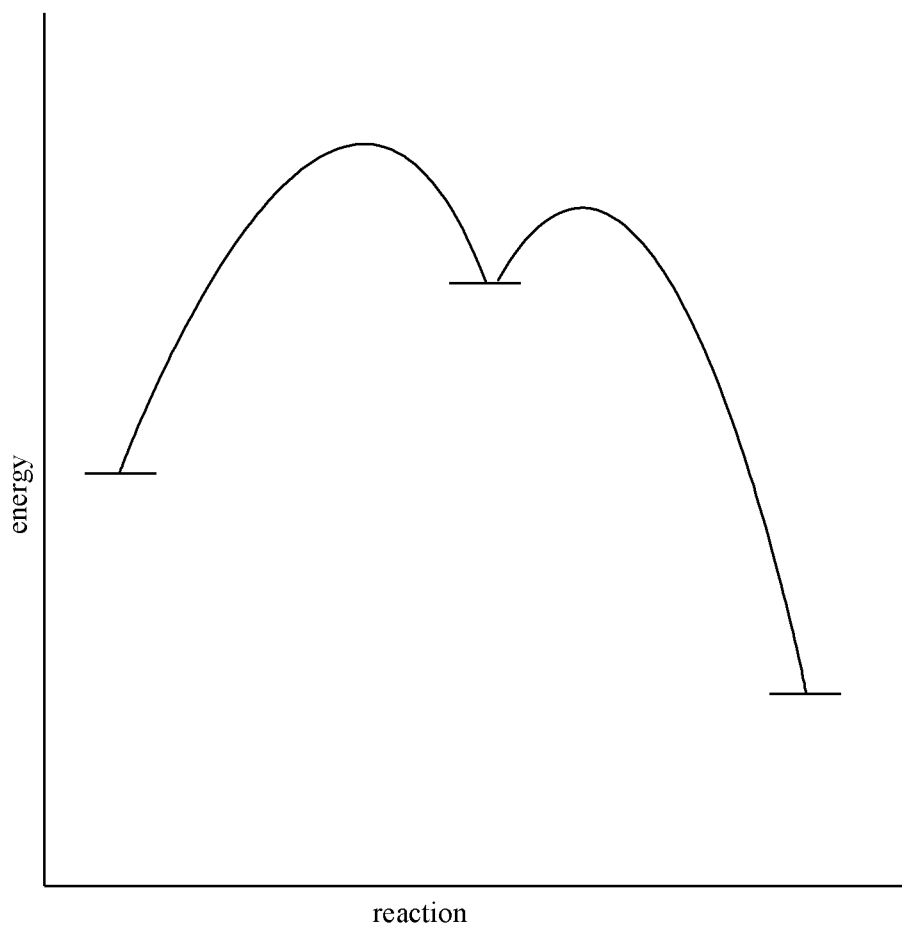




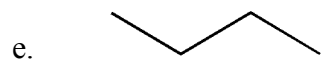
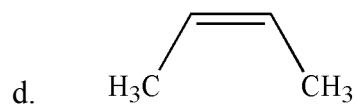
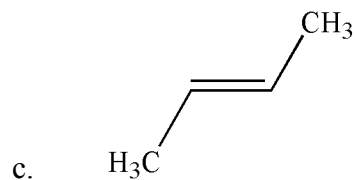
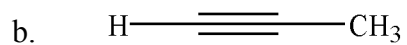
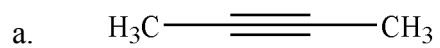
Circle the single best answer to each multiple choice question (1-15). (4 pts each)

1. How many transition states are there in this energy diagram?

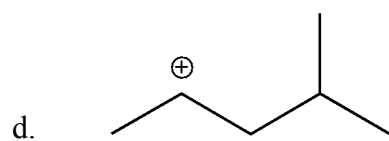
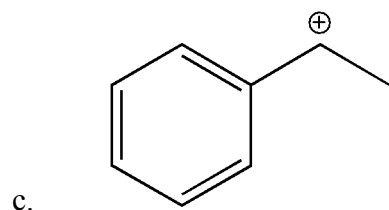
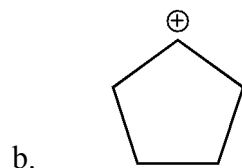
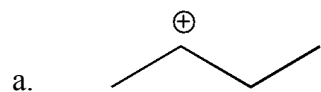


- a. 1
  - b. 2
  - c. 3
  - d. 4
  - e. 5
2. In the first step of the reaction between HBr and 2-methylpropene, identify the HOMO and the LUMO.
- a. HOMO is C-C  $\pi$ , LUMO is H-Br  $\sigma$ .
  - b. HOMO is C-C  $\pi$ , LUMO is H-Br  $\sigma^*$ .
  - c. HOMO is C-C  $\sigma$ , LUMO is H-Br  $\sigma$ .
  - d. HOMO is C-C  $\pi^*$ , LUMO is H-Br  $\sigma$ .
  - e. HOMO is H-Br  $\sigma$ , LUMO is C-C  $\pi$ .

3. Which of these is the **most acidic** hydrocarbon?

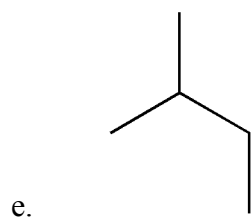
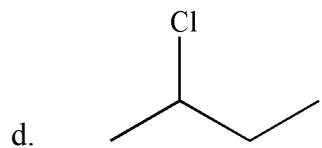
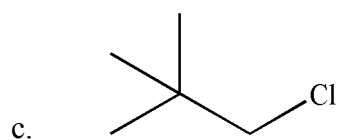
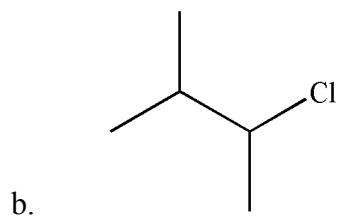
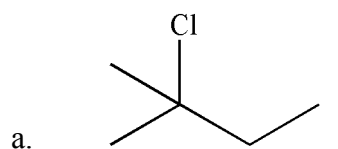
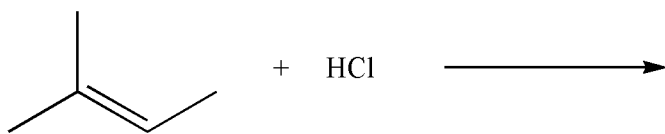


4. Which of the following structures is the **most stable** carbocation?

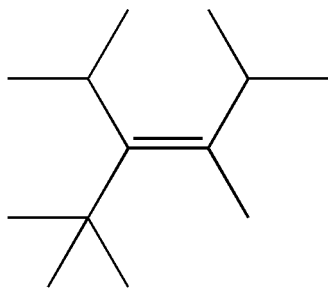


e. All are equally stable.

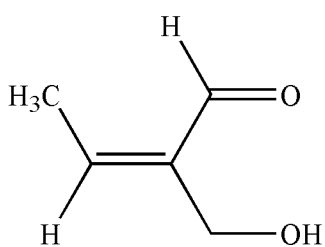
5. What is the major product of the reaction shown here?



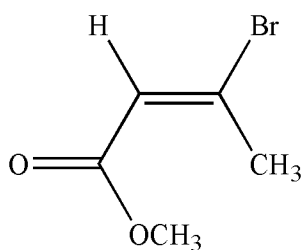
6. Which of the following structures is properly designated as a *Z* alkene? (*Note*: “D” is deuterium ( $^2\text{H}$ ) an isotope of hydrogen ( $^1\text{H}$ ) that has one neutron and one proton. (Hydrogen has one proton and no neutrons.) Heavier isotopes take priority over lighter isotopes.)



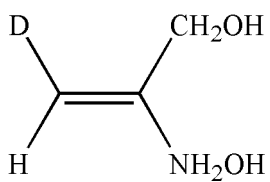
a.



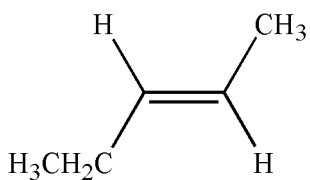
b.



c.

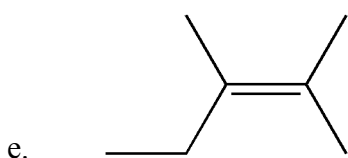
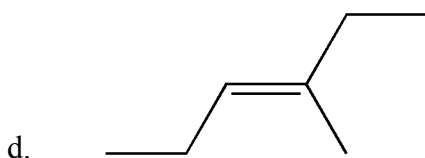
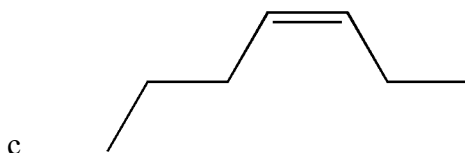
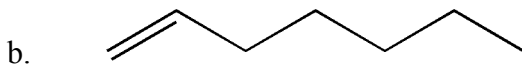
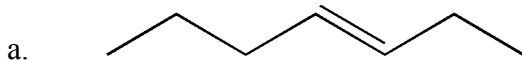


d.

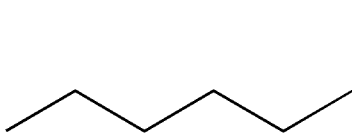


e.

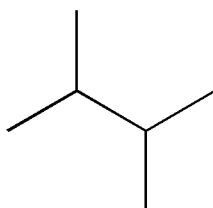
7. Which of the following  $C_7H_{14}$  isomers do you expect to be **most stable**?



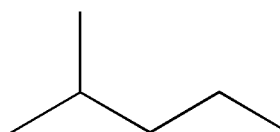
8. Which of the following statements is **true** concerning the three compounds shown?



**A**



**B**

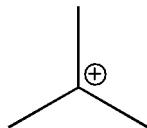


**C**

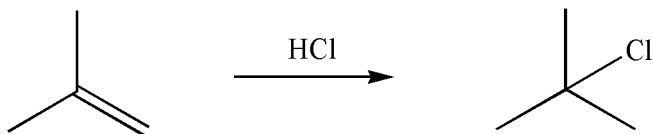
- I. The three compounds are constitutional isomers.
- II. Structure **C** is properly named as a hexane.
- III. Structure **B** has the highest boiling point of the three compounds.
- IV. Structure **A** has the greatest dispersion forces of the three compounds.

- a. I and II
- b. I, II and III
- c. I and III
- d. I and IV
- e. I only

9. Identify the orbitals that are mixing to stabilize the carbocation by hyperconjugation.

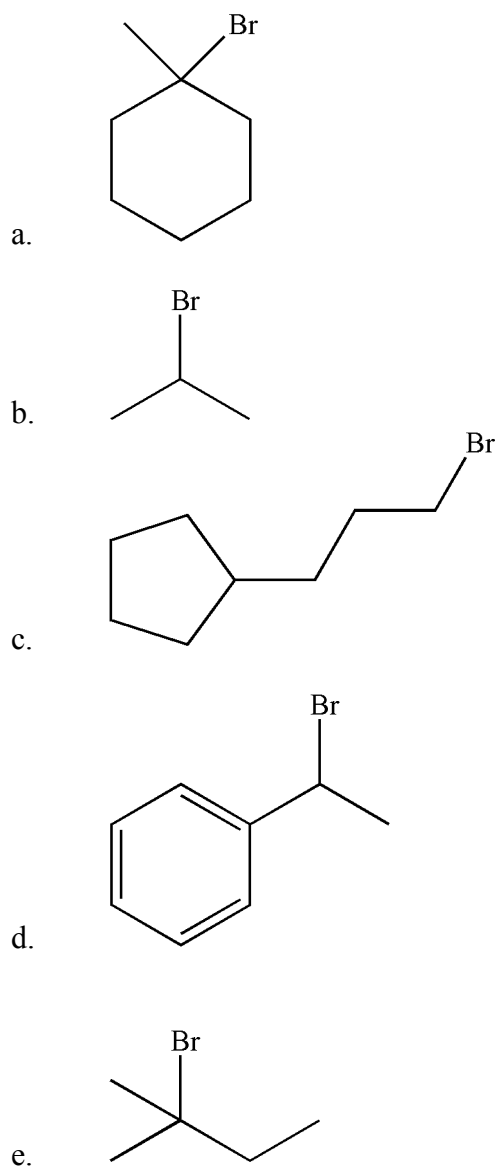


- a. C-H  $\sigma$  and C-H  $\sigma^*$
  - b.  $p$  and  $sp^3$
  - c.  $p$  and  $sp^2$
  - d.  $p$  and C-H  $\sigma$
  - e.  $p$  and C-H  $\sigma^*$
10. Which of the following statements about the reaction shown here is **true**?



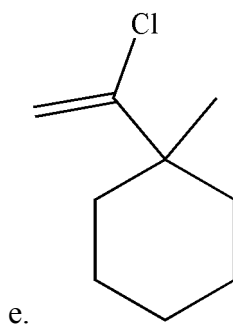
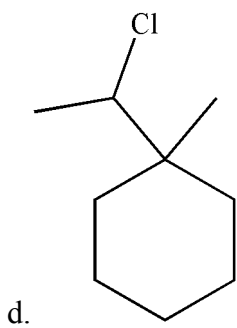
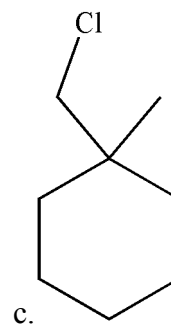
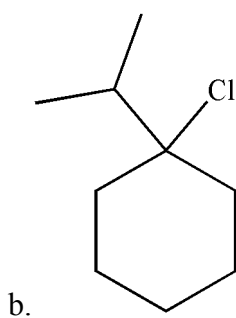
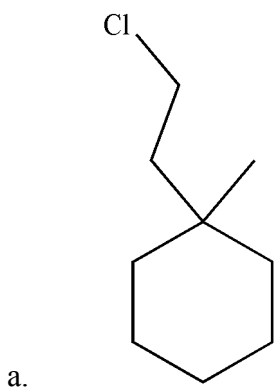
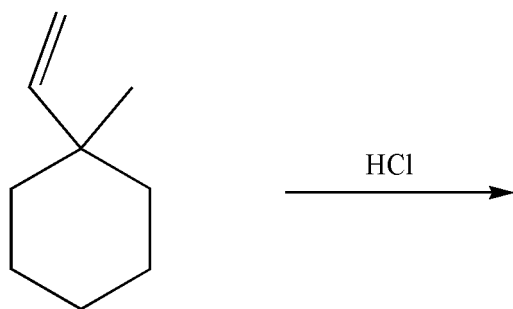
- I. The alkene is a Bronsted base.
  - II. The alkene is a Bronsted acid.
  - III. The rate-limiting step is carbocation formation.
  - IV. The rate-limiting step is nucleophilic attack by chloride ion on a carbocation.
- a. I, III
  - b. I, IV
  - c. II, III
  - d. II, IV
  - e. I only

11. Which of these products **could not** be the result of Markovnikov addition to an alkene?

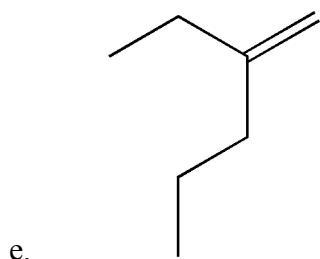
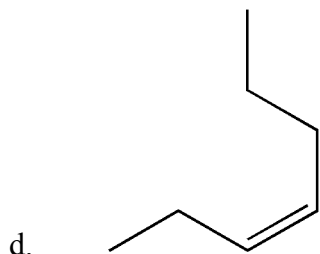
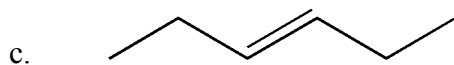
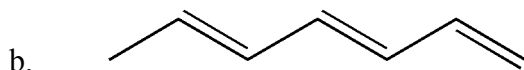
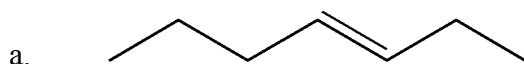




12. Which of the following is the major product of this reaction?



13. Which of the following structures correctly represents *trans*-3-heptene?



14. Which of these statements is *false*?

- a. Staggered ethane is destabilized by interactions between filled C-H  $\sigma$  and empty C-H  $\sigma^*$  orbitals.
- b. Staggered ethane is stabilized by interactions between filled C-H  $\sigma$  and empty C-H  $\sigma^*$  orbitals.
- c. Hyperconjugation involves the interaction of a filled orbital and an empty orbital.
- d. Both torsional strain and hyperconjugation have been proposed to explain why the staggered conformation of ethane is lower in energy than the eclipsed.

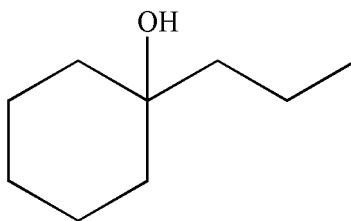
15. Which of these bases can deprotonate acetylene ( $pK_a$  26)? The  $pK_a$  value for the conjugate acid of each base is shown in parentheses.

- a. Hydroxide (15.7)
- b. A carbanion (50-60)
- c. Amide ion (36)
- d. Bicarbonate (6.3)
- e. Both b and c

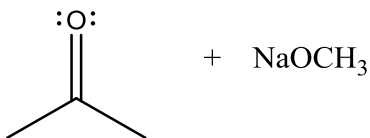
16. Cis and trans alkene isomers do not equilibrate; that is, they do not interconvert. Explain why in **one or two sentences**. (10 pts)



17. The alcohol shown can be made from two different alkene precursors. Draw both precursors and the reagents you would use to convert each of them to this alcohol. (10 pts)



18. (15 pts) Draw a mechanism for the reaction between acetone ( $pK_a$  20) and sodium methoxide. For full credit, include the products of the reaction and all lone pairs, non-zero formal charges, and curved arrows. You may omit the spectator ion, sodium cation, in your mechanism.



Identify the HOMO and the LUMO in the reaction

HOMO: \_\_\_\_\_ LUMO: \_\_\_\_\_

Circle which side of the reaction is favored at equilibrium. **Reactants** **Products**

Estimate the value of the equilibrium constant,  $K_{eq}$ , for the reaction: \_\_\_\_\_

19. Define the term **molecule**. (5 pts)