Chemistry 3351: Organic Chemistry/3rd Exam/HLMS 252
Tuesday: Nov. 13th from **7:00pm → 9:00pm**

Name: Ryo Tamura (please print, 1 points)
Note: See Pages 11 and 12 for IR/NMR references

Page	Possible Points	Score
1	1	
2	12	
3	12	
4	10	
5	15	
6	10	
7	10	
8	10	
9	10	
10	10	
TOTAL	100	

1. Clickers in Action (3 pts each):

1) Which compound has the highest boiling point?

A) Dimethylamine
B) Dimethyl ether
C) Ethanol
D) Ethyl fluoride
E) Propane

2) Order these nucleophiles from strongest to weakest under S_N2 reaction conditions.

A) $I^- > Br^- > H_2O > NH_3$
B) $I^- > Br^- > NH_3 > H_2O$
C) $Br^- > I^- > H_2O > NH_3$
D) $Br^- > I^- > NH_3 > H_2O$

3) The rate law for S_N2 reaction of $CH_3CH_2CH_2Cl$ with NaCN in DMSO is:

A) rate = k $[CH_3CH_2CH_2Cl]$
B) rate = k $[CH_3CH_2CH_2Cl][CN^-]$
C) rate = k $[CH_3CH_2CH_2Cl]^2[CN^-]$
D) rate = k $[CH_3CH_2CH_2Cl][CN^-]^2$

4) Which nucleophile would react at the fastest rate in this reaction?

A) Nucleophile = CH_3OH
B) Nucleophile = CH_3O^-
C) Nucleophile = CH_3S^-
D) Nucleophile = $CH_3CO_2^-$

5) Which alcohol is the relatively strongest acid?

A) CH_3CH_2OH
B) CF_3CH_2OH
C) $CF_3CH_2CH_2OH$
D) $CF_3CH_2CH_2CH_2OH$

6) Predict which alcohol is the relatively strongest acid in aqueous solution.

A) CH_3OH
B) CH_3CH_2OH
C) $(CH_3)_2CHOH$
D) $(CH_3)_3COH$

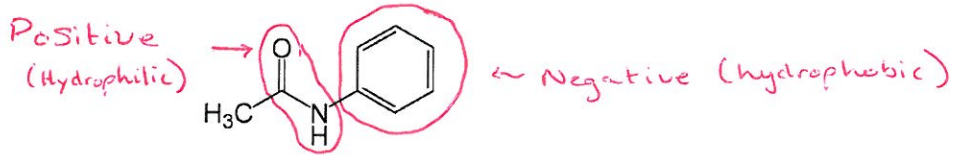
7) How many constitutional isomers of C_4H_9Br are possible? How many of these are primary alkyl bromides?

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

8) Which type of intermolecular forces account for the decreasing solubility of alcohols such as methanol, ethanol, propanol, etc. in water and their increasing solubility in hexane as the solvent?

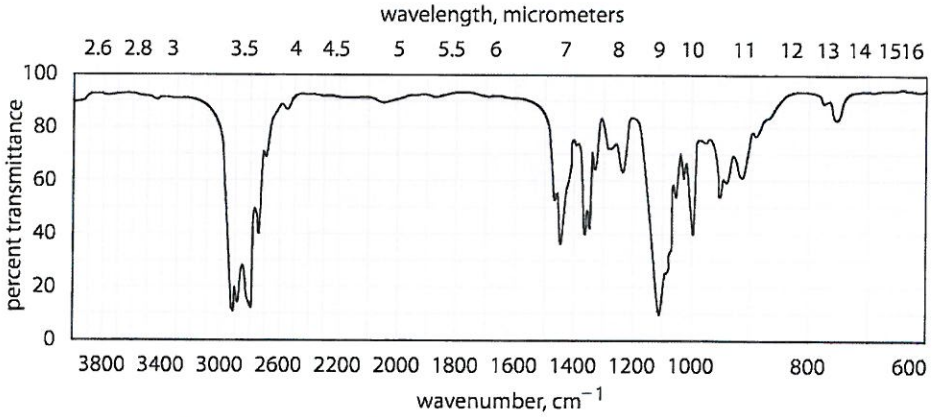
A) van der Waals forces
B) Hydrogen bonding
C) Dipole-dipole forces
D) Ion-dipole forces

2. (5 pts). A widely used undergraduate experiment is the recrystallization of acetanilide from water. Acetanilide (structure shown below) is moderately soluble in hot water, but much less soluble in cold water. Identify one structural feature of the acetanilide molecule that would be expected to contribute positively to its solubility in water and one that would be expected to contribute negatively.



Acetanilide

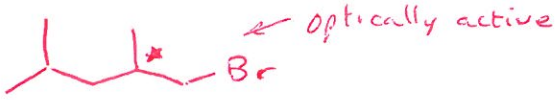
3. (5 pts).

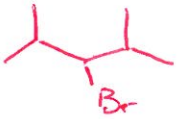


Which compound matches the IR spectrum?

- ○ 1,5-hexadiene
- ○ *trans*-4-octene
- ○ cyclohexane
- ○ 1-methylcyclopentene
- ◉ dipropyl ether
- ○ 1-hexen-3-ol
- ○ 3-hexanol

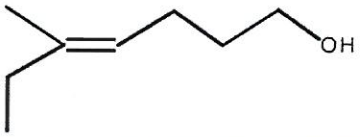
4. (9 pts). Three alkyl halides, each with the formula $C_7H_{15}Br$, have different boiling points. One of the compounds is optically active. Following reaction with Mg in ether, then with water, each compound gives 2, 4-dimethylpentane. After the same reaction with D_2O instead of water, a different product is obtained from each compound. Suggest a structure for each of the three alkyl halides.





5. (6 pts)

Select the correct name for the following compound, including the correct (E) or (Z) designation where appropriate.



- ○ (Z)-5-methyl-4-hepten-1-ol
- ○ (Z)-2-ethyl-2-hexen-1-ol
- ○ (E)-5-ethyl-4-hexen-1-ol
- ● (E)-5-methyl-4-hepten-1-ol

6. (10 pts). Rank the following compounds in order of increasing S_N2 reaction rate with KI in acetone.

   A: $(CH_3)_3CCl$

   B: $(CH_3)_2CHCl$

   C: $(CH_3)_2CHCH_2Cl$

   D: $CH_3CH_2CH_2CH_2Br$

   E: $CH_3CH_2CH_2CH_2Cl$

A < B < C < E < D

7. (10 pts). The mass spectrum of an organic compound shows the relative abundances of M to be 49.96% and M+1 to be 2.702%. Assuming the peaks are caused by ^{12}C and ^{13}C isotopes, determine the number of carbon atoms in the compound (Natural abundances: 12C is 98.93% and 13C is 1.07%).

$$\text{Relative abundance} = \left(\frac{\text{abundance } C^{13}}{\text{abundance } C^{12}}\right)$$

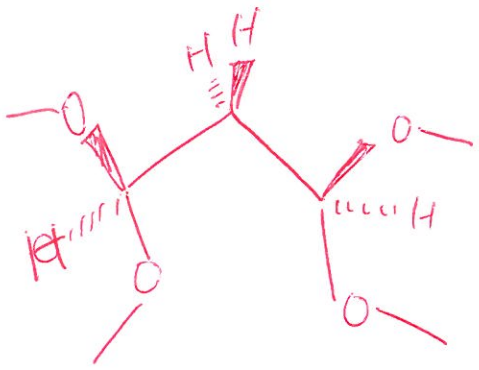
$$= (\#\text{ of C}) \times \left(\frac{\text{Natural abundance of } ^{13}C}{\text{Natural abundance of } ^{12}C}\right)$$

$$= (\#\text{ of C}) \times \left(\frac{0.0107}{0.9893}\right)$$

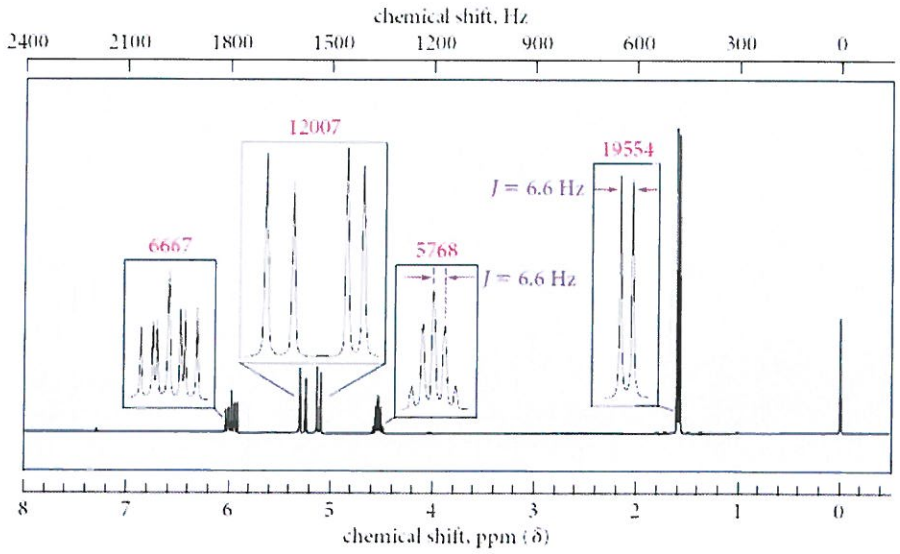
$$\frac{0.02702}{0.4996} = (\#\text{ of C}) \times 0.0111$$

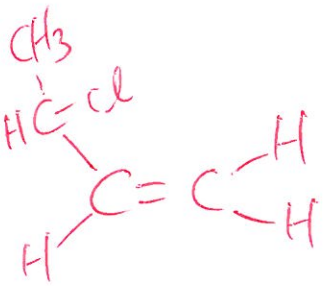
$$\#\text{ of C} \approx 5$$

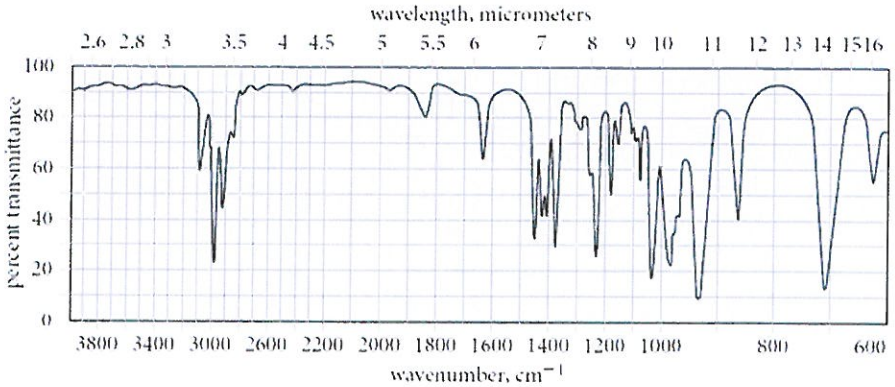
8. (10 pts). Give the structure that corresponds to the following molecular formula and ^{1}H NMR spectrum: $C_7H_{16}O_4$: δ=1.93 (t, *J*=6 Hz); δ= 3.35 (s); δ= 4.49 (t, *J*=6 Hz); relative integral 1:6:1

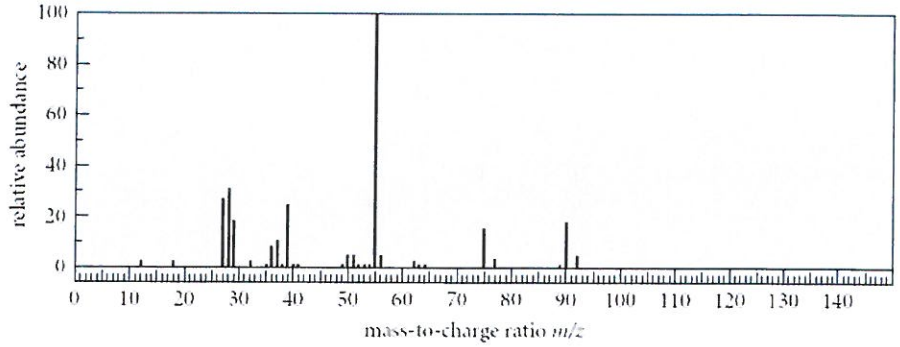


9. (10 pts). Propose a structure for the compound with IR, NMR, and EI mass spectra shown below. See appendix for the common reference values.









10. (10 pts) Tell whether each of the following reactions favors reactants or products at equilibrium (assume that all reactants and products are soluble).

a)

$CH_3Cl + F^- \rightarrow CH_3F + Cl^-$

b)

$CH_3Cl + I^- \rightarrow CH_3I + Cl^-$

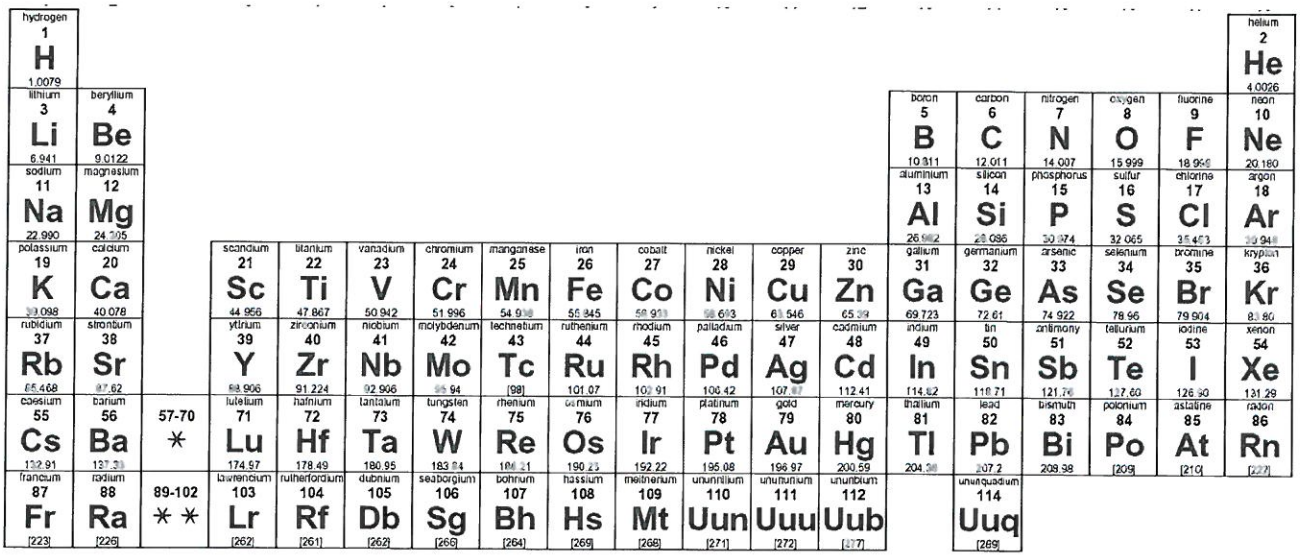
c)

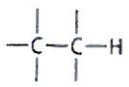
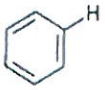
$CH_3Cl + N_3^- \rightarrow CH_3N_3 + Cl^-$

(Hint: the pKa of HN_2 is 4.72)

d)

$CH_3Cl + {}^-OCH_3 \rightarrow CH_3)CH_3 + Cl^-$



Group	Chemical shift, ppm
	0.7–1.5
	4.6–5.7
—O—H	varies with solvent and with acidity of O—H
—C≡C—H	1.7–2.5
	6.5–8.5

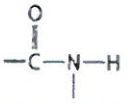
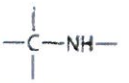
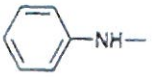
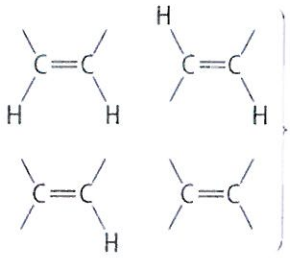
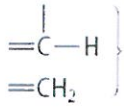
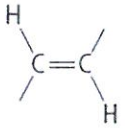
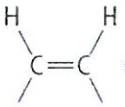
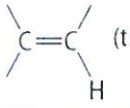
Group	Chemical shift, ppm
	9–11
	7.5–9.5
	0.5–1.5
	2.5–3.5

TABLE 12.1 Regions of the Infrared Spectrum

Wavenumber range, cm^{-1}	Type of absorptions	Name of region
3400–2800	O—H, N—H, C—H stretching	Functional group
2250–2100	C≡N, C≡C stretching	
1850–1600	C=O, C=N, C=C stretching	
1600–1000	C—C, C—O, C—N stretching; various bending absorptions	Fingerprint
1000–600	C—H bending	C—H bending

TABLE 12.2 Important Infrared Absorptions of Alkenes

Functional group	Absorption*
C=C stretching absorptions	
—CH=CH_2 (terminal vinyl)	1640 cm^{-1} (m, sh)
C=CH_2 (terminal methylene)	1655 cm^{-1} (m, sh)
	1660–1675 cm^{-1} (w) (absent in some compounds)
=C—H stretching absorptions	
	3000–3100 cm^{-1} (m)
=C—H bending absorptions	
—CH=CH_2 (terminal vinyl)	910, 990 cm^{-1} (s) two absorptions
C=CH_2 (terminal methylene)	890 cm^{-1} (s)
 (*trans*-alkene)	960–980 cm^{-1} (s)
 (*cis*-alkene)	675–730 cm^{-1} (br) (ambiguous and variable for different compounds)
 (trisubstituted)	800–840 cm^{-1} (s)

Intensity designations: s = strong; m = moderate; w = weak
Shape designations: sh = sharp (narrow); br = broad (wide)