

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.

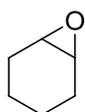
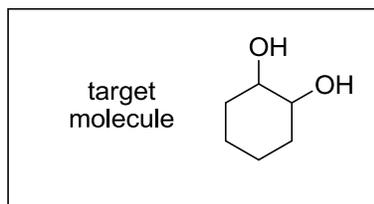
At the end of the exam, turn in your Scantron and this signed cover sheet. You may keep the rest of the exam to check your answers against the key later.

Good luck!

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)						

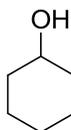
1. Which of the following compounds could be used to make this target in one step (including any necessary workup)?



A



B



C

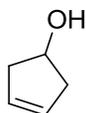
Either
A or B

D

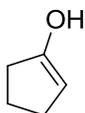
A, B or C

E

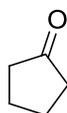
2. Select the enol from the structures shown.



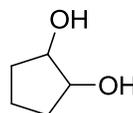
A



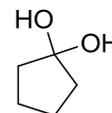
B



C



D

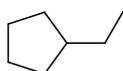
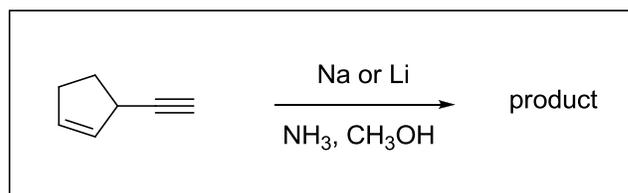


E

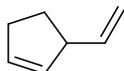
3. Which of these hydride sources is non-nucleophilic?

- NaBH_4
- LAH
- NaH
- All are nucleophilic
- All are non-nucleophilic

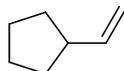
4. Which of these structures is the product of the reaction?



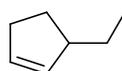
A



B



C



D

None of these is the product

E

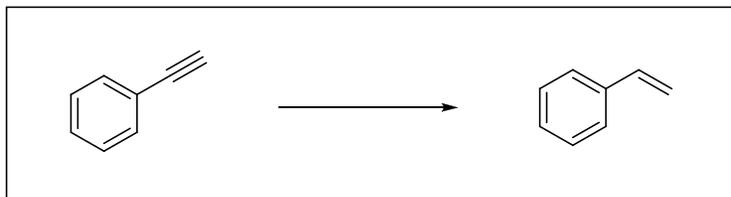
5. You wish to make an epoxide from an alkene, but you have no mCPBA. However, you do have access to all the reagents listed below, plus all the materials necessary for appropriate aqueous workups. Can you make the epoxide?

Reagents available:

NaOCH ₃ /CH ₃ OH	LDA	NaH
NaOH(aq)	H ₂ O	Hg(OAc) ₂
OsO ₄	TBHP	HIO ₄
NaNH ₂	O ₃	

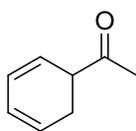
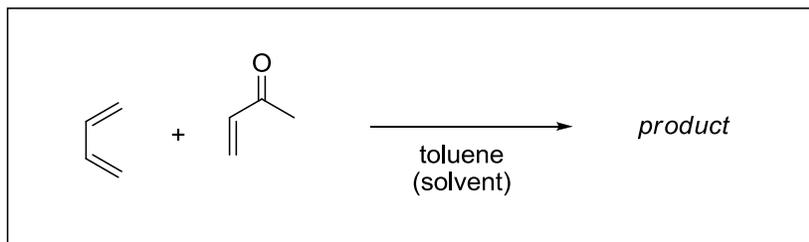
- Yes! I can make the epoxide using some or all of the reagents above.
- No! An epoxide cannot be made from an alkene with the reagents shown above.

6. What are the best conditions to use to accomplish this transformation?

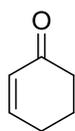


- H₂ and Lindlar's catalyst
- Na, NH₃
- H₂ and Pd/C
- Either a or b
- a, b or c would all work

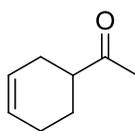
7. Which is the correct product of this reaction?



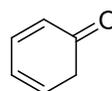
A



B



C

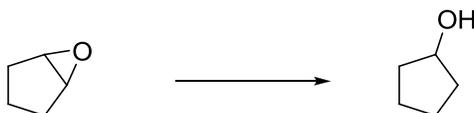


D

None of these is the product

E

8. Select the reagent you would use to accomplish the following transformation.

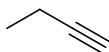


- a. LAH, then H_3O^+ workup
- b. $\text{NaOH}(\text{aq})$
- c. H_3O^+
- d. NaH, then H_3O^+ workup
- e. This transformation cannot be accomplished in one step.

9. Which of these is the *most* acidic hydrocarbon?



A



B



C

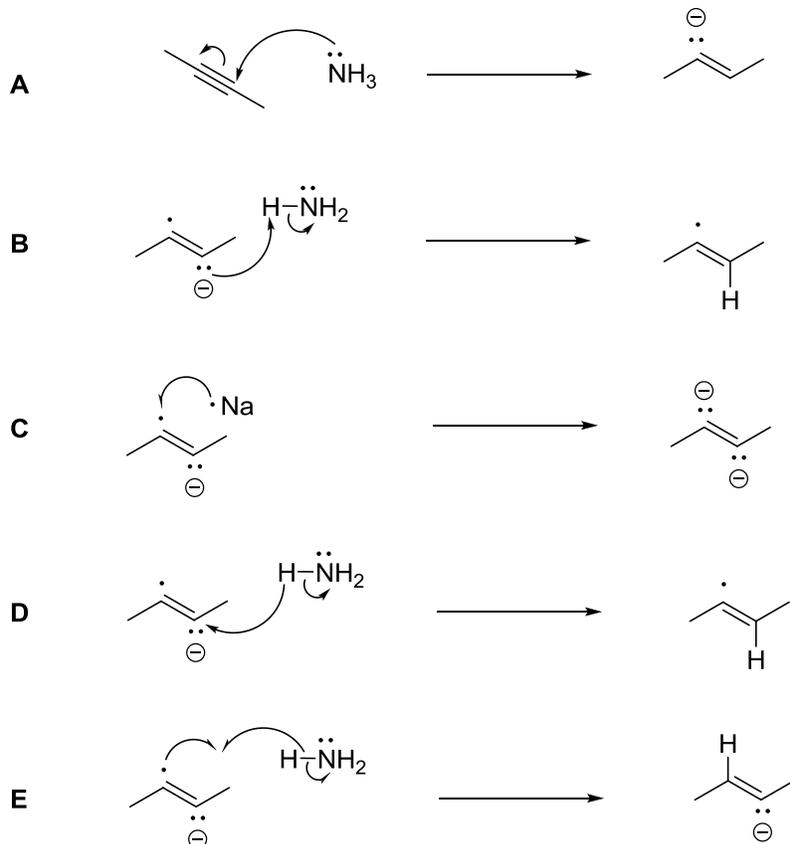


D

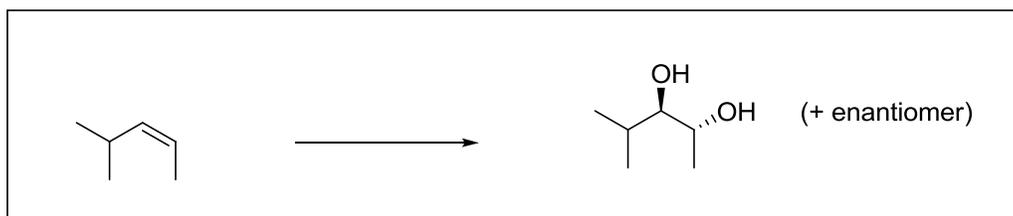
All are equally acidic

E

10. Which of the following is a mechanistic step in the dissolving metal reduction of an alkyne with sodium metal in liquid ammonia as the solvent?

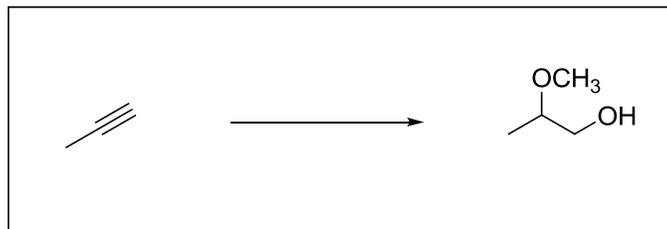


11. What conditions could be used to accomplish this transformation?

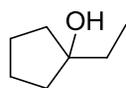
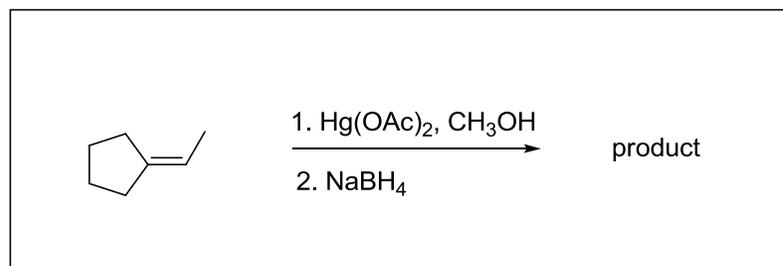


- mCPBA, then H_3O^+
- HIO_4 (periodic acid)
- OsO_4 , TBHP, and H_2O
- $\text{Hg}(\text{OAc})_2$, H_2O ; then NaBH_4
- None of these conditions would work

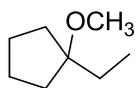
12. Which of the following synthetic sequences produces the target molecule from the starting material? (Assume appropriate aqueous workups for all steps even if not explicitly written.)



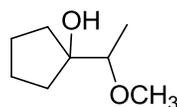
1. H_2 , Pd
2. mCPBA
3. CH_3OH , H_2SO_4
 1. Na, NH_3
2. mCPBA
3. NaOCH_3 , CH_3OH , then H_3O^+
 1. H_2 /Lindlar catalyst
2. mCPBA
3. NaOH , H_2O , then H_3O^+
 1. H_2 /Lindlar catalyst
2. mCPBA
3. CH_3OH , H_2SO_4
 - None of these syntheses will produce the target molecule
13. What is the major product of this reaction?



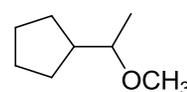
A



B



C

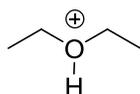
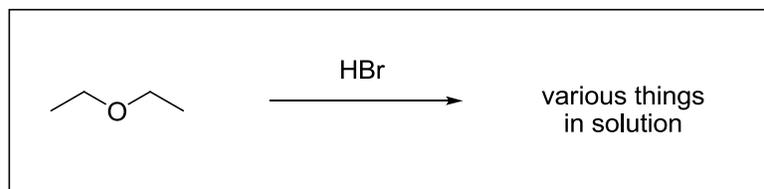


D

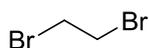
None of these is the major product

E

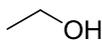
14. When a small amount of HBr is added to diethyl ether, there are various species present in solution. Which of the structures shown would you NOT expect to find in this solution?



A



B



C

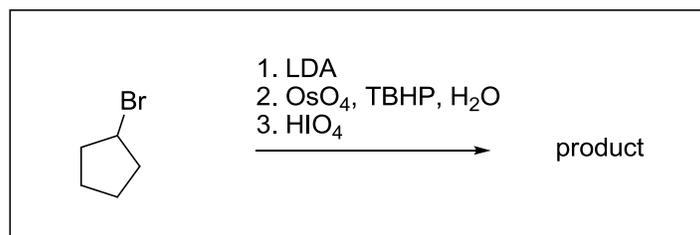


D

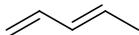


E

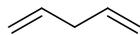
15. Which statement about the final product of the sequence of reactions shown is *true*?



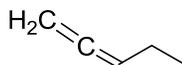
- The product contains at least one ketone
 - The product contains at least one OH group
 - The product contains at least one aldehyde
 - The product contains an epoxide
 - The product contains an alkene
16. Which of these C_5H_8 dienes is least stable?



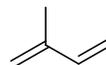
A



B



C

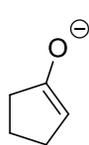
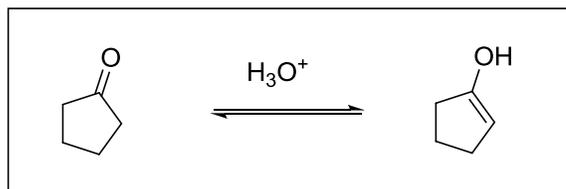


D

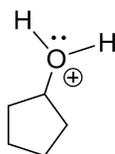
All are equally stable

E

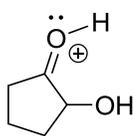
17. In aqueous acid, carbonyls are in equilibrium with their enol forms through a process called keto-enol tautomerization. In the example below, a ketone is placed in aqueous acid and allowed to come to equilibrium with its enol form. Which of these intermediates is observed in the tautomerization mechanism shown in class?



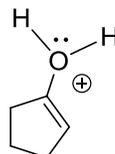
A



B



C

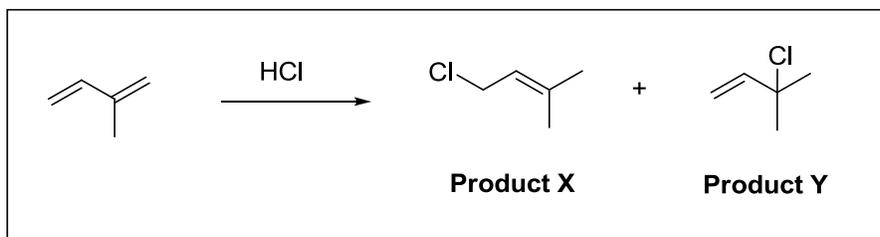


D

None of these intermediates is observed in the mechanism

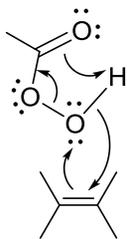
E

18. Which of the following statements is true about this reaction? (Note that if any part of a statement is not true, then you should reject the entire statement.)

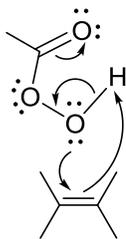


- Product X is the thermodynamic product and could be formed using short reaction times and low temperatures.
- Product X is the thermodynamic product and could be formed using long reaction times and high temperatures.
- Product Y is the thermodynamic product and could be formed using short reaction times and low temperatures.
- Product Y is the thermodynamic product and could be formed using long reaction times and high temperatures.

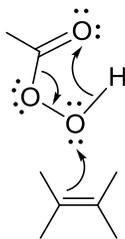
19. Which of these mechanisms is the correct depiction of the reaction of a peroxydicarboxylic acid (such as mCPBA or peracetic acid) with an alkene?



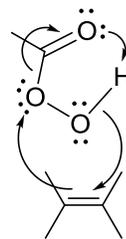
A



B



C

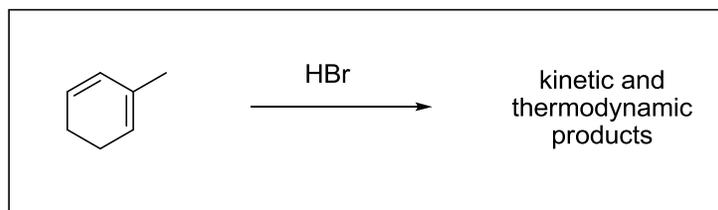


D

None of these mechanisms is correct

E

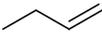
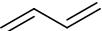
20. Consider this reaction:



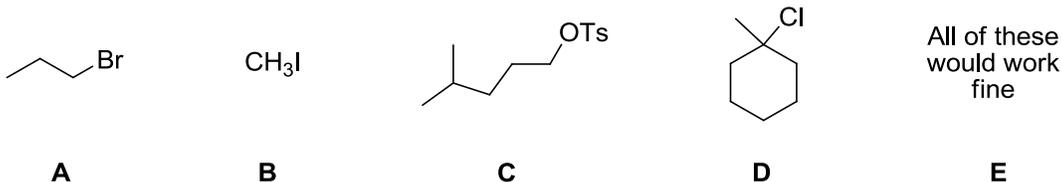
Both kinetic and thermodynamic products can be formed in this reaction, depending on the conditions used. Which of these statements about this reaction is incorrect?

- The kinetic product forms fastest because the nucleophile is close to the new carbocation that forms when the diene is protonated.
- To form the thermodynamic product, the reaction mixture needs time to equilibrate.
- The thermodynamic product is more stable than the kinetic product.
- The path leading to the thermodynamic product has a lower activation energy than the path leading to the kinetic product.
- Both the kinetic product and the thermodynamic product share a common intermediate, which is a carbocation.

21. Given the following information, what is the resonance energy for 1,3-butadiene? (The heats of hydrogenation in this table are experimentally determined.)

Compound	$ \Delta H_{\text{hydrogenation}} $ (kcal/mol)
1-butene 	30
1,3-butadiene 	56.6

- a. $56.6 - 30$
 b. $56.6 + 30$
 c. $60 - 56.6$
 d. $60 - (30 + 56.6)$
 e. $56.6 + 60$
22. Acetylide ions can be alkylated by treating them with a variety of electrophiles. One of these compounds would not be appropriate for an alkylation reaction with an acetylide ion. Which is it?



23. One version of the Lindlar catalyst includes Pd, CaCO_3 or BaSO_4 , a lead(II) (Pb^{2+}) salt such as $\text{Pb}(\text{OAc})_2$, and a compound called quinoline. The Lindlar catalyst is called a “poisoned” catalyst. What is a poisoned catalyst?
- a. It is a catalyst that has no effect on the reaction it is supposed to catalyze
 b. It is a catalyst that is less effective than a catalyst that is not poisoned
 c. It is a catalyst that accelerates the rate of the forward reaction, but slows the rate of the reverse reaction so that you get more product
 d. It is a deadly, evil catalyst that goes around poisoning people

24. Which of the following reagents would you use to make a quantitative yield of an alkoxide ion from an alcohol?
- H_2 (with or without a metal catalyst)
 - NaH
 - NaOH
 - Any alkoxide ion
 - None of the above
25. It's official -- Kim Kardashian and Kanye West are a couple! Even better, they're going to open a new business called "Kim 'n' Kanye's Ketone Korner". They want to produce ketones using alkynes as the starting material. Which of the following reagents should they order to make their ketones?
- Catechol borane, hydrogen peroxide, and aqueous NaOH
 - Disiamylborane, hydrogen peroxide, and aqueous NaOH
 - Mercury (II) sulfate, sulfuric acid, water
 - Periodic acid, hydrogen peroxide, and water
 - The business will fail. Ketones cannot be produced from alkynes.