Name: Note: See	Pages 11 and 12 for IR	(please print, 1 poin R/NMR references	ıts)
Page	Possible Points	Score	
1	1		
2	12		
3	12		
4	10		
5	15		
6	10		
7	10		
8	10		
9	10		
10	10		

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

TOTAL ______

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) $Br^{-} > I^{-} > NH_{3} > H_{2}O$

3) The rate law for $S_N 2$ reaction of $CH_3CH_2CH_2Cl$ with NaCN in DMSO is:

A) rate = k [CH₃CH₂CH₂Cl] B) rate = k [CH₃CH₂CH₂Cl][CN⁻] C) rate = k [CH₃CH₂CH₂Cl]²[CN⁻] D) rate = k [CH₃CH₂CH₂Cl][CN⁻]²

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

Br + Nucleophile DMSO

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) CH₃CH₂OH
B) CF₃CH₂OH
C) CF₃CH₂CH₂OH
D) CF₃CH₂CH₂CH₂OH

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

A) CH₃OH
B) CH₃CH₂OH
C) (CH₃)₂CHOH
D) (CH₃)₃COH

7) How many constitutional isomers of C₄H₉Br 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.



3. (5 pts).



4. (9 pts). Three alkyl halides, each with the formula C₇H₁₅Br, 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 D₂O 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.



- 6. (10 pts). Rank the following compounds in order of increasing S_N2 reaction rate with KI in acetone.
 A: (CH₃)₃CCl
 B: (CH₃)₂CHCl
 C: (CH₃)₂CHCH₂Cl
 D: CH₃CH₂CH₂CH₂Br
 - E: CH₃CH₂CH₂CH₂Cl

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 ¹²C and ¹³C isotopes, determine the number of carbon atoms in the compound (Natural abundances: ¹²C is 98.93% and ¹³C is 1.07%).

8. (10 pts). Give the structure that corresponds to the following molecular formula and ¹H NMR spectrum: C₇H₁₆O₄: δ =1.93 (t, *J*=6 Hz); δ = 3.35 (s); δ = 4.49 (t, *J*=6 Hz); relative integral 1:6:1



mass-to-charge ratio m/z

100 110

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 HN₂ is 4.72) d)
 - $CH_3Cl + OCH_3 \rightarrow CH_3)CH_3 + Cl^-$

	11	
-	T T	-

						-	-	1.00	-				·	1000	505			0.0	
	hydrogen																		helium
	- da -																		2
	HI																		He
	1.0079																		4.0026
ſ	lithium	beryllium												boron	carbon	nitrogen	oxygen	fluorine	neon
	3	4												5	6	1	8	9	10
	Li	Be												В	С	N	Ο	F	Ne
ļ	6.941	9.0122												10.811	12.011	14.007	15.999	18.998	20.180
	sodium	magnesium 42												aluminium 12	silicon	phosphorus	sulfur 16	chlorine 17	argon 40
		12													14	15		~	
	Na	Md												AI	SI	Р	S	CI	Ar
l	22.990	24.305												26.982	28.086	30.974	32.065	35.453	39.948
	potassium	calcium		scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton
	19	20		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
		-		-															
	K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	K 39.098	Ca		Sc 44.956	Ti 47.867	V 50.942	Cr 51.996	Mn 54.938	Fe 55.845	Co 58.933	Ni 58.693	Cu 63.546	Zn 65.39	Ga 69.723	Ge 72.61	As 74.922	Se 78.96	Br 79.904	Kr 83.80
2	8 39.098 rubidium	Ca 40.078 strontium		44.956 yttrium	47.867 zirconium	50.942 niobium	51.996 molybdenum	Mn 54.938 technetium	55.845	58.933 rhodium	58.693 palladium	63.546 silver	Zn 65.39 cadmium	Ga 69.723 Indium	Ge 72.61 tin 50	As 74.922 antimony	8e 78.96 tellurium	Br 79,904 Iodine	83.80 xenon
2	K 39.098 rubidium 37	Ca 40.078 strontium 38		Sc 44.956 yttrium 39	47,867 zirconium 40	50.942 niobium 41	51.996 molybdenum 42	Mn 54.938 technetium 43	Fe 55.845 ruthenium 44	Co 58.933 rhodium 45	Ni 58.693 palladium 46	63.546 silver 47	Zn 65.39 cadmium 48	Ga 69.723 indium 49	Ge 72.61 tin 50	As 74.922 antimony 51	Se 78.96 tellurium 52	8r 79.904 iodine 53	83.80 xenon 54
2	K 39.098 rubidium 37 Rb	Ca 40.078 strontium 38 Sr		Sc 44.956 yttrium 39 Y	Ti 47.867 zirconium 40 Zr	V 50.942 niobium 41 Nb	Cr 51.996 molybdenum 42 Mo	Mn 54.938 technetium 43 TC	Fe 55.845 ruthenium 44 Ru	Co 58.933 rhodium 45 Rh	Ni 58,693 palladium 46 Pd	Cu 63,546 silver 47 Ag	Zn 65.39 cadmium 48 Cd	Ga 69,723 indium 49 In	Ge 72.61 50 Sn	As 74.922 antimony 51 Sb	Se 78.96 tellurium 52 Te	Br 79,904 iodine 53 I	Kr 83.80 xenon 54 Xe
	K 39.098 rubidium 37 Rb 85.468	Ca 40.078 strontium 38 Sr 87.62		Sc 44.956 yttrium 39 Y 88.906	47.867 zirconium 40 Zr 91.224	V 50.942 niobium 41 Nb 92.906	51.996 molybdenum 42 Mo 95.94	Mn 54.938 technetium 43 TC [98]	Fe 55.845 ruthenium 44 Ru 101.07	Co 58.933 rhodium 45 Rh 102.91	Ni 58.693 palladium 46 Pd 106.42	63.546 silver 47 Ag 107.87	Zn 65.39 cadmium 48 Cd 112.41	Ga 69.723 indium 49 In 114.82	Ge 72.61 tin 50 Sn 118.71	As 74.922 antimony 51 Sb 121.76	Se 78.96 tellurium 52 Te 127.60	Br 79,904 Iodine 53 I 126,90	Kr 83.80 xenon 54 Xe 131.29
2	K 39.098 rubidium 37 Rb 85.468 caesium	Ca 40.078 strontium 38 Sr 87.62 barium 56	57 70	SC 44.956 yttrium 39 Y 88.906 lutetium 71	Ti <u>47.867</u> zirconium 40 Zr <u>91.224</u> hafnium 72	50.942 niobium 41 Nb 92.906 tantalum 72	51.996 molybdenum 42 Mo 95.94 tungsten 74	Mn 54.938 technetium 43 TC [98] rhenium 75	Fe 55.845 ruthenium 44 Ru 101.07 osmium 76	Co 58.933 rhodium 45 Rh 102.91 iridium	Ni 58.693 palladium 46 Pd 106.42 platinum 79	Cu 63,546 silver 47 Ag 107,87 gold 79	Zn 65.39 cadmium 48 Cd 112.41 mercury 90	Ga 69,723 indium 49 In 114.82 thallum 91	Ge 72.61 tin 50 Sn 118.71 lead	As 74.922 antimony 51 Sb 121.76 bismuth 92	52 127.60 polonium	Br 79.904 iodine 53 1 126.90 astatine 95	Kr 83.80 xenon 54 Xe 131.29 radon se
	K 39,098 rubidium 37 Rb 85,468 caesium 55	Ca 40.078 strontium 38 Sr 87.62 barium 56	57-70	Sc <u>44.966</u> yttrium 39 Y <u>88.906</u> lutetium 71	47,867 zirconium 40 Zr 91,224 hafnium 72	50.942 niobium 41 Nb 92.906 tantalum 73	51.996 molybdenum 42 Mo 95.94 tungsten 74	Mn 54.938 technetium 43 Tc [98] rhenium 75	Fe 55.845 ruthenium 44 Ru 101.07 osmium 76	Co 58.933 rhodium 45 Rh 102.91 iridium 77	Ni 58,693 palladium 46 Pd 106,42 platinum 78	63,546 silver 47 Ag 107.87 gold 79	Zn 65.39 cadmium 48 Cd 112.41 mercury 80	Ga 69,723 indium 49 In 114,82 thallium 81	Ge 72.61 50 Sn 118.71 lead 82	As 74.922 antimony 51 Sb 121.76 bismuth 83	Se 78.96 tellurium 52 Te 127.60 polonium 84	Br 79,904 iodine 53 1 126,90 astatine 85	83.80 xenon 54 Xee 131.29 radon 86
2	K 39.098 rubidium 37 Rb 85.468 caesium 55 Cs	Ca 40.078 strontium 38 Sr 87.62 barium 56 Ba	57-70 ★	Sc 44.966 yttrium 39 Y 88.906 lutetium 71 Lu	Ti 47.867 zirconium 40 Zr 91.224 hafnium 72 Hf	V 50,942 niobium 41 Nb 92,906 tantalum 73 Ta	Cr 51.996 molybdenum 42 Mo 95.94 tungsten 74 W	Mn 54.938 technetium 43 Tc 198 rhenium 75 Re	Fe 55.845 ruthenium 44 Ruu 101.07 osmium 76 Os	Co 58.933 rhodium 45 Rh 102.91 iridium 77 Ir	Ni 58.693 palladium 46 Pd 106.42 platinum 78 Pt	Cu 63.546 silver 47 Ag 107.87 gold 79 Au	Zn 65.39 cadmium 48 Cd 112.41 mercury 80 Hg	Ga 69.723 indium 49 In 114.82 thallium 81 TI	Ge 72.61 tin 50 Sn 118.71 lead 82 Pb	As 74.922 antimony 51 Sb 121.76 bismuth 83 Bi	Se 78.96 tellurium 52 Te 127.60 potonium 84 PO	Br 79,904 Iodine 53 I 126.90 astatine 85 At	Kr 83.80 xenon 54 Xe 131.29 radon 86 Rn
	K 39.098 rubidium 37 Rb 85.468 caesium 55 Cs 132.91	Ca 40.078 strontium 38 Sr 87.62 barium 56 Baa 137.33	57-70 ★	Sc 44.966 yttrium 39 Y 88.906 lutetium 71 Lu 174.97	Ti 47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49	V 50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95	Cr 51.996 molybdenum 42 MO 95.94 tungsten 74 W 183.84	Mn 54.938 technetium 43 Tc 988 rhenium 75 Re 186.21	Fe 55.845 ruthenium 44 Ruu 101.07 osmium 76 Os 190.23	Co 58.933 rhodium 45 Rh 102.91 iridium 77 Ir 192.22	Ni 58.693 palladium 46 Pd 106.42 platinum 78 Pt 195.08	Cu 63.546 silver 47 Ag 107.87 gold 79 Au 196.97	Zn 65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59	Ga 69,723 Indium 49 In 114,82 thallium 81 TI 204,38	Ge 72.61 tin 50 Sn 118.71 lead 82 Pb 207.2	As 74.922 antimony 51 Sb 121.76 bismuth 83 Bi 208.98	Se 78.96 tellurium 52 Te 127.60 potonium 84 PO [209]	Br 79,904 iodine 53 I 126.90 astatine 85 At [210]	Kr 83.80 xenon 54 Xe 131.29 radon 86 Rn [222]
	K 39,098 rubidium 37 Rb 85,468 caesium 55 CS 132,91 francium 87	Ca 40.078 strontium 38 Sr 87.62 barium 56 Ba 137.33 radium 88	57-70 ★ 89-102	Sc 44.966 yttrium 39 Y 88.906 lutetium 71 Lu 174.97 lawrencium 103	Ti 47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49 rutherfordium 104	V 50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95 dubnium 105	Cr 51.996 molybdenum 42 Mo 95.94 tungsten 74 W 183.84 seaborgium 106	Mn 54,938 technetium 43 TC 198 rhenium 75 Re 186.21 bohrium 107	Fe 55.845 ruthenium 44 Ru 101.07 osmium 76 OS 190.23 hassium 108	Co 58.933 rhodium 45 Rh 102.91 iridium 77 Ir 192.22 meitnerium 109	Ni 58.693 palladium 46 Pd 106.42 platinum 78 Pt 195.08 ununnillum 110	Cu 63,546 silver 47 Ag 107.87 gold 79 Au 196.97 unununum	Zn 65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59 unumbium 112	Ga 69,723 indium 49 In 114,82 thallium 81 TI 204,38	Ge 72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadum 114	As 74.922 antimony 51 Sb 121.76 bismuth 83 Bi 208.98	Se 78.96 tellurium 52 Te 127.60 polonium 84 Po [209]	Br 79.904 iodine 53 I 126.90 astatine 85 At [210]	Kr 83.80 xenon 54 Xe 131.29 radon 86 Rn [222]
	K 39,098 rubidium 37 Rb 85,468 caesium 55 CS 132,91 francium 87	Ca 40.078 strontium 38 Sr 87.62 barium 56 Ba 137.33 radium 88	57-70 × 89-102	Sc 44.966 yttrium 39 Y 88.906 lutetium 71 Lu 174.97 lawrencium 103	Ti 47.867 zirconium 40 Zr 91.224 hafnium 72 Hf 178.49 rutherfordium 104 56	V 50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95 dubnium 105	Cr 51.996 molybdenum 42 Mo 95.94 tungsten 74 W 183.84 seaborgium 106	Mn 54,938 technetium 43 TC 98 rhenium 75 Re 186.21 bohrium 107	Fe 55.845 ruthenium 44 Ruu 101.07 osmium 76 OS 190.23 hassium 108	Co 58.933 rhodium 45 Rh 102.91 irdium 77 Ir 192.22 meitnerium 109	Ni 58,693 palladium 46 Pd 106,42 platinum 78 Pt 195,08 ununnilium 110	Cu 63,546 silver 47 Ag 107.87 gold 79 Au 196.97 unununium 111	Zn 65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59 ununbium 112	Ga 69,723 indium 49 In 114,82 thallium 81 TI 204,38	Ge 72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadum 114	As 74.922 antimony 51 Sb 121.76 bismuth 83 Bi 208.98	Se 78.96 tellurium 52 Te 127.60 polonium 84 PO [209]	Br 79.904 iodine 53 I 126.90 astatine 85 At [210]	Kr 83.80 xenon 54 Xe 131.29 radon 86 Rn [222]
	K 39,098 rubidium 37 Rb 85,468 caesium 55 CS 132,91 francium 87 Fr	Ca 40.078 strontium 38 Sr 87.62 barium 56 Baa 137.33 radium 88 Ra	57-70 ★ 89-102 ★ ★	Sc 44,956 yttrium 39 Y 88,906 lutetium 71 Luu 174.97 lawrendum 103 Lr	Ti 47,867 zirconlum 40 Zr 91,224 hafnium 72 Hff 178,49 rutherforchum 104 Rff	V 50.942 niobium 41 Nb 92.906 tantalum 73 Ta 180.95 dubnium 105 Db	Cr 51.996 molybdenum 42 Mo 95.94 tungsten 74 W 183.84 seaborgium 106 Sg	Mn 54.938 technetium 43 Tc 988 rhenium 75 Ree 186.21 bohrium 107 Bh	Fe 55.845 ruthenium 44 Ruu 101.07 osmium 76 OS 190.23 hassium 108 HS	Co 58.933 rhodium 45 Rh 102.91 iridium 77 Ir 192.22 meitnerium 109 Mt	Ni 58,693 palladium 46 Pd 106,42 platinum 78 Pt 195,68 ununnilium 110 Uun	Cu 63.546 silver 47 Ag 107.87 gold 79 Au 196.97 unununium 111 Uuu	Zn 65.39 cadmium 48 Cd 112.41 mercury 80 Hg 200.59 ununblum 112 Uub	Ga 69,723 indium 49 In 114,82 thailium 81 TI 204,38	Ge 72.61 tin 50 Sn 118.71 lead 82 Pb 207.2 ununquadium 114 Uuq	As 74.922 antimony 51 Sb 121.76 bismuth 83 Bi 208.98	Se 78.96 tellurium 52 Te 127.60 potonium 84 PO [209]	Br 79.904 iodine 53 I 126.90 astatine 85 At [210]	Kr 83.80 xenon 54 Xe 131.29 radon 86 Rn [222]



venumber range, cm ⁻¹	Type of absorptions	Name of region
3400-2800	O—H, N—H, C—H stretching	
2250-2100	C≡N, C≡C stretching }	Functional group
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 1640 cm⁻¹ (m, sh) -CH=CH₂ (terminal vinyl) $C = CH_2$ (terminal methylene) 1655 cm⁻¹ (m, sh) $1660 - 1675 \text{ cm}^{-1} \text{ (w)}$ (absent in some compounds) =C—H stretching absorptions $3000 - 3100 \text{ cm}^{-1} \text{ (m)}$ =C—H bending absorptions $910,990 \text{ cm}^{-1}$ (s) -CH=CH₂ (terminal vinyl) two absorptions $C = CH_2$ (terminal methylene) $890 \text{ cm}^{-1}(\text{s})$ (trans-alkene) $960-980 \text{ cm}^{-1}$ (s) (cis-alkene) 675-730 cm⁻¹ (br) (ambiguous and variable for different compounds) (trisubstituted) $800-840 \text{ cm}^{-1}$ (s)

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