NAME:_____ Section:_____ Student Number:_____

Spring 2017 **Chemistry 2600 Midterm** ____/ 78 marks

INSTRUCTIONS:

1) Please read over the test carefully before beginning. You should have 9 pages of questions in addition to this cover page and a periodic table.
2) You have also 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 any papers or other written materials in your model kit.
4) You may use a calculator. It may not have wireless capability. You may not have any other electronic devices (phone, iPod, etc.) with you when you write the exam.
5) If your work is not legible, it will be given a mark of zero.
6) Marks will be deducted for incorrect information added to an otherwise correct answer.
7) You have 2 hours to complete this test.

Confidentiality Agreement:

I agree not to discuss (or in any other way divulge) the contents of this exam until after 7:00pm Mountain Time on Friday, February 10th, 2017. I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/78 on this exam and removal of the "overwrite midterm mark with final exam mark" option for my grade in this course; the maximum punishment would include expulsion from this university.

Signature: _____ Date: _____

Course: CHEM 2600 (Organic Chemistry II)
Semester: Spring 2017
The University of Lethbridge

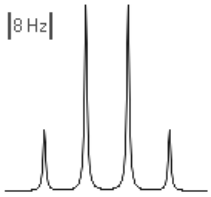
Question Breakdown

Q1	/ 10
Q2	/ 6
Q3	/ 4
Q4	/ 6
Q5	/ 12
Q6	/ 20
Q7	/ 20
Total	/ 78

NAME:_____ Section:_____ Student Number:_____

1. The two signals below both have four lines; however, they communicate different information about the hydrogen atom(s) to which they correspond. **[10 marks]**

Signal A



Signal B

multiplicity: _____ _____

coupling constant(s): _____ _____

(a) On the lines below each picture, describe each signal by identifying the multiplicity and reporting the coupling constant(s).
For reference, both pictures show the distance corresponding to 8 Hz.

(b) What does Signal A tell you about the hydrogen atom(s) to which it corresponds?
Give an example of a molecule that could produce Signal A, and circle the hydrogen atom(s) giving that signal.

(c) What does Signal B tell you about the hydrogen atom(s) to which it corresponds?
Give an example of a molecule that could produce Signal B, and circle the hydrogen atom(s) giving that signal.

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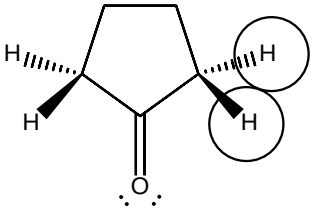
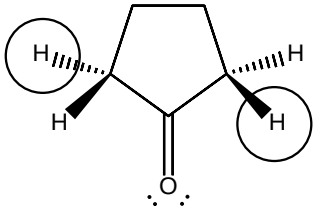
2. Below each molecule, write one of the following abbreviations (H, E, D or CD) to indicate the relationship between the circled hydrogen atoms: **[6 marks]**

- Homotopic (H)
- Enantiotopic (E)
- Diastereotopic (D)
- Constitutionally different (CD)

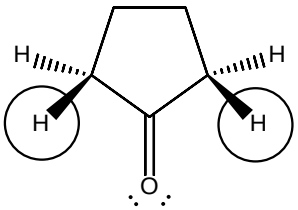
(a)



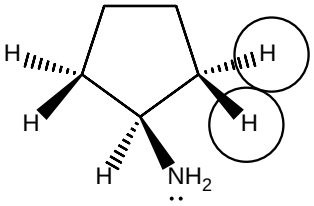
(b)



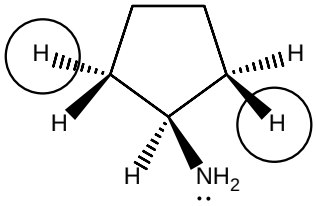
(c)



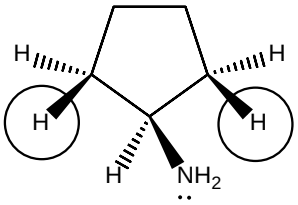
(d)



(e)

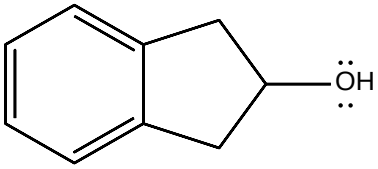


(f)

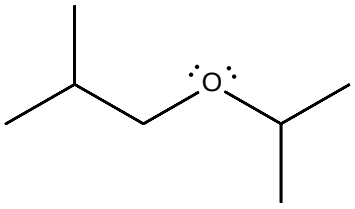


3. How many signals would you expect to see on the ^{1}H NMR and ^{13}C NMR spectra for each of the following molecules? *Assume that none of the signals coincidentally overlap.* **[4 marks]**

(a)



(b)



^{1}H NMR	____ signals	____ signals
^{13}C NMR	____ signals	____ signals

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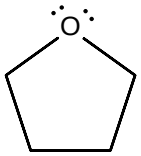
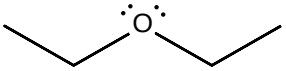
4. Tetrahydrofuran (THF) and diethyl ether (Et_2O) are commonly used solvents in the organic chemistry lab: **[6 marks]**



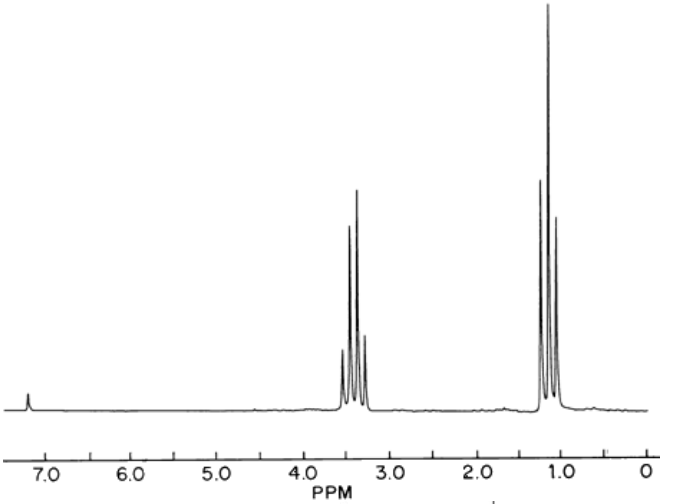
THF

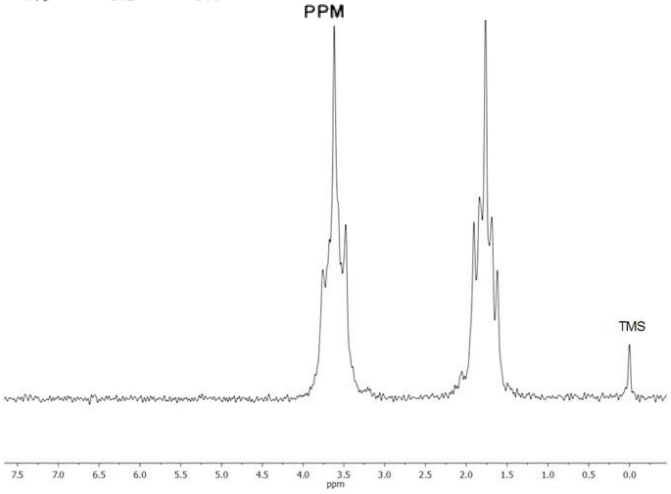


diethyl ether

The ^1H spectra for these two solvents are shown below.

(a) Clearly indicate which spectrum corresponds to which solvent. In the space next to the spectra, explain your reasoning.





(b) Explain why the first spectrum has clearly defined peak shapes but the second one does not. Why do we not see clearly defined peak shapes on the second spectrum?

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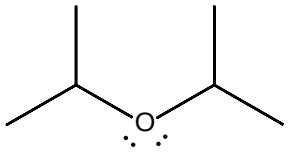
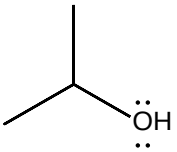
5. For each of the following pairs of molecules, explain how you would use **<u>two</u>** spectroscopic methods to distinguish between them. Be specific. What peak(s) are you looking for? Where are they? Give numbers or ranges where possible. **[12 marks]**
You may choose from ^{1}H NMR, ^{13}C NMR, IR and MS. You may choose different spectroscopic methods for each pair of molecules. It must be clear which methods you have chosen.

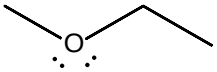
(a)



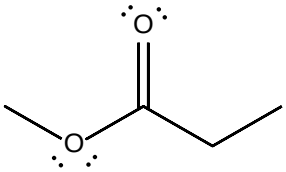
vs.



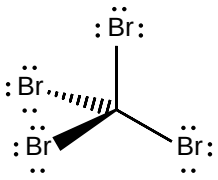
(b)



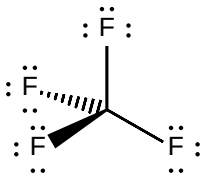
vs.



(c)



vs.



NAME:_____ Section:_____ Student Number:_____

6. The following **two** pages contain spectra for Unknown X. **[20 marks]**

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

(b) Use this page to explain your logic (including how you determined the molecular formula).

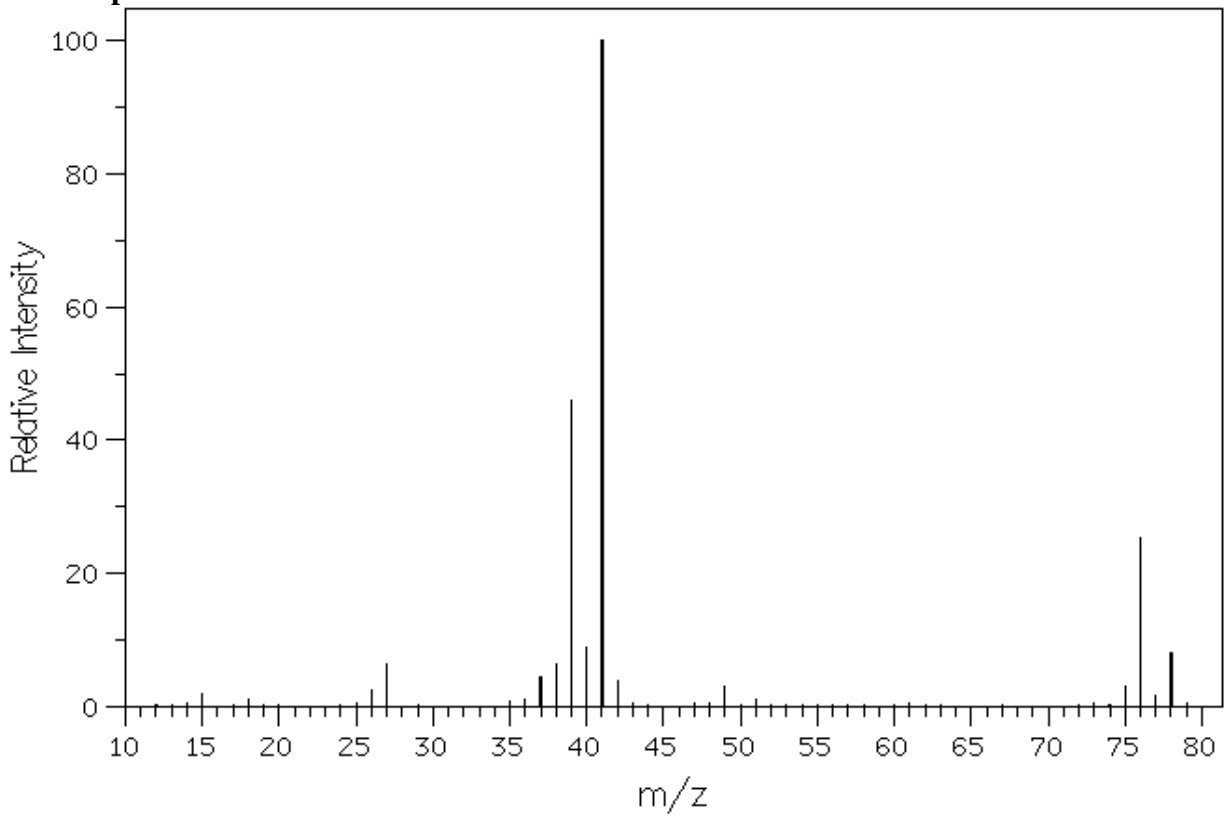
(c) On both NMR spectra, assign as many peaks as you can by numbering the peaks from left to right, drawing Unknown X in the box provided, and labeling each carbon or hydrogen atom with the appropriate peak number. *For atoms that cannot be assigned with certainty, list the signals to which they might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

(d) Label any important peaks on the IR and Mass Spectrum.

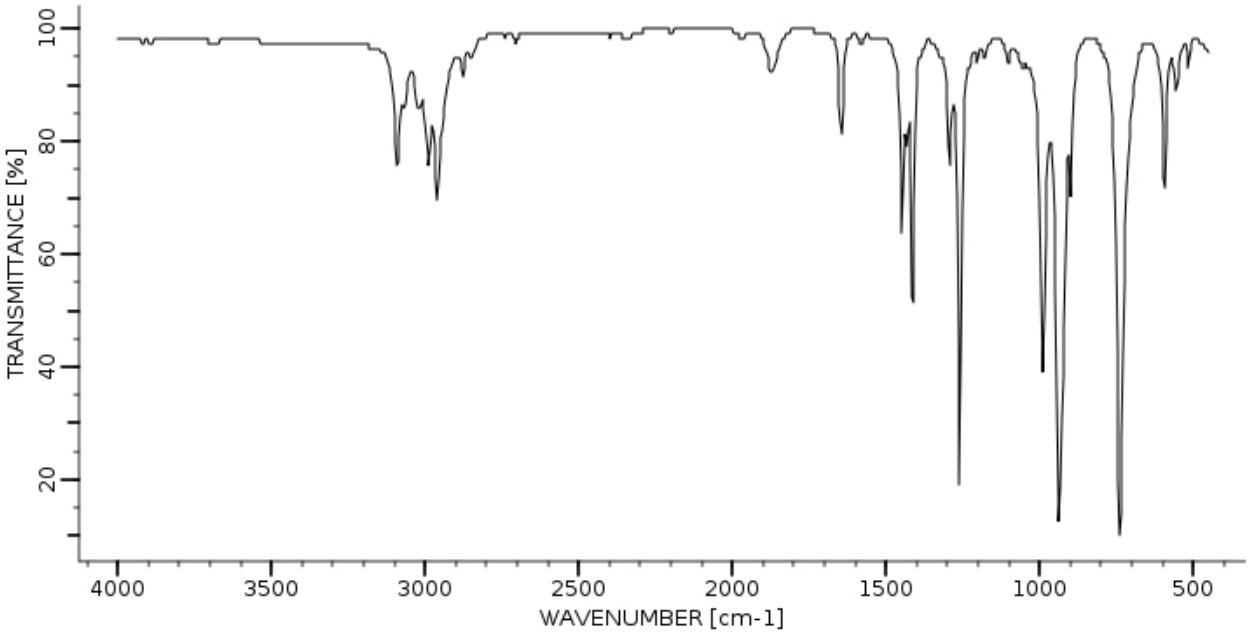
Unknown X:

NAME:_____ Section:_____ Student Number:_____

Mass Spectrum

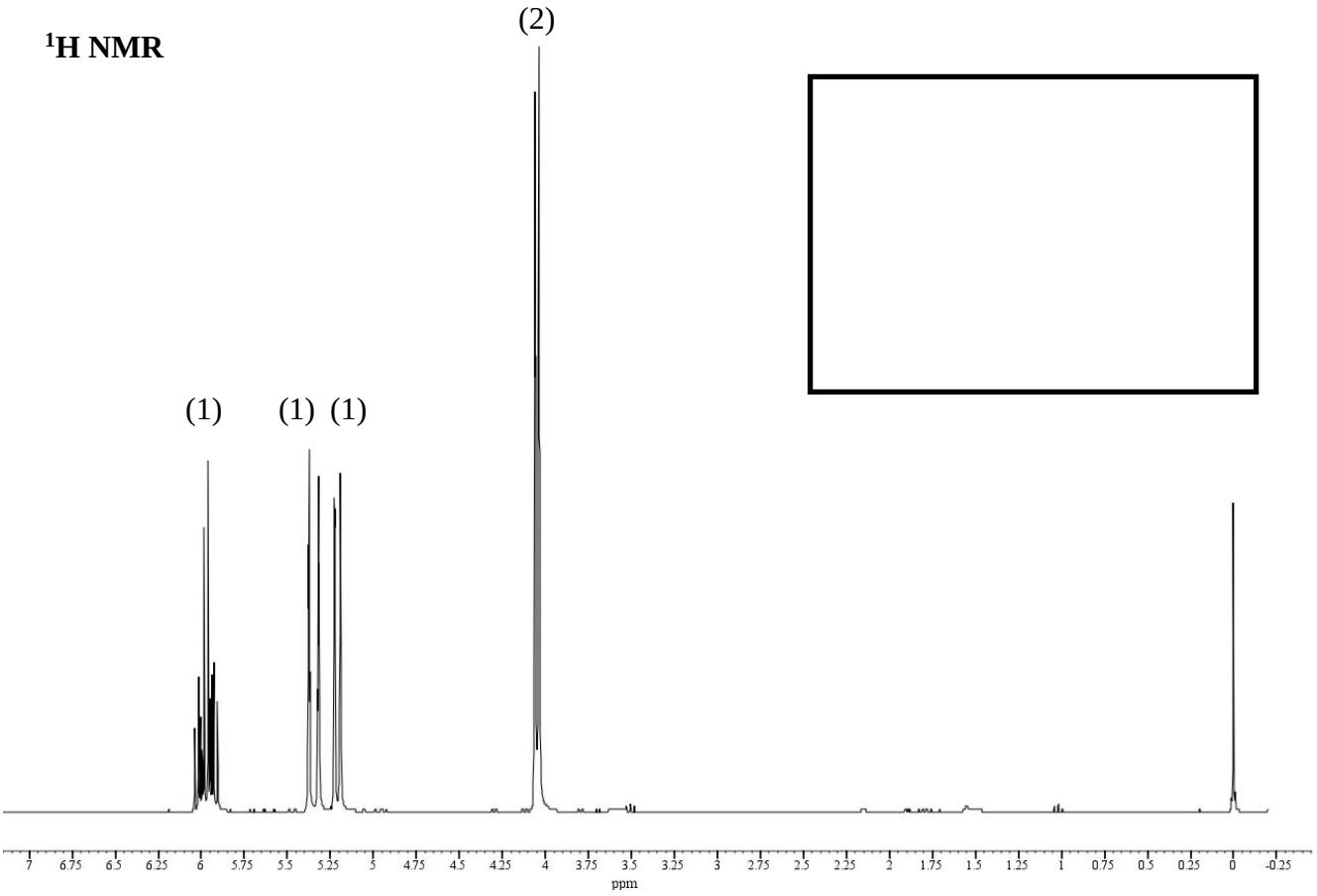


IR

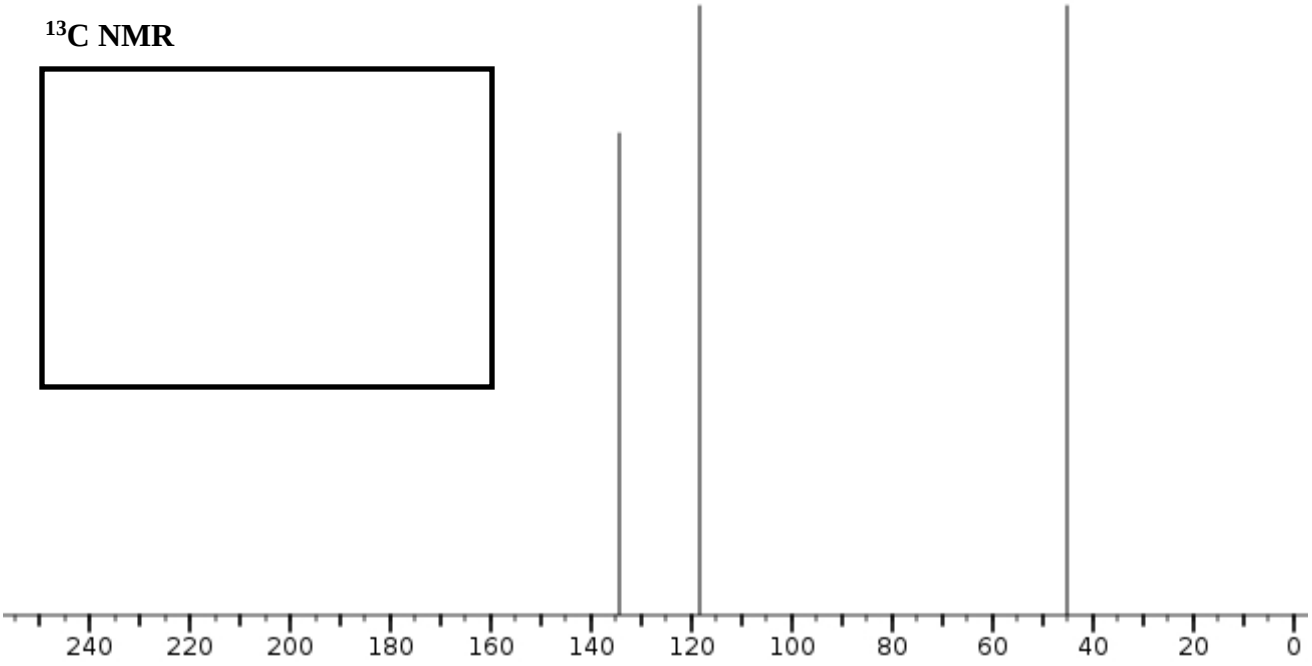


NAME:_____ Section:_____ Student Number:_____

^{1}H NMR



^{13}C NMR



NAME:_____ Section:_____ Student Number:_____

7. The following page contains NMR spectra for Unknown Y ($C_6H_{10}O_3$). **[20 marks]**

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

(b) Use this page to explain your logic.

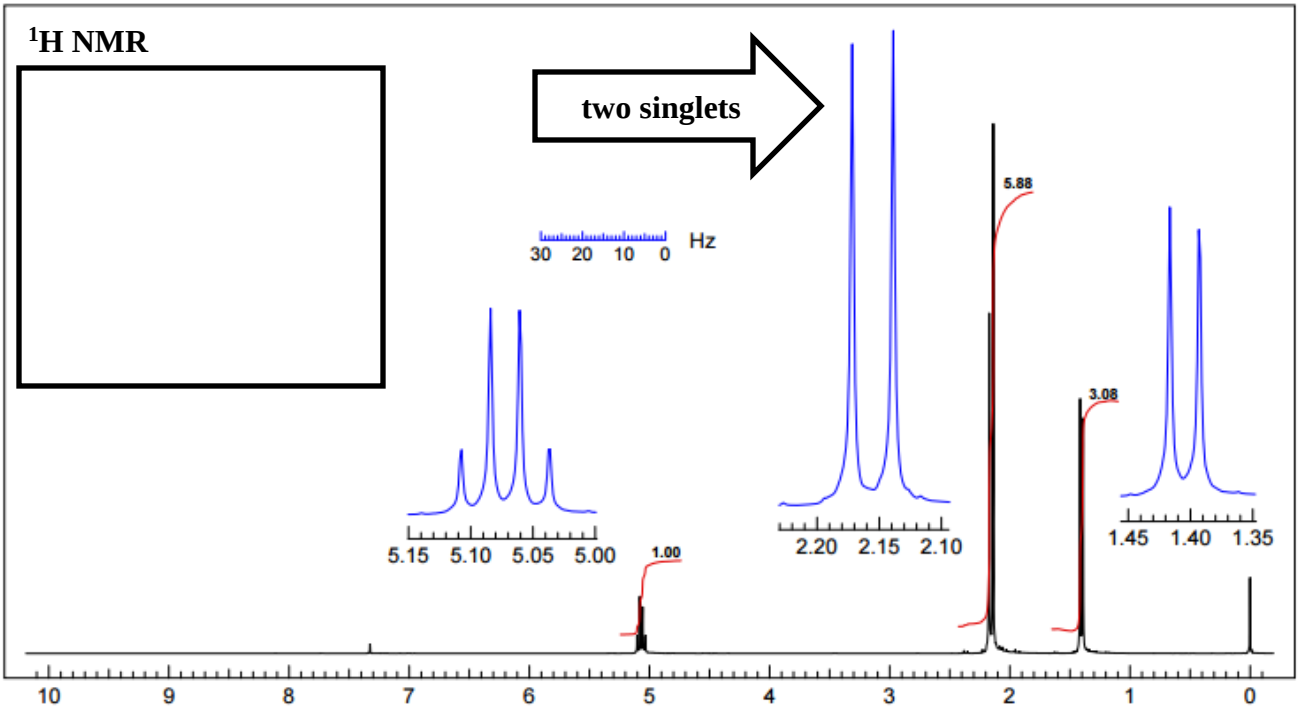
(c) On both NMR spectra, assign as many peaks as you can by numbering the peaks from left to right, drawing Unknown Y in the box provided, and labeling each carbon or hydrogen atom with the appropriate peak number. *For atoms that cannot be assigned with certainty, list the signals to which they might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

Unknown Y:

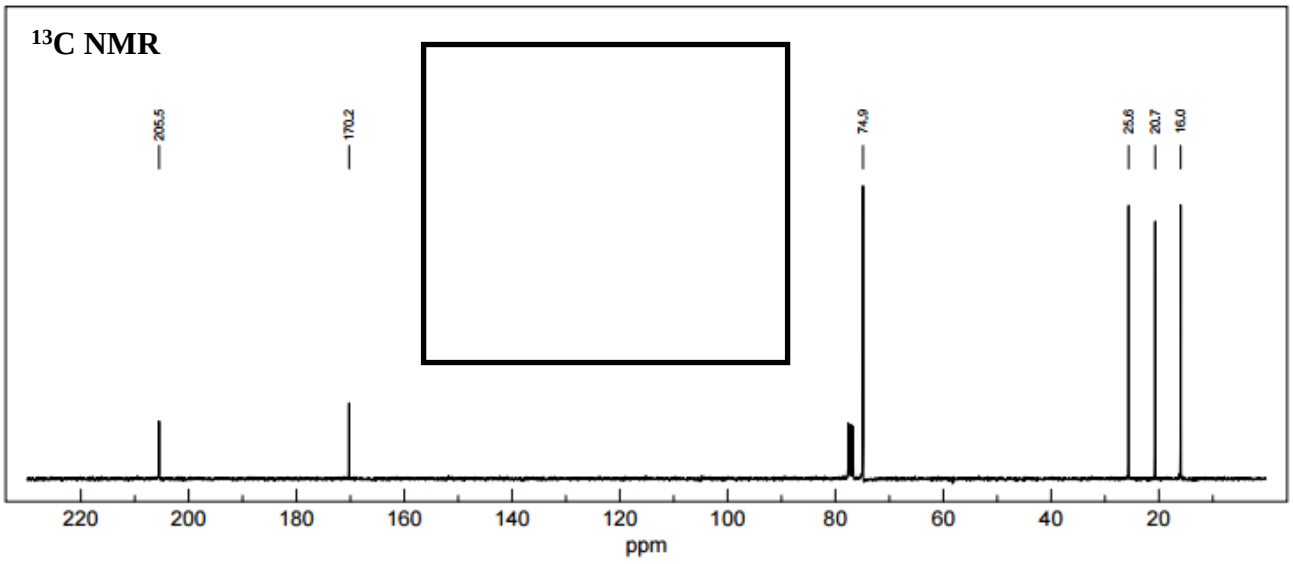
NAME:_____ Section:_____ Student Number:_____

$C_6H_{10}O_3$

^{1}H NMR



^{13}C NMR



NAME:_____ Section:_____ Student Number:_____

CHEM 1000 Standard Periodic Table

1												13	14	15	16	17	18
1.0079 **H** 1	**2**																4.0026 **He** 2
6.941 **Li** 3	9.0122 **Be** 4											10.811 **B** 5	12.011 **C** 6	14.0067 **N** 7	15.9994 **O** 8	18.9984 **F** 9	20.1797 **Ne** 10
22.9898 **Na** 11	24.3050 **Mg** 12	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	26.9815 **Al** 13	28.0855 **Si** 14	30.9738 **P** 15	32.066 **S** 16	35.4527 **Cl** 17	39.948 **Ar** 18
39.0983 **K** 19	40.078 **Ca** 20	44.9559 **Sc** 21	47.88 **Ti** 22	50.9415 **V** 23	51.9961 **Cr** 24	54.9380 **Mn** 25	55.847 **Fe** 26	58.9332 **Co** 27	58.693 **Ni** 28	63.546 **Cu** 29	65.39 **Zn** 30	69.723 **Ga** 31	72.61 **Ge** 32	74.9216 **As** 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
85.4678 **Rb** 37	87.62 **Sr** 38	88.9059 **Y** 39	91.224 **Zr** 40	92.9064 **Nb** 41	95.94 **Mo** 42	(98) **Tc** 43	101.07 **Ru** 44	102.906 **Rh** 45	106.42 **Pd** 46	107.868 **Ag** 47	112.411 **Cd** 48	114.82 **In** 49	118.710 **Sn** 50	121.757 **Sb** 51	127.60 **Te** 52	126.905 **I** 53	131.29 **Xe** 54
132.905 **Cs** 55	137.327 **Ba** 56	**La-Lu**	178.49 **Hf** 72	180.948 **Ta** 73	183.85 **W** 74	186.207 **Re** 75	190.2 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.967 **Au** 79	200.59 **Hg** 80	204.383 **Tl** 81	207.19 **Pb** 82	208.980 **Bi** 83	(210) **Po** 84	(210) **At** 85	(222) **Rn** 86
(223) **Fr** 87	226.025 **Ra** 88	**Ac-Lr**	(265) **Rf** 104	(268) **Db** 105	(271) **Sg** 106	(270) **Bh** 107	(277) **Hs** 108	(276) **Mt** 109	(281) **Ds** 110	(280) **Rg** 111	(285) **Cn** 112	(284) **Nh** 113	(289) **Fl** 114	(288) **Mc** 115	(293) **Lv** 116	(294) **Ts** 117	(294) **Og** 118

138.906 **La** 57	140.115 **Ce** 58	140.908 **Pr** 59	144.24 **Nd** 60	(145) **Pm** 61	150.36 **Sm** 62	151.965 **Eu** 63	157.25 **Gd** 64	158.925 **Tb** 65	162.50 **Dy** 66	164.930 **Ho** 67	167.26 **Er** 68	168.934 **Tm** 69	173.04 **Yb** 70	174.967 **Lu** 71
227.028 **Ac** 89	232.038 **Th** 90	231.036 **Pa** 91	238.029 **U** 92	237.048 **Np** 93	(240) **Pu** 94	(243) **Am** 95	(247) **Cm** 96	(247) **Bk** 97	(251) **Cf** 98	(252) **Es** 99	(257) **Fm** 100	(258) **Md** 101	(259) **No** 102	(262) **Lr** 103

Developed by Prof. R. T. Boeré (updated 2016)