You can access the online videos following these links. You will be prompted to register for the class.

The class code is the last seven letters in the link.

https://www.educreations.com/sr/LPKNSVE

http://www.educreations.com/sr/FJXRJHS

http://www.educreations.com/sr/CVWKXBD

All videos and problems are based on the following textbook:

How many times did you watch each video?

- <1 time: 4%
- 1 time: 77%
- >1 time: 19%
Do you think that watching the videos took too much time out of your day?

- Yes: 15%
- No: 73%
- Not Sure: 12%
Would you recommend that the instructor continue with the type of teaching where videos are prepared for group work in class once a week and the other class day is in-class lecture?

- Yes: 69%
- Not Sure: 27%
- No: 4%
Would you prefer that videos and in class group work be prepared for every class period rather than only once per week?

- Yes: 12%
- No: 68%
- Not Sure: 20%
Do you believe that you learned from your colleagues by participating in team-based learning? That is by working problems in groups in class?

- Yes: 80%
- No: 12%
- Not Sure: 8%
Did working in groups in class encourage you to work in groups outside of class?

- Yes: 36%
- No: 48%
- Not Sure: 16%
Did working in groups in class encourage you to seek help from others (teacher, peers, tutors)?

- Yes: 48%
- No: 48%
- Not Sure: 4%
Would you have participated in this “experiment” if you had not received extra credit?

- Yes: 68%
- No: 12%
- Not Sure: 20%
I. This semester, there was a difficulty matching concepts learned during lecture with lab. As a result, time was taken during lab to explain these concepts in more detail. Was this helpful?

II. Should these detailed lectures in the Lab be continued?

III. These lectures required extra time and that has curtailed the time assigned to complete the Lab work within the given time periods. In the future, to save lab time, would it be useful to design it as flipped organic classes (as currently used in lecture).
IV. This semester as an experiment, the instructors had tried to grade lab reports twice in order to give students the opportunity to revise and improve their grades. Was this activity helpful in improving grades?

V. Should this activity be continued?
1. Which atom make less number of bonds than usual in the following molecule?

   \[
   \begin{aligned}
   & \text{H} - \text{C} - \text{C} = \text{O} - \text{C} = \text{Br} \\
   & \text{H} \quad \text{H} \\
   & \text{Cl} \\
   \end{aligned}
   \]
Q. In which of these Lewis structures would the iodine be assigned a formal charge of +2?

(A) \[ \text{CH}_3\text{I} = \text{O} \]

(B) \[ \text{CH}_3\text{I} = \text{O} \]

(C) \[ \text{CH}_3\text{I} = \text{O} \]

(D) \[ \text{CH}_3\text{O} = \text{I} = \text{O} \]

(E) \[ \text{CH}_3\text{O} = \text{I} = \text{O} \]
The Formal charges on the bolded atoms in green are

a) +1 on O, 0 on S, 0 on C, +1 on O, -1 on C, +1 on Br
b) 0 on O, +1 on S, 0 on C, +1 on O, 0 on C, -1 on Br
c) 0 on O, 0 on S, 0 on C, +1 on O, 0 on C, +1 on Br
d) +1 on O, 0 on S, 0 on C, 0 on O, 0 on C, -1 on Br
4. What would you do to give the bolded C a +1 formal Charge?

- a. Add H as H\(^+\) to that carbon
- b. Remove H as H\(^-\) from that C
- c. Remove H as H\(^+\) from that C
- d. Add H as H\(^-\) to that C
- e. None of the above
6) Which structure is equivalent to the condensed formula \((\text{CH}_3)_2\text{CH(CH}_2)_3\text{Br}\)?

(A) \(\text{CH}_3\cdot\text{CH}\cdot\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}\)

(B) \(\text{Br}_\text{C}\text{CH}_2\text{CH}_2\text{CH}_2\text{C}_\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}\)

(C) \(\text{H}_3\text{C}\cdot\text{CH}\cdot\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}\)

(D) \(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}\)

(E) \(\text{CH}_3\cdot\text{C}\cdot\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\cdot\text{Br}\)
7) The electron pair geometry and the molecular geometry around iodine in the following molecule are?

a) Trigonal planar: tetrahedral
b) Tetrahedral: Tetrahedral
c) Tetrahedral: Trigonal pyramidal
d) Trigonal Pyramidal: Tetrahedral
e) Octahedral: Tetrahedral
8) The electron pair geometry and the molecular geometry around S in
the following molecule are?

a) Trigonal planar: tetrahedral
b) Octahedral: Tetrahedral
c) Tetrahedral: cross
d) Tetrahedral : Tetrahedral
e) Trigonal Pyramidal: linear
9) Most polar bond in the following?

a. Na-Cl
b. Li-H
c. H-C
d. Rb-O
e. H-F

Given:
Electronegativity values
Na = 0.9, Cl = 3.0
Li = 1.0, H = 2.1
C = 2.5, F = 4.0
Rb = 0.8, O = 3.5
1) Which is the strongest bond?

2) Which is the weakest bond?
3) Identify which two compounds are constitutional isomers

CH$_3$)$_3$COCH$_3$  (CH$_3$)$_2$CHOCH$_3$  (CH$_3$)$_2$CHOCH$_2$CH$_3$

D

A  B  C  CH$_3$CH$_2$CH$_2$COCH$_3$

a) A and B  b) B and C  c) A and C  d) B and D  e) C and D
4) Find the degree of unsaturation $\text{C}_8\text{H}_8\text{NOBr}$

a) 5  b) 6  c) 4  d) 5.5  e) 6.5

5) Find the degree of unsaturation

![Chemical Structure]

a) 5  b) 4  c) 7  d) 8  e) 6
6) Which is a constitutional isomer of the following molecule?

- a) CH₃CH₂C(CH₃)₂CH₂C(CH₃)CH₂
- b) CH₃CH₂C(CH₃)₂CH₂C(CH₃)CH₂
- c) CH₂C(CH₃)CH₂C(CH₃)CHCH₃
- d) CH₂C(CH₃)CH₂C(CH₃)CHCH₃
- e) NONE OF THE ABOVE
7) Which of the following will form H-bonds between its molecules?

a. HBr  b. HN  c. HO  d. HO  e. HF

8) If compound A has a BP of 78 °C, C has a BP of 36 °C and D has a BP of 117 °C, what will be the BP of B?

a) Between 36-78 °C  b) Above 117 °C  c) Between 78-117 °C  d) Below 36 °C  e) Can’t predict based on the above info

9) Rank the following compounds in the order of increasing solubility in water.

10) Which are the functional groups present in the following compounds in the A,B,C,D order?

A) Amine, ketone, amine ketone, ester ether
B) Nitrile, alcohol, amine carbonyl, acid
C) Cyanide, Ketone, Amide, Acid
D) Nitrile, carbonyl, carbonyl amide, anhydride
E) Nitrile, ketone, amide, ester
11) Identify a five carbon containing cyclic anhydride

![Chemical structures](image)

- a.
- b.
- c.
- d.
- e.

12) What is the best description of the following compound?

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H
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- a. A six carbon containing ketone
- b. A seven carbon containing aromatic aldehyde
- c. A seven carbon containing cyclic aldehyde
- d. A seven carbon containing aliphatic aldehyde
- e. A six carbon containing aromatic carboxylic acid
1) The correct geometry around oxygen in CH₃OCH₃ is
   a. linear.
   b. bent.
   c. tetrahedral.
   d. trigonal planar
   e. Trigonal pyramidal

2) The C-N bond in the following molecule is formed by the overlap of what type of orbitals?
   a. S-SP2.
   b. Sp3-SP.
   c. Sp2-Sp3.
   d. Sp2-Sp2
   e. SP2-SP
3) Which lone pair in the following molecule is in an SP2 hybridized orbital?

A) a and d  
B) a and c  
C) e and d  
D) b and e  
E) c and b
4) What are the hybridizations of carbons 1 and 2 respectively in the following structure?

a. sp\(^3\) and sp\(^2\)
b. sp\(^2\) and sp\(^3\)
c. sp\(^3\) and sp

d. sp\(^2\) and sp\(^2\)
e. sp\(^3\) and sp\(^3\)

5) Which sp\(^3\) hybridized atom is on the same plane as that of the one with arrow?
28) Which atom (atoms) in the above molecule is not in the same plane with atom # 6?

(A) 4  (B) 5, 8  (C) 4 and 9  (D) 3  (E) 8
7) What is the bond angle between C-CH-CH\textsubscript{3} in the following molecule?

\[ \text{CH}_3\text{C}(=\text{O})\text{CHCH}_3 \]

a) 109.5
b) 120
c) 90
d) 180
e) 60

8) Which represents a pair of resonance structures?

- (A) \text{CH}_3\text{C}-\text{C}-\text{CH}_3 \text{ and } \text{CH}_3\text{C}==\text{CH}_2
- (B) \text{CH}_3\text{C}==\text{C}_2\text{H}_2 \text{ and } \text{CH}_3\text{C}==\text{C}_2\text{H}_2
- (C) \text{CH}_3\text{C}==\text{C}_2\text{H}_2 \text{ and } \text{CH}_3\text{C}==\text{C}_2\text{H}_2
- (D) \text{CH}_3\text{C}==\text{C}_2\text{H}_2 \text{ and } \text{CH}_3\text{C}==\text{C}_2\text{H}_2
- (E) \text{CH}_3\text{C}-\text{C}-\text{CH}_3 \text{ and } \text{CH}_3\text{C}-\text{C}-\text{CH}_3
9) Which of the following compounds have delocalized electrons?

a. \[ \text{CH}_2=\text{CH}-\text{CH}=\text{CH}_2 \]

b. \[ \text{C}_6\text{H}_5\text{N}^- \]

c. \[ \text{C}_6\text{H}_5\text{N}^+ \]

d. \[ \text{CH}_2\text{NH}_2 \]

10) Which of the molecules have the strongest C-Cl bond?

a) \( \text{CH}_3\text{CH}_2\text{Cl} \)

b) \( \text{CH≡CCl} \)

c) \( \text{CH}_2\text{CHCl}^- \)

d) \( \text{CH}_2=\text{CHCl} \)

e) all have the same strength
11) How many **resonance structures** can be drawn for the following molecule? Including the one shown.

a. 1  
b. 4  
c. 2  
d. 3  
e. None of the above

12) How many **total resonance structures** can be drawn for the following anion (include those without separation of charge)? Including the one shown.

a. 1  
b. 4  
c. 3  
d. 5  
e. 2
13) Pair of structures that is resonance structures is

a. \( \text{CH}_3\text{CHC}≡\text{N} \quad \text{CH}_3\text{CH}=\text{C}≡\text{NH} \)

b. 

c. \( \text{CH}_3\text{CHC}≡\text{N} \quad \text{CH}_3\text{CH}=\text{C}≡\text{N} \)

d. 

e. None of the above

14) Which is the **most delocalized** lone pair electrons in the following molecule?
15) Which of the following species has the most conjugation?
16 What hybrid orbitals are used to form the sigma bond between C-1 and C-2, respectively, in the structure shown?

(A) $sp^3$ and $sp$  (B) $sp$ and $sp$  (C) $sp$ and $sp^2$  (D) $sp^2$ and $sp^2$  (E) $sp^2$ and $sp$

17 For which free radical can the most resonance forms be written that show the delocalization of the radical?

(A) \[ \text{Cyclohexyl} \cdot \text{CH}_2 \]

(B) \[ \text{Phenyl} \cdot \]

(C) \[ \text{Phenyl} \cdot \text{CH}_2 \]

(D) \[ \text{Phenyl} \cdot \text{Cyclohexyl} \]

(E) \[ \text{Phenyl} \cdot \text{Phenyl} \]
18 Which pair consists of resonance structures?

(A) \[ \begin{array}{c}
\text{CH}_3 \\
{\text{pentadienyl cation}}
\end{array} \]

(B) \[ \begin{array}{c}
\text{CH}_3 \\
\text{C} = \text{C} \\
\text{CH}_3 \\
{\text{pentadienyl cation}}
\end{array} \]

(C) \[ \begin{array}{c}
\text{CH}_2 \\
\text{pentadienyl cation} \\
\text{cyclohexadienyl cation}
\end{array} \]

(D) \[ \begin{array}{c}
\text{N} \\
\text{OH} \\
\text{phenacyl cation} \\
\text{phenacyl cation}
\end{array} \]

19 Which resonance structure contributes the most to the overall picture of this molecule?

(A) \[ \begin{array}{c}
\ddot{\text{O}} = \text{C} = \text{N} = \text{N}-\text{CH}_3
\end{array} \]

(B) \[ \begin{array}{c}
\text{O} = \text{C} = \text{N} = \text{N}-\text{CH}_3
\end{array} \]

(C) \[ \begin{array}{c}
\ddot{\text{O}} = \text{C} = \text{N} = \text{N}-\text{CH}_3
\end{array} \]

(D) \[ \begin{array}{c}
\text{O} = \text{C} = \text{N} = \text{N}-\text{CH}_3
\end{array} \]

(E) \[ \begin{array}{c}
\ddot{\text{O}} = \text{C} = \text{N} = \text{N}-\text{CH}_3
\end{array} \]

E) None of the above
20. Which carbocation is the most stable?

(A) \[
\begin{array}{c}
\text{CH}_3 \\
\end{array}
\]

(B) \[
\begin{array}{c}
\text{CH}_3 \\
\end{array}
\]

(C) \[
\begin{array}{c}
\text{CH}_3 \\
\end{array}
\]

(D) \[
\begin{array}{c}
\text{CH}_3 \\
\end{array}
\]

Key from 1-20 (down)

| B | D | A | A | E | A | B | B | B | D | B | B | C | C | B | A | E | E | A | E | D |
1) Which of the following species is most nucleophilic?

- a) 
- b) 
- c) 
- d) 

2) Arrange the following in the order of decreasing nucleophilicity.

- a) 
- b) 
- c) 
- d) 

3) Write the product of the following $S_N2$ reaction. Propose a mechanism for its formation.
4) The following reaction is a unimolecular reaction.

When the concentrations of both the reactants are 0.160 M, the rate of the reaction is 0.0080 M/s. What is the rate of the reaction when the concentration of the alkyl bromide is 0.08 M and methanol is 0.160 M?

\[
\text{Br} - \text{CH}_3\text{OH} + \rightarrow \text{CH}_3\text{OH} - \text{O}
\]

5) Which of the following alkyl bromides reacts slowest in an \( \text{S}_\text{N}2 \) reaction.
   a) 1-bromo-2-methylbutane
   b) 2-bromo-2-methylbutane
   c) 1-bromo-3-methylbutane
   d) 1-bromopropane
6) Arrange the following alkyl bromides in the order of decreasing reactivity in an $S_N2$ reaction.
   a) 1-bromo-2-methylbutane
   b) 1-bromo-3-methylbutane
   c) 1-bromo-2,2-dimethylbutane
   d) Bromobenzene

7) Determine the product that would be formed from the $S_N2$ reaction of
   (R)-2-bromobutane and $CH_3COONa$

   (S)-3-chlorohexane and NaCN
8) Which of the following $S_N2$ reactions occur faster?

a)

\[
\text{H}_3\text{C} - \text{C} - \text{C} - \text{Br} + \text{OH}^- \quad \text{or} \quad \text{CH}_3\text{CH}_2\text{CHBr} + \text{OH}^-
\]

b)

\[
\text{CH}_3\text{CH}_2\text{Cl} + \text{I}^- \quad \text{or} \quad \text{CH}_3\text{CH}_2\text{Br} + \text{I}^-
\]

9) Which of the following species is most nucleophilic in water?

a) \( \text{COONa} \)

b) \( \text{CH}_3\text{OH} \)

c) \( \text{NaOH} \)

d) \( \text{ONa} \)
10) Write the product of the following $S_N$ 1 reaction. Propose a mechanism for its formation.
15) Which alkyl halide would you expect to undergo S$_{N}$1 hydrolysis most rapidly?

(A) (CH$_3$)$_3$CF       (B) (CH$_3$)$_3$CBr       (C) (CH$_3$)$_3$CCl       (D) (CH$_3$)$_3$Cl       (E) all of them have equal reactivity

16) From the data given in the right-hand box, what is the specific rotation of the alcohol produced in the bimolecular nucleophilic displacement shown below?

\[ [\alpha]_D = -34.6 \quad [\alpha]_D = ? \]

(A) +34.6       (B) -34.6       (C) 0.0       (D) -9.9       (E) +9.9
17) Which bromide will undergo hydrolysis by an $S_N1$ mechanism the fastest?

(A) $\text{Br} \quad \text{CH}_3\text{CH}=\text{CHCHCH}_2\text{CH}_3$

(B) $\text{Br} \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{CHCH}_2\text{CH}_3$

(C) $\text{Br} \quad \text{CH}_3\text{CH}=\text{CHCH}_2\text{CHCH}_3$

(D) $\text{Br} \quad \text{CH}_3\text{CH}=\text{CCH}_2\text{CH}_2\text{CH}_3$

(E) $\text{H} \quad \text{CH}_3\text{CH}=\text{CCH}_2\text{CH}_2\text{CH}_2\text{Br}$
18) Which two compounds ionize with loss of bromide ion to form the same carbocation?

(A) 1 and 2  
(B) 2 and 3  
(C) 1 and 4  
(D) 3 and 4  
(E) 1 and 3
19) Which set of products is expected from the reaction shown?

\[
\text{Concentrated HBr (excess)} \quad \text{heat} \quad \text{phenol} + \text{alkyl bromide}
\]

(A) \( \text{phenol} + \text{alkyl bromide} \)

(B) \( \text{phenol} + \text{alkyl bromide} \)

(C) \( \text{phenol} + \text{ether} \)

(D) No reaction will occur.

(E) None

20) Which carbocation would not be likely to undergo rearrangement?

(A) \( \text{primary carbocation} \)

(B) \( \text{secondary carbocation} \)

(C) \( \text{tertiary carbocation} \)

(D) \( \text{secondary carbocation} \)

(E) None
21) What is the principal substitution product of the reaction shown?

(A) \( \text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \)

(B) \( \text{CH}_3\text{CHCHCH}_2\text{CH}_3 \)

(C) \( \text{Br} \)

(D) \( \text{CH}_3\text{CH}_2\text{CCH}_2\text{CH}_3 \)

(E) \( \text{CH}_3\text{CHCHCH}_2\text{CH}_3 \)

22) Which is the order from fastest to slowest for the rates of the \( S_{N2} \) reactions of these alkyl bromides with \( \text{CH}_3\text{S}^-/\text{DMSO} \)?

(A) 1 > 2 > 3

(B) 1 > 3 > 2

(C) 3 > 1 > 2

(D) 2 > 3 > 1

(E) 3 > 2 > 1
23) Which reaction would produce phenyl propyl ether?

(A) \[ \text{O}^- \text{Na}^+ \]
(B) \[ \text{Br} \]
(C) \[ \text{O}^- \text{Na}^+ \]
(D) \[ \text{Br} \]

24) What reagents could be used to accomplish the synthesis of this compound?

\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{C}≡\text{CCH}_3 \]

(A) \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{Na}^+ \text{C}≡\text{CCH}_3 \]
(B) \[ \text{CH}_3\text{CH}_2\text{Br} + \text{Na}^+ \text{C}≡\text{CCH}_3 \]
(C) \[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{Na}^+ \text{C}≡\text{CCH}_3 \]
(D) \[ \text{CH}_3\text{CH}_2\text{CH}_3 + \text{HC}≡\text{CCH}_3 \]
(E) None
32) Which of the following cannot exist as cis-trans isomer?

a) CH₃CHCHCH₃  b) CH₂CHCH₂CH₃  c) CHBrCHCH₂CH₃  d) CH(CH₃)C(CH₃)CH₂CH₃
e) None

33) Which of the following molecules has the most steric strain?

a)  b)  c)  d)  e) None
34) Determine the double bond stereochemistry (E or Z) for the following molecules

a. A: $E$; B: $E$

b. A: $Z$; B: $E$

c. A: $E$; B: $Z$

d. A: $Z$; B: $Z$

e. None
35) Determine the double bond stereochemistry \((E\) or \(Z\)) for the following molecules

- **A**: \(E\); **B**: \(E\)
- **A**: \(E\); **B**: \(Z\)
- **A**: \(Z\); **B**: \(Z\)
- **A**: \(Z\); **B**: \(E\)
- **A**: None

36) Determine the double bond stereochemistry \((E\) or \(Z\)) for the following molecules

- **A**: \(E\); **B**: \(E\)
- **A**: \(Z\); **B**: \(E\)
- **A**: \(Z\); **B**: \(Z\)
- **A**: \(E\); **B**: \(Z\)
- **A**: None

37) Determine the double bond stereochemistry \((E\) or \(Z\)) for the following molecules

- **A**: \(E\); **B**: \(Z\)
- **A**: \(Z\); **B**: \(E\)
- **A**: \(Z\); **B**: \(Z\)
- **A**: \(E\); **B**: \(E\)
- **A**: None
Which Newman projection corresponds to point A on the graph of potential energy vs. rotation about the C₂–C₃ bond?

(A) \[ \text{HCH}_3 \]

(B) \[ \text{HHCH}_3 \]

(C) \[ \text{HHCH}_3 \]

(D) \[ \text{HHCH}_3 \]

(E) \[ \text{HHCH}_3 \]
39) Identify the most stable Newman projection of the following compound along C₂ – C₃ bond.

\[ \text{CH₃CHBrCH₂CH₂CH₃} \]
What is the order from most stable to least stable for these conformations of propylene glycol?

(A) II > III > I   (B) I > II > III
(C) I > III > II   (D) III > II > I
(E) None
41) Which is the chair conformation of the following molecule?
42) Which is the planar representation of the following molecule?
43) In the following molecule, which groups are on the equatorial bond?

- Cl
- CH₃
- Br
- CH₂CH₃
- OH

a) Ethyl, Methyl, Chlorine
b) Chlorine, bromine and methyl
c) Chlorine, hydroxyl, ethyl and methyl
d) Methyl, Ethyl and hydroxyl and bromine
e) Methyl, ethyl and hydroxyl

44) Which of the following cyclohexane conformations has the MOST energy (is the LEAST stable)?

- a. half-chair
- b. chair
- c. boat
- d. twist-boat
e. Boat and half chair has the same energy and the most
45) Which of the following molecules is trans-1, 2-dimethylcyclohexane?
46) Which diastereoisomer is most stable?

(A) \[
\begin{align*}
\text{CH}_3 & \quad \text{H} & \quad \text{OH} \\
\text{H} & \quad \text{CH} & \quad \text{CH(CH}_3)_2 \\
\text{H} & \quad & \quad \\
\end{align*}
\]

(B) \[
\begin{align*}
\text{CH}_3 & \quad \text{H} & \quad \text{H} & \quad \text{H} & \quad \text{OH} & \quad \text{CH(CH}_3)_2 \\
\text{H} & \quad & \quad & \quad & \quad & \quad \\
\end{align*}
\]

(C) \[
\begin{align*}
\text{CH}_3 & \quad \text{H} & \quad \text{H} & \quad \text{OH} & \quad \text{CH(CH}_3)_2 \\
\text{H} & \quad & \quad & \quad & \quad \\
\end{align*}
\]

(D) \[
\begin{align*}
\text{CH}_3 & \quad \text{OH} & \quad \text{H} & \quad \text{H} & \quad \text{CH(CH}_3)_2 \\
\text{H} & \quad & \quad & \quad & \quad \\
\end{align*}
\]
47) Which is the same structure as the following?

\[ \text{Given Structure} \]

\[ \text{Options:} \]

- a.
- b.
- c.
- d.
- e. None

\[ \text{Diagram Images} \]
36) Which is the *weakest* nucleophile?

(A) $\text{CH}_3\text{CH}_2\text{ONa}$  
(B) $\text{O}^\ominus$  
(C) $(\text{CH}_3\text{CH}_2)_2\text{NLi}$  
(D) $\text{CF}_3\text{CH}_2\text{ONa}$  
(E) $\text{CH}_3\text{CONa}$

37) Which bromide would react the fastest in the $S_{\text{N}2}$ reaction shown?

\[ \text{R-Br} + \text{CN} \xrightarrow{\text{acetone}} \text{R-CN} + \text{Br}^- \]

(A) $\text{Br}^-$  
(B) $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$  
(C) $\text{CH}_3\text{CH}=$  
(D) $\text{CH}_2=$  
(E) $\text{CH}_2=\text{CHCH}_2\text{Br}$

38) Which bromide will undergo hydrolysis by an $S_{\text{N}1}$ mechanism the fastest?

(A) $\text{Br}^-$  
(B) $\text{Br}^-$  
(C) $\text{Br}^-$  
(D) $\text{Br}^-$  
(E) $\text{CH}_3\text{CH}=$  

(D) $\text{CH}_3\text{CH}=$  

(E) $\text{CH}_3\text{CH}=$
39) What reagent could accomplish this reaction?

(A) CH₃I (B) NaN₃ (E) HN₃
(C) HI (D) IN₃

40) What is the principal product of the reaction shown?

(A) CH₃OCC(CH₃)₃ (B) CH₃OCH₃ (E) None of the above
(C) CH₂= C(CH₃)₂ (D) CH₃OCH₂CHCH₃

41) What is the order of rates from fastest to slowest for the reactions of the three nucleophiles with propyl bromide?

(A) CH₃OH > CH₃NH₂ > CH₃O⁻ (B) CH₃NH₂ > CH₃O⁻ > CH₃OH
(C) CH₃NH₂ > CH₃OH > CH₃O⁻ (D) CH₃O⁻ > CH₃OH > CH₃NH₂
(E) CH₃O⁻ > CH₃NH₂ > CH₃OH
42) When 2-bromo-2-methylbutane is treated with a base, a mixture of 2-methyl-2-butene and 2-methyl-1-butene is produced.

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{-C-Br} & \quad \xrightarrow{\text{base}} \quad \text{CH}_3\text{CH}=\text{CCH}_3 + \text{CH}_3\text{CH}_2\text{C}=\text{CH}_2 \\
\text{CH}_3 & \\
\end{align*}
\]

When potassium hydroxide is the base, 2-methyl-1-butene accounts for 45% of the mixture. But when potassium tert-butoxide is the base, 2-methyl-1-butene accounts for 70% of the mixture. What would you predict for the percent of 2-methyl-1-butene in the mixture if potassium propoxide were the base?

(A) less than 45%

(B) 45%

(C) between 45% and 70%

(D) more than 70%

(E) None of the above
(43) What is the major product of the reaction shown?

(A) \[
\begin{array}{c}
\text{Br} \\
\text{CH}_3 \\
\end{array}
\]

(B) \[
\begin{array}{c}
\text{CH}_3 \\
\end{array}
\]

(C) \[
\begin{array}{c}
\text{CH}_3 \\
\end{array}
\]

(D) \[
\begin{array}{c}
\text{CH}_3 \\
\end{array}
\]

(E) \[
\begin{array}{c}
\text{OCH}_3 \\
\end{array}
\]

(44) Which reaction is best suited for the preparation of the ether shown?

(A) \[
(\text{CH}_3)_3\text{CBr} \xrightarrow{\text{CH}_3\text{CH}_2\text{OK}} (\text{CH}_3)_3\text{COCH}_2\text{CH}_3
\]

(B) \[
\text{CH}_3\text{CH}_2\text{MgBr} \xrightarrow{(\text{CH}_3)_2\text{COH}} (\text{CH}_3)_3\text{COCH}_2\text{CH}_3
\]

(C) \[
\text{CH}_3\text{CH}_2\text{Br} \xrightarrow{(\text{CH}_3)_2\text{COH}} (\text{CH}_3)_3\text{COCH}_2\text{CH}_3
\]

(D) \[
(\text{CH}_3)_3\text{CMgBr} \xrightarrow{\text{CH}_3\text{CH}_2\text{OH}} (\text{CH}_3)_3\text{COCH}_2\text{CH}_3
\]

(E) \[
\text{CH}_3\text{CH}_2\text{Br} \xrightarrow{(\text{CH}_3)_3\text{COK}} (\text{CH}_3)_3\text{COCH}_2\text{CH}_3
\]
1. Which two of these reaction sequences will effect this transformation?

\[
\begin{align*}
\text{I} & \quad \text{H}_2 \\
& \quad \text{Lindlar's catalyst} \\
& \quad \overset{1. \text{OsO}_4, \text{ether}}{\rightarrow} \\
& \quad \overset{2. \text{Na}_2\text{SO}_3, \text{H}_2\text{O}}{\rightarrow} \\
\text{II} & \quad \text{Na, NH}_3 (l) \\
& \quad \overset{1. \text{OsO}_4, \text{ether}}{\rightarrow} \\
& \quad \overset{2. \text{Na}_2\text{SO}_3, \text{H}_2\text{O}}{\rightarrow} \\
\text{III} & \quad \text{H}_2 \\
& \quad \text{Lindlar's catalyst} \\
& \quad \overset{\text{CH}_3\text{CO}_3\text{H}}{\rightarrow} \\
& \quad \overset{\text{NaOH}}{\rightarrow} \\
\text{IV} & \quad \text{Na, NH}_3 (l) \\
& \quad \overset{\text{CH}_3\text{CO}_3\text{H}}{\rightarrow} \\
& \quad \overset{\text{NaOH}}{\rightarrow}
\end{align*}
\]

(A) I and IV  (B) I and III  (C) II and III  (D) II and IV  (E) none of these

2. What is the product of this reaction?

3. Ozonoiyis of which terpene would give equimolar amounts of these compounds?

(A) \(\text{A}\)  (B) \(\text{B}\)  (C) \(\text{C}\)  (D) \(\text{D}\)  (E) None of these
4. Alkene derivatives of pristane (2,6,10,14-tetramethylpentadecane) can be isolated from marine zooplankton and are important in the study of the marine food chain. Which of these routes is best for the preparation of pristane?

(A) \[\text{NaNH}_2 \rightarrow \text{H}_2\text{(excess)} \rightarrow \text{Pd}\]

(B) \[\text{NaNH}_2 \rightarrow \text{Br} \rightarrow (1/2 \text{ molar equiv.)} \rightarrow \text{Pd}\]

(C) \[\text{NaNH}_2 \rightarrow \text{H}_2\text{(excess)} \rightarrow \text{Pd}\]

(D) \[\text{NaNH}_2 \rightarrow \text{Br} \rightarrow (2 \text{ molar equiv.)} \rightarrow \text{Pd}\]

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

\[
\begin{align*}
\text{C}_6\text{H}_5\text{C} &\equiv \text{C} = \text{H} \\
&\xrightarrow{1. \text{BH}} \text{C}_6\text{H}_5\text{C} &\equiv \text{C} = \text{H} \\
&\xrightarrow{2. \text{H}_2\text{O}_2, \text{NaOH}} \text{C}_6\text{H}_5\text{C} &\equiv \text{C} = \text{H}
\end{align*}
\]

(A) \(\text{C}_6\text{H}_5\text{C}=\text{O})\text{CH}_3\)  
(B) \(\text{C}_6\text{H}_5\text{CH(OH)}\text{CH}_3\)

(C) \(\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{OH}\)  
(D) \(\text{C}_6\text{H}_5\text{CH(OH)}\text{CH}_2\text{OH}\)  
(E) \(\text{C}_6\text{H}_5\text{CH}_2\text{CHO}\)

6. Which intermediate is involved in the reaction shown?

(A) Cl−C−Cl  
(B) Cl−C−Cl  
(C) Cl−C−Cl  
(D) Cl−C−Cl  
(E) None of these

7. What is the major product of this reaction?

(A) \[
\begin{align*}
\text{CH}_3 \\
\text{Cl}
\end{align*}
\]

(B) \[
\begin{align*}
\text{CH}_3 \\
\text{Cl}
\end{align*}
\]

(C) \[
\begin{align*}
\text{Cl} \\
\text{CH}_3
\end{align*}
\]

(D) \[
\begin{align*}
\text{Cl} \\
\text{CH}_3
\end{align*}
\]
18. Which is the best reagent for this conversion?

\[ \text{CH}_3\text{CHCH}_2\text{CH} \rightarrow \text{CH}_3\text{CHCH}_2\text{CH-OH} \]

(A) \( \text{D}_2\text{O}, \) containing catalytic amounts of \( \text{HCl} \)  (B) \( \text{NaBD}_4 \) in \( \text{CH}_3\text{CH}_2\text{OH} \) (and an aqueous workup)

(C) \( \text{NaOD} \) in \( \text{CH}_3\text{CH}_2\text{OD} \) (and an aqueous workup)  (D) \( \text{D}_2\text{O}_2 \) in \( \text{CH}_3\text{CO}_2\text{H} \)

19. Predict the products of the reaction shown.

\[ \text{CH}_3\text{CHCH}_2\text{CH} \xrightarrow{1. \text{CH}_3\text{MgBr} (1 \text{ equiv.})} \xrightarrow{2. \text{H}_2\text{O}, \text{H}^+} \text{CH}_3\text{CHCH}_2\text{CH} + \text{CH}_4 \]

(A) \( \text{CH}_3\text{CHCH}_2\text{CH} \)  (B) \( \text{CH}_3\text{CHCH}_2\text{CH} \)

(C) \( \text{CH}_3\text{CHCH}_2\text{CCH}_3 \)  (D) \( \text{CH}_3\text{CHCH}_2\text{CH} \)

20. Arrange the ketones in order of decreasing reactivity toward cyanohydrin formation with \( \text{HCN/KCN} \).

\[
\begin{array}{ccc}
\text{CHO} & \text{CH}_3\text{CCH}_3 & \text{CF}_3\text{CCF}_3 \\
1 & 2 & 3
\end{array}
\]

(A) \( 1 > 2 > 3 \)  (B) \( 2 > 1 > 3 \)

(C) \( 2 > 3 > 1 \)  (D) \( 3 > 2 > 1 \)

(E) \( 3 > 1 > 2 \)

21. Which of these methods will produce 1-pentanol?

\[ \begin{align*}
\text{I} & \quad \text{CH}_3\text{CHCH}_2\text{MgBr} \xrightarrow{1. \Delta, \text{H}_2\text{O}, \text{H}^+} \\
\text{II} & \quad \text{CH}_3\text{CHCH}_2\text{CH} = \text{CH_2} \xrightarrow{1. \text{B}_2\text{H}_6, \text{THF}} \\
\text{III} & \quad \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_2\text{Br} \xrightarrow{\text{KOC(CH}_3}_3} \xrightarrow{\text{H}_2\text{O}, \text{H}^+} \\
\text{IV} & \quad \text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_2\text{MgBr} \xrightarrow{0. \text{HCH}}
\end{align*} \]

(A) \( \text{I, II, III, IV} \)  (B) \( \text{I, II, III} \)

(C) \( \text{I, III, IV} \)  (D) \( \text{II, III, IV} \)

(E) \( \text{I, II, IV} \)
22. What set of ketone (1) and aldehyde (2) will provide the same alcohol product (3) when submitted to the reaction conditions shown?

(A)

(B)

(C)

(D)

23. For the reaction shown, the rate of reaction when $X = \text{Cl}$ is about the same as that when $X = \text{Br}$. Based on this information, which statement represents a valid deduction concerning the mechanism of this reaction?

(A) This is a one-step displacement reaction.

(B) The C–X bond is broken after the rate-determining step.

(C) The C–X bond is broken in the rate-determining step.

(D) The reaction proceeds $via$ a benzyne intermediate.

24. Which combination would not produce the alcohol shown?

(A)

(B)

(C)

(D)
25. What is the product of the reaction sequence shown?

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} \xrightarrow{\text{(C}_6\text{H}_5)_3\text{P}} \text{C}_6\text{H}_5\text{Li} \xrightarrow{\text{O}}
\]

(A) \[\text{CH}_2=\text{CHCH}_2\text{CH}_3\]  
(B) \[\text{CH}_2=\text{OCHCH}_2\text{CH}_3\]  
(C) \[\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\]  
(D) \[\text{CH}_2\text{CH}_2\text{CH}_3\]

26. What is the expected product of this reaction?

\[
\text{O}_2\text{N} \quad \text{Cl} \quad \text{Cl} \quad \text{CH}_3\text{ONa} \quad \text{I molar equivalent}
\]

(A) \[\text{O}_2\text{N} \quad \text{Cl} \quad \text{Cl} \quad \text{OCH}_3\]  
(B) \[\text{O}_2\text{N} \quad \text{Cl} \quad \text{Cl} \quad \text{OCH}_3\]  
(C) \[\text{O}_2\text{N} \quad \text{Cl} \quad \text{Cl} \quad \text{OCH}_3\]  
(D) \[\text{O}_2\text{N} \quad \text{Cl} \quad \text{Cl} \quad \text{OCH}_3\]

27. In addition to the product indicated, what other compound is expected to be formed in the reaction?

\[
\text{CH}_3\text{Cl} \xrightarrow{\text{NaNH}_2, \text{liquid NH}_3} \text{CH}_3\text{NH}_2
\]

(A) \[\text{Cl} \quad \text{NH}_2\]  
(B) \[\text{CH}_3\]  
(C) \[\text{CH}_3\]  
(D) \[\text{Cl} \quad \text{NH}_2\]  
(E) \[\text{Cl} \quad \text{NH}_2\]
8. Which position will be attacked most rapidly by the nitronium ion when the compound undergoes nitration with nitric acid/sulfuric acid?

![Chemical structure image]

8. Which position will be attacked most rapidly by the nitronium ion when the compound undergoes nitration with nitric acid/sulfuric acid?

9. Which of these compounds are aromatic?

(A) II, III, and IV (B) I, II, and IV (C) I, II, and III (D) I and II (E) I, III, and IV

10. The electrophilic aromatic substitution reaction is exothermic. Which potential energy reaction diagram best describes the reaction of benzene with Br₂/FeBr₃?

![Potential energy reaction diagrams]

11. Which structure represents a major intermediate in the bromination of nitrobenzene?

(A) NO₂ (B) NO₂ (C) NO₂ (D) NO₂

NOTE: Nitrobenzene is a benzene ring with a nitro group attached.
12. Arrange these compounds in order of decreasing reactivity (fastest to slowest) towards HNO_3/H_2SO_4.

(A) III > IV > II > I
(B) IV > I > II > III
(C) I > II > IV > III
(D) IV > II > I > III
(E) None of these

13. Which statement best describes why anisole brominates faster than benzene?

(A) The inductive effect of the methoxy group stabilizes the cationic intermediate.
(B) The inductive effect of the methoxy group stabilizes the anionic intermediate.
(C) The resonance effect of the methoxy group stabilizes the cationic intermediate.
(D) The resonance effect of the methoxy group stabilizes the anionic intermediate.

14. Which sequence of reactions is expected to give the best yield of 3-nitrobenzoic acid?

(A) \( \text{C}_{6}\text{H}_5\text{NO}_2 + \text{CH}_3\text{Cl} \xrightarrow{\text{AlCl}_3} \text{K}_2\text{Cr}_2\text{O}_7, \text{H}_2\text{O}^+ \xrightarrow{\text{heat}} \text{3-nitrobenzoic acid} \)
(B) \( \text{C}_{6}\text{H}_5\text{CH}_3 + \text{K}_2\text{Cr}_2\text{O}_7, \text{H}_2\text{O}^+ \xrightarrow{\text{heat}} \text{HNO}_3, \text{H}_2\text{SO}_4 \xrightarrow{\text{heat}} \text{3-nitrobenzoic acid} \)
(C) \( \text{C}_{6}\text{H}_5\text{CH}_3 + \text{HNO}_3, \text{H}_2\text{SO}_4 \xrightarrow{\text{heat}} \text{K}_2\text{Cr}_2\text{O}_7, \text{H}_2\text{O}^+ \xrightarrow{\text{heat}} \text{3-nitrobenzoic acid} \)
(D) \( \text{C}_{6}\text{H}_5\text{CH}_3 \xrightarrow{\text{K}_2\text{Cr}_2\text{O}_7, \text{H}_2\text{O}^+ \text{heat}} \xrightarrow{\text{heat}} \text{NaNO}_2, \text{HCl} \xrightarrow{\text{c}^\circ} \text{3-nitrobenzoic acid} \)

NOTE: \( \text{K}_2\text{Cr}_2\text{O}_7, \text{H}_2\text{O}^+ \), heat reacts the same way as \( \text{KMnO}_4, \text{NaOH} \)
15. Which of these reaction sequences will produce \textit{m}-bromochlorobenzene?

\textbf{(A)} \[ \begin{array}{c} \text{Br} \\ \text{HNO}_3 \\ \text{H}_2\text{SO}_4 \end{array} \xrightarrow{\text{H}_2 \text{Pt}} \begin{array}{c} \text{HCl, 0 °C} \\ \Delta \end{array} \xrightarrow{\text{NaNO}_2} \begin{array}{c} \text{CuCl} \\ \Delta \end{array} \]

\textbf{(B)} \[ \begin{array}{c} \text{NO}_2 \\ \text{Pt} \end{array} \xrightarrow{\text{H}_2} \begin{array}{c} \text{Br}_2 \text{FeBr}_3 \\ \text{HCl, 0 °C} \end{array} \xrightarrow{\text{NaNO}_2} \begin{array}{c} \text{CuCl} \\ \Delta \end{array} \]

\textbf{(C)} \[ \begin{array}{c} \text{NO}_2 \\ \text{FeBr}_3 \text{Pt} \end{array} \xrightarrow{\text{Br}_2} \begin{array}{c} \text{H}_2 \text{HCl, 0 °C} \end{array} \xrightarrow{\text{NaNO}_2} \begin{array}{c} \text{CuCl} \\ \Delta \end{array} \]

\textbf{(D)} \[ \begin{array}{c} \text{Br} \\ \text{HNO}_3 \\ \text{H}_2\text{SO}_4 \end{array} \xrightarrow{\text{HCl, 0 °C}} \begin{array}{c} \text{NaNO}_2 \\ \Delta \end{array} \xrightarrow{\text{CuCl}} \]

\textbf{NOTE:} \textit{m}-\text{bromochlorobenzene} is a benzene ring with a bromo and chloro \textit{meta} to each other.

16. Which reaction sequence will accomplish this transformation in good yield?

\textbf{(A)} \[ \begin{array}{c} \text{CH}_3\text{CH}_2\text{Cl} \\ \text{AlCl}_3 \end{array} \xrightarrow{\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}} \begin{array}{c} \text{AlCl}_3 \\ \text{con. HCl} \end{array} \xrightarrow{\text{Zn(Hg)}} \begin{array}{c} \text{CH}_3\text{CH}_2\text{H}_2\text{CH}_3 \\ \text{Note: Zn(Hg)} \end{array} \]

\textbf{(B)} \[ \begin{array}{c} \text{CH}_3\text{Cl} \\ \text{AlCl}_3 \end{array} \xrightarrow{\text{CH}_3\text{CH}_2\text{Cl}} \begin{array}{c} \text{AlCl}_3 \end{array} \xrightarrow{\text{Zn(Hg)}} \begin{array}{c} \text{con. HCl} \\ \text{conc. HCl} \end{array} \]

\textbf{(C)} \[ \begin{array}{c} \text{CH}_3\text{CH}_2\text{Cl} \\ \text{AlCl}_3 \end{array} \xrightarrow{\text{CH}_3\text{CH}_2\text{Cl}} \begin{array}{c} \text{AlCl}_3 \end{array} \xrightarrow{\text{Zn(Hg)}} \begin{array}{c} \text{con. HCl} \\ \text{con. HCl} \end{array} \]

\textbf{(D)} \[ \begin{array}{c} \text{CH}_3\text{Cl} \\ \text{AlCl}_3 \end{array} \xrightarrow{\text{CH}_3\text{CH}_2\text{Cl}} \begin{array}{c} \text{AlCl}_3 \end{array} \xrightarrow{\text{Zn(Hg)}} \begin{array}{c} \text{con. HCl} \\ \text{con. HCl} \end{array} \]

\textbf{Note:} Zn(Hg) conc. HCl reacts the same way as H2, Pt

17. Which would be the major product of this reaction?

\textbf{(A)} \[ \begin{array}{c} \text{CH}_3\text{O} \\ \text{Br} \end{array} \xrightarrow{\text{CH}_3\text{CH}_3} \]

\textbf{(B)} \[ \begin{array}{c} \text{CH}_3\text{O} \\ \text{Br} \end{array} \xrightarrow{\text{CH}_3\text{CH}_3} \]

\textbf{(C)} \[ \begin{array}{c} \text{CH}_3\text{O} \\ \text{CH}_2\text{CH}_3 \end{array} \xrightarrow{\text{Br} \text{FeCl}_3} \]

\textbf{(D)} \[ \begin{array}{c} \text{CH}_3\text{O} \\ \text{Br} \end{array} \xrightarrow{\text{CH}_3\text{CH}_3} \]

\textbf{(E)} \[ \begin{array}{c} \text{CH}_3\text{O} \\ \text{Br} \end{array} \xrightarrow{\text{CH}_3\text{CH}_3} \]
28. Which is the product that can be isolated from the reaction shown?

\[
\begin{align*}
\text{(A)} & \quad \text{CH}_3 \quad \text{O} \\
\text{CH}_3\text{OCHCH}_2\text{CCH}_3 \\
\text{(C)} & \quad \text{CH}_3 \quad \text{CH}_3 \\
\text{HOCHCH}_2\text{C(OCH}_3)_2
\end{align*}
\]

29. What is the product of the following reaction?

\[
\begin{align*}
\text{CH}_3 \quad \text{CH}_3 & \quad \xrightarrow{\text{H}_2\text{O}, \text{H}^+} \\
\text{CH}_3\text{OCHCH}_2\text{C(OCH}_3)_2 \\
\end{align*}
\]

30. β-D-glucose forms by a hemiacetal cyclization, as shown. Which oxygen atom is in the ring?

\[
\begin{align*}
\text{(A) 1} & \quad \text{(B) 2} & \quad \text{(C) 3} & \quad \text{(D) 4}
\end{align*}
\]

31. Which reagent will accomplish the conversion shown?

\[
\begin{align*}
\text{(A) CH}_3\text{I} & \quad \text{(B) (CH}_3)_2\text{CuLi} & \quad \text{(C) CH}_3\text{Li} & \quad \text{(D) CH}_3\text{MgBr}
\end{align*}
\]
32. Which of the following is considered an oxidation?

I – The conversion of CH₃CH₂OH to CH₂=CH₂  
II – The conversion of CH₂=CH₂ to CH₃CH₃  
III – The conversion of CH₃CH₂OH to CH₃CHO  
IV – The conversion of CH₃CH₂OH to CH₃CO₂H

(A) I, II and III  
(B) III and IV  
(C) I and II  
(D) I, III and IV

33. Which reaction sequence would accomplish the synthesis of this alcohol?

(A) CH₃CH₂CH₂OH → HBr → Mg → ether  
(B) CH₃CH₂CH₂OH → 1. CH₃MgBr → 2. H₂O, H⁺  
(C) CH₃CH₂CH₂OH → conc. H₂SO₄ → H₂O  
(D) CH₃CH₂CH₂OH → NH₄⁺ CrO₃⁻Cl⁻ (PCC) → 1. CH₃MgBr → 2. H₂O, H⁺

34. What is the expected product from this reaction sequence?

(A) OCH₂CH₂OH → NaCl = CCH₃ → H₂O, H⁺  
(B) CH₃C = CCH₂CH₂CH₂  
(C) CH₃C = CCH₂CH₂CC = CCH₃  
(D) BrCH₂CH₂CH₂CH = CCH₃

35. Which product would result from this reaction?

(A) HO  
(B) O  
(C) OH  
(D) BrCH₂CH₂CH₂CH = CCH₃

Note: K₂Cr₂O₇, H₂SO₄ reacts the same as CrO₃, H₂SO₄, H₂O.
25) Which H will most likely be removed in an E₂ reaction in the following molecule?
26) Which of the following substrates in an E2 reaction will likely violate ZAITSEV’S rule?

a.  

b.  

c.  

d.  

e.  

27) Which of the following substrate in an E2 reaction will produce the most substituted double bond?

a.  

b.  

c.  

d.  

e.  

28) Which of the following can undergo Hoffman elimination?

a. 

b. 

c. 

d. 

e. none

Propose a mechanism for the formation of the following product through E1
29) Which of the following carbocations will not undergo rearrangement?
30) Identify a nucleophile which upon reaction with 2-bromo-2-methylpentane will produce 2-methyl-2-pentene.

a. \( \text{H}_2\text{C}=-\text{C}-\text{NH}_2 \)  
   b. MeOH  
   c. HNO₃  
   d. H₂N--Ph  
   e. \( \text{\( \Theta \)C==C-CH}_3 \)

31) If this alcohol is dehydrated, which alkene is likely to be formed in the largest quantity?

\[ \text{CH}_3 \]
\[ \text{CH}_3\text{-C-CH-CH-CH}_2\text{CH}_3 \overset{\text{H}_2\text{SO}_4}{\rightarrow} \]

(A) \[ \text{CH}_3\text{-C-CH=CHCH}_3 \]
   \[ \text{CH}_3\text{-C-CH=CHCH}_3 \]
   \[ \text{CH}_3\text{-CH=CHCH}_3 \]
   \[ \text{CH}_3\text{-C=CHCH}_3 \]
   \[ \text{CH}_3\text{-C=CHCH}_2\text{CH}_3 \]
   \[ \text{CH}_3\text{-C=CHCH}_2\text{CH}_3 \]

E) None
32) Which of the mechanistic steps shown is not a reasonable one in the mechanism to describe the formation of 2-methyl-1-butene by dehydration of 3-methyl-2-butanol?
33) Which is the proper representation of the "flow" of electrons in this E2 elimination?

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CHCH}_3 & \quad \text{OTs} \\
& \quad \text{C}_2\text{H}_5\text{ONa} \\
\rightarrow & \quad \text{CH}_3\text{CH} = \text{CHCH}_3 + \text{NaOTs} + \text{C}_2\text{H}_5\text{OH} \\
\end{align*}
\]

(A) \[
\begin{align*}
\text{CH}_3 & \quad \text{CH} \quad \text{CH} \quad \text{CH}_3 \\
& \quad \text{H} \\
& \quad \text{H} \\
& \quad \text{CH}_3 \\
& \quad \text{OTs} \\
& \quad \text{C}_2\text{H}_5\text{O} \\
\end{align*}
\]

(B) \[
\begin{align*}
\text{CH}_3 & \quad \text{CH} \quad \text{CH} \quad \text{CH}_3 \\
& \quad \text{H} \\
& \quad \text{H} \\
& \quad \text{CH}_3 \\
\end{align*}
\]

(C) \[
\begin{align*}
\text{CH}_3 & \quad \text{CH} \quad \text{CH} \quad \text{CH}_3 \\
& \quad \text{H} \\
\end{align*}
\]

(D) \[
\begin{align*}
\text{CH}_3 & \quad \text{CH} \quad \text{CH} \quad \text{CH}_3 \\
& \quad \text{H} \\
\end{align*}
\]

(E) None