NAME:_____ Section:_____ Student Number:_____

Fall 2018 **Chemistry 2600 Midterm** ____/ 60 marks

INSTRUCTIONS:

1) Please read over the test carefully before beginning. You should have 7 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 8:00pm Mountain Time on Wednesday, October 10th, 2018. I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/60 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: Fall 2018
The University of Lethbridge

Question Breakdown

Q1	/ 12
Q2	/ 10
Q3	/ 6
Q4	/ 6
Q5	/ 6
Q6	/ 20
Total	/ 60

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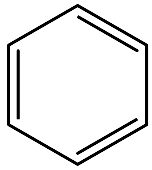
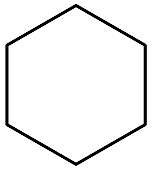
1. For each of the following pairs of molecules, explain how you would use **two** spectroscopic methods to distinguish between them. Be specific. What peak(s) are you looking for? Where are they? Give numbers or ranges where possible. **[12 marks]**
You may choose from ^{1}H NMR, ^{13}C NMR, IR and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

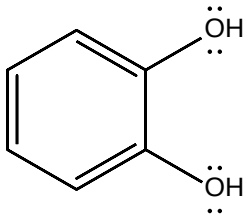
(a)



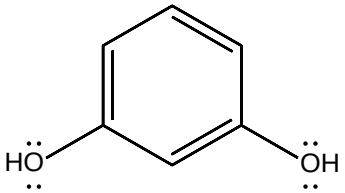
vs.



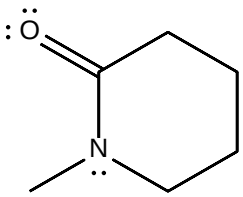
(b)



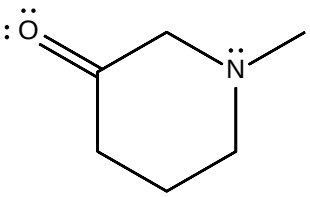
vs.



(c)



vs.



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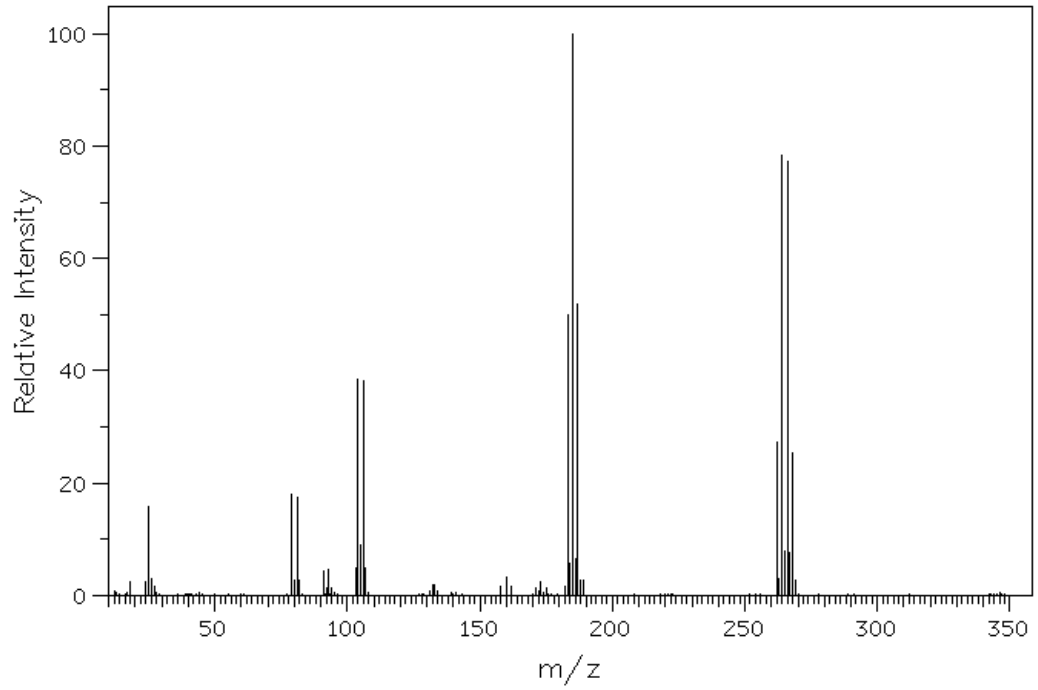
2. Consider the following mass spectrum for Unknown A: **[10 marks]**



The following table lists the heights of all peaks with relative intensity higher than 10:

m/z	**intensity**		**m/z**	**intensity**		**m/z**	**intensity**		**m/z**	**intensity**		**m/z**	**intensity**
25	15.9		79	18.0		104	38.4		183	50.0		262	27.2
			81	17.4		106	38.3		185	100.0		264	78.4
									187	51.8		266	77.2
												268	25.4

(a) Which peak is the molecular ion? *[1 mark]*

(b) What is the molecular formula for Unknown A? *[2 marks]*

(c) Draw Unknown A. *[2 marks]*

continued on next page…

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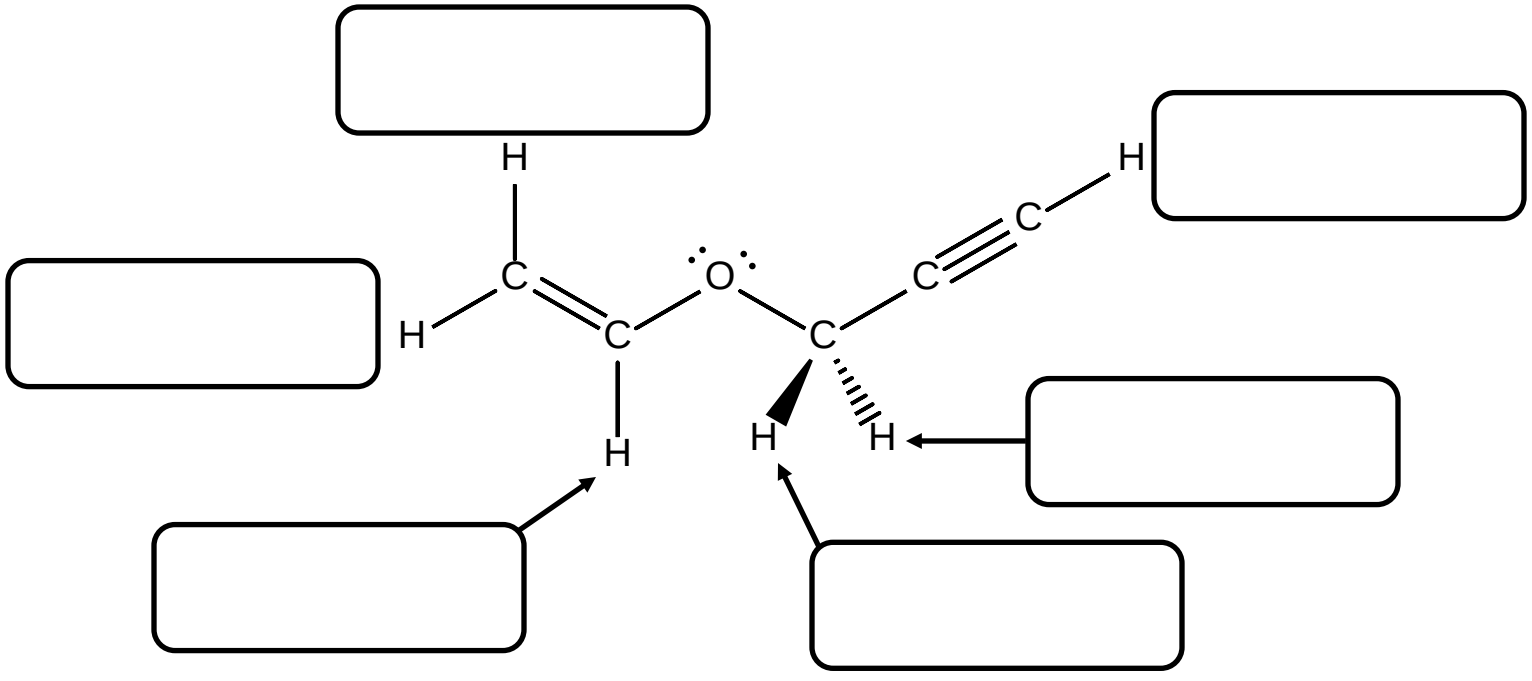
2. *...continued*

(d) Explain the cluster of peaks from m/z 262 to m/z 268. Your answer should address exactly what each of the four peaks corresponds to as well as the ratio of the heights of the four peaks.

[5 marks]

3. Consider the molecule below. In the boxes provided, label each proton with the predicted splitting pattern it would exhibit in a ^{1}H NMR spectrum. **[6 marks]**
Assume that any long range coupling has J > 0 Hz.



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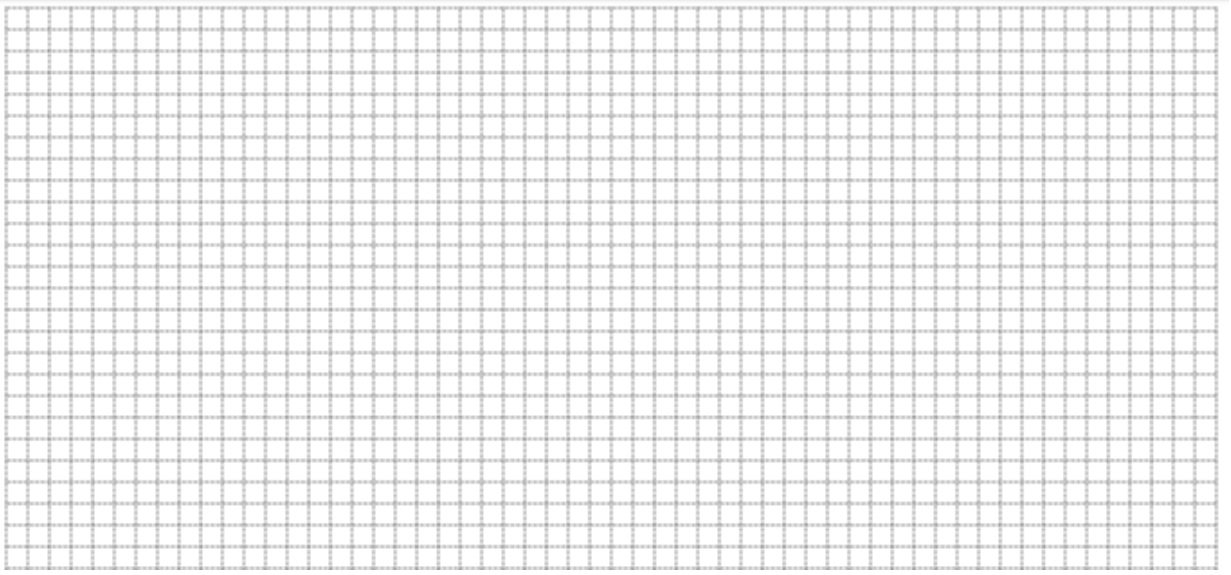
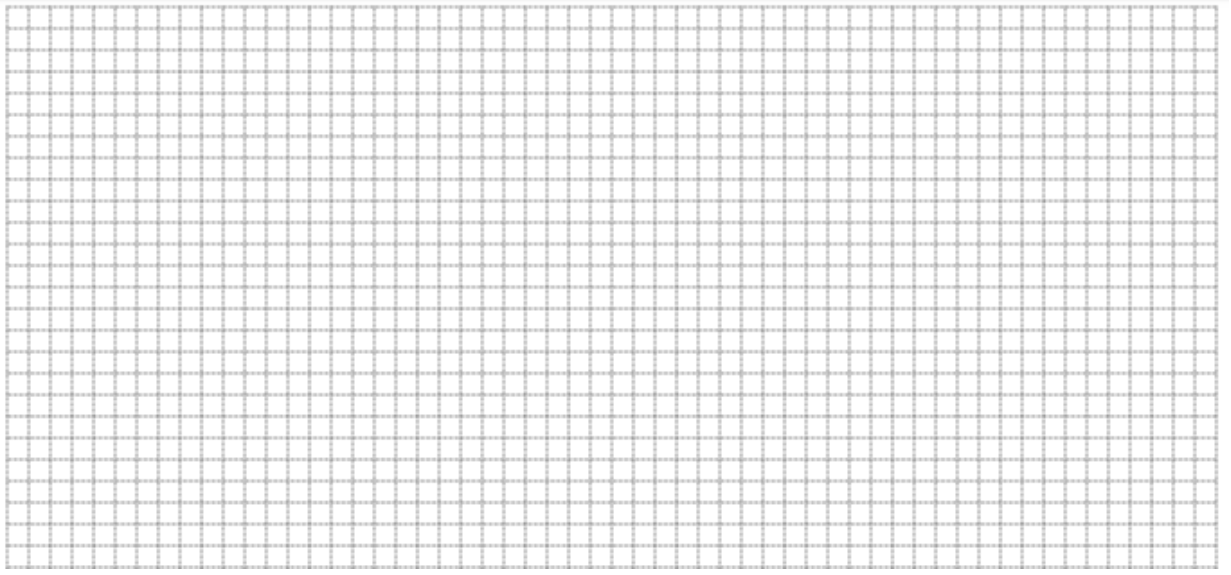
4. **[6 marks]**

(a) Use the graph paper below to draw (to scale) a pentet ($J = 8\ Hz$).
You do not need to draw the tree diagram.
Use 1 square = 1 Hz as your horizontal scale. Line heights must also be to scale. *[2 marks]*



(b) Use the graph paper below to draw (to scale) a doublet ($J = 10\ Hz$) of triplets ($J = 2\ Hz$).
You do not need to draw the tree diagram.
Use 1 square = 1 Hz as your horizontal scale. Line heights must also be to scale. *[4 marks]*



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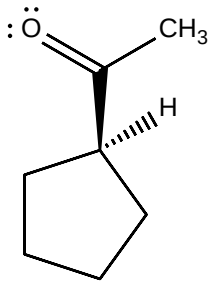
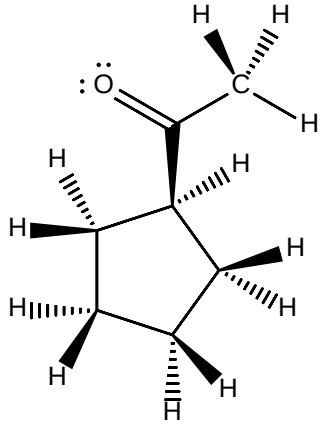
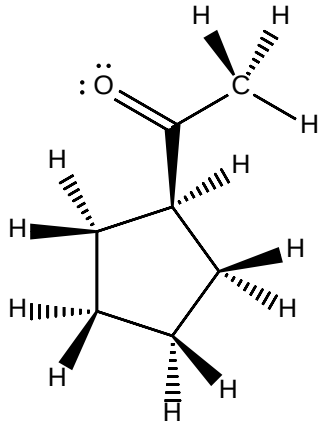
5. Consider the following molecule: **[6 marks]**



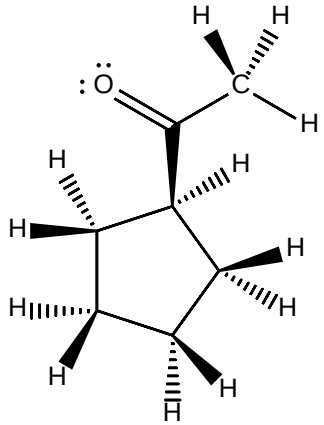
(a) On the picture below, circle two hydrogen atoms which are homotopic: *[2 marks]*



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



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



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6. The following page contains spectra for Unknown X ($C_8H_{14}O_4$). **[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 reasoning.

(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.

Unknown X:

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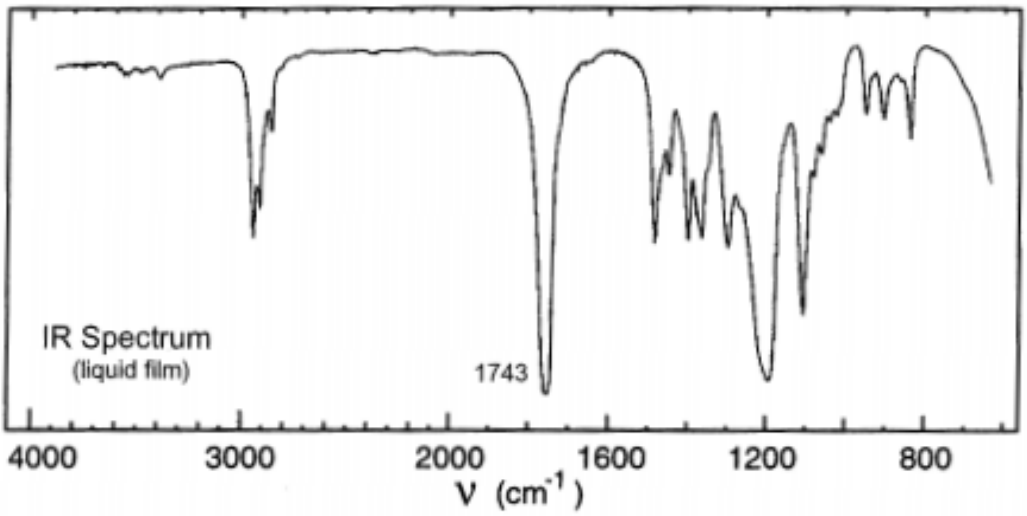
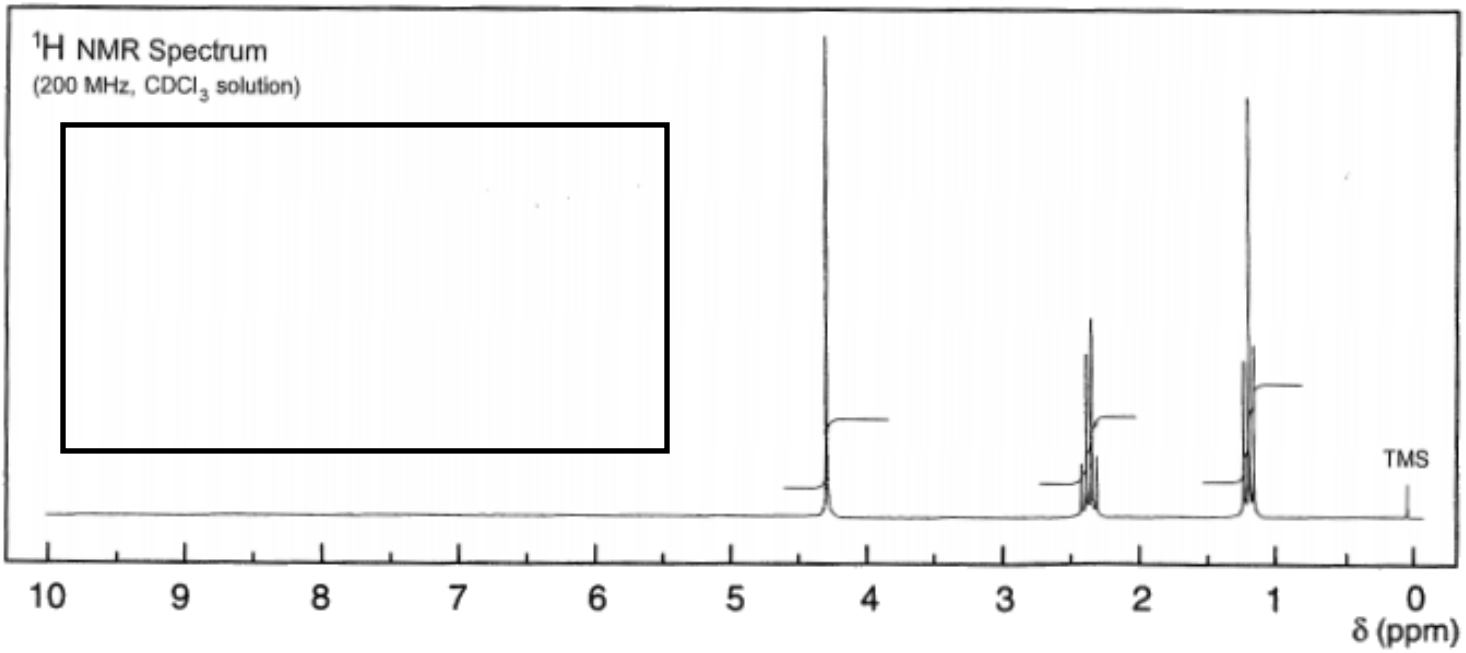
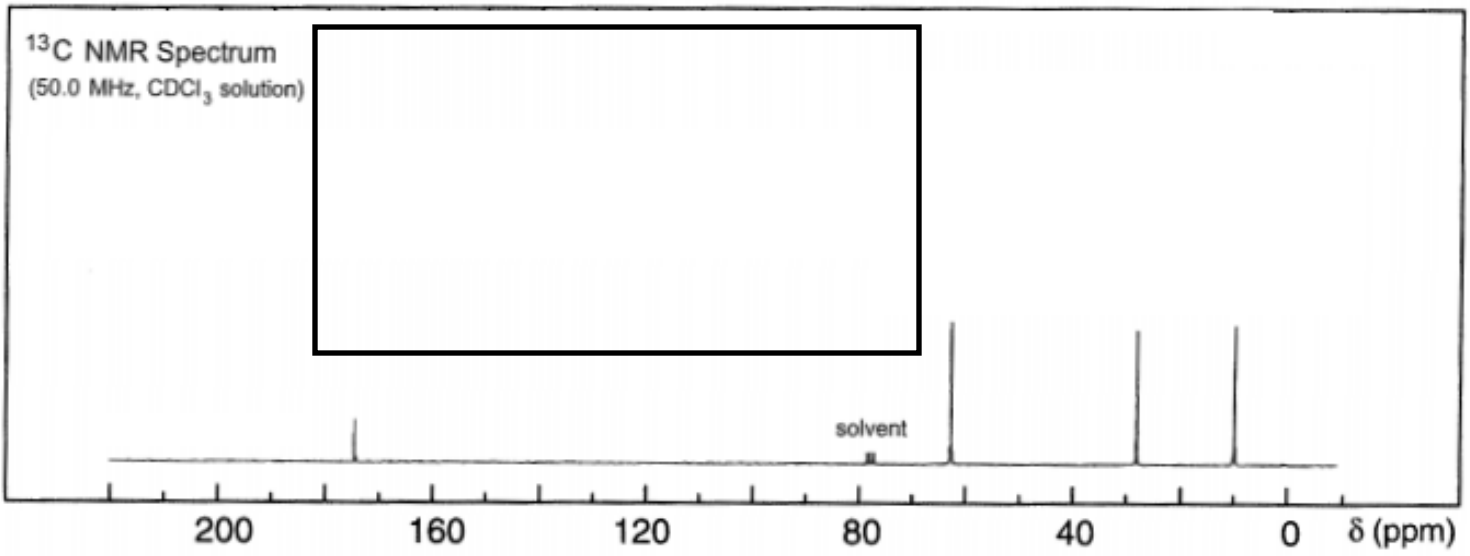
$C_8H_{14}O_4$







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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)