

# Chemistry 2541, Fall 2015

## Final Exam

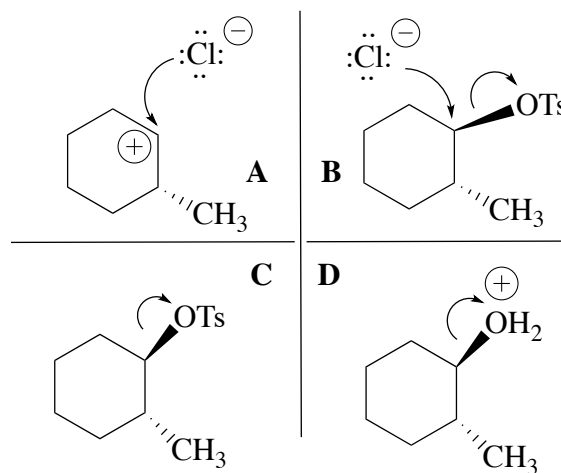
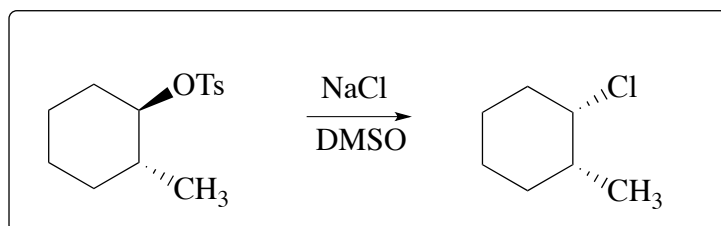
(200 points)

### Important notes:

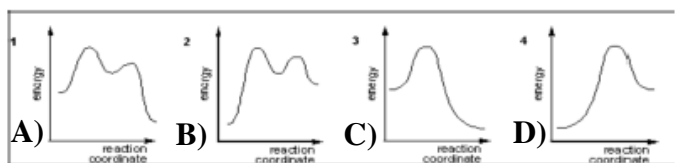
- Please use the provided Scantron form for your answers; you can keep the sheet with the questions and can use it as scratch paper
- Do not forget to write your name on the Scantron form
- You will not receive credit for unmarked answers or for more than one mark on answer line
- Your scores will be posted on eGradebook; graded Scantron forms will not be returned to students.

**Questions 1-50 (150 pts): Please mark the appropriate box on the front of the Scantron form (3 pts each).**

**1.** Which one of the following four schemes (A-D) represents a **step** in the **mechanism** of the reaction in the box?



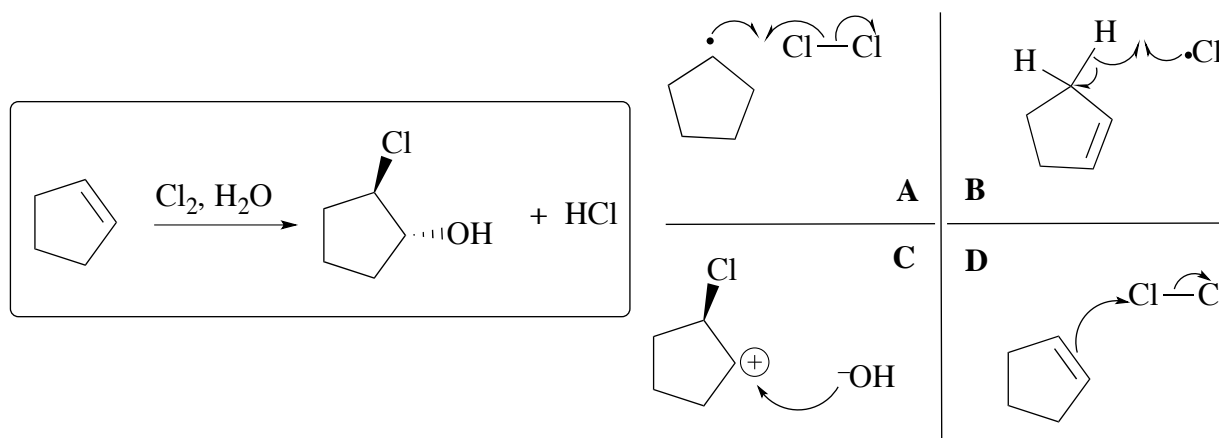
**2.** What is the **energy diagram** for the reaction shown above in **Question 1**?



**3.** What type of **mechanism** the reaction shown in **Question 1** has?

- A) E1      B) E2      C) S<sub>N</sub>1      D) S<sub>N</sub>2

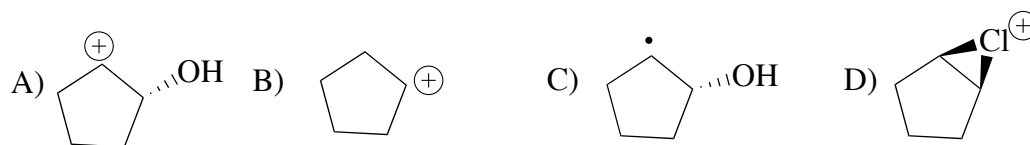
4. Which one of the following four schemes (A-D) represents a **step** in the **mechanism** of the reaction in the box?



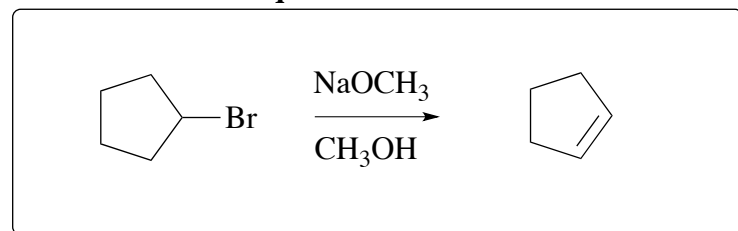
5. What type of **mechanism** the reaction shown in **Question 4** has?

- A) Electrophilic addition      B) E2      C) Radical addition      D) S<sub>N</sub>2

6. What is the structure of an **intermediate** in the reaction shown in **Question 4**?



7. What is the **rate equation** for the reaction in the box?



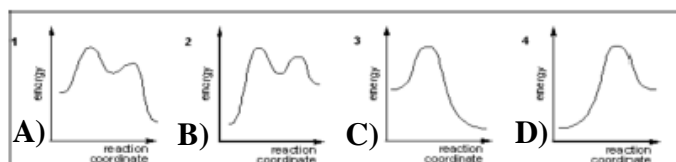
A) Rate =  $k [\text{RX}][\text{NaOCH}_3]$

B) Rate =  $k [\text{RX}]$

C) Rate =  $k [\text{RX}][\text{CH}_3\text{OH}]$

D) Rate =  $k [\text{CH}_3\text{OH}]$

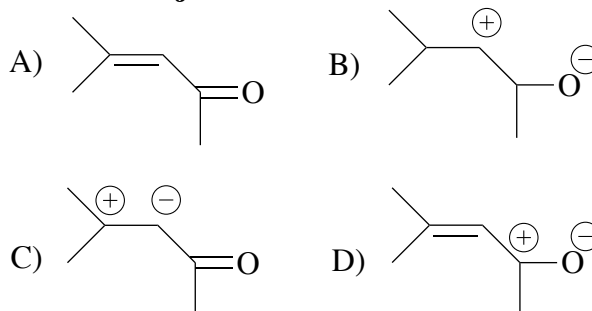
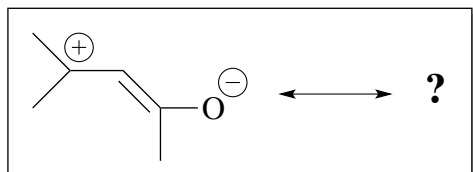
8. What is the **energy diagram** for the reaction shown above in **Question 7**?



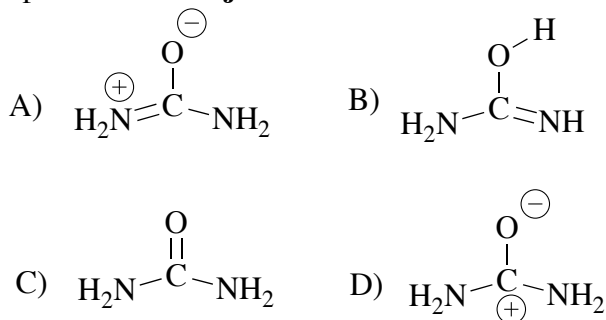
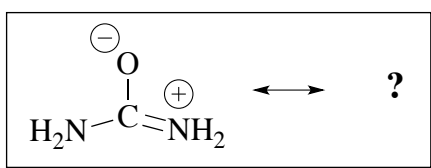
9. What type of **mechanism** the reaction shown in **Question 7** has?

- A) E1      B) E2      C) S<sub>N</sub>1      D) S<sub>N</sub>2

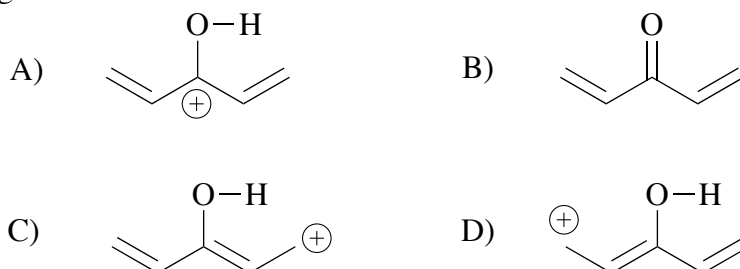
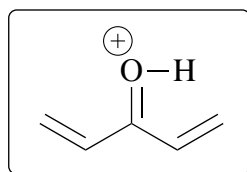
10. Which of the following structures represents the **major** resonance contributor of molecule in the box?



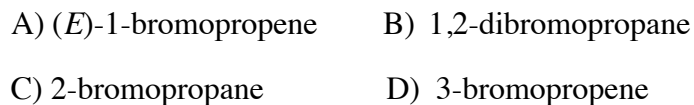
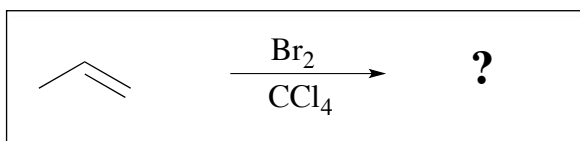
11. Which of the following structures represents the **major** resonance contributor of molecule in the box?



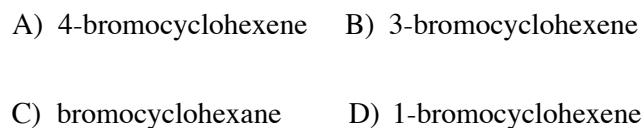
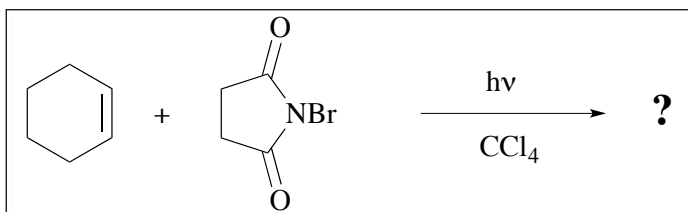
12. Which of the following is **NOT** a resonance structure of the molecule shown in the box?



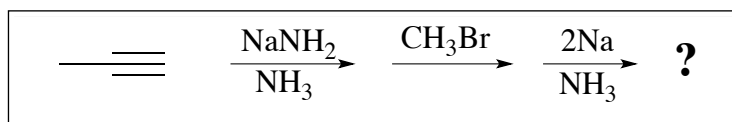
13. What is the IUPAC name of the major **product** for the reaction shown in the box?



14. What is the IUPAC name of the major **product** for the reaction shown in the box?

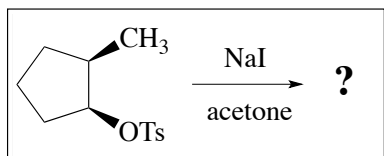


15. What is the IUPAC name of the major **product** for the reaction sequence shown in the box?



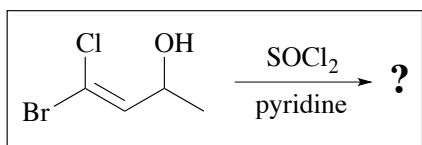
- A) (Z)-2-butene    B) (Z)-2-pentene  
C) (E)-2-butene    D) (E)-2-pentene

16. What is the IUPAC name of the major **product** for the reaction shown in the box?



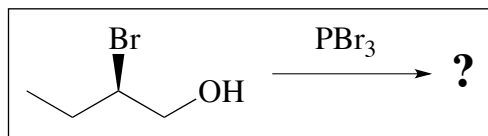
- A) (1S,2S)-1-iodo-2-methylcyclopentane    B) (1R,2S)-1-iodo-2-methylcyclopentane  
C) (1S,2R)-1-iodo-2-methylcyclopentane    D) (1R,2R)-1-iodo-2-methylcyclopentane

17. What is the IUPAC name of the major **product** for the reaction shown in the box?



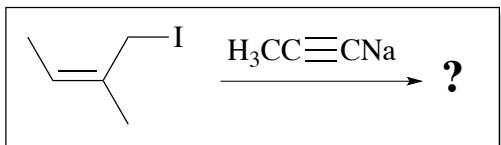
- A) (E)-1-bromo-1,3-dichloro-1-butene    B) (Z)-1-bromo-1,3-dichloro-1-butene  
C) (E)-1-bromo-1,3-dichloro-2-butene    D) (Z)-1-bromo-1,3-dichloro-2-butene

18. What is the IUPAC name of the major **product** for the reaction shown in the box?



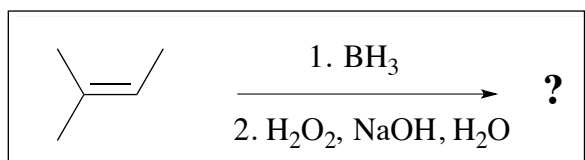
- A) (2S,3S)-2,3-dibromobutane    B) (2R,3S)-2,3-dibromobutane  
C) (R)-1,2-dibromobutane    D) (S)-1,2-dibromobutane

19. What is the IUPAC name of the major **product** for the reaction shown in the box?



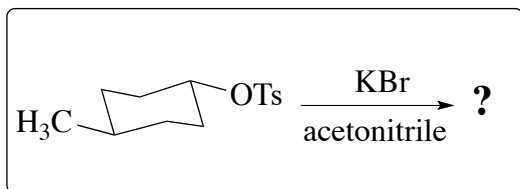
- A) (Z)-3-methyl-2-hepten-5-yne    B) (E)-3-methyl-2-hepten-5-yne  
C) 2-methyl-2-heptyne    D) 2-methyl-1-hepten-5-yne

20. What is the IUPAC name of the major **product** for the reaction shown in the box?



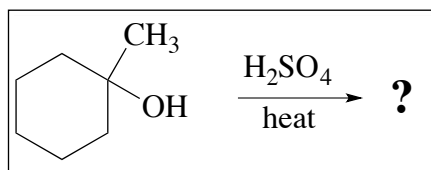
- A) 2-methyl-2-butanol    B) 3-methyl-2-butanol  
C) 3-methyl-1-butanol    D) 2-methyl-4-butanol

21. What is the IUPAC name of the major **product** for the reaction shown in the box?



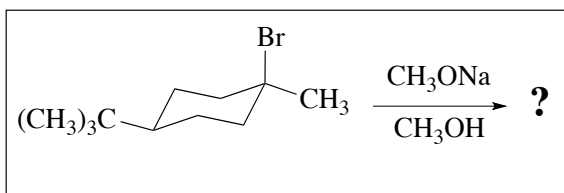
- A) *cis*-1-bromo-4-methylcyclohexane
- B) *trans*-1-bromo-4-methylcyclohexane
- C) *cis*-1-bromo-3-methylcyclohexane
- D) *trans*-1-bromo-3-methylcyclohexane

22. What is the main **product** of the reaction shown in the box?



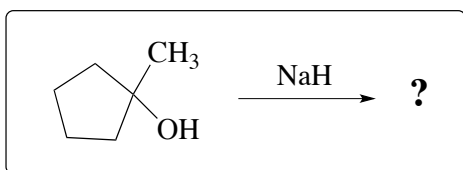
- A) 1-methylcyclohexene
- B) 3-methylcyclohexene
- C) 4-methylcyclohexene
- D) methylenecyclohexene

23. What is the main **product** of the reaction shown in the box?



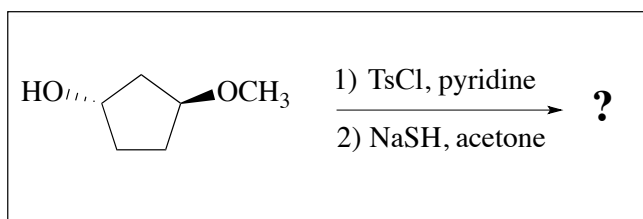
- A) CC(C)(C)C1=CCCCC1
- B) CC(C)(C)C1C=CCCC1
- C) CC(C)(C)C1CCCCC1O
- D) CC(C)(C)C1C=CCCC1

24. What is the main **product** of the reaction shown in the box?



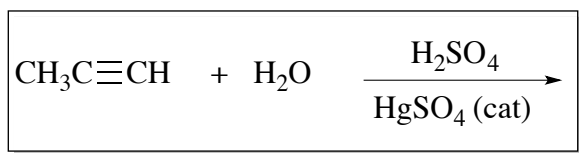
- A) CC1CCCC1[O-][Na+]
- B) CC1CCCC1[Na]
- C) CC1CCCC1
- D) CC1=CCCC1

25. What is the main **product** of the reaction shown in the box?



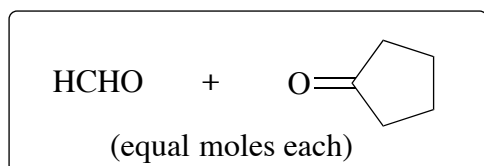
- A) COC[C@H]1CCCC1S
- B) COC[C@@H]1CCCC1S
- C) COC[C@H]1CCCC1S
- D) COC[C@@H]1CCCC1S

26. What is the main **product** of the reaction shown in the box?



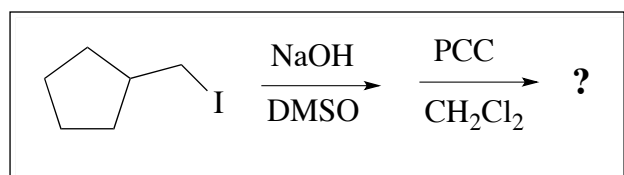
- A)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$     B)  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$   
 C)  $\text{CH}_3\text{COCH}_3$     D)  $\text{CH}_3\text{CH}_2\text{CHO}$

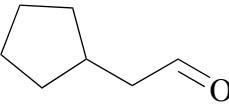
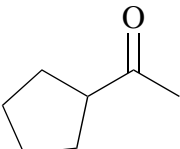
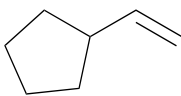
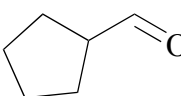
27. What **alkene** when treated with **ozone** and then with  $(\text{CH}_3)_2\text{S}$  gives the products shown in the box?



- A) 1-methylcyclopentene    B) vinylcyclopentane  
 C) methylenecyclopentane    D) allylcyclopentane

28. What is the main **product** of the reaction sequence shown in the box?

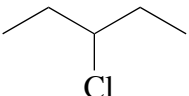
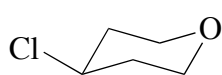
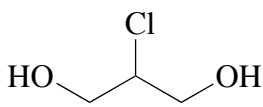


- A)     B)   
 C)     D) 

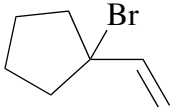
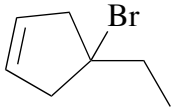
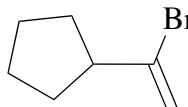
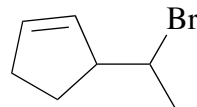
29. Which one of the following compounds is the **strongest acid**?

- A)  $\text{CH}_3\text{CO}_2\text{H}$     B)  $\text{CH}_3\text{CH}_2\text{Br}$     C)  $\text{CH}_3\text{NH}_2$     D) *t*-BuOH

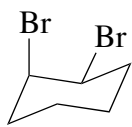
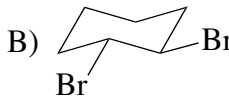
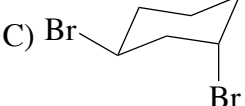

30. Which one of the following compounds has high **solubility in water**?

- A)  $\text{CHCl}_3$     B)     C)     D) 

31. Which molecule is the best substrate for **S<sub>N</sub>1** reaction?

- A)     B)     C)     D) 

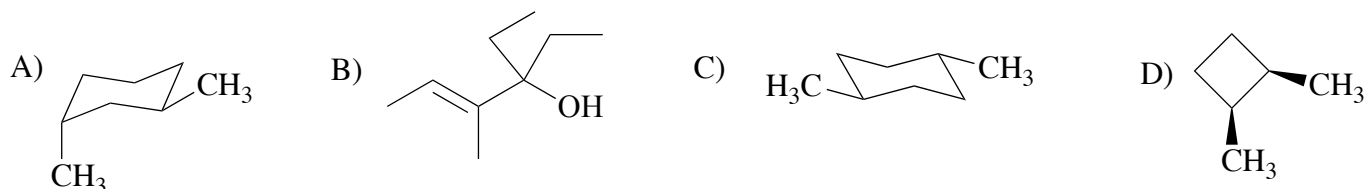
32. Which one of the following molecules is a **meso** compound?

- A)     B)     C)     D) 

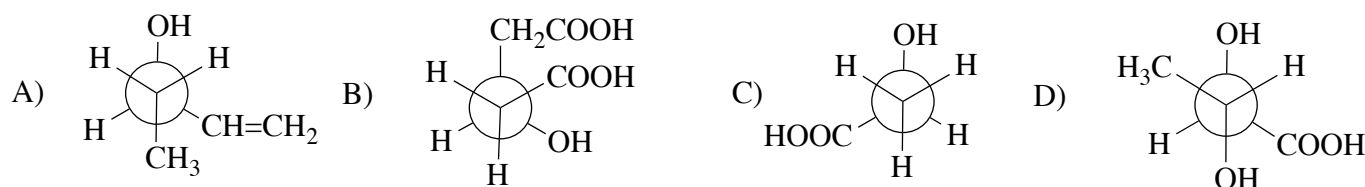
33. Which of the following compounds is the **strongest base**?

- A) NaF      B)  $\text{NaN}(\text{CH}_3)_2$       C)  $\text{NaOCH}_3$       D) NaI

34. Which one of the following molecules is **chiral**?



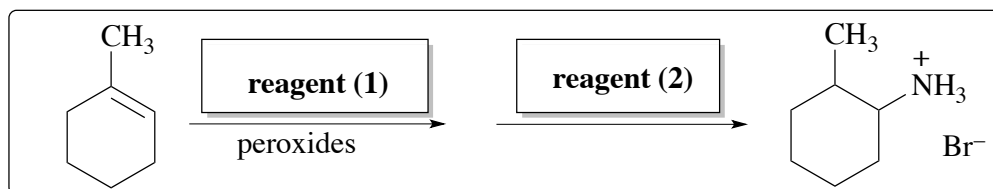
35. Which of the following molecules contains **two chiral centers**?



36. Consider the following **orders of priority** (highest to lowest). Which order is incorrect?

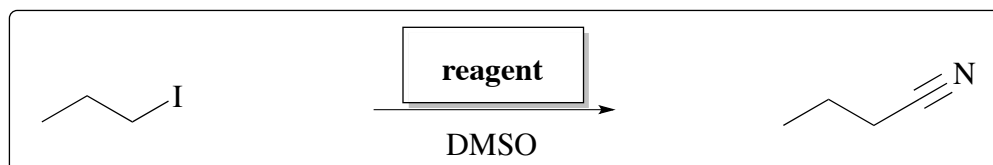
- A)  $\text{Cl} > \text{CH}_2\text{CH}_3 > \text{CH}_3 > \text{H}$       B)  $\text{Cl} > \text{CH}=\text{CH}_2 > \text{CH}_3 > \text{H}$   
 C)  $\text{OH} > \text{CH}_2\text{CH}_2\text{OH} > \text{CHO} > \text{CH}_3$       D)  $\text{NH}_3^+ > \text{CH}_2\text{SH} > \text{CH}_2\text{OH} > \text{CH}_3$

37. Which sequence of **reagents** can be used for the reaction shown in the box?



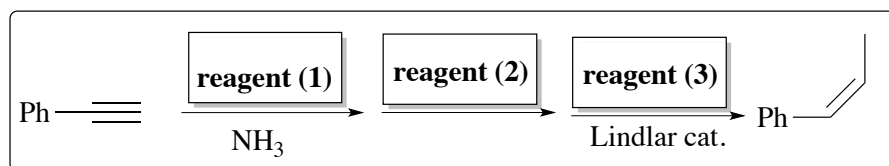
- A) (1) HBr, (2)  $\text{NH}_3$   
 B) (1) NBS, (2)  $\text{NH}_3$   
 C) (1)  $\text{NaNH}_2$ , (2)  $\text{Br}_2$   
 D) (1) NBS, (2)  $\text{NaNH}_2$

38. Which **reagent** can be used for the reaction shown in the box?



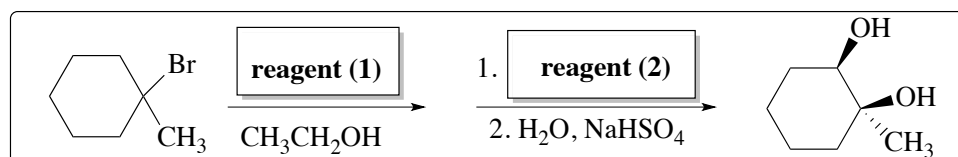
- A) NaCN    B)  $\text{CH}_3\text{CN}$   
 C)  $\text{NaN}_3$     D)  $\text{NH}_3$

39. Which sequence of **reagents** can be used for the reaction shown in the box?



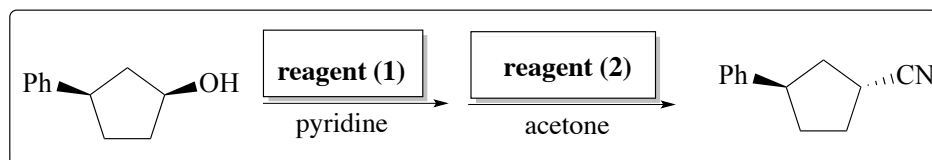
- A) (1)  $\text{Br}_2$ , (2)  $\text{NaNH}_2$ , (3)  $\text{H}_2$   
 B) (1)  $\text{CH}_3\text{Br}$ , (2)  $\text{NH}_3$ , (3)  $\text{Na}$   
 C) (1)  $\text{CH}_3\text{Br}$ , (2)  $\text{NaNH}_2$ , (3)  $\text{H}_2$   
 D) (1)  $\text{NaNH}_2$ , (2)  $\text{CH}_3\text{Br}$ , (3)  $\text{H}_2$

40. Which sequence of **reagents** can be used for the reaction shown in the box?



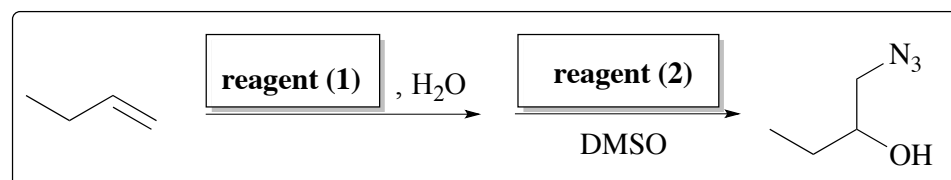
- A) (1)  $\text{NH}_3$ , (2)  $\text{O}_3$   
 B) (1)  $\text{CH}_3\text{CH}_2\text{ONa}$ , (2)  $\text{OsO}_4$   
 C) (1)  $\text{CH}_3\text{CH}_2\text{ONa}$ , (2)  $\text{O}_3$   
 D) (1)  $\text{PCC}$ , (2)  $\text{OsO}_4$

41. Which sequence of **reagents** can be used for the reaction shown in the box?



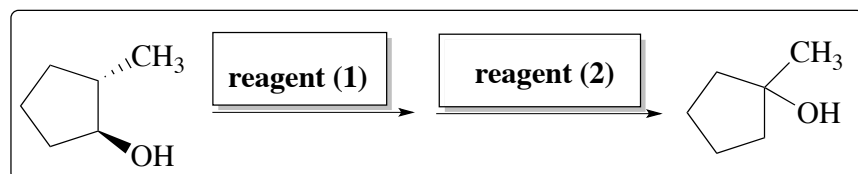
- A) (1)  $\text{TsCl}$ , (2)  $\text{NaCN}$   
 B) (1)  $\text{CH}_3\text{CH}_2\text{ONa}$ , (2)  $\text{NaCN}$   
 C) (1)  $\text{TsCl}$ , (2)  $\text{NH}_3$   
 D) (1)  $\text{PCC}$ , (2)  $\text{NaCN}$

42. Which sequence of **reagents** can be used for the reaction shown in the box?



- A) (1)  $\text{TsCl}$ , (2)  $\text{NaN}_3$   
 B) (1)  $\text{CH}_3\text{CH}_2\text{ONa}$ , (2)  $\text{NaN}_3$   
 C) (1)  $\text{Cl}_2$ , (2)  $\text{NaN}_3$   
 D) (1)  $\text{TsCl}$ , (2)  $\text{NaCN}$

43. Which sequence of **reagents** can be used for the reaction shown in the box?



- A) (1)  $\text{H}_2\text{SO}_4$ , heat, (2)  $\text{H}_2\text{SO}_4$ ,  $\text{H}_2\text{O}$   
 B) (1)  $\text{CH}_3\text{CH}_2\text{ONa}$ , (2)  $\text{NaOH}$ ,  $\text{H}_2\text{O}$   
 C) (1)  $\text{HBr}$ , (2)  $\text{NaOH}$ ,  $\text{H}_2\text{O}$   
 D) (1)  $\text{PCC}$ , (2)  $\text{H}_2\text{SO}_4$ ,  $\text{H}_2\text{O}$

44. Which is the **most stable** alkene?

- A) 2-methyl-2-pentene    B) *trans*-2-pentene    C) *cis*-2-pentene    D) 2,3-dimethyl-2-pentene

45. Arrange the compounds in the box in order of **decreasing boiling point**.

I) 1-butanol   II) 1-chlorobutane   III) pentane

A) (highest) III > II > I   B) (highest) I > II > III   C) (highest) II > III > I   D) (highest) II > I > III

46. Which of the following represents the order of increasing **acidity** for compounds the box?

(1) CH<sub>3</sub>Br   (2) CH<sub>3</sub>CO<sub>2</sub>H   (3) CH<sub>3</sub>CH<sub>2</sub>OH   (4) FCH<sub>2</sub>CO<sub>2</sub>H   (5) HCl

A) 1 (strongest) > 2 > 4 > 3 > 5 (weakest)   B) 1 (strongest) > 5 > 4 > 2 > 3 (weakest)  
C) 4 (strongest) > 1 > 2 > 3 > 5 (weakest)   D) 5 (strongest) > 4 > 2 > 3 > 1 (weakest)

47. Which species is **NOT a Lewis acid**?

A) B(CH<sub>2</sub>CH<sub>3</sub>)<sub>3</sub>   B) BF<sub>4</sub><sup>-</sup>   C) AlCl<sub>3</sub>   D) (CH<sub>3</sub>)<sub>3</sub>C<sup>+</sup>

48. A terminal alkyne, **1-butyne** is NOT deprotonated by the **ethoxide ion**. What does this indicate?

A) 1-Butyne is the conjugate base of ethanol.   B) 1-Butyne is stronger base than ethanol.  
C) Alkynyl ion is a weaker base than the hydroxide ion.   D) Ethanol is a stronger acid than 1-butyne.

49. Which of the following is a tertiary alcohol?

A) 3-buten-1-ol   B) (R)-2-methyl-1-butanol  
C) 2-methyl-3-buten-2-ol   D) (R)-3-buten-2-ol

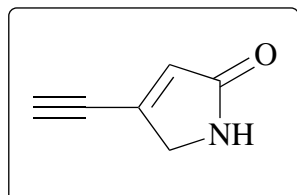
50. Which of the following molecules contains both an **acid** AND an **alcohol** functional group?

A)  $\text{CH}_3\overset{\text{O}}{\parallel}\text{CCH}_2\text{COOH}$    B)  $\text{CH}_3\overset{\text{NH}_2}{\mid}\text{CHCOOCH}_3$    C)  $\text{CH}_3\overset{\text{OH}}{\mid}\text{CHCOOH}$    D)  $\text{CH}_3\overset{\text{OH}}{\mid}\text{CHCHO}$

**SEE NEXT PAGE FOR THE QUESTIONS ON THE BACK OF THE SCANTRON FORM**  
**(50 points total):**

**Question 51 (30 pts): Please mark your answers in boxes 51-60 on the back of the Scantron form**

Consider the molecule shown below and answers the following questions. Indicate your answers by marking the appropriate number in boxes 51-60 on the back of the Scantron form (3 pts each).



**Box 51:** Number of  $\sigma$  bonds formed by overlap of  $sp^2$  and  $sp^3$  orbitals

**Box 52:** Number of  $\sigma$  bonds formed by overlap of  $sp$  and  $sp$  orbitals

**Box 53:** Number of  $\sigma$  bonds formed by overlap of  $sp^2$  and  $sp$  orbitals

**Box 54:** Number of  $\sigma$  bonds formed by overlap of  $s$  and  $sp^3$  orbitals

**Box 55:** Number of  $\sigma$  bonds formed by overlap of  $s$  and  $sp^2$  orbitals

**Box 56:** Number of  $\sigma$  bonds formed by overlap of  $s$  and  $sp$  orbitals

**Box 57:** Number of  $\sigma$  bonds formed by overlap of  $sp^2$  and  $sp^2$  orbitals

**Box 58:** Total number of  $\sigma$  bonds

**Box 59:** Total number of  $\pi$  bonds

**Box 60:** Total number of non-bonding electrons in this molecule

**Question 52 (20 pts): Please write your answers in boxes 66-70 on the back of the Scantron form**

Provide the **reagents** that give indicated products in high yield (4 pts each):

