

## Answer Key

### Chemistry 233-001/002 Exam 3 – Version A

Fall 2019

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**Instructions:** Answer the first 17 questions of this exam using the bubble sheet attached to the end of this exam booklet. You may detach this sheet if you wish. Answer the remaining questions directly on this exam. Show all work.

**The Periodic Table**

IA	1	2											13	14	15	16	17	VIII A	2
	<b>H</b>																		<b>He</b>
	1.01																		4.00
	3	4											5	6	7	8	9	10	
	<b>Li</b>	<b>Be</b>											<b>B</b>	<b>C</b>	<b>N</b>	<b>O</b>	<b>F</b>	<b>Ne</b>	
	6.94	9.01											10.81	12.01	14.01	16.00	19.00	20.18	
	11	12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
	<b>Na</b>	<b>Mg</b>											<b>Al</b>	<b>Si</b>	<b>P</b>	<b>S</b>	<b>Cl</b>	<b>Ar</b>	
	22.99	24.31											26.98	28.09	30.97	32.07	35.45	39.95	
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
	<b>K</b>	<b>Ca</b>	<b>Sc</b>	<b>Ti</b>	<b>V</b>	<b>Cr</b>	<b>Mn</b>	<b>Fe</b>	<b>Co</b>	<b>Ni</b>	<b>Cu</b>	<b>Zn</b>	<b>Ga</b>	<b>Ge</b>	<b>As</b>	<b>Se</b>	<b>Br</b>	<b>Kr</b>	
	39.1	40.08	44.96	47.88	50.94	52.00	54.94	55.85	58.93	58.69	63.55	65.39	69.72	72.61	74.92	78.96	79.90	83.80	
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
	<b>Rb</b>	<b>Sr</b>	<b>Y</b>	<b>Zr</b>	<b>Nb</b>	<b>Mo</b>	<b>Tc</b>	<b>Ru</b>	<b>Rh</b>	<b>Pd</b>	<b>Ag</b>	<b>Cd</b>	<b>In</b>	<b>Sn</b>	<b>Sb</b>	<b>Te</b>	<b>I</b>	<b>Xe</b>	
	85.47	87.62	88.91	91.22	92.91	95.94	(98)	101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.6	126.9	131.29	
	55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	
	<b>Cs</b>	<b>Ba</b>	<b>La*</b>	<b>Hf</b>	<b>Ta</b>	<b>W</b>	<b>Re</b>	<b>Os</b>	<b>Ir</b>	<b>Pt</b>	<b>Au</b>	<b>Hg</b>	<b>Tl</b>	<b>Pb</b>	<b>Bi</b>	<b>Po</b>	<b>At</b>	<b>Rn</b>	
	132.9	137.3	138.9	178.5	180.9	183.9	186.2	190.2	192.2	195.1	197.0	200.6	204.4	207.2	209	(209)	(210)	(222)	
	87	88	89	104	105	106	107	108	109	110	111								
	<b>Fr</b>	<b>Ra</b>	<b>Ac^</b>	<b>Rf</b>	<b>Db</b>	<b>Sg</b>	<b>Bh</b>	<b>Hs</b>	<b>Mt</b>	<b>Ds</b>	<b>Rg</b>								
	(223)	(226)	(227)	(261)	(262)	(263)	(264)	(265)	(268)	(271)	(272)								

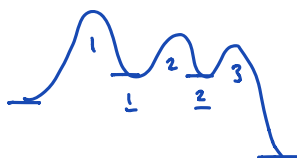
*	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	<b>Ce</b>	<b>Pr</b>	<b>Nd</b>	<b>Pm</b>	<b>Sm</b>	<b>Eu</b>	<b>Gd</b>	<b>Tb</b>	<b>Dy</b>	<b>Ho</b>	<b>Er</b>	<b>Tm</b>	<b>Yb</b>	<b>Lu</b>
	140.1	140.9	144.2	(145)	150.4	152.0	157.3	158.9	162.5	164.9	167.3	168.9	173.0	175.0
^	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	<b>Th</b>	<b>Pa</b>	<b>U</b>	<b>Np</b>	<b>Pu</b>	<b>Am</b>	<b>Cm</b>	<b>Bk</b>	<b>Cf</b>	<b>Es</b>	<b>Fm</b>	<b>Md</b>	<b>No</b>	<b>Lr</b>
	232.0	(231)	238.0	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(260)

### Multiple-Choice

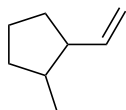
Choose the best answer for each of the following questions. Record each answer on the attached bubble sheet. **Ensure you completely bubble in your answers.** (2 points each)

1. The reaction coordinate for a three step reaction will have 2 intermediates and 3 transition states.

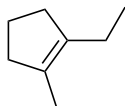
- a. three; four  
b. one; three  
c. two; three  
d. three; two  
e. three; three



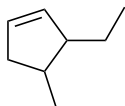
2. Which compound below will undergo hydrogenation at the fastest rate?



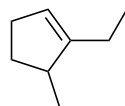
a



b



c

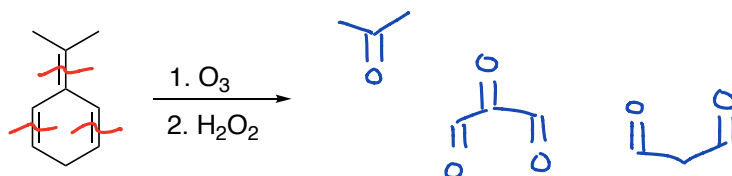


d

↓ C=C substitution =  
faster rate

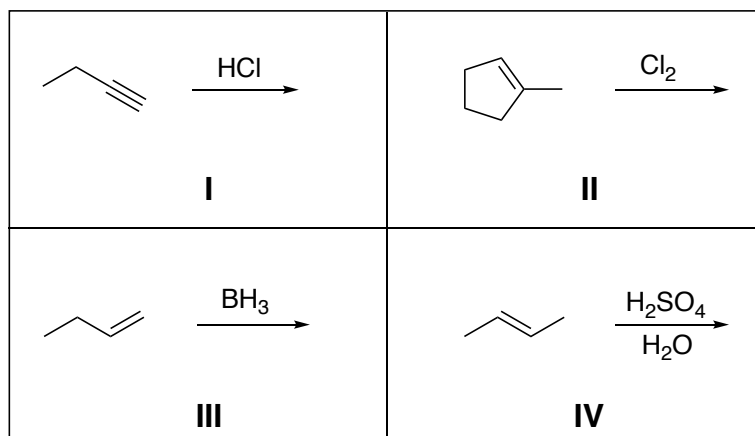
3. How many different organic products result from the following reaction?

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



4. Which of the following reactions involve a carbocation intermediate?

- a. I only  
b. I and II  
c. I and IV  
d. IV only  
e. II and III

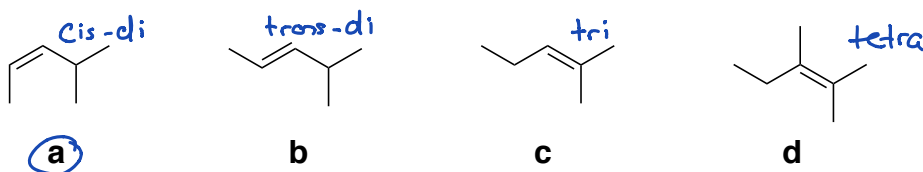


5. The following reaction produces:

- a. A single stereoisomer
- b. A pair of enantiomers
- c. A pair of diastereomers**
- d. A pair of constitutional isomers

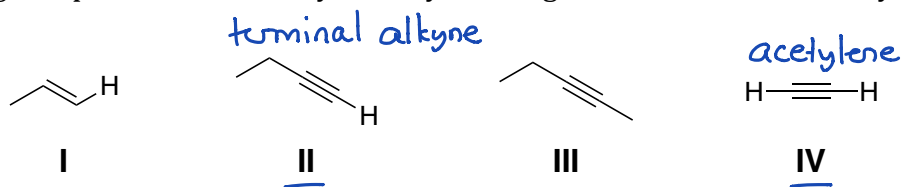


6. Which alkene shown below is the least stable?

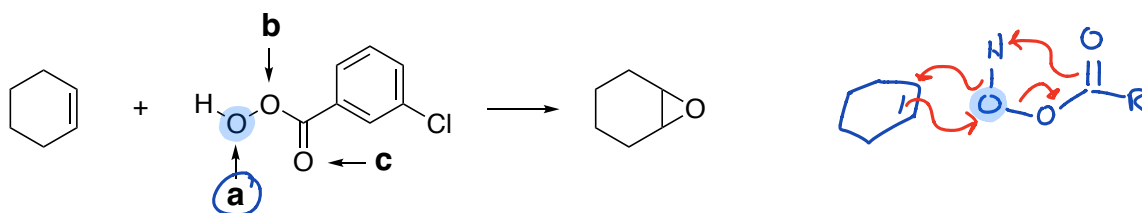


7. Which of the following compounds can be alkylated by treating with  $\text{NaNH}_2$  followed by  $\text{CH}_3\text{I}$ ?

- a. II only
- b. II and IV**
- c. II, III, and IV
- d. II and III
- e. I, II, and IV

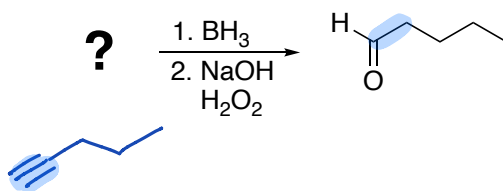


8. In the following reaction, which oxygen from the peroxyacid ends up in the epoxide product?



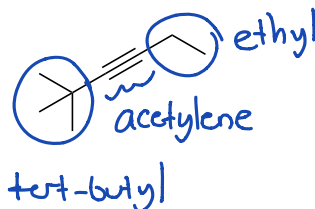
9. What is the starting material in the following reaction?

- a. 1-pentene
- b. 1-pentyne**
- c. 2-pentyne
- d. 1-hexyne
- e. 2-hexyne



10. What is the common name of the following compound?

- a. 2,2-dimethylhexyl acetylene
- b. tert-butyl ethyl ethyne
- c. dimethylbutyl ethyl acetylene
- d. tert-butyl ethyl acetylene**
- e. ethyl isopropyl acetylene

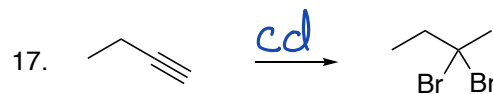
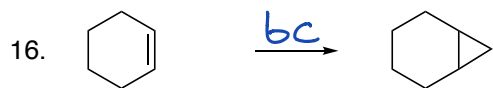
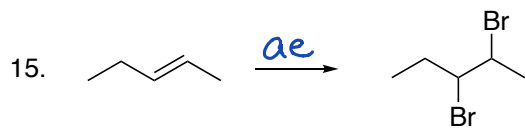
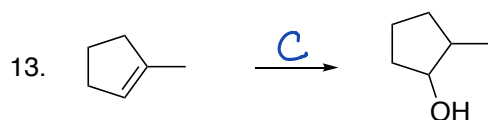
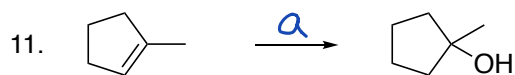


### Reagent Matching

Select the best reagent from the reagent bank to accomplish each of the following transformations. You may use a reagent more than once. (2 points each)

**Bubble each answer in on your bubble sheet for credit! You will not receive credit if these answers are not bubbled in.**

Note: Some answers will require you to bubble in two letters.

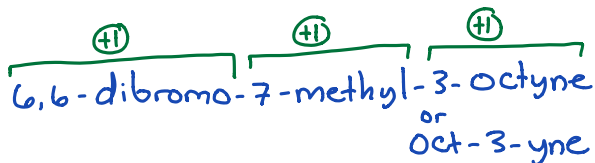
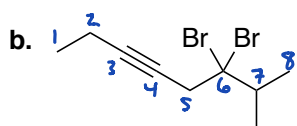
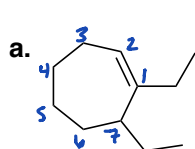


Reagent Bank		
$\text{H}_2\text{SO}_4$ $\text{H}_2\text{O}$ <b>a</b>	$\text{OsO}_4$ NMO $\text{H}_2\text{O}$ <b>b</b>	1. $\text{BH}_3$ 2. NaOH $\text{H}_2\text{O}_2$ <b>c</b>
HCl $\text{H}_2\text{O}$ <b>e</b>	Na-CH <sub>2</sub> <b>e</b>	1. $\text{O}_3$ 2. $\text{H}_2\text{O}_2$ <b>ab</b>
mCPBA <b>ac</b>	$\text{HgSO}_4$ $\text{H}_2\text{SO}_4$ $\text{H}_2\text{O}$ <b>ad</b>	$\text{Br}_2$ <b>ae</b>
$\text{CH}_2\text{I}_2$ Zn-Cu <b>bc</b>	$\text{Cl}_2$ $\text{H}_2\text{O}$ <b>bd</b>	$\text{H}_2$ Pd/C <b>be</b>
HBr (excess) <b>cd</b>	$\text{H}_2\text{SO}_4$ $\text{CH}_3\text{OH}$ <b>ce</b>	NaBr (2 equiv) <b>de</b>

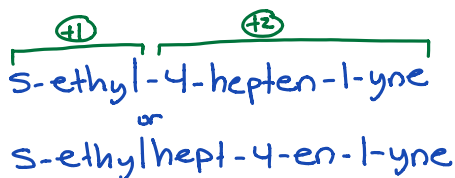
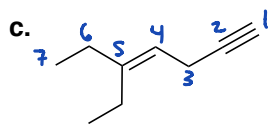
### Completion Section

Answer the remaining questions directly on the exam itself. Please write neatly and **darkly** as your answers will be scanned for grading.

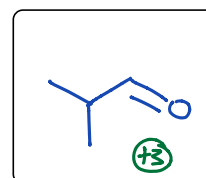
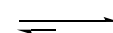
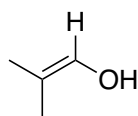
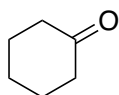
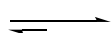
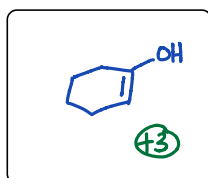
18. Provide IUPAC systematic names for each compound shown below. (3 points each)



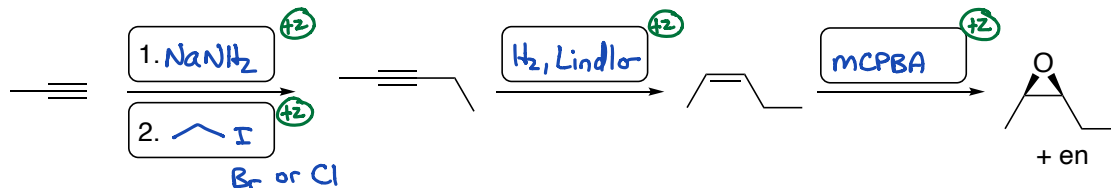
-1 Wrong #  
-1 Wrong abc order of  
Substituents



19. Draw the missing tautomer for each of the following. (3 points each)



20. Provide the missing reagents to accomplish the following synthetic sequence. (2 points each)



21. Draw representative structures for each of the following. (1 point each)



vinyl carbocation

$\text{+1}$



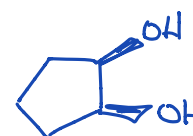
bromonium ion

$\text{+1}$



acetylene

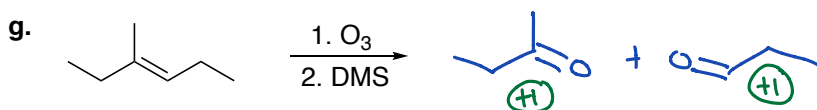
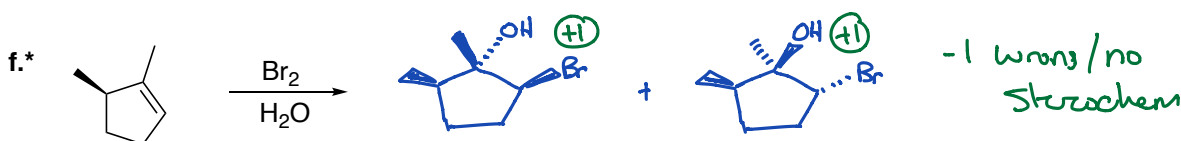
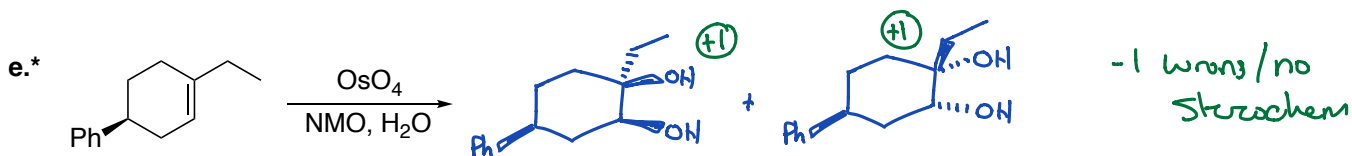
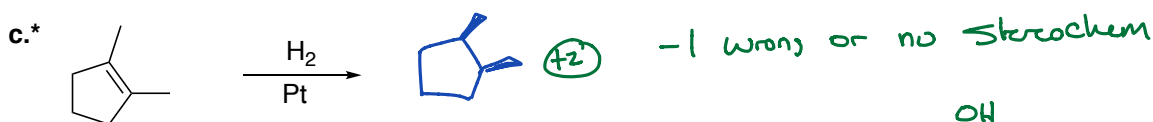
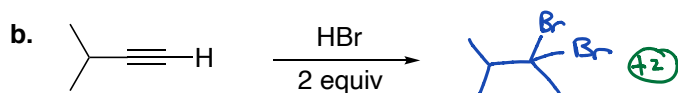
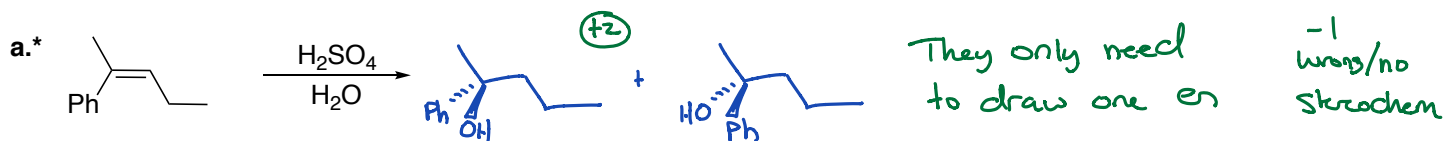
$\text{+1}$



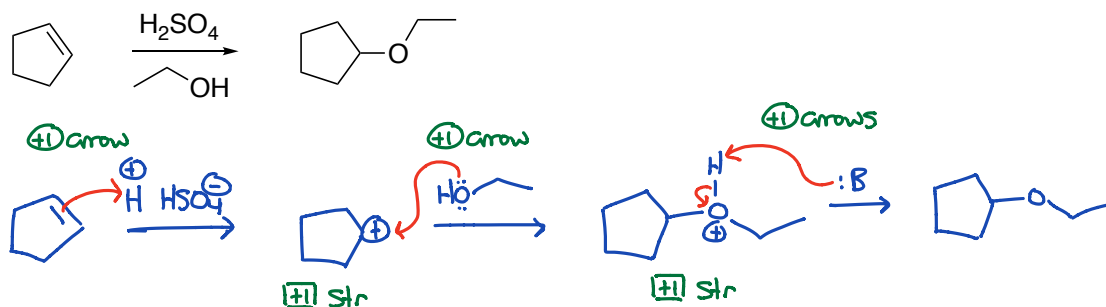
syn 1,2-diol

$\text{+1}$

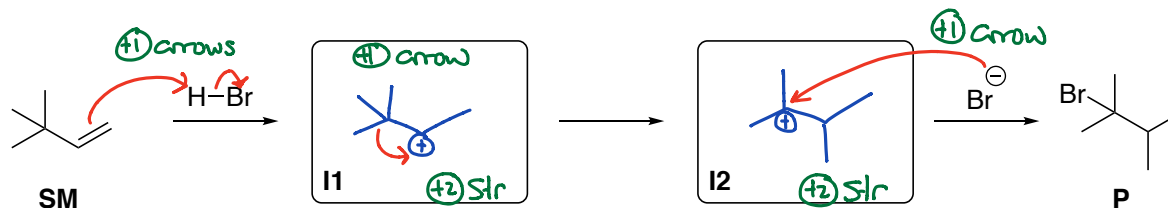
22. Predict the major organic product for each of the following reactions. Include stereochemistry for reactions indicated with an asterisk(\*). If the reaction produces enantiomers, you only need to draw one enantiomer. If diastereomers are formed, draw all diastereomers. (2 points each)



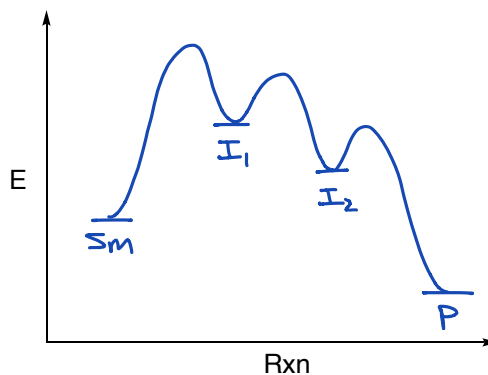
23. Draw the complete electron pushing mechanism for the following reaction. (5 points)



24. For the following reaction: **a.** Draw the missing intermediates; **b.** Draw in curved arrows to show electron flow; **c.** Draw a reaction coordinate/energy diagram. (11 points)

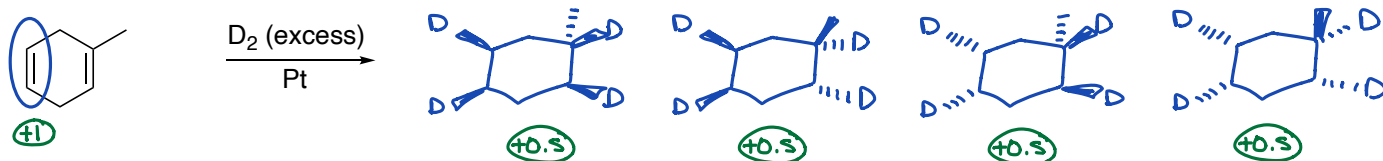


Kinetic experiments have revealed that the first step is rate determining



- (+) P lower E than SM
- (+) I<sub>1</sub> + I<sub>2</sub> higher E than SM + P
- (+) I<sub>2</sub> lower E than I<sub>1</sub>
- (+) Step 1 has highest E TS

25. Draw all of the stereoisomers that result from the following reaction. Then circle the alkene that reacts the fastest. Note: deuterium is just a heavy isotope of hydrogen. *Hint: This problem is from recitation.* (3 points)



26. Each of the following are single-step reactions. Draw in the curved arrows to show the electron flow in each and then draw the product. (3 points each)

