

NAME: _____ Section: _____ Student Number: _____

Spring 2019

Chemistry 2600 Midterm 2

_____/ 65 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) Electronic devices (including calculators) are **not** allowed for this test.
 - 5) If your work is not legible, it will be given a mark of zero.
 - 6) 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.
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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 Monday, March 18th, 2019. I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/65 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 2019

The University of Lethbridge

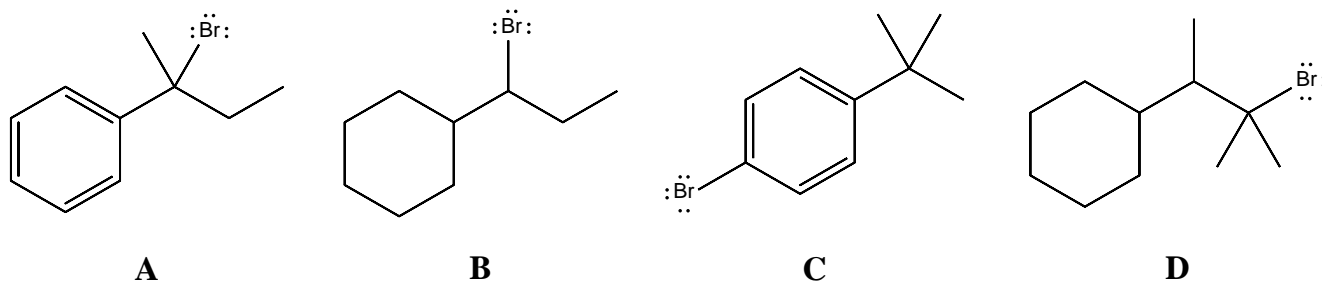
Question Breakdown

Q1	/ 6
Q2	/ 6
Q3	/ 5
Q4	/ 7
Q5	/ 8
Q6	/ 7
Q7	/ 7
Q8	/ 10
Q9	/ 9

Total	/ 65
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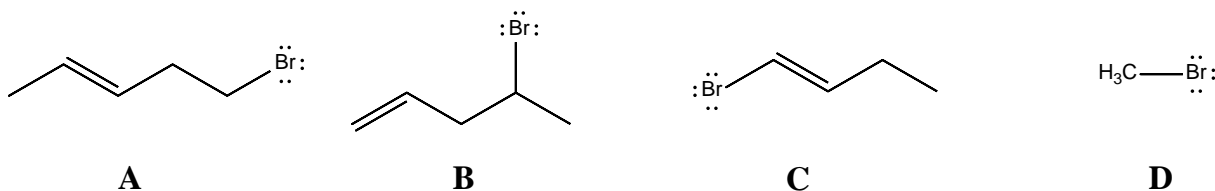
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1. [6 marks]
(a) Rank the following substrates in order from slowest E1 reaction rate to fastest. [2 marks]



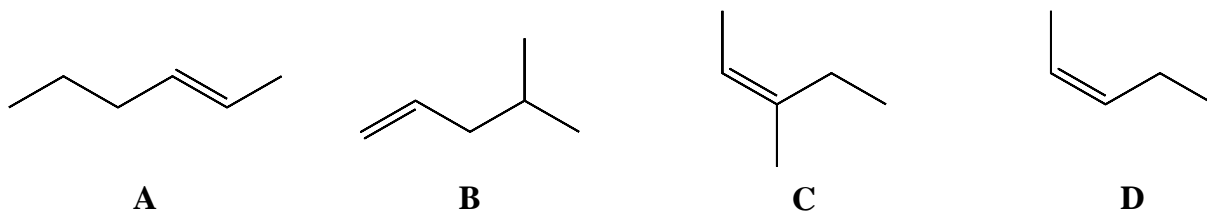
slowest _____ fastest

(b) Rank the following substrates in order from slowest S_N2 reaction rate to fastest. [2 marks]



slowest _____ fastest

(c) Rank the following alkenes from least to most stable. [2 marks]



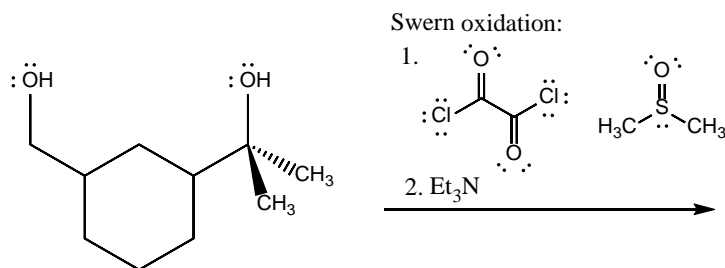
least stable _____ most stable

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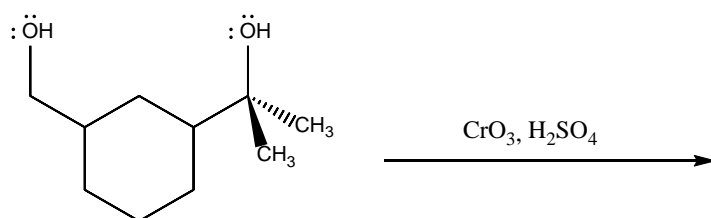
2. Draw the organic product for each of the following reactions:

[6 marks]

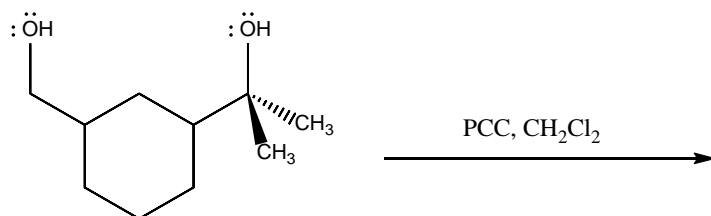
(a)



(b)



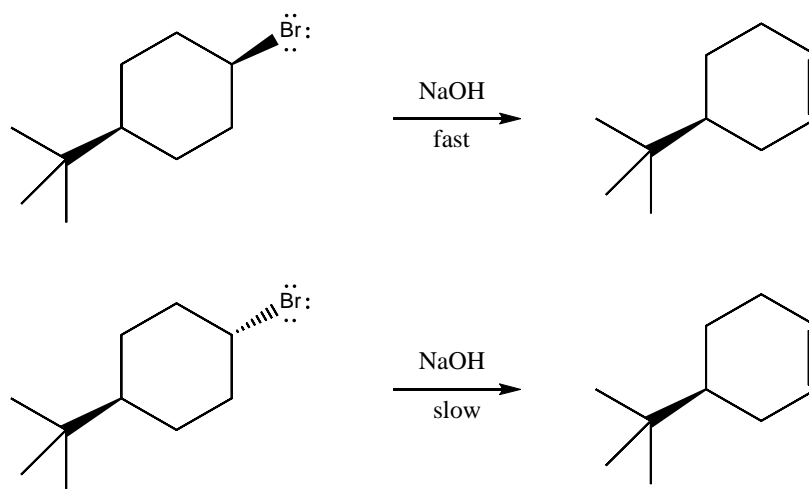
(c)



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3. The *cis* isomer of 1-bromo-4-*tert*-butylcyclohexane undergoes E2 elimination ~1000 times faster than the *trans* isomer. Explain why the *cis* isomer reacts faster. **[5 marks]**

For full credit, your answer should include one or more diagrams.



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4. A kinetic study of the reaction between an alkyl bromide (RBr) and a non-nucleophilic base ($base$) provided the following data: [7 marks]

$[RBr]$ ($\frac{mol}{L}$)	$[base]$ ($\frac{mol}{L}$)	Rate of reaction ($\frac{mol}{L \cdot s}$)
1	1	6
1	2	6
2	4	12
3	4	18

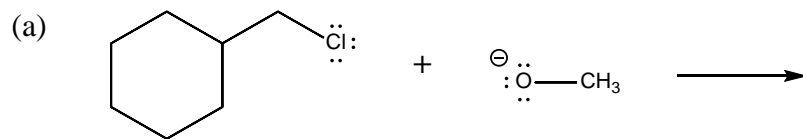
- (a) Write the rate law for this reaction. Include a numerical value and units for k . [4 marks]
Clearly identify the order of each reactant.

- (b) Did this reaction proceed via an S_N1 , S_N2 , $E1$ or $E2$ mechanism? Explain your choice. It must be clear why all three alternative options were rejected. [3 marks]

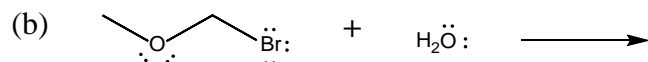
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5. Indicate whether or not you would expect to see a significant amount of reaction according to each mechanism type by circling 'yes' or 'no'. In the bottom row of each table, justify your answer by: **[8 marks]**

- For each 'yes', drawing the organic product(s) that will be observed.
- For each 'no', briefly explaining why you expect little-to-no reaction.



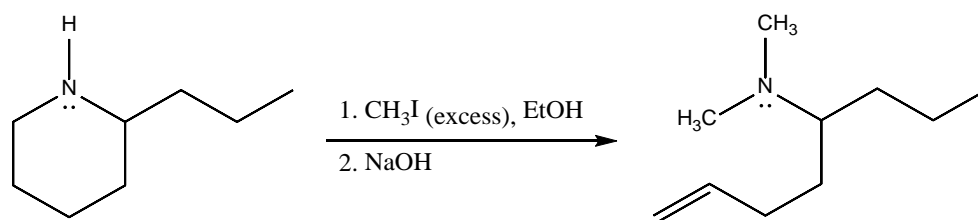
S_N1? yes / no	S_N2? yes / no	E1? yes / no	E2? yes / no



S_N1? yes / no	S_N2? yes / no	E1? yes / no	E2? yes / no

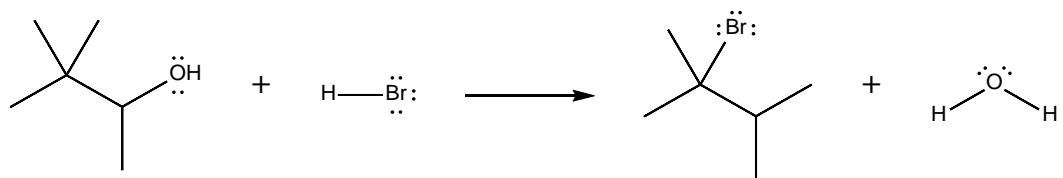
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6. Propose a reasonable reaction mechanism for the following reaction: **[7 marks]**



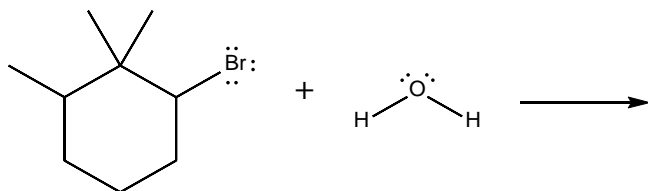
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7. Propose a reasonable reaction mechanism for the following reaction: [7 marks]



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8. The following reaction gives 5 different products (not including stereoisomers): 2 different substitution products and 3 different elimination products. **[10 marks]**



- (a) Draw the two substitution products.

[4 marks]

- (b) Draw the three elimination products.

[6 marks]

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9. ^1H NMR analysis of Compound A ($\text{C}_4\text{H}_9\text{Cl}$) gives a spectrum with one singlet at 1.6 ppm. When Compound A is reacted with water, a mixture of two products is formed:

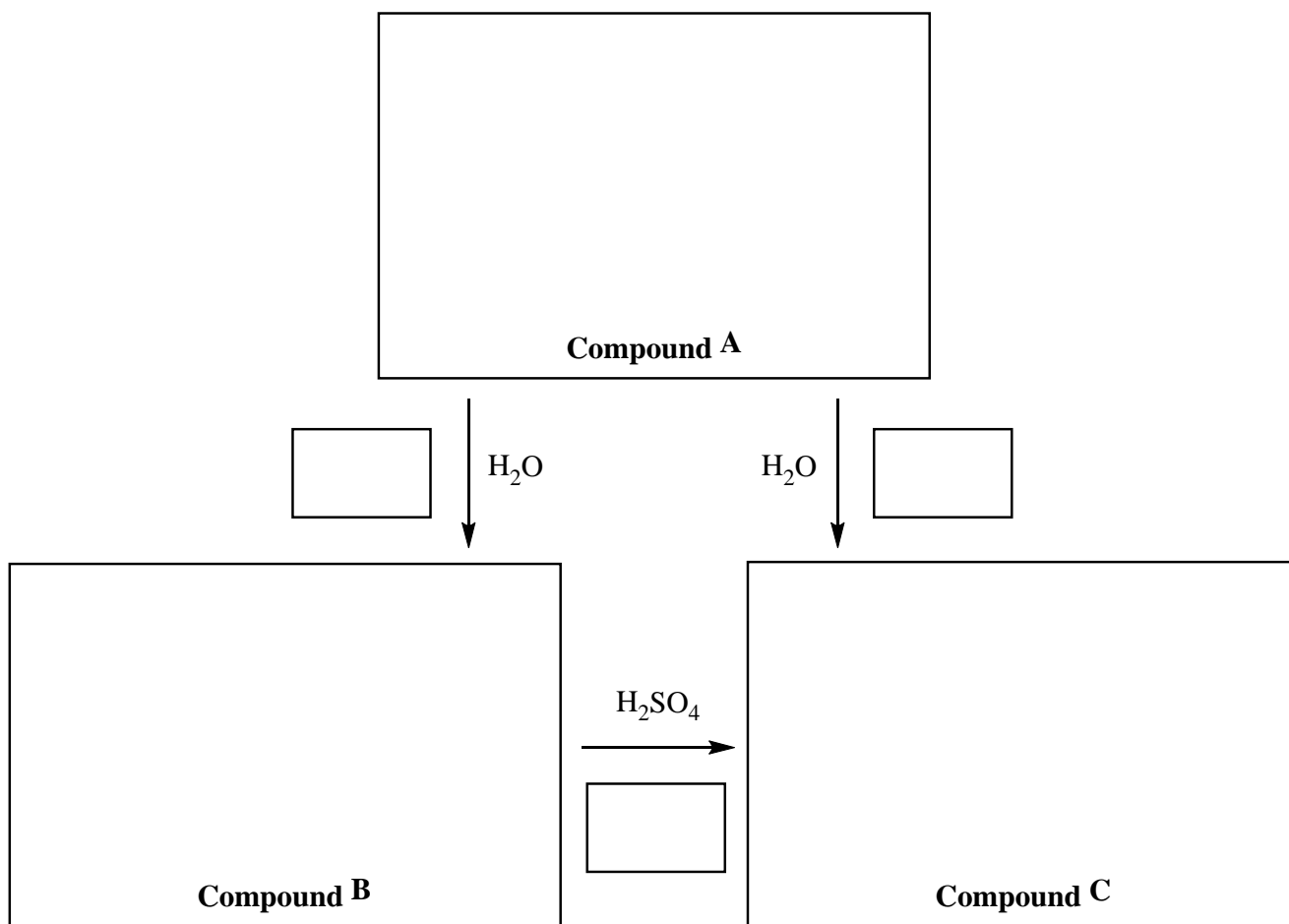
- ^1H NMR analysis of Compound B gives two signals: 1.3 ppm and 2.0 ppm
- ^1H NMR analysis of Compound C gives two signals: 1.7 ppm and 4.7 ppm.

If Compound B is treated with concentrated sulfuric acid, Compound C is produced.

Complete the diagram below by

- drawing the structures of Compounds A, B and C in the boxes provided, and
- identifying each reaction as proceeding via $\text{S}_{\text{N}}1$, $\text{S}_{\text{N}}2$, E1 or E2 mechanism in the boxes provided next to the arrows.

[9 marks]



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CHEM 1000 Standard Periodic Table

1																		18
1.0079 H 1												He 2						
2												13	14	15	16	17		
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. Boéré (updated 2016)