

Please read and sign the Honor Code statement below:

I pledge that on my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this exam.

Signature _____

General Instructions: There are 25 questions. Be sure you have them all. Read each question carefully so that you know exactly what is being asked.

Each multiple choice question (1-25) is worth 4 points and has only one correct answer. Bubble in your answers to these questions on the Scantron provided. Only the Scantron will be graded, not anything that you write on the exam.

At the end of the exam, turn in your Scantron and this signed cover sheet. You may keep the rest of the exam to check your answers against the key later.

Good luck!

1A 2A 3A 4A 5A 6A 7A 8A

Hydrogen 1 H 1.008																	Helium 2 He 4.003				
Lithium 3 Li 6.941	Beryllium 4 Be 9.0122															Boron 5 B 10.811	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Neon 10 Ne 20.180
Sodium 11 Na 22.990	Magnesium 12 Mg 24.305															Aluminum 13 Al 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 S 32.065	Chlorine 17 Cl 35.453	Argon 18 Ar 39.948
Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.867	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.845	Cobalt 27 Co 58.933	Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.38	Gallium 31 Ga 69.723	Germanium 32 Ge 72.61	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.80				
Rubidium 37 Rb 85.468	Sr 38 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc [98]	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.91	Palladium 46 Pd 106.42	Silver 47 Ag 107.87	Cadmium 48 Cd 112.41	Indium 49 In 114.82	Sn 50 118.71	Sb 51 121.76	Te 52 127.60	Iodine 53 I 126.90	Xenon 54 Xe 131.29				
Cesium 55 Cs 132.91	Ba 56 137.33	* 57-70	Lanthanum 57 Lu 138.91	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.95	Tungsten 74 W 183.84	Rhenium 75 Re 186.21	Osmium 76 Os 190.23	Iridium 77 Ir 192.22	Platinum 78 Pt 195.08	Gold 79 Au 196.97	Mercury 80 Hg 200.59	Thallium 81 Tl 204.38	Pb 82 207.2	Bi 83 208.98	Po 84 [209]	At 85 [210]	Rn 86 [222]			
Francium 87 Fr [223]	Ra 88 [226]	* *	Lr 103 [262]	Rf 104 [261]	Db 105 [262]	Sg 106 [263]	Bh 107 [264]	Hs 108 [265]	Mt 109 [266]	Uun 110 [271]	Uuu 111 [272]	Uub 112 [273]	Uuq 114 [289]								

* Lanthanide series

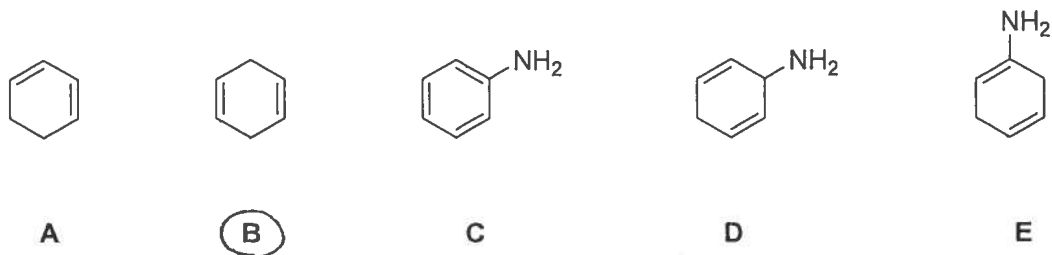
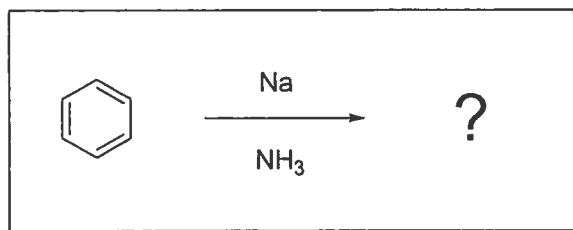
57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04
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* Actinide series

89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]
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1. Select the correct product of the reaction conditions. Assume appropriate workup.

B



2. Which of these is the most appropriate solvent to use for a Grignard reaction?

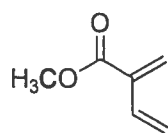
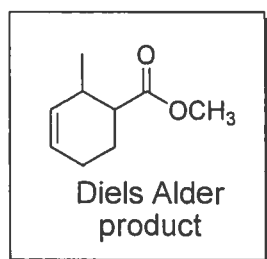
B

- a. H_2O
b. Et_2O
 c. MeOH
 d. EtOH
 e. Acetic acid

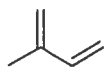
The others are protic

3. Which of these structures was the diene that was used to make this Diels Alder product?

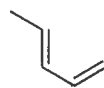
C



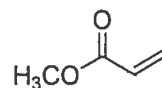
A



B



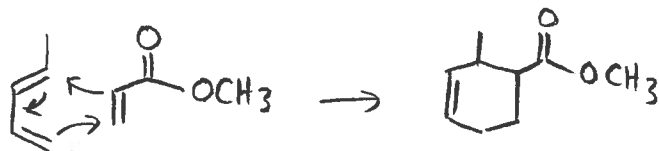
C



D

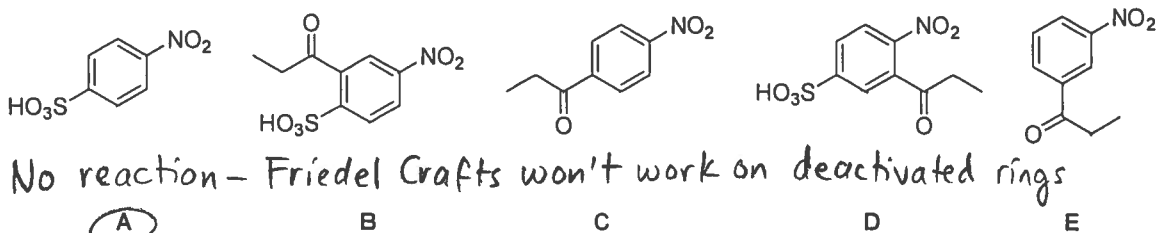
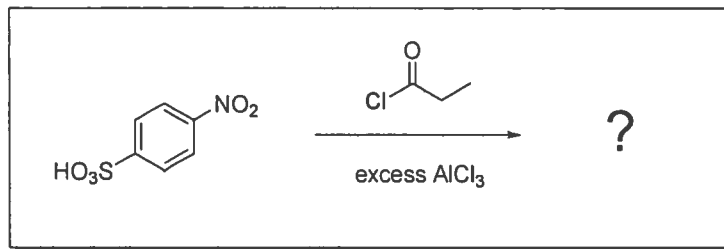


E



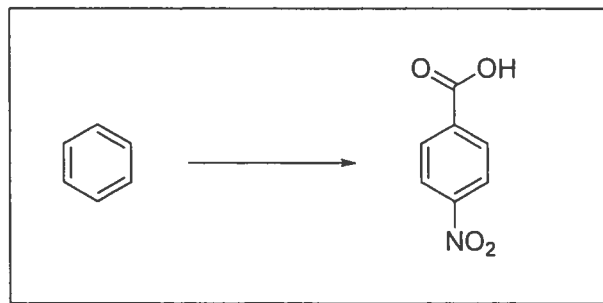
4. What is the most likely outcome of these reaction conditions?

A



5. You wish to make the target molecule shown from benzene using a multistep synthesis:

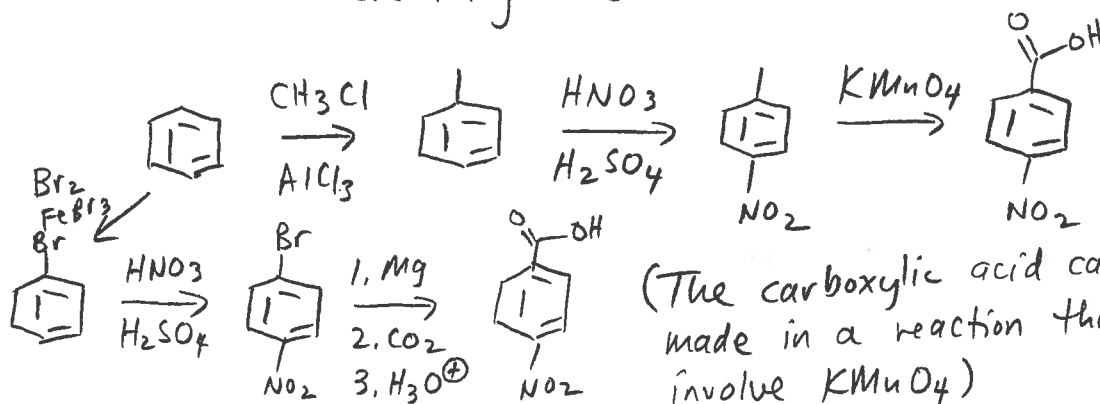
C



Which of the following reagents must be used to accomplish this transformation using chemistry that we have discussed in class?

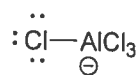
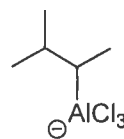
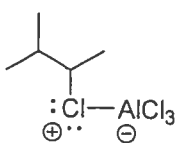
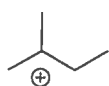
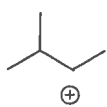
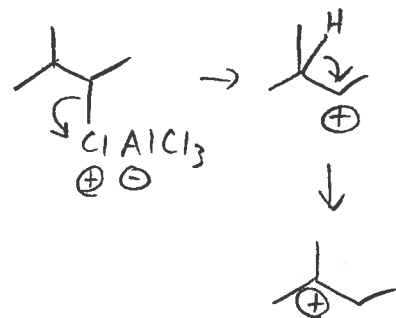
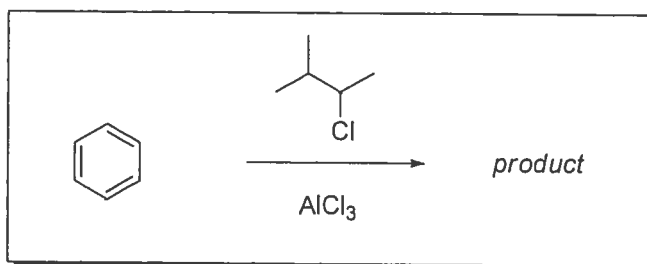
- a. KMnO_4
- b. Br_2
- c. H_2SO_4
- d. AlCl_3
- e. NBS

You must use a nitration to install the NO_2 group if you are limited to chemistry discussed in class.



6. Select the electrophile from which the major product is formed in the Friedel Crafts acylation shown.

B



A

B

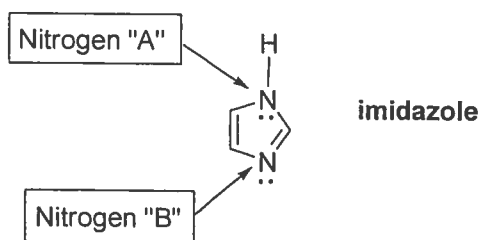
C

D

E

7. Which of the nitrogen atoms in imidazole is more basic? Use the labels on the structure to answer the question.

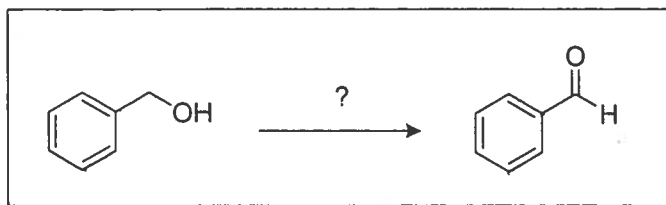
B



- a. Nitrogen A
 b. Nitrogen B
 c. Both nitrogens are equally basic
 d. Cannot be determined

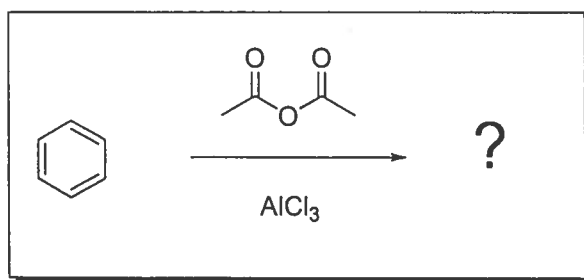
Lone pair on A is involved in aromaticity

8. Select the reagent that will successfully convert the starting material to the product. Assume an appropriate solvent and workup.

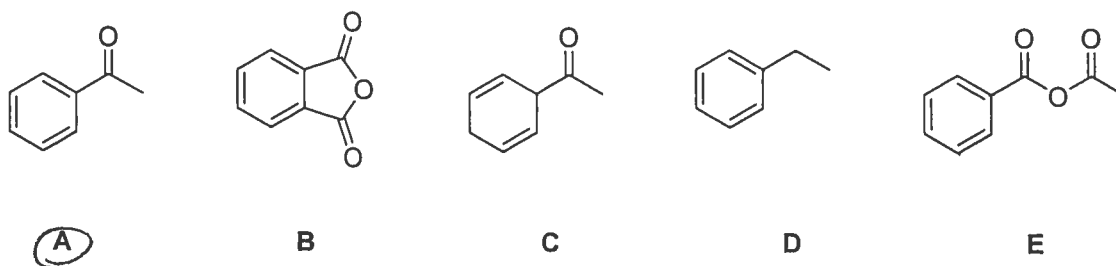


D

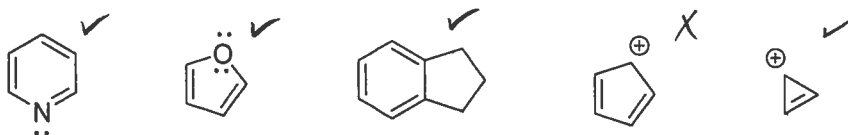
- a. NBS
 - b. CO, HCl, CuCl, AlCl₃
 - c. HCl, Hg/Zn
 - d. MnO₂
 - e. None of these reagents will accomplish this transformation.
9. Select the correct product of the reaction conditions.



A



10. How many of these compounds are aromatic?



D

- a. One
- b. Two
- c. Three
- d. Four
- e. Five

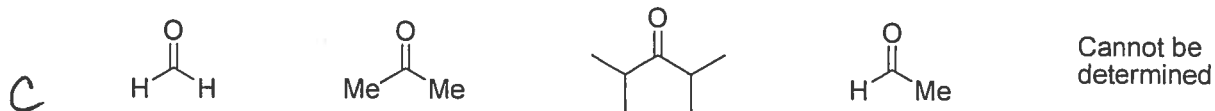
11. Select the correct reagent to accomplish this transformation. Assume appropriate workup.



D

- a. NaBH_4
- b. LAH
- c. HCl (aq), Hg/Zn
- d. $\text{H}_2\text{NNH}_2, \text{KOH, heat}$
- e. None of these

12. Select the compound with the smallest value of $K_{\text{hydration}}$.



A

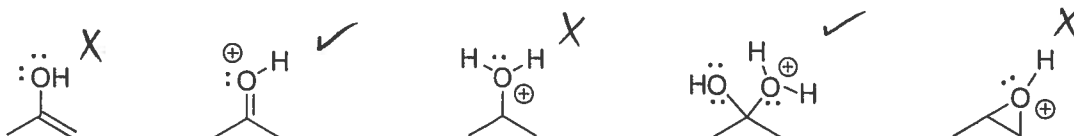
B

C

D

E

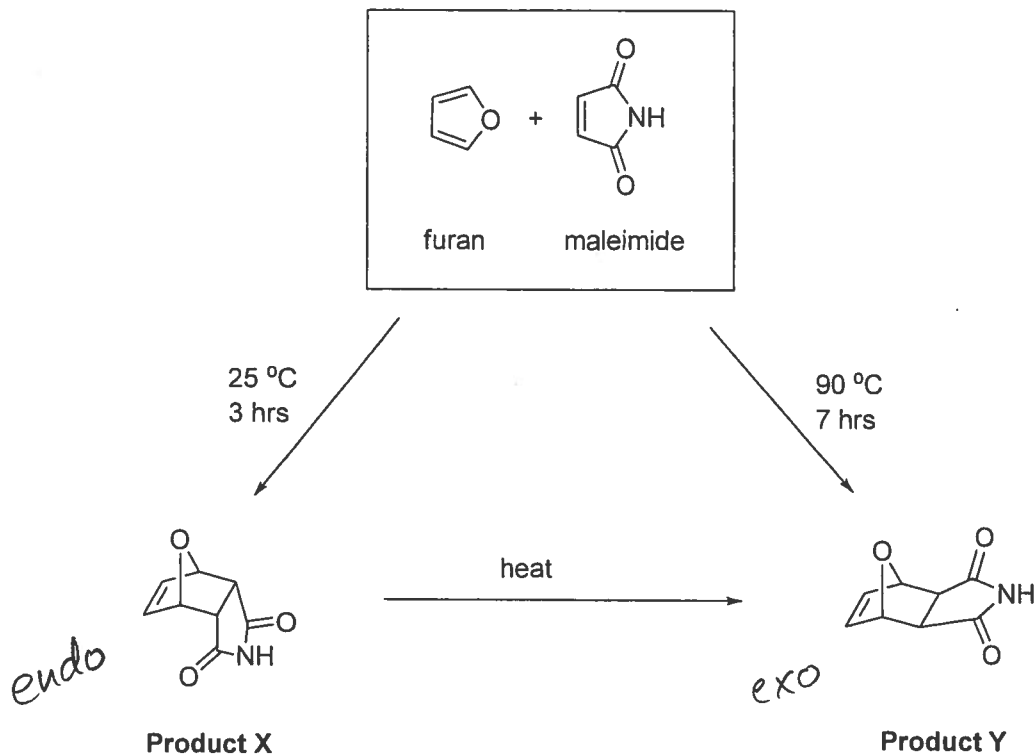
13. How many of these structures are intermediates in the acid-catalyzed hydration of a ketone?



B

- a. One
- b. Two
- c. Three
- d. Four
- e. Five

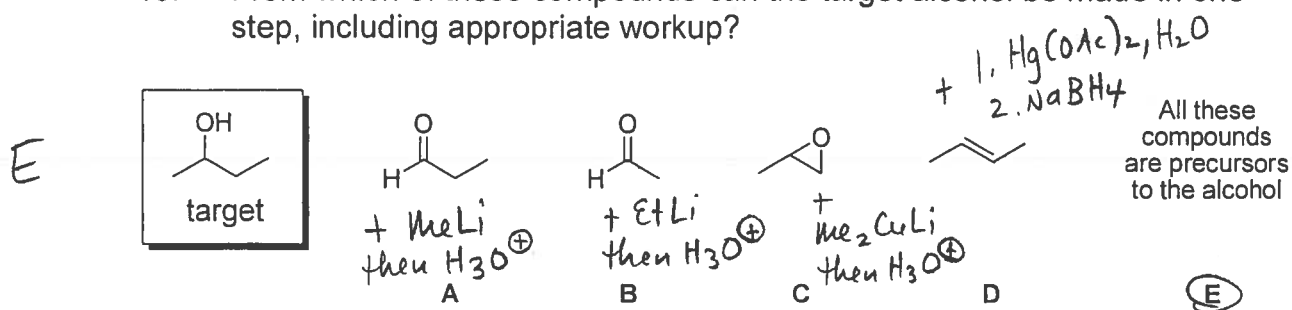
14. Furan and maleimide are allowed to react in a Diels Alder reaction under different conditions, as shown here. Depending on conditions, one of two possible products forms. Product "X" is converted to Product "Y" if it is heated.



Which of the following statements is true?

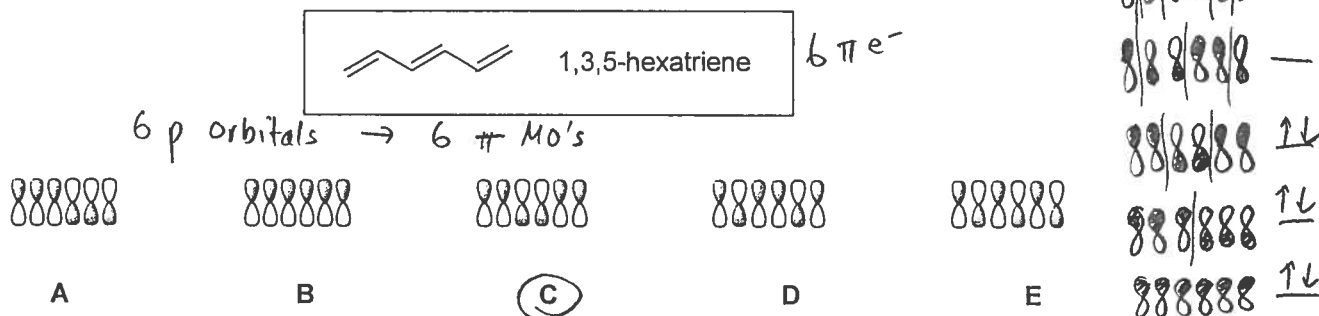
- a. The endo product is the kinetic product of the reaction.
- b. The endo product is the more stable product.
- c. Running the reaction at 150 °C is likely to increase the amount of Product "X" produced in the reaction. *It will give you more exo*
- d. The reaction is not reversible. *It must be if Y can form from X*
- e. None of these statements is true.

15. From which of these compounds can the target alcohol be made in one step, including appropriate workup?



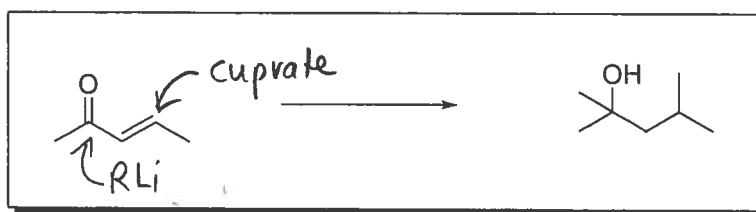
16. Which of these orbitals is the HOMO of 1,3,5-hexatriene? (Use the same approach discussed in class regarding the π molecular orbitals of 1,3-butadiene.)

C

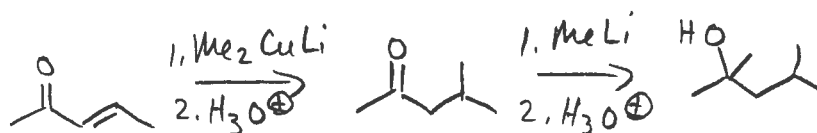


17. Assuming appropriate workup for all steps (e.g., H_3O^+ after a reaction with an organometallic reagent), which of these choices describes how you would make the target from the starting material?

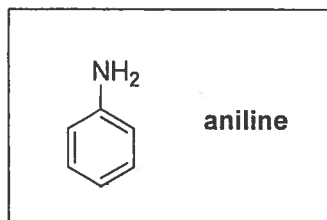
B



- a. MeLi, then Me_2CuLi
 b. Me_2CuLi , then MeLi
 c. Me_2CuLi , then $NaBH_4$ or LAH
 d. $NaBH_4$ or LAH, then MeLi
 e. None of these would work

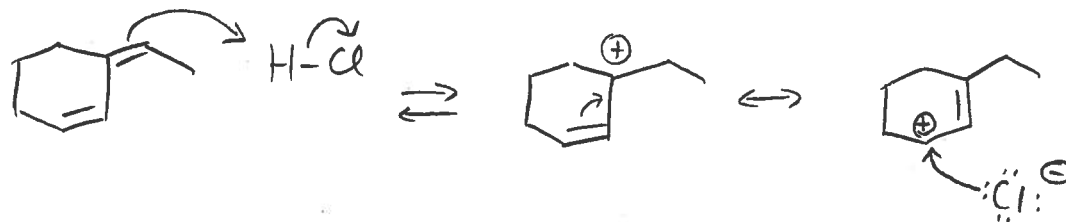
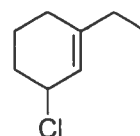
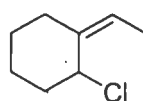
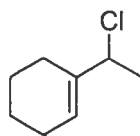
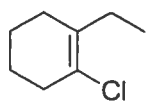
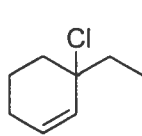
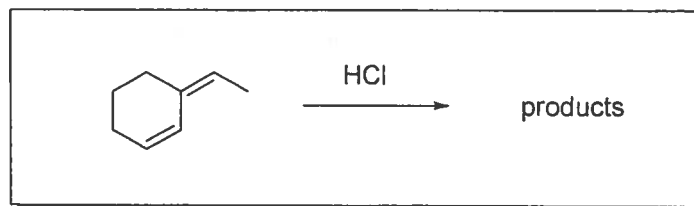


18. Which of these statements about acetylating the nitrogen in aniline is true?

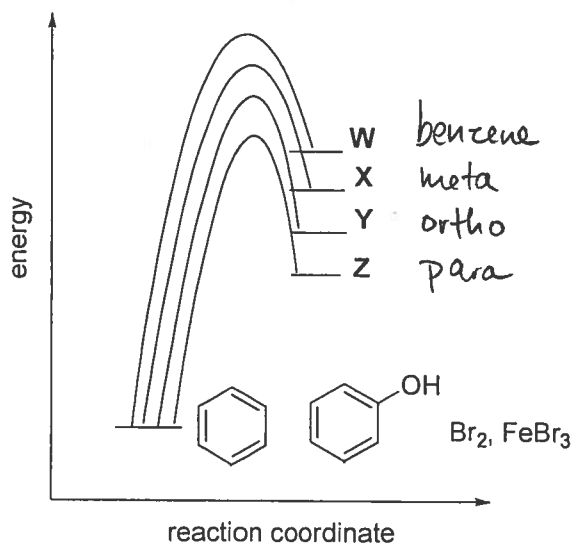


- a. It makes the ring more activated toward electrophilic aromatic substitution.
- b. It completely deactivates the ring toward electrophilic aromatic substitution. *It just "tones it down"*
- c. It makes the group containing the nitrogen a meta director. *Still o,p*
- d. It causes a Friedel Crafts reaction to occur.
- e. None of these statements is true.

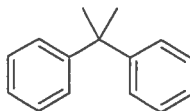
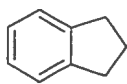
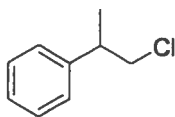
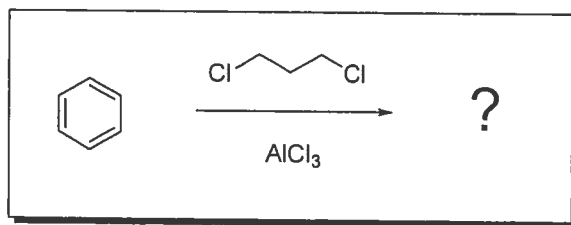
19. Select the thermodynamic product of the reaction.



20. Equal amounts of benzene and phenol are mixed and allowed to react with bromine in the presence of the Lewis acid, FeBr₃, in an electrophilic aromatic substitution. An energy vs. reaction coordinate diagram for the rate-limiting step of the reaction is shown. Which structure corresponds to the intermediate for the ortho substitution pathway of phenol?



- a. W
b. X
c. Y
d. Z
e. Cannot be determined
21. Which of the products shown in the answer choices is a possible outcome of these reaction conditions? (Note that you are not being asked to determine a major product, just whether something can possibly form.)



All of these might form

Only A and B could form

A

B

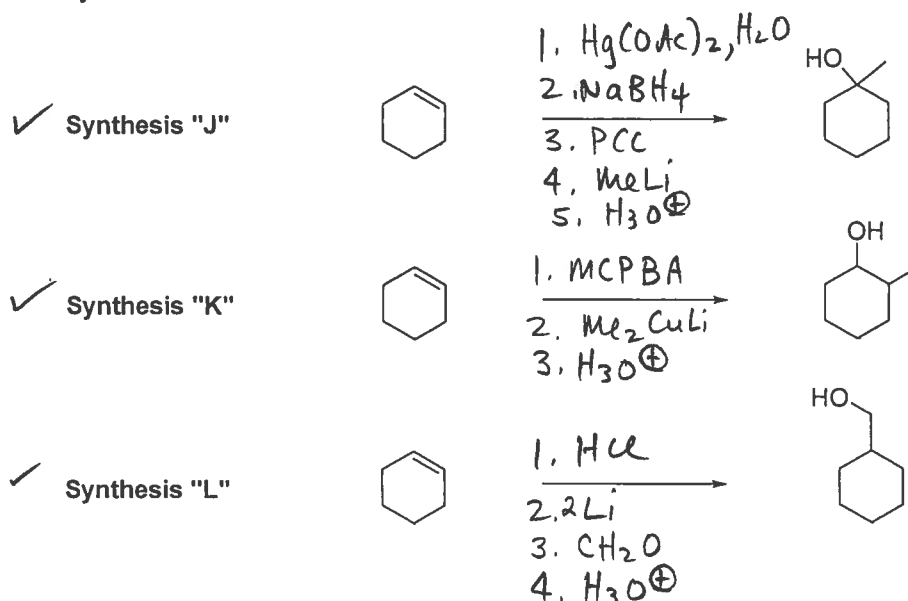
C

D



E

22. Consider the following three syntheses and the reagents that are available for you to use:

D



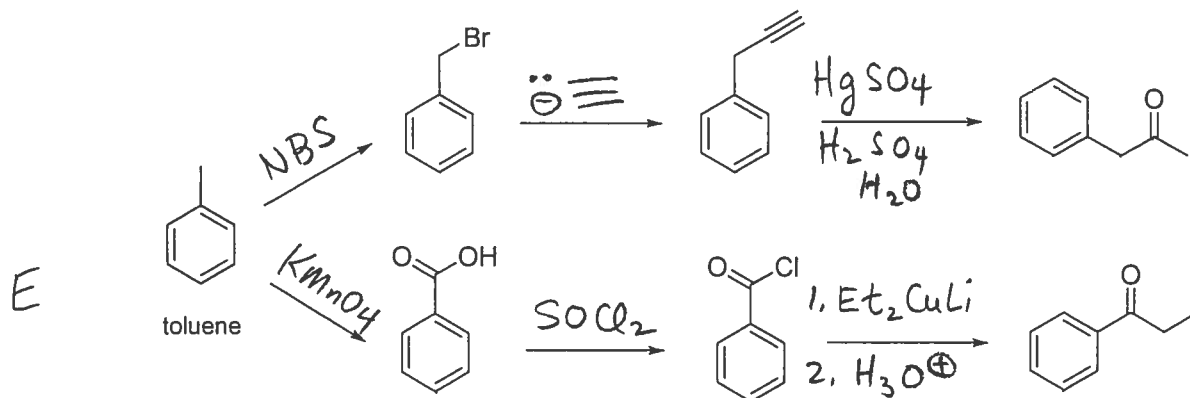
Available reagents:

LAH	Si_2BH	AlCl_3		CH_3Li
OsO_4	Aqueous acid (H_3O^+)	$\text{Hg}(\text{OAc})_2, \text{H}_2\text{O}$		$(\text{CH}_3)_2\text{CuLi}$
H_2O_2	Aqueous base (HO^-)	KMnO_4		CO
O_3	LDA	NaBH_4		HCl
DMS	Na metal	Jones reagent		CuCl
NBS	Li metal	SOCl_2		PCC
FeBr_3	NH_3	Br_2		MCPBA

Using only the reagents that are available to you (along with any necessary solvents), which of these three syntheses cannot be successfully accomplished?

- J
- K
- L
- All three can be successfully accomplished.
- None of the three can be accomplished.

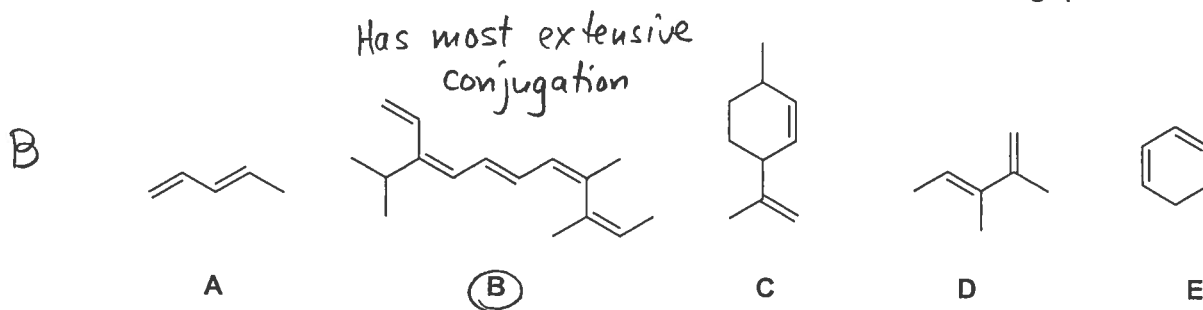
23. Here are two multi-step syntheses using toluene as the starting material:



Which of these reagents is used in both syntheses?

- PCC
- LAH
- NBS
- AlCl_3
- There are no reagents common to both syntheses (not counting aqueous acid or base workups).

24. Which of these molecules has the *smallest* HOMO-LUMO gap?



25. Justin Bieber and his pet monkey are playing in the lab one day. The monkey decides that it would be funny to push Justin Bieber into a vat of dye. And it was! The dye absorbs visible light at a λ_{max} of 524 nm. What color is Justin Bieber now?

E

- Violet
- Blue
- Green
- Orange
- Red

