

# CHEM 3331 (Richardson) First Hour Exam – September 20, 2016

Your Name \_\_\_\_\_

Student ID \_\_\_\_\_

- Recitation
- 1:00 Monday w/ Thomas Carey
  - 2:00 Monday w/ Thomas Carey
  - 3:00 Monday w/ Matthew Farmer
  - 9:00 Tuesday w/ Ryan McCaffrey
  - 11:00 Tuesday w/ Ryan McCaffrey
  - 1:00 Tuesday w/ Ryan McCaffrey
  - 2:00 Tuesday w/ Patrick Nordeen
  - 3:00 Tuesday w/ Matthew Farmer

Question	Score	Out of
1		20
2		30
3		30
4		10
5		10
6		10 e.c.
<b>Total</b>		<b>100</b>

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.

hydrogen 1 <b>H</b> 1.0079																		helium 2 <b>He</b> 4.0026	
lithium 3 <b>Li</b> 6.941	beryllium 4 <b>Be</b> 9.0122																		boron 5 <b>B</b> 10.811
sodium 11 <b>Na</b> 22.990	magnesium 12 <b>Mg</b> 24.305																		carbon 6 <b>C</b> 12.011
potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078																		nitrogen 7 <b>N</b> 14.007
rubidium 37 <b>Rb</b> 85.468	strontium 38 <b>Sr</b> 87.62																		oxygen 8 <b>O</b> 15.999
cesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33																		fluorine 9 <b>F</b> 18.998
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]																		neon 10 <b>Ne</b> 20.180
																			aluminum 13 <b>Al</b> 26.982
																			silicon 14 <b>Si</b> 28.086
																			phosphorus 15 <b>P</b> 30.974
																			sulfur 16 <b>S</b> 32.065
																			chlorine 17 <b>Cl</b> 35.453
																			argon 18 <b>Ar</b> 39.948
																			germanium 32 <b>Ge</b> 72.61
																			arsenic 33 <b>As</b> 74.922
																			selenium 34 <b>Se</b> 78.96
																			iodine 53 <b>I</b> 126.90
																			tin 50 <b>Sn</b> 118.71
																			antimony 51 <b>Sb</b> 121.76
																			tellurium 52 <b>Te</b> 127.60
																			lead 82 <b>Pb</b> 208.28
																			bismuth 83 <b>Bi</b> 208.98
																			polonium 84 <b>Po</b> [209]
																			astatine 85 <b>At</b> [210]
																			thallium 81 <b>Tl</b> 204.38
																			mercury 80 <b>Hg</b> 200.59
																			gold 79 <b>Au</b> 196.97
																			platinum 78 <b>Pt</b> 195.08
																			silver 47 <b>Ag</b> 107.87
																			cadmium 48 <b>Cd</b> 112.41
																			indium 49 <b>In</b> 114.82
																			zinc 30 <b>Zn</b> 65.39
																			gallium 31 <b>Ga</b> 69.723
																			iron 26 <b>Fe</b> 55.845
																			nickel 28 <b>Ni</b> 58.693
																			cobalt 27 <b>Co</b> 58.933
																			rhodium 45 <b>Rh</b> 101.07
																			technetium 43 <b>Tc</b> [98]
																			niobium 41 <b>Nb</b> 92.906
																			zirconium 40 <b>Zr</b> 91.224
																			yttrium 39 <b>Y</b> 88.906
																			vanadium 23 <b>V</b> 50.942
																			chromium 24 <b>Cr</b> 51.996
																			iron 26 <b>Fe</b> 55.845
																			osmium 76 <b>Os</b> 190.23
																			iridium 77 <b>Ir</b> 192.22
																			platinum 78 <b>Pt</b> 195.08
																			gold 79 <b>Au</b> 196.97
																			mercury 80 <b>Hg</b> 200.59
																			thallium 81 <b>Tl</b> 204.38
																			lead 82 <b>Pb</b> 208.28
																			unquadrium 114 <b>Uuq</b> [289]
																			unnilquadium 110 <b>Uun</b> [271]
																			ununium 111 <b>Uuu</b> [272]
																			unbibium 112 <b>Uub</b> [277]

\* Lanthanide series

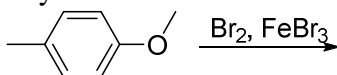
lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [145]	samarium 62 <b>Sm</b> 150.36	europium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium 67 <b>Ho</b> 164.93	erbium 68 <b>Er</b> 167.26	thulium 69 <b>Tm</b> 168.93	ytterbium 70 <b>Yb</b> 173.04
actinium 89 <b>Ac</b> [227]	thorium 90 <b>Th</b> 232.04	protactinium 91 <b>Pa</b> 231.04	uranium 92 <b>U</b> 238.03	neptunium 93 <b>Np</b> [237]	plutonium 94 <b>Pu</b> [244]	americium 95 <b>Am</b> [243]	curium 96 <b>Cm</b> [247]	berkelium 97 <b>Bk</b> [247]	californium 98 <b>Cf</b> [251]	einsteinium 99 <b>Es</b> [252]	fermium 100 <b>Fm</b> [257]	mendelevium 101 <b>Md</b> [258]	nobelium 102 <b>No</b> [259]

\*\* Actinide series

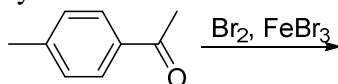
## pKa Values

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

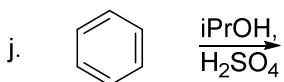
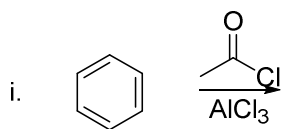
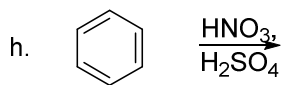
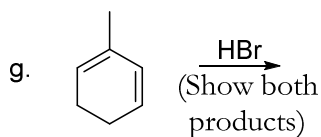
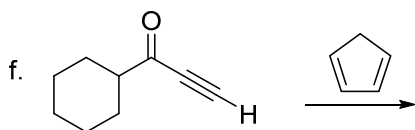
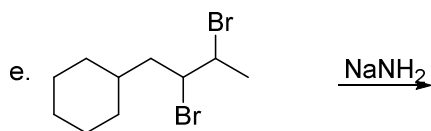
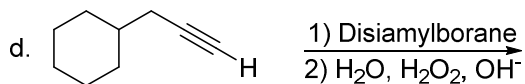
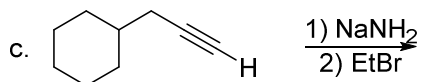
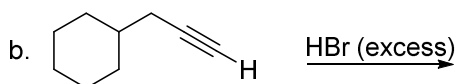
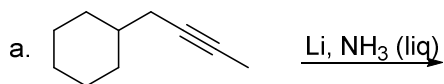
- 1) The directing effects of groups during electrophilic aromatic substitution reactions can be explained by resonance. (20 pts; 10 pts each)
- a. The reaction below produces a single isomer as the major product. Show the mechanism for its formation, including all resonance forms for the intermediate. In thirty words or less, explain the regiochemistry of this reaction.



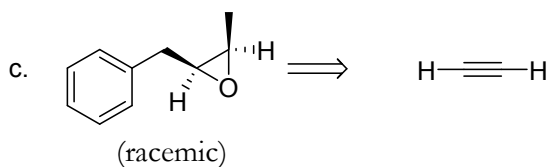
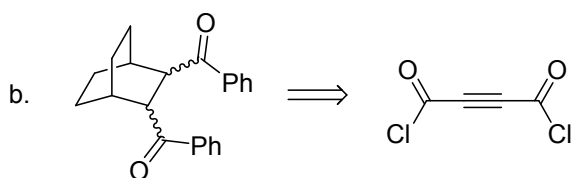
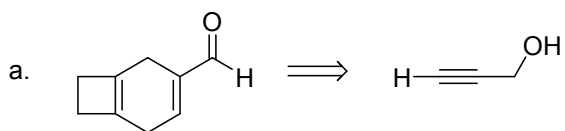
- b. The reaction below produces a single isomer as the major product. Show the mechanism for its formation, including all resonance forms for the intermediate. In thirty words or less, explain the regiochemistry of this reaction.



2) 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”. (30 pts; 3 pts each)



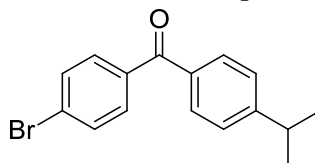
- 3) Find a way to synthesize the desired product from the given starting material. (Remember that the retrosynthesis arrow points from reactants to products! Also remember squiggly bonds mean that either bold or dashed bonds are okay.) If more than one step is necessary, show the product of each step. Do not show mechanisms. (30 pts; 10 pts each)



- 4) One of these reactions occurs much more rapidly than the other. Determine which reaction is faster and explain why in thirty words or less, plus whatever structures are necessary. (10 pts)



- 5) Show two ways this compound could be synthesized via a Friedel-Crafts reaction. Which of the two methods is likely to be a faster reaction? (10 pts)



- 6) Extra credit! Arrange each of the following groups of compounds in order of decreasing reactivity towards electrophilic aromatic substitution. Show the product(s) for each of them reacting with  $\text{CH}_3\text{Cl}$  and  $\text{AlCl}_3$ , or write NR if no reaction occurs. (10 pts e.c.)  
1,3-dinitrobenzene, toluene, anisole, chlorobenzene, nitrobenzene