Fall 2017 **Chemistry 2600 Midterm I**

INSTRUCTIONS:

1) Please read over the exam carefully before beginning. This exam consists of 7 questions.
2) You have also been given a Spectral Data Booklet. **Please do not write on theses data sheets!** If you need scrap paper, use the back of the cover page or the back of the last page.
3) You may use a molecular model kit and a ruler. You may not have any papers or other written materials in your model kit.
4) No electronic devices can be present with you during the exam unless authorized by the instructor.
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 exam.
8) Most of the marks on the exam are for explaining/showing your work rather than for reaching the correct answer. Explain all of your answers fully. Hint: Figures really are worth a thousand words! If you are using a resonance argument to make a point, you must show the pertinent structures.
9) Marks will be deducted for poorly drawn structures.
10) Although complete sentences are not required (point form is acceptable), marks will be deducted for poor spelling and grammar.

Confidentiality Agreement:

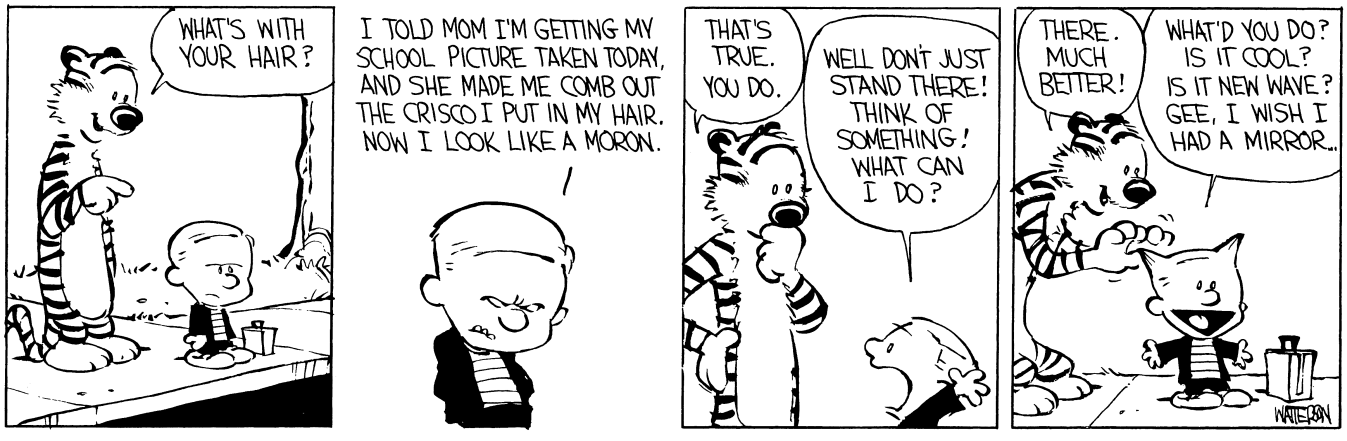
I agree not to discuss (or in any other way divulge) the contents of this exam until they have all been marked and returned. I understand that, if I were to break this agreement, I would be choosing to commit academic misconduct, a serious offense which will be punished. The minimum punishment would be a mark of 0% on this exam and the maximum punishment would include expulsion from this university.

Signature: _____ Date: _____

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

Question Breakdown

Q1	**/8**
Q2	**/4**
Q3	**/10**
Q4	**/25**
Q5	**/6**
Q6	**/6**
Q7	**/6**
Total	**/65**

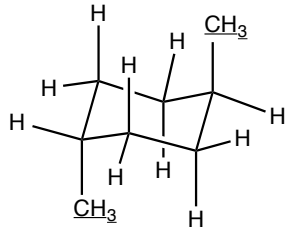


Chem 2600 Midterm #1
October, 2017

Question One (8 marks)

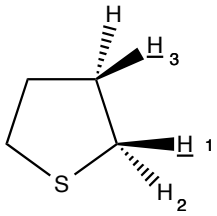
Referring to the structures below, are the underlined atoms/groups homotopic, enantiotopic, diastereotopic or none of the above? No explanation is required.

a)



CH_3 and CH_3

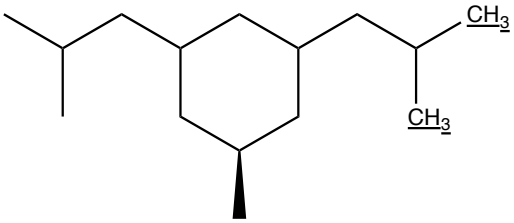
b)



H_1 and H_3

H_1 and H_2

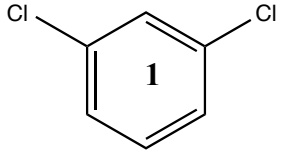
c)

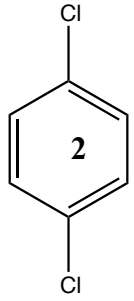


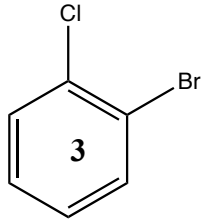
CH_3 and CH_3

Question Two (4 marks)

How could you distinguish between the following 4 molecules using only ^{1}H decoupled ^{13}C NMR ($^{13}C\{^{1}H\}$) and ^{13}C DEPT 135 NMR (CH and CH_3: ↑, CH_2↓, quaternary C not observed)?



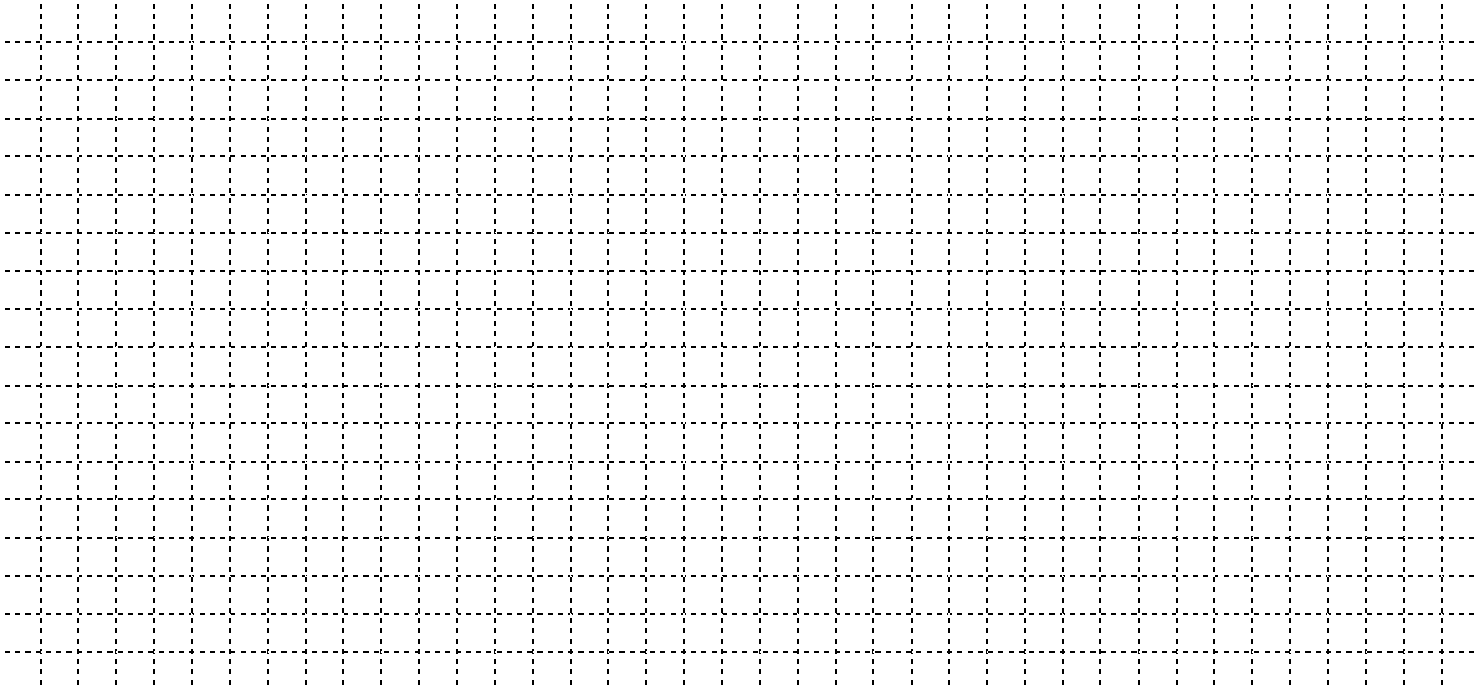




Question Three (10 marks)

(a) Use the grid below and the provided scale to draw and label a ***complete*** tree diagram with accompanying spectrum for a doublet (18 Hz) of doublets (8 Hz) of quartets (2 Hz).

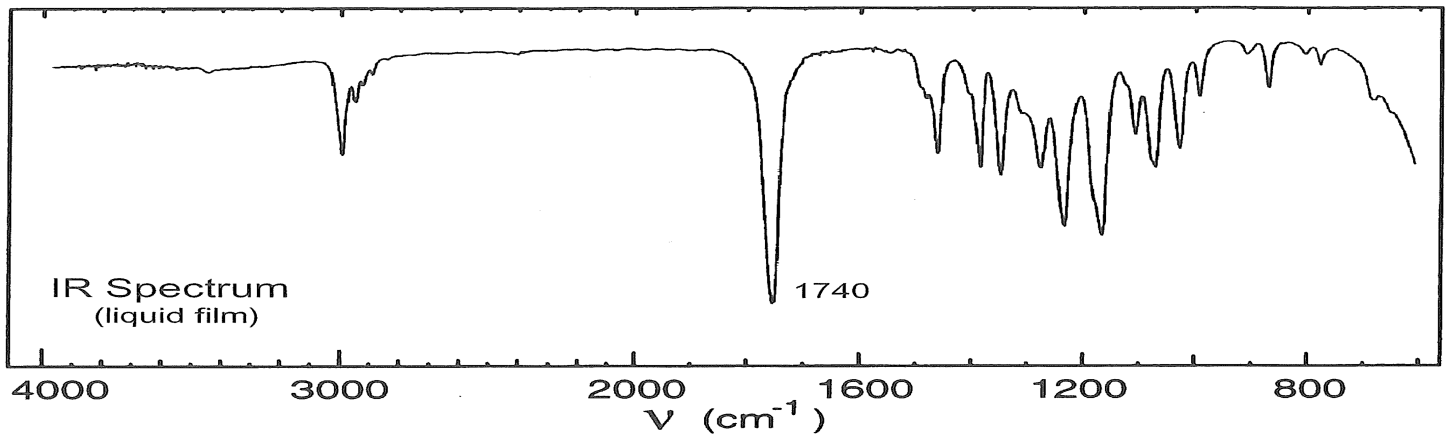
1 cube = 1 Hz

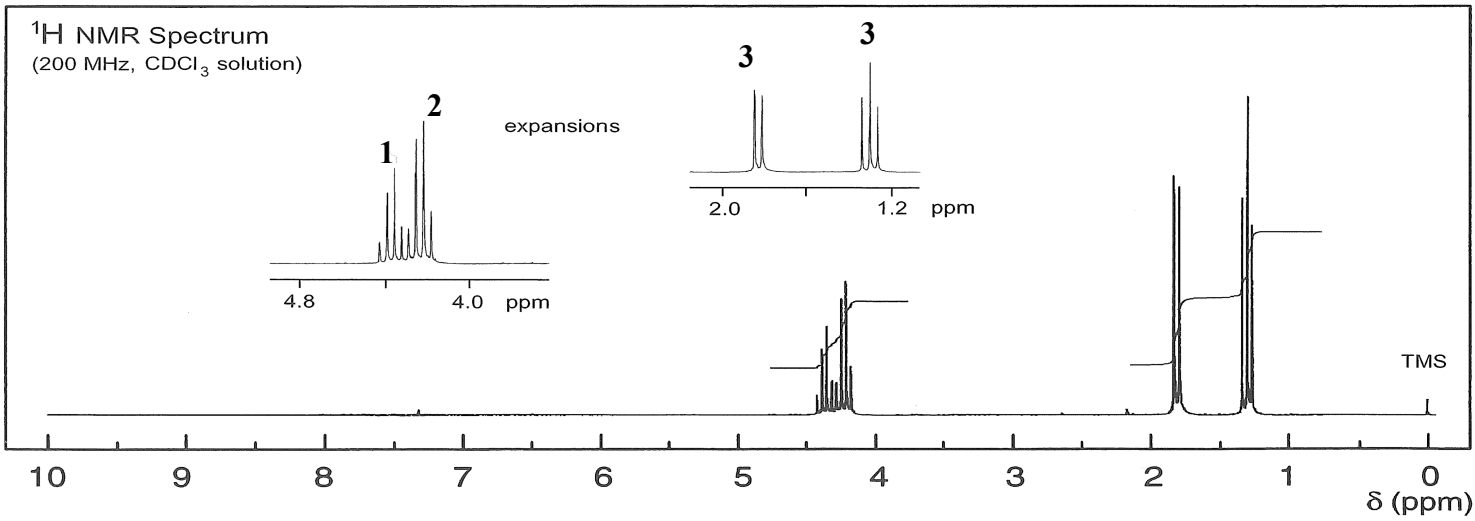


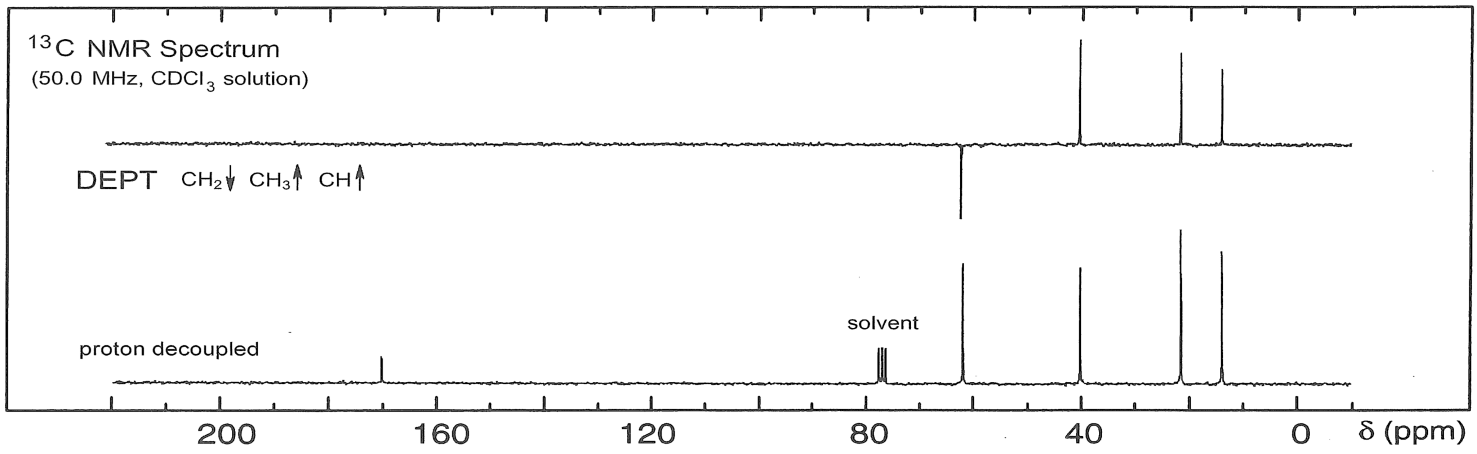
(b) Draw a molecule or part of a molecule containing a proton (Ha) which could give this doublet of doublets of quartets pattern. Make sure that your labels are consistent with those of your tree diagram.

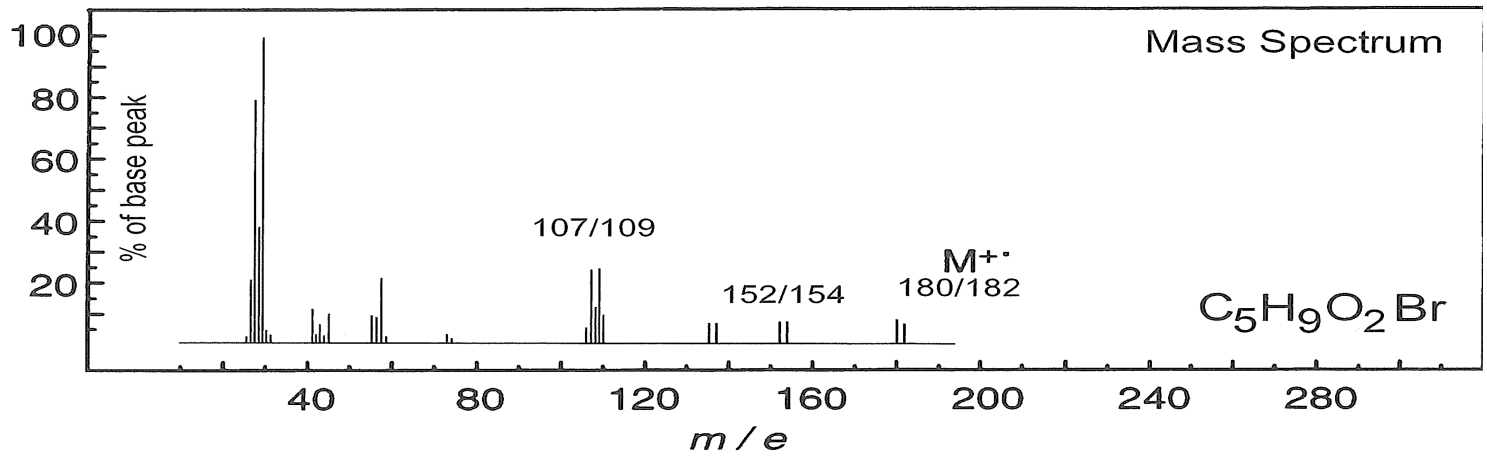
Question Four (25 marks)

- Using the following spectra, deduce the structure of this unknown molecule with a molecular formula of $C_5H_9O_2Br$.
- **Label each peak** on each NMR spectrum (^1H and ^{13}C) as much as is possible and label any important IR bands.
- In the Mass Spectrum, identify and explain the origin of the two peaks at 107/109 amu and 180/182 amu.
- Explain all the logic you used to determine the structure of the unknown molecule.





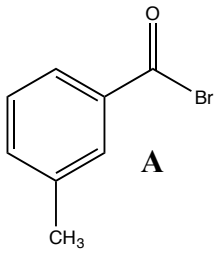




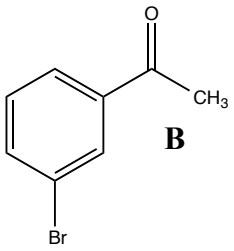
(question four con't)

Question Five (6 marks)

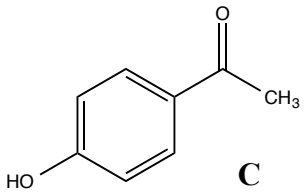
In the boxes provided, label the ^{13}C NMR spectra (**1-6**) with the matching letter of the correct chemical structure (**A-F**). No explanation is required.



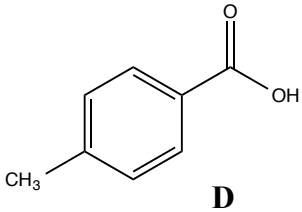
A



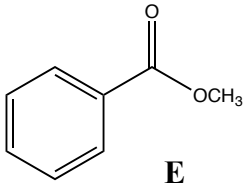
B



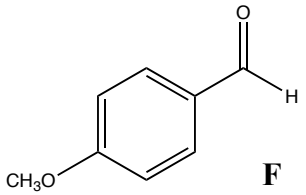
C



D

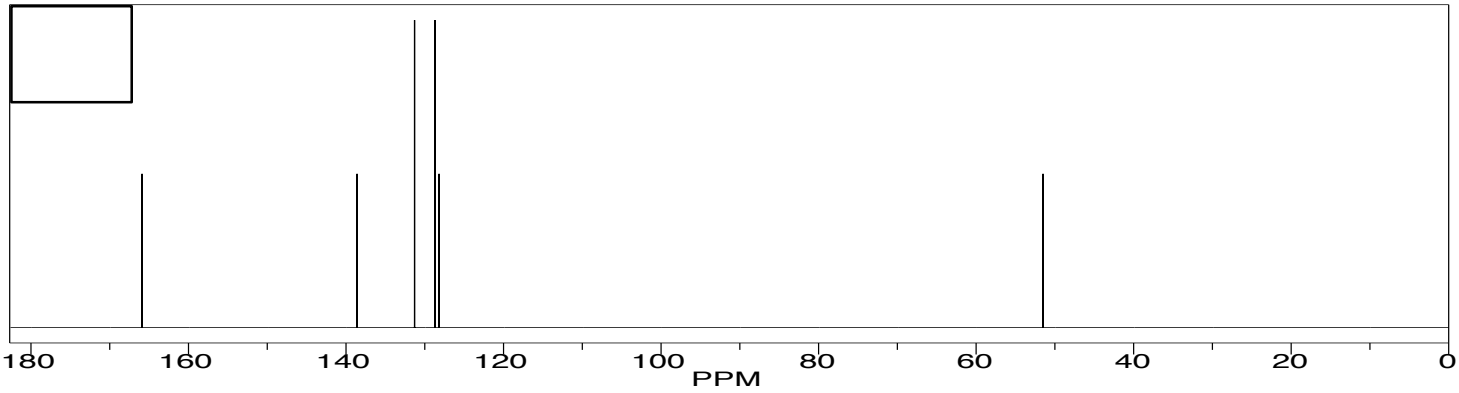


E

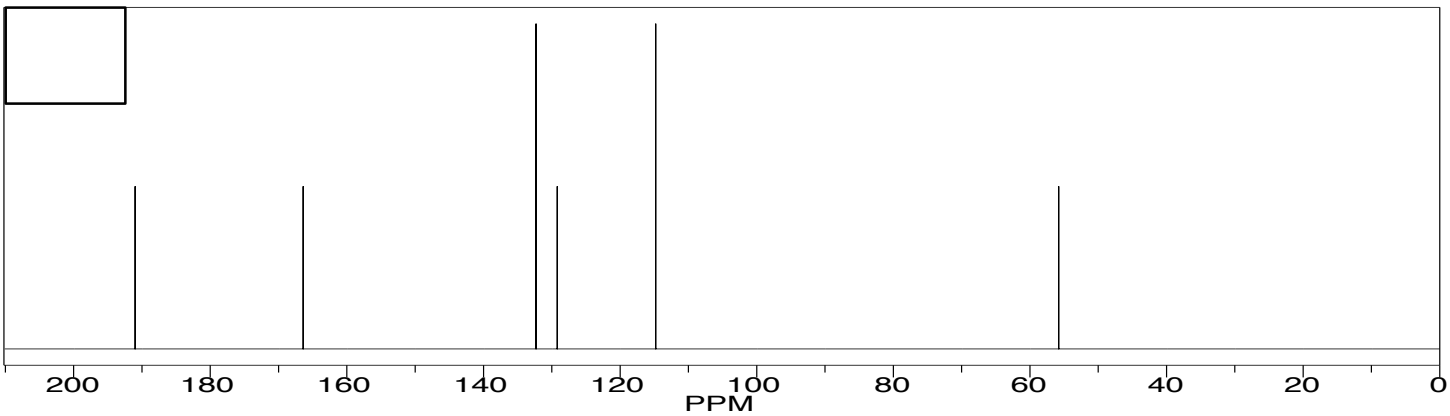


F

spectrum 1:

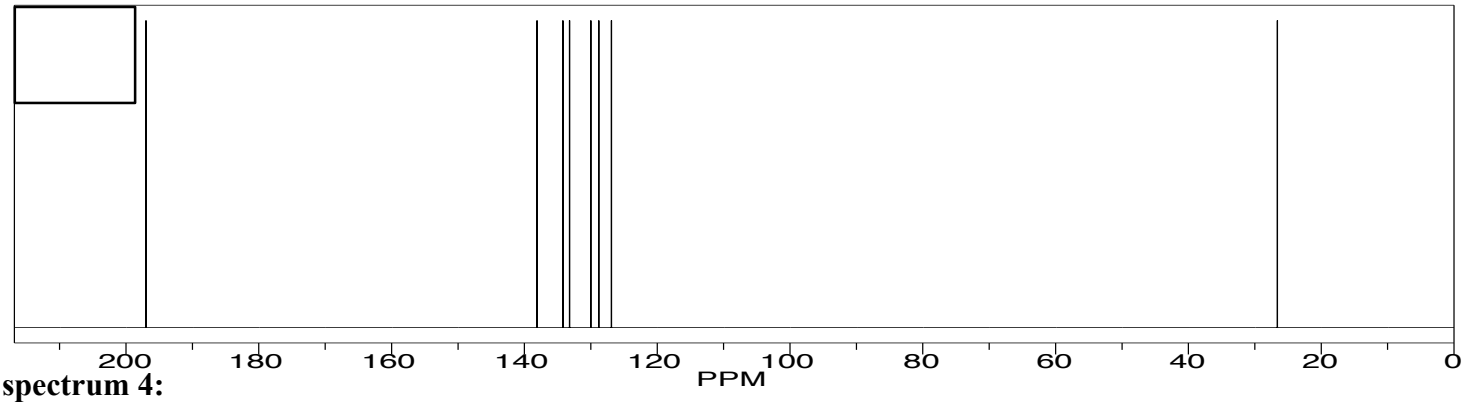


spectrum 2:

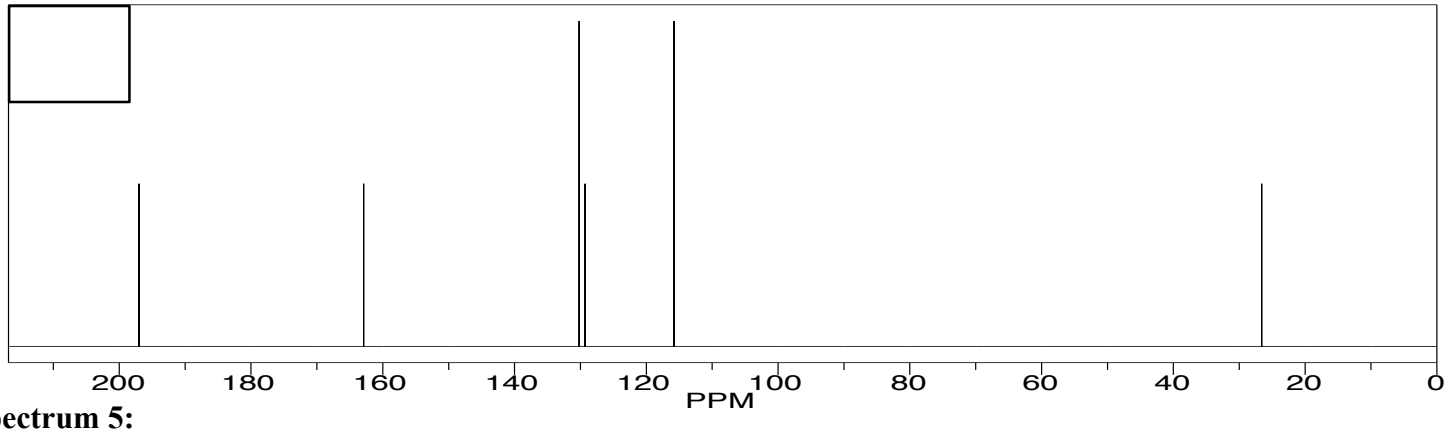


(question five con't)

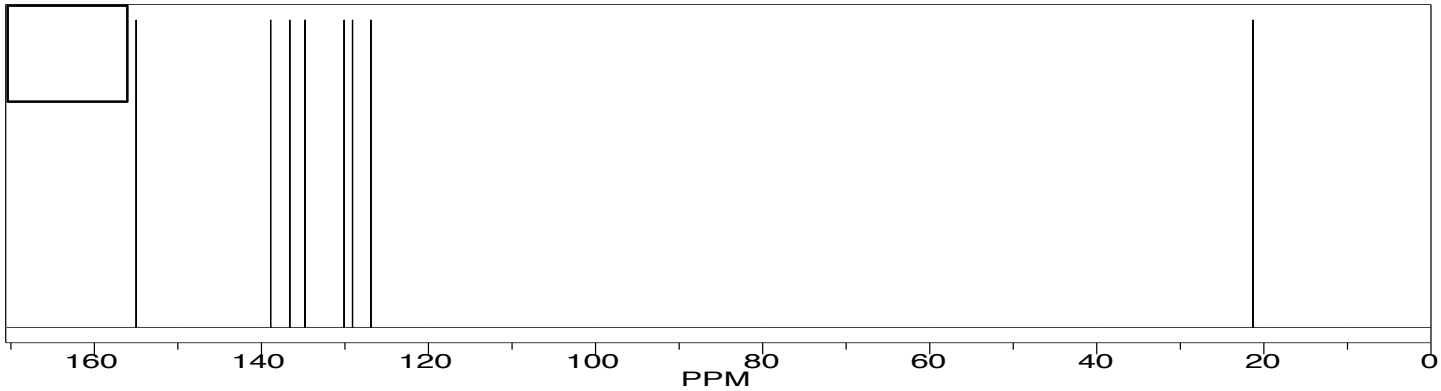
spectrum 3:



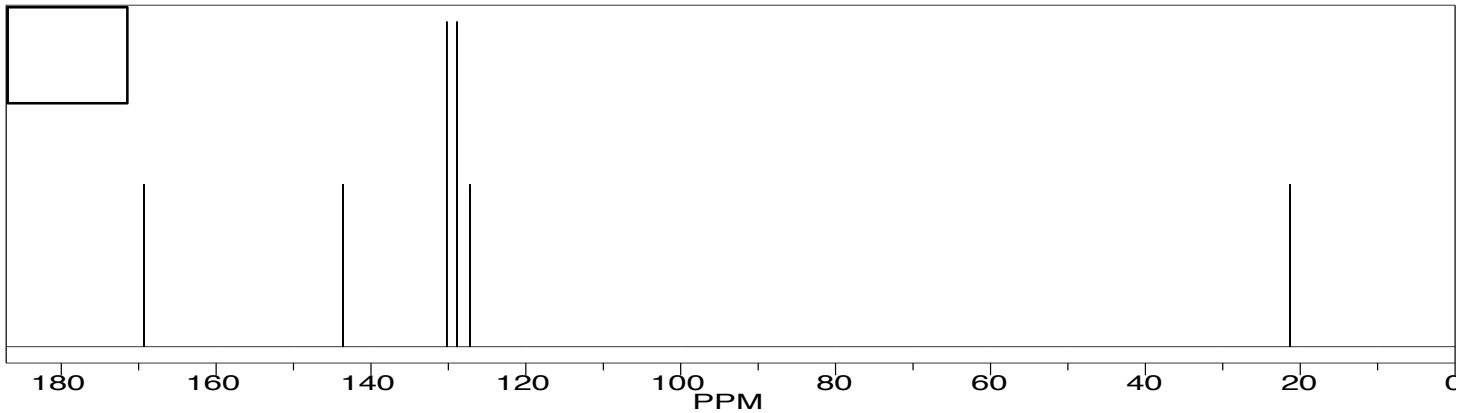
spectrum 4:



spectrum 5:



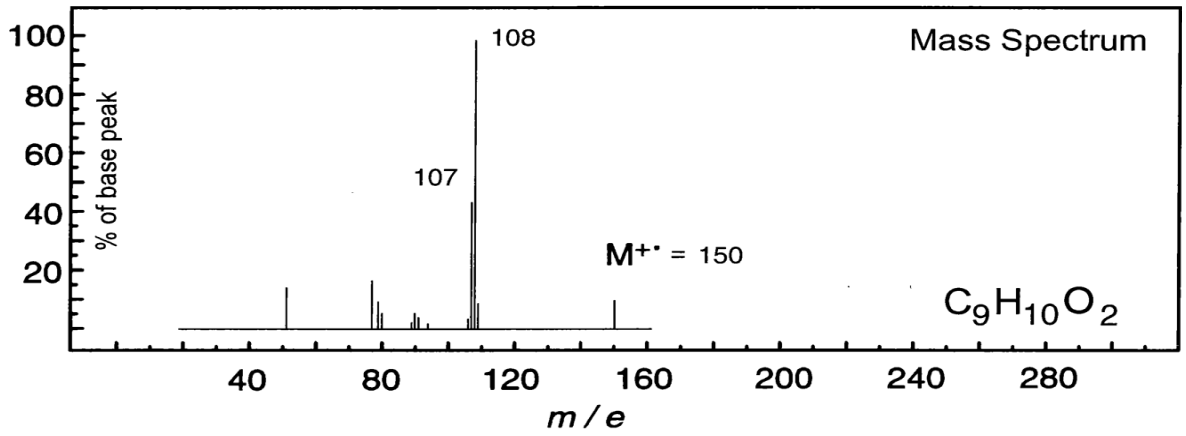
spectrum 6:

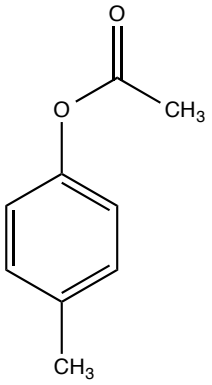


Question Six (6 marks)

Consider the structure of *p*-tolyl acetate and its Mass Spectrum shown below.

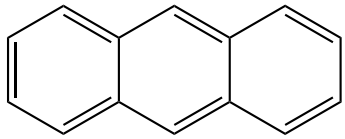
- Give the structure of the fragment giving the peak at 107 amu.
- The peak at 108 amu is due to a McLafferty rearrangement. Give the structure of the rearrangement product and show the mechanism of its formation.





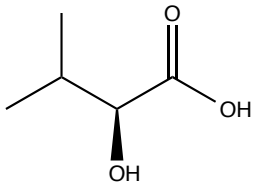
Question Seven (6 marks)
How many ^{1}H signals and how many ^{13}C signals would you expect from each of the following molecules? No explanation is required.

(a)



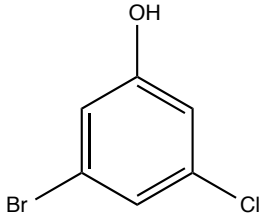
^{1}H = _____ ^{13}C = _____

(b)

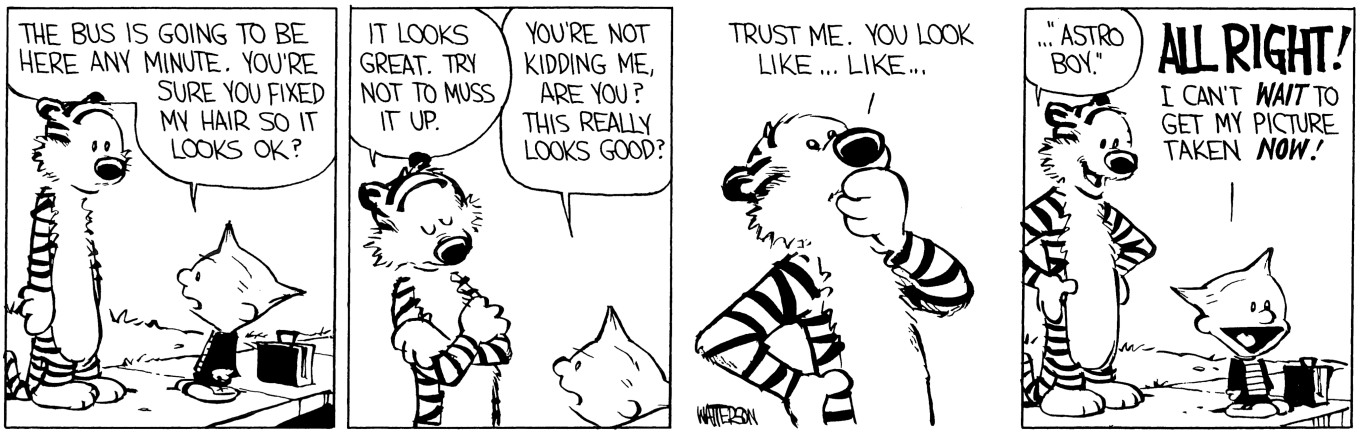


^{1}H = _____ ^{13}C = _____

(c)



^{1}H = _____ ^{13}C = _____



hydrogen 1 **H** 1.0079																	helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122											boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305											aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.39	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 **	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	ununnilium 110 **Uun** [271]	unununium 111 **Uuu** [272]	ununbium 112 **Uub** [277]		ununquadium 114 **Uuq** [289]				

Key:

element name
atomic number
symbol
atomic weight (mean relative mass)

*lanthanoids	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.04
**actinoids	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]