CHEM 2312 practice final

Version - II

The following standardized final examination covers the entire introductory year of organic chemistry (CHEM 2311 and 2312 at Georgia Tech).

The exam consists of 70 multiple choice questions, each with four choices for the correct answer. There is a single correct answer to each question.

To most effectively use this as a guide to the final: complete the examination in a single uninterrupted two-hour session without reference to other materials (lock your door, turn off your phone and switch off your computer). Then enter your answers into T-square (there is a link to Practice Final – II on the WebCT course page). Your exam will be scored (out of 70) and you will get access to the solutions.
**Question 1**
What is the ground-state electronic configuration of a sodium cation (sodium: atomic number 11)?
(a) 1\(^s^22s^22p^63s^1\)  
(b) 1\(^s^22s^22p^63s^1\)  
(c) 1\(^s^22s^22p^6\)  
(d) 1\(^s^22s^22p^63s^2\)

**Question 2**
Which of the following species possesses a formal charge?
(a) CCl\(_4\)  
(b) SiCl\(_4\)  
(c) AlCl\(_4\)  
(d) PCl\(_3\)

**Question 3**
Which of the following is a tertiary amine?
(a) CH\(_3\)CH\(_2\)N(CH\(_3\))\(_2\)  
(b) (CH\(_3\))\(_3\)CNH\(_2\)  
(c) CH\(_3\)CH\(_2\)NHCH\(_3\)  
(d) CH\(_3\)CH\(_2\)NHCH(CH\(_3\))\(_2\)

**Question 4**
Which of the following bonds has the smallest dipole moment?
(a) C-N  
(b) C-O  
(c) C-F  
(d) O-H

**Question 5**
Rank the following in order of decreasing importance as a contributing resonance structure to the molecular structure of acetone, CH\(_3\)COCH\(_3\) (more important > less important)

```
1. \(\overset{\circ}{H}\)\(_3\)C=\(\overset{\circ}{H}\)\(_2\)CH  
2. \(\overset{\circ}{H}\)\(_3\)C=\(\overset{\circ}{H}\)\(_3\)CH  
3. \(\overset{\circ}{H}\)\(_3\)C=\(\overset{\circ}{H}\)\(_2\)CH\(_3\)  
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(a) 1 > 2 > 3  
(b) 1 > 3 > 2  
(c) 2 > 1 > 3  
(d) 3 > 1 > 2

**Question 6**
What is the approximate value of the H-C-H bond angles in a methyl cation, CH\(_3\)^+?
(a) 90°  
(b) 109.5°  
(c) 120°  
(d) 180°

**Question 7**
How many constitutional isomers are there with the molecular formula C\(_6\)H\(_{14}\)?
(a) 3  
(b) 4  
(c) 5  
(d) 8

**Question 8**
Which of the following Newman projections represents the most stable conformation of 2,3-dimethylbutane?

```
1.  
2.  
3.  
4.  
```

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

**Question 9**
Which of the following is the most stable conformation of trans-1-ethyl-3-methylcyclohexane?

```
1.  
2.  
3.  
4.  
```

(a)  
(b)  
(c)  
(d) 

**Question 10**
What is the IUPAC name for the following compound?

```
1.  
2.  
3.  
4.  
```

(a) bicyclo[5.4.3]octane  
(b) bicyclo[3.2.1]octane  
(c) bicyclo[3.2.1]hexane  
(d) bicyclo[2.2.1]octane

**Question 11**
What is the approximate dihedral angle between the two chlorine atoms in the diequatorial conformation of trans-1,2-dichlorocyclohexane?
(a) 0°  
(b) 60°  
(c) 120°  
(d) 180°

**Question 12**
Which of the following compounds can adopt a chair conformation in which there are no axial methyl groups?
(a) cis-1,2-dimethylcyclohexane  
(b) cis-1,3-dimethylcyclohexane  
(c) trans-1,3-dimethylcyclohexane  
(d) cis-1,4-dimethylcyclohexane

**Question 13**
Which of the following is the definition of a meso compound?
(a) A molecule with stereocenters which is chiral  
(b) A molecule with stereocenters which is not chiral  
(c) A diastereomer with no stereocenters  
(d) A chiral compound with more than one stereocenter

**Question 14**
Which of the following statements is not true regarding pairs of enantiomers?
(a) They have identical melting points  
(b) They have identical boiling points.  
(c) They rotate plane polarized light in opposite directions  
(d) They react at identical rates with chiral reagents
Question 15
Which of the following compounds is/are chiral?

(a) only 1  
(b) only 1 and 2  
(c) only 2 and 3  
(d) 1, 2 and 3

Question 16
Which of the following Newman projections represents (2R,3R)-dibromobutane?

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

Question 17
Which of the following structures represent the same stereoisomer?

(a) only 1 and 2  
(b) only 1 and 3  
(c) only 2 and 3  
(d) 1, 2 and 3

Question 18
How many stereoisomers of 3-bromo-2-butanol, CH$_3$CH(OH)CHBrCH$_3$, exist?

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

Question 19
A solution containing 0.2 g/mL of a pure R enantiomer in a 1 dm polarimeter rotates plane polarized light by +2.8°. What is the rotation of a solution containing 0.4 g/mL of the R isomer in the same polarimeter?

(a) +0.7°  
(b) +1.4°  
(c) +2.8°  
(d) +5.6°

Question 20
Which of the following compounds is the strongest acid?

(a) CH$_3$COOH  
(b) FCH$_2$COOH  
(c) CICH$_2$COOH  
(d) BrCH$_2$COOH

Question 21
Which of the following anions is the strongest base?

(a) CH$_3$COO$^-$  
(b) HO$^-$  
(c) NH$_2^-$  
(d) Cl$^-$

Question 22
What is the IUPAC name of the following compound?

(a) 1-methylbicyclo[2.2.2]oct-1-ene  
(b) 1-methylbicyclo[2.2.2]oct-2-ene  
(c) 2-methylbicyclo[2.2.2]oct-1-ene  
(d) 2-methylbicyclo[2.2.2]oct-2-ene

Question 23
What is the hybridization of carbon atoms labeled $i$ – $iii$ in the following structure?

(a) $i$ = sp; $ii$ = sp; $iii$ = sp  
(b) $i$ = sp$^2$; $ii$ = p; $iii$ = sp$^2$  
(c) $i$ = sp$^2$; $ii$ = sp; $iii$ = sp$^2$  
(d) $i$ = sp$^2$; $ii$ = sp$^2$; $iii$ = sp$^2$

Question 24
What is the best choice of reagent(s) to convert 1-pentyne to 2-pentanone?

(a) H$_2$O, H$_2$SO$_4$  
(b) H$_2$O, H$_2$SO$_4$, HgSO$_4$  
(c) BH$_3$; followed by H$_2$O$_2$, NaOH  
(d) OsO$_4$; followed by NaHSO$_3$

Question 25
What is (are) the major organic product(s) obtained from the following reaction?

(a) only 1  
(b) only 2  
(c) only 3  
(d) only 2 and 3
Question 26
What is (are) the major organic product(s) obtained from the following reaction?

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\[
\begin{array}{c}
1. \text{OsO}_4 \\
2. \text{NaHSO}_3 \\
\text{H}_2\text{O}
\end{array}
\]
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1. \((2R,3R)\)-butanediol
2. \((2S,3S)\)-butanediol
3. meso-2,3-butanediol

(a) only 1  
(b) only 2  
(c) only 3  
(d) only 1 and 2

Question 27
What type of reactive intermediate is formed in the reaction of an alkene with \(\text{Br}_2\) and water to give a bromohydrin?

(a) carbocation  
(b) carbanion  
(c) radical  
(d) cyclic bromonium ion

Question 28
What type of carbocation is shown?

(a) primary  
(b) secondary  
(c) tertiary  
(d) quaternary

Question 29
Which of the following reactions of alkenes is stereospecific?

(a) addition of \(\text{HCl}\) (treatment with \(\text{HCl}\))  
(b) hydrogenation (treatment with \(\text{H}_2/\text{Pt}\))  
(c) addition of \(\text{HBr}\) (treatment with \(\text{HBr}\))  
(d) acid-catalyzed hydration (treatment with aqueous \(\text{H}_2\text{SO}_4\))

Question 30
What type of reactive intermediate is formed in the reaction of propene with \(\text{N}-\text{bromosuccinimide}\) to give 3-bromo-1-propene?

(a) allylic carbocation  
(b) allylic carbanion  
(c) allylic radical  
(d) cyclic bromonium ion

Question 31
Which of the following alkenes undergoes allylic bromination to form a single monobrominated product?

1.  
2.  
3.  
4.  

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

Question 32
The reaction of \(\text{tert}-\text{butyl bromide}, \,(\text{CH}_3)_2\text{CBr},\) with methanol in an inert solvent proceeds by an \(\text{S}_\text{n}1\) mechanism to give \(\text{tert}-\text{butyl methyl ether}, \,(\text{CH}_3)_2\text{COCH}_3\). What is the effect of doubling the concentration of methanol on the rate of the reaction?

(a) the rate remains the same  
(b) the rate decreases by a factor of 2  
(c) the rate increases by a factor of 2  
(d) the rate increases by a factor of 4

Question 33
Which of the following sets consists of only polar aprotic solvents?

(a) water, hexane, methanol  
(b) acetic acid, DMF, toluene  
(c) DMSO, ethanol, acetonitrile  
(d) DMF, acetonitrile, DMSO

Question 34
Which of the following alkyl halides undergoes the fastest \(\text{S}_\text{n}2\) reaction with sodium cyanide, \(\text{NaCN}\)?

(a) methyl iodide  
(b) ethyl iodide  
(c) 2-iodopropane  
(d) \(\text{tert}-\text{butyl iodide}\)

Question 35
Which of the following statements is true regarding the reaction of \(\text{tert}-\text{butyl bromide}\) with water?

(a) the rate is proportional to the concentration of \(\text{tert}-\text{butyl bromide}\)  
(b) the rate is proportional to the concentration of water  
(c) the rate is independent of the identity of the solvent  
(d) the rate of the reaction is independent of the temperature

Question 36
Which of the following represents the transition state of the reaction between methyl iodide sodium methylthiolate, \(\text{NaSCH}_3\)?

1.  
2.  
3.  
4.  

(a) 1  
(b) 2  
(c) 3  
(d) 4
Question 37
What is the IUPAC name of the following compound?

(a) (E)-2-methyl-3-penten-2-ol
(b) (Z)-2-methyl-3-penten-2-ol
(c) (E)-4-methyl-2-penten-4-ol
(d) (Z)-2-methyl-4-penten-2-ol

Question 38
What is the best choice of reagent to perform the following transformation?

(a) HCl
(b) NaOH
(c) H$_2$SO$_4$
(d) KMnO$_4$

Question 39
What is the IUPAC name of the following compound?

(a) (R)-4-methyl-2-hexyne
(b) (S)-4-methyl-2-hexyne
(c) (R)-3-methyl-4-hexyne
(d) (S)-3-methyl-4-hexyne

Question 40
What is the major organic product obtained from the following reaction?

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

Question 41
What is the major organic product obtained from the following series of reactions?

(a) (Z)-2-heptene
(b) (Z)-1,5-heptene
(c) 1-heptene
(d) heptane

Question 42
Which of the following reactions provides tert-butyl methyl ether in a high yield?

(a) potassium tert-butoxide + fluoromethane
(b) sodium methoxide + tert-butyl bromide
(c) methanol + tert-butyl bromide
(d) iodomethane + tert-butyl iodide in the presence of KOH

Question 43
Which of the following bonds undergoes stretching at the highest frequency?

(a) C=O
(b) C-O
(c) C=C
(d) C-C

Question 44
Which of the following compounds gives an infrared spectrum with peaks at 3000-3500 cm$^{-1}$ and ~1750 cm$^{-1}$?

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

Question 45
Which of the following combinations of peaks appears in the $^1$H NMR spectrum of diethyl ether, CH$_3$CH$_2$OCH$_2$CH$_3$?

(a) a triplet and a doublet
(b) a quartet and a sextet
(c) two singlets
(d) a triplet and a quartet

Question 46
What is the hydrogen deficiency index for a compound with a molecular formula of C$_n$H$_m$Br$_2$?

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

Question 47
Which of the following compounds gives a $^1$H NMR spectrum consisting of only a singlet, triplet and pentet?

(a) CH$_3$OCH$_2$CH$_2$CH$_2$OH
(b) CH$_3$OCH$_2$CH$_2$OCH$_2$CH$_3$
(c) CH$_3$OCH$_2$CH$_2$OCH$_3$
(d) CH$_3$OCH$_2$CH(CH$_3$)OCH
Question 48
Which of the following alcohols can be prepared from a Grignard reagent and ethylene oxide?

(a) only 1
(b) only 1 and 2
(c) only 1, 2 and 3
(d) 1, 2, 3 and 4

Question 49
What is the major organic product obtained from the following reaction?

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

Question 50
What is the major organic product obtained from the following reaction?

(a) 2-pentanone
(b) (E)-3-penten-2-ol
(c) 2-pentanol
(d) 4-hydroxy-2-pentanone

Question 51
Which ketone-diol undergoes cyclization to form the following ketal?

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

Question 52
Which of the following statements is not true?

(a) The reaction of a ketone with methanol in the presence of acid to give a ketal proceeds via a resonance stabilized cation
(b) Protonation of a ketone increases its electrophilicity
(c) The conversion of a hemiacetal to an acetal under acidic conditions proceeds via an S_N1 mechanism
(d) The conversion of a hemiacetal to an acetal is catalyzed by both acid and base

Question 53
What is the major organic product obtained from the following sequence of reactions?

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

Question 54
Which of the following has the highest $K_{eq}$ for enolization?

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

Question 55
What is the IUPAC name of the following compound?

(a) (E)-N-methyl 3-methyl-3-pentenamide
(b) (Z)-N-methyl 3-methyl-3-pentenamide
(c) (E)-1-methylamino-3-methyl-3-pentenal
(d) (Z)-1-methylamino-3-methyl-3-pentenal
**Question 56**
What is the major organic product obtained from the following reaction?

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

**Question 57**
What is the major organic product obtained from the following reaction?

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

**Question 58**
What is the major organic product obtained from the following reaction?

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

**Question 59**
What is the major organic product obtained from the following reaction?

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

**Question 60**
What is the major organic product obtained from the following sequence of reactions?

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

**Question 61**
Which of the following ions is aromatic?

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

**Question 62**
Which of the following has the compounds shown in the correct order of decreasing acidity (i.e., more acidic > less acidic)?

(a) 1 > 2 > 3  (b) 2 > 3 > 1  (c) 3 > 2 > 1  (d) 2 > 1 > 3
Question 63
Which of the following reactions or reaction sequences will not give 2-propylbenzene as the major product?
(a) treatment of benzene with isopropyl alcohol and HF
(b) treatment of benzene with 1-chloropropane and AlCl₃
(c) treatment of benzene with propanoyl chloride and AlCl₃; followed by reaction with Zn(Hg) and HCl
(d) treatment of benzene with 1-propene and HF

Question 64
What is the major organic product obtained from the following reaction?

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

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

Question 65
What is the major organic product obtained from the following sequence of reactions?

\[
\begin{array}{c}
\text{CH}_3\text{CH}=\text{CH}_2 \\
\text{HF} \\
\text{HNO}_3 \\
\text{Na}_2\text{Cr}_2\text{O}_7 \\
\text{H}_2\text{SO}_4 \\
\end{array}
\]

(a) 4-nitro-tert-butylbenzene
(b) 3-nitro-tert-butylbenzene
(c) 4-nitrobenzoic acid
(d) 3-nitrobenzoic acid

Question 66
Which of the following is the Meisenheimer complex intermediate in the nucleophilic substitution of 4-bromo-1-nitrobenzene with hydroxide?

\[
\begin{array}{c}
\text{Br} \\
\text{OH} \\
\text{NO}_2 \\
\end{array}
\]

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

Question 67
Which mechanism accounts for the reaction of chlorobenzene with acetyl chloride and AlCl₃ to form 4-chloroacetophenone?
(a) Bimolecular nucleophilic substitution (S_N2)
(b) Nucleophilic aromatic substitution by elimination-addition
(c) Nucleophilic aromatic substitution by addition-elimination
(d) Electrophilic aromatic substitution

Question 68
What is the major organic product obtained from the following reaction?

\[
\begin{array}{c}
\text{CH}_3\text{C} = \text{N} \\
\text{H}_2\text{O} \\
\end{array}
\]

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

Question 69
What is the major organic product obtained from the following sequence of reactions?

\[
\begin{array}{c}
\text{Br} \\
\text{NaCN} \\
\text{H}_2\text{O}, \text{Ni} \\
\end{array}
\]

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

Question 70
What is the kinetic product obtained from the addition of 1 mole of bromine to 1,3-butadiene?
(a) 3,4-dibromo-1-butene  (b) (E)-1,4-dibromo-2-butene
(c) (Z)-1,4-dibromo-2-butene  (d) (Z)-2,3-dibromo-2-butene