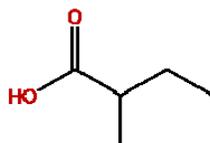
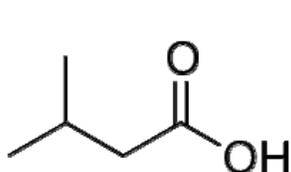
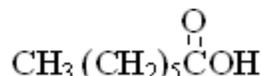
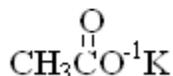
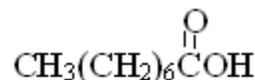
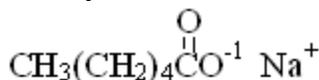


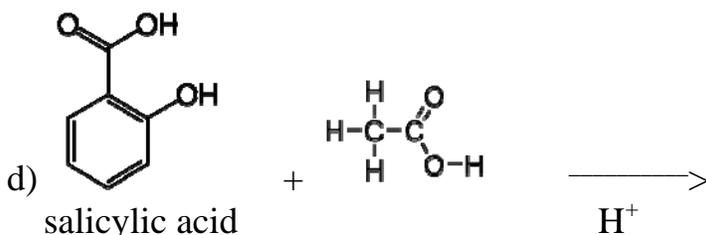
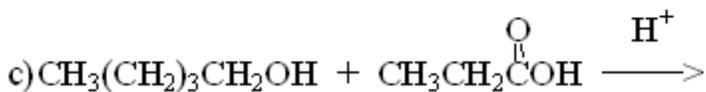
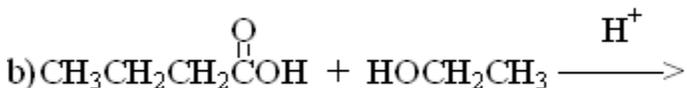
## CARBOXYLIC ACIDS STUDY GUIDE

1. Name the following carboxylic acids and carboxylate ions:

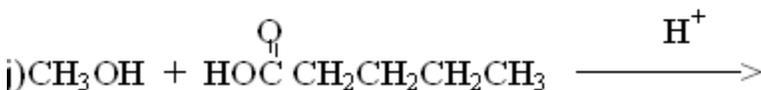
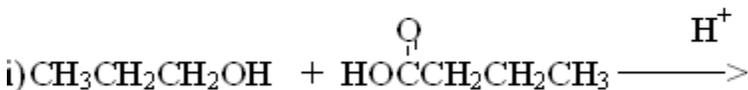
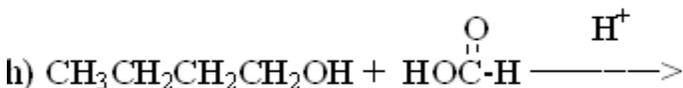
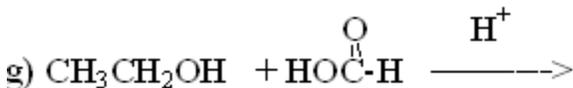
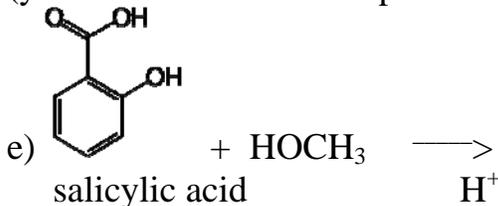


- Write the general chemical equation (using an R group) showing the formation of a hydrogen ion from a carboxylic acid. Is this reaction reversible or irreversible? Are carboxylic acids weak or strong acids in general? Compare the length of the two C-O bonds in the carboxylic acid with the C-O bond lengths in a carboxylate ion. Explain how resonance/delocalization explains the difference and why it stabilizes the carboxylate ion.
- Write the chemical equation for the neutralization of a general carboxylic acid with NaOH. (Use an R + the carboxylic acid functional group.)
- Give at least one practical use or natural source for
  - formic acid
  - acetic acid
  - trichloroacetic acid
  - propanoic acid
  - pyruvic acid
  - GABA
  - GHB
  - benzoic acid
  - lactic acid
  - glycolic acid
  - oxalic acid
  - citric acid
  - undecylenic acid

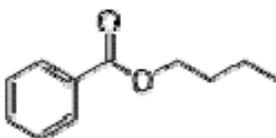
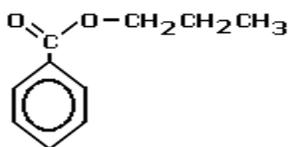
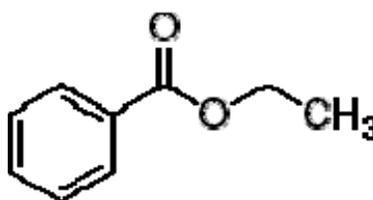
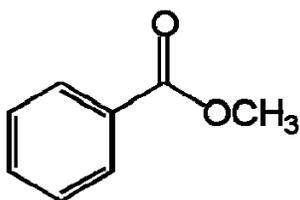
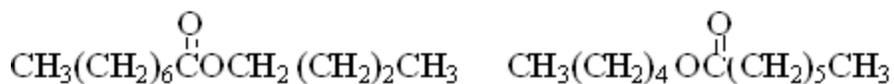
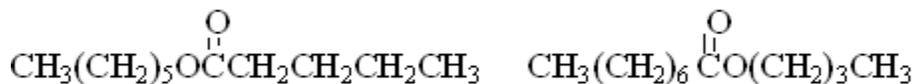
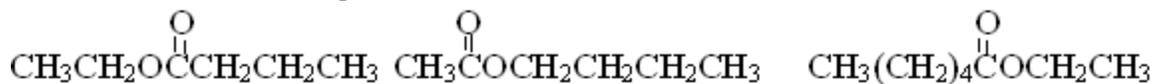
5. Write the structure of the ester product and give the systematic or common name for the carboxylic acid reactants and the ester product.



(you don't need to name product of this reaction)

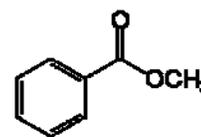
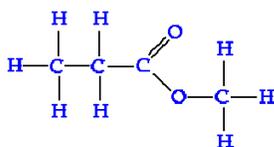


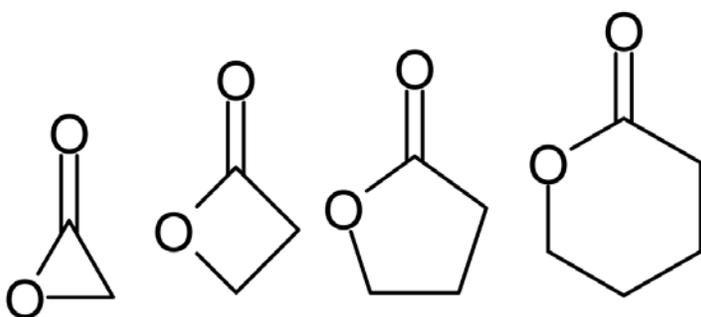
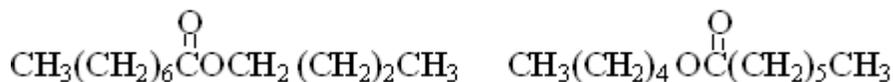
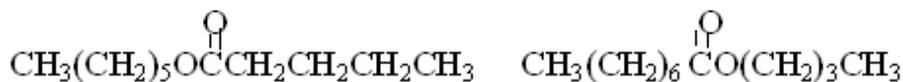
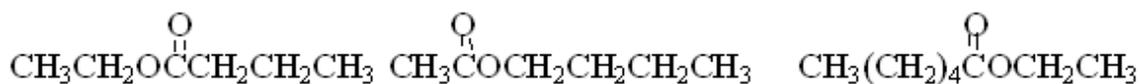
6. Name the following esters



7. Name two examples of polyester polymers. Which one has become a matter of significant health concern. Name the component of concern and why the concern.

8. Write the products formed from acid catalyzed **hydrolysis** of the following molecules:



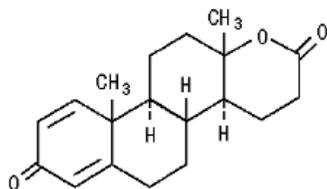


9. Is ester hydrolysis typically exergonic or endergonic? Why doesn't the hydrolysis occur spontaneously in many circumstances? What can be done to speed up the hydrolysis?

10. What important neurotransmitter contains an ester group? How is it inactivated?

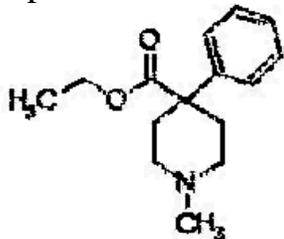
11. What functional groups are responsible for fruity smells and flavors? What chemical reaction causes these flavors to become sharp and unpleasant? What functional group is responsible for this?

12. Testolactone is a drug occasionally used in the treatment of post-menopausal breast cancer. Identify the various functional groups, including the lactone ring.



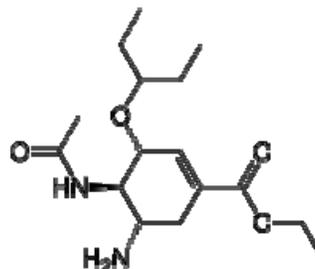
$\text{C}_{19}\text{H}_{24}\text{O}_3$  MW300.40 CAS-968-93-4

13. Meperidine (Demerol) is an opiate analgesic with structure shown below. Its metabolism is somewhat complex, but one step is ester hydrolysis. Show the products that will result from hydrolysis of the meperidine molecule.

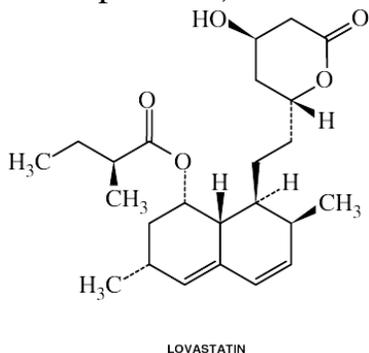


14a. Oseltamavir (Tamiflu) has been widely used since 2001 to reduce the symptoms and severity of flu infection. Oseltamavir molecule itself is activated by hydrolyzing an ester linkage in the structure (shown below). Show the structure of the products which result from ester hydrolysis of oseltamavir. (You don't need to draw the structure of the whole carboxylic acid portion of the molecule, just the carboxylic acid and the ring it is attached to.)

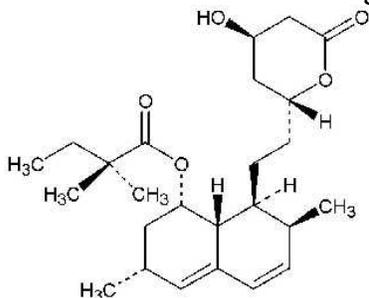
Identify all the functional groups in Tamiflu.



14b. Lovastatin (Mevacor) (structure shown below) is a drug commonly prescribed for lowering blood cholesterol. It has to be activated by hydrolysis of the ester linkage in the 6 membered ring. Show the structure of the hydrolyzed ring product. (You don't have to show the structure of rest of the product.)

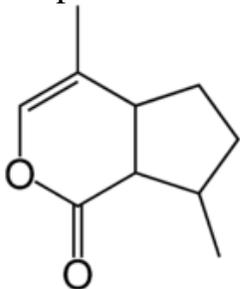


14c Simvastatin (structure shown below) is another drug in the statin family that is commonly prescribed for lowering blood cholesterol. It has to be activated by hydrolysis of the ester linkage in the 6 membered ring. What do we call an ester linkage in a ring? Show the structure of the product.

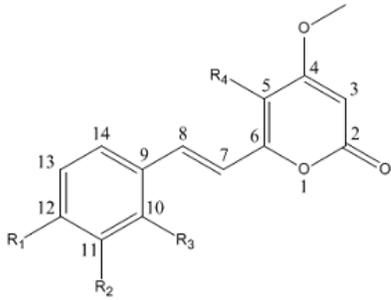


How does simvastatin differ from lovastatin in terms of its structure? This is a classic case of a “me too drug”. When the patent on the original drug lovastatin ran out Merck came out with simvastatin which appears to be somewhat more effective but only has very minor differences in structure and hence was relatively easy to synthesize.

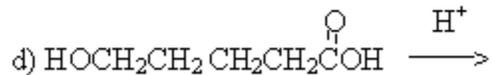
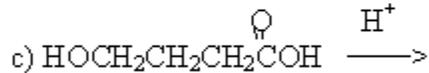
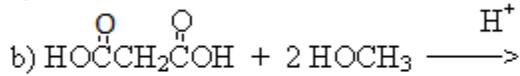
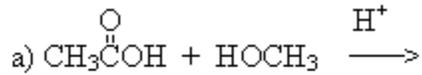
14d. Nepetolactone is the active ingredient in catnip. Show the structure of the product formed by the hydrolysis of the lactone ring.



14e) Kavalactone is regarded as the active ingredient in kava kava, a Polynesian drink. Show the structure of the product result from the hydrolysis of the kava lactone.



15. Show the products formed for the following:



16. Draw the structure of glycerol and of a monoglyceride, diglyceride, and triglyceride

17. Explain why some food products' claims in the 90s and early 2000s of being "fat free" were misleading. What equivalent product did they contain?

18. Write the reaction for hydrolysis of a triglyceride. Draw a typical structure of a soap molecule (using R groups for the hydrophobic chains). Label the hydrophilic and hydrophobic portions.

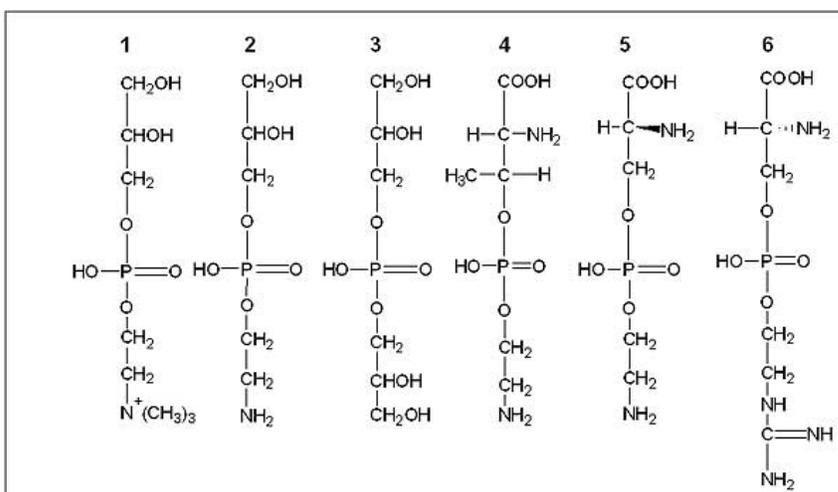
19. What is meant by the term saponification? What is the structural and physical differences between a soft soap and a hard soap?

20. Explain how soaps work in terms of micelle formation.

21. What is meant by the term emulsion? emulsifying agent? surfactant?

22. Draw the structure of a detergent molecule and label the hydrophilic, lipophilic, and hydrophobic portions. How does the hydrophilic portion of the detergent differ from that of a soap? What advantages do detergents have over soaps?

23. Explain how the bile salts work. What physiological problems occur in the absence of bile salts?
24. What is the difference between an anionic surfactant, a cationic surfactant, and an amphipathic surfactant. Give examples of an anionic and amphipathic surfactant. Where are cationic surfactants often used?
25. Draw the structure of lecithin. Explain why lecithin is used in salad dressing and how it works. What common food product is added to home made salad dressing which is very rich in lecithin?
26. Name a surfactant ( full name and abbreviation ) that is used as a laxative. What medical procedure frequent uses it as a “prep”?
27. Why are nonionic surfactants often combined with ionic surfactants?
28. What is the difference between anionic and cationic surfactants?
29. What are some of the practical uses of cationic surfactants?
30. Draw an “oil-in-water” micelle and a “water-in-oil” micelle, making the differences clear. Where are “water-in-oil” emulsions commonly found?
31. Check the ingredients on your shampoo, dishwashing detergent, toothpaste and see how many surfactants discussed in this chapter you can find.
32. Give two examples of medically important nitrate esters. Why is one of them rarely if ever given orally?
33. Explain why the formation of polyphosphate esters is an endergonic process.
34. What sort of functional group do all the molecules below have in common?



35. What is a common physiological purpose for adding a sulfate group to a biological molecule? What is the generic name given for the addition of such a group? Give two examples where this reaction occurs in molecules we have talked about earlier.

#### Questions Digging deeper

36. Artemisinin is a compound isolated from a Chinese herb *Artemisia* which has traditional use for treating malaria and is also being investigated as an anti-cancer drug. Do a web search and learn more about this molecule and identify the various functional groups in the molecule.

37. The web sites below are to several studies looking at the effect of sodium lauryl sulfate on oral cankers. Review the essentials of these studies (number of patients, single blind, double blind, source of funding, statistical

probability) and discuss your findings on strengths, weaknesses, and conflicting results.

1. ^ <A>> [Herlofson B, Barkvoll P \(1994\). "Sodium lauryl sulfate and recurrent aphthous ulcers. A preliminary study. <http://www.wealthpartners.net/pdf/0535.pdf> " \(PDF\). Acta Odontol Scand 52 \(5\): 257-9. PMID 7825393 <http://www.ncbi.nlm.nih.gov/pubmed/7825393> .](#)
2. ^ <A>> [Herlofson B, Barkvoll P \(1996\). "The effect of two toothpaste detergents on the frequency of recurrent aphthous ulcers.". Acta Odontol Scand 54 \(3\): 150-3. PMID 8811135 <http://www.ncbi.nlm.nih.gov/pubmed/8811135> .](#)
3. ^ <A>> [Chahine L, Sempson N, Wagoner C \(1997\). "The effect of sodium lauryl sulfate on recurrent aphthous ulcers: a clinical study.". Compend Contin Educ Dent 18 \(12\): 1238-40. PMID 9656847 <http://www.ncbi.nlm.nih.gov/pubmed/9656847> .](#)
4. ^ <A>> [Healy CM, Paterson M, Joyston-Bechal S, Williams DM, Thornhill MH \(1999\). "The effect of a sodium lauryl sulfate-free dentifrice on patients with recurrent oral ulceration". Oral Dis 5 \(1\): 39-43. PMID 10218040 <http://www.ncbi.nlm.nih.gov/pubmed/10218040> .](#)

38. The dose of oxalic acid needed to kill humans is estimated as approximately 375 mg of oxalic acid per kg weight of the person. How many grams would be needed to kill a person weighing 150 pounds? If the concentration of oxalic acid in rhubarb leaves is typically about 0.5%, how many grams of leaves would have to be eaten to risk death? How many pounds is that? (Remember 454 grams = 1 pound).

39.a) Write the equation for the reaction of benzoic acid with sodium hydroxide.

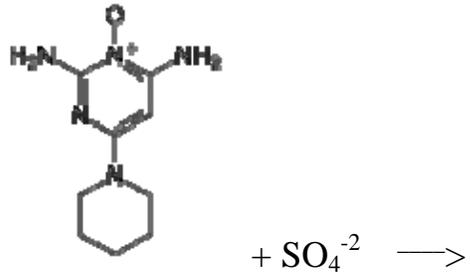
b) The product is frequently used as an alternative to benzoic acid to inhibit mold growth

c) What solubility advantages might the product have over benzoic acid.

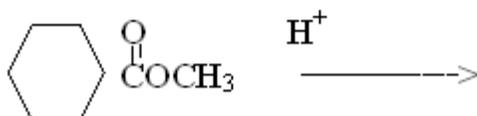
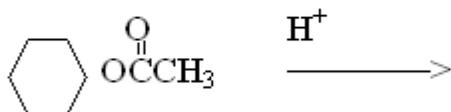
40. Sulfation of drugs does not always lead to inactivation.

Minoxidil (Rogaine) is used in the treatment of male baldness. It turns out

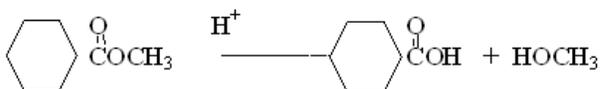
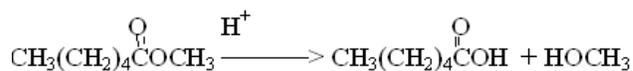
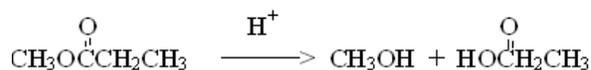
that minoxidil is actually a pro-drug and is sulfated on the O atom to produce minoxidil sulfate, the actual active drug.



Additional hydrolysis problems.



Answers:



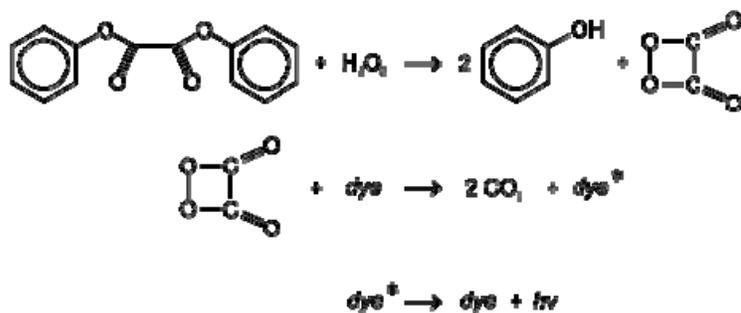
Skip answers below.

11. Esters are responsible for many fruity smells and flavors. Hydrolysis causes formation of carboxylic acids which have a sharp often unpleasant flavor.

13. Monoglycerides are essentially equivalent to triglycerides in terms of calorie/gram and in terms of atherogenic potential. Hence, using mono- and diglycerides in place of triglycerides serves no useful nutritional purpose. But it does allow the manufacturer to claim that their product is “fat-free”.

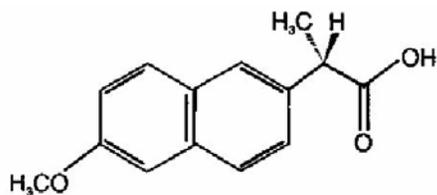
14. Soft soaps have a potassium ion balancing the negatively charged carboxylate ion while hard bar soap has a sodium ion balancing the carboxylate ion.
15. Lecithin is an emulsifying agent that emulsifies the vinegar (primarily water) and the oil in salad dressings.
16. DSS (dioctylsulfosuccinate) is used in Colace and other laxative products; PEG (polyethyleneglycol) is used in some preparations designed to cleanse the bowel prior to a GI exam.
17. Non-ionic surfactants are usually not as effective as ionic surfactants in forming micelles (particularly oil-in-water micelles). They are usually combined with ionic surfactants to improve micelle formation.
18. Water-in-oil emulsions are commonly found in hand lotions and cold creams.

19. Glow sticks work by undergoing the following reaction:

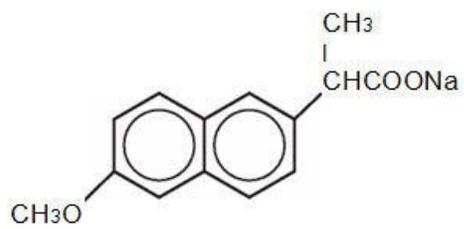


(The asterisk after the dye indicates a molecule with an excited electron.)

Explain why the molecule that reacts with the dye is particularly reactive. Compare the water solubility of naproxen and naproxen sodium (structures shown below) and explain.



Naproxen



Naproxen sodium