Fall 2023 **Chemistry 2600 Midterm #2** ____/56 marks

Confidentiality Agreement:
I agree not to discuss (or in any other way divulge) the contents of this exam with (or in the presence of) any CHEM 2600 student who has yet to write it. 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, use the back of any page of the test. On questions with spectra, you may also do rough work directly on the spectra.
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**
/ 6	/ 8	/ 12	/ 22	/ 8									/ 56

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

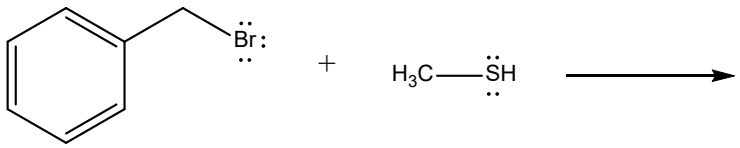
   For full marks, your answer must include the rate law for this reaction including a numerical value and units for k. It must also include a brief verbal explanation of your choice between E1 and E2.

$[RI]$ $\left(\frac{mol}{L}\right)$	$[base]$ $\left(\frac{mol}{L}\right)$	Rate of reaction $\left(\frac{mol}{L \cdot s}\right)$
0.025	0.040	3.6×10^{-5}
0.025	0.060	5.4×10^{-5}
0.075	0.040	1.08×10^{-4}
0.075	0.060	1.62×10^{-4}

2. Indicate whether or not you would expect to see a significant amount of reaction according to each mechanism type by circling 'yes' or 'no'. In the bottom row of each table, justify your answer by:
   - For each 'yes', drawing the organic product(s) that will be observed.
   - For each 'no', briefly explaining why you expect little-to-no reaction. **[8 marks]**

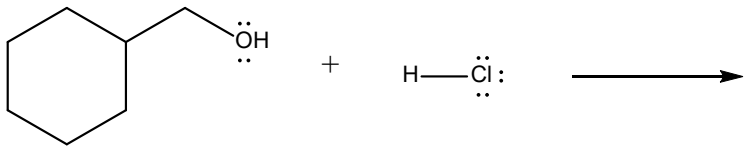
   The marks are for the product(s) and/or explanations. The yes/no part is just to help you think.

(a)



S_N1? yes / no	**S_N2?** yes / no	**E1?** yes / no	**E2?** yes / no

(b)

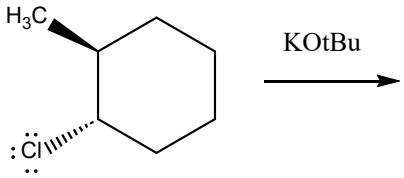


S_N1? yes / no	**S_N2?** yes / no	**E1?** yes / no	**E2?** yes / no

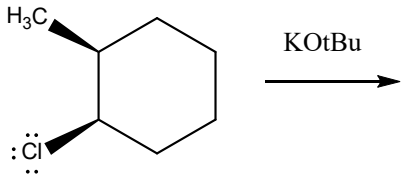
3. You are working on a project to optimize conditions for elimination reactions. **[12 marks]**

For the purposes of this question, the number of products listed does not include protonated base.

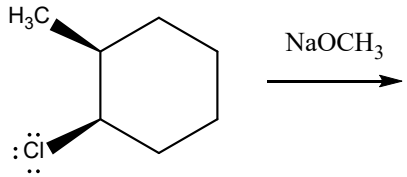
(a) Your first reaction works well, giving you a single organic product. Use curved arrows to show the mechanism for this reaction, and draw the resulting product. *[4 marks]*



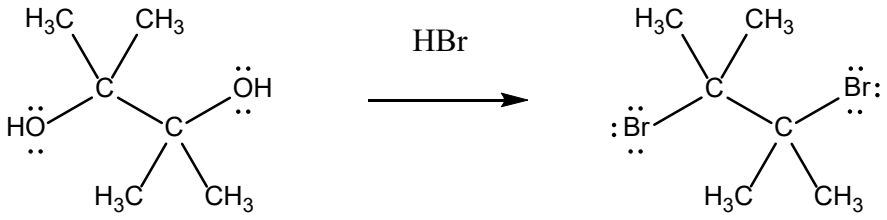
(b) Buoyed by your success, you attempt the reaction shown below. It gives you a mixture of two organic products. Draw them both. *[4 marks]*



(c) You run out of potassium *tert*-butoxide but find a bottle of sodium methoxide in the lab. When you repeat the reaction in part (b) using sodium methoxide instead of potassium tert-butoxide, now you're up to **<u>three</u>** different organic products! Two of them are the same as your answer to part (b). Draw the third one and briefly explain why it started to form. *[4 marks]*



4. You wish to prepare 2,3-dibromo-2,3-dimethylbutane (**B**), so you try reacting 2,3-dimethylbutane-2,3-diol (**A**) with hydrobromic acid: **[22 marks]**

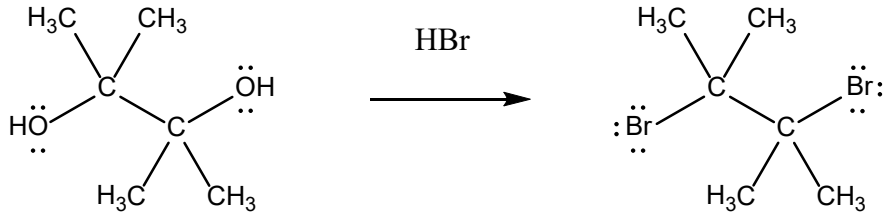


A **B**

(a) Use curved arrows to propose a valid mechanism for the reaction shown above. *[10 marks]*
You may use as many molecules of HBr as you need.

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4. *…continued*



A **B**

(b) You decide to monitor this reaction by ^{1}H NMR. *[3 marks]*

For chemical shifts, ranges are fine – as are approximate values.

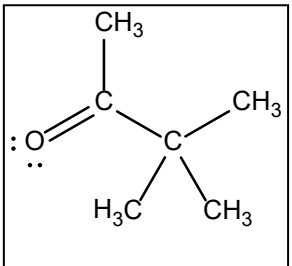
i. What do you expect to see on the ^{1}H NMR for reactant **A**? Your answer should address multiplicity, integration and approximate chemical shift (where appropriate) for each peak.

ii. What do you expect to see on the ^{1}H NMR for product **B**? Your answer should address multiplicity, integration and approximate chemical shift (where appropriate) for each peak.

(c) Much to your dismay, the ^{1}H NMR spectrum you obtain does not match the one you predicted for product **B**. Astounded, you analyze the sample by ^{13}C NMR and are shocked to see four peaks, one of which is at 214 ppm!!! IR analysis shows a strong peak at 1708 cm^{-1}. With the help of your lab partner, you deduce that the only possible structure compatible with the spectra you obtained is that of 3,3-dimethylbutan-2-one (**C**), shown at the right. *[2 marks]*

i. Which carbon atom is responsible for the peak at 214 ppm?

ii. Which bond is responsible for the peak at 1708 cm^{-1}?



C

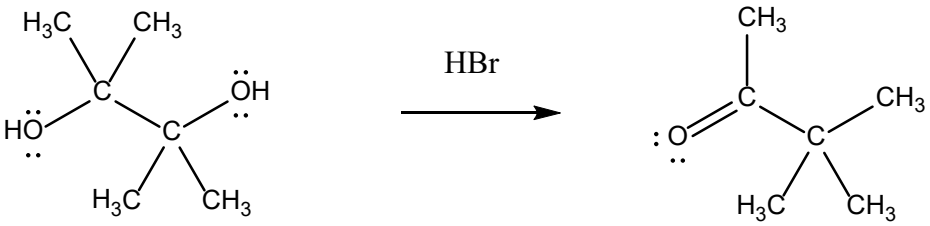
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4. *…continued*

(d) What happened?!?!?!

Use curved arrows to propose a valid mechanism for the reaction shown below. *[7 marks]*

You may use as many molecules of HBr as you need.



A **C**

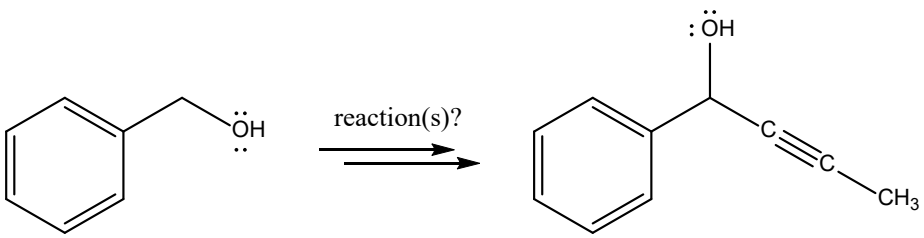
5. Propose a route to make each product from the given starting material. **[8 marks]**

In cases where more than one reaction is required, please draw each reaction with its own arrow and draw the product of each reaction. We are NOT asking for mechanisms. But we are asking that if you react A and B to make C and then, in a later step, react C with D to make E, that there be two separate arrows (one for each reaction) and that the structure of C be shown:



If you wish to use a reaction which requires that you add multiple reagents in a given sequence, showing that using numbered steps over a single arrow is fine. That's still one arrow per reaction. If you're not sure, err on the side of showing more.

(a) *[3 marks]*



continued on next page…

5. *…continued*

(b) *[5 marks]*

