Questions 1–3 refer to this reaction:

1. (2) In the space above complete the reaction by writing the molecular structure for the necessary reactant for step 2.

2. (1) Write the letter for the most likely mechanism for this reaction in the blank. Answer choices: (a) S_N2; (b) S_N1; (c) E2; (d) E1; and (e) EAS. Answer: ______

3. (2) In the blank write the letter of the solvent that would make the reaction fastest. Answer choices: (a) Water; (b) DMF; and (c) hexane. Answer: ______

The Torrance ExxonMobil Refinery, that large industrial-looking complex south of the 405 freeway, uses hydrofluoric acid (HF; a moderate acid with pK_a = 3) to produce alkylated aromatics for gasoline, aviation fuel, and other products. HF is quite dangerous. Because of recent safety and environmental issues at the refinery, there has been a move to ban HF. It would be replaced with sulfuric acid (a strong acid with pK_a = -9), but at greater cost. In a typical alkylation reaction, toluene is reacted with isobutylene and HF:

4. (1) In the blank write a letter for the major product of this reaction: 'O' if ortho is the major product, 'M' for meta, or 'P' for para. Answer: ______

5. (6) Write the mechanism for the formation of the product you selected in question 4.
6. (2) Which molecule reacts faster in this reaction, toluene or benzene? In the answer blank write 'B' if the reaction is faster with benzene, 'T' for toluene, 'E' if the rates are equal, or 'C' if the relative rates cannot be predicted. Answer: 

7. (2) Draw in the box the major product formed when $\text{H}_2\text{SO}_4$ is used instead of HF.

In human vision, 11-cis-retinal (as part of rhodopsin) absorbs a photon and is converted to all-cis-retinal. To isomerize all-cis-retinal back into 11-cis retinal, the all-trans-retinal is converted to all-trans-retinol, then to all-trans-retinol acetate. All-trans-retinol acetate is then isomerized to 11-cis-retinol acetate:

8. (2) If the conversion of trans-retinal into trans-retinol is an oxidation, write 'O' in the answer blank. Write 'R' if this is reduction, 'S' for a substitution, or 'N' for none of these. Answer: 

9. (3) The carbocation is produced when acetate ion leaves from all-trans-retinol acetate. Complete this sentence by writing 'better', 'equal', or 'poorer' in the blank, and then add no more than fifteen words of explanation. Acetate ion is a ______________ leaving group than trifluoromethanesulfonate ('triflate') because acetate ion...

10. (2) In lecture we learned of three common carbocation fates. The reaction scheme above illustrates one of these fates. Write the names of the other two common carbocation fates.
11. (2) In the answer box write the letter of the most stable carbocation:

Carbocation A
Carbocation B
Carbocation C
Carbocation D
Answer box

12. (4) Ketoprofen is a nonsteroidal anti-inflammatory and analgesic drug related to ibuprofen. Two of the steps used in the manufacture of ketoprofen are shown below. Complete these steps by writing something in each empty box.

13. (9) Phenoxide ion (PhO⁻) was reacted with a 1:1:1:1 mixture of the four molecules shown. Only one major product was formed. Acetone (ε =21) was the solvent used.

(a) Write the major product in the box above.

(b) Complete each statement by adding no more than ten words in each case. Make the reasons as different as possible.

Phenoxide reacted with the chosen alkyl halide because this alkyl halide...

Phenoxide reacted with the chosen alkyl halide because this alkyl halide...

14. (3) In the blank write three general mechanisms (such as E2) that always involve a carbocation: ___________________

15. (4) When writing a reaction, what set or reactants would cause us to consider each of the rules written below? Write a letter after each rule name. Answer choices: (a) alkene + HBr; (b) alkene + Br₂; (c) benzene + Br₂ + FeBr₃; and (d) alkyl bromide + NaOCH₃.

For Markovnikov's Rule, reactants = ______  For Zaitsev's Rule, reactants = ______
16. (8) Write a reasonable mechanism:

17. (2) Complete this statement by adding **no more than fifteen words**: A Sn1 reaction often gives a mixture of stereoisomeric products because...

18. (9) Complete each reaction by writing the major organic product in each box. Assume all reactants above and below the arrow are present in excess. Do not include any mechanism details. If no reaction occurs write 'NR' in the box.

(a) \[
\text{phenyl} \quad \text{C} \equiv \text{C} \quad \text{CH}_3 \quad \text{HBr} \quad \text{major product}
\]

(b) \[
\text{phenyl} \quad \text{C} \equiv \text{C} \quad \text{CH}_3 \quad \text{H}_2\text{O} \quad \text{major product}
\]

(c) \[
\text{Cl} \quad \text{Cl} \quad \text{H}_2\text{O} \quad \text{major product}
\]
19. (2) Complete this statement by adding **no more than fifteen words**: A carbonyl group is electrophilic because...

20. (6) Write a mechanism:

![Chemical structure](image)

21. (2) In lecture we learned of the three common carbonyl fates. In the space below write the name(s) of all of these fates that do not occur in the mechanism of question 20. If all of the common carbonyl fates are used write, "all are used".

22. (10) Write a complete mechanism for this reaction:

![Chemical structure](image)
23. (3) In the box write the major product of the following reaction:

\[
\begin{array}{c}
\text{OCH}_3 \\
\text{1. CH}_3\text{MgBr} \\
\text{2. H}_3\text{O}^+ \\
\end{array}
\]

24. (8) Write a mechanism for the formation of the major organic product of the reaction in question 23.

25. (2) In the box below each structure write the pK_a of the indicated hydrogen atom. pK_a choices: 23, 17, and 7. Each number will be used exactly once.

26. (3) The product of this reaction has molecular formula C_{16}H_{14}O. Draw the structure of this product in the box.