NAME ________________________

ID # ________________________

ORGANIC CHEMISTRY I (2301)

9:05 – 9:55 am, October 29, 2014

Exam 2

If you want to pick this exam up on Friday in class (in public), please check the box on the right: ☐

If you do not check the box, I will not bring your exam to class on Friday, and you will need to pick up your exam in private from Chemistry department staff in 115 Smith beginning Friday, October 31st, after 3:00 pm. Exams that are not picked up within two weeks will be disposed of.

A periodic table is attached to the back of this exam as an aid. Otherwise, you are not permitted to use any other materials (including notes, books, or electronic devices of any kind).

Right now, write your name and student ID number at the top of this page. When the exam begins, please write your name at the top of the next page.

You may use pen or pencil. However, re-grades will be considered only for exams completed in pen.

Please write your answers in the boxes/spaces provided. If your answer is not in the appropriate space (say, for example, it's on the back of the page), draw us an arrow and/or note telling us where to look.

NAME ________________________

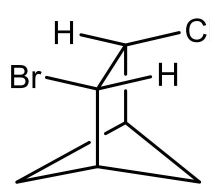
Scoring: 1. _________ / 12 4. _________ / 10

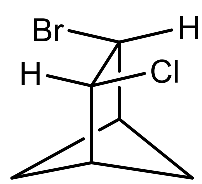
2. _________ / 19 5. _________ / 24

3. _________ / 20 6. _________ / 15

Total Score: _________ / 100

1. (12 pts) How would you describe the relationship between each of the pairs of structures below? Are they enantiomers or diastereomers, or are they just two ways of illustrating the same molecule? **Circle one answer** for each pair**.**





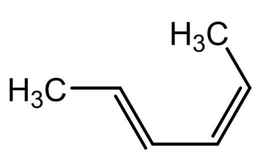
ENANTIOMERS

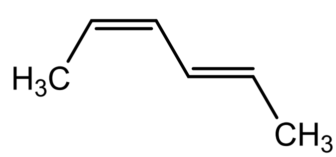
or

DIASTEREOMERS

or

SAME MOLECULE





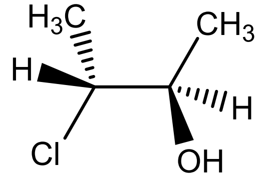
ENANTIOMERS

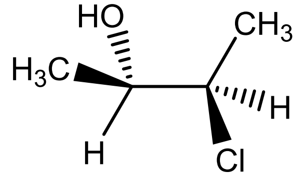
or

DIASTEREOMERS

or

SAME MOLECULE





ENANTIOMERS

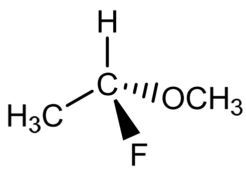
or

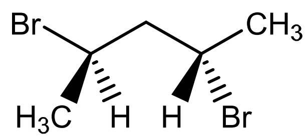
DIASTEREOMERS

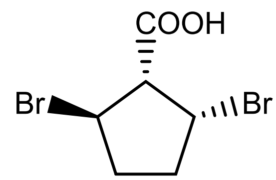
or

SAME MOLECULE

2. (19 pts) On the structures below, **label each chiral center** with its appropriate Cahn-Ingold-Prelog designation [(*R*) or (*S*)]. Make it clear which atom in the drawing you are labeling. Then, for each structure, **circle** whether you think the molecule is chiral or achiral.

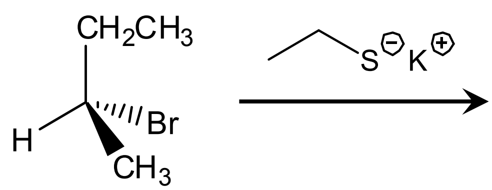




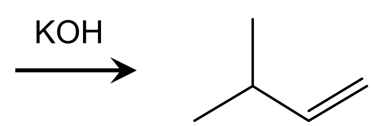


CHIRAL	**CHIRAL**	**CHIRAL**
or	*or*	*or*
ACHIRAL ?	**ACHIRAL** ?	**ACHIRAL** ?

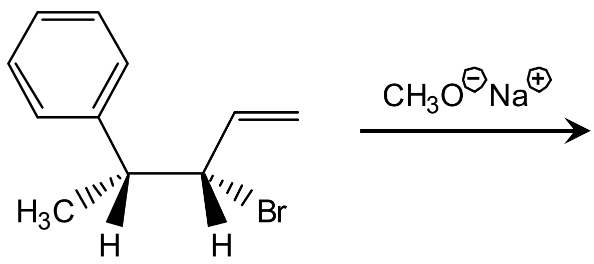
3. (20 pts) Draw the missing reactant or product in the empty boxes. For products, give the predominant, most favored product. Illustrate stereochemistry in your answer where appropriate. For reactions that yield multiple enantiomers, draw only one enantiomer in the box, and include the note "+ enantiomer".

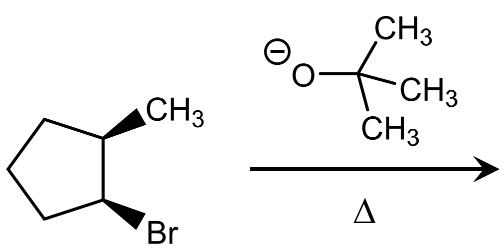


an alkyl halide

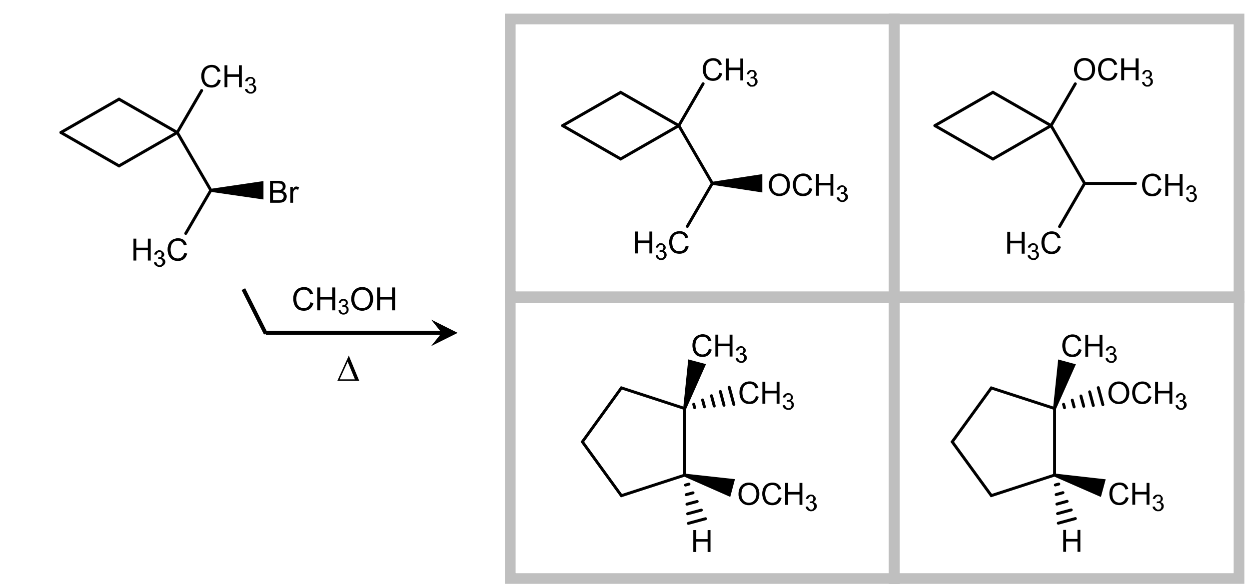


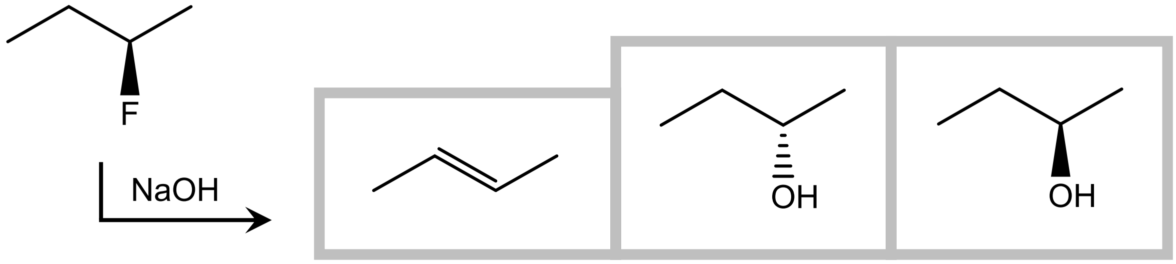
(as the major product)



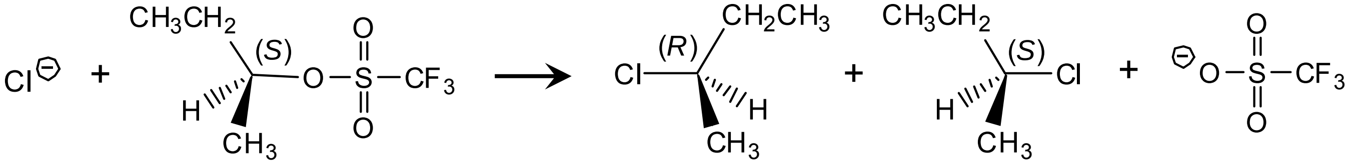


4. (10 pts) For each reaction shown below, **circle all potential products**. Keep in mind that, for each case, you might circle one, multiple, or no molecules.





5. (24 pts) The triflate group ($CF_3SO_3^-$) is such a good leaving group that alkyl triflates will undergo nucleophilic substitution reactions even with poor nucleophiles, such as chloride ions.



[α] = -23°
(rotates polarized light ***counterclockwise****)*

[α] = +23°
(rotates polarized light ***clockwise****)*

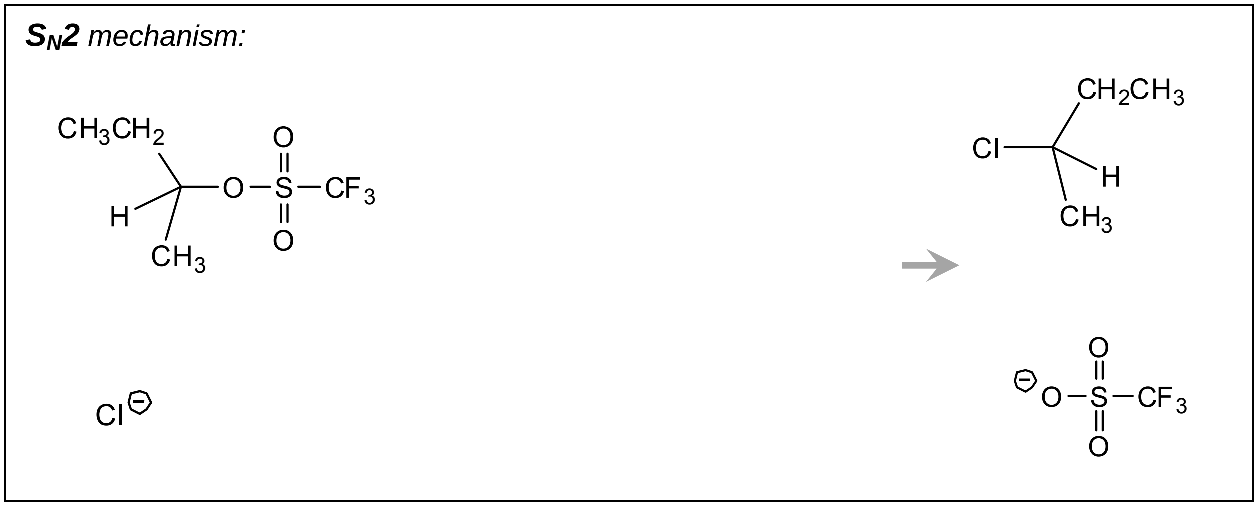
For the reaction of the triflate shown above, both S_N1 and S_N2 mechanisms occur, and some of each product enantiomer would be generated. We'll assume that the rates of S_N1 and S_N2 reactions are exactly equal.

a. In the boxes below, draw mechanisms that explain how the products above are generated from starting materials via S_N1 and S_N2 reactions. In your answer, make sure that you:

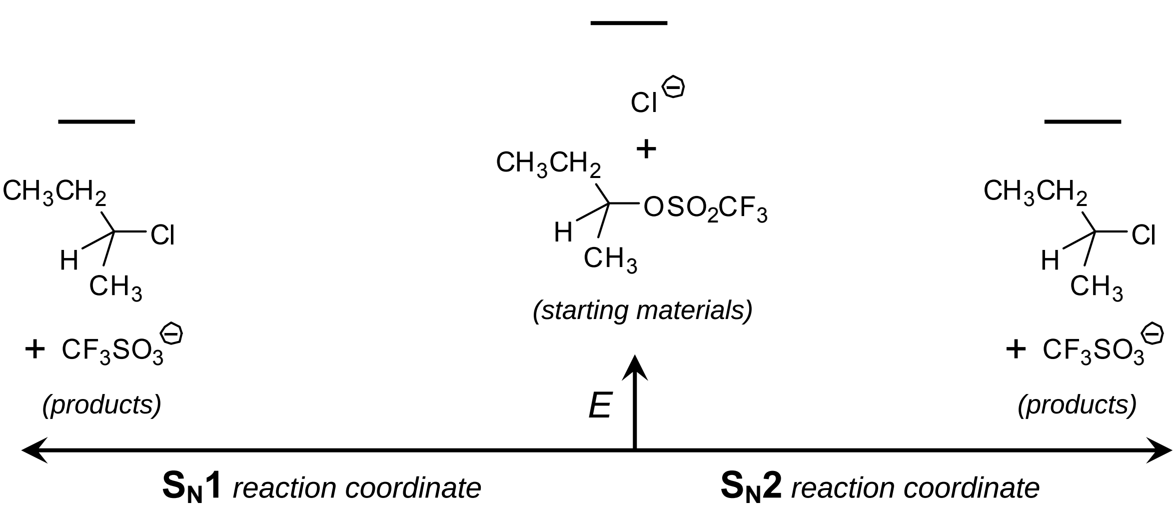
- Draw each step of the mechanism separately;
- Use "electron pushing" to show where the electrons in each step go;
- Use only the molecules that you are given.

Feel free to add arrows, any necessary electron pairs, and intermediates directly to my drawings. Ignore stereochemistry for this part of the problem.

S_N1 *mechanism:*



b. On the diagram below, draw potential energy curves for these two mechanisms. (I have already drawn the energies of starting materials and products; you need to connect them with curves. You do *not* need to draw transition-state structures.) Make sure your curves illustrate the relative energies of the rate-determining transition states for the two mechanisms.



c. Once the reaction is complete, and all the starting material has been converted to products, would the product mixture rotate plane-polarized light? If so, in which direction? (Circle one answer on the next page.)

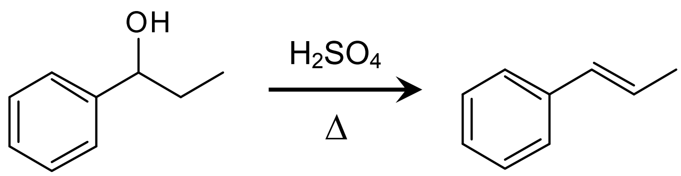
The product mixture rotates polarized light **CLOCKWISE**	The product mixture rotates polarized light **COUNTERCLOCKWISE**	The product mixture **DOES NOT ROTATE** polarized light

d. What would happen if iodide (I^-) were used as the nucleophile instead of chloride? Would the stereoselectivity of the total reaction—that is, the preference for one product enantiomer over the other,

INCREASE , **DECREASE** , *or* **STAY THE SAME** ?

6. (15 pts) For the reaction shown below, draw a mechanism that explains how the product is generated from the starting material. In your answer, make sure that you:

- Draw each step of the mechanism separately;
- Use "electron pushing" to show where the electrons in each step go;
- Use only the molecules that you are given; do not invoke reactants or solvents that aren't in the problem.



Chemistry Reference Sheet

Key

11	Atomic number
Na	Element symbol
Sodium	Element name
22.99	Average atomic mass*

Period	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** Hydrogen 1.01																	2 **He** Helium 4.00
2	3 **Li** Lithium 6.94	4 **Be** Beryllium 9.01											5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
3	11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31											13 **Al** Aluminum 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.07	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
4	19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.87	23 **V** Vanadium 50.94	24 **Cr** Chromium 52.00	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93	28 **Ni** Nickel 58.69	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92	34 **Se** Selenium 78.96	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
5	37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.91	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.87	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.76	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90	54 **Xe** Xenon 131.29
6	55 **Cs** Cesium 132.91	56 **Ba** Barium 137.33	57 **La** Lanthanum 138.91	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.95	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.21	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.08	79 **Au** Gold 196.97	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
7	87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (266)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (269)	109 **Mt** Meitnerium (268)									

58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.91	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.93	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.97
90 **Th** Thorium 232.04	91 **Pa** Protactinium 231.04	92 **U** Uranium 238.03	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.