Fall 2021 **Chemistry 2600 Midterm #2** ____/56 marks

Confidentiality Agreement:
I agree not to discuss (or in any other way divulge) the contents of this exam until after 8:30pm Mountain Time on Thursday, November 18th, 2021. I understand that breaking this agreement would constitute academic misconduct. The minimum penalty would be a mark of 0/56 on this exam.

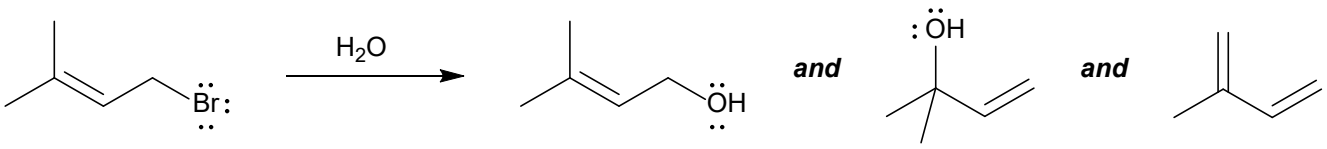
Signature: _____ Date: _____

1) Please read the test carefully before starting. It has 8 pages of questions and a periodic table.
2) You have been given a 6-page Spectroscopy Data Package. **PLEASE DO NOT WRITE ON THE SPECTROSCOPY DATA PACKAGE**! If you need scrap paper/extra space, use the back of any test page.
3) You may use a molecular model kit and ruler. You may not have written materials in your model kit.
4) You may use a calculator but only for calculation. No other electronic devices are allowed.
5) **DO NOT WRITE ON ANY QR CODE!!!** Work on pages without a QR code will not be graded.
6) If your work is not legible, it will be given a mark of zero. For full credit, explanations must be complete. In many cases, complete explanations include drawing relevant structures. If delocalization of electrons is invoked, the relevant resonance structures must be drawn.
7) Marks will be deducted for incorrect information added to an otherwise correct answer.
8) You have 2 hours to complete this test.

Question Breakdown

Q1	**Q2**	**Q3**	**Q4**	**Q5**									**Total**
/ 20	/ 6	/ 6	/ 14	/ 10									/ 56

1. A student adds water to 1-bromo-3-methyl-2-butene and observes three products: **[20 marks]**

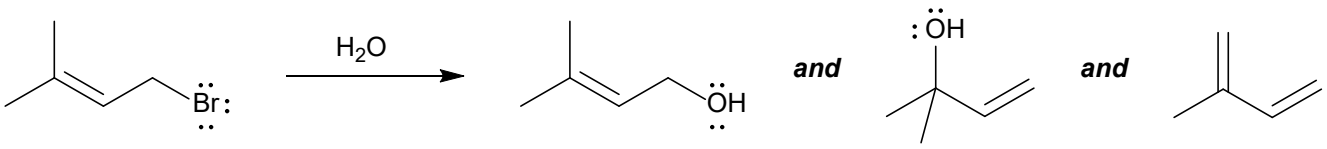


(a) For each product: *[14 marks]*

- Classify the reaction giving that product as S_N1, S_N2, E1 or E2, and
- Use curved arrows to show the mechanism for its formation.

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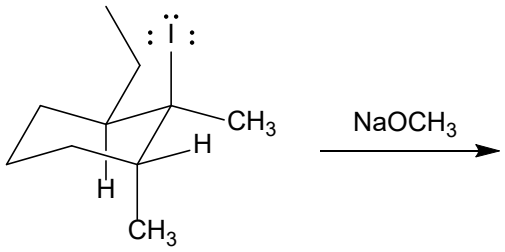
1. *…continued from previous page*



(b) Briefly explain how you could use ^{1}H NMR to distinguish between the three products. *[3 marks]*
It is not necessary to provide complete descriptions of the spectra. Identify key differences between them.

(c) Briefly explain how you could use ^{13}C NMR to distinguish between the three products. *[3 marks]*
It is not necessary to provide complete descriptions of the spectra. Identify key differences between them.

2. Consider the following reaction mixture: **[6 marks]**



Two organic products are possible if the reaction proceeds according to an E2 mechanism. Draw both. Clearly label the major product, and briefly explain why it is favoured (especially at high temperatures).

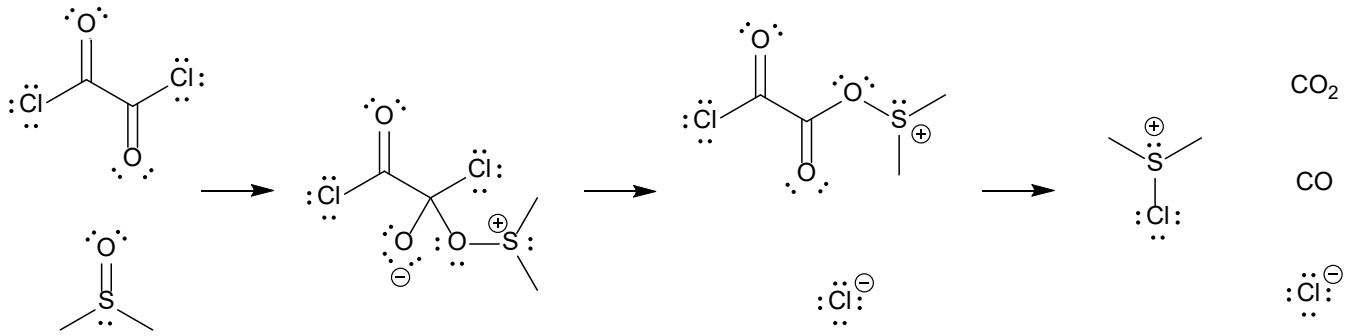
3. Use the data provided in the table below to determine whether the reaction between the alkyl chloride (RCl) and base proceeds via E1 or E2 mechanism. **[6 marks]**

For full marks, your answer must include the rate law for this reaction including a numerical value and units for k. It must also include a brief verbal explanation of your choice between E1 and E2.

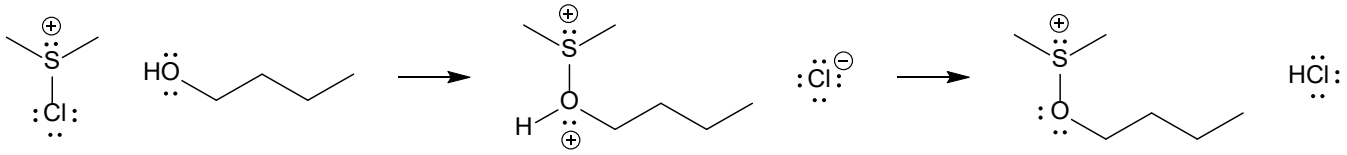
$[RCl]$ $\left(\frac{mol}{L}\right)$	$[base]$ $\left(\frac{mol}{L}\right)$	Rate of reaction $\left(\frac{mol}{L \cdot s}\right)$
0.030	0.030	0.072
0.030	0.060	0.144
0.045	0.045	0.162
0.045	0.060	0.216

4. The Swern oxidation is an effective (if smelly) method of oxidizing alcohols. **[14 marks]**

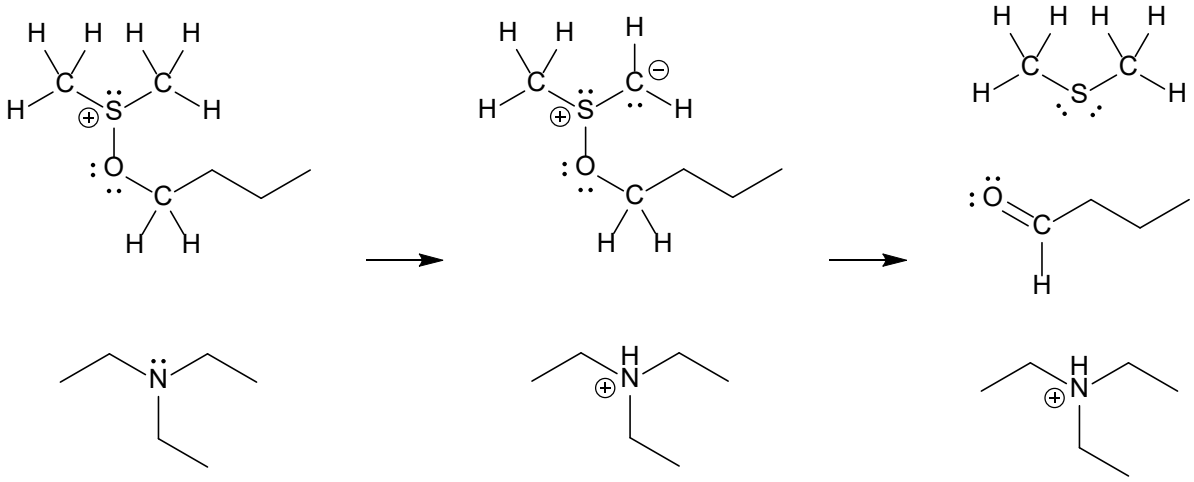
In the first step of a Swern oxidation, dimethyl sulfoxide and oxalyl chloride are combined at low temperature:



In the second step, an alcohol is added to the mixture:



In the third step, triethylamine is added:



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4. *…continued from previous page*

(a) Add curved arrows to the diagrams on the previous page to show the movement of electrons in each step of this reaction. *[7 marks]*

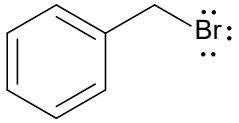
(b) Given that it proceeds at low temperature, the first step of the Swern oxidation must be highly favourable. What makes this step so favourable? Your answer should include the name of the key property. *[2 marks]*

(c) In the second step of the Swern oxidation, a chloride ion is used as a base. This is highly unusual. Why is it possible to use chloride as a base in this case? *[1 mark]*

(d) The second step of the Swern oxidation (in which the alcohol reacts with the sulfur-containing cation) contains a substitution reaction. Is it best classified as S_N1 or S_N2? Why? *[2 marks]*

(e) The final step of the Swern oxidation contains an elimination reaction. Is it best classified as E1 or E2? Why? *[2 marks]*

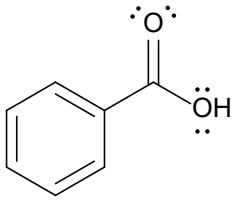
5. Use benzyl bromide *(shown below)* as your starting material for each synthesis. **[10 marks]**

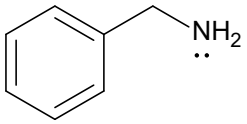


Each answer should consist of a series of reaction equations. It is not necessary to show mechanisms. It is not necessary to show by-products.

If you show work for both products, clearly indicate which one you wish to be graded. If no such indication is given, the first answer will be marked.

(a) **CHOOSE <u>ONE</u> OF THE PRODUCTS BELOW.** Show how it could be prepared from benzyl bromide using any reactions discussed in CHEM 2500 or CHEM 2600. *[4 marks]*





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5. *…continued from previous page*

(b) **CHOOSE <u>ONE</u> OF THE PRODUCTS BELOW.** Show how it could be prepared from benzyl bromide using any reactions discussed in CHEM 2500 or CHEM 2600. *[6 marks]*

Please note that Grignard reagents are not able to act as nucleophiles in S_N1 or S_N2 reactions; they can only react with electrophiles containing pi bonds.

