecule shown?

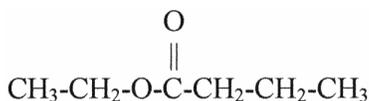
18) \_\_\_\_\_



- A) acetyl butyrate
- B) butyl acetate
- C) butyl ethanoate
- D) 2-hexanoic ester
- E) ethyl butanoate

19) What is the **common** name of the molecule shown?

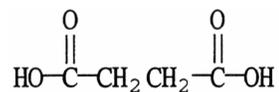
19) \_\_\_\_\_



- A) 2-hexanoic ester
- B) butyl ethanoate
- C) ethyl butanoate
- D) ethyl butyrate
- E) butyl acetate

20) What is the IUPAC name of the molecule shown?

20) \_\_\_\_\_



- A) ethanedioic
- B) diethanoic acid
- C) dibutanoic acid
- D) pentanedioic acid
- E) butanedioic acid

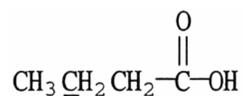
21) An acyl group is a group in which

21) \_\_\_\_\_

- A) a hydroxyl and an alkene are bonded to the same carbon atom.
- B) an amine and a carbonyl are bonded to the same carbon atom.
- C) an alpha carbon is bonded to an alkyl group.
- D) an acidic group is bonded to an aromatic group.
- E) an alkyl group is bonded to a carbonyl carbon atom.

22) When common names are used for acids, the underlined carbon atom in the molecule shown would be designated as the \_\_\_\_\_ C atom.

22) \_\_\_\_\_

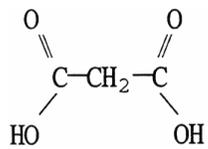


- A) gamma                      B) alpha                      C) #2                      D) beta                      E) #1

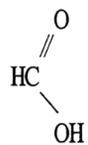
23) Which molecule is acetic acid?

23) \_\_\_\_\_

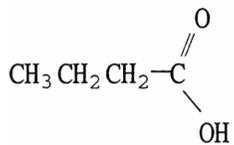
A)



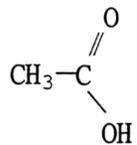
B)



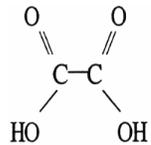
C)



D)



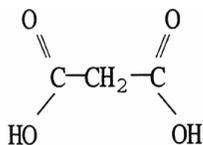
E)



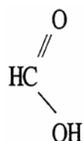
24) Which molecule is oxalic acid?

24) \_\_\_\_\_

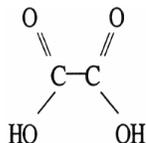
A)



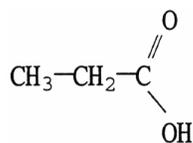
B)



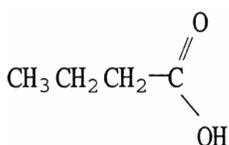
C)



D)

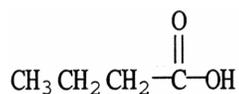


E)



25) What is the common name of the molecule shown?

25) \_\_\_\_\_



- A) formic acid
- B) oxalic acid
- C) lactic acid
- D) butyric acid
- E) acetic acid

26) Which acid would be expected to have the **lowest** boiling point?

26) \_\_\_\_\_

- A) benzoic
- B) formic
- C) stearic
- D) oxalic
- E) acetic

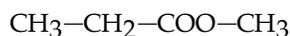
27) Which acid would be expected to have the **highest** boiling point?

27) \_\_\_\_\_

- A) stearic
- B) acetic
- C) formic
- D) oxalic
- E) benzoic

28) What is the IUPAC name of the compound shown?

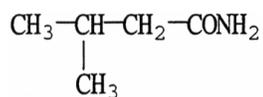
28) \_\_\_\_\_



- A) methyl propanoate
- B) methyl ethanoate
- C) propyl methanoate
- D) 3-butanoic acid
- E) 2-butanoic acid

29) What is the IUPAC name of the compound shown?

29) \_\_\_\_\_



- A) 2-methyl propanamide
- B) 3-methyl butanamide
- C) N-methyl propanamide
- D) N-methyl butanamide
- E) 2-methyl butanamide

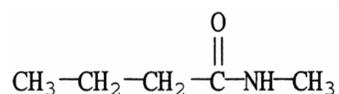
30) An alpha hydroxy carboxylic acid has an additional -OH group attached to the molecule at which location?

30) \_\_\_\_\_

- A) the carbon atom that contains the amine group
- B) the carbon atom farthest from the carboxyl group
- C) the #2 carbon atom
- D) the carbonyl carbon atom
- E) none of the above

31) What is the IUPAC name of the compound shown?

31) \_\_\_\_\_



- A) N-butylethanamide
- B) N-methylpropanamide
- C) N-butylformamide
- D) N-methylbutanamide
- E) 1-methylpropanamide

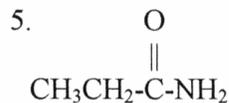
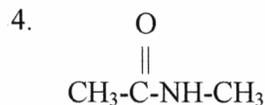
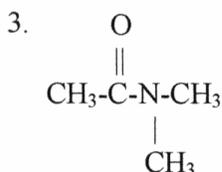
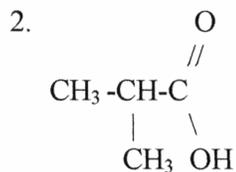
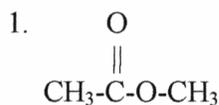
32) Carboxylic acids generally taste \_\_\_\_\_.

32) \_\_\_\_\_

- A) spicy
- B) sweet
- C) salty
- D) sour
- E) bitter

**SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.**

- 33) Which of the compounds shown can form hydrogen bonds with other identical molecules? 33) \_\_\_\_\_  
Explain each case.

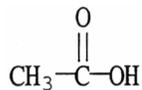


**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

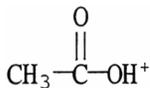
- 34) The solubility of compounds containing the carboxylic acid group can be increased by reaction with \_\_\_\_\_ 34) \_\_\_\_\_  
A) nitric acid.  
B) sodium hydroxide.  
C) water.  
D) sulfuric acid.  
E) benzoic acid.
- 35) Which equation correctly represents the dissociation of a carboxylic acid in water? 35) \_\_\_\_\_  
A)  $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{CHCOOH}_2^+ + \text{OH}^-$   
B)  $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$   
C)  $\text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}^+$   
D)  $\text{CH}_3\text{COOH} + 2 \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^{2-} + 2 \text{H}_3\text{O}^+$   
E)  $\text{CH}_3\text{COOH} + \text{H}_3\text{O}^+ \rightleftharpoons \text{CH}_3\text{COOH}_2^+ + \text{H}_2\text{O}$
- 36) The ion formed from a carboxylic acid is called the \_\_\_\_\_ 36) \_\_\_\_\_  
A) amide cation.  
B) carboxylate anion.  
C) ester anion.  
D) ester cation.  
E) carboxylate cation.

37) Which formula correctly illustrates the form which acetic acid would take in a basic solution? 37) \_\_\_\_\_

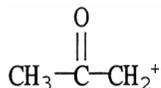
A)



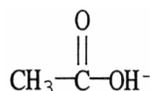
B)



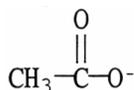
C)



D)



E)



38) Reaction of a carboxylic acid with a base like sodium hydroxide, NaOH gives \_\_\_\_\_ 38) \_\_\_\_\_

A) an alkoxide salt.

B) an ester.

C) an alcohol.

D) a carboxylate salt.

E) none of the above.

39) In the production of an ester, the carboxylic acid loses which atom or group of atoms? 39) \_\_\_\_\_

A) the entire  $-\text{COOH}$  group

B) oxygen from the  $-\text{OH}$

C) H from the  $-\text{OH}$  group

D) the  $-\text{OH}$  group

E) oxygen from the  $-\text{C}=\text{O}$

40) When an alcohol reacts with a carboxylic acid the major product is \_\_\_\_\_ 40) \_\_\_\_\_

A) a soap.

B) an amine.

C) a salt.

D) an ester.

E) an amide.

41) Reaction of butanoic acid with ethanol produces \_\_\_\_\_ 41) \_\_\_\_\_

A) ethyl butanoate.

B) butyl ethyl ester.

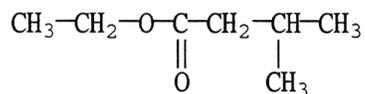
C) butyl ethanoate.

D) ethyl butanamide.

E) butyl ethanamide.

42) Which carboxylic acid is used to prepare the ester shown?

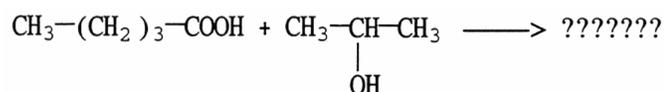
42) \_\_\_\_\_



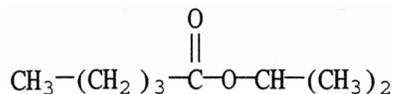
- A)  $\text{CH}_3\text{---}(\text{CH}_2)_3\text{---COOH}$
- B)  $\text{CH}_3\text{---CH}_2\text{---COOH}$
- C)  $\text{CH}_3\text{---COOH}$
- D)  $(\text{CH}_3)_2\text{---CH---COOH}$
- E)  $(\text{CH}_3)_2\text{---CH---CH}_2\text{---COOH}$

43) What is the major organic product of the reaction shown?

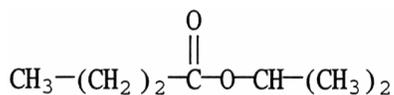
43) \_\_\_\_\_



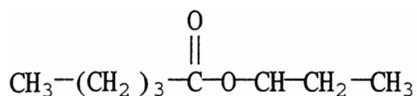
A)



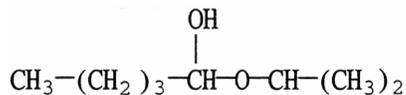
B)



C)



D)



E)  $\text{CH}_3\text{---}(\text{CH}_2)_3\text{---O---CH}_2\text{---O---CH---}(\text{CH}_3)_2$

44) When an amine reacts with a carboxylic acid at high temperature the major product is

44) \_\_\_\_\_

- A) an ether.
- B) an ester.
- C) an alcohol.
- D) an amide.
- E) a thiol.

45) The common chemical name of aspirin is

45) \_\_\_\_\_

- A) acetylsalicylic acid.
- B) phenylalanyl aspartic acid.
- C) acetamide.
- D) acetaminophen.
- E) lidocaine.

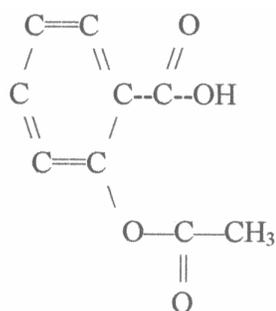
46) The reactants needed to produce simple polyamides (nylons) are 46) \_\_\_\_\_

A) diacids and phosphates.  
 B) diacids and diamines  
 C) diacids and dialcohols.  
 D) alkenes and catalysts.  
 E) diamines and dialcohols.

47) The reactants needed to produce simple polyesters are 47) \_\_\_\_\_

A) diacids and phosphates.  
 B) diacids and diamines  
 C) diacids and dialcohols.  
 D) diamines and dialcohols.  
 E) alkenes and catalysts.

48) The functional groups in the aspirin molecule shown are 48) \_\_\_\_\_



- A) aromatic, carboxylic acid, ester  
 B) aromatic, ester  
 C) aromatic, carboxylic acid  
 D) carboxylic acid, ester  
 E) amide, aromatic, carboxylic acid

49) One requirement for the reactants in the formation of polyester is that each molecule contain 49) \_\_\_\_\_

A) an amine group somewhere on the carbon skeleton.  
 B) one aromatic ring.  
 C) at least one carbon-carbon double bond.  
 D) at least two functional groups that can form ester linkages.  
 E) none of these

50) The products of acid hydrolysis of an ester are 50) \_\_\_\_\_

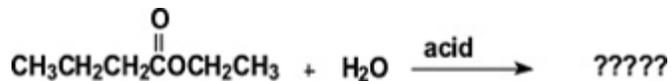
A) another ester + water.  
 B) alcohol + acid.  
 C) acid + water.  
 D) salt + water.  
 E) alcohol + water.

51) The products of basic hydrolysis of an ester are 51) \_\_\_\_\_

A) alcohol + water.  
 B) carboxylate salt + alcohol.  
 C) another ester + water.  
 D) alcohol + acid.  
 E) acid + water.

52) What are the major organic products of the reaction shown?

52) \_\_\_\_\_



- A)  $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{OH} + \text{CH}_3\text{—CH}_2\text{OH}$
- B)  $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—COO}^- + \text{H}_2\text{+O—CH}_2\text{—CH}_3$
- C)  $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—COOH} + \text{HO—CH}_2\text{—CH}_3$
- D)  $\text{CH}_3\text{—COOH} + \text{HO—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_3$
- E)  $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—COOH} + \text{CH}_3\text{—COOH}$

53) Reaction of an ester with a strong base is called

53) \_\_\_\_\_

- A) esterification.
- B) oxidation.
- C) saponification.
- D) condensation.
- E) reverse esterification.

54) Hydrolysis of the ester ethyl acetate produces \_\_\_\_\_

54) \_\_\_\_\_

- A) butanal and ethanol.
- B) butanol.
- C) butanoic acid.
- D) ethanol and acetic acid.
- E) ethanal and acetic acid.

55) The potassium or sodium salt of a long chain carboxylic acid is called a

55) \_\_\_\_\_

- A) emollient.
- B) soap.
- C) ester.
- D) triglyceride.
- E) none of the above

56) Hydrolysis of a carboxylic acid ester using base is called \_\_\_\_\_.

56) \_\_\_\_\_

- A) saponification
- B) detoxification
- C) extraction.
- D) alcoholysis
- E) decarboxylation

57) When an alcohol reacts with phosphoric acid, the product is referred to as a

57) \_\_\_\_\_

- A) phosphate anion.
- B) phosphate salt.
- C) phosphate ester.
- D) pyrophosphate.
- E) none of the above

- 58) Nylons and proteins are both referred to as polyamides because 58) \_\_\_\_\_
- A) each reactant molecule contains an amide group.
  - B) they are produced by basic hydrolysis of an amine.
  - C) they are formed when an acid functional group reacts with an amine functional group.
  - D) they are produced by reaction between an amide and an ester.
  - E) they are formed when an acid reacts with ammonia.

**MATCHING. Choose the item in column 2 that best matches each item in column 1.**

*Match the following.*

- |                         |  |           |
|-------------------------|--|-----------|
| 59) ethanoic acid       | A) the type of ester produced when phosphoric acid reacts with three molecules of alcohol  | 59) _____ |
| 60) amide group         |  | 60) _____ |
| 61) methanoic acid      | B) The common name of this compound is acetic acid.  | 61) _____ |
| 62) ester               | C) a functional group formed when two acid molecules give up one water molecule  | 62) _____ |
| 63) acid anhydride      |  | 63) _____ |
| 64) alpha carbon        | D) the carbon atom bonded directly to the carbonyl carbon atom   | 64) _____ |
| 65) nylon               | E) a polymer produced by reacting diamines with diacids or diacyl chlorides  | 65) _____ |
| 66) phosphate triester  |  | 66) _____ |
| 67) phosphate monoester | F) a functional group consisting of an amine group bonded to a carbonyl carbon   | 67) _____ |
| 68) triphosphate        | G) a molecule that contains one phosphate ester linkage and two phosphoric anhydride linkages  | 68) _____ |
|                         | H) The common name of this compound is formic acid.  |           |
|                         | I) a functional group consisting of a carbonyl carbon with a single bond to another oxygen; the remaining bonds are formed with R groups |           |
|                         | J) the type of ester produced when phosphoric acid reacts with one molecule of alcohol   |           |

69) diphosphate

A) a molecule that contains one phosphate ester linkage and one phosphoric anhydride linkage

69) \_\_\_\_\_

70) phosphorylation

B) the type of ester produced when phosphoric acid reacts with two molecules of alcohol

70) \_\_\_\_\_

71) phosphate diester

C) the transfer of a phosphoryl group from one molecule to another

71) \_\_\_\_\_

## Answer Key

Testname: UNTITLED1

- 1) C
- 2) A
- 3) D
- 4) D
- 5) E
- 6) C
- 7) A
- 8) A
- 9) D
- 10) A
- 11) B
- 12) E
- 13) C
- 14) C
- 15) B
- 16) C
- 17) B
- 18) E
- 19) D
- 20) E
- 21) E
- 22) D
- 23) D
- 24) C
- 25) D
- 26) B
- 27) A
- 28) A
- 29) B
- 30) C
- 31) D
- 32) D

33) Molecules 2, 4, and 5 can form hydrogen bonds. In each case there is at least one hydrogen atom bonded to oxygen or nitrogen. This causes the hydrogen atom to become polarized resulting in  $\delta+$  and  $\delta-$  portions of each molecule so that hydrogen bonds can form. In the ester and the tertiary amide, #1 and #3, the functional groups are very polar, but there is no  $\delta+$  charge.

- 34) B
- 35) B
- 36) B
- 37) E
- 38) D
- 39) D
- 40) D
- 41) A
- 42) E
- 43) A
- 44) D
- 45) A
- 46) B
- 47) C

## Answer Key

Testname: UNTITLED1

- 48) A
- 49) D
- 50) B
- 51) B
- 52) C
- 53) C
- 54) D
- 55) B
- 56) A
- 57) C
- 58) C
- 59) B
- 60) F
- 61) H
- 62) I
- 63) C
- 64) D
- 65) E
- 66) A
- 67) J
- 68) G
- 69) A
- 70) C
- 71) B