Winter 2025 **Chemistry 2600 Midterm #1** ____/57 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 0/57 on this exam.

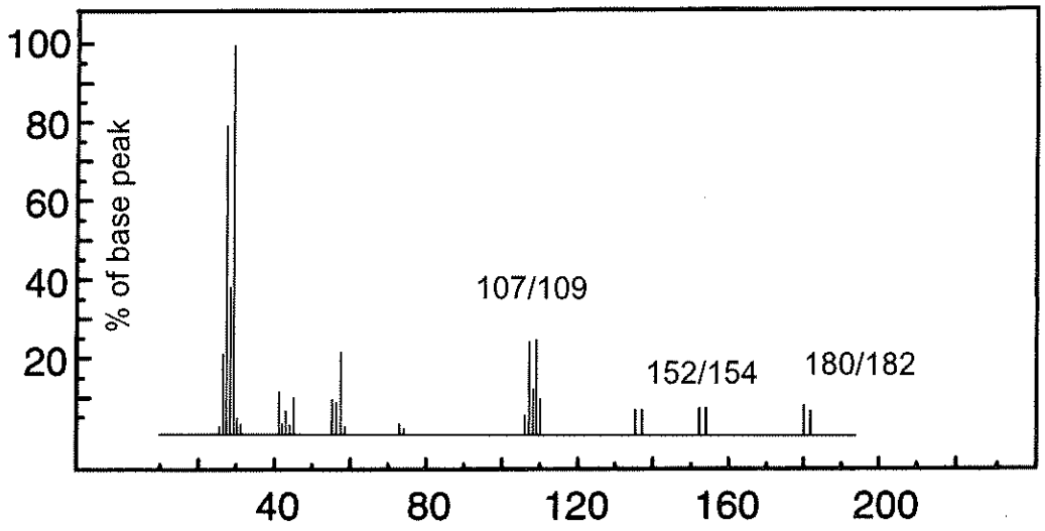
Signature: _____ Date: _____

1) Please read the test carefully before starting. It has 6 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**
/ 3	/ 2	/ 12	/ 6	/ 12	/ 22									/ 57

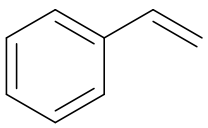
1. The following mass spectrum corresponds to a compound containing one halogen atom. **[3 marks]**



(a) Clearly label the molecular ion on the mass spectrum. *[1 mark]*

(b) Of which element is the halogen atom, and how can you tell? *[2 marks]*

2. For both parts of this question, assume that you are using an instrument capable of resolving all distinct peaks. In other words, do **not** attempt to account for peaks that might coincidentally overlap. **[2 marks]**



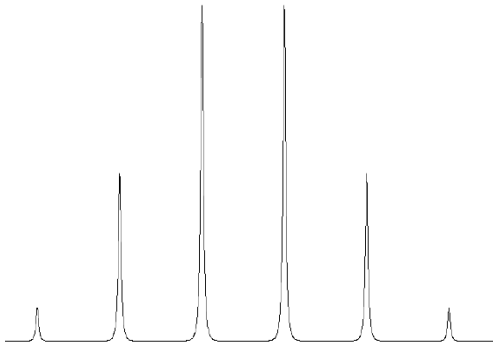
(a) How many peaks would you expect to see on the ^{1}H NMR of styrene (drawn above)?

(b) How many peaks would you expect to see on the ^{13}C NMR of styrene (drawn above)?

3. For each of the following peaks: **[12 marks]**

- Identify the splitting pattern. *In other words, name the multiplicity, or shape, of the peak.*
- Indicate the number of different coupling constants required to generate this splitting pattern. *(**Not** the number of neighbouring atoms. The number of different J values!)*
- On the diagram, clearly show the distance corresponding to each coupling constant. (Just do this once for each coupling constant!) You do not need to give numerical values for the coupling constants; label them as $J_{1\text{-}2}$, $J_{1\text{-}3}$, $J_{1\text{-}4}$, etc.

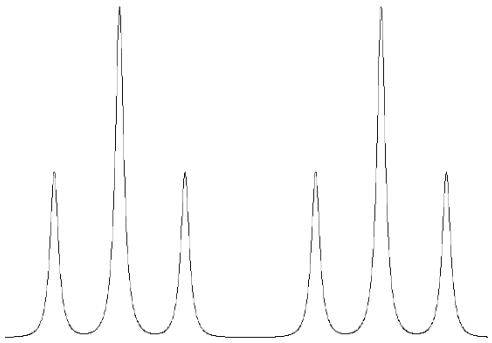
(a)



Splitting pattern: _____

Different J values: _____

(b)

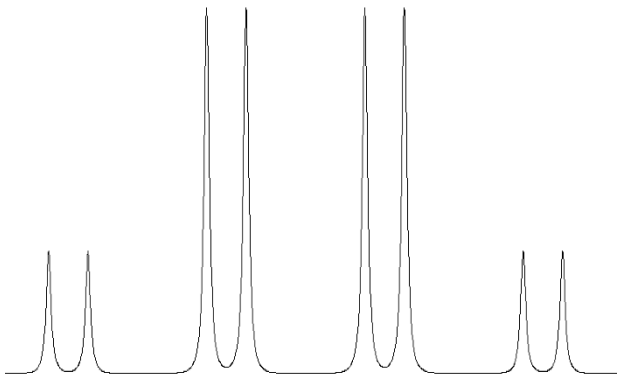


Splitting pattern: _____

Different J values: _____

Draw coupling constant(s) onto diagrams!

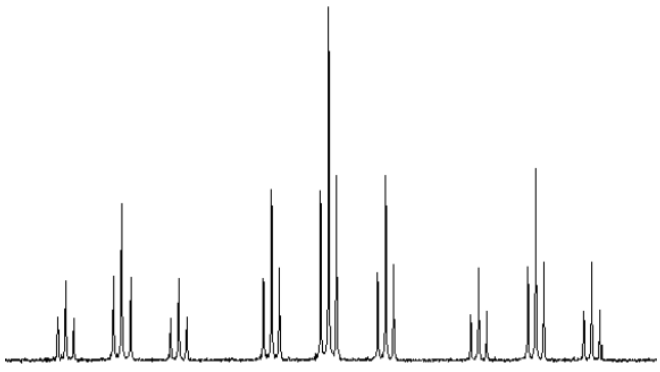
(c)



Splitting pattern: _____

Different J values: _____

(d)

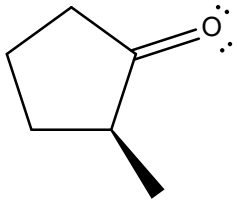


Splitting pattern: _____

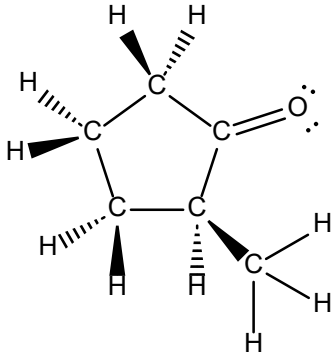
Different J values: _____

Draw coupling constant(s) onto diagrams!

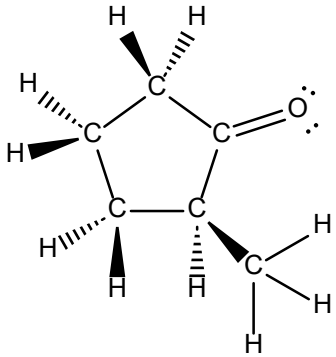
4. Consider the following molecule: **[6 marks]**



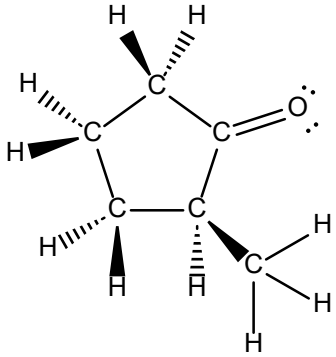
(a) On the picture below, circle two hydrogen atoms which are homotopic. *[2 marks]*



(b) On the picture below, circle two hydrogen atoms which are diastereotopic. *[2 marks]*



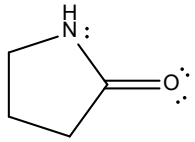
(c) On the picture below, circle two hydrogen atoms which are constitutionally different. *[2 marks]*



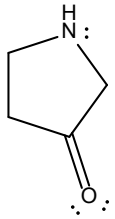
5. For each of the following pairs of molecules, explain how you would use **two** different spectroscopic methods to distinguish between them. Be specific. What peak(s) are you looking for? Where are they? Give numbers or ranges where possible. Unless the distinguishing feature of a spectrum is its lack of interesting peaks, mention at least one peak per molecule. **[12 marks]**

You may choose from ^{1}H NMR, ^{13}C NMR, IR and MS. You may choose different spectroscopic methods for each pair of molecules. It must be clear which methods you have chosen.

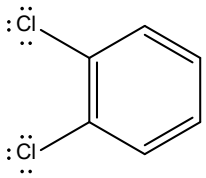
(a)



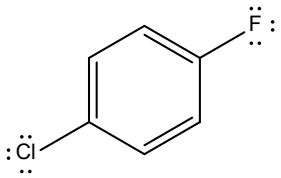
vs.



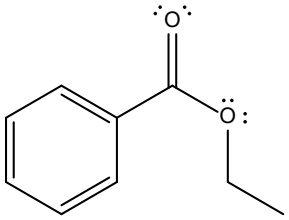
(b)



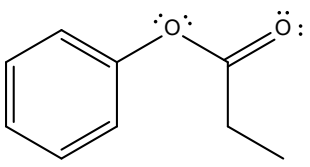
vs.



(c)



vs.



6. The following page contains spectra for Unknown X ($C_5H_9BrO_2$). **[22 marks]**

(a) Identify Unknown X based on these spectra. Draw your answer in the box provided below.

(b) Use this page to explain your reasoning. **Calculation of integrals is required for full marks.**

(c) On both NMR spectra, assign as many peaks as you can by numbering the peaks from left to right, drawing Unknown X in the box provided, and labeling each carbon or hydrogen atom with the appropriate peak number. For atoms that cannot be assigned with certainty, list the signals to which they might reasonably correspond.

(d) Label any important peaks on the IR, clearly identifying which bond(s) correspond(s) to each peak.

Unknown X:

6. *…continued*

$C_5H_9BrO_2$

