

Instructions:

On the Scantron card:

1. Put your name and course number on the right.
2. Under ID number, fill in your student ID number.
3. Under section number and Test Master, **LEAVE BLANK**.
4. Fill in the best choice **A, B, C, D, E** to answer each of the questions that follow. Fill in only one answer for each question.

There is 0 marks for an incorrect or missing answer. **Total marks possible = 55.**

Calculators and/or molecular models may be used by individual students but may not be shared around during the examination period.

You may take this examination paper with you at the end of the exam, handing in only your Scantron.

The following abbreviations may appear:

Ac = acetyl, $\text{CH}_3\text{C}(\text{O})$

t-Bu = tertiary (*tert*) butyl

cat. = catalytic amount of

Et = ethyl, C_2H_5

Me = methyl, CH_3

Ph = phenyl, C_6H_5

Only the answers marked on the computer card will be counted (regardless of what you may have marked on this exam paper).

1) Consider the Lewis structures of the following compounds. Which of the following compounds possess a single unpaired electron?

- a) N_2O b) HNC c) NO d) N_2 e) HOOH

2) Which of the following compounds can act as **both** a hydrogen bond donor and a hydrogen bond acceptor?

- 1) $\text{CH}_3\text{CO}_2\text{H}$ 2) CH_3OCH_3 3) CH_3CHO

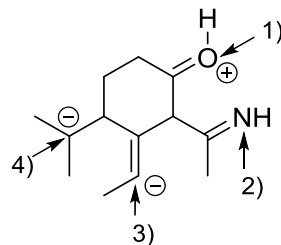
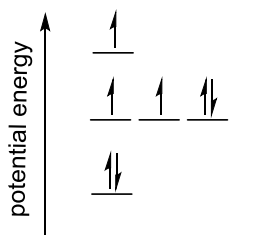
- a) Only 1)
 b) Only 3)
 c) 2) and 3)
 d) 1) and 2)
 e) 1), 2) and 3)

3) Sodium cyanate (NaOCN) is a herbicide used to control weeds. How many σ bonds does NaOCN have?

- a) 1 b) 2 c) 3 d) 4

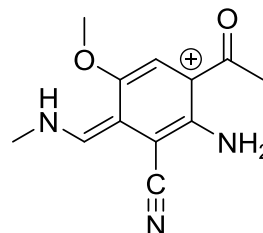
4) Which of the following atoms has the hybridization shown in the potential energy diagram?

- a) Only 2)
 b) Only 4)
 c) 3) and 4)
 d) 1), 2) and 3)
 e) 1), 2), 3) and 4)



5) Consider all **valid** resonance structures for the following molecule. How many **different** nitrogen **and** oxygen atoms will bear a positive charge?

- a) 1 oxygen atom, 1 nitrogen atom
 b) 2 oxygen atoms, 2 nitrogen atoms
 c) 1 oxygen atom, 2 nitrogen atoms
 d) 2 oxygen atoms, 3 nitrogen atoms
 e) 2 oxygen atoms, 1 nitrogen atoms



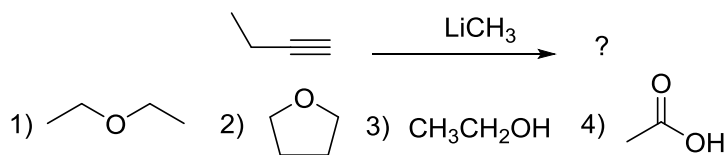
6) For the following pairs of acids (1 and 2, 3 and 4, 5 and 6) select the **strongest** acid:

- a) 1, 3, 5
- b) 2, 4, 5
- c) 2, 3, 6
- d) 1, 3, 6
- e) 2, 4, 6

1) $\text{Cl}_3\text{CCO}_2\text{H}$	2) $(\text{CH}_3)_3\text{CCO}_2\text{H}$
3) CH_3SH	4) CH_3OH
5) H_3CNH_2	6) $\text{HC}\equiv\text{CH}$

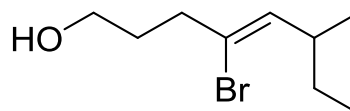
7) Which of the following solvent(s) **could be used** in the reaction shown below?

- a) 1, 2, 3 and 4
- b) 1 and 2
- c) 3 and 4
- d) 1
- e) 3



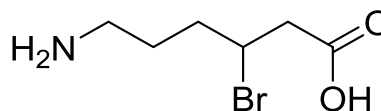
8) What is the IUPAC name for the following compound?

- a) (Z)-4-bromo-6-methyl-4-octene-1-ol
- b) (Z)-4-bromo-6-ethyl-4-hepten-1-ol
- c) (E)-5-bromo-3-methyl-4-octene-8-ol
- d) (E)-4-bromo-6-methyl-4-octene-1-ol
- e) (Z)-5-bromo-3-methyl-4-octene-8-ol



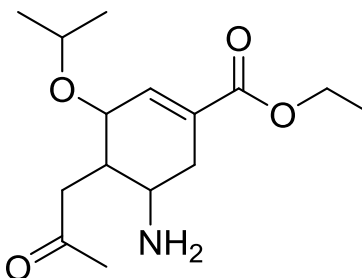
9) What is the IUPAC name for the following compound?

- a) 4-bromo-5-carboxy-1-aminopentane
- b) 5-amino-2-bromopentanoic acid
- c) 6-amino-2-bromo-1-hydroxy-1-hexanone
- d) 4-bromo-5-carboxy-pentamine
- e) 6-amino-3-bromohexanoic acid



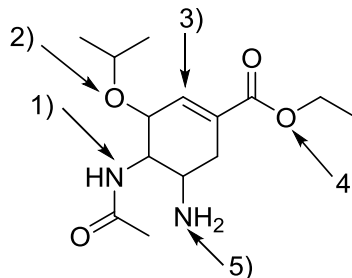
10) The following molecule is Oseltamivir, the biologically active component of Tamiflu™, which has been shown to be an effective anti-viral drug for the bird flu. How many stereocenters are present in Oseltamivir?

- a) 1
- b) 2
- c) 3
- d) 4
- e) 5



11) Tamiflu™ is usually sold as a phosphate salt, which can be obtained via the acid-base reaction of Oseltamivir with H_3PO_4 . As a base, Oseltamivir has several functional groups for the acid to react with. Which atom is the **most** basic?

- a) 1
- b) 2
- c) 3
- d) 4
- e) 5

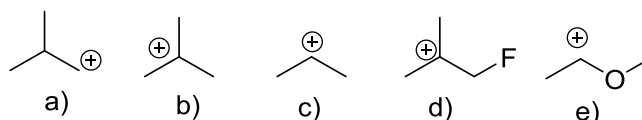


12) For the following pairs (1 and 2, 3 and 4, 5 and 6), select the **strongest** nucleophile in a polar protic solvent:

- a) 1, 4, 6
- b) 1, 3, 5
- c) 2, 4, 6
- d) 2, 3, 6
- e) 1, 4, 5

1) CH_3SH	2) CH_3OH
3) $NaOMe$	4) $NaOC(CH_3)_3$
5) CH_3ONa	6) CH_3COONa

13) Which of the following carbocations would be the **most** stable?

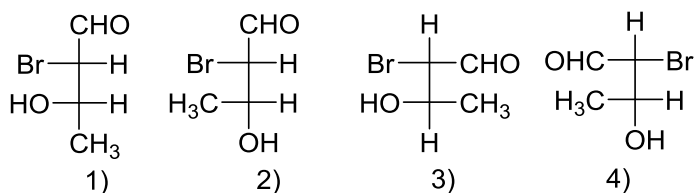


14) The **most** stable conformation of (1R, 2S, 3S)-1-bromo-2-chloro-3-fluorocyclohexane has

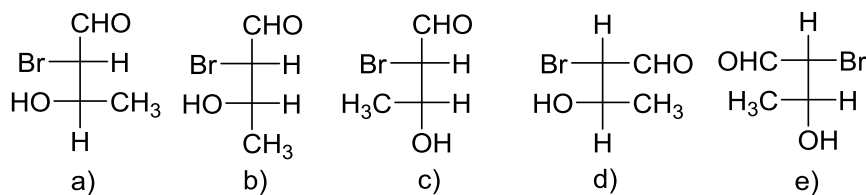
- a) Bromine equatorial, chlorine equatorial, fluorine equatorial
- b) Bromine axial, chlorine equatorial, fluorine equatorial
- c) Bromine equatorial, chlorine equatorial, fluorine axial
- d) Bromine axial, chlorine equatorial, fluorine axial
- e) Bromine equatorial, chlorine axial, fluorine equatorial

15) Which pair of compounds represent enantiomers?

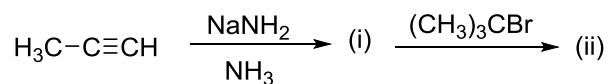
- a) 1 and 2
- b) 2 and 3
- c) 3 and 4
- d) 1 and 3
- e) 2 and 4



16) Which of the following molecules is (2*R*, 3*R*)-2-bromo-3-hydroxybutanal?

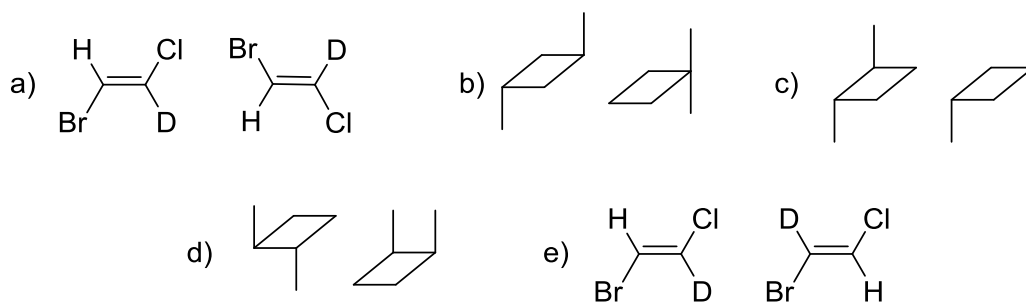


17) Propyne reacts with sodium amide (NaNH_2) in liquid ammonia (NH_3) to produce product (i). Product (i) reacts with *t*-butyl bromide to form product (ii). What is product (ii)?

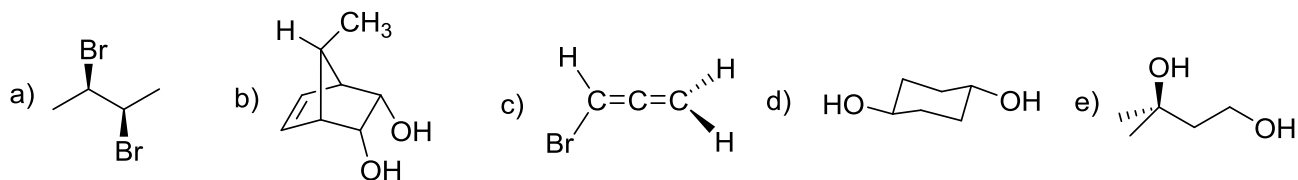


- a) $(\text{CH}_3)_3\text{CNHC}\equiv\text{CCH}_3$
- b) $(\text{CH}_3)_2\text{C}=\text{CHNH}_2$
- c) $(\text{CH}_3)_3\text{CC}\equiv\text{CCH}_3$
- d) $(\text{CH}_3)_3\text{CC}\equiv\text{CC}(\text{CH}_3)_3$
- e) $(\text{CH}_3)_2\text{C}=\text{CH}_2$

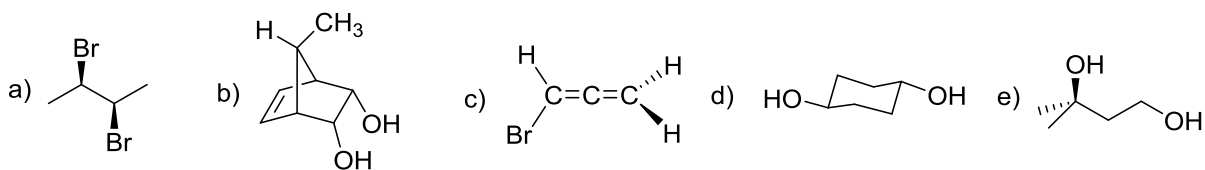
18) Which of the following pairs of molecules represent diastereomers?



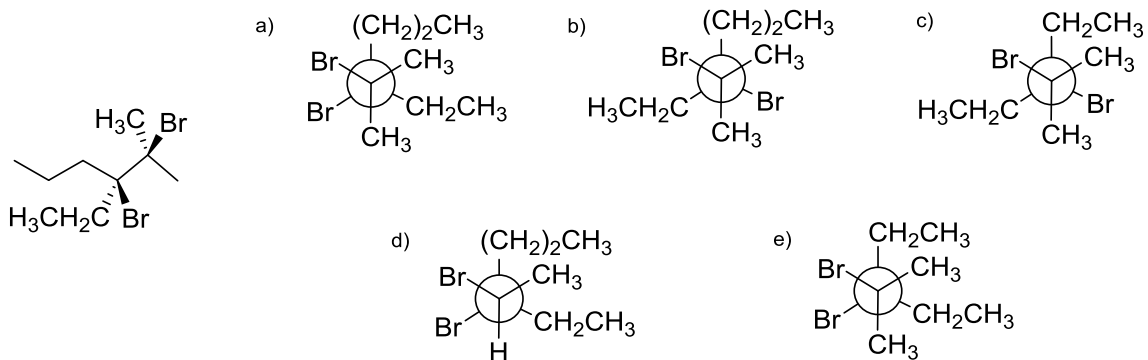
19) Which of the following compounds has an enantiomer?



20) Which of the following compounds is a meso compound?

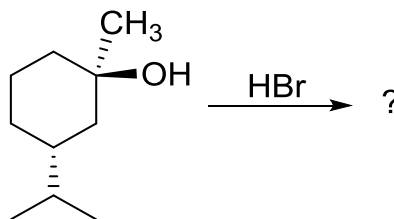


21) What is the **correct** Newman projection of the following molecule?

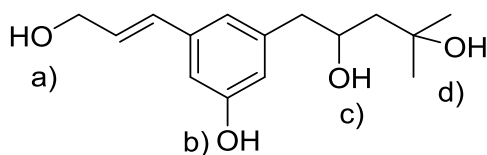


22) What is the stereochemical relationship between the **major** products in the following reaction?

- a) Enantiomers
- b) Meso
- c) Diastereomers
- d) Constitutional isomers
- e) Only one compound is produced



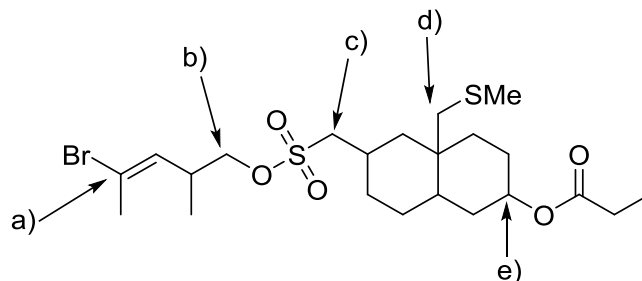
23) Which alcohol would undergo a dehydration reaction the **fastest** when treated with concentrated H_2SO_4 ?



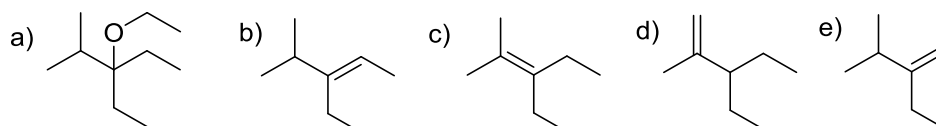
24) Which compound reacts the **fastest** when treated with NaSCH_3 in acetone?

- a) 2-Bromopentane
- b) 2-bromo-2-methylpentane
- c) 1-Bromopentane
- d) 1-bromo-2-pentene
- e) 1-bromo-2-methylbenzene

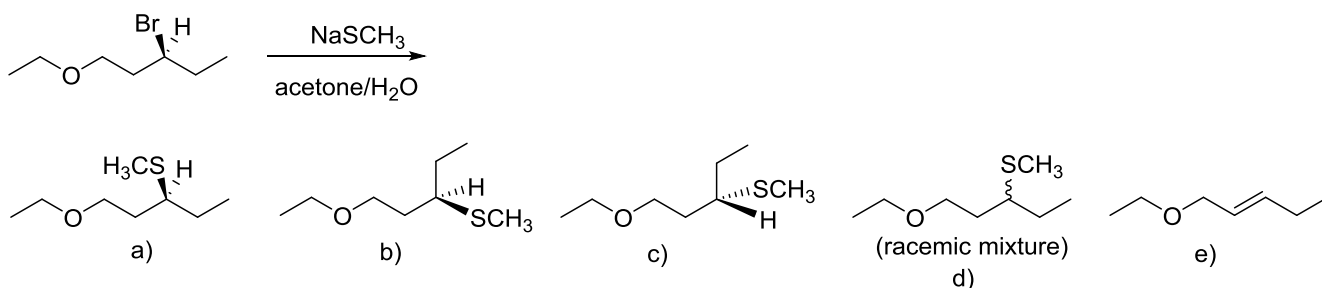
25) The following molecule is reacted with a strong nucleophile in an S_N2 reaction. **Where** will the reaction occur?



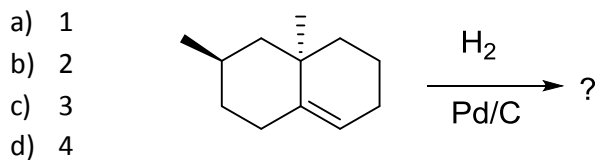
26) What is the **major** product when 3-bromo-3-ethyl-2-methylpentane is heated with sodium ethoxide ($\text{NaOCH}_2\text{CH}_3$)?



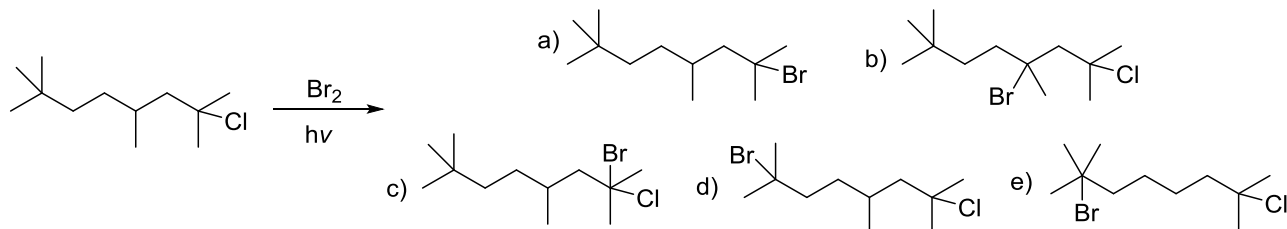
27) What is the **major** product in the following reaction?



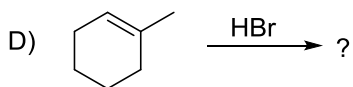
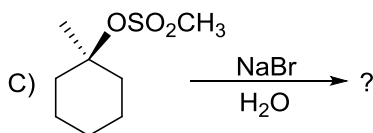
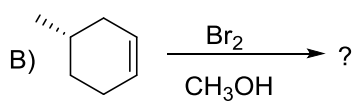
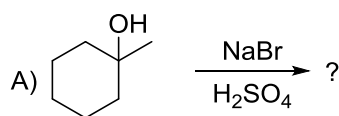
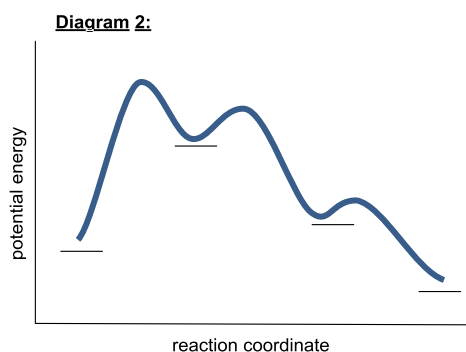
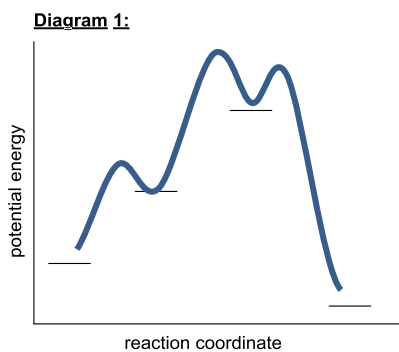
28) For the following hydrogenation reaction, how **many** possible stereoisomers can be formed?



29) What is the **major** mono-substituted product formed in the following reaction?

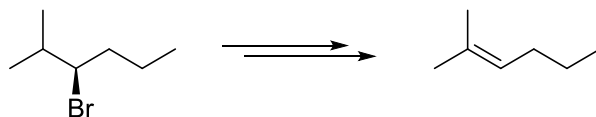


30) Match the following potential energy diagrams to the correct reaction:



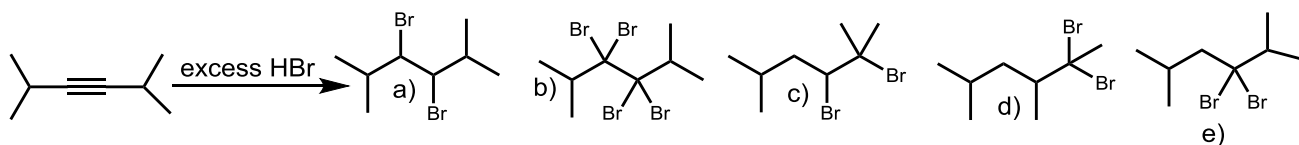
- a) Diagram 1 matches Reaction B; Diagram 2 matches Reaction C
 b) Diagram 1 matches Reaction D; Diagram 2 matches Reaction B
 c) Diagram 1 matches Reaction A; Diagram 2 matches Reaction C
 d) Diagram 1 matches Reaction A; Diagram 2 matches Reaction B
 e) Diagram 1 matches Reaction D; Diagram 2 matches Reaction A

31) Which of the following reagents can be used to transform (3*R*)-3-bromo-2-methylhexane into 2-methyl-2-hexene as the **major** product?

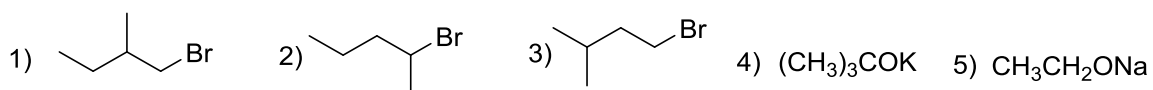


- a) NaSH/H₂O
 b) ((CH₃)₂CH)₂NLi/(CH₃CH₂)₂O
 c) (CH₃)₃CONa/(CH₃)₃COH
 d) CH₃CH₂ONa/CH₃CH₂OH
 e) Concentrated H₂SO₄/heat

32) What is the **major** product formed in the following reaction?

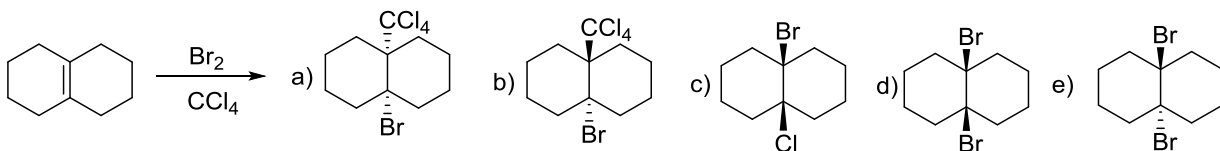


33) Select the **correct** alkyl halide and base that would yield 3-methylbut-1-ene as the **major** product.

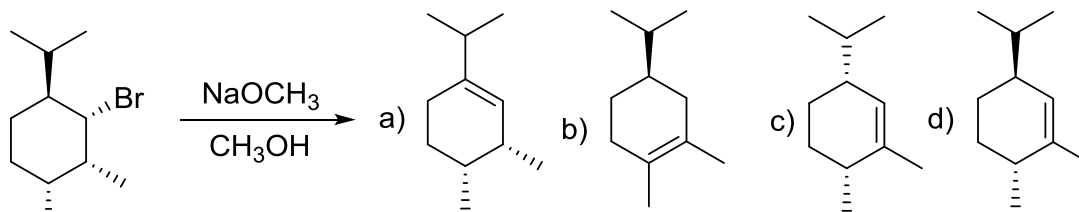


- a) 1 and 5
- b) 2 and 4
- c) 3 and 5
- d) 2 and 5
- e) 3 and 4

34) What **major** product formed in the following reaction?

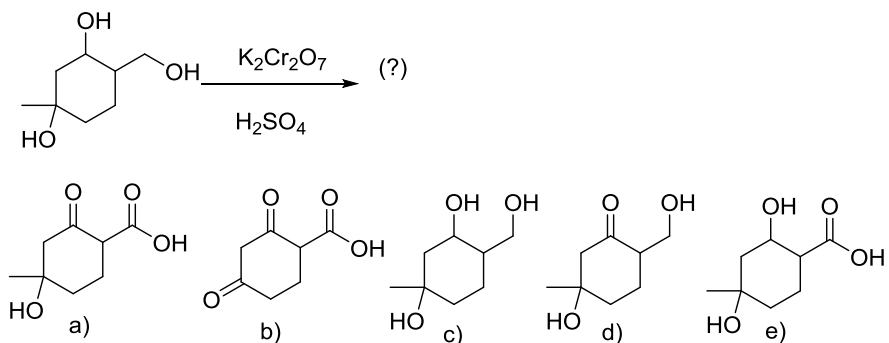


35) What is the **major** product in the following reaction?

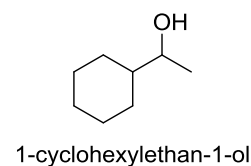
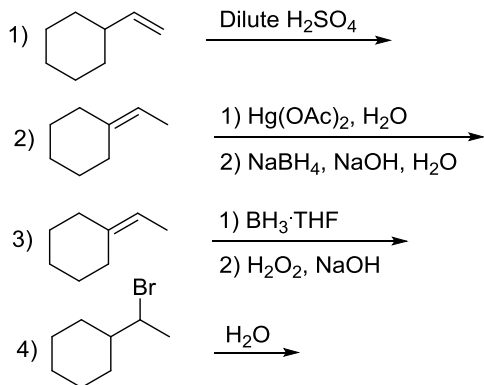


e) a mixture of a and c

36) What is the **major** product in the following reaction?

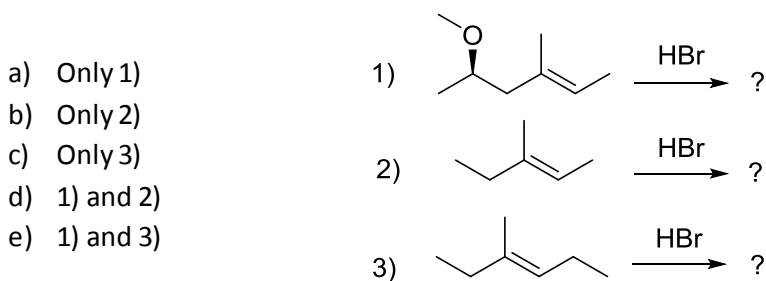


37) Which of the following reactions will produce 1-cyclohexylethan-1-ol as the **major** product?

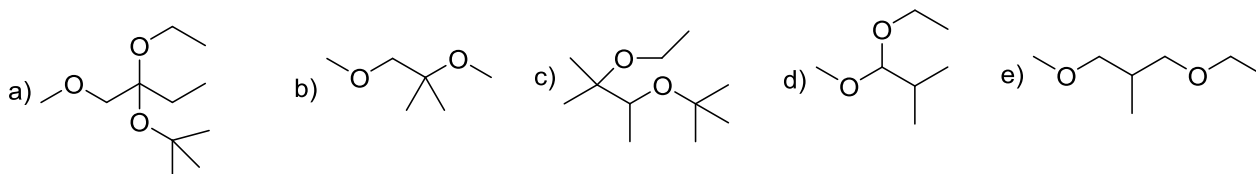
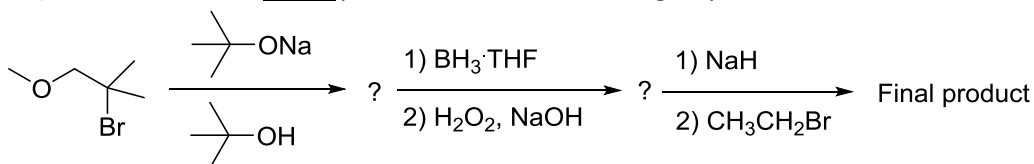


- a) Only 2)
 b) Only 3)
 c) 1) and 4)
 d) 1), 2) and 4)
 e) 1), 3) and 4)

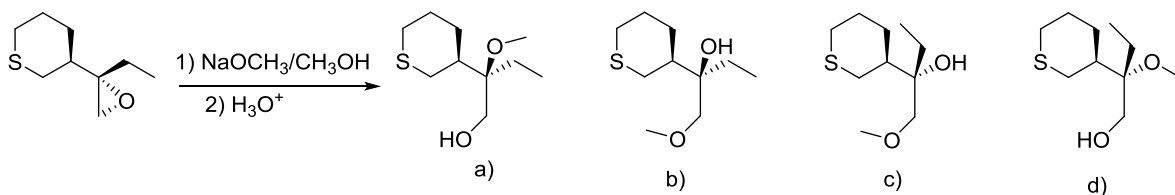
38) Which of the following reactions **will** produce a pair of enantiomers?



39) What is the final **major** product after the following sequence of reactions?

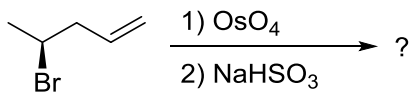


40) What is the **major** product formed in the following reaction?

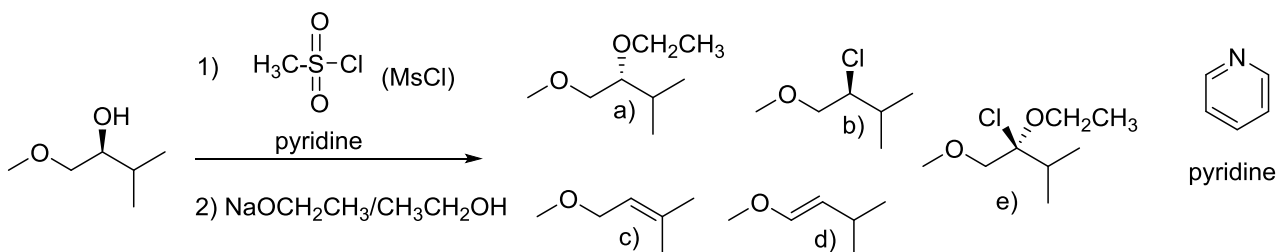


41) What is the stereochemical relationship between the **major** products in the following reaction?

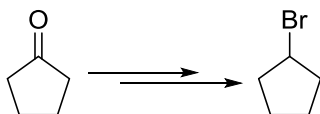
- a) Only one compound is produced
 b) Meso
 c) Enantiomers
 d) Constitutional isomers
 e) Diastereomers



42) What is the **major** product formed in the following reaction?

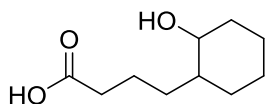
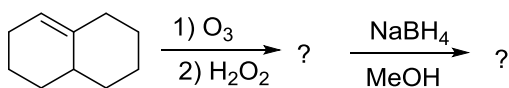


43) Select the reagents that would accomplish the following transformation.

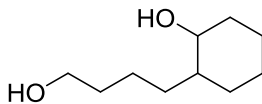


- a) 1) NaBH₄/CH₃OH, 2) PBr₃/Et₂O
 b) 1) LiAlH₄, 2) H₃O⁺, 3) Br₂
 c) 1) Na₂Cr₂O₇/H₂SO₄, 2) PBr₃
 d) 1) PCC/CH₂Cl₂, 2) HBr

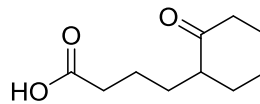
44) What is the final **major** product after the following sequence of reactions?



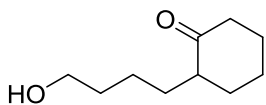
a)



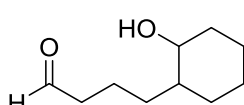
b)



c)

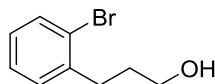
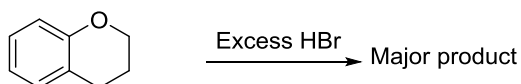


d)

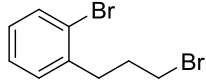


e)

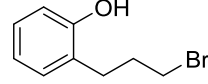
45) What is the **major** product formed in the following reaction?



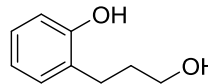
a)



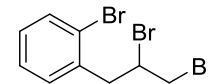
b)



c)

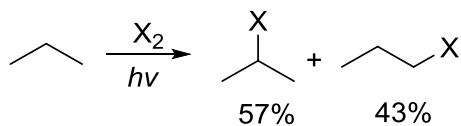


d)



e)

46) Which halogen would produce the following product ratio in the following radical reaction?



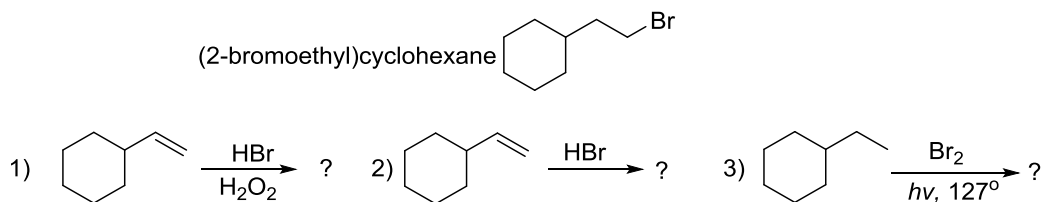
a) Cl₂

b) Br₂

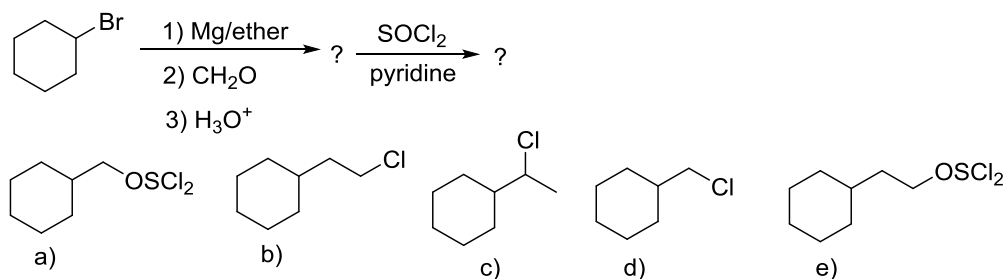
c) I₂

47) Which of the following reactions will produce (2-bromoethyl)cyclohexane as the **major** product?

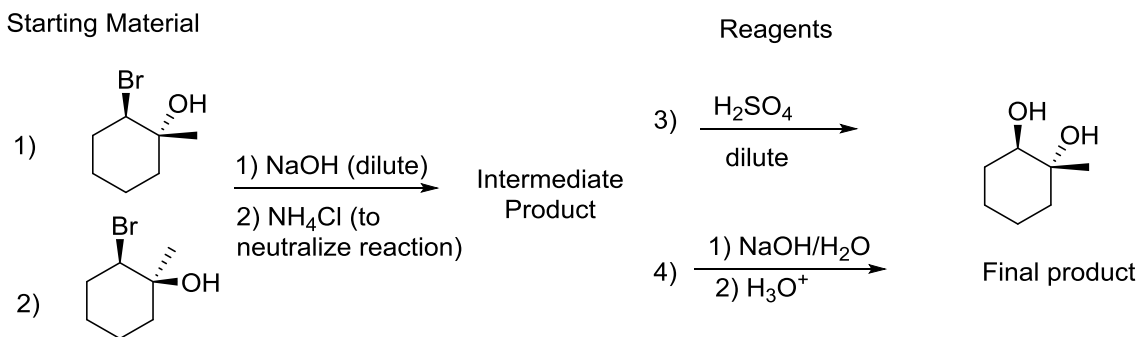
- a) 1, 2 and 3
 b) Only 1
 c) Only 3
 d) 1 and 3
 e) 2 and 3



48) What is the final **major** product formed in the following sequence of reactions?

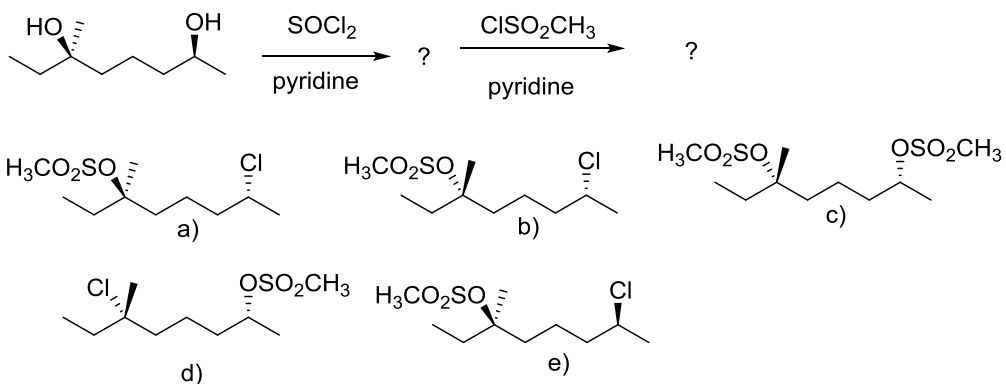


49) Choose the starting material 1) or 2) and the reagent 3) or 4) that would produce the final product (trans diol) as the **major** product?

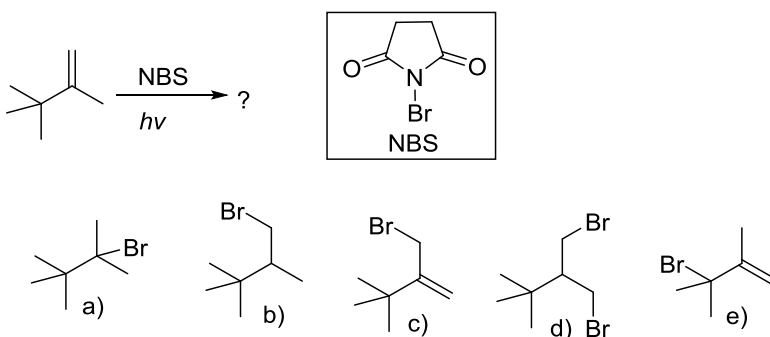


- a) Starting material 1) Reagent 3)
 b) Starting material 1) Reagent 4)
 c) Starting material 2) Reagent 3)
 d) Starting material 2) Reagent 4)

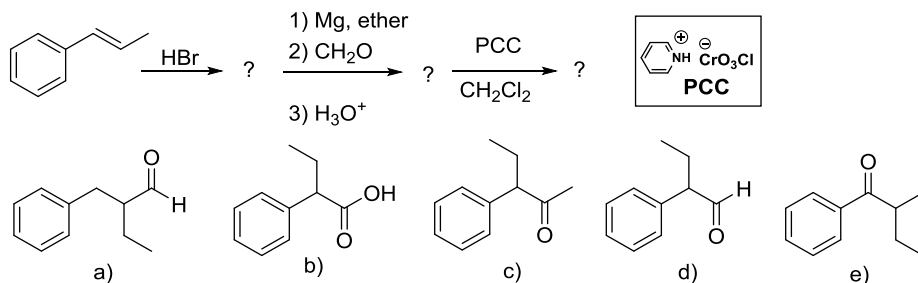
50) What is the **major** final product produced in the following sequence of reactions?



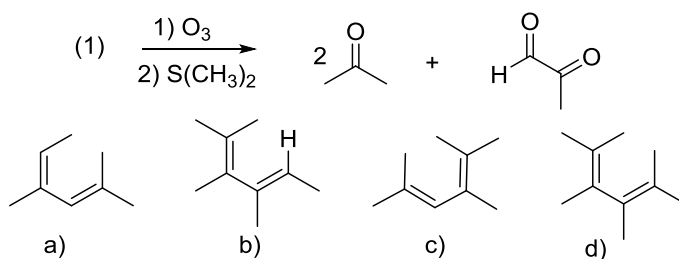
51) What is the **major** product produced in the following bromination reaction?



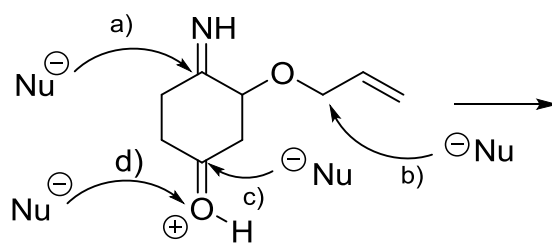
52) What is the final **major** product (C) after the following sequence of reactions?



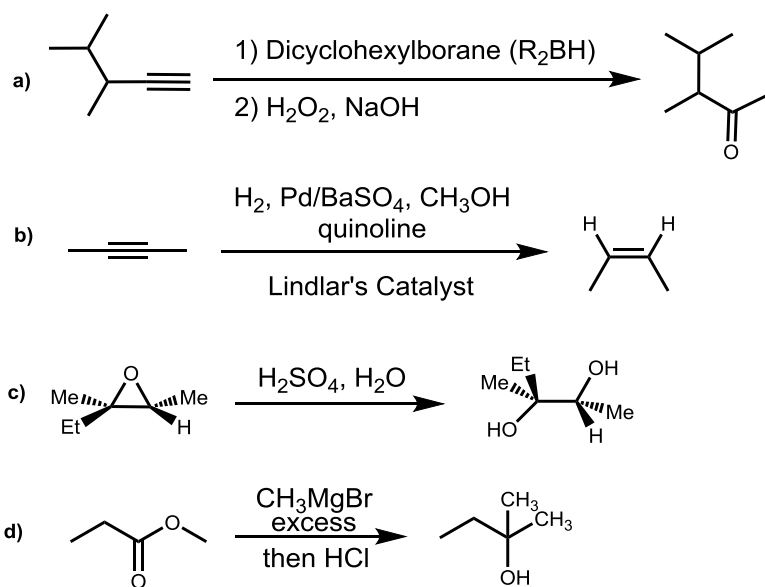
53) Which of the following **starting materials** (1) would generate the products shown when treated with ozone followed by dimethylsulfide?



54) The mechanism for the nucleophilic attack on the given electrophile would require two arrows. The first arrow is given. Which nucleophilic attack would give the most stable product and thus has the most electrophilic atom?



55) Which of the following reactions would **not** occur as written?



Periodic Table:

(1) IA											(13) IIIA	(14) IVA	(15) VA	(16) VIA	(17) VIIA	(18) Noble Gases													
1 H 1.008 Hydrogen											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon													
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											13 Al 26.98 Aluminum	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.06 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon												
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium	(3) IIIB	(4) IVB	(5) VB	(6) VIB	(7) VII B	(8) VIII B	(9) VIII B	(10) VIII B	(11) IB	(12) IIB	19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.90 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.71 Nickel	29 Cu 63.55 Copper	30 Zn 65.37 Zinc	31 Ga 69.72 Gallium	32 Ge 72.59 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 98.91 Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon												
55 Cs 132.9 Cesium	56 Ba 137.3 Barium	57 La 138.9 Lanthanum	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po (210) Polonium	85 At (210) Astatine	86 Rn (222) Radon												
87 Fr (223) Francium	88 Ra 226.0 Radium	89 Ac (227) Actinium	104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (264)	108 Uno (265)	109 Une (266)																					

KEY

47	Atomic Number
Ag	SYMBOL
107.9	Atomic Weight
Silver	Name