NAME:_____ Section:_____ Student Number:_____

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

INSTRUCTIONS:

1) Please read over the test carefully before beginning. You should have 6 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 9th, 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: Spring 2018
The University of Lethbridge

Question Breakdown

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

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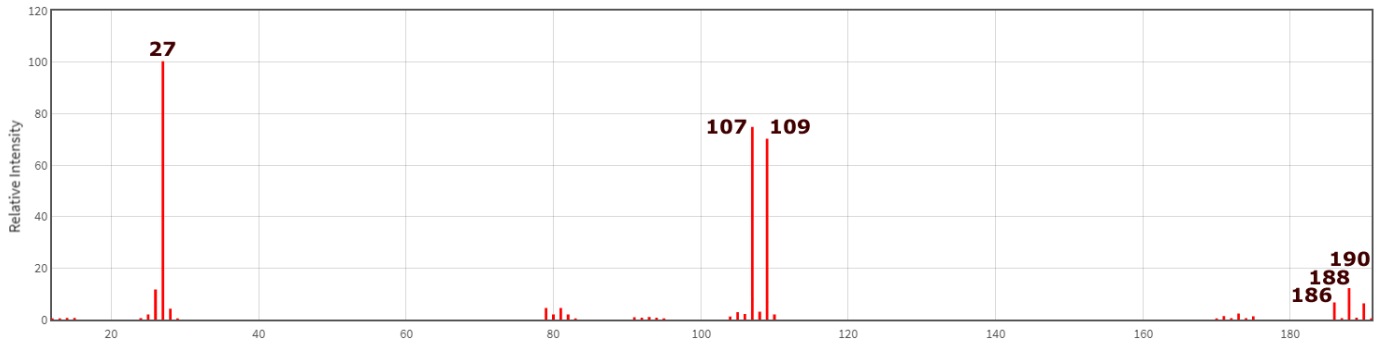
1. The mass spectrum below corresponds to Compound A (which is organic). **[10 marks]**



(a) What is the molecular formula for Compound A? *[1 mark]*

(b) Explain the logic you used to answer part (a). As part of your answer, it should be clear that you know what each of the numbered peaks corresponds to. *[5 marks]*

(c) There are two possible structures for Compound A. Briefly explain how you could use ^{1}H NMR to distinguish between them. *[2 marks]*

(d) There are two possible structures for Compound A. Briefly explain how you could use ^{13}C NMR to distinguish between them. *[2 marks]*

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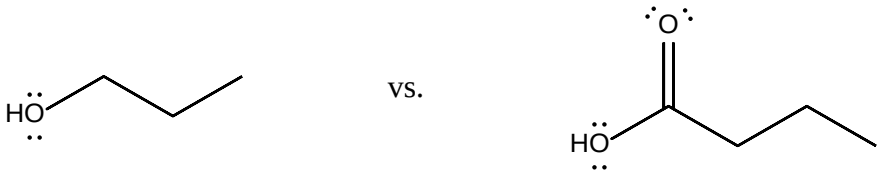
2. For each of the following pairs of molecules, explain how you would use **<u>two</u>** spectroscopic methods to distinguish between them. Be specific. What peak(s) are you looking for? Where are they? Give numbers or ranges where possible. **[12 marks]**
You may choose from ^{1}H NMR, ^{13}C NMR,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

(a)



(b)

(c)

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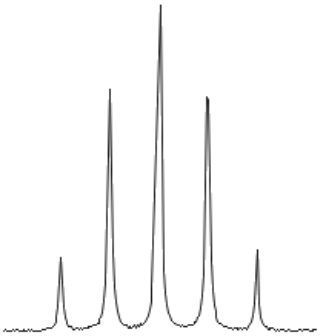
3. For each of the following peaks: **[12 marks]**

- 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.

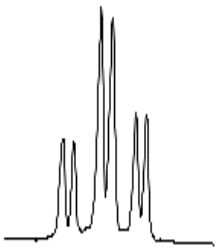
(a)



Splitting pattern: _____

Different J values: _____

(b)

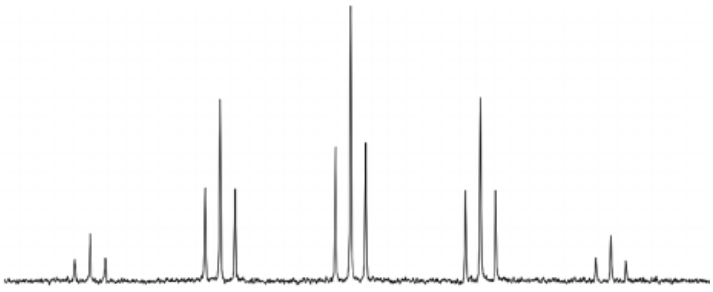


Splitting pattern: _____

Different J values: _____

Draw coupling constant(s) onto diagrams!

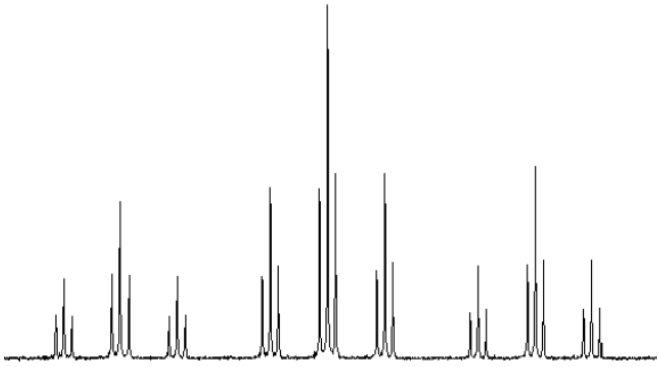
(c)



Splitting pattern: _____

Different J values: _____

(d)



Splitting pattern: _____

Different J values: _____

Draw coupling constant(s) onto diagrams!

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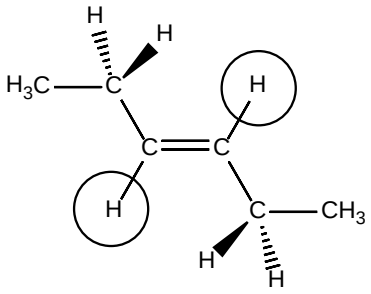
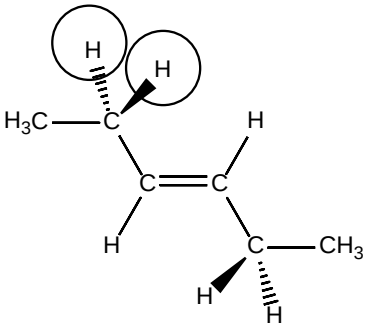
4. Below each molecule, write one of the following abbreviations (H, E, D or CD) to indicate the relationship between the circled hydrogen atoms: **[6 marks]**

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

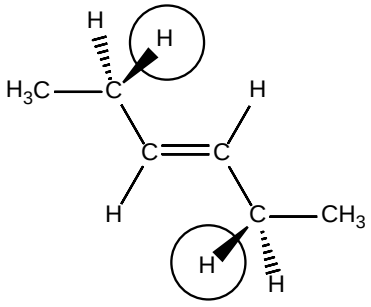
(a)



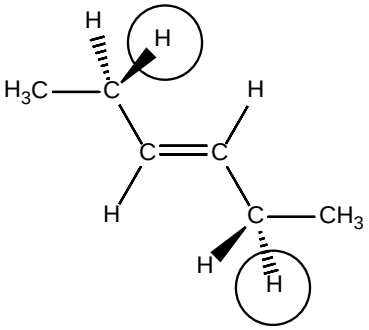
(b)



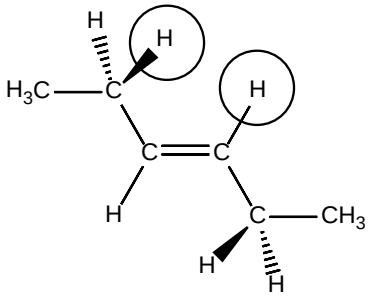
(c)



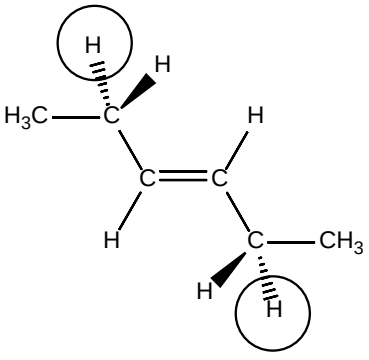
(d)



(e)



(f)



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5. The following page contains spectra for Unknown X ($C_6H_{10}O_6$). **[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. **ALL THREE PEAKS ON THE ^{1}H NMR ARE SINGLETS. YOUR EXPLANATION SHOULD ADDRESS WHY THIS IS THE CASE.**

(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:

NAME:_____ Section:_____ Student Number:_____

$C_6H_{10}O_6$

IR

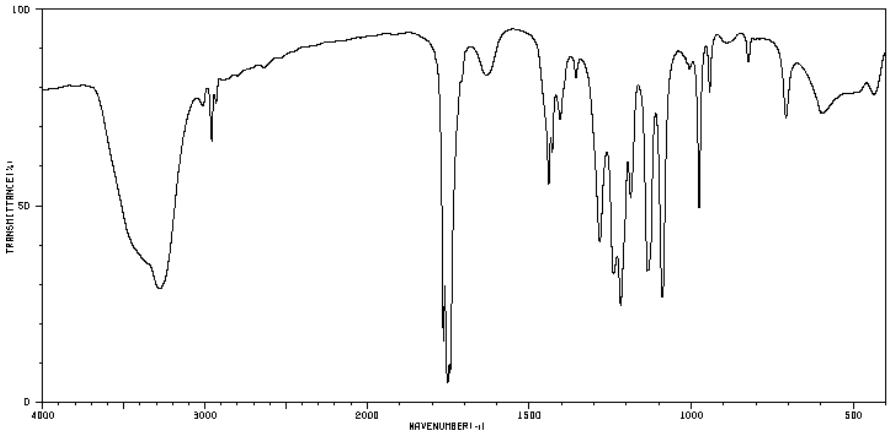
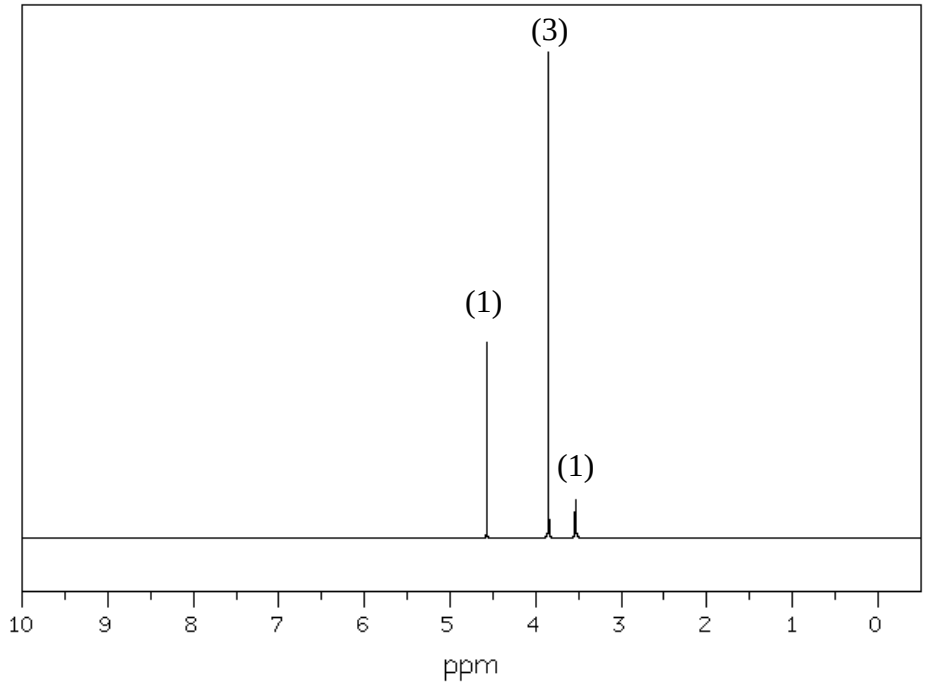


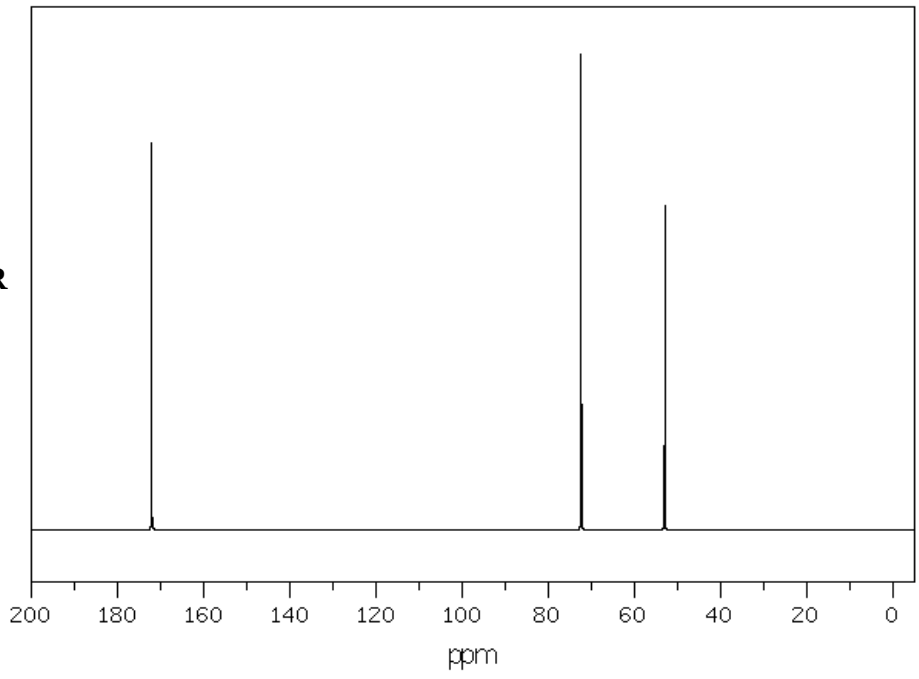
Table of wavenumbers and transmittances

3279	27	1744	7	1241	31	944	77
3013	72	1631	79	1218	23	825	84
2958	84	1440	55	1166	50	708	70
2942	74	1429	60	1136	32	602	70
2931	72	1405	70	1089	26	594	70
1765	15	1357	79	1006	81	437	74
1763	4	1283	39	976	47		

^{1}H NMR



^{13}C NMR



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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)