

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 10 pages and 16 questions, including this cover sheet. Be sure you have them all. Read each question carefully so that you know exactly what is being asked and what you need to write or draw. Your work on scratch pages will not be graded, so be sure everything you want graded is written on the exam itself and that your answers to the multiple choice questions are correctly bubbled in on the Scantron.

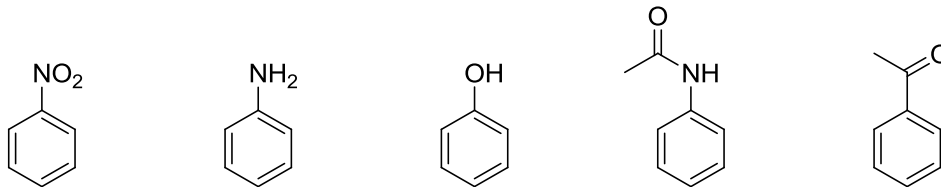
Each multiple choice question (1-12) is worth **4 points** and has **only one correct answer**. Good luck!

**PERIODIC CHART OF THE ELEMENTS**

IA	IIA	IIIB	IVB	VB	VIB	VIIIB	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES		
1 H 1.00797														1 H 1.00797	2 He 4.0026		
3 Li 6.939	4 Be 9.0122										5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183	
11 Na 22.9898	12 Mg 24.312										13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948	
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc [99]	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po [210]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]	+89 Ac [227]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [262]	108 Hs [265]	109 Mt [266]	110 ? [271]	111 ? [272]	112 ? [277]						

Circle the single best answer to each multiple choice question (1-12). (4 pts each)

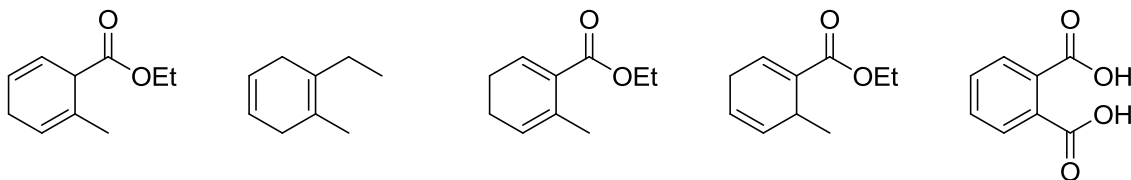
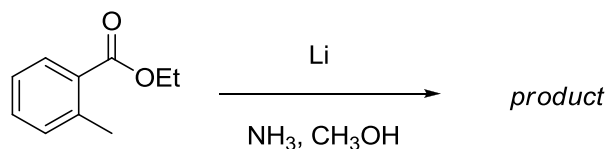
1. Which of the following compounds will undergo a sulfonation reaction *faster* than benzene?



V                      W                      X                      Y                      Z

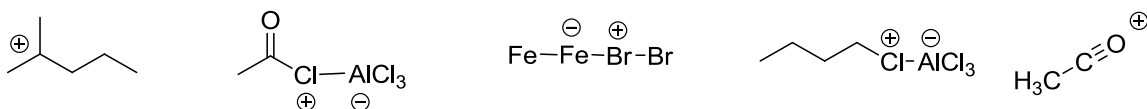
- V and W
- V, W, Y
- V, W, X, Y
- W and X
- W, X, Y

2. The following compound was treated with lithium metal in a mixture of ammonia and methanol. What is the major organic product of this reaction?



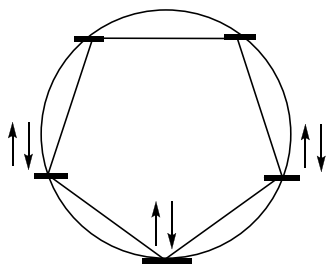
A                      B                      C                      D                      E

3. One of these compounds is *not* an intermediate in an electrophilic aromatic substitution reaction. Which one is it?



A                      B                      C                      D                      E

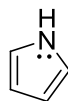
4. Consider this Frost circle:



Which of these compounds is described by this Frost circle?



**G**



**H**



**I**



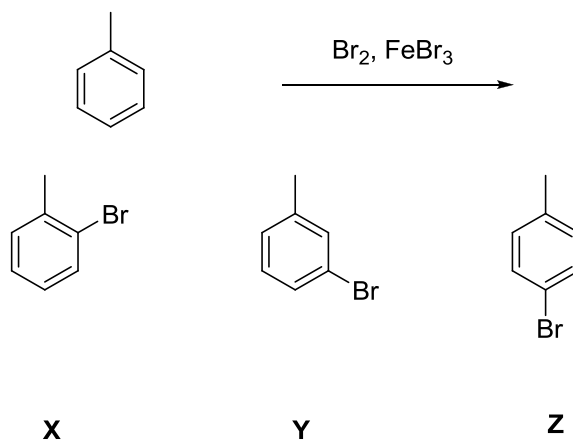
**J**



**K**

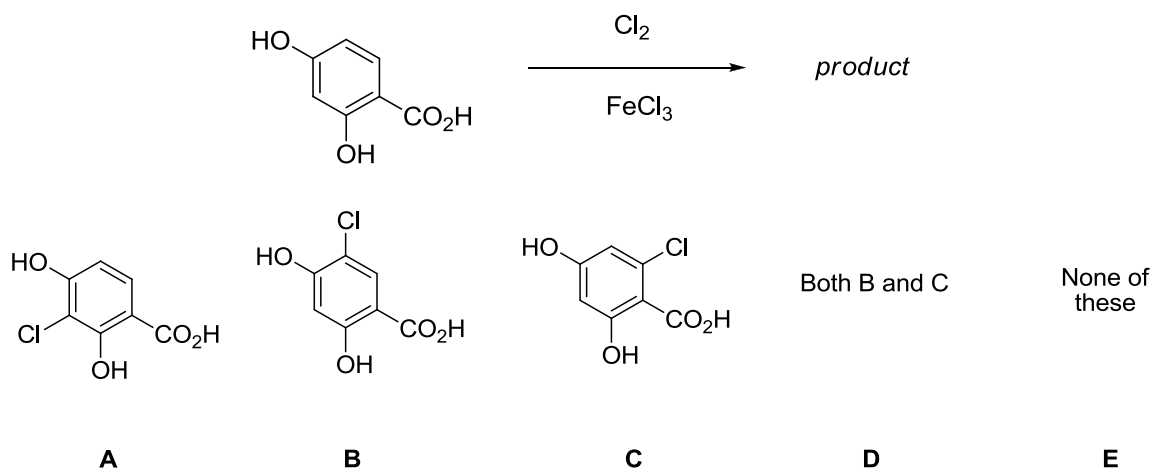
- a. G, H, I
- b. G, H, I, J
- c. G, H, I, K
- d. G, I, J, K
- e. G, I, K

5. What is the major organic product of this reaction?

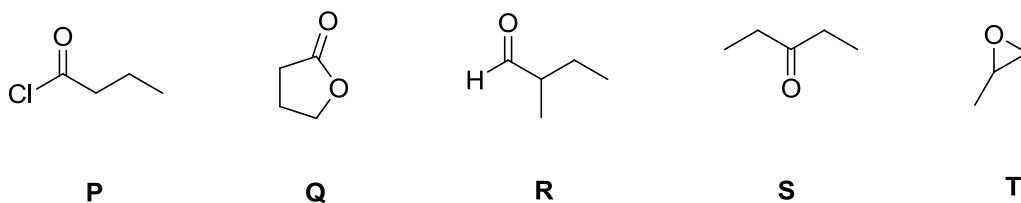


- a. only X
- b. only Y
- c. only Z
- d. X and Z
- e. Y and Z

6. What is the major organic product of this reaction?

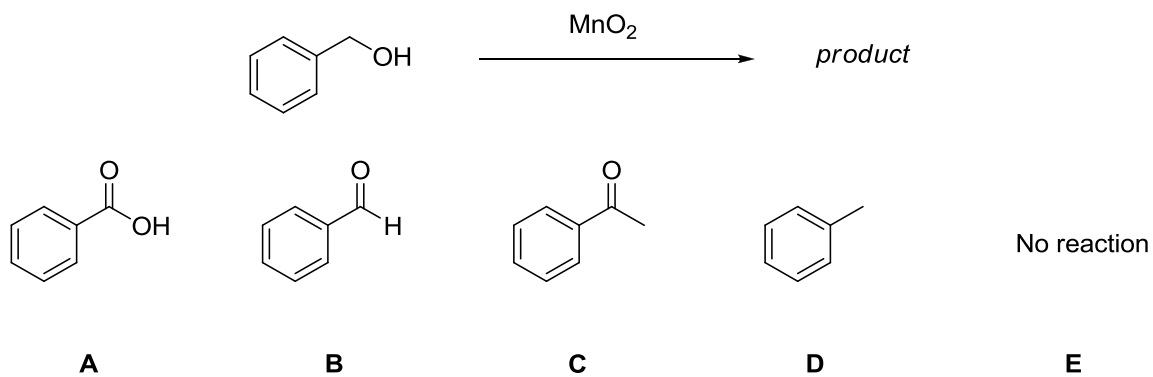


7. Which of the following compounds, when treated with the appropriate amount of a Grignard reagent or organolithium reagent, can be used to make a tertiary alcohol?

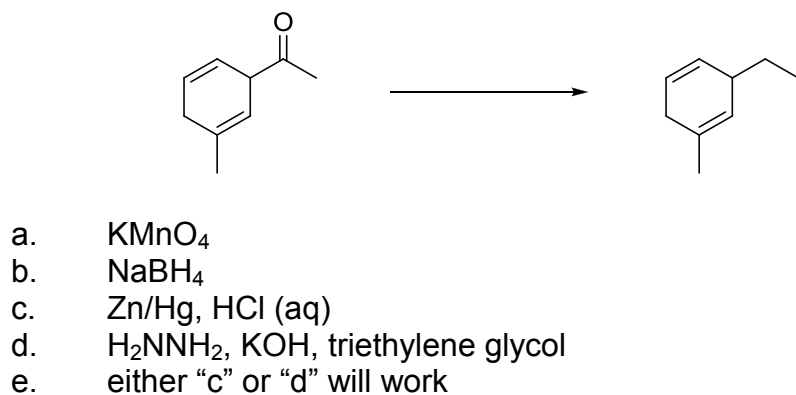


- a. P, Q, S
- b. P, Q, R, S
- c. P, S
- d. P, S, T
- e. All of these compounds would yield tertiary alcohols when treated with  $\text{RMgX}$  or  $\text{RLi}$

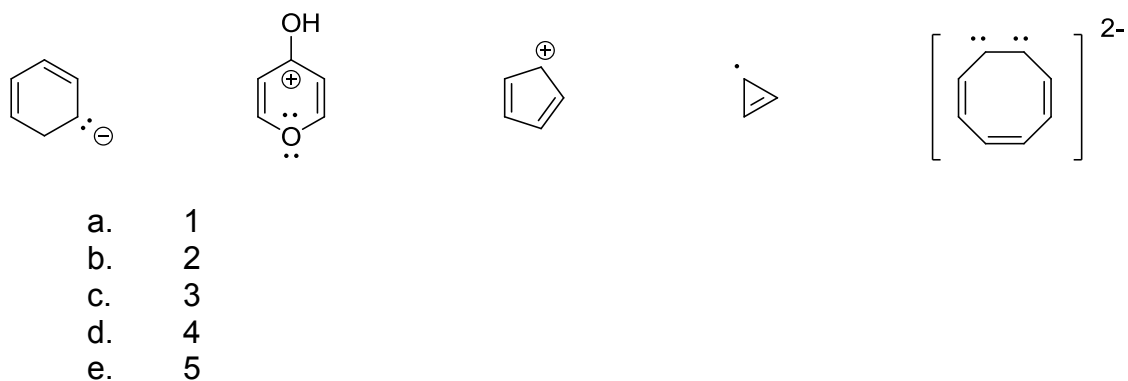
8. What is the product of this reaction?



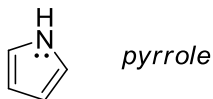
9. What reagent would you use for this transformation?



10. How many of these structures are aromatic?

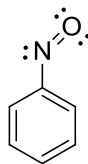


11. The lone pair on nitrogen in pyrrole is contained in which type of orbital?



- a.  $sp$
- b.  $sp^2$
- c.  $sp^3$
- d.  $s$
- e.  $p$

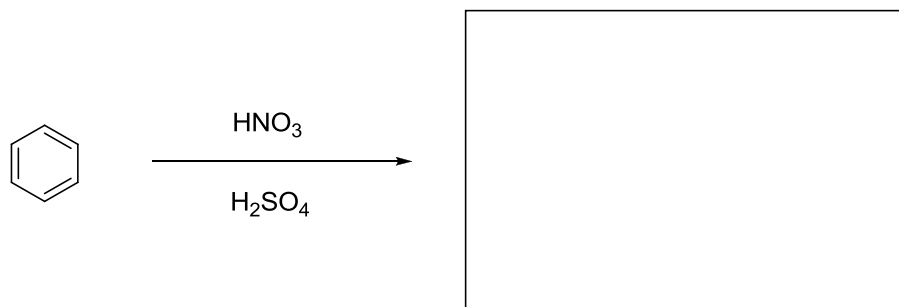
12. The nitroso group is a functional group we have not seen. Nitrosobenzene has the following structure:



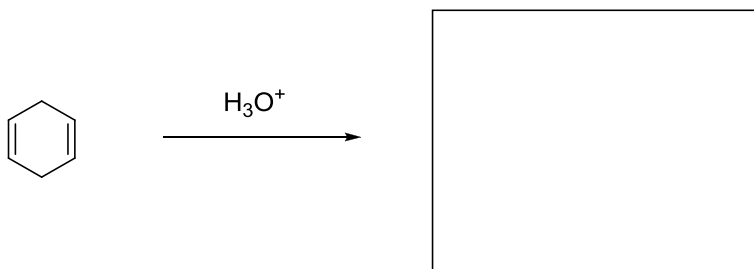
Based on the behavior of other groups you have seen, which of these phrases do you expect will best describe the chemical behavior of the nitroso group?

- a. Meta director, deactivating
- b. Meta director, activating
- c. Ortho/para director, deactivating
- d. Ortho/para director, activating
- e. Can direct ortho, para or meta, and is activating and deactivating at the same time, depending on its mood and how much coffee it's had that day

13. Predict the major organic product of the following reaction and provide a mechanism to show how it is formed. Include all curved arrows, intermediates, lone pairs of electrons, and non-zero formal charges for full credit. (15 pts)

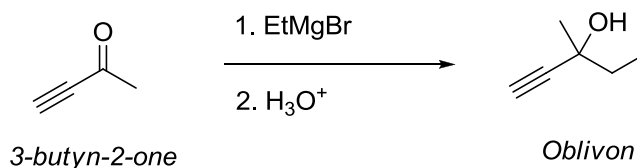


14. It is common in old horror movies for unsuspecting victims to be pushed into vats of acid by monsters. They then emerge as zombie skeletons who terrorize entire cities. In one such movie ("*O-Chem: Summer of Doom*"), 1,4-cyclohexadiene is dropped into a vat of aqueous acid, as shown in the following scene from the movie:



Draw the product of this reaction and a mechanism to show the formation of the product. Include all necessary curved arrows, intermediates, electrons and nonzero formal charges. (9 pts)

15. Synthesis of the tranquilizer 3-methyl-1-pentyn-3-ol (Oblivon) was attempted using 3-butyn-2-one as the starting material and treating it with ethylmagnesium bromide in diethyl ether. Will this synthesis be successful? Explain why or why not. (4 pts)



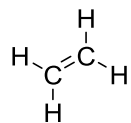
Circle one: **Yes (successful)** **No (unsuccessful)**

Reason: (2 sentences MAX):

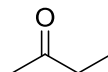


16. Design a multi-step synthesis for each of the following transformations. Show the reagents needed for each step and the product of each step. Do not draw any mechanisms. Do not provide a list of reagents without showing the product of each step or you will not receive full credit. Note any special requirements for each synthesis. **NOTE THAT ONE SYNTHESIS IS ON THIS PAGE, AND THE OTHER IS ON THE NEXT PAGE.**

**Synthesis A:** Propose a synthetic sequence to prepare 2-butanone using ethylene as the only source of carbon atoms. If you use an organometallic reagent, you must show how it is synthesized. (15 pts)



*ethylene*



*2-butanone*

16. (continued)

**Synthesis B:** (9 pts)

