

## CHEM 2410 – Organic Chemistry 1 – Fall 2016

Instructors: Paul Bracher &amp; Erin Witteck

Exam Booklet No.

# Hour Examination #3

Wednesday, November 9<sup>th</sup>, 2016

6:10–8:10 p.m. in the Lecture Halls at Saint Louis University

Student Name (Printed)	
Student Signature	

## Instructions & Scoring

- Please write your answers on the official answer sheet. No answers marked in this booklet will be graded.
- You may use one letter-sized sheet of hand-written notes (on the “official” template) and your plastic model kit. No electronic resources are permitted and you may not communicate with others.
- Your exam answer sheet may be copied or scanned.
- The examination room may be photographed or videotaped.

Problem	Points Earned	Points Available
I		66
II		4
III		9
IV		9
V		12
TOTAL		100

This exam focuses on Chapters 9, 10, 11, and 12 in Janice Smith's *Organic Chemistry*, 4<sup>th</sup> ed.

## Examination Instructions

**DO NOT TURN THE PAGE ON THIS BOOKLET UNTIL DIRECTED BY A PROCTOR TO BEGIN**

### **Please Make Sure to Do the Following Before Starting Your Exam**

1. Both print your name and sign the front of the answer sheet and this exam booklet in the appropriate boxes.
2. Also print your name at the top of the back of the answer sheet.
3. Enter your SLU Banner ID number on the front of the answer sheet and bubble the corresponding numbers. Failure to do this correctly will result in the loss of 2 points.
4. Write the serial number of this exam booklet on your answer sheet in the appropriate box.
5. Check the “Hold for Pick-Up” box on the back of the answer sheet if you want your graded sheet withheld from the distribution pile on Monday and handed back to you privately. Checking this box will delay your receipt of your graded exam.

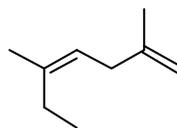
### **Please Make Sure to Do the Following After Completing Your Exam**

1. Ensure that all of your selected circles are darkened completely.
2. Submit your answer sheet, exam booklet, and scratch paper to the proctors. You may not remove these items from the exam room.
3. Turn in your note sheet with your name and Banner ID written clearly in the appropriate space. Your note sheet will be returned to you on Monday.

**DO NOT TURN THE PAGE ON THIS BOOKLET UNTIL DIRECTED BY A PROCTOR TO BEGIN**

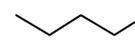
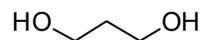
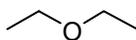
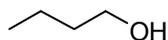
**Problem I.** Multiple Choice (66 points total). Correct answers score +3 points, answers of 'E' score +1 point, and incorrect answers score 0 points. For each question, select the best and most complete answer of the choices given. Bubble the answer, darkly, in the space provided on the answer sheet.

(1) \_\_\_\_\_ What is the IUPAC name of compound **A**?



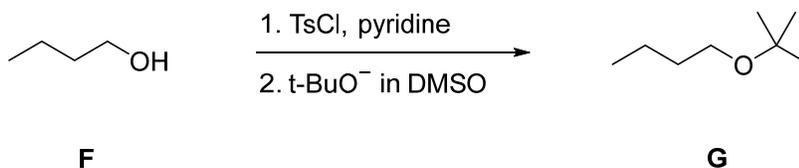
- (A) (*E*)-3,6-dimethyl-3,6-heptadiene
- (B) (*Z*)-3,6-dimethyl-3,6-heptadiene
- (C) (*E*)-2,5-dimethyl-1,4-heptadiene
- (D) (*Z*)-2,5-dimethyl-1,4-heptadiene

(2) \_\_\_\_\_ Rank the following compounds in order of increasing solubility in water (i.e., from the least soluble to the most soluble).



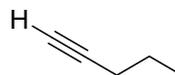
- (A) **B < C < D < E**
- (B) **E < C < D < B**
- (C) **E < D < C < B**
- (D) **E < C < B < D**

- (3) \_\_\_\_\_ What statement best describes the role of the reagents TsCl and pyridine in the following preparation of compound **G**?



- (A) to convert the hydroxyl group into a good leaving group  
 (B) to protonate the hydroxyl group such that water can leave  
 (C) to avoid the formation of an unstable primary carbocation  
 (D) to improve yield by disfavoring the competing E1 reaction

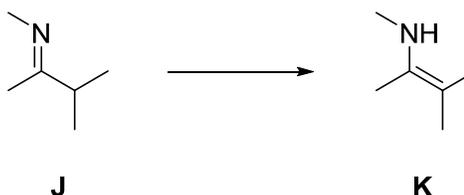
- (4) \_\_\_\_\_ Which of the following statements is not true regarding the alkyne **H**?



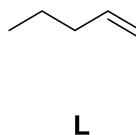
**H**

- (A) compound **H** has a  $pK_a$  between 20 and 30  
 (B) compound **H** reacts with  $Hg(OAc)_2$ ,  $H_2SO_4$ , and  $H_2O$  to generate an aldehyde  
 (C) compound **H** is an isomer of cyclopentene  
 (D) none of the above (i.e., all of the above statements are true)

- (5) \_\_\_\_\_ Which of the following most accurately and completely describes the relationship of compounds **J** and **K**?

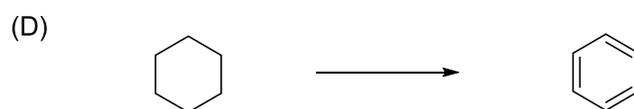
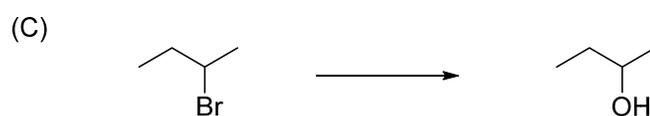
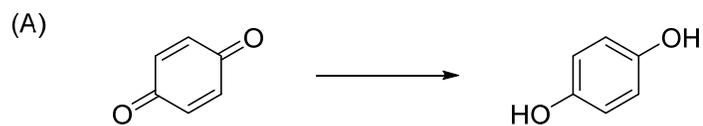


- (A) tautomers  
(B) constitutional isomers  
(C) different molecules  
(D) all of the above
- (6) \_\_\_\_\_ Which of the following statements is correct regarding compound **L**?

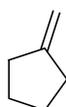
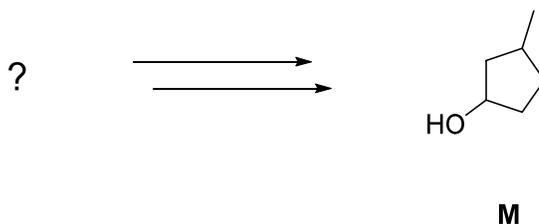


- (A) compound **L** forms two products upon reaction with  $H_2$ , Pd/C  
(B) compound **L** forms two products upon reaction with *m*CPBA  
(C) compound **L** is named (*E*)-1-pentene  
(D) compound **L** is named (*E*)-4-pentene

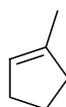
(7) \_\_\_\_\_ Which of the following reactions is not an oxidation or reduction reaction?



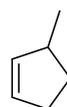
(8) \_\_\_\_\_ Which of the following substrates is the best choice of starting material to synthesize compound **M** as efficiently as possible?



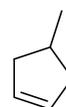
(A)



(B)



(C)

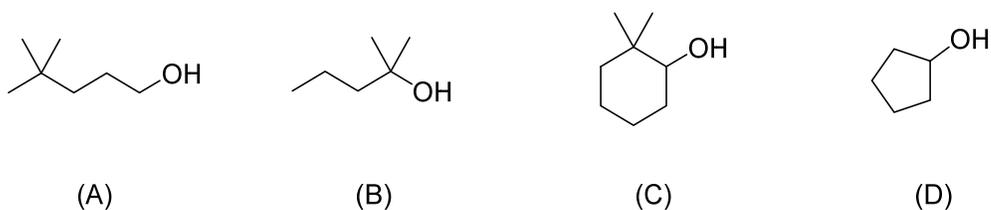


(D)

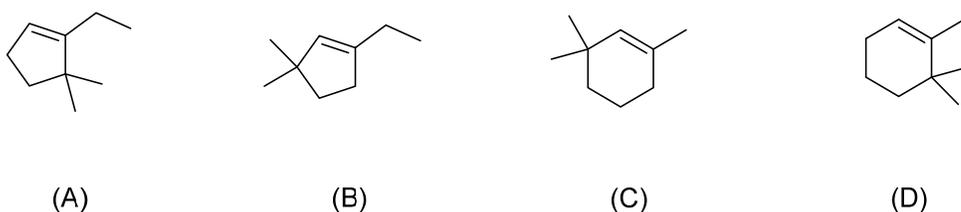
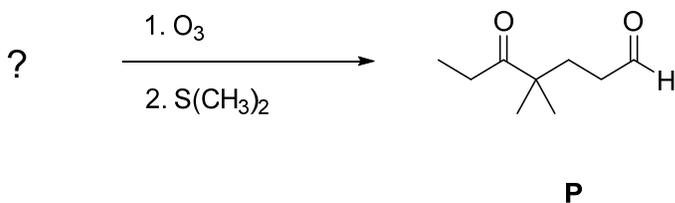
(9) \_\_\_\_\_ Compound **N** has no triple bonds and its molecular formula of  $C_6H_8F_2N_2O$ . Which of the following could accurately describe **N**?

- (A) compound **N** could have 1 C=C, 1 C=O bond, and 1 ring
- (B) compound **N** could have 2 C=O bonds
- (C) compound **N** could have 2 C=C bonds and 2 rings
- (D) none of the above (i.e., it is impossible for **N** to have a structure described by any of the above)

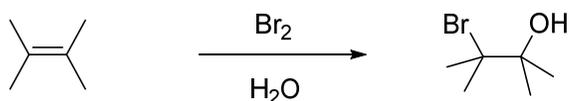
(10) \_\_\_\_\_ Which of the following substrates is most likely to undergo an alkyl migration (carbocation rearrangement) upon treatment with sulfuric acid?



(11) \_\_\_\_\_ Which of the following substrates would give compound **P** upon ozonolysis?

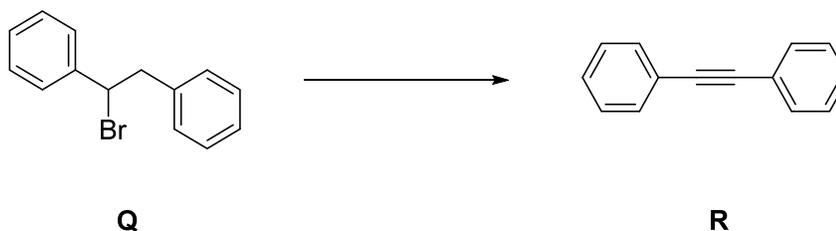


- (12) \_\_\_\_\_ What statement does not accurately describe at least one step or aspect of the mechanism for the reaction drawn below?



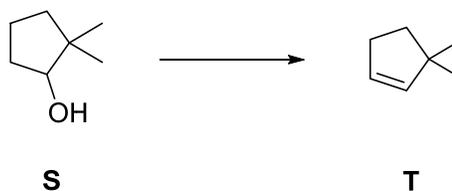
- (A) water serves as a nucleophile  
 (B) the  $\pi$  bond on the alkene serves as a nucleophile  
 (C) each equivalent of  $\text{Br}_2$  consumed generates two molecules of product  
 (D) this is a type of reduction–oxidation reaction

- (13) \_\_\_\_\_ Which of the following sequences of reactions will convert **Q** to **R**?



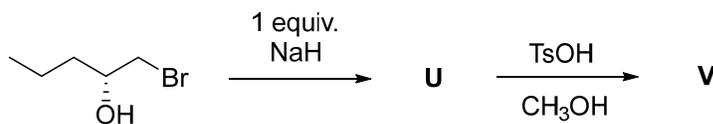
- (A)  $\xrightarrow{\text{Br}_2} \xrightarrow[\text{NaNH}_2]{\text{excess}}$
- (B)  $\xrightarrow{\text{NaH}} \xrightarrow{\text{H-C}\equiv\text{C-H}} \xrightarrow{\text{NaH}}$
- (C)  $\xrightarrow[\text{H}_2\text{O}]{\text{H}_2\text{SO}_4} \xrightarrow[\text{H}_2\text{SO}_4, \text{H}_2\text{O}]{\text{K}_2\text{Cr}_2\text{O}_7}$
- (D)  $\xrightarrow[\text{tBuOH}]{\text{tBuOK}} \xrightarrow{\text{Br}_2} \xrightarrow[\text{NaNH}_2]{\text{excess}}$

(14) \_\_\_\_\_ Which of the following conditions is the best choice to convert **S** to **T**?



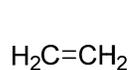
- (A)  $\text{H}_2\text{SO}_4$ , heat  
 (B) 1. TsCl, pyridine; 2. *t*BuOK in *t*BuOH  
 (C)  $\text{PBr}_3$   
 (D)  $\text{SOCl}_2$ , pyridine

(15) \_\_\_\_\_ What is the major product, **V**, expected of the following sequence of reactions?  
 Compounds **U** and **V** both contain no bromine.

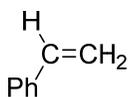


- (A)
- (B)
- (C)
- (D)

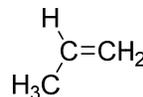
- (16) \_\_\_\_\_ Which of the following alkenes reacts fastest with HBr? Note: Ph = a phenyl group ( $-C_6H_5$ ).



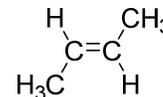
(A)



(B)

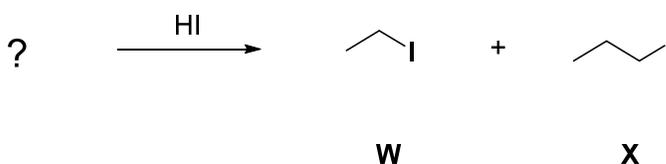


(C)



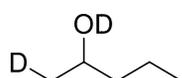
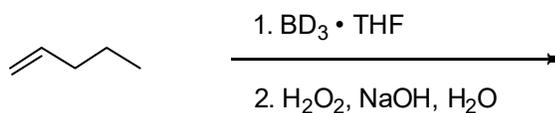
(D)

- (17) \_\_\_\_\_ Treatment of what ether with concentrated hydroiodic acid will produce alkyl iodides **W** and **X**?

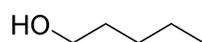


- (A) diethyl ether  
 (B) ethyl methyl ether  
 (C) ethyl isopropyl ether  
 (D) ethyl propyl ether

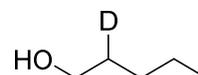
- (18) \_\_\_\_\_ What is the product of the following reaction? Note: D is just the isotope of hydrogen containing one neutron ( $^2H$ ).



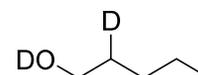
(A)



(B)

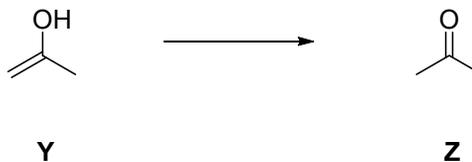


(C)



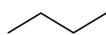
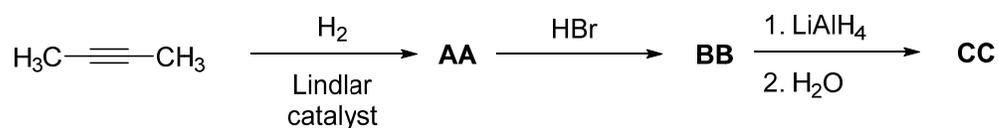
(D)

- (19) \_\_\_\_\_ Which of the following statements most accurately and completely describes the conversion of **Y** to **Z**?

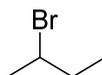


- (A) the mechanism for this conversion in acidic water proceeds via a resonance-stabilized intermediate  
 (B) the mechanism for this conversion in basic/alkaline water proceeds via a resonance-stabilized intermediate  
 (C) the mechanisms for this conversion in both acid and base proceed via resonance-stabilized intermediates  
 (D) the mechanisms for this conversion in neither acid nor base proceed via a resonance-stabilized intermediates

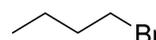
- (20) \_\_\_\_\_ What is the major product of the following sequence of reactions, compound **CC**?



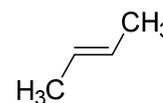
(A)



(B)



(C)

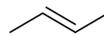


(D)

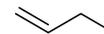
- (21) \_\_\_\_\_ Rank the following compounds from least exothermic to most exothermic heat of hydrogenation (i.e., start with that which release the least heat upon addition of H<sub>2</sub> and end with that which will release the most heat.)



DD



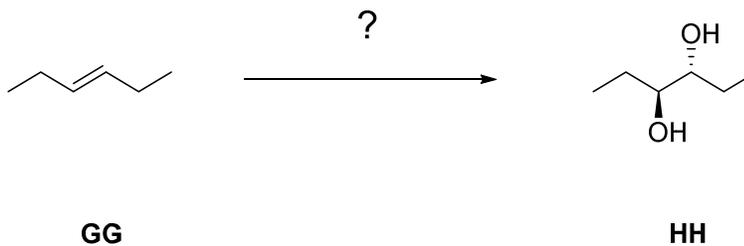
EE



FF

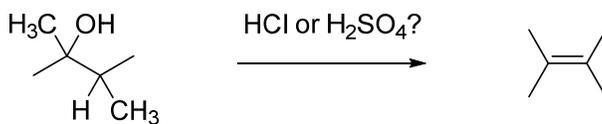
- (A) DD → EE → FF  
 (B) DD → FF → EE  
 (C) EE → DD → FF  
 (D) FF → DD → EE

- (22) \_\_\_\_\_ Which of the following sequences will carry out the conversion of **GG** to **HH**?



- (A) 1. OsO<sub>4</sub>; 2. NaHSO<sub>3</sub>, H<sub>2</sub>O  
 (B) 1. mCPBA; 2. catalytic H<sub>2</sub>SO<sub>4</sub>, H<sub>2</sub>O  
 (C) 2. mCPBA; 2. catalytic NaOH, H<sub>2</sub>O  
 (D) both (B) and (C) will carry out this conversion

**Problem II.** Explanation (4 points). Consider the transformation drawn below. Would hydrochloric acid or sulfuric acid be a better reagent for this transformation? Circle your preferred reagent on your answer sheet, and in one sentence, explain your choice.



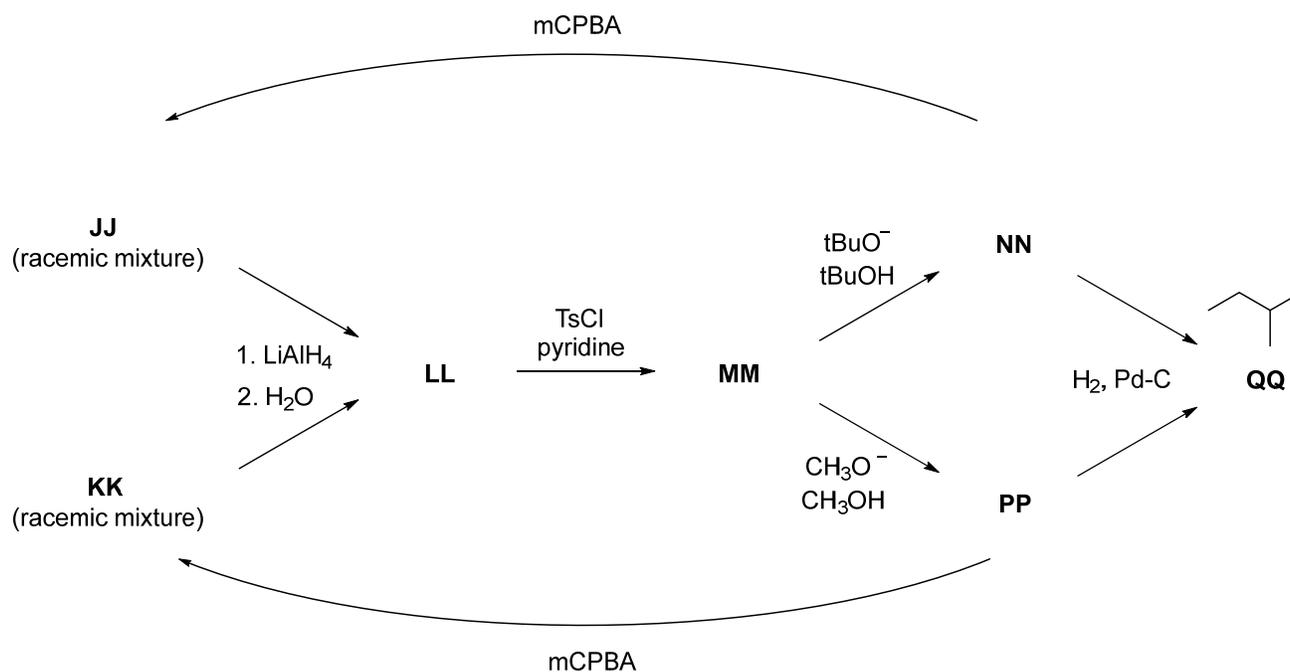
Circle the better reagent:                    HCl                    H<sub>2</sub>SO<sub>4</sub>

One-sentence explanation:

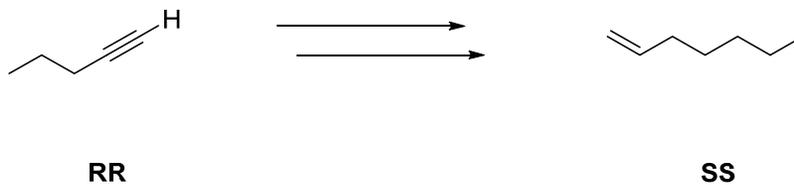
**Problem III.** Roadmap Problem. Provide structures for compounds **KK**, **LL**, and **NN** in the reaction scheme below. Do not write the structures of the other compounds on your answer sheet.

Compound **JJ** exists as a racemic mixture of enantiomers, as does compound **KK**. Compounds **JJ** and **KK** are constitutional isomers of each other. Upon treatment with lithium aluminum hydride ( $\text{LiAlH}_4$ ) followed by quenching with water, compounds **JJ** and **KK** give the identical product, **LL**. Compound **LL** can be tosylated to form **MM**. Upon treatment with *tert*-butoxide, **MM** yields **NN** as the major product. However, when **MM** is treated with methoxide, **PP** is the major product. Catalytic hydrogenation of both **NN** and **PP** produce the identical product, methylbutane (**QQ**). When compound **NN** is treated with *meta*-chloroperbenzoic acid, the racemic mixture of **JJ** is produced. When compound **PP** is treated with *meta*-chloroperbenzoic acid, the racemic mixture of **KK** is produced.

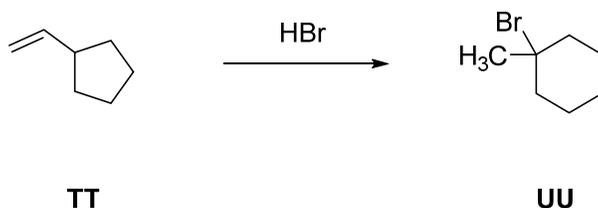
On your answer sheet, provide structures of compounds **KK**, **LL**, and **NN** that are consistent with these data. Do not provide the structures of other compounds.



**Problem IV.** Synthesis (9 points). Provide a synthetic route—i.e, a sequence of reactions—to produce 1-heptene (**SS**) from 1-pentyne (**RR**) and any other starting materials or reagents you need that contain six or fewer carbon atoms.



**Problem V.** Mechanism (12 points). Draw a sensible mechanism for the following reaction. Remember to use proper “curved arrow notation” to account for the redistribution of electrons in the making and breaking of bonds. Show all significant resonance forms that account for the stability of the intermediates in the reaction. Hint: This mechanism has four steps.





**Scratch Paper**

You may rip this sheet out of the exam booklet, but you are responsible for turning it in at the end of the exam.

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