Name: _____ Student Number: _____

Chemistry 2600 Final Exam (Version A)
April 10th, 2019

INSTRUCTIONS

1) Read the exam carefully before beginning. There are 9 questions on pages 2 to 13 followed by a periodic table and a blank page for rough work. You are also provided with a Spectroscopy Data Package (as posted on the class website). **Please ensure that you have a complete exam. If not, let an invigilator know immediately**. All pages must be submitted.
2) You are allowed to bring one index card (maximum size 3"x5") into the exam with you as a "cheat sheet". This card must be submitted with your exam.
3) You are allowed to bring a ruler and a molecular 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) When drawing molecules, clearly show any relevant stereochemistry. If a mixture of diastereomers is produced, draw both/all of them.
8) **DO NOT OPEN THE EXAM UNTIL YOU ARE TOLD TO BEGIN.**
   Beginning prematurely will result in removal of your exam paper and a mark of 0.
9) You have **3 hours** to complete this exam. Nobody may leave the exam room during the first hour or the last 15 minutes of the exam.

Q	Mark
1	/ 8
2	/ 12
3	/ 9
4	/ 8
5	/ 10

Q	Mark
6	/ 24
7	/ 18
8	/ 6
9	/ 1
10	

Total	/ 96

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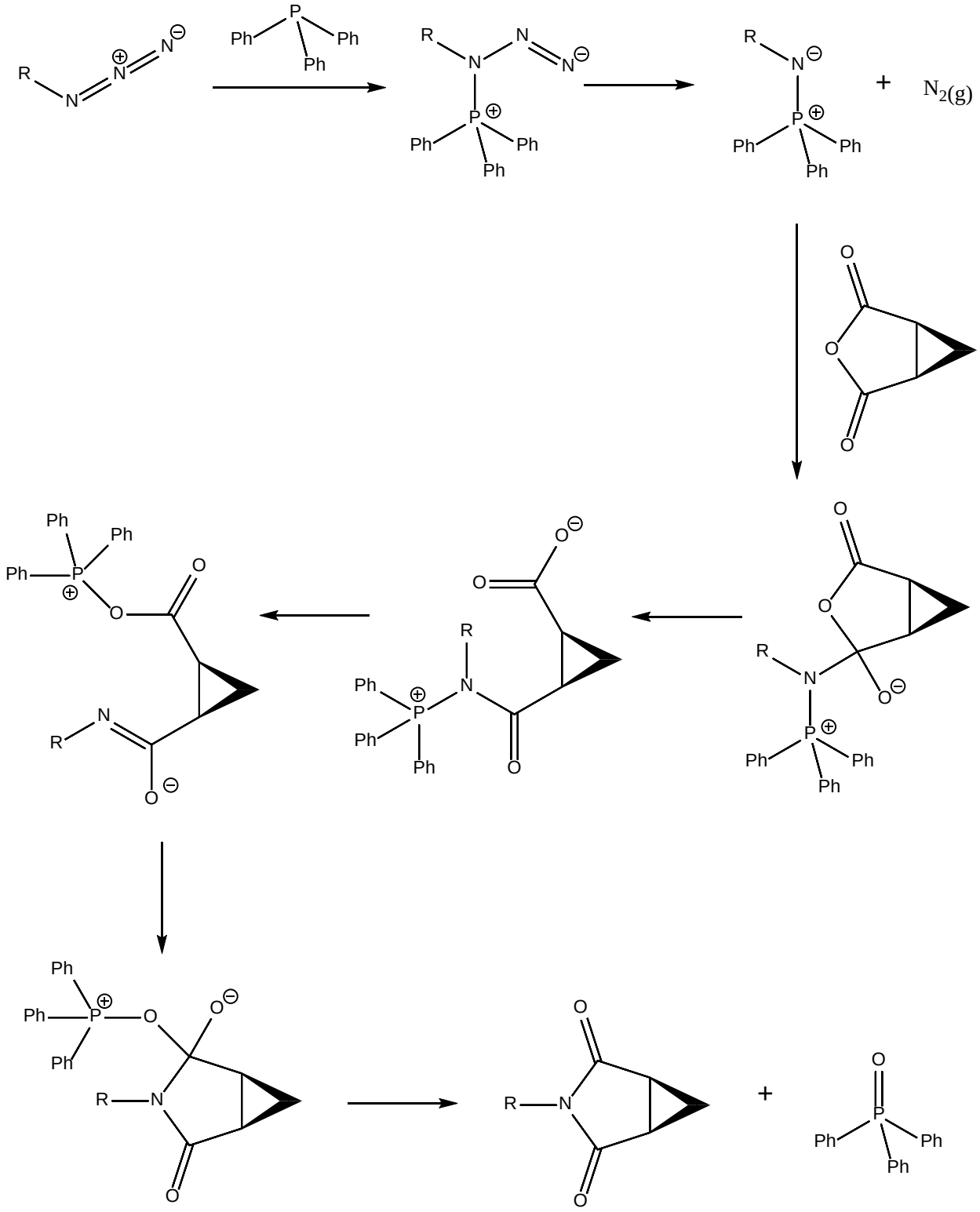
1. Complete the following mechanism by adding all lone pair electrons and curly arrows to show electron movement. **[8 marks]**



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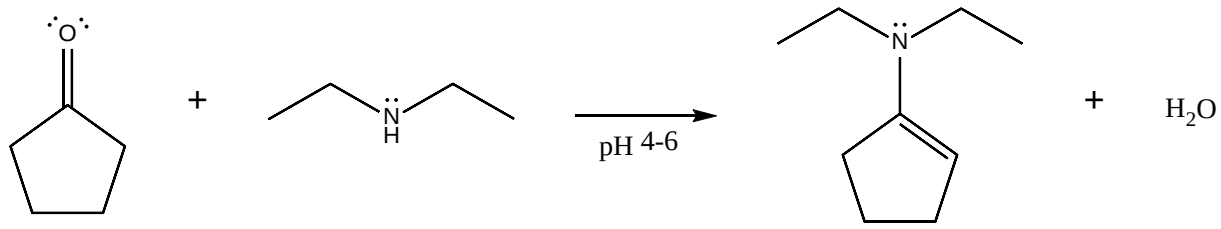
2. Propose a reasonable mechanism for the following reaction. You may assume the presence of water and catalytic amounts of H^+. **[12 marks]**



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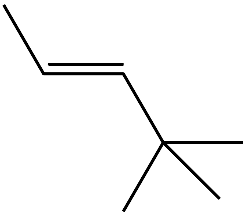
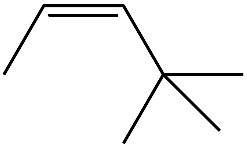
3. An alkyl bromide is reacted with sodium hydroxide. E2 reaction gives a mixture of the following two products (one major; one minor): **[9 marks]**



and



A **B**

(a) Draw the alkyl bromide that will **only give these two products** when reacted with hydroxide. *[2 marks]*

(b) Briefly explain why no S_N2 reaction is observed when the alkyl bromide (your answer to part (a)) is reacted with hydroxide. *[2 marks]*

(c) Which is the major product, **A** or **B**? *[1 mark]*

(d) How could you use ^{1}H NMR spectroscopy to distinguish between **A** and **B**? *[4 marks]*

For full credit, your answer must be specific, including any relevant numerical values/ranges.

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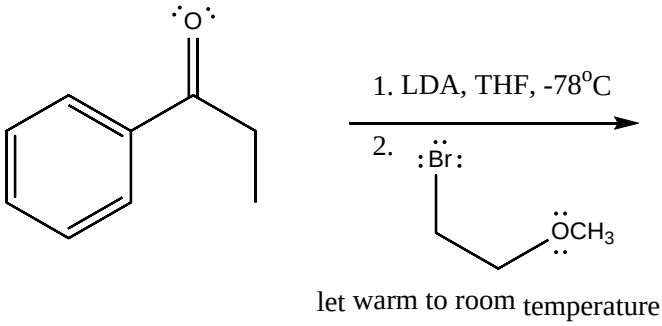
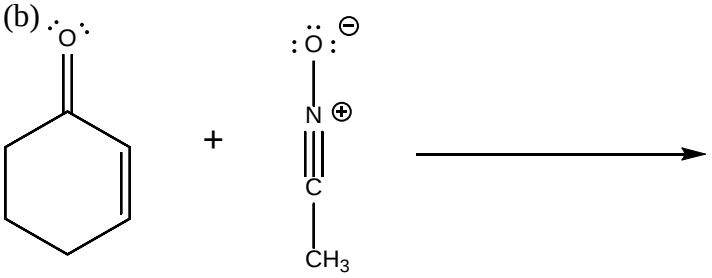
4. For each of the following reactions, draw the major organic product. Your answer should clearly show any relevant regiochemistry and/or stereochemistry. **[8 marks]**

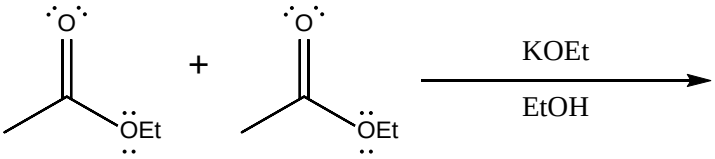
(a)



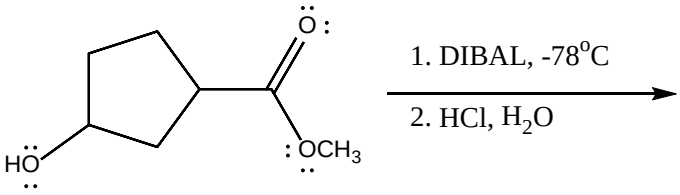
(b)



(c)



(d)



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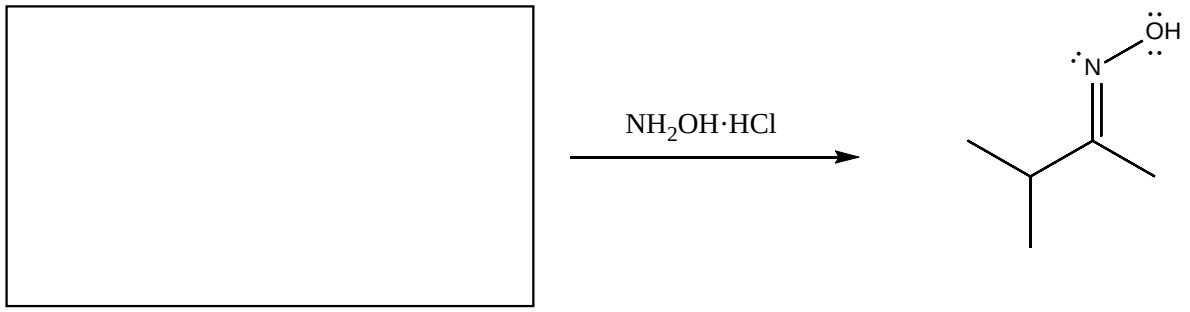
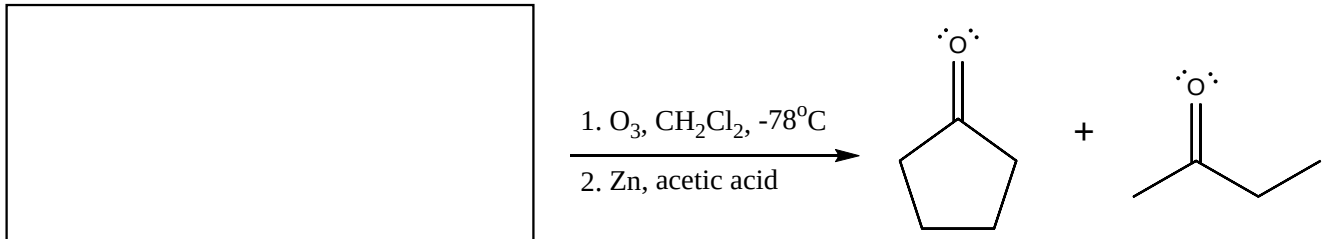
5. For each of the following reactions, draw the missing reactant(s). Your answer should clearly show any relevant regiochemistry and/or stereochemistry. **[10 marks]**

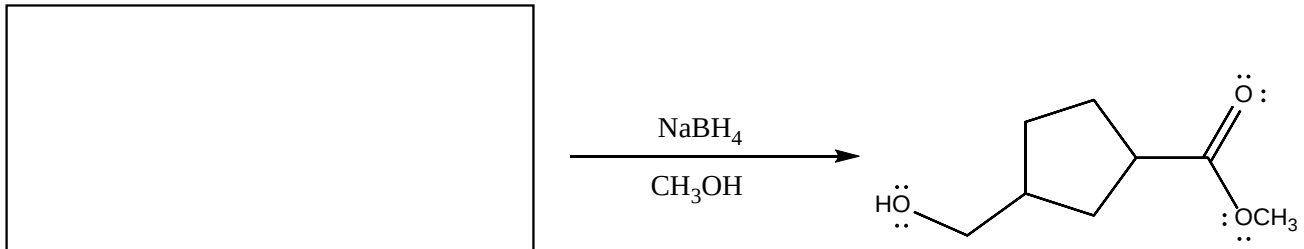
(a)



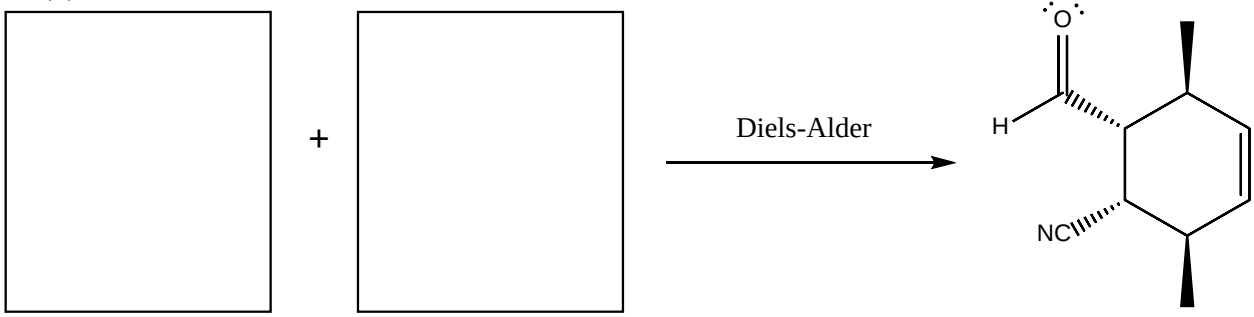
(b)



(c)



(d)



Name: _____ Student Number: _____

6. The following page contains spectra for Unknown X. **[24 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, redrawing 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.*

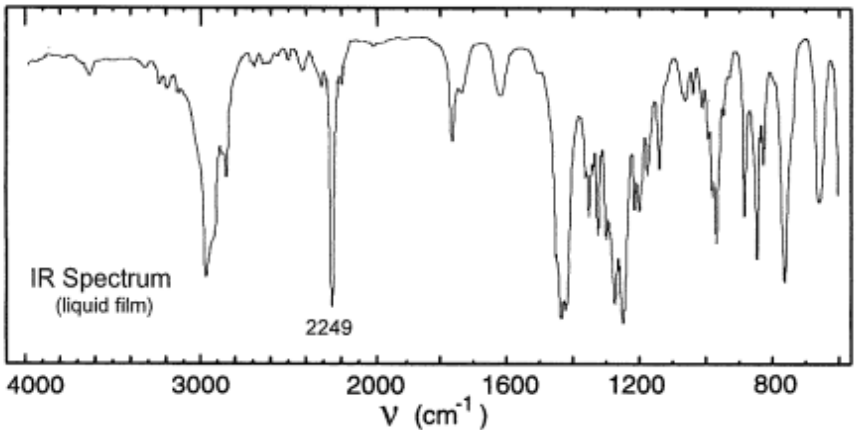
(d) Label the numbered peaks on the MS with the formulas of the corresponding fragments.

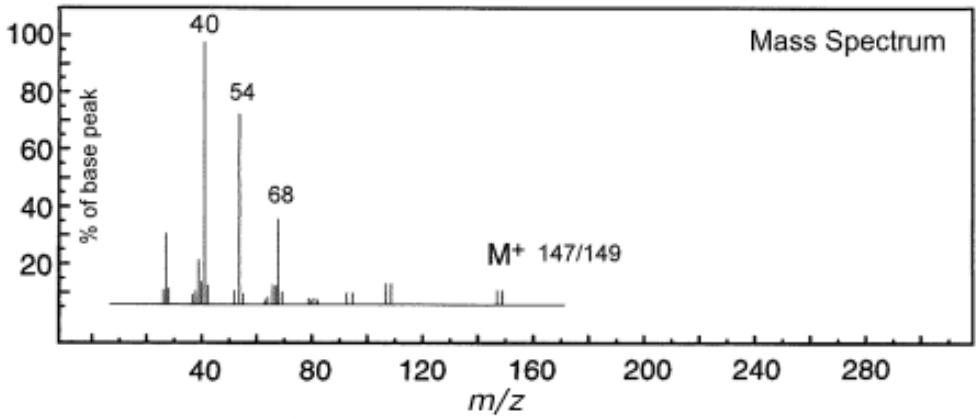
(e) Label any important peaks on the IR with the corresponding stretch.

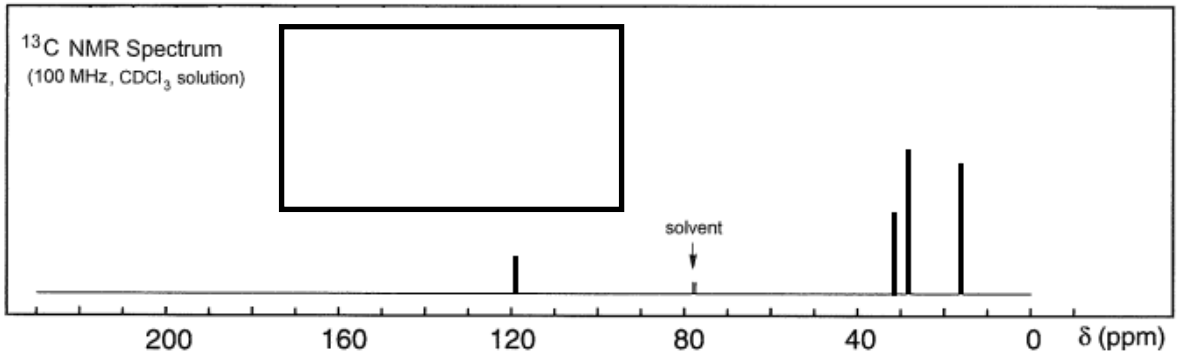
Unknown X:

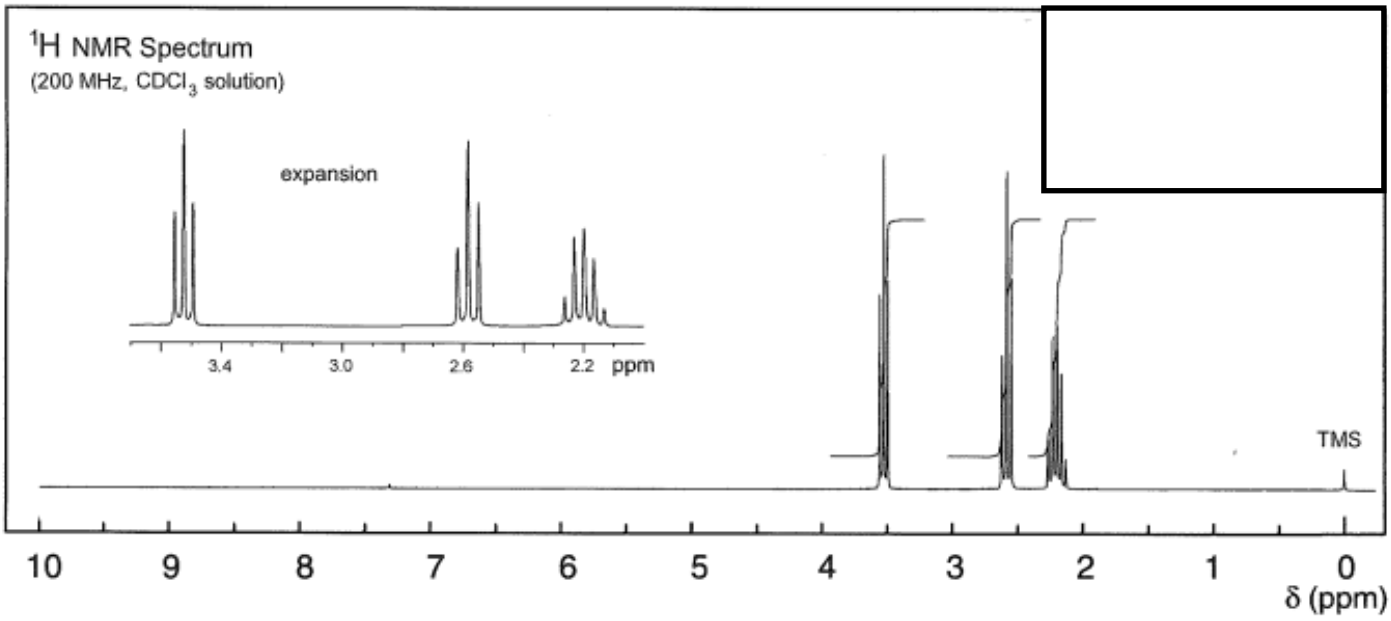
Name: _____ Student Number: _____

6. *continued…* *(peaks on ^{13}C NMR were darkened for clarity; each is a single line)*









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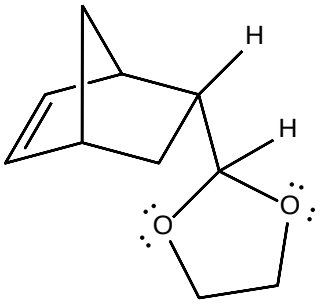
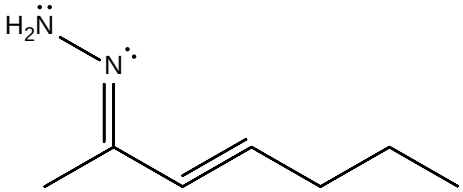
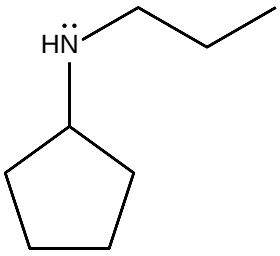
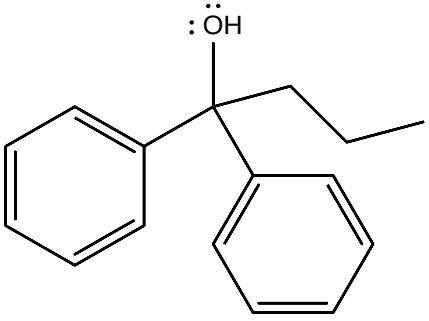
7. Choose any **three** of the molecules below and propose a synthesis for each one. **[18 marks]**

- If your synthesis involves more than one step, write an equation for each step. Show all required reactants. Number steps within a reaction if order of addition is important.
- All organic reactants must be stable compounds containing **no more than five carbon atoms**. They may be **hydrocarbons, alkyl halides or alcohols** and may contain C=C or C≡C bonds. The only exception to this rule is that you are **also allowed** to use **benzene, bromobenzene or phenol**.
- If you wish to use an organic reactant (including Grignard reagent) that does not meet these requirements, you must show how to make it from starting materials that do.
- You may use any inorganic reagents, acids, bases, catalysts, etc.
- Acids, bases, catalysts, etc. do not need to meet the "organic reactant" requirements if the organic part will not be present in the final product.
- Clearly indicate stereochemistry of reaction products where appropriate. Assume that all stereochemistry shown is relative and that you are to make racemic product.
- You are **not** required to show mechanisms for this question.
- There are three pages after this page. Use one of those pages for each synthesis and clearly identify the synthetic target at the top of the page. This page is scrap paper.
- If you give more than three syntheses, I will only mark the first three (ignoring any that are crossed out).









Name: _____ Student Number: _____

7. *continued…* *[6 marks]*

Synthetic Target #1:

Synthesis:

Name: _____ Student Number: _____

7. *continued…* *[6 marks]*

Synthetic Target #2:

Synthesis:

Name: _____ Student Number: _____

7. *continued…* *[6 marks]*

Synthetic Target #3:

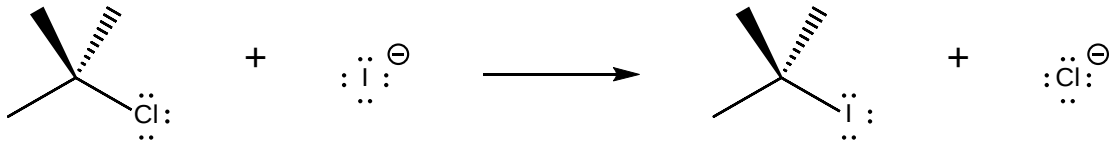
Synthesis:

Name: _____ Student Number: _____

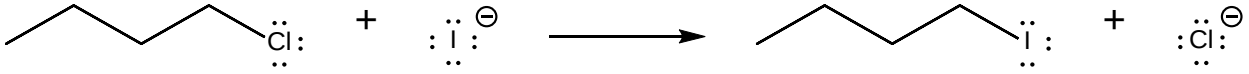
8. For each of the following reactions, **[6 marks]**

- classify it as E1, E2, S_N1 or S_N2, and
- write the rate law.

(a)



(b)



9. What was the most interesting and/or useful thing you learned in CHEM 2600? **[1 mark]**

…AND THAT'S ALL FOR CHEM 2600.
HAVE A GREAT SUMMER!

DATA SHEET/SCRAP PAPER

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)