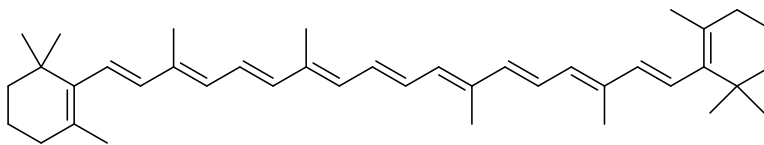




1. How many pi molecular orbitals are there in  $\beta$ -carotene?



$\beta$ -carotene

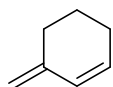
- a. 9  
b. 11  
c. 18  
d. 22  
e. None of these
2. How many pi electrons are there in furan?



- a. 2  
b. 4  
c. 6  
d. 8  
e. None
3. Which of these compounds will react fastest as a diene in a Diels Alder reaction?



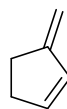
**A**



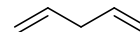
**B**



**C**

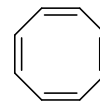


**D**



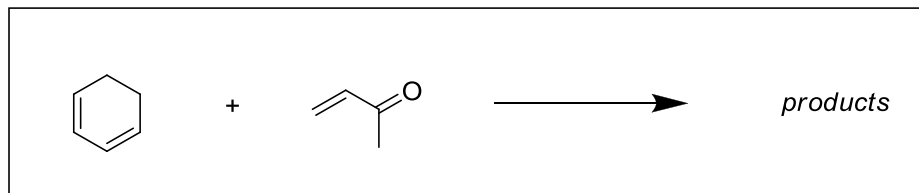
**E**

4. Which of these statements best describes cyclooctatetraene?

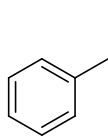


- a. Planar and aromatic
- b. Nonplanar and aromatic
- c. Planar and antiaromatic
- d. Nonplanar and antiaromatic
- e. Nonplanar and nonaromatic

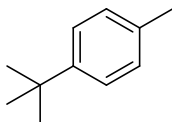
5. How many different stereoisomers will form in this Diels Alder reaction? (Include all possible stereoisomers; don't worry about "major" or "minor" product arguments.)



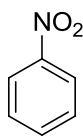
- a. 2
  - b. 3
  - c. 4
  - d. 6
  - e. Too many to count
6. Which of these substituted benzenes will not undergo a Friedel-Crafts alkylation?



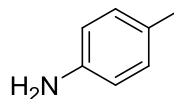
**A**



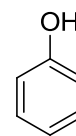
**B**



**C**

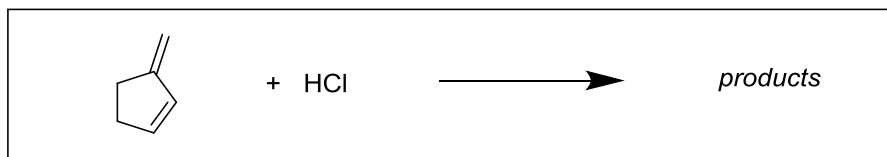


**D**

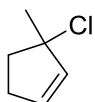


**E**

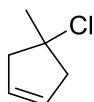
For questions 7 and 8, consider the following reactants:



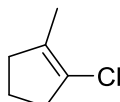
and the following answer choices (again, these apply to both 7 and to 8):



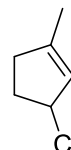
**A**



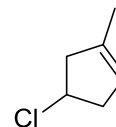
**B**



**C**



**D**



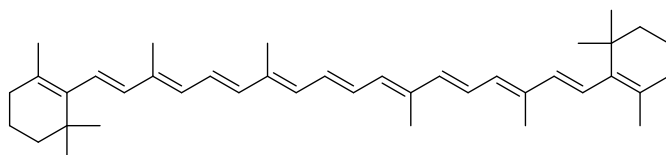
**E**

7. You combine the reactants and allow them to react for a short period of time at a low temperature. Which compound do you expect to be the major product?
8. You combine the reactants and allow them to react for a long period of time at a high temperature. Which compound do you expect to be the major product?

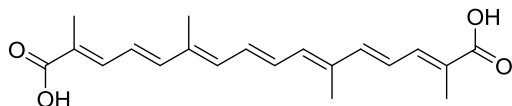
9. Beta-carotene, a molecule you saw in class, absorbs energy in the visible region of the electromagnetic spectrum and appears orange to us. Another molecule, crocetin (structure shown below) also absorbs in the visible region not far from beta-carotene, but is not orange. Which of the following statements about the color of crocetin is most likely to be true?

Potentially helpful information:  $E = hc/\lambda$

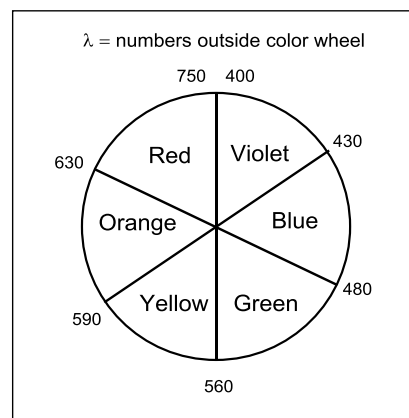
- Crocetin is red, because it has a larger HOMO-LUMO gap than beta-carotene.
- Crocetin is yellow, because it has a larger HOMO-LUMO gap than beta-carotene.
- Crocetin is red, because it has a smaller HOMO-LUMO gap than beta-carotene.
- Crocetin is yellow, because it has a smaller HOMO-LUMO gap than beta-carotene.



**$\beta$ -carotene**



**Crocetin**  
isolated from saffron

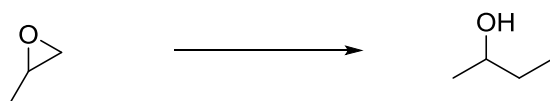


For questions 10-14, select from the following answer choices. Answer choices may be used once, more than once, or not at all.

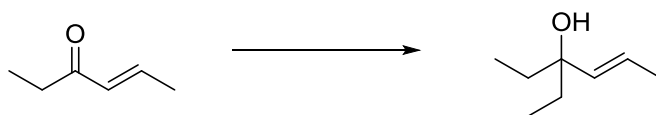
- A** Et<sub>2</sub>CuLi, followed by H<sub>3</sub>O<sup>+</sup> workup  
**B** EtLi, followed by H<sub>3</sub>O<sup>+</sup> workup  
**C** Either "A" or "B"  
**D** LAH, followed by H<sub>3</sub>O<sup>+</sup> workup  
**E** NaBH<sub>4</sub>

- F** Either "D" or "E"  
**G** NaH  
**H** NBS, AIBN, CCl<sub>4</sub>, heat  
**I** KMnO<sub>4</sub>  
**J** None of these.  
The reagent needed is not on this list.

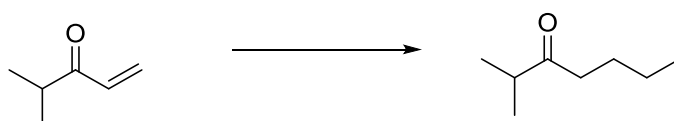
10.



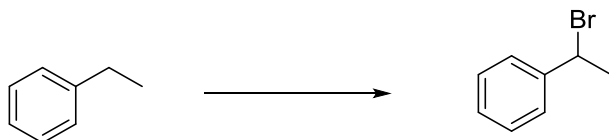
11.



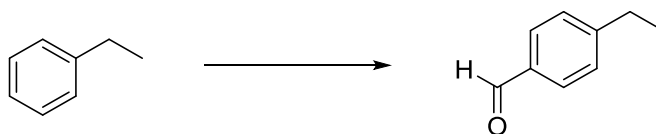
12.



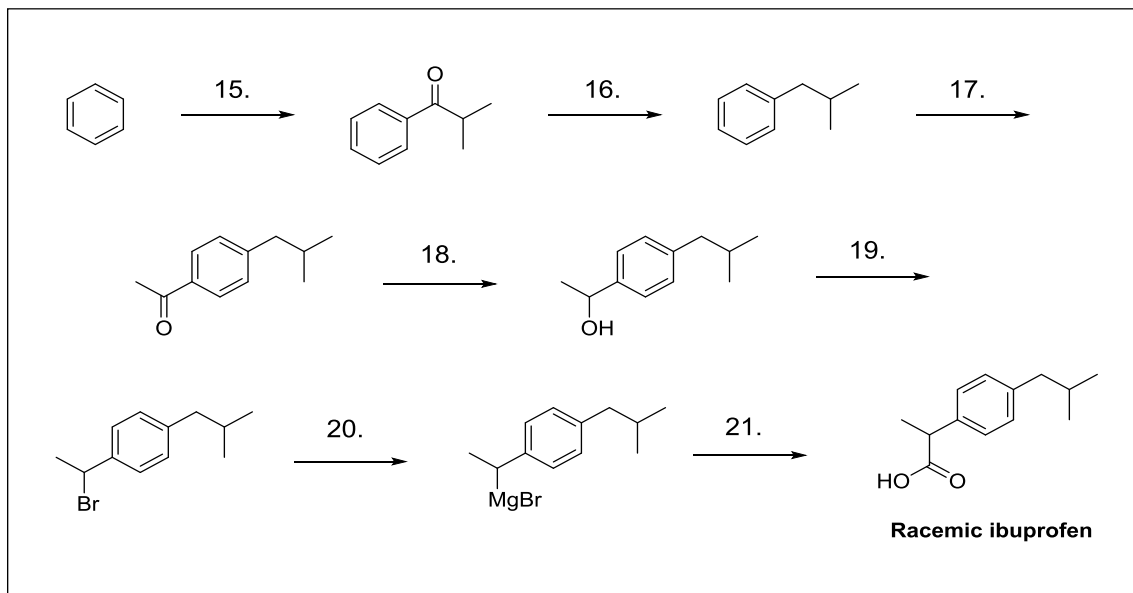
13.



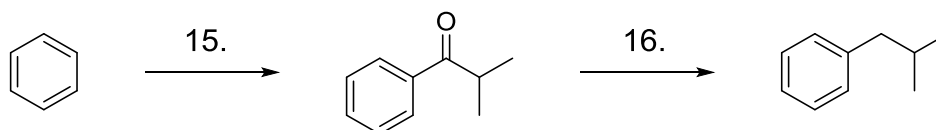
14.



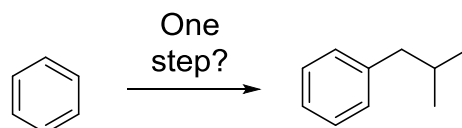
Questions 15 through 21 relate to the multi-step synthesis of racemic ibuprofen from benzene, shown in the following scheme:




15. Benzene is transformed in two steps to sec-butyl benzene in the synthesis:



Can this transformation be successfully accomplished instead in ONE step, using a Friedel Crafts alkylation?

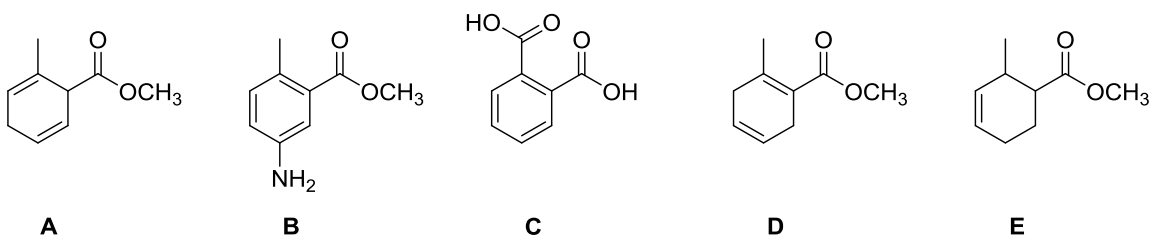
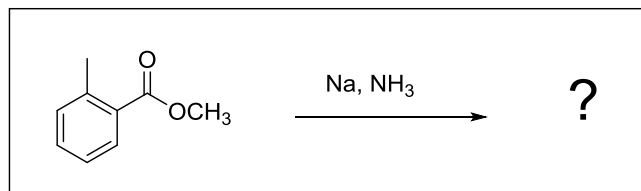


- a. Yes  
b. No
16. Of these choices, what reagent should be used for the step labeled "16"?
- a. Clemmensen reduction (HCl, H<sub>2</sub>O, Zn/Hg)  
b. Gattermann Koch formylation (CO, HCl, CuCl, AlCl<sub>3</sub>)  
c. LAH  
d. NaH  
e. Either "a" or "b" would work

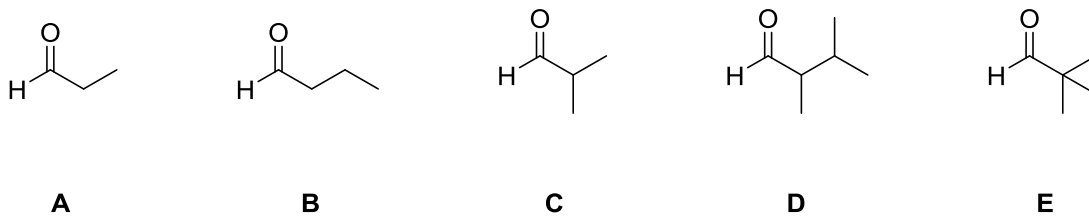
17. The step labeled "17" is referred to as
- Alkylation
  - Acylation
  - Reduction
  - Addition
  - None of these
18. Of these choices, what reagent should be used for the step labeled "18"?
- Clemmensen reduction (HCl, H<sub>2</sub>O, Zn/Hg)
  - Wolff- Kishner reduction (H<sub>2</sub>NNH<sub>2</sub>, KOH, heat)
  - LAH
  - NaH
  - Either "a" or "b" would work
19. What reagent should be used in the step labeled "19"?
- Br<sub>2</sub>, heat
  - NBS, AIBN, CCl<sub>4</sub>, heat
  - Br<sub>2</sub>, FeBr<sub>3</sub>
  - PBr<sub>3</sub>
  - None of these
20. In the step labeled "20", which is the most appropriate solvent to use?
- Water
  - Methanol
  - Ethanol
  - Diethyl ether
  - Any of these solvents would be fine
21. The transformation labeled as "21" should be accomplished using what reagents?
- Oxirane  then H<sub>3</sub>O<sup>+</sup>, then KMnO<sub>4</sub>
  - CO<sub>2</sub>, then H<sub>3</sub>O<sup>+</sup>
  - H<sub>2</sub>O/H<sub>3</sub>O<sup>+</sup>
  - Any of these would work fine



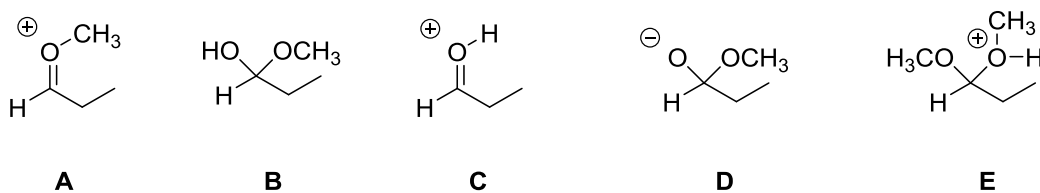
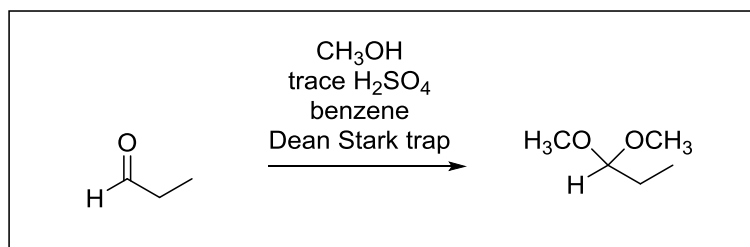
22. Select the correct product of the reaction conditions.



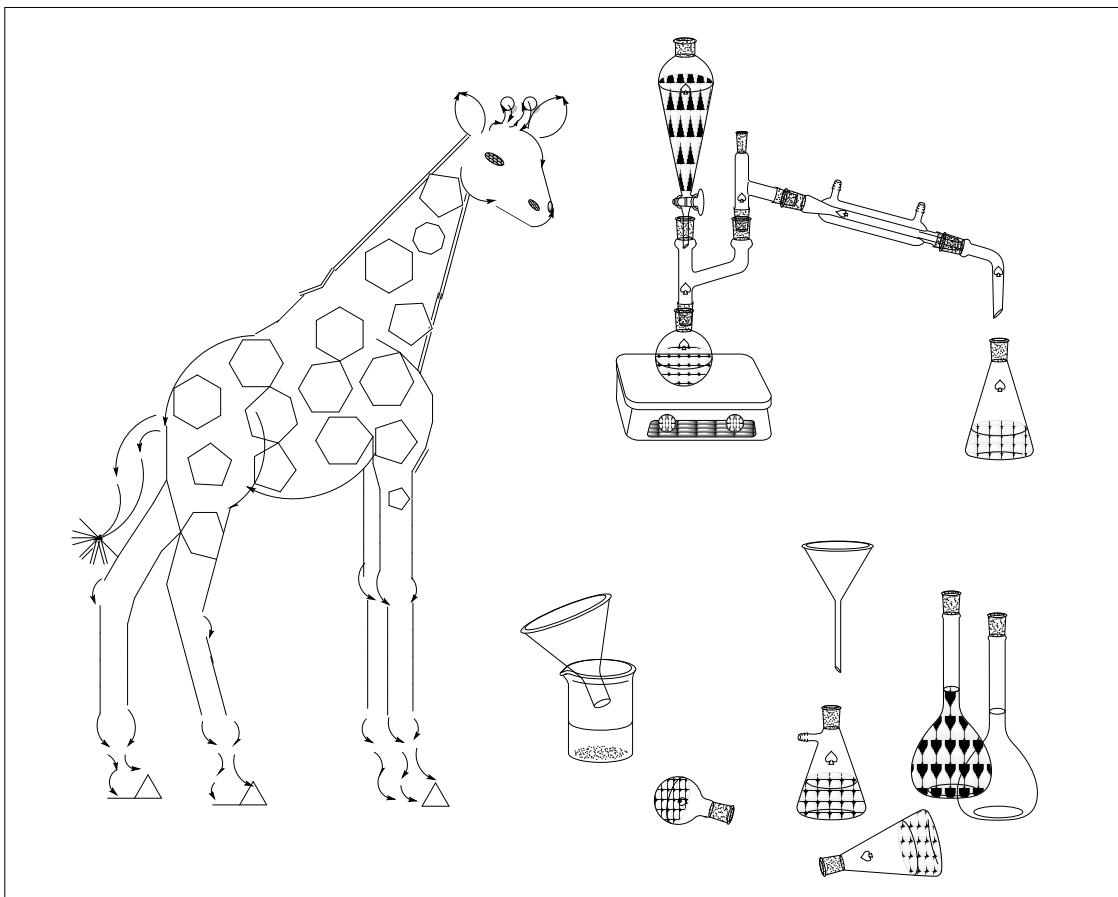
23. Select the compound that you expect to have the *largest* value of  $K_{\text{hydration}}$ .



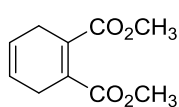
24. Which of the following is a hemiacetal intermediate in this acetal formation reaction? (Lone pairs are omitted for clarity.)



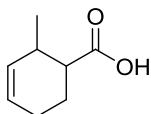
25. The ChemDraw Giraffe is in the house! Here it is in its lab, working on some reactions. (Notice that the giraffe's technique is poor: It has not clamped its distillation apparatus to a ring stand.)



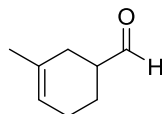
The giraffe is an accomplished organic chemist and claims that it has published many complicated scientific papers. However, it has a very narrow research focus: It insists on only performing multi-step syntheses that involve the use of the Diels Alder reaction. Which of these molecules would the giraffe be LEAST likely to make using a Diels Alder reaction as part of the synthetic plan?



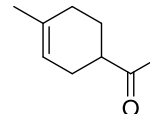
A



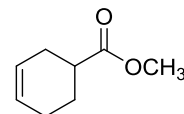
B



C



D



E