

1. MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question (50 pts).

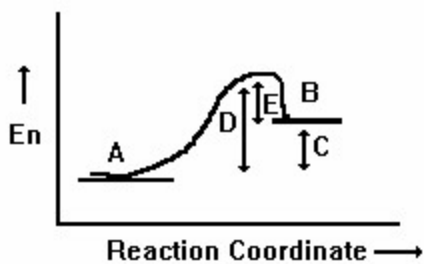
- 1) Which of the following statements about propene, $\text{CH}_3\text{CH}=\text{CH}_2$, is correct? 1) A
- A) There is a total of eight sigma bonds.
 B) All the carbon atoms are sp^2 hybridized.
 C) All nine atoms lie in the same plane.
 D) It generally acts as a Lewis acid.
 E) The compound has a cis and trans isomer.
- 2) Which of the following is an allylic alcohol? 2) D
- A) $\text{CH}_2=\text{CHCH}_2\text{OCH}_3$
 B) $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{OH}$
 C) $\text{HOCH}=\text{CHCH}_2\text{CH}_3$
 D) $\text{CH}_3\text{CH}=\text{CHCH}_2\text{OH}$
 E) $\text{CH}_2=\text{CHCH}_2\text{CH}_3$
- 3) An increase in which of the following will occur if the reaction temperature is increased? 3) B
- I. Energy of activation
 II. Collision frequency
 III. Fraction of collisions with sufficient energy
- A) I and III
 B) II and III
 C) I, II, and III
 D) I
 E) I and II
- 4) An increase in which of the following results in a decrease in the rate of the chemical reaction? 4) C
- A) temperature
 B) fraction of collisions with proper orientation
 C) energy of activation
 D) concentration
 E) collision frequency

- 5) Which of the following correctly describes intermediates and/or transition states? 5) B
 A) Both transition states and intermediates occur at maxima on reaction coordinate diagrams.
 B) Transition states have partially formed bonds whereas intermediates have fully formed bonds.
 C) Transition states occur at minima on reaction coordinate diagrams.
 D) An intermediate is always produced after the rate-determining step of a reaction mechanism.
 E) none of the above

- 6) The Arrhenius equation models how the rate constant k _____. 6) E
 A) increases as both E_a and T decrease
 B) increases as both E_a and T increase
 C) increases as reactant concentrations increase
 D) increases most when E_a increases and T decreases
 E) increases most when E_a decreases and T increases

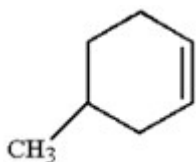
- 7) Which of the following is not an electrophile? 7) C
 A) $+NO_2$
 B) H^+
 C) $CH_2=CH_2$
 D) BF_3
 E) Fe^{+3}

- 8) What is the activation energy for the reaction $B \rightarrow A$ in the following diagram? 8) E



- A) A B) B C) C D) D E) E

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

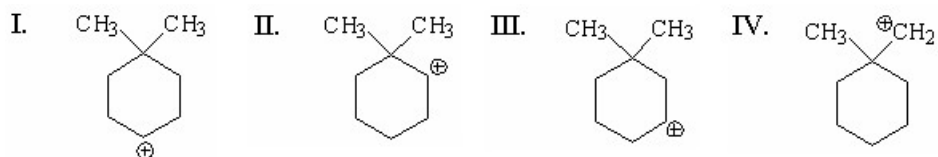


- A) 5-methylcyclohexene
 B) 1-methyl-4-cyclohexene
 C) 4-methylcyclohexene
 D) 1-methyl-3-cyclohexene
 E) methylcyclohexene

10) Upon hydrogenation, which of the following alkenes releases the least heat per mole? 10) E

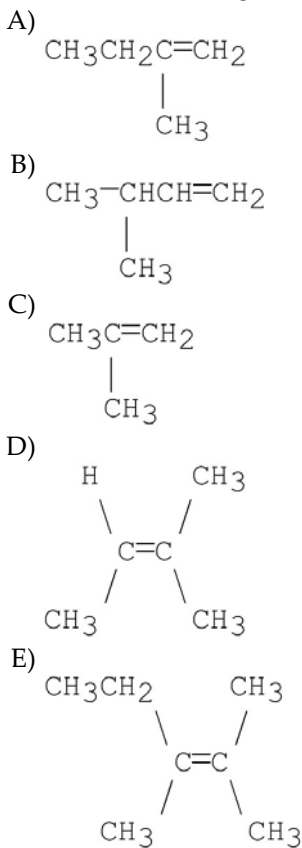
- A) (Z)-3,4-dimethyl-2-hexene
- B) 3,4-dimethyl-1-hexene
- C) (E)-3,4-dimethyl-2-hexene
- D) (Z)-3,4-dimethyl-3-hexene
- E) (E)-3,4-dimethyl-3-hexene

11) Which of the following carbocations is likely to rearrange? 11) E



- A) I
- B) II
- C) III
- D) IV
- E) II and IV

12) Which of the following is the most stable alkene? 12) E



13) If (S)-glyceraldehyde has a specific rotation of -8.7° , what is the specific rotation of (R)-glyceraldehyde? 13) C

- A) -8.7°
- B) 0.0°
- C) $+8.7^\circ$

D) cannot be determined from the information given

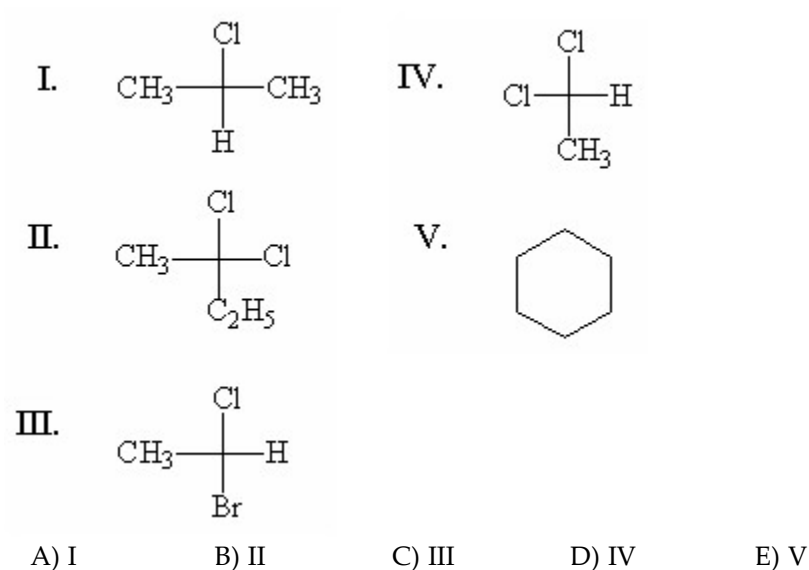
14) Which of the following is a meso compound?

14) C

- A) *cis*-1, 4-dimethylcyclohexane
- B) *trans*-1, 2-dimethylcyclohexane
- C) *cis*-1, 3-dimethylcyclohexane
- D) *trans*-1, 4-dimethylcyclohexane
- E) *trans*-1, 3-dimethylcyclohexane

15) Which of the following compounds has an asymmetric center?

15) C



16) What is the relationship between the following compounds?

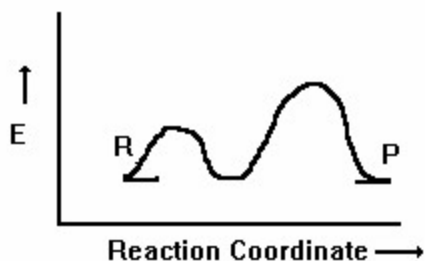
16) A



- A) diastereomers
- B) enantiomers
- C) constitutional isomers
- D) conformational isomers
- E) identical compounds

17) How many transition states are present in the following reaction diagram?


17) D



- A) 1 B) 4 C) 5 D) 2 E) 3

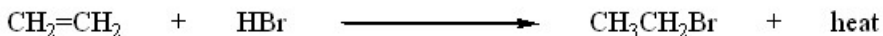
18) Which of the following is not a nucleophile?

18) B

- A) CH_3OCH_3
 B) FeBr_3
 C) 
 D) NH_3
 E) Br^-

19) Which of the following correctly describes the reaction shown?

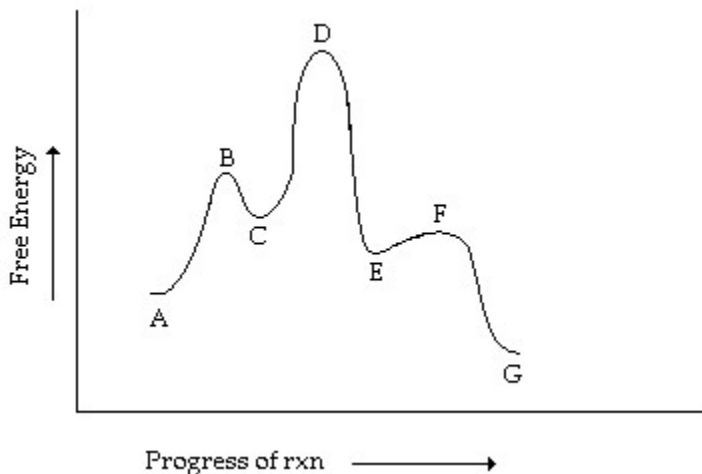
19) E



- A) $\Delta H^\circ < 0$ and $\Delta S > 0$
 B) $\Delta H^\circ > 0$ and $\Delta S < 0$
 C) $\Delta H^\circ > 0$ and $\Delta S^\circ > 0$
 D) $\Delta H^\circ = \Delta S = 0$
 E) $\Delta H^\circ < 0$ and $\Delta S < 0$

20) Consider the reaction coordinate diagram shown. Which step has the greatest activation energy?

20) A



- A) E going to C
 B) A going to C
 C) C going to E
 D) E going to G

E) C going to A

21) For an endergonic reaction step, the Hammond postulate allows one to say that _____ 21) B

- A) the reaction containing this step is overall first order
- B) the transition state of the step resembles the products of the step
- C) the transition state of the step resembles the reactants of the step
- D) the step is rate-determining since it has the smallest E_a
- E) the transition state is precisely symmetric with bond-breaking and bond-forming occurring to the same extent

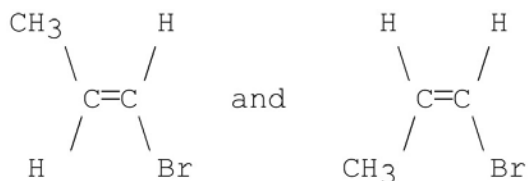
22) According to the Hammond Postulate, which of the following is correct? 22) E

- A) All transition states are more reactant-like than product-like.
- B) The transition state of an endothermic reaction step will be more reactant-like than product-like.
- C) All transition states are more product-like than reactant-like.
- D) The intermediate of an endothermic reaction step will be more reactant-like than product-like.
- E) The transition state of an exothermic reaction step will be more reactant-like than product-like.

23) Which of the following is not true of enantiomers? 23) A

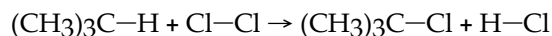
- A) They have the same specific rotation.
- B) They have the same melting point.
- C) They have the same chemical reactivity with non-chiral reagents.
- D) They have the same boiling point.
- E) They have the same density.

24) What is the relationship between the following compounds? 24) B



- A) constitutional isomers
- B) configurational isomers
- C) structural isomers
- D) positional isomers
- E) conformational isomers

25) What is the value of ΔH in kcal/mole for the reaction shown? 25) C

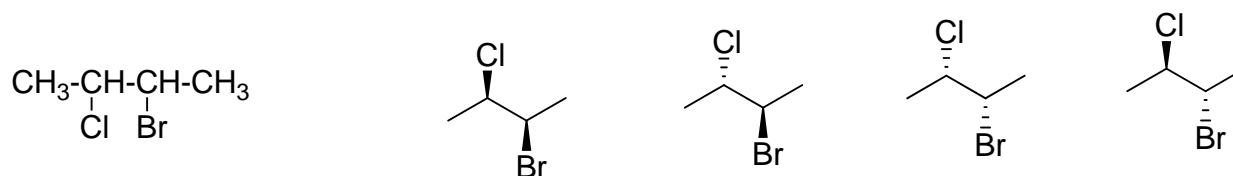


Bond energies are: $(\text{CH}_3)_3\text{C}-\text{H} = 91$ kcal/mole
 $(\text{CH}_3)_3\text{C}-\text{Cl} = 78.5$ kcal/mole
 $\text{Cl}-\text{Cl} = 58$ kcal/mole
 $\text{H}-\text{Cl} = 103$ kcal/mole

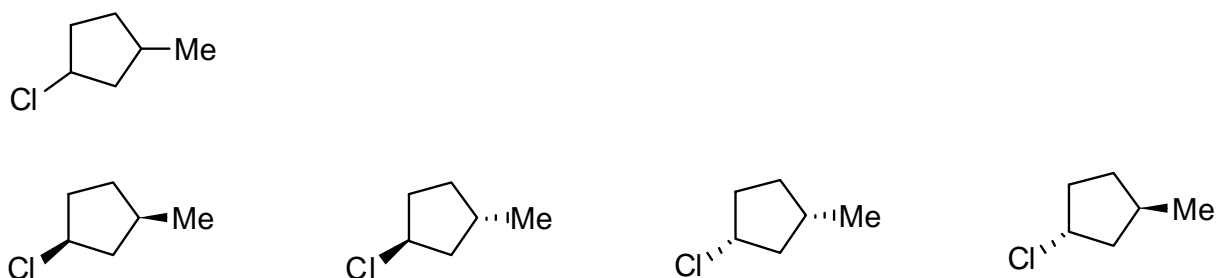
- A) -57.5
- B) -8.5
- C) -32.5
- D) +57.5
- E) +32.5

2. Draw all the possible stereoisomers of each of the following compounds. If no isomers are possible so state (9 pts)

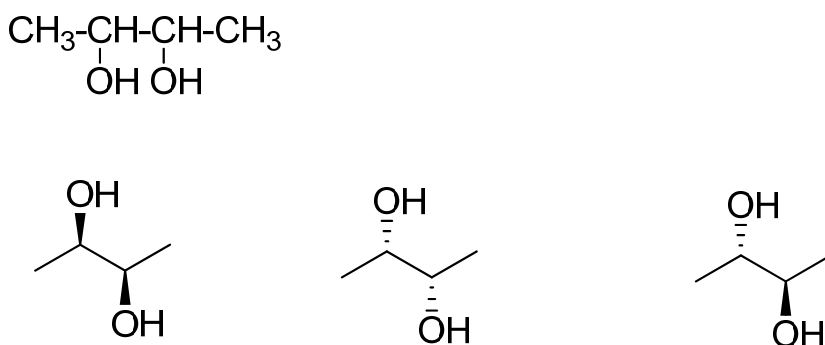
1)



2)

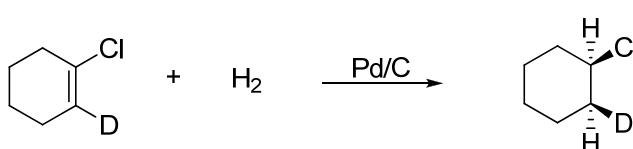


3)

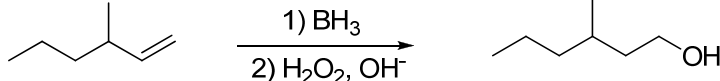


3. Give the major product of each of the following reactions, if no reaction will occur so state. Do not give minor products. If the reaction is stereoselective, please indicate the stereochemistry outcome (15 pts).

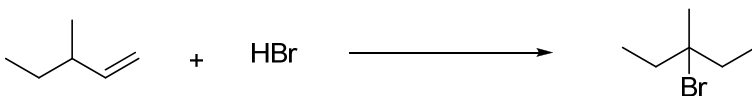
1)



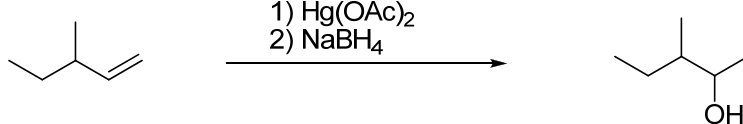
2)

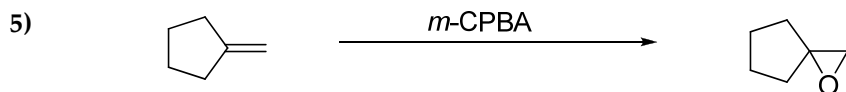


3)

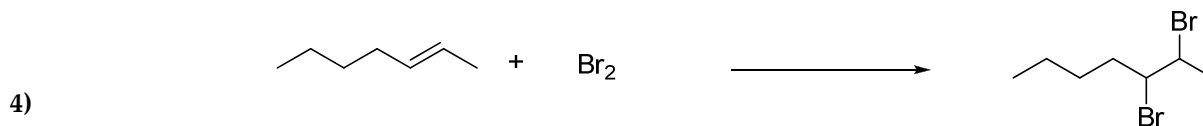
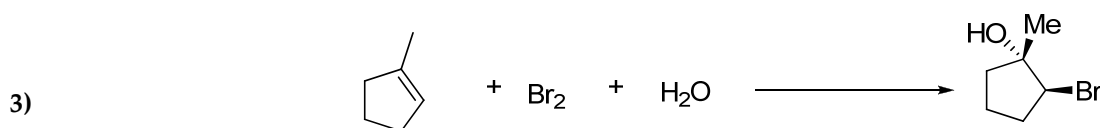
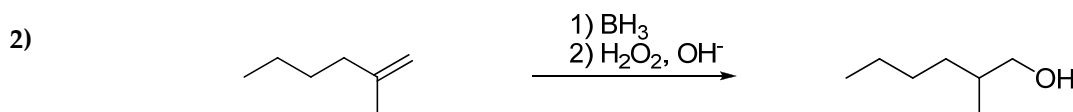
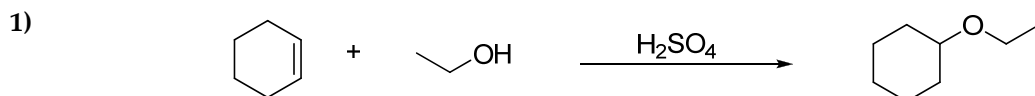


4)



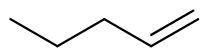


4) Indicate how each of the following compounds can be made from an alkene. Give the structure of the best alkene to use and write the required reagents over and/or under each arrow (12 pts).

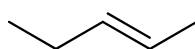


5. SHORT ANSWER (18 pts). Write the word or phrase that best completes each statement or answers the question

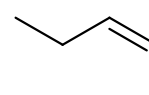
1) Draw and name the six alkenes which have the molecular formula C₅H₁₀.



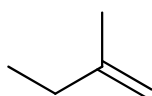
pent-1-ene



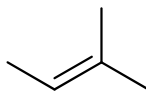
(E)-pent-2-ene



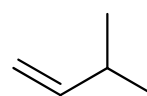
(Z)-pent-2-ene



2-methylbut-1-ene



2-methylbut-2-ene



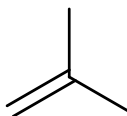
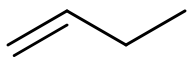
3-methylbut-1-ene

2) Why do reactions tend to proceed at a faster rate as T increases?

Arrhenius equation

$k = A e^{-E_a/T}$ T increases, k increases, so faster

3) Draw the structure of two alkenes with molecular formula C_4H_8 that do not exhibit cis-trans isomerism



4) The ΔG° for the conversion of "axial" isopropylcyclohexane to "equatorial" isopropylcyclohexane is -2.1 kcal/mol. Calculate the percentage of isopropylcyclohexane molecules that have the isopropyl substituent in the axial position at this temperature. [$R = 1.987 \times 10^{-3}$ kcal mol $^{-1}$ K $^{-1}$]

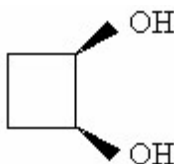
$$\Delta G^\circ = -RT \ln K_{eq}$$

$$-2.1 \text{ kcal/mol} = -1.987 \times 10^{-3} \times 298 \times \ln K_{eq}$$

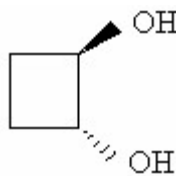
$$\ln K_{eq} = 3.5465$$

$$K_{eq} = 35 = [\text{equatorial}]/[\text{axial}]; \text{axial}\% = 1/36 = 2.8\%$$

5) Indicate the molecules shown below chiral or achiral? explain why?



this is achiral, it has a plane symmetry



chiral, no plane symmetry

6) Complete the following reaction and provide a detailed, step-by-step mechanism for the process.

