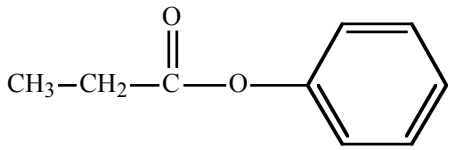
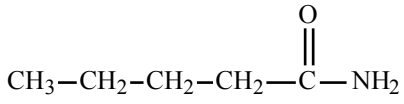
CHAPTER 12: ANSWERS TO SELECTED PROBLEMS

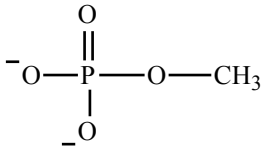
SAMPLE PROBLEMS ("Try it yourself")

12.1 $CH_3–CH_2–CH_2–O–CH_2–CH_2–CH_3$

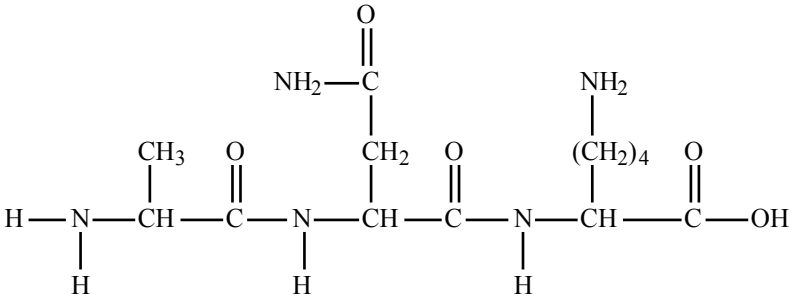
12.2 $CH_3–CH_2–CH_2–CH_2–O–CH_2–CH_2–CH_2–CH_3$

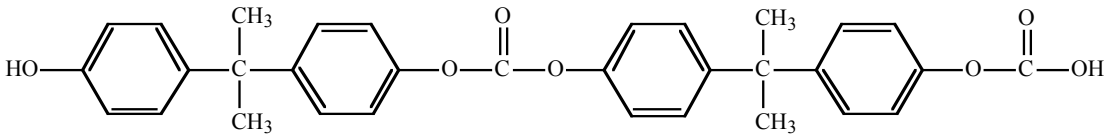
12.3 

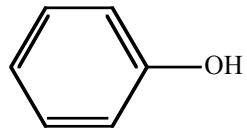
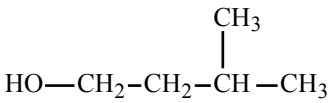
12.4 

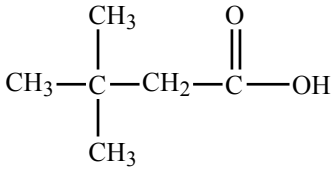
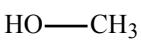
12.5 

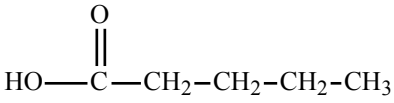
12.6 $HO–CH_2–CH_2–CH_2–O–CH_2–CH_2–CH_2–O–CH_2–CH_2–CH_2–OH$

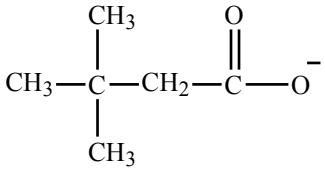
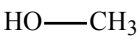
12.7 

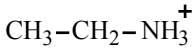
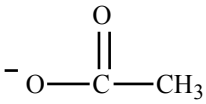
12.8 

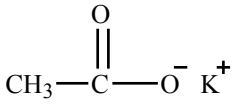
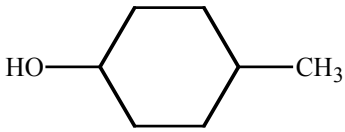
12.9  and 

12.10  and 

12.11 NH_3 and 

12.12  and 

12.13  and 

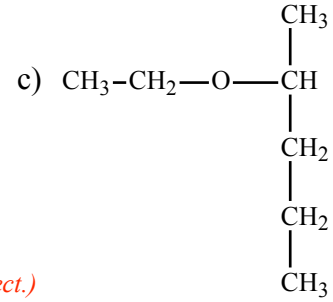
12.14  and 

SECTION PROBLEMS

Section 12.1

12.1 a) $CH_3–CH_2–O–CH_2–CH_2–CH_2–CH_3$

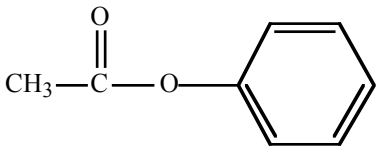
b) $CH_3–CH_2–CH_2–O–CH_2–CH_2–CH_3$

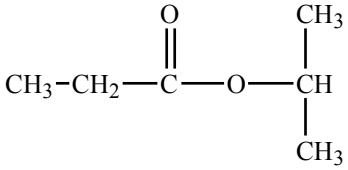
c) 

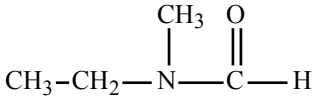
(Note that usually there are several ways to draw the product of a condensation reaction, depending on how you orient the reactants. Your answers may look somewhat different from mine, but still be correct.)

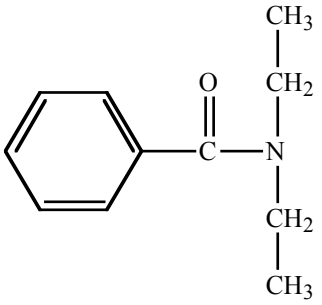
12.2 a) ethyl pentyl ether b) dimethyl ether

Section 12.2

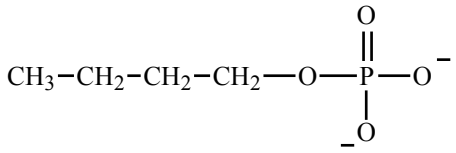
12.3 a) 

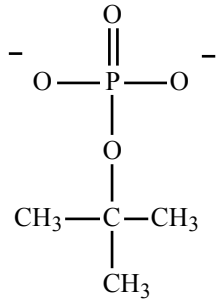
b) 

12.4 a) 

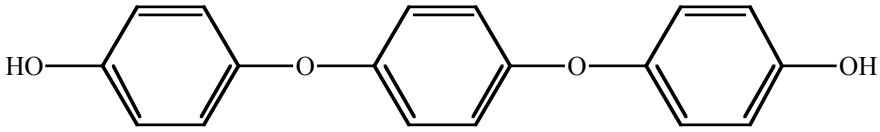
b) 

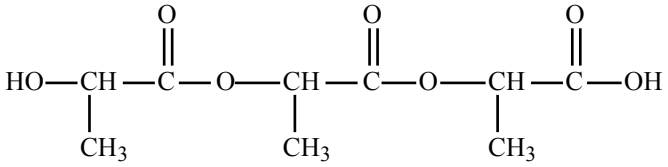
12.5 Molecule "a" will give a pH above 7, but molecule "b" will not. Molecule "b" is an amide, and amides are not bases. Molecule "a" is an amine, and amines are bases.

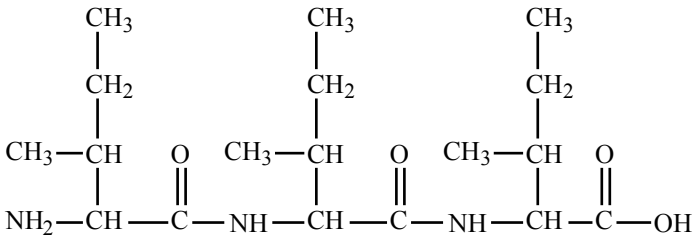
12.6 a) 

b) 

Section 12.3

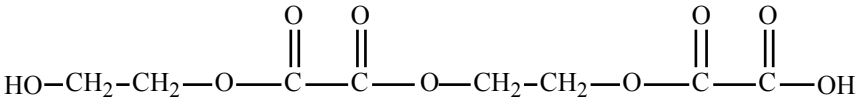
12.7 

12.8 

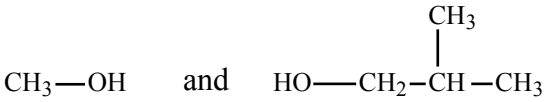
12.9 

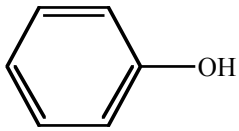
12.10 To make the product, first arrange the molecules so that they alternate:

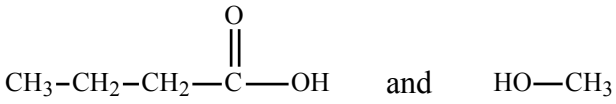
Then carry out the condensation reactions to form the final product:

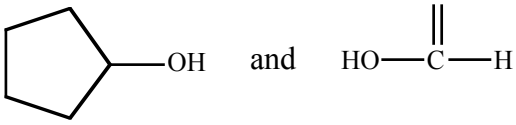


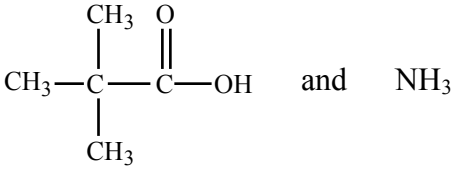
Section 12.4

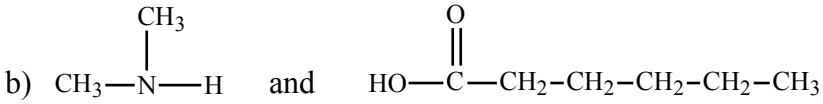
12.11 a) 

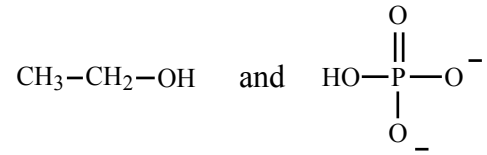
b) Two molecules of 

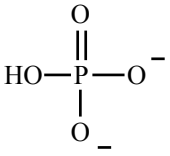
12.12 a) 

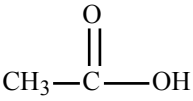
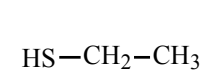
b) 

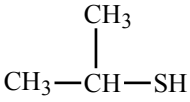
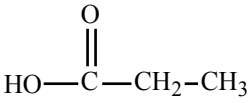
12.13 a) 

b) 

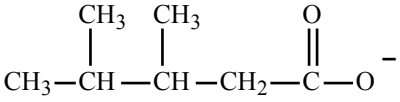
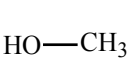
12.14 a)  and

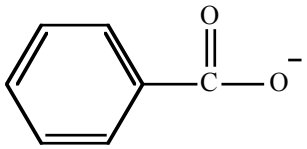
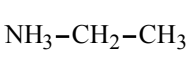
b)  and 

12.15 a)  and 

b)  and 

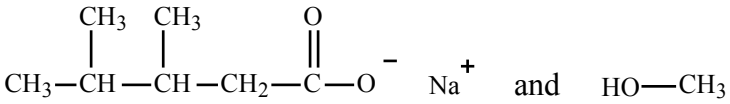
Section 12.5

12.16  and 

12.17  and 

12.18 A saponification reaction is the reaction of an ester with a strong base (NaOH or KOH), to form an alcohol and the sodium or potassium salt of a carboxylic acid.

12.19 The answer to this problem is virtually the same as the answer to Problem 12.16. The only difference is that you make the sodium salt of the carboxylate ion. The products are:

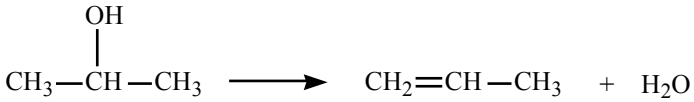
 and

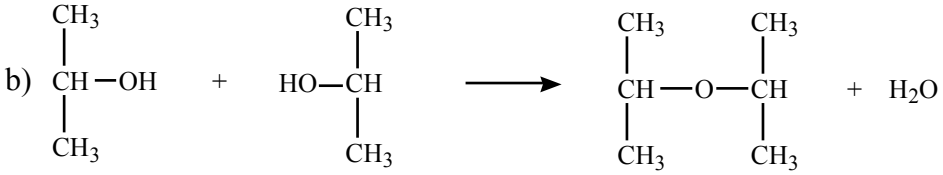
12.20 A soap is an ionic compound that contains a long-chain carboxylate ion and a sodium or potassium ion.

CUMULATIVE PROBLEMS (Odd-numbered problems only)

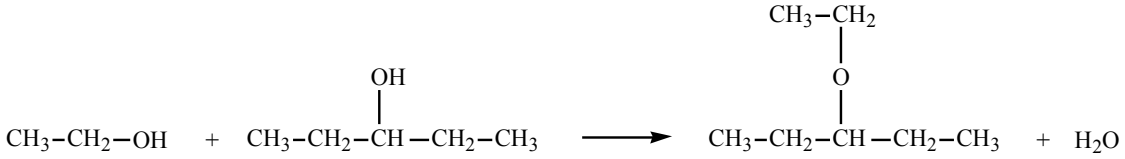
12.21 A condensation reaction is a reaction in which two molecules combine to form a larger molecule. In the process, one molecule loses H and the other loses OH, and the H and OH combine to form water.

12.23 A dehydration removes H and OH from one molecule, converting a C–C single bond into a double bond. A condensation removes H from one molecule and OH from a different molecule, and links the remaining pieces into a single organic compound.

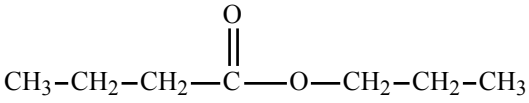
12.25 a) 

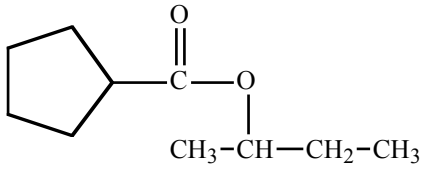
b) 

12.27 In a dehydration, an alcohol loses the OH group and a hydrogen atom from the carbon adjacent to the functional group carbon. Methanol does not contain a carbon atom adjacent to the functional group carbon, so it cannot be dehydrated.

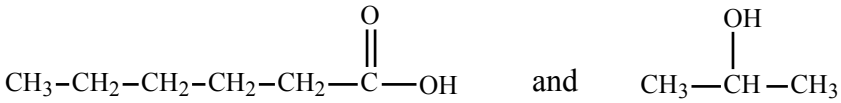
12.29 

12.31 Only the organic product is shown here. Water is also a product of any condensation reaction.

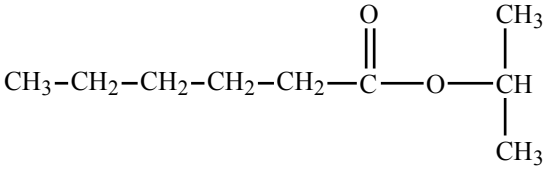
a) 

b) 

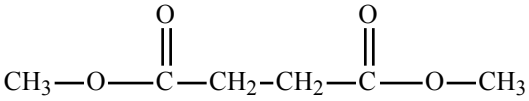
c) The structures of the reactants are:

 and

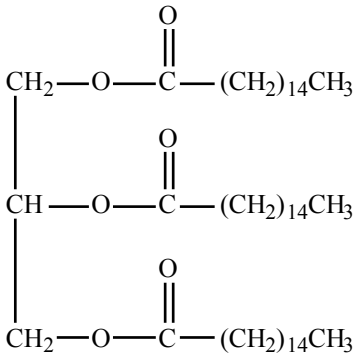
The structure of the product is:



12.33

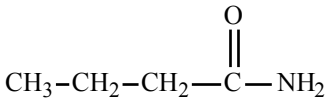


12.35

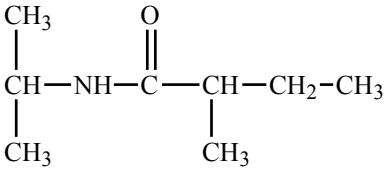


12.37 As before, only the organic product is shown here. Water is also a product of these reactions.

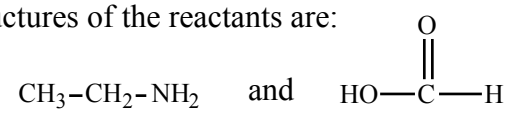
a)



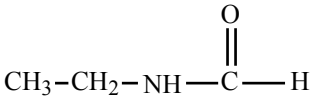
b)

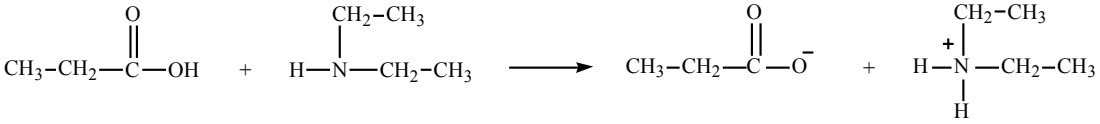


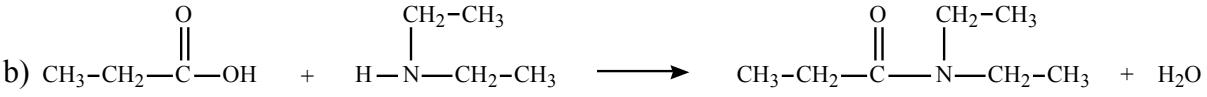
c) The structures of the reactants are:



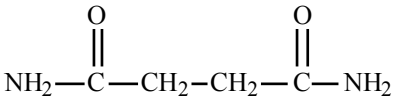
The structure of the product is:



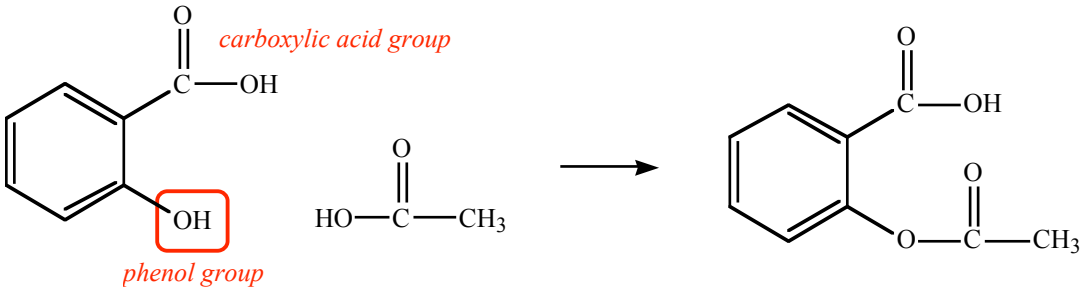
12.139 a) 

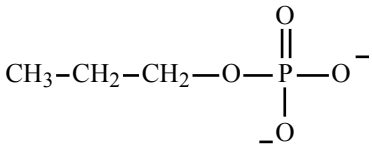
b) 

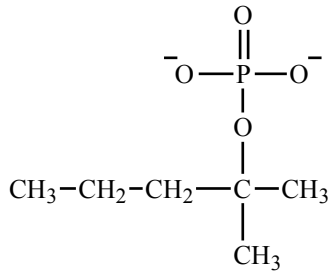
12.41 In order for an amine to condense with a carboxylic acid, the amine must have at least one hydrogen atom that is directly bonded to the nitrogen atom. Triethylamine does not have a hydrogen atom bonded to nitrogen (the nitrogen is bonded to three carbon atoms), so it cannot undergo condensation reactions.

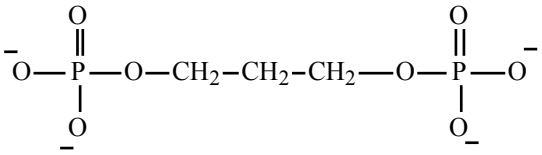
12.43 

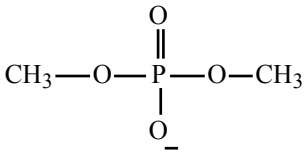
12.45 Note that acetic acid reacts with the alcohol group in salicylic acid, not the carboxylic acid group.

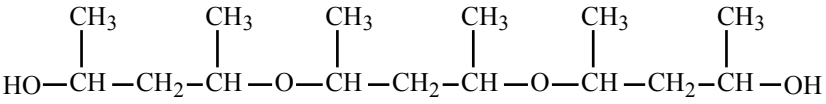


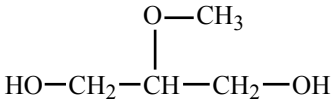
12.47 a) 

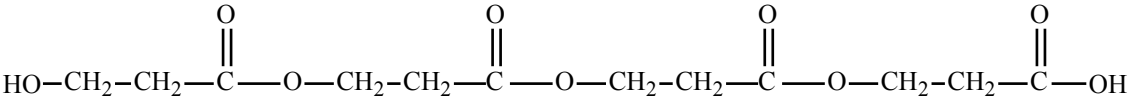
b) 

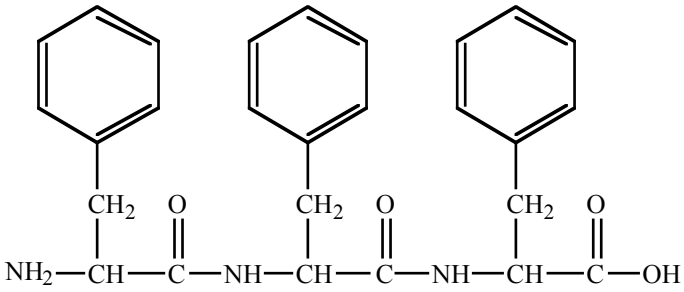
12.49 

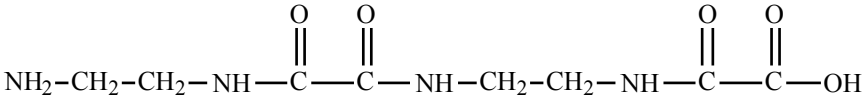
12.51 

12.53 

12.55 

12.57 

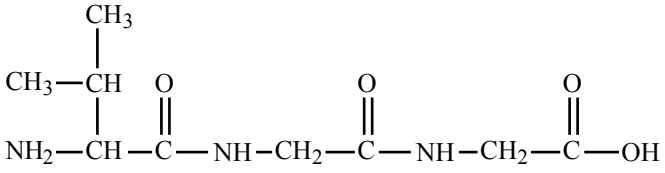
12.59 

12.61 

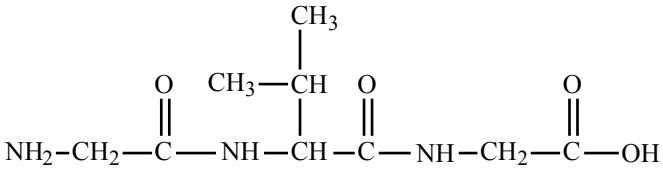
12.63 There are three different ways that we can arrange two molecules of glycine and one molecule of valine. We can put the valine on the left side, in the middle, or on the right side:

Option #1: valine – glycine – glycine
Option #2: glycine – valine – glycine
Option #3: glycine – glycine – valine

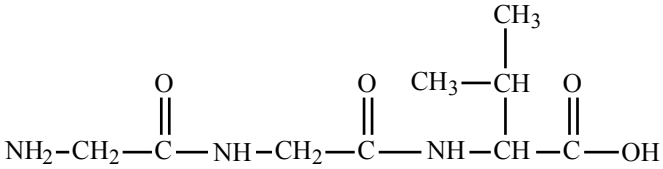
Here is option #1:



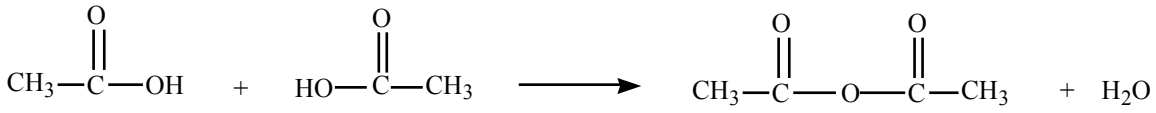
Here is option #2:



Here is option #3:



12.65 You must draw the two molecules of acetic acid with their carboxylic acid groups facing one another.

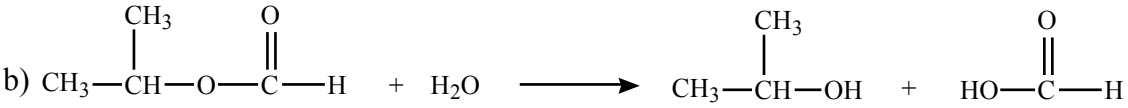


an anhydride

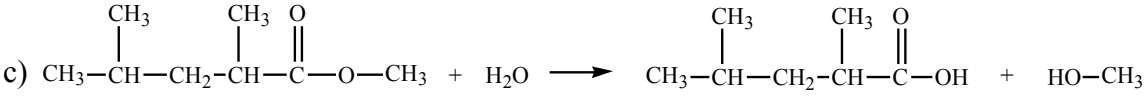
Note that this type of reaction does NOT normally occur.

12.67 a) $CH_3-CH_2-O-CH_2-CH_2-CH_3 + H_2O \longrightarrow CH_3-CH_2-OH + HO-CH_2-CH_2-CH_3$

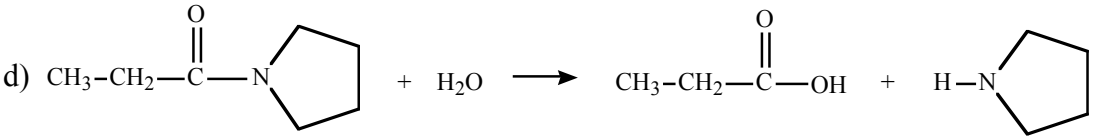
b)



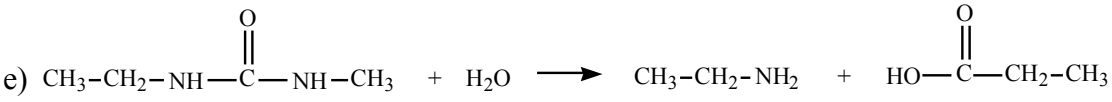
c)

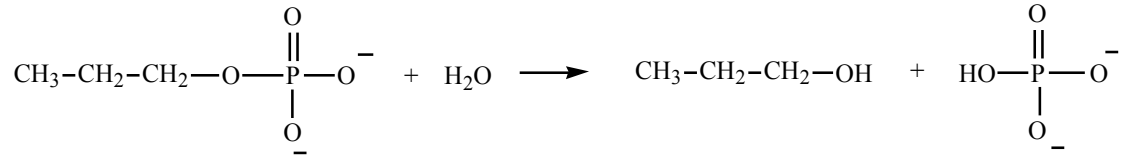


d)

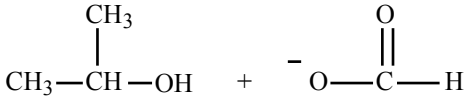


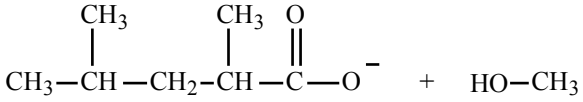
e)

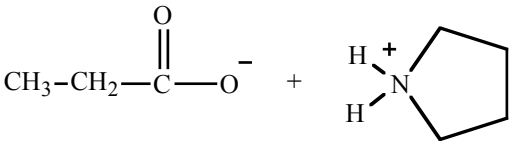


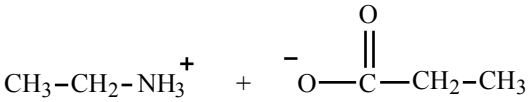
f) 

12.69 a)

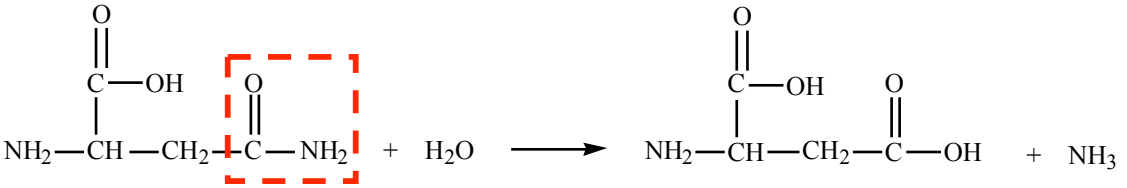
b) 

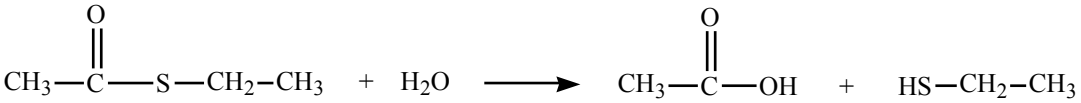
c) 

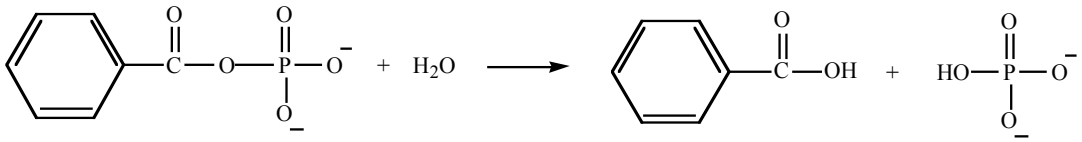
d) 

e) 

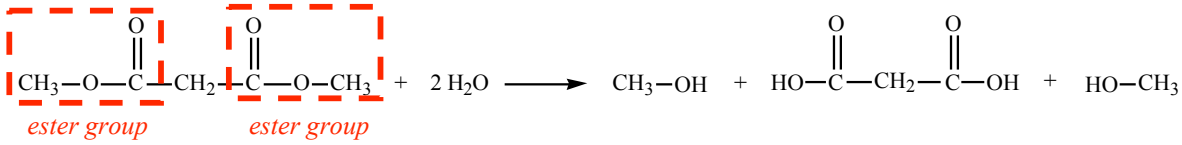
12.71 Only the amide group on the right side of the asparagine structure can be hydrolyzed. The products are a carboxylic acid and ammonia.



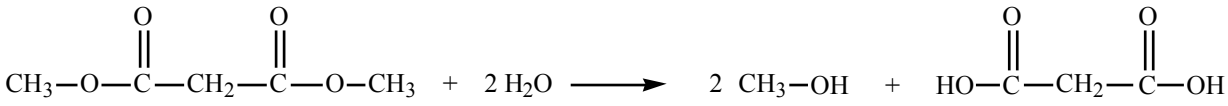
12.73 a) 

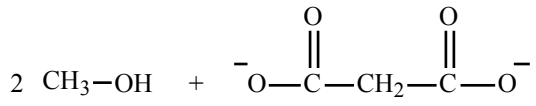
b) 

12.75 The organic reactant contains two ester groups, both of which can be hydrolyzed.



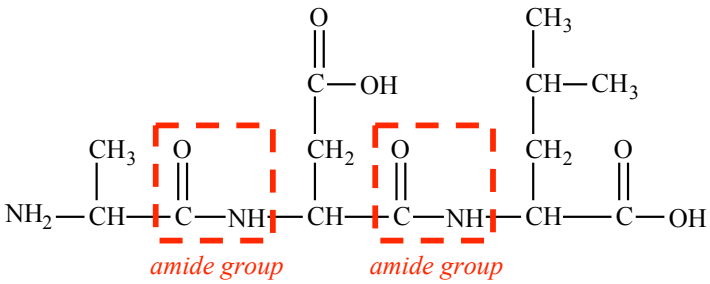
The first and third products are actually the same molecule (methanol), so you can also write this reaction as:



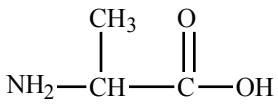
12.77 

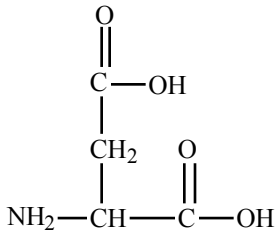
(Both carboxylic acid groups are ionized at pH 7.)

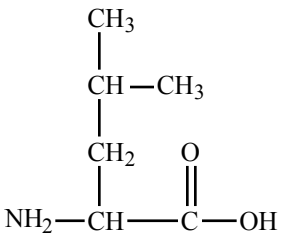
12.79 There are two amide functional groups in the reactant. Both of them will be hydrolyzed.



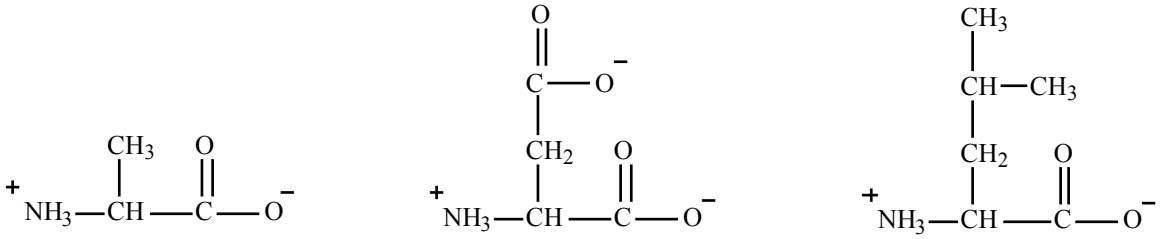
Here are the structures of the three amino acids that will be formed, drawn in their unionized forms.



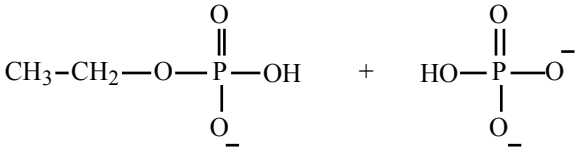


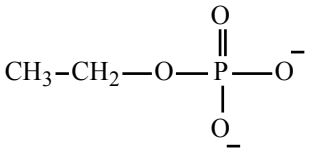


12.81 At pH 7, all of the carboxylic acid and amine groups will be ionized.

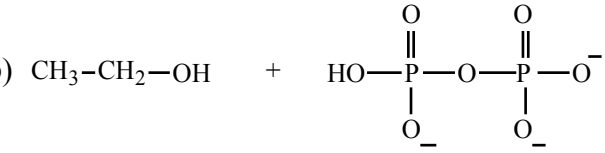


12.83 a)

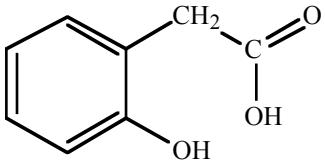


(Note: you can also draw the first product as )

b)

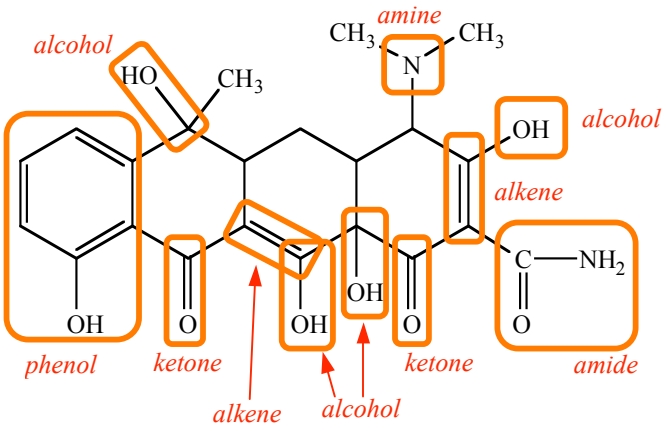


12.85



12.87 a) $CH_3–CH_2–O–CH_2–CH_3$ b) $CH_3–CH_2–O–CH_2–CH_3$
c) $CH_3–CH_2–O–CH_2–O–CH_2–CH_3$

12.89 There are eleven functional groups in this molecule!



12.91 Look at the functional group. Carboxylic acids, phenol, and thiols are acidic and produce acidic solutions when they dissolve in water. Amines are basic and produce basic solutions when they dissolve in water. The other functional groups you have studied are neither acidic nor basic, so they do not affect pH.

a) basic: this is an amine
b) neutral: this is an amide
c) neutral: this is an ester
d) acidic: this is a carboxylic acid
e) neutral: this is an alcohol
f) neutral: this is an aldehyde
g) basic: this is an amine
h) acidic: this is a phenol

12.93 For the condensation reaction, the balanced equation (using molecular formulas) is:

$$2\ C_2H_6O \rightarrow C_4H_{10}O + H_2O$$

When you use 10.0 g of ethanol, you form 1.96 g of water.

For the dehydration reaction, the balanced equation is:

$$C_2H_6O \rightarrow C_2H_4 + H_2O$$

When you use 10.0 g of ethanol, you form 3.91 g of water. (Use the formula weights of ethanol and water as a conversion factor, and don't forget to multiply the formula weight of ethanol by 2 in the condensation reaction.)

12.95