

CHEM 3331 (Richardson) First Midterm Exam – Feb. 13, 2018

Your Name: Key

Student ID: _____

- Recitation (check one) O 8:00 Wed (Rachel Weintraub)
 O 12:00 Wed (Patrick Li) O 2:00 Wed (Patrick Li)
 O 4:00 Wed (Michael Ortiz) O 9:00 Thu (Josh Kamps)
 O 11:00 Thu (Josh Kamps) O 1:00 Thu (Aaron Hinds)
 O 3:00 Thu (Rachel Weintraub) O 5:00 Thu (Rachel Weintraub)

Question	Score	Out of
1		15
2		15
3		15
4		10
5		30
6		15
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 ziplock 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.

<table border="1"> <tr> <td>Hydrogen 1 H 1.0079</td> <td colspan="16"></td> <td>Helium 2 He 4.0026</td> </tr> <tr> <td>Lithium 3 Li 6.941</td> <td>Beryllium 4 Be 9.0122</td> <td colspan="14"></td> <td>Boron 5 B 10.811</td> <td>Carbon 6 C 12.011</td> <td>Nitrogen 7 N 14.007</td> <td>Oxygen 8 O 15.999</td> <td>Fluorine 9 F 18.998</td> <td>Neon 10 Ne 20.180</td> </tr> <tr> <td>Sodium 11 Na 22.990</td> <td>Magnesium 12 Mg 24.305</td> <td colspan="14"></td> <td>Aluminum 13 Al 26.982</td> <td>Silicon 14 Si 28.086</td> <td>Phosphorus 15 P 30.974</td> <td>Sulfur 16 S 32.065</td> <td>Chlorine 17 Cl 35.453</td> <td>Argon 18 Ar 39.948</td> </tr> <tr> <td>Potassium 19 K 39.098</td> <td>Calcium 20 Ca 40.078</td> <td>Scandium 21 Sc 44.956</td> <td>Titanium 22 Ti 47.867</td> <td>Vanadium 23 V 50.942</td> <td>Chromium 24 Cr 51.996</td> <td>Manganese 25 Mn 54.938</td> <td>Iron 26 Fe 55.845</td> <td>Cobalt 27 Co 58.933</td> <td>Nickel 28 Ni 58.693</td> <td>Copper 29 Cu 63.546</td> <td>Zinc 30 Zn 65.38</td> <td>Gallium 31 Ga 69.723</td> <td>Germanium 32 Ge 72.61</td> <td>Arsenic 33 As 74.922</td> <td>Selenium 34 Se 78.96</td> <td>Bromine 35 Br 79.904</td> <td>Krypton 36 Kr 83.80</td> </tr> <tr> <td>Rubidium 37 Rb 85.468</td> <td>Sr 87.62</td> <td>Yttrium 39 Y 88.906</td> <td>Zirconium 40 Zr 91.224</td> <td>Niobium 41 Nb 92.906</td> <td>Molybdenum 42 Mo 95.94</td> <td>Technetium 43 Tc [98]</td> <td>Ruthenium 44 Ru 101.07</td> <td>Rhodium 45 Rh 102.91</td> <td>Palladium 46 Pd 106.42</td> <td>Silver 47 Ag 107.87</td> <td>Cadmium 48 Cd 112.41</td> <td>Indium 49 In 114.82</td> <td>Tin 50 Sn 118.71</td> <td>Antimony 51 Sb 121.76</td> <td>Te 127.60</td> <td>Iodine 53 I 126.90</td> <td>Xenon 54 Xe 131.29</td> </tr> <tr> <td>Cesium 55 Cs 132.91</td> <td>Ba 137.33</td> <td>* 57-70</td> <td>Lanthanum 57 La 138.91</td> <td>Hafnium 72 Hf 178.49</td> <td>Tantalum 73 Ta 180.95</td> <td>Tungsten 74 W 183.84</td> <td>Rhenium 75 Re 186.21</td> <td>Osmium 76 Os 190.23</td> <td>Iridium 77 Ir 192.22</td> <td>Pt 195.08</td> <td>Au 196.97</td> <td>Hg 200.59</td> <td>Tl 204.38</td> <td>Pb 207.2</td> <td>Bi 208.98</td> <td>Po [209]</td> <td>At [210]</td> <td>Rn [222]</td> </tr> <tr> <td>Ra [226]</td> <td>* 89-102</td> <td>* *</td> <td>Actinium 89 Ac [227]</td> <td>Rf [261]</td> <td>Db [262]</td> <td>Sg [263]</td> <td>Bh [264]</td> <td>Hs [265]</td> <td>Mt [266]</td> <td>Uun [271]</td> <td>Uuu [272]</td> <td>Uub [273]</td> <td colspan="5">Uuq [284]</td> </tr> </table>																		Hydrogen 1 H 1.0079																	Helium 2 He 4.0026	Lithium 3 Li 6.941	Beryllium 4 Be 9.0122															Boron 5 B 10.811	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Neon 10 Ne 20.180	Sodium 11 Na 22.990	Magnesium 12 Mg 24.305															Aluminum 13 Al 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 S 32.065	Chlorine 17 Cl 35.453	Argon 18 Ar 39.948	Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.867	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.845	Cobalt 27 Co 58.933	Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.38	Gallium 31 Ga 69.723	Germanium 32 Ge 72.61	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.80	Rubidium 37 Rb 85.468	Sr 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc [98]	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.91	Palladium 46 Pd 106.42	Silver 47 Ag 107.87	Cadmium 48 Cd 112.41	Indium 49 In 114.82	Tin 50 Sn 118.71	Antimony 51 Sb 121.76	Te 127.60	Iodine 53 I 126.90	Xenon 54 Xe 131.29	Cesium 55 Cs 132.91	Ba 137.33	* 57-70	Lanthanum 57 La 138.91	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.95	Tungsten 74 W 183.84	Rhenium 75 Re 186.21	Osmium 76 Os 190.23	Iridium 77 Ir 192.22	Pt 195.08	Au 196.97	Hg 200.59	Tl 204.38	Pb 207.2	Bi 208.98	Po [209]	At [210]	Rn [222]	Ra [226]	* 89-102	* *	Actinium 89 Ac [227]	Rf [261]	Db [262]	Sg [263]	Bh [264]	Hs [265]	Mt [266]	Uun [271]	Uuu [272]	Uub [273]	Uuq [284]				
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* Lanthanide series

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04

* Actinide series

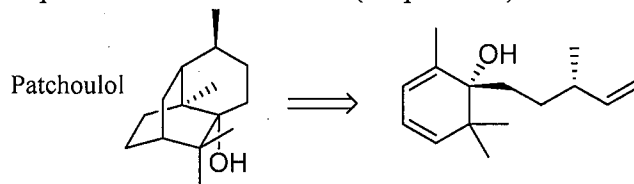
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[259]	[259]

pKa Values

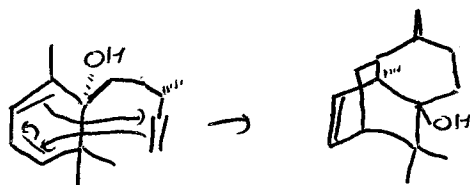
HI	-10	CH ₃ COOH	4.7	ArOH	10	H ₂	35
HBr	-8	HN ₃	4.7	RSH	10-12	NH ₃	36
HCl	-6	H ₂ S	7.0	H ₂ O	15.7	H ₂ C=CH ₂	45
H ₃ O ⁺	-1.7	NH ₄ ⁺	9.3	ROH (R=alkyl)	16-18	CH ₄	60
HF	3.2	HCN	9.4	HC≡CH	26		

Average: 76
 St Dev: 20.4
 Max: 108
 Min: 3

- 1) Patchouli oil, or patchoulol, is responsible for the smell of many types of incense and also hippies. In addition, it is used as a precursor to the chemotherapy drug Taxol. Patchoulol can be synthesized from the precursor shown below. (15 pts total)



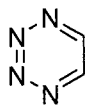
- a. There are two steps in this synthesis: one generates a new ring, and the other changes a functional group. Show the mechanism for the ring formation step. You don't have to show the 3d shape perfectly – just focus on correct connectivity. (10 pts)



- b. What reagents are needed for the second step, to finish converting the precursor to patchoulol? (5 pts)

H_2 & Pd/C

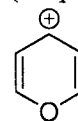
- 2) Describe each of the structures below as aromatic, nonaromatic, or antiaromatic. Assume each structure is planar. In addition, list the hybridization of each heteroatom. (15 pts total)



Aromatic
Each N is sp^2



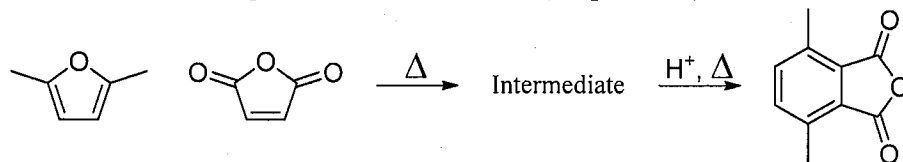
Nonaromatic
O is sp^3



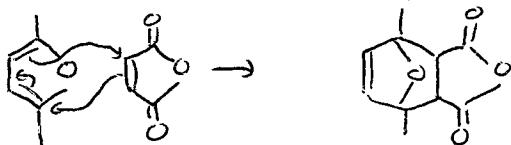
Aromatic
O is sp^2

3 pts per structure
1 pt per heteroatom

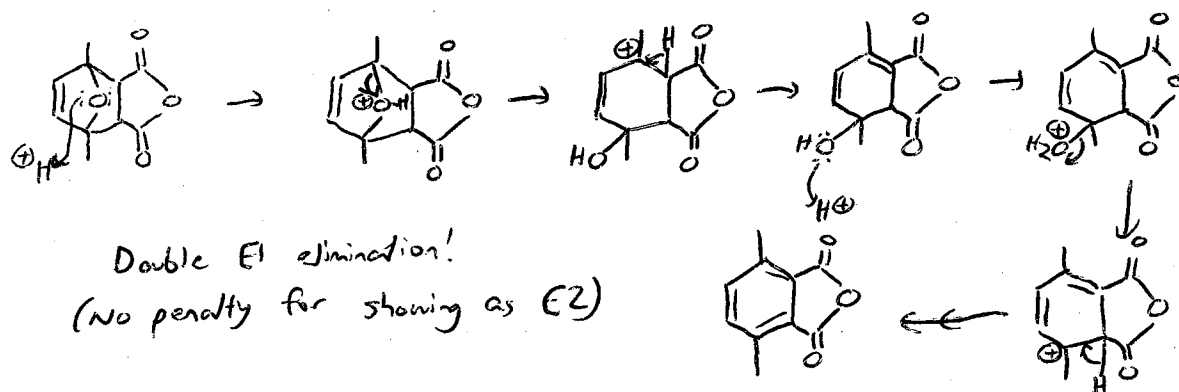
- 3) The reagents shown below react to form an intermediate, which, in the presence of acid, continues on to form the final product shown below. (15 pts total)



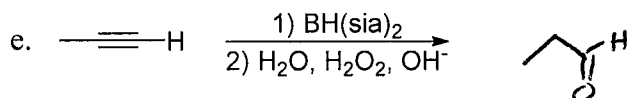
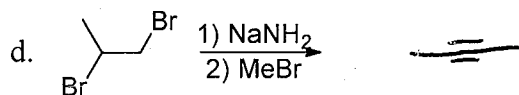
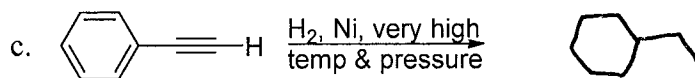
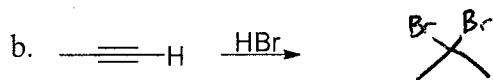
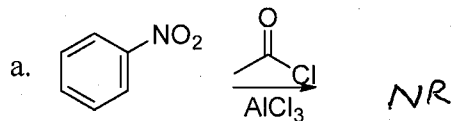
- a. Show the structure of the intermediate, and the mechanism for its formation. (5 pts)



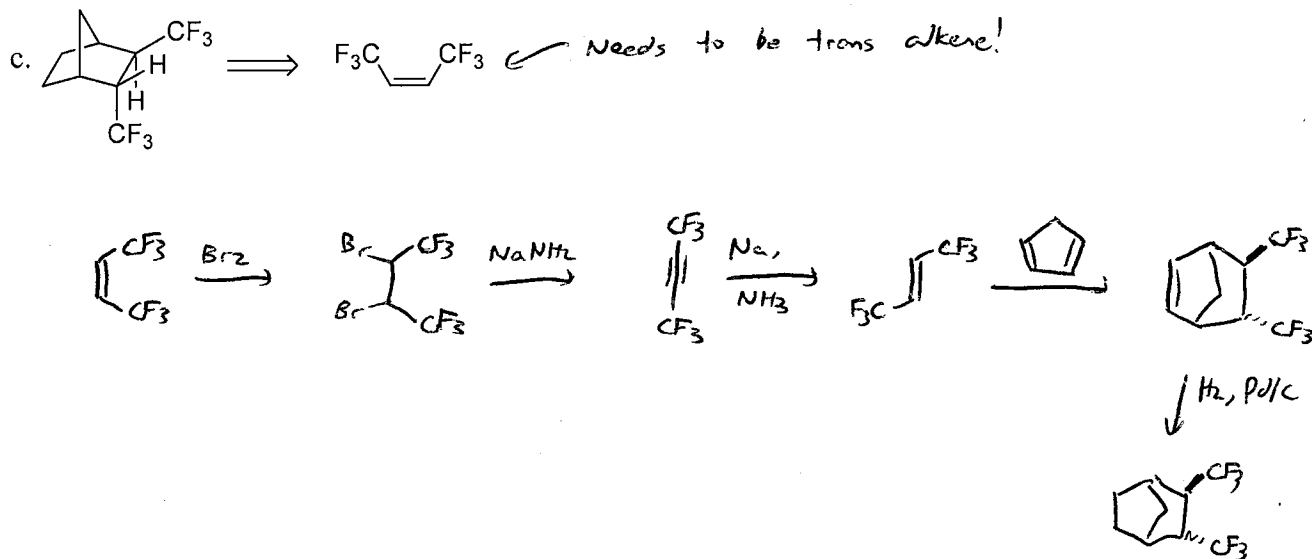
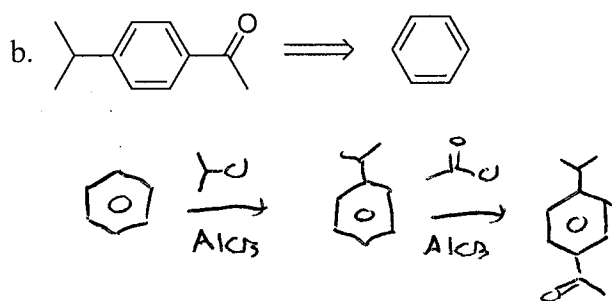
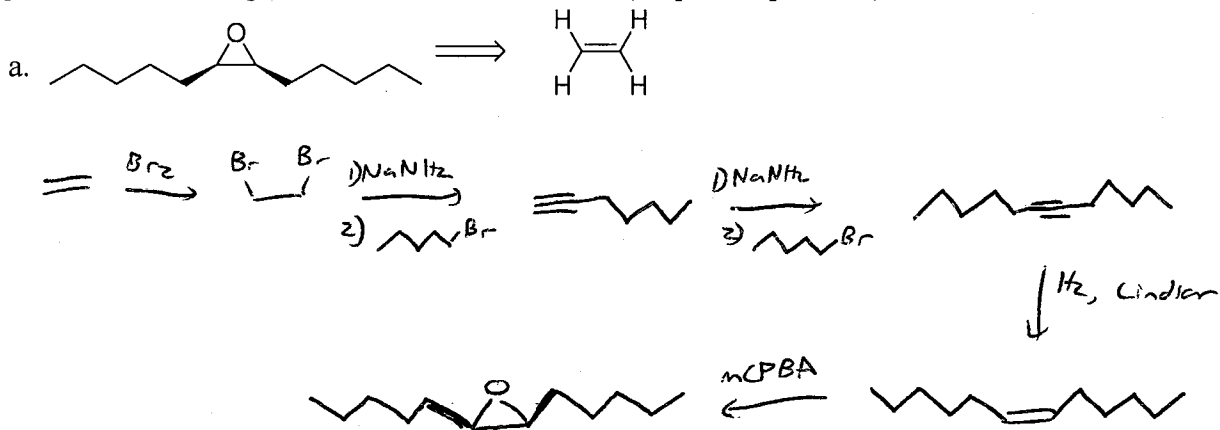
- b. Show the mechanism for the formation of the final product. (10 pts)



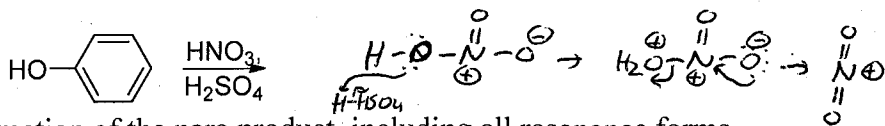
- 4) Predict the major product of the following reactions. If no reaction occurs, then write NR. Show stereochemistry where necessary – if a racemic mixture is formed, you can show only one product and write “racemic” or “rac”. (10 pts; 2 pts each)



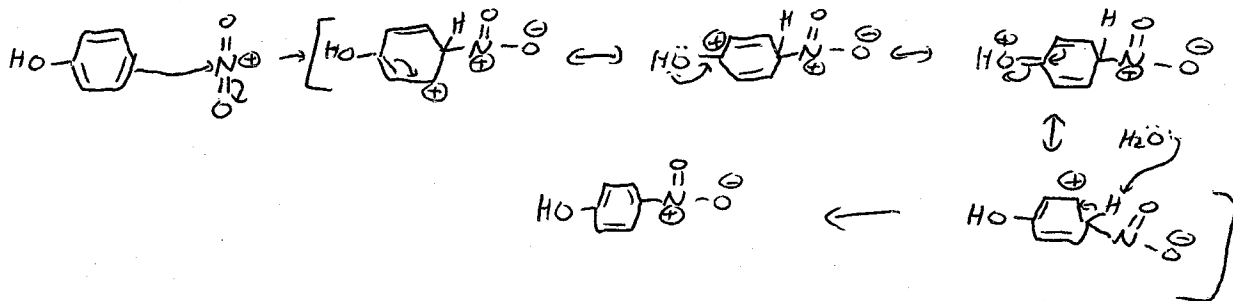
- 5) Find a way to synthesize the desired product from the given starting material(s) and any other reagents containing at most 5 carbon atoms. If more than one step is necessary, show the product of each step. Do not show mechanisms. (30 pts; 10 pts each)



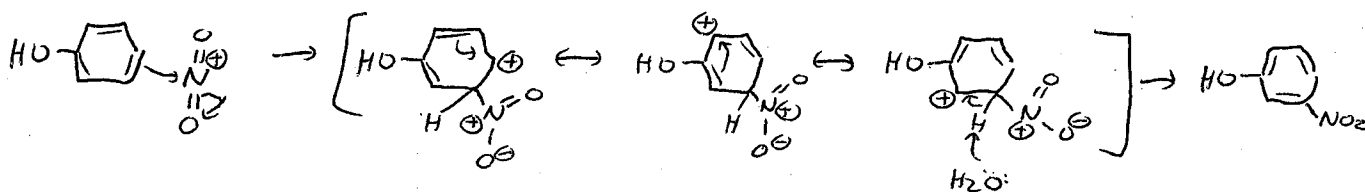
- 6) The reaction shown below could hypothetically produce three isomers – the ortho, meta, and para products. (15 pts)



- a. Show the mechanism for the formation of the para product, including all resonance forms for the intermediate. (5 pts)



- b. Show the mechanism for the formation of the meta product, including all resonance forms for the intermediate. (5 pts)



- c. In twenty words or less, explain which of these outcomes is favored and why. (5 pts)

Para is favored b/c it creates best resonance form, w/ \oplus on oxygen.

- 7) Extra credit! Calicene, shown below, has a surprisingly high dipole moment for a hydrocarbon. Explain why this is true in thirty words or less, and show the dominant resonance form for this molecule. (10 pts e.c.)

