

# CHEM 3471/3491, Professor M. Walczak, Fall 2018

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

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

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

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

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

1. \_\_\_\_\_ / 20

2. \_\_\_\_\_ / 20

3. \_\_\_\_\_ / 20

4. \_\_\_\_\_ / 25

5. \_\_\_\_\_ / 15

Total: \_\_\_\_\_ / 100

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).

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> 65.39	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selenium 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> 101.07	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> 126.90	xenon 54 <b>Xe</b> 131.29						
cesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33	57-70 *	lutetium 71 <b>Lu</b> 174.97	holmium 72 <b>Hf</b> 178.49	tantalum 73 <b>Ta</b> 180.95	tungsten 74 <b>W</b> 183.84	rhenium 75 <b>Re</b> 186.21	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> 207.2	bismuth 83 <b>Bi</b> 208.98	polonium 84 <b>Po</b> [209]	astatine 85 <b>At</b> [210]	radon 86 <b>Rn</b> [222]					
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]	89-102 **	lawrencium 103 <b>Lr</b> [262]	rutherfordium 104 <b>Rf</b> [261]	dubnium 105 <b>Db</b> [262]	seaborgium 106 <b>Sg</b> [269]	bohrium 107 <b>Bh</b> [264]	hassium 108 <b>Hs</b> [265]	meitnerium 109 <b>Mt</b> [269]	unnilium 110 <b>Uun</b> [271]	ununium 111 <b>Uuu</b> [273]	unbinium 112 <b>Uub</b> [277]	unquadium 114 <b>Uuq</b> [289]										

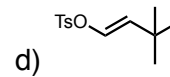
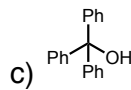
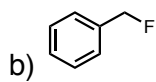
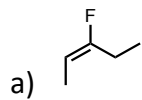
\* Lanthanide series

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
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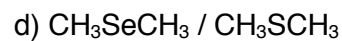
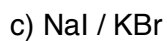
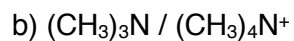
\*\* Actinide series

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]
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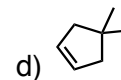
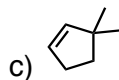
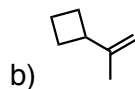
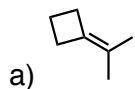
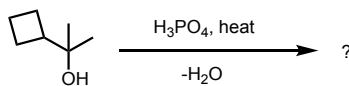
1.  
 (a) Please circle only those compounds that do not form a stable carbocation. (8 points)



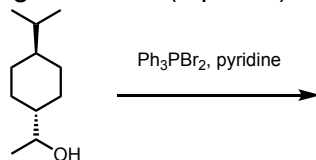
(b) Among the pairs of compounds, please circle only the one that is a better nucleophile in an S<sub>N</sub>2 reaction. (8 points, 2 points each)



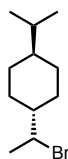
(c) What is the major product of the following reaction? (2 points)



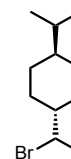
(d) What is the major product of the following reaction? (2 points)



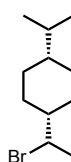
(a)



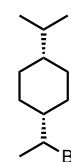
(b)



(c)

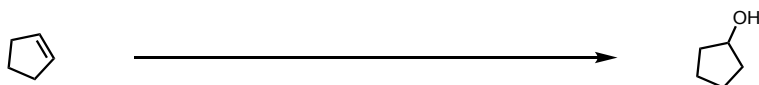


(d)

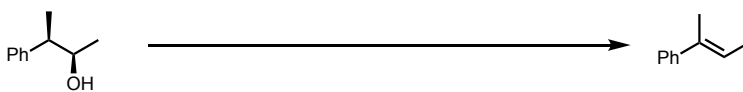


2. Which reagents will accomplish the following transformations? Assume that each reaction was finished by quenching with water (aqueous work-up). Please note that more than one step may be necessary. (4 points each, 20 points total)

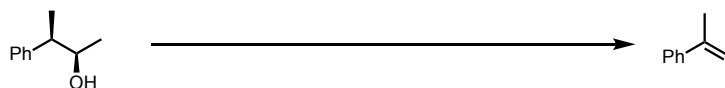
(a)



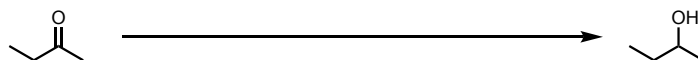
(b)



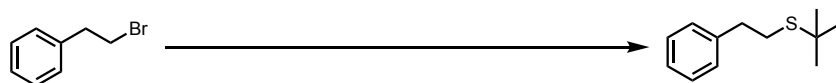
(c)



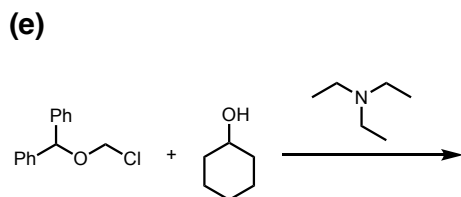
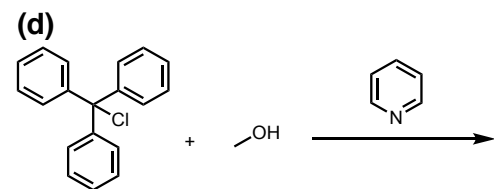
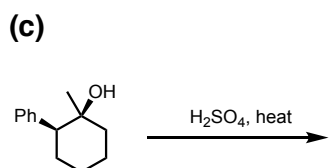
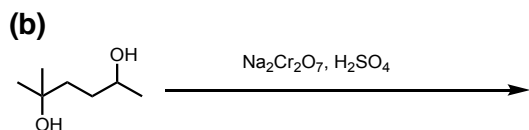
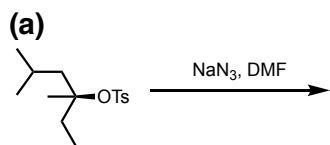
(d)



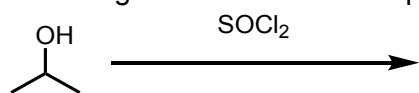
(e)



3. What are the organic products in the following reactions? If you expect to obtain a mixture of isomers, indicate the major product. You may skip the structures of all inorganic by-products. (4 points each, 20 points total)

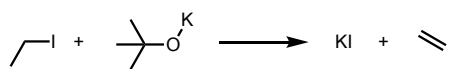


4. Please provide all the products of the following reaction and draw a plausible mechanism. (25 points)



5. In the following questions, please circle only the correct answer(s): (3 points each, 15 points total)

(a) The expected reaction rate of the following transformation can be written as:

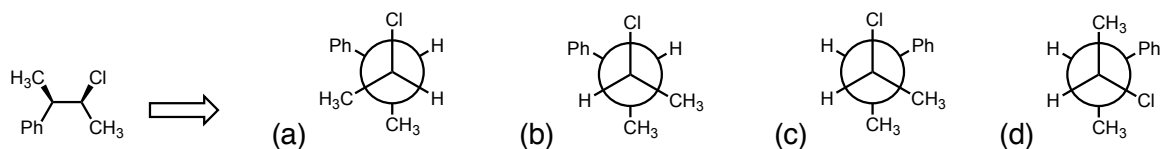


(a) rate =  $k[\text{CH}_3\text{CHI}]$  (b) rate =  $k[\text{CH}_3\text{CH}_2\text{I}][\text{DMF}]$  (c) rate =  $k[\text{CH}_3\text{CH}_2\text{I}][\text{tBuOK}]$  (d) rate =  $k[\text{CH}_3\text{CH}_2\text{I}]^2$

(e) rate =  $k[\text{CH}_3\text{CH}_2\text{I}]^{1/2}$  (f) rate =  $k[\text{tBuOK}]$

where  $k$  is the rate constant.

(b) What is the correct Newman projection of the following molecule?



(c) Which of the following solvents is least suitable for  $\text{S}_{\text{N}}1$  reactions?

(a) DMF (b) DMSO (c) benzene (d) acetone (e)  $(\text{CH}_3\text{CH}_2)_2\text{O}$

(d) Which compound(s) is not a suitable substrate for elimination reactions with KOH (assume that this reaction proceeds via an E2 mechanism)?



(e) What is the expected product of the following reaction?

