

CHEM 3331 (Richardson) Midterm Exam 1 – Sep. 20, 2022

Your Name: Key

Student ID: _____

Recitation (fill in one circle):

- O 134 (Wed 12:20 w/ Will)
- O 135 (Wed 1:25 w/ Will)
- O 136 (Wed 2:30 w/ Will)
- O 137 (Wed 3:35 w/ Will)
- O 142 (Thu 10:10 w/ Ethan)
- O 143 (Thu 11:15 w/ Ethan)
- O 144 (Thu 12:20 w/ Ethan)
- O 147 (Thu 3:35 w/ Hongxuan)

Question	Score	Out of
1	15	
2	10	
3	30	
4	15	
5	10	
6	20	
7	10 e.c.	
Total		100

This is a closed-book exam. The use of notes, calculators, or cell phones will not be allowed during the exam. You may use models sets brought in a clear bag. Use the backs of the pages for scratch work. If your final answer is not clearly specified, you will lose points. For mechanisms, show all intermediates including correct formal charges, but do not show transition states.

Periodic Table of the Elements																		
1 IA 1A	2 IIA 2A	3 III 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VII 7B	8	9	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A	
1 H Hydrogen 1.008	2 Be Boron 3.012	3 Li Lithium 6.941	4 Be Boron 3.012	5 V Scandium 44.956	6 Ti Titanium 47.888	7 Cr Chromium 51.921	8 Mn Manganese 54.938	9 Fe Iron 55.845	10 Co Cobalt 58.931	11 Ni Nickel 58.693	12 Cu Copper 63.546	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948	
11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Sc Scandium 44.956	14 V Vanadium 50.942	15 Cr Chromium 51.921	16 Mn Manganese 54.938	17 Fe Iron 55.845	18 Co Cobalt 58.931	19 Ni Nickel 58.693	20 Cu Copper 63.546	21 Zn Zinc 65.401	22 Ga Gallium 69.721	23 Ge Germanium 72.031	24 As Arsenic 74.971	25 Se Selenium 74.971	26 Br Bromine 79.911	27 Kr Krypton 83.791		
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.888	23 V Vanadium 50.942	24 Cr Chromium 51.921	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.931	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.401	31 Ga Gallium 69.721	32 Ge Germanium 72.031	33 As Arsenic 74.971	34 Se Selenium 74.971	35 Br Bromine 79.911	36 Kr Krypton 83.791	
37 Rb Rubidium 85.458	38 Sr Strontium 87.52	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.909	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.816	50 Sn Tin 118.711	51 Sb Antimony 121.791	52 Te Tellurium 127.8	53 I Iodine 126.904	54 Xe Xenon 131.294	
55 Cs Cesium 132.955	56 Ba Barium 137.329	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.548	74 W Tungsten 183.45	75 Re Rhenium 186.207	76 Os Osmium 190.223	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 197.027	80 Hg Mercury 200.59	81 Tl Thallium 204.363	82 Pb Lead 207.2	83 Bi Bismuth 208.981	84 Po Polonium 208.981	85 At Astatine 210.587	86 Rn Radon 222.018	
87 Fr Francium 221.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium 261	105 Db Dubnium 262	106 Sg Seaborgium 263	107 Bh Bohrium 264	108 Hs Hassium 265	109 Mt Meitnerium 266	110 Ds Darmstadtium 268	111 Rg Roentgenium 269	112 Cn Copernicium 269	113 Nh Nihonium 269	114 Fl Flerovium 269	115 Mc Moscovium 269	116 Lv Livermorium 269	117 Ts Tennessine 264	118 Og Oganesson 264	
Lanthanide Series																		
57 La Lanthanum 138.905	58 Ce Cerium 140.118	59 Pr Praseodymium 140.954	60 Nd Neodymium 144.241	61 Pm Promethium 144.931	62 Sm Samarium 150.95	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.547	67 Ho Holmium 164.526	68 Er Erbium 167.249	69 Tm Thulium 168.934	70 Yb Ytterbium 173.052	71 Lu Lutetium 174.962				
89 Ac Actinium 227.022	90 Th Thorium 232.058	91 Pa Protactinium 231.055	92 U Uranium 238.028	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.076	97 Bk Berkelium 247.076	98 Cf Californium 247.086	99 Es Einsteinium 254.051	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium 263.051				

pKa Values

HI	-10	CH ₃ COOH	4.7	ArOH	10	HC≡CH	26
HBr	-8	HN ₃	4.7	RSH	10-12	H ₂	35
HCl	-6	H ₂ S	7.0	H ₂ O	15.7	NH ₃	36
H ₃ O ⁺	-1.7	NH ₄ ⁺	9.3	ROH	16-18	H ₂ C=CH ₂	45
HF	3.2	HCN	9.4	O=C-CH ₃	9-25	CH ₄	60

Avg: 59.5

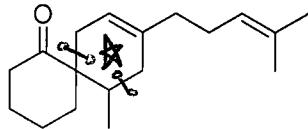
Cvne: 16

St. Dev: 24.8

Max: 108

Min: 10

- 1) The molecule below was recently synthesized in one step via a Diels-Alder reaction, as a precursor to several *spiro* bicyclic compounds isolated from sea plants. (15 pts total)

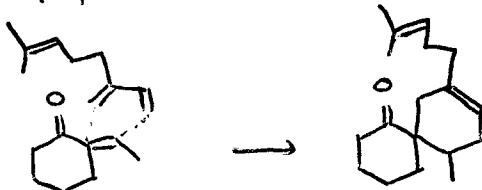


- Draw a star inside the ring which was formed during the Diels-Alder reaction. (3 pts)
- Draw the two disconnect lines ($\text{---}\text{---}$) across the bonds that were formed during this reaction. (2 pts)
- Draw the two molecules that reacted to form this product. (5 pts)

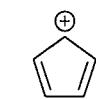


- If they came together with a different orientation, these molecules could have reacted to form another product with slightly different connectivity. Draw this product. (5 pts)

Flip 1 molecule upside down:



- 2) Describe each of the structures below as aromatic, nonaromatic, or antiaromatic. Assume each structure is planar. (10 pts)

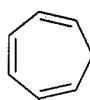


Cyclic, planar,
every atom in π ,
 4π = antiaromatic

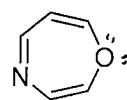


Cyclic,
planar,
Every atom
in π system,

6π = aromatic



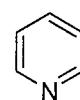
Cyclic,
planar,
not every
atom in π =
nonaromatic



* If you include
1 LP from O:
Every atom in
 π system

& $8\pi e^-$
= antiaromatic

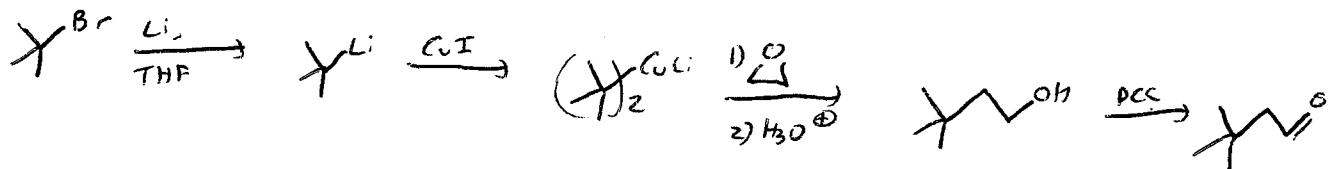
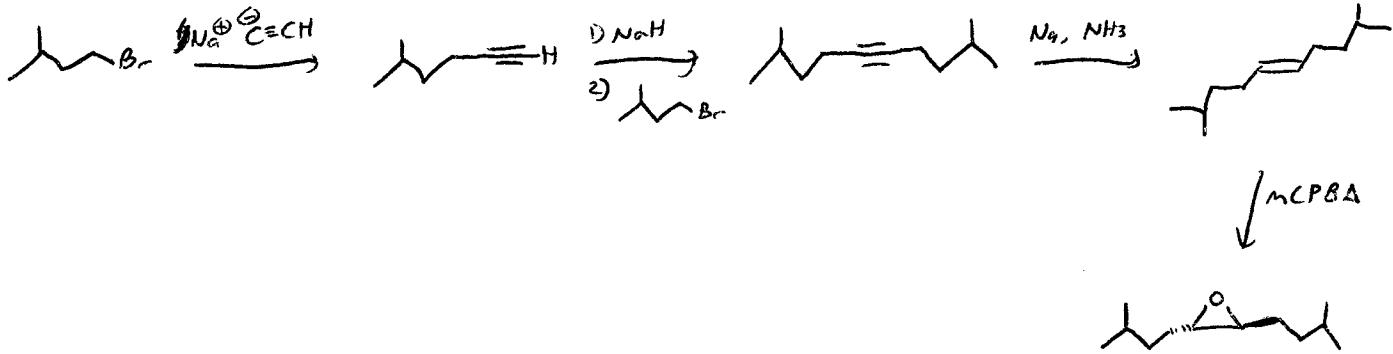
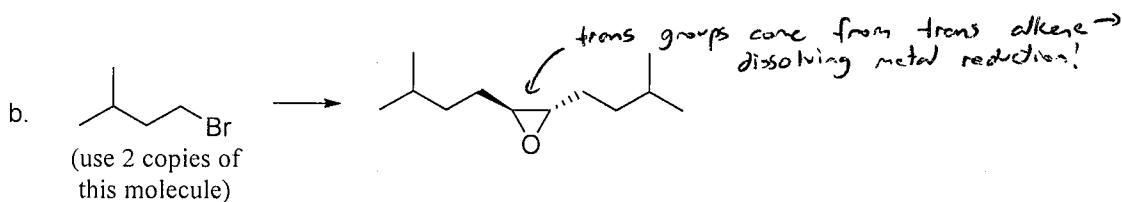
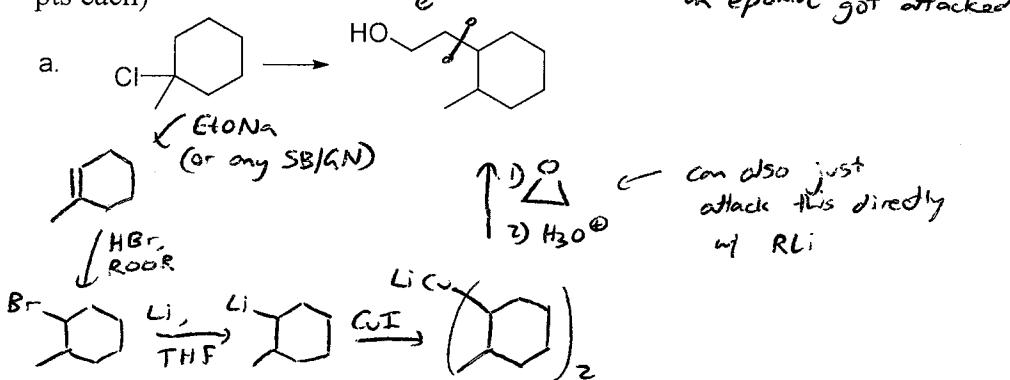
* If you don't
include LP on O:
not every atom in
 π system =
nonaromatic



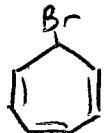
Can't include LP on N
due to it already being
in a π bond.

Every atom in π
system & $6\pi e^-$ =
aromatic.

- 3) Find a way to synthesize the desired product from the given starting material. If more than one step is necessary, show the product of each step. Do not show mechanisms. (30 pts - 10 pts each)



- 4) Most alkyl bromides are water-insoluble liquids. But when 7-bromo-1,3,5-cycloheptatriene was first isolated, its high melting point of 203 °C and its water solubility led its discoverers to comment that it behaves more like a salt. (15 pts total)
- a. Draw this structure, based on its name. (2 pts)



- b. Draw the mechanism for bromine detaching from the molecule to create two ions. (3 pts)



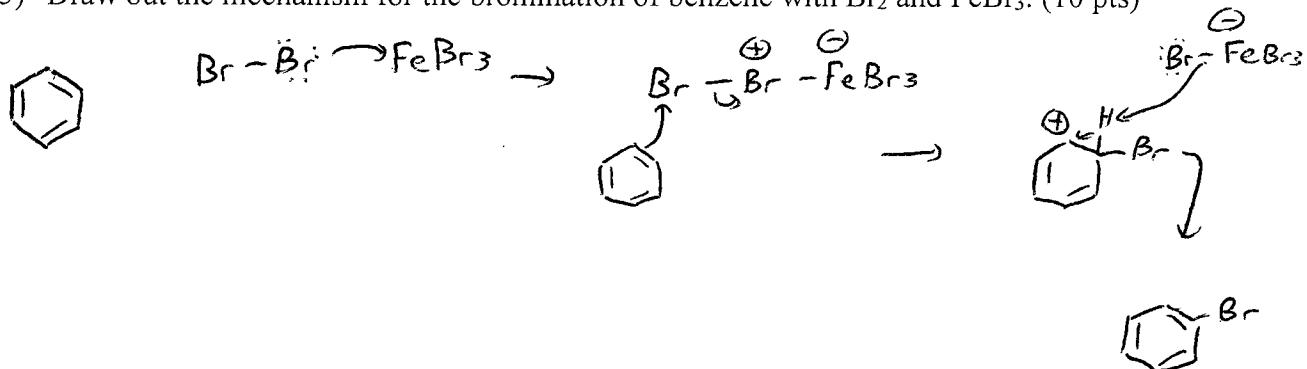
- c. One of these ions is unusually stable. Explain why in under thirty words. (5 pts)

The ring is aromatic! Cyclic, assume planar, every atom in π system, and 6π electrons.

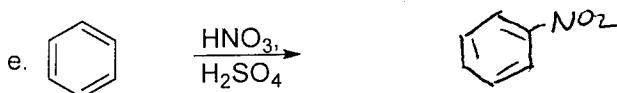
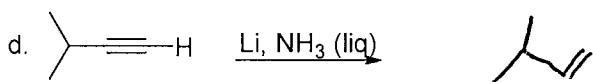
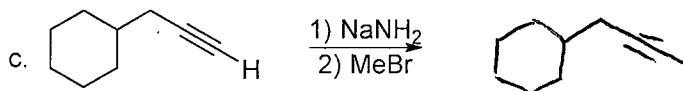
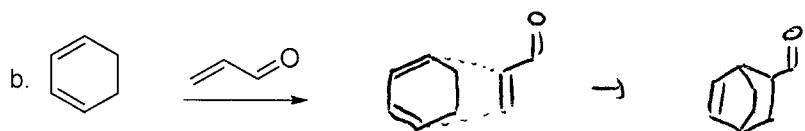
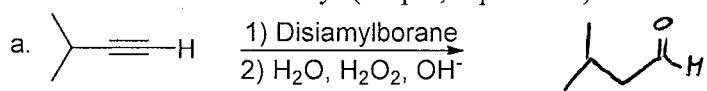
- d. Explain why this molecule behaves like a salt, in under thirty words. (5 pts)

There is a large increase in stability when the ring becomes aromatic, so the compound favors splitting into two ions.

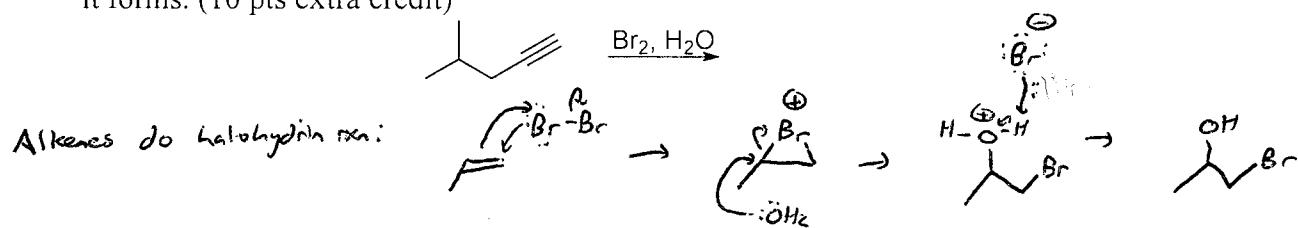
- 5) Draw out the mechanism for the bromination of benzene with Br₂ and FeBr₃. (10 pts)



- 6) Predict the major product of the following reactions. If no reaction occurs, then write NR. Do not show stereochemistry. (20 pts; 4 pts each)



- 7) Extra credit! This reaction forms a molecule with a carbonyl in it. Based on what you know of alkyne and alkene reactions, draw the product of this reaction and the mechanism for how it forms. (10 pts extra credit)



Alkynes do the same thing...

