1. (3) True or False? A TMS ether "protects" an alcohol from reaction with acids.

2. (3) True or False? The molecule shown below could undergo a substitution reaction with a nucleophile.

3. (6) In the molecule shown below, the C=C could react with ___________ (choose one: nucleophiles; electrophiles; both nucleophiles and electrophiles) and the C=O could react with ___________ (choose one: nucleophiles; electrophiles; both nucleophiles and electrophiles).

4. (3) True or False? The molecule shown is an α,β-unsaturated ketone.

5. (3) With the molecule shown below, borane (BH₃) would react with the C=O oxygen, rather than the OR oxygen, because:

   a) BH₃ is an electrophile
   b) There is a considerable δ+ on the C of the C=O
   c) There is a greater δ- on the O of the C=O
   d) The OR group is electron withdrawing

6. (3) The carboxylic acid proton appears in its NMR spectrum at about:

   a) 7-8 δ
   b) 1-2 δ
   c) 3-4 δ
   d) 9-10 δ
   e) 11-12 δ

7. (3) True or False? The carbonyl oxygen in a ketone is sp² hybridized.

8. (6) Classify each of the following reagents as oxidizing or reducing.

   a) CrO₃ / H₂SO₄   b) Zn / Hg / HCl   c) KMnO₄

   oxidizing    reducing    oxidizing
9. (14) For each of the following, indicate with an asterisk (*) the atom or atoms which could be attacked by a nucleophile / base (without the addition of any catalyst). More than one site is a possible answer.

a) ![O](image1)  b) ![O](image2)  c) ![O](image3)  d) ![O](image4)  e) ![O](image5)

10. (6) For each of the molecules shown below, indicate with an asterisk (*) the atom or atoms which would attack an acid such as sulfuric acid.

a) ![O](image6)  b) ![O](image7)  c) ![O](image8)

11. (4) In reactions of esters or amides with water it is common to add a small amount of acid. The purpose of the acid is:
   a) to polarize the carbonyl group to make it more electrophilic
   b) to convert the ester or amide to an intermediate carboxylic acid
   c) to convert the water to an anion which is a better nucleophile
   d) all of the above

12. (4) The first step of the reaction between an anhydride (RCOOCR) and MeMgBr involves:
   a) attack by Me\(^-\) upon the C=O oxygen
   b) attack of the C=O oxygen upon the Mg
   c) initial protonation of the C=O oxygen
   d) attack of the C-O oxygen upon the Mg
   e) attack by Me\(^-\) upon the C=O carbon

13. (4) Compound A (shown below) would react faster than B with MeMgBr because:

   ![A](image9)  ![B](image10)
   a) there is less steric interference in A
   b) there is less steric interference in B
   c) B is a stronger acid
   d) protonation of B is slower
   e) A has more angle strain

14. (4) One of the following is not true about esters. Which one?
   a) they react generally with Grignard reagents to form 3° alcohols
   b) they show a peak at ~180 ppm in their carbon NMR spectra
   c) they react less readily with nucleophiles than do aldehydes
   d) they react with nucleophiles to form substitution products (with release of RO\(^-\))
   e) they are more easily reduced than aldehydes

15. (44) Fill in the missing products or reactants in each of the following reactions.

   a) ![H\(_3\)C](image11)  ![C\(_2\)O](image12)  ![Ph\(_3\)P](image13)  ![CH\(_3\)](image14)  →  ![H\(_3\)C](image15)  ![CH\(_3\)C](image16)  +  ![Ph\(_3\)P=O](image17)
16. (9) In each of the following pairs circle the more reactive partner.

a) NaCl or H₃O⁺

b) HCN or MeOH

c) Me₂CuLi or MeOH

17. (3) True or False? After attack of a nucleophile upon the C of a C=O, the double bond will reform only if there is at least one hydrogen attached to the nucleophilic atom.

18. (3) True or False? The first step of the reaction between any alcohol and an aldehyde under acidic conditions involves attack of the O of the alcohol upon the C of the C=O.
19. (3) Reaction of the species shown with a primary amine would lead to:

\[
\text{Ph} - \text{OCH}_3
\]

a) formation of an enamine
b) formation of a species containing a \( \text{C}=\text{N} \)
c) displacement of the \( \text{OMe} \)
d) conjugate addition
e) formation of an amino alcohol

20. (3) Reaction of the species shown with a primary amine would lead to:

\[
\text{Ph} - \text{O}
\]

a) formation of an enamine
b) formation of a species containing a \( \text{C}=\text{N} \)
c) displacement of the \( \text{OMe} \)
d) conjugate addition
e) formation of an amino alcohol

21. (9) In each of the following pairs, circle the compound which will react more readily with the reagent indicated. You need not explain why.

a) \( \text{Ph} - \text{H} \) and \( \text{Ph} - \text{Cl} \) with \( \text{MeMgBr} \)

b) \( \text{Ph} - \text{NH}_2 \) and \( \text{Ph} - \text{CH}_3 \) with \( \text{LiAlH}_4 \)

22. (6) In each of the following pairs, assign an appropriate infrared \( \text{C}=\text{O} \) stretching vibration value (choose from the numbers to the right) to each molecule.

a) \( \text{H} - \text{O} \) and \( \text{O} - \text{H} \) with 1720 and 1705

b) \( \text{N} - \text{O} \) and \( \text{H} - \text{C} \) with 1685 and 1700

23. (4) An ester reacts much less readily with a nucleophile than does an aldehyde. Give two reasons why.

• Resonance from the \( \text{OR} \) group in the ester reduces the partial positive charge on the carbonyl carbon – making it harder for a nucleophile to attack (compared to with an aldehyde).

• The \( \text{OR} \) group is larger than the hydrogen in the aldehyde – making it more difficult for the nucleophile to get into the carbonyl carbon atom of the ester (compared to with an aldehyde).