Winter 2025 **Chemistry 2600 Midterm #2** ____/55 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 0/55 on this exam.

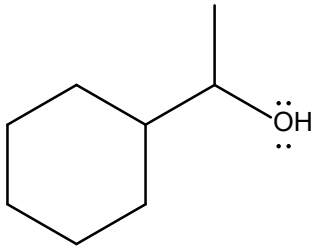
Signature: _____ Date: _____

1) Please read the test carefully before starting. It has eight 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** | **Q6** | | | | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| / 14 | / 9 | / 8 | / 6 | / 10 | / 8 | | | | | | | | | / 55 |

1. When the alcohol below is reacted with hydrobromic acid $(HBr_{(aq)})$, **<u>two</u>** different organic substitution products are possible. The two products are constitutional isomers. **[14 marks]**




(a) What does the fact that this reaction can produce either of two constitutional isomers tell you about whether it is expected to proceed via $S_N1$ and/or $S_N2$? Explain briefly. *[2 marks]*

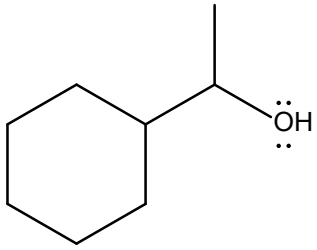
(b) Use curved arrows to propose valid mechanisms for formation of each of the two products. *[10 marks]*

(c) Briefly explain how you could use $^1H\ NMR$ to distinguish between the two products. Your answer should include something positive to look for on each spectrum; do not rely on a peak's absence. *[2 marks]*

*more space on next page…*

1. *…continued*

2. When the alcohol below is reacted with sulfuric acid $\left(H_2SO_{4(aq)}\right)$, **three** different organic elimination products are possible. Draw all three elimination products, classify each as a major product or a minor product, and briefly justify your classifications. **[9 marks]**

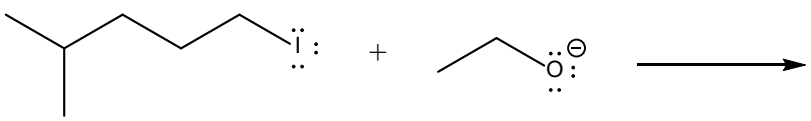



*You are **not** required to show mechanisms for this question; however, there will be no penalty for including them.*

3. 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]**

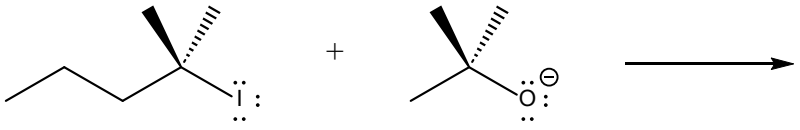
   *The marks are for the product(s) and/or explanations. The yes/no part is just to help you think.*

(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 |
|---|---|---|---|
| | | | |

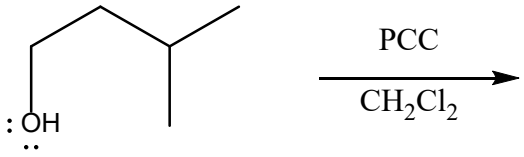
4. Use the data provided in the table below to determine whether the reaction between the alkyl chloride $(RCl)$ and base proceeds via $E1$ or $E2$ mechanism. **[6 marks]**

   *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 $E2$.*

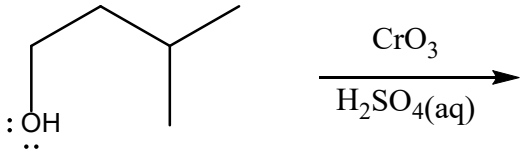
| $[RCl]$ $\left(\frac{mol}{L}\right)$ | $[base]$ $\left(\frac{mol}{L}\right)$ | Rate of reaction $\left(\frac{mol}{L \cdot s}\right)$ |
|---|---|---|
| 0.15 | 0.20 | $3.6 \times 10^{-4}$ |
| 0.15 | 0.40 | $3.6 \times 10^{-4}$ |
| 0.30 | 0.60 | $7.2 \times 10^{-4}$ |
| 0.60 | 0.80 | $1.44 \times 10^{-3}$ |

5. Draw the major organic product for each of the following reactions. **[10 marks]**

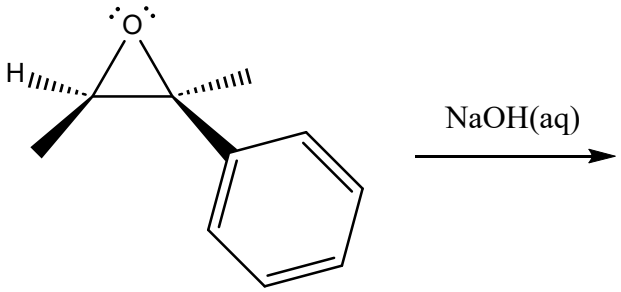
(a)



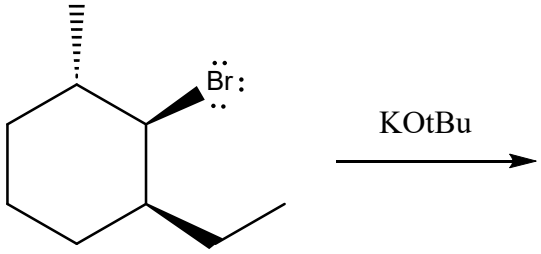

(b)



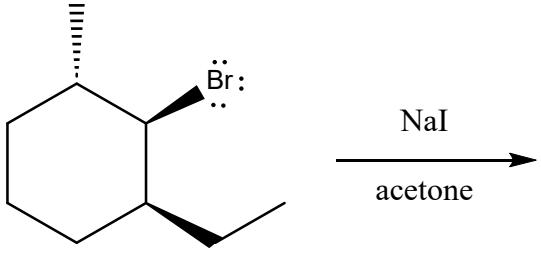

(c)




(d)




(e)



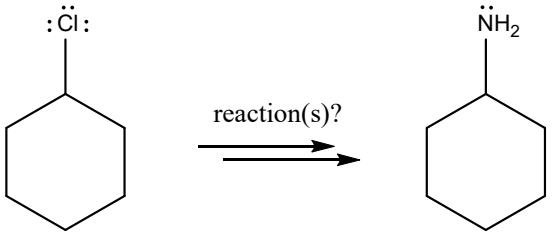
6. Propose a route to make each product from the given starting material. **[8 marks]**

*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…*

6. *…continued*

(b) *[5 marks]*

