

Chemistry 2600 Final Exam (Version A)
April 22nd, 2009

INSTRUCTIONS

- 1) Read the exam carefully before beginning. There are 11 questions on pages 2 to 11 followed by a periodic table and a blank page for rough work. You are also provided with an NMR Data Package and a page with pi MOs. **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) No electronic devices of any kind (including calculators) are permitted.
- 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) IF YOU USE RESONANCE ARGUMENTS AS PART OF YOUR REASONING, THEN DRAW THE RELEVANT STRUCTURES.
- 9) If you think that you see another student cheating, write a note on your exam paper and raise your hand to show an invigilator so that we can investigate the situation.
- 10) **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.
- 11) 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.

Confidentiality Agreement:

I agree not to discuss (or in any other way divulge) the contents of this exam with or in the presence of any CHEM 2600 student who has not yet written their final exam. (*The last official exam timeslot ends at 5pm on Saturday, April 25th, 2009.*)

Signature: _____

Date: _____

Course: CHEM 2600 (Organic Chemistry II)

Semester: Spring 2009

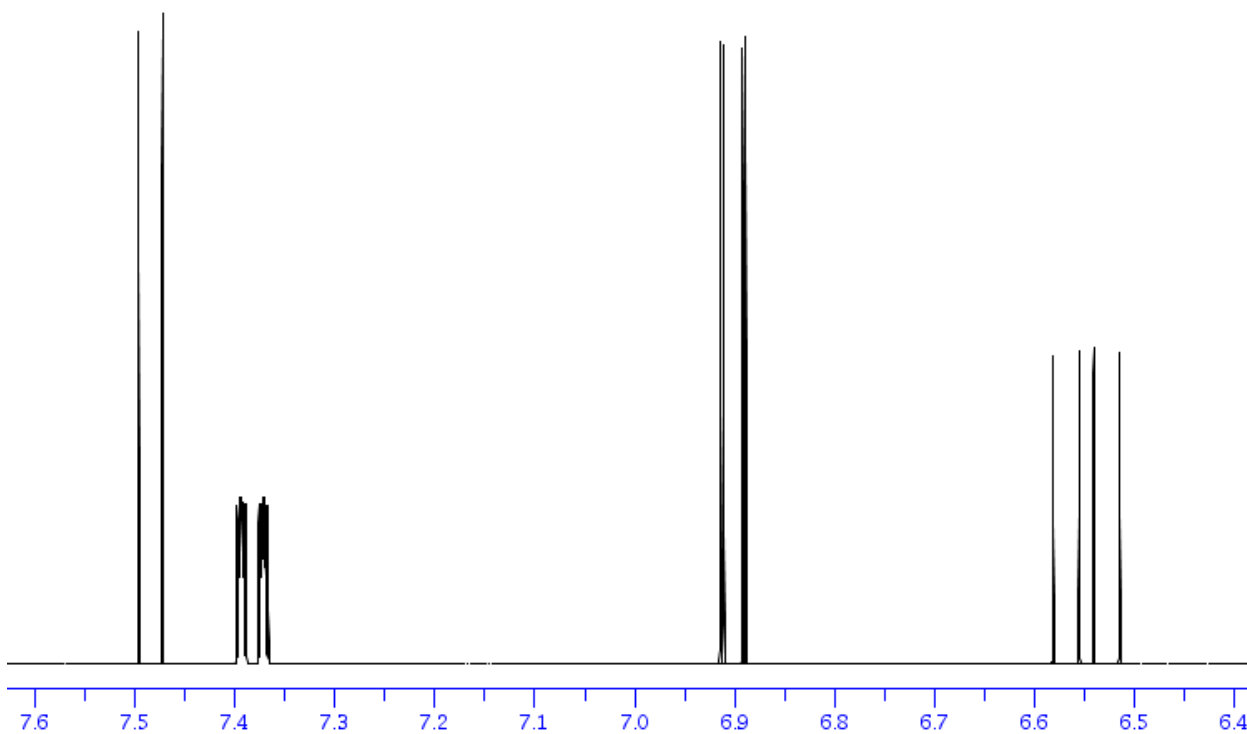
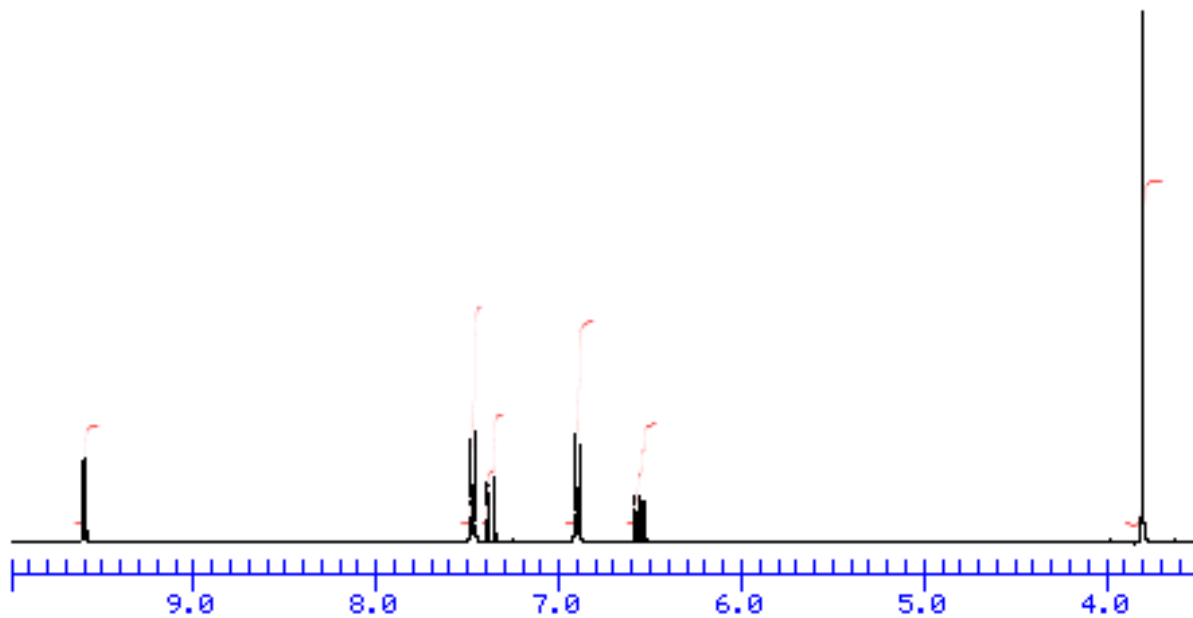
The University of Lethbridge

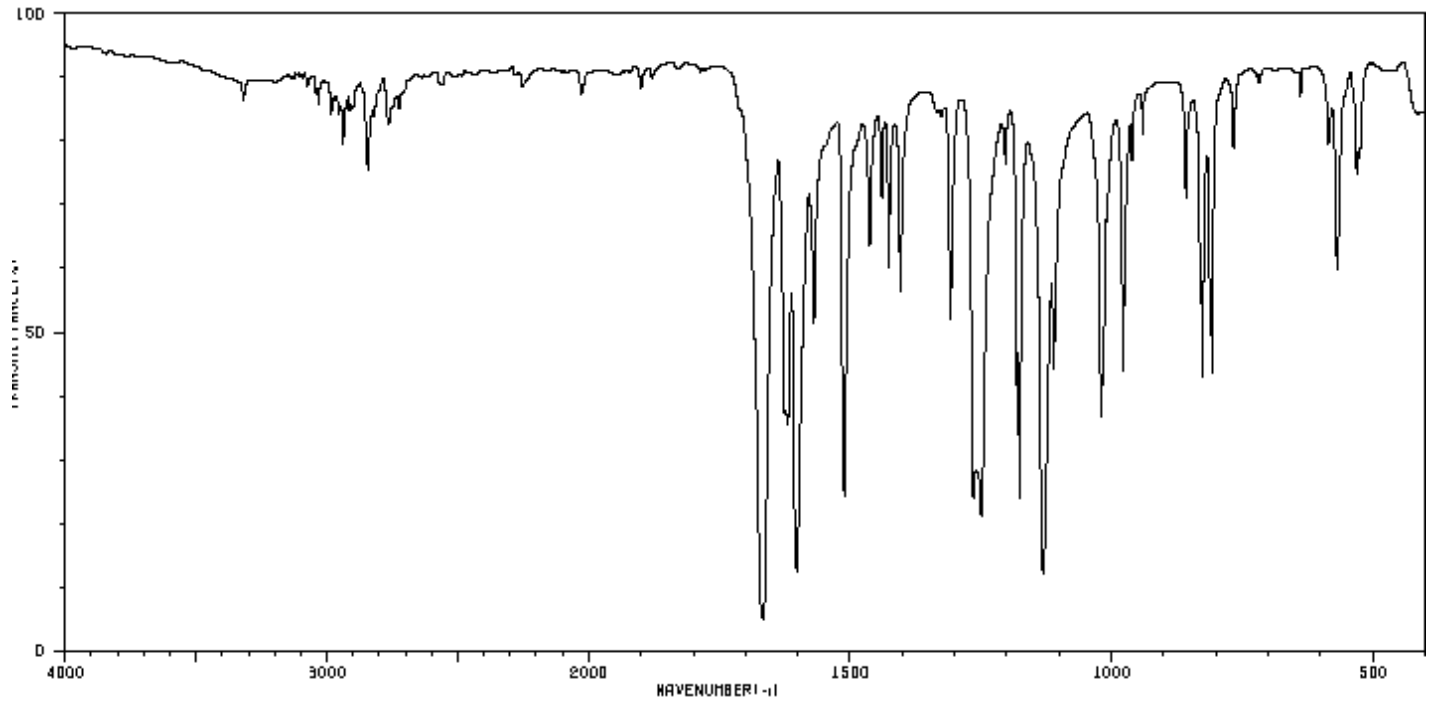
Q	Mark
1	/ 10
2	/ 10
3	/ 4
4	/ 4
5	/ 2
6	/ 3

Q	Mark
7	/ 4
8	/ 5
9	/ 7
10	/ 15
11	/ 1

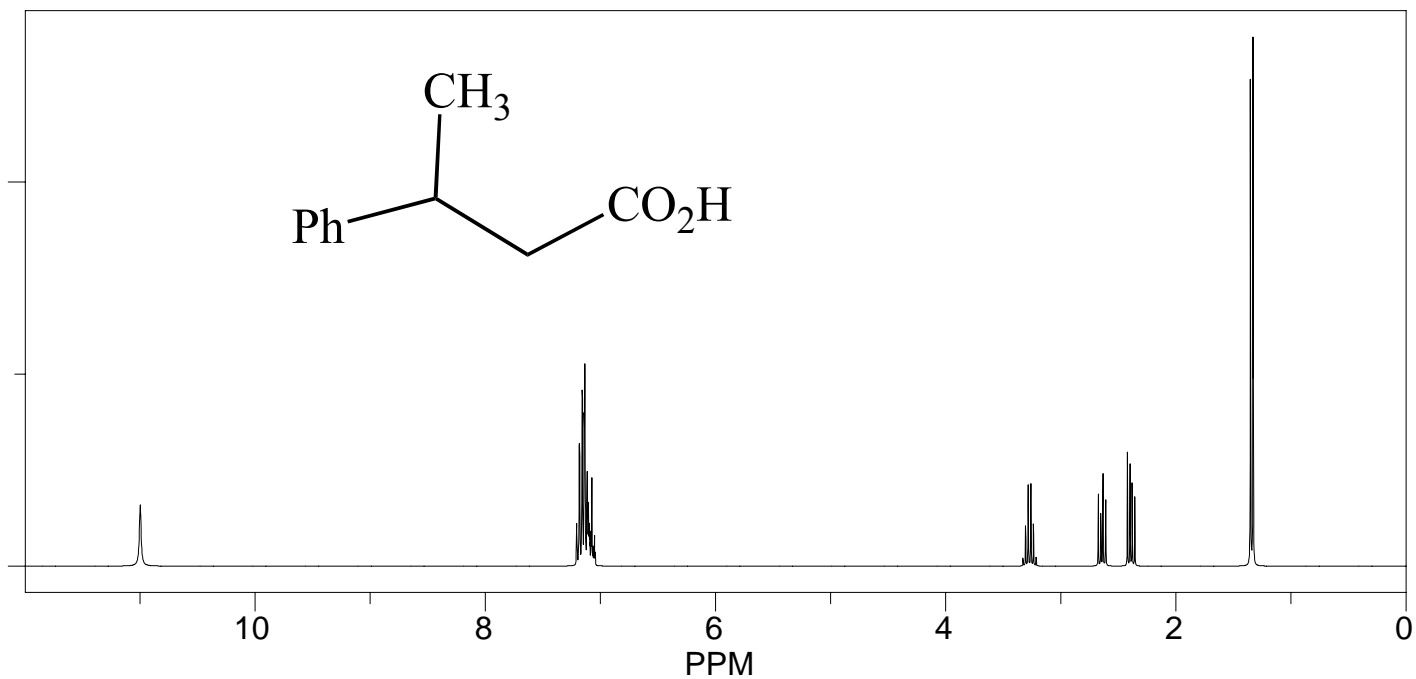
Total	/ 65
--------------	-------------

1. **[10 marks]**
- (a) Deduce the structure of the molecule, $C_{10}H_{10}O_2$, that gives the following proton NMR (400 MHz) and IR spectra.
- (b) Assign all signals on the proton NMR, and assign two meaningful IR bands.
- (c) Measure the coupling constants for the signal at 6.55 ppm, and indicate what this information tells you about the structure of this molecule.



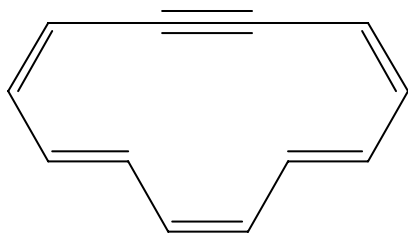


2. The 400 MHz proton NMR spectrum of 3-phenylbutanoic acid appears below. Assign all signals and account for the two signals between 2 and 3 ppm. **[10 marks]**

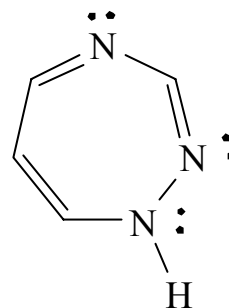


3. Identify whether each of the following molecules is aromatic, nonaromatic or antiaromatic **in the planar conformation**. If it is a factor in your decision, you must also indicate the number of electrons in the pi system. [4 marks]

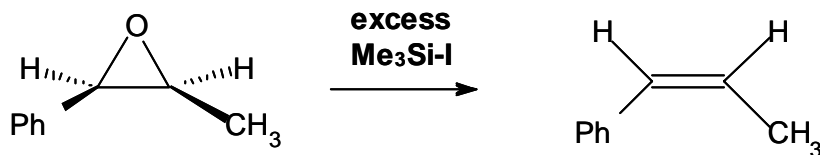
(a)



(b)

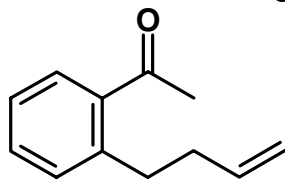


4. You are studying the following reaction. It gives only the product shown. Does this result mean that this reaction is stereospecific? If not, what experiment might you do to test whether it is stereospecific or not, and what other information might be useful? [4 marks]



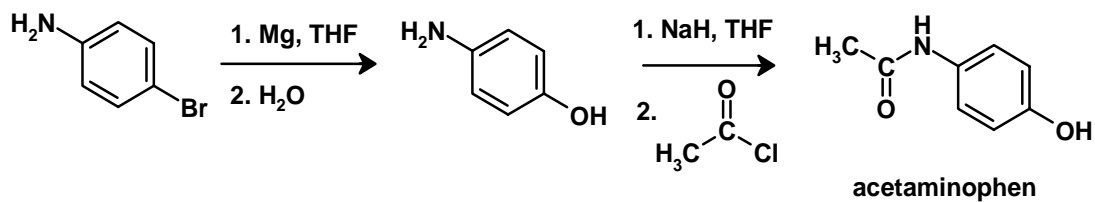
5. Consider the following molecule:

[2 marks]



When treated with 1 equivalent of H_2 in the presence of Pd/C, what is the product?
Briefly explain why reaction occurs at the site you have chosen.

6. A student proposed the following synthesis of acetaminophen:



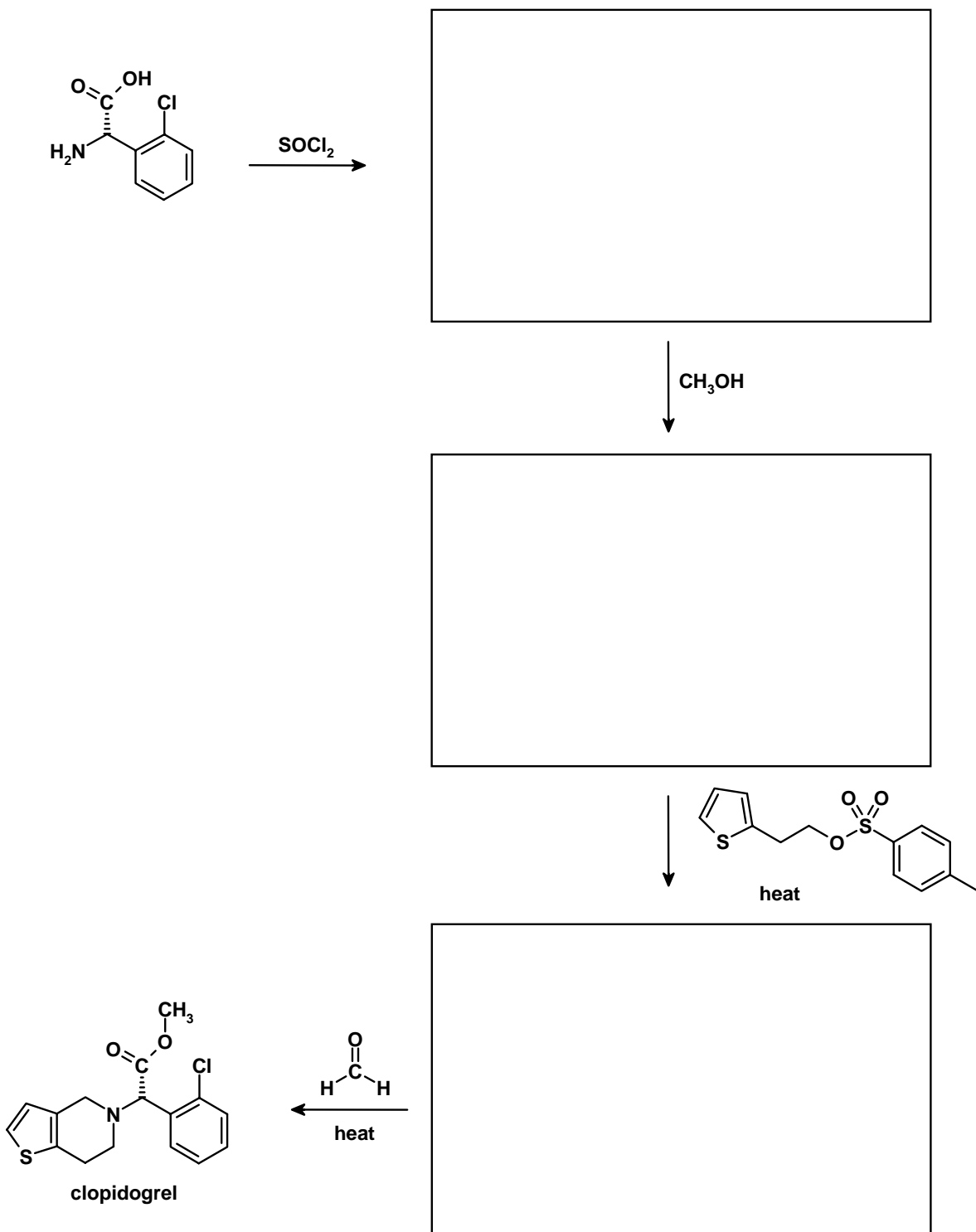
Identify three problems with this synthetic route.

[3 marks]

7. Clopidogrel (marketed as Plavix®) is an antithrombotic drug that inhibits platelet aggregation. **[4 marks]**

(a) Fill in the blanks in the following synthesis of Plavix®. **[3 marks]**

Some reaction conditions have been simplified for clarity. You do not need to show mechanisms.

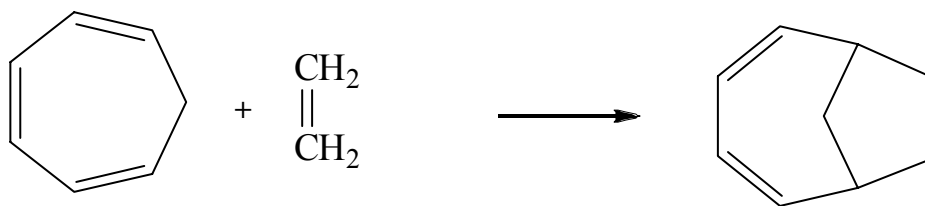


(b) Which enantiomer of clopidogrel is shown in the diagram above?

[1 mark]

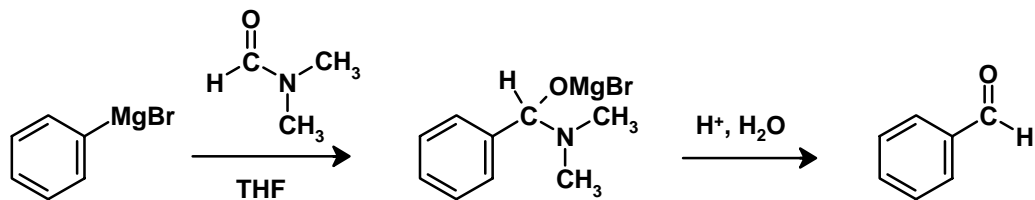
8. Showing the appropriate pi molecular orbitals, indicate whether the following reaction is thermally allowed. You may assume that the reaction involves the HOMO of the triene.

[5 marks]

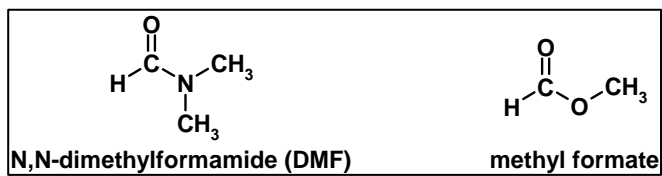


- (b) Come up with a rule, similar to the Huckel rule, that relates the number of pi electrons involved in a cycloaddition reaction to whether it is thermally allowed. You may name it after yourself if you wish.

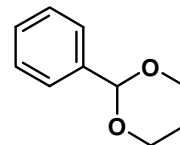
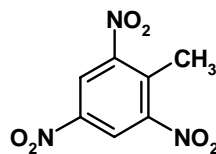
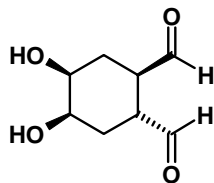
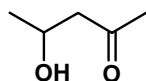
9. When phenylmagnesium bromide is reacted with N,N-dimethylformamide (DMF), the final product (after work-up with aqueous acid) is benzaldehyde: [7 marks]



- (a) Propose a mechanism for this reaction **including the work-up**. [5 marks]
- (b) If methyl formate is used instead of DMF, a different product is obtained. Draw this product and explain why DMF gives benzaldehyde but methyl formate does not. [2 marks]



10. Choose any **three** of the molecules below and propose a synthesis of each. [15 marks]
- Your organic reactants must be stable compounds that contain no more than five carbon atoms. They may be hydrocarbons, alkyl halides or alcohols and may contain C=C or C≡C bonds. 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.
 - If you work out syntheses for more than three of the molecules, clearly indicate which three you want marked by circling those compounds. Otherwise, I will mark the first three syntheses given.
 - If you run out of space on this page, continue your work on the next page.



Name: _____

Student Number: _____

10. *continued*

11. 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 2000 Standard Periodic Table

1																	18
1.0079 H 1												13	14	15	16	17	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	(261) Rf 104	(262) Db 105	(263) Sg 106	(262) Bh 107	(265) Hs 108	(266) Mt 109	(281) Dt 110	(283) Rg 111							
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	(260) Lr 103			

Developed by Prof. R. T. Boeré