Multiple choice problems

1. Given the chlorination of acetone shown below, choose the correct rate law.

\[ \text{CH}_3\text{COCH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{COCH}_2\text{Cl} + \text{HCl} \]

a. rate \(= k[\text{CH}_3\text{COCH}_3]\)
b. rate \(= k[\text{Cl}_2]\)
c. rate \(= k[\text{CH}_3\text{COCH}_3][\text{Cl}_2]\)
d. rate \(= k[\text{CH}_3\text{COCH}_3][\text{Cl}_2]^2\)

Cannot be determined from stoichiometry; must be determined experimentally.

2. Given the bond dissociation energies below (in Kcal), the overall delta H for the following reaction is?

\[(\text{CH}_3)_2\text{C}-\text{H} + \text{Br}_2 \rightarrow (\text{CH}_3)_2\text{CBr} + \text{HBr}\]

C-H = 91 kcal/mol  Br-Br = 46 kcal/mol  (CH₃)$_2$C-Br = 65 kcal/mol  H-Br = 88 kcal/mol

a. +16 kcal/mol  

b. -16 kcal/mol  

c. +24 kcal/mol  

d. -24 kcal/mol

3. For a given reaction, if delta G is less than zero, then:

a. \(K_\text{eq} < 0\)

b. \(K_\text{eq} > 1\)

c. \(K_\text{eq} = 1\)

d. \(K_\text{eq} = 0\)

4. Which of the following statements is a correct description of the MOST STABLE conformation of 1,1,3-trimethycyclohexane?

a. The methyl group at C-3 is equatorial

b. C-1 is a tertiary carbon and C-3 is a primary carbon

c. C-1 is a quaternary carbon and C-3 is a secondary carbon

d. C-1 is a tertiary carbon and C-3 is a secondary carbon

e. Both methyl groups at C-1 are equatorial

5. The structures below are:

\[+ \text{methylheptane} \]

\[\text{C}_{\text{conformation isolers}}\]

\[\text{cis-trans isomers (structural isomers)}\]

\[\text{n-octane}\]

a. not isomers  
b. conformation isomers  
c. cis-trans isomers  

e. both B and C
6. Which of the following is bicyclo[3.2.0]heptane

![Chemical structures]

7. The major product of the mono-bromination of 1-methylcyclopentane is:
   a. 1-bromomethylcyclopentane  
   b. 2-bromo-1-methylcyclopentane  
   c. 1-bromo-1-methylcyclopentane  
   d. 3-bromo-1-methylcyclopentane

8. How many mono-chlorinated products would be formed by the chlorination of 2-methylhexane?
   a. 6  
   b. 5  
   c. 7  
   d. 8

9. Consider the reaction of t-BuBr + EtOH → t-BuOBr + HBr. Experimentally one finds that if the concentration of t-BuBr is tripled, the rate of the reaction triples. One also finds that if the concentration of EtOH is doubled, the rate of the reaction remains unchanged. Which of the following correctly describes the kinetics of the reaction?
   a. The reaction is first order in t-BuBr  
   b. The reaction is second order in t-BuBr  
   c. The reaction is first order in EtOH  
   d. The reaction is second order overall

10. How many tertiary hydrogens are in the hydrocarbon shown below?

![Chemical structure]

   a. 0  
   b. 1  
   c. 2  
   d. 3  
   e. 4  
   f. 5

11. Which of the following statements is (are) true for the compound (R)-2-butanol?
   a. This compound is chiral  
   b. This compound is optically active  
   c. This compound has an enantiomer  
   d. All of the above  
   e. None of the above

12. Which one of the following has the highest priority?
   a. tert-Butyl  
   b. Isobutyl  
   c. CH₃OH  
   d. -CO₂H

13. Which radical is the most stable?
   a. 2,2,6,6-tetramethyl-4-piperyl radical  
   b. sec-butyl radical  
   c. n-butyl radical  
   d. Isobutyl radical
14. The following is a possible mechanism for the elimination of HBr from t-BuBr.

Which statement fits the mechanism?

a. The reaction exhibits a deuteron isotope effect.

b. The reaction does not exhibit a deuteron isotope effect.

c. The reaction is first-order in HOH.

d. The reaction is zero order in (CH₃)₂CBr.

15. Which of the following terms best describes the pair of compounds shown:

- a. enantiomers
- b. same compound
- c. structural isomers
- d. not isomers

16. If a 0.1M solution of (S)-leucine rotates the plane of polarized light +0.76°, then a 0.1M solution of (R)-leucine rotates the plane of polarized light:

- a. 0.00°
- b. +0.76°
- c. -0.76°
- d. +1.52°

17. Which of the following molecules would rotate the plane of polarized light?

- a. all of them
- b. none of them

18. Which of the following would yield a single (only one) mono-chlorinated product?

- a. 2-methylpentane
- b. cyclohexane
- c. butane
- d. all of them
- e. none of them.
10. The chlorination of 2,3-dimethylbutane leads to the production of two major mono-chlorinated products, 1-chloro-2,3-dimethylbutane and 2-chloro-2,3-dimethylbutane. 

\[
\begin{align*}
\text{C}_8\text{H}_{16} & \quad + \quad 2\text{Cl}_2 \\
\text{C}_8\text{H}_{14}Cl & \quad \text{or} \quad \text{C}_8\text{H}_{14}Cl_2
\end{align*}
\]

Assuming the relative reactivity of tertiary hydrogens as compared to primary hydrogens is 5.6:1, calculate the percent yields of the 1-chloro and 2-chloro compounds. *SHOW WORK.*

\[
\frac{2 \times 5.6}{12} = 11.2 \quad \frac{12 \times 5.6}{23.2} = 2.0 \quad \frac{2.0}{11.2} = 5.2\%
\]

20. Write the rate-determining step (RDS) for the bromination of cyclohexane and the fluorination of cyclohexane.

a. Bromination RDS

\[
\begin{align*}
\text{C}_6\text{H}_{12} & \quad + \quad \text{Br}_2 \\
\text{C}_6\text{H}_{11}Br & \quad \text{or} \quad \text{C}_6\text{H}_{10}Br_2
\end{align*}
\]

\[
\text{AH} = -87.5 \text{ kcal/mol}
\]

b. Fluorination RDS

\[
\begin{align*}
\text{C}_6\text{H}_{12} & \quad + \quad \text{F}_2 \\
\text{C}_6\text{H}_{11}F & \quad \text{or} \quad \text{C}_6\text{H}_{10}F_2
\end{align*}
\]

\[
\text{AH} = -136 \text{ kcal/mol}
\]

Given the following bond dissociation values, calculate the AH for each RDS. (Place answer in appropriate spot in the above equations.

- H-F = 136 kcal/mol (568kJ/mol)
- H-Br = 87.5 kcal/mol (366kJ/mol)
- Cyclohexane C-H = 95 Kcal/mol (397 kJ/mol)

In which RDS (i.e. a. or b.) does the transition state resemble intermediate radical? __a__

In which RDS (i.e. a. or b.) does the transition state resemble reactants? __b__

Which one of these reactions goes faster? __b__

Based on above results, which of the two halogenating agents (F or Br) would react more selectively with 2-methylpropane? __b__
21a. Write the three staggered conformations for 2-methylbutane (rotate about the C-2 – C-3 axis. (CH₃CH₂CH₂CH₂CH₃) put the three groups on C-2 on the front part of the Newman projection

\[ \text{C}_2 \cdot \text{C}_3 \cdot \text{C}_4 \cdot \text{C}_5 \]

21b. Given that a Me-Me gauche costs 0.9 kcal/mol, calculate the relative energy content of each isomer and circle the one/s that is/are the most stable.

22. Write the bow-tie projection of S-2-chlorobutane.

\[ \text{H} \quad \text{Cl} \quad \text{CH}_3 \quad \text{Cl} \quad \text{H} \]

23. Indicate the following pairs are enantiomers, same compound, conformers, or different compounds.

- Enantiomers
- Different
- Enantiomers
24.
Write the two chair conformations for compound a and b and the chair conformation for compound b given below.

a. cis-1-t-butyl-4-bromocyclohexane

\[ \Delta \text{PE} = 8.70 \]

b. trans-1-t-butyl-4-bromocyclohexane

Given that e-Br-H 1,3-diaxial costs 0.9 kcal/mol and e-t-Bu-H 1,3-diaxial costs 2.75 kcal/mol, calculate the energy differences between the two conformers of the cis (a) compound and the energy differences between the two conformers of the trans compound (b). Circle the more stable conformer for each compound and indicate which conformer is the most stable of the four conformers.

most stable of all four