

**CHEM3471/3491, Professor M. Walczak, Fall 2018**  
**Final exam – December 19, 2018, 1.30-4.00 PM**

Printed Name: \_\_\_\_\_

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

Recitation TA: \_\_\_\_\_

Recitation Day and Time: \_\_\_\_\_

Signature: \_\_\_\_\_

1. \_\_\_\_\_ / 30
2. \_\_\_\_\_ / 35
3. \_\_\_\_\_ / 20
4. \_\_\_\_\_ / 40
5. \_\_\_\_\_ / 40
6. \_\_\_\_\_ / 35

This is a closed-book exam. You are not allowed to use molecular models, lecture notes, personal class notes, textbooks, and electronic copies of the above materials on mobile devices. Use the backs of the pages for scratch notes.

**Honor Code:** All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion).

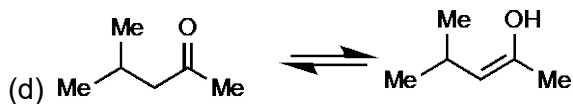
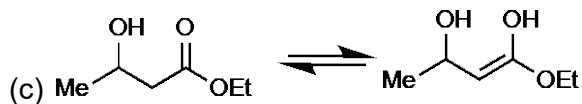
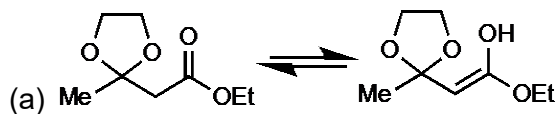
Total: \_\_\_\_\_ / 200

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	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.007	oxygen 8 <b>O</b> 15.999	fluorine 9 <b>F</b> 18.998	neon 10 <b>Ne</b> 20.180	
sodium 11 <b>Na</b> 22.990	magnesium 12 <b>Mg</b> 24.305											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	
potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078	scandium 21 <b>Sc</b> 44.956	titanium 22 <b>Ti</b> 47.867	vanadium 23 <b>V</b> 50.942	chromium 24 <b>Cr</b> 51.996	manganese 25 <b>Mn</b> 54.938	iron 26 <b>Fe</b> 55.845	cobalt 27 <b>Co</b> 58.933	nickel 28 <b>Ni</b> 58.693	copper 29 <b>Cu</b> 63.546	zinc 30 <b>Zn</b> 65.38	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selecnium 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	krypton 36 <b>Kr</b> 83.80	
rubidium 37 <b>Rb</b> 85.468	strontium 38 <b>Sr</b> 87.62	yttrium 39 <b>Y</b> 88.906	zirconium 40 <b>Zr</b> 91.224	niobium 41 <b>Nb</b> 92.906	molybdenum 42 <b>Mo</b> 95.94	technetium 43 <b>Tc</b> [98]	ruthenium 44 <b>Ru</b> 101.07	rhodium 45 <b>Rh</b> 102.91	palladium 46 <b>Pd</b> 106.42	silver 47 <b>Ag</b> 107.87	cadmium 48 <b>Cd</b> 112.41	indium 49 <b>In</b> 114.82	tin 50 <b>Sn</b> 118.71	antimony 51 <b>Sb</b> 121.76	tellurium 52 <b>Te</b> 127.60	iodine 53 <b>I</b> 126.905	xenon 54 <b>Xe</b> 131.29	
cesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33	* 57-70	lanthanum 57 <b>La</b> 138.905	hafnium 58 <b>Hf</b> 140.907	tantalum 59 <b>Ta</b> 140.907	wolfram 60 <b>W</b> 140.907	reuterium 61 <b>Re</b> 140.907	osmium 62 <b>Os</b> 140.907	iridium 63 <b>Ir</b> 140.907	platinum 64 <b>Pt</b> 140.907	gold 65 <b>Au</b> 140.907	mercury 66 <b>Hg</b> 140.907	thallium 67 <b>Tl</b> 140.907	lead 68 <b>Pb</b> 140.907	bismuth 69 <b>Bi</b> 140.907	polonium 70 <b>Po</b> [209]	astatine 71 <b>At</b> [210]	radon 72 <b>Rn</b> [222]
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]	* *	actinium 89 <b>Ac</b> [227]	thorium 90 <b>Th</b> [232]	protactinium 91 <b>Pa</b> [231]	uranium 92 <b>U</b> [238]	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]	esboium 99 <b>Es</b> [252]	fermium 100 <b>Fm</b> [257]	mendelevium 101 <b>Md</b> [258]	nobelium 102 <b>No</b> [259]		

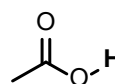
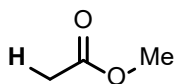
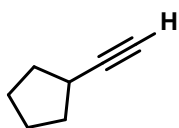
\* Lanthanide series

\*\* Actinide series

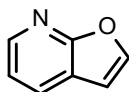
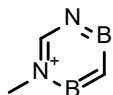
1.  
 (a) Which of the following compounds will exist predominantly in an enol form (5 points)?



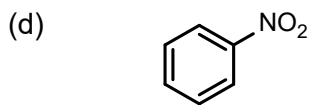
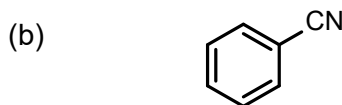
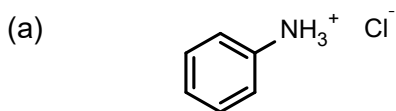
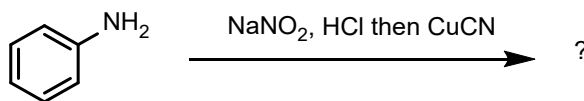
- (b) Provide approximate pKa values of the circled protons ( $\pm$ pKa 2 units) (5 points each, 15 points total).



- (c) Which of the following compounds are aromatic? Please circle only the correct answer(s) (5 points).

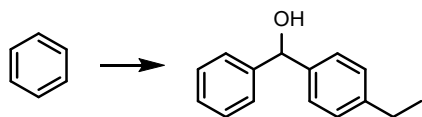


- (d) For the following reaction, predict the major product (5 points):

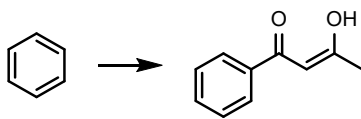


2. Propose the best syntheses of the following two compounds using the starting materials provided below. More than one step may be required to complete the synthesis (35 points).

(a) (20 points)

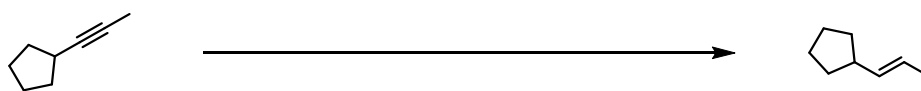


(b) (15 points)

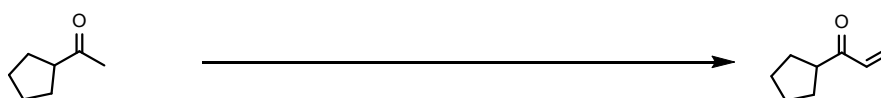


3. Complete the following short syntheses (one or two steps) using any reagents you need. You do not have to show the synthesis of the reagents you use, but you must use the starting material indicated (5 points, 20 points total).

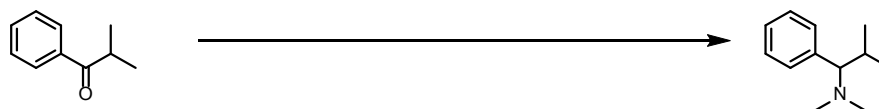
(a)



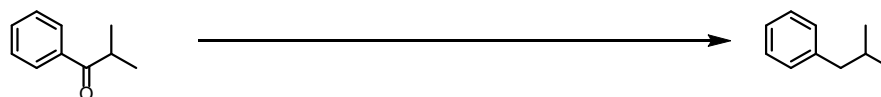
(b)



(c)

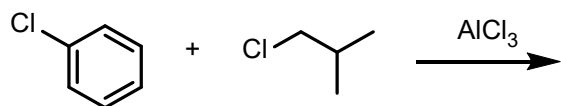


(d)

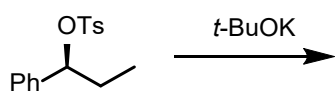


4. Provide the products of the following reactions (all reactions have an appropriate aqueous work up). If no reaction would occur, write NR. Ignore stereochemistry in the products unless otherwise indicated (4 points each, 40 points total).

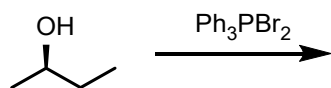
(a)



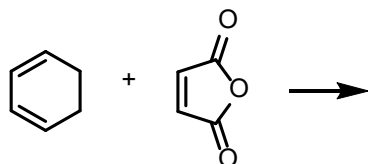
(b)



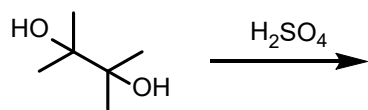
(c)



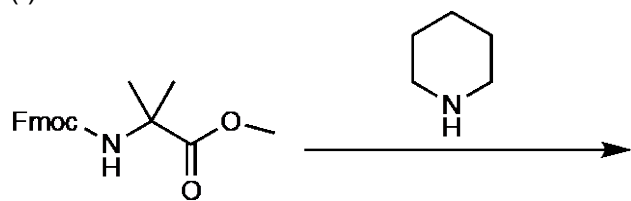
(d)



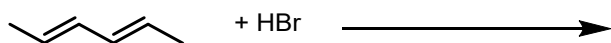
(e)



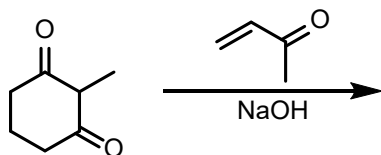
(f)



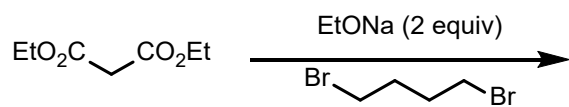
(g)



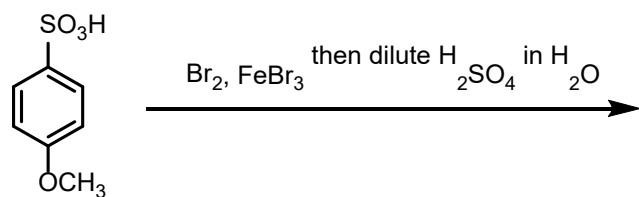
(h)



(i)

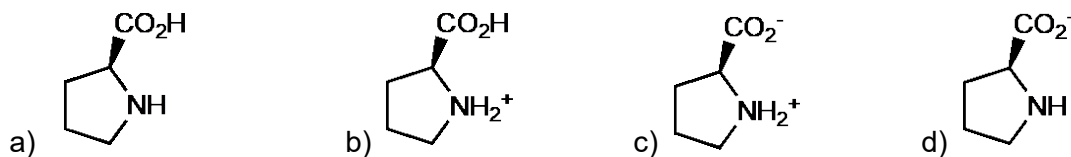


(j)

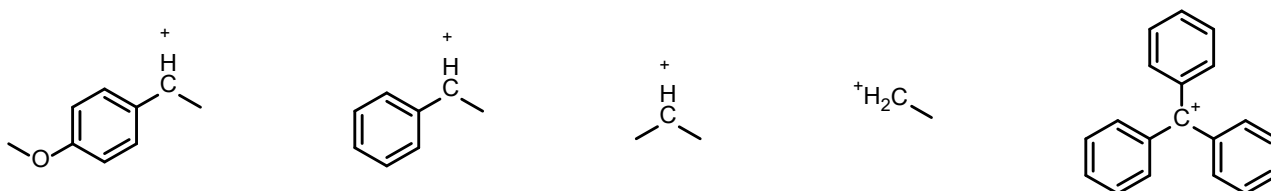


5. Please circle only the correct answer in each question (40 points total).

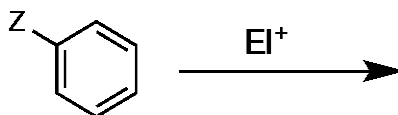
i) At pH 13, the most likely structure of proline is (10 points):



ii) Rank the following carbocation based on their stability (most stable as number 1, least stable as number 5).



iii) Label the following groups as activating or deactivating and ortho / para or meta directors in electrophilic aromatic substitution (20 points).



Z = NO <sub>2</sub>	Activating or deactivating?	Ortho / para or meta directing?
Z = CN	Activating or deactivating?	Ortho / para or meta directing?
Z = N(CH <sub>3</sub> ) <sub>2</sub>	Activating or deactivating?	Ortho / para or meta directing?
Z = CO <sub>2</sub> CH <sub>3</sub>	Activating or deactivating?	Ortho / para or meta directing?
Z = N(CH <sub>3</sub> ) <sub>3</sub> <sup>+</sup>	Activating or deactivating?	Ortho / para or meta directing?



6. Draw a reasonable mechanism of the following reaction (35 points).

